



HAL
open science

Impact of the COVID-19 pandemic on online gambling in France and Sweden

Marianne Balem

► **To cite this version:**

Marianne Balem. Impact of the COVID-19 pandemic on online gambling in France and Sweden. Human health and pathology. Nantes Université; Lunds universitet (Lund, Suède), 2024. English. NNT : 2024NANU1025 . tel-04848516

HAL Id: tel-04848516

<https://theses.hal.science/tel-04848516v1>

Submitted on 19 Dec 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

THESE DE DOCTORAT DE

NANTES UNIVERSITE
LUND UNIVERSITY

ECOLE DOCTORALE n° 605

Biologie-Santé

Spécialité : Epidémiologie, Analyse de Risque, Recherche Clinique

Par

Marianne BALEM

Impact de la pandémie du COVID-19 sur l'activité de jeux de hasard et d'argent en ligne en France et en Suède

Thèse présentée et soutenue à Nantes, le 4 septembre 2024

Unité de recherche : UMR INSERM 1246 SPHERE « methodS in Patient-centered outcomes and Health ResEarch »

Rapporteurs avant soutenance :

Morgane Guillou-Landreat PU-PH, Université de Brest, France
Guillaume Airagnès MCU-PH, Université Paris Descartes, France

Composition du Jury :

Président :	Marie Grall-Bronnec	PU-PH, Nantes Université, France
Examineurs :	Cécile Proust-Lima	Directrice de recherche, Université de Bordeaux, France
	Marie Grall-Bronnec	PU-PH, Nantes Université, France
Directrice de thèse :	Gaëlle Challet-Bouju	Ingénieure de recherche hospitalier, Nantes Université, France
Co-directeur de thèse :	Anders Håkansson	Professeur, Lund University, Suède
Co-encadrant de thèse :	Bastien Perrot	Ingénieur de recherche, Nantes Université, France

Invité :

Stanislas Spilka Chargé de recherche, Observatoire Français des Drogues et Tendances addictives, France

Remerciements

À travers ces pages, je tiens à exprimer ma profonde gratitude à toutes celles et ceux qui ont contribué, de près ou de loin, à la réalisation de cette thèse, dont le cheminement a été marqué par des défis, de l'apprentissage et un soutien inestimable.

Pour commencer ces remerciements, je tiens chaleureusement à remercier ceux sans qui cette thèse n'aurait pas vu le jour : mes directeurs et encadrant de thèse.

Gaëlle, je me souviens encore de ce fameux mail d'avril 2020 avec pour objet « idée folle... » où tu m'as proposé ce sujet de thèse. Ce moment a marqué le début d'une aventure académique inoubliable. Alors, merci "+++" de m'avoir encouragée, soutenue et surtout de t'être démenée pour que cette "idée folle" se concrétise. Grâce à toi, j'ai découvert le monde passionnant de la recherche, et plus particulièrement celui du "gambling". Tu m'as réellement inspirée à poursuivre dans cette voie. Je te suis très reconnaissante pour tous tes conseils, ta rigueur et ta patience tout au long de ce parcours. Merci sincèrement pour tout ce que tu as fait pour moi.

Bastien, je tiens à te remercier particulièrement pour ta disponibilité infallible. Merci pour toutes les fois où je suis venue à ton bureau, souvent à l'improviste, avec toutes mes questions et mes doutes. À chaque fois, tu as pris le temps de m'écouter et de m'aider à y voir plus clair. Ta patience et ta façon de rendre les problèmes méthodo bien plus simple ont été d'une aide précieuse pour l'avancement de cette thèse.

Un grand merci à vous deux pour la confiance que vous m'avez accordée il y a presque cinq ans, lors de mon stage de master 2.

Anders, je tiens à te remercier sincèrement pour ton accueil chaleureux en Suède. Tu m'as permis de découvrir non seulement la culture suédoise mais aussi les spécificités de la réglementation des jeux dans ton pays, grâce à nos nombreuses discussions enrichissantes. Merci aussi pour ta patience, surtout lorsque je jonglais entre l'anglais et le français ! Tu as toujours su rendre ces échanges fluides et agréables. J'espère vraiment que nous aurons l'occasion de collaborer à nouveau à l'avenir sur des projets communs.

Un immense MERCI à vous trois pour votre gentillesse, votre expertise et enfin votre confiance. Merci d'avoir été présents à chaque étape et d'avoir rendu ce parcours aussi enrichissant. Vous avez constitué une équipe encadrante formidable, chacun contribuant de manière précieuse !

Je tiens ensuite à remercier les membres du jury d'avoir accepté d'évaluer ce travail de thèse en qualité de rapporteurs : Madame la Professeure Morgane Guillou-Landreat, et Monsieur le Docteur Guillaume Airagnes. Merci pour le temps consacré à la relecture de ce travail. J'ai hâte de discuter de tout cela lors de la soutenance.

Merci également à Madame la Docteure Cécile Proust-Lima et Monsieur Stanislas Spilka, qui ont accepté, il y a plus de trois ans, de faire partie du comité de suivi de ma thèse. Je vous suis reconnaissante pour vos échanges enrichissants et vos précieux conseils.

Un grand merci également à toi, Marie, particulièrement pour la confiance que tu m'accordes en me permettant de travailler sur de nouveaux projets au sein de l'équipe. Je te suis également reconnaissante pour tes conseils avisés et ton expertise. Travailler à tes côtés est extrêmement enrichissant et je suis impatiente de poursuivre cette belle aventure professionnelle avec toi et Gaëlle. Merci encore pour tout !

Je souhaite maintenant exprimer ma gratitude envers l'équipe de l'IFAC, avec une pensée toute particulière pour les TECs : Juliette, Elsa, Morgane, Anaïs, Yann, Charlotte, Solenne et Marie. Merci à chacun d'entre vous pour tous ces moments de convivialité partagés pendant les pauses, les déjeuners, et nos sorties au bar après le travail. Merci aussi de m'avoir aussi bien accueillie au sein de l'équipe, avec une mention spéciale pour Juliette, toujours si dévouée à chaque nouvelle arrivée ! Je tiens à remercier également Benoît, Claire, Valérie, Nina, Karine, ainsi que toutes celles qui ont fait partie de cette belle aventure, même si elles ont quitté l'équipe depuis...

Un grand merci à toi, Élodie, pour m'avoir accueillie avec tant de gentillesse et de bienveillance dès mon arrivée dans notre "bureau côté cours". Ta disponibilité, ta patience, et tous tes précieux conseils m'ont vraiment aidée, surtout au début de la thèse avec le CSI, les premières soumissions et tout le reste.

J'en viens maintenant naturellement à vous deux Agathe et Anne-Pascale... Votre amitié tout au long de ces trois dernières années a été un vrai rayon de soleil dans cette aventure de thèse. Votre présence quotidienne a apporté une touche de joie et de convivialité à chaque journée au bureau. Alors, un grand merci à toutes les deux pour toutes ces discussions (même celles qui n'étaient pas toujours très constructives...), pour les pauses café qui se sont trop souvent transformées en véritables séances de thérapie, et pour les soirées au café du cinéma à refaire le monde. J'espère que l'on continuera à partager encore plein de bons moments ensemble.

Merci également à l'unité INSERM 1246 SPHERE, et tout particulièrement à Véronique et Bruno, pour m'avoir si chaleureusement accueillie dans votre équipe. Votre soutien et votre accompagnement ont été essentiels tout au long de mon parcours de thèse. Je tiens aussi à remercier le reste de l'équipe, et surtout les doctorants/anciens doctorants : Yseulys, Yvan, Lucas, Vincent, Corentin, Odile, et tous les autres. Votre bonne humeur et l'atmosphère conviviale que vous maintenez au labo ont vraiment rendu ces trois années de thèse plus agréable et stimulante. Mention spéciale à Yseulys, un grand merci pour ton aide précieuse ! Je souhaite aussi remercier Céline et Joëlle, particulièrement pour l'organisation de mes aller-retours en Suède.

Je tiens aussi à remercier l'équipe du Malmö Addiction Center et en particulier Anna, Mitchell, Merve et Yassir. Même si je ne m'habituerai jamais aux dîners à 17h30, je vous remercie pour les bons moments passés ensemble à Malmö et pour m'avoir fait découvrir toutes les excellentes adresses de la ville !

Je souhaite maintenant adresser ma reconnaissance à ma famille, qui m'a soutenu malgré le fait que cette thèse semblait parfois abstraite pour eux. Votre présence constante et vos encouragements ont été inestimables tout au long de ce parcours.

Maman, Papa, merci du fond du cœur pour m'avoir toujours encouragé dans mes projets. Je me souviens encore de votre réaction le jour où je vous annonçais que je me lançais dans un doctorat. Aujourd'hui je peux enfin vous le dire : c'est promis, mes études sont enfin terminées ! Maman, un merci tout particulier pour ton soutien infailible, depuis la relecture de mon mémoire de master 2 jusqu'à chacun de tes messages d'encouragement avant toutes mes présentations en congrès.

Merci également à mon grand frère Yann et surtout à la vie nantaise qui nous a permis de nous rapprocher, tant sur le plan géographique mais aussi sur le plan personnel. Merci pour ton soutien et tes encouragements !

Merci aussi au reste de la famille et particulièrement à mes cousines Bleu, Gwenn et Nono pour avoir depuis toujours joué ce rôle de « grande sœur ».

Merci également à ma belle-famille. Votre accueil chaleureux, votre gentillesse et votre soutien m'ont été précieux, en particulier tout au long de ma thèse.

Je remercie aussi chaleureusement mes amis, vous avez toujours été présent pour me changer les idées et me rappeler de prendre du temps pour moi. Sans vous, ce parcours aurait été tellement plus difficile.

Un immense merci à Sarah, Nolwen, Iris, et Camille. Je ne compte même plus les années d'amitié qu'on a accumulées ensemble, tellement on en a vécu des choses, bande de folles ! C'est incroyable de repenser à tous les moments qu'on a partagés et aux souvenirs qu'on a créés au fil du temps. On pourrait presque écrire un livre avec toutes les situations inattendues dans lesquelles on s'est retrouvées... Je suis profondément reconnaissante d'avoir des amies comme vous. Merci pour tout, les filles, et merci d'être vous. Vous êtes de véritables rayons de soleil !

Merci également à la bande de Saint-Thois, votre bonne humeur n'égale que votre humour. Un merci particulier pour Max et Benj, vivement le prochain voyage avec la team Safari !!!

Un grand merci aussi à mes amies d'enfance Deelia et Manon. On a grandi ensemble et partagé un paquet de souvenirs mémorables. Le temps passe, mais notre complicité reste intacte. Merci pour votre gentillesse, votre bienveillance et votre simplicité.

Je souhaite également exprimer ma gratitude à la bande de Concarneau. Cela fait maintenant près de 6 ans que vous m'avez intégrés dans votre groupe, passant de la simple +1 de « Momo » à une amie à part entière. Merci à vous tous pour votre bonne humeur contagieuse et votre bienveillance. Un merci tout particulier à mes Nantais préférés, Céline et Alex. C'est toujours un plaisir de passer du temps en votre compagnie... La vie Nantaise n'aurait pas la même saveur sans vous ! A quand le prochain escape game ?

Un grand merci aussi à Benj et Perrine, nos bobos parisiens préférés.

Enfin et surtout, merci infiniment à toi, Axel. Les mots me manquent pour exprimer toute ma gratitude et à quel point je suis reconnaissante de t'avoir à mes côtés. Ta patience, ton soutien inébranlable et ton amour ont été les piliers essentiels de cette aventure doctorale. Merci d'avoir cru en moi et de m'avoir encouragée, surtout dans les moments les plus difficiles. Ta présence à mes côtés et tes petites attentions quotidiennes ont été une source de réconfort et de motivation, rendant cette expérience tellement plus agréable. Merci pour tout ce que tu as fait pour moi, et surtout d'être la personne merveilleuse que tu es. Je suis impatiente de découvrir ce que l'avenir nous réserve ♡.

Valorisations scientifiques

Publications issues de la thèse :

- **Balem M.**, Perrot B., Hardouin J. B., Thiabaud E., Saillard A., Grall-Bronnec M., & Challet-Bouju G. (2022). Impact of wagering inducements on the gambling behaviors of on-line gamblers: A longitudinal study based on gambling tracking data. *Addiction*, 117(4), 1020–1034. <https://doi.org/10.1111/add.15665>
- **Balem M.**, Karlsson A., Widinghoff C., Perrot B., Challet-Bouju G., & Håkansson A. (2023). Gambling and COVID-19: Swedish national gambling data from a state-owned gambling sports and casino operator. *Journal of behavioral addictions*, 12(1), 230–241. <https://doi.org/10.1556/2006.2022.00089>
- **Balem M.**, Perrot B., Grall-Bronnec M., Widinghoff C., Karlsson A., Håkansson A. & Challet-Bouju G. (2024). Impact of the COVID-19 pandemic on online gambling behaviors: a descriptive analysis on all legal French websites. *[Soumis]*
- **Balem M.**, Perrot B., Grall-Bronnec M., Håkansson A. & Challet-Bouju G. (2024). Typology of online behaviors during the COVID-19 pandemic: a longitudinal study based on French gambling tracking data. *[En cours de soumission]*
- **Balem M.**, Perrot B., Grall-Bronnec M., Widinghoff C., Karlsson A., Håkansson A. & Challet-Bouju G. (2024). Typology of online gambling behaviors during the COVID-19 pandemic: Swedish national gambling tracking data from state-owned gambling sports and casino operator. *[En cours de soumission]*

Autres publications en lien avec la thèse :

- Andersson M. J., **Balem M.**, & Håkansson A. (2022). An interrupted time series analysis of gambling behavior based on gambling operator revenue-based taxation during the COVID-19 pandemic in Sweden. *Public health*, 211, 14–20. <https://doi.org/10.1016/j.puhe.2022.07.003>

Communications orales :

Congrès international :

- **Balem M.**, Karlsson A., Widinghoff C., Perrot B., Challet-Bouju G., & Håkansson A. (2023). Gambling and COVID-19: Swedish national gambling data from a state-owned gambling sports and casino operator. *3rd Nordic Gambling Research Network – Gambling in context (GAMIC)*, Aalborg, Denmark, 19-20 May 2022.
- **Balem M.**, Perrot B., Hardouin J. B., Thiabaud E., Saillard A., Grall-Bronnec M., & Challet-Bouju G. (2022). Impact of wagering inducements on the gambling behaviors of on-line gamblers: A longitudinal study based on gambling tracking data. *7th International Conference on Behavioral Addictions (ICBA)*, Nottingham, England, 20-22 June 2022.
- **Balem M.**, Karlsson A., Widinghoff C., Perrot B., Challet-Bouju G., & Håkansson A. (2023). Gambling and COVID-19: Swedish national gambling data from a state-owned gambling sports and casino operator. *7th International Conference on Behavioral Addictions (ICBA)*, Nottingham, England, 20-22 June 2022.
- **Balem M.**, Perrot B., Grall-Bronnec M., Widinghoff C., Karlsson A., Håkansson A. & Challet-Bouju G. (2024). Impact of the COVID-19 pandemic on online gambling among users of the Swedish state-owned gambling sports and casino operator and French national online websites: a comprehensive analysis. *4th Nordic Gambling Research Network – Gambling in context (GAMIC)*, Helsinki, Finland, 30-31 March 2023.
- **Balem M.**, Perrot B., Grall-Bronnec M., Widinghoff C., Karlsson A., Håkansson A. & Challet-Bouju G. (2024). Impact of the COVID-19 pandemic on online gambling among users of the French national online websites. *8th International Conference on Behavioral Addictions (ICBA)*, Incheon, South Korea, 23-25 August 2023.
- **Balem M.**, Perrot B., Grall-Bronnec M., Widinghoff C., Karlsson A., Håkansson A. & Challet-Bouju G. (2024). Impact of the COVID-19 pandemic on online gambling among users of the French national online websites. *11th International Conference Pathological Gambling & Other Behavioural Addictions*, Warsaw, Poland, 13-14 November 2023.

Congrès national :

- **Balem M.**, Perrot B., Håkansson A., & Challet-Bouju G. (2023). Impact de la pandémie du COVID-19 sur les activités de jeux de hasard et d'argent en ligne en France et en Suède. *Journées scientifiques de l'Ecole Doctorale Biologie Santé – Nantes Université*, Nantes, France, 4-5 Avril 2023.

Vulgarisation :

- **Balem M.**, Perrot B., Håkansson A., & Challet-Bouju G. (2023). Impact de la pandémie du COVID-19 sur les activités de jeux de hasard et d'argent en ligne en France et en Suède. *Ma thèse en 180 secondes – finale nantaise*, Nantes, France, 9 Mars 2022.

Table des matières

Remerciements	i
Valorisations scientifiques	v
Abréviations	xii
Liste des Tables	xiv
Liste des Figures	xv
1 INTRODUCTION	1
1.1 Practice of gambling in France and Sweden	1
1.1.1 Definition of gambling	1
1.1.2 History of gambling regulation and offer in France and Sweden	2
1.1.3 Practices of gambling in French and Swedish societies	10
1.1.4 The addictive power of online gambling	17
1.2 Gambling disorder	18
1.2.1 Definition and assessment of gambling disorders	18
1.2.2 Prevalence in French and Swedish population	20
1.2.3 Risk factors associated with gambling disorder	25
1.3 The coronavirus disease 2019 (COVID-19) pandemic	28
1.3.1 Public health measures implemented in France and Sweden	28
1.3.2 Impact of the pandemic restrictions on gambling offer availability	38
1.4 Justification and objectives of the thesis	39
1.4.1 Motivations	39
1.4.2 Objectives	40
2 FROM MASTER'S DEGREE INTERNSHIP TO THESIS PROJECT	42
2.1 Justification and objectives of the Master's degree internship	44
2.2 The EDEIN study	45
2.2.1 Objectives of the study	45
2.2.2 Data collection	46
2.2.3 Gambling indicators	47
2.2.4 Statistical methods	48
2.3 Manuscript 1:	52
2.3.1 Abstract	52
2.3.2 Introduction	53
	viii

2.3.3	Methods	55
2.3.4	Results	58
2.3.5	Discussion	67
2.3.6	Conclusion	70
2.3.7	References	70
2.3.8	Supplementary information	70
2.4	Overview and conclusion of the chapter 2	78
2.4.1	Main results of the manuscript 2	78
2.4.2	Conclusion	79
3	THE CONGA STUDY	81
3.1	Aim and objectives	82
3.2	Data collection	83
3.2.1	Study population and inclusion criteria	83
3.2.2	Extraction and circulation of data	83
3.2.3	Description of data	83
3.3	COVID-19-affected periods	86
3.4	Gambling-related events	89
3.4.1	Sports competitions	90
3.4.2	Horse races	94
3.4.3	Jackpots in draw-based games	96
4	IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS: A COMPREHENSIVE-LEVEL APPROACH	98
4.1	Statistical methods	99
4.1.1	Generalized linear models	99
4.1.2	Models for longitudinal data	104
4.2	Manuscript 2: Impact of the COVID-19 pandemic on online gambling behaviors: A descriptive analysis of all legal French websites	107
4.2.1	Abstract	107
4.2.2	Introduction	108
4.2.3	Methods	110
4.2.4	Results	113
4.2.5	Discussion	121
4.2.6	Conclusion	124
4.2.7	References	124
4.2.8	Supplementary information	124
4.3	Manuscript 3:	130
4.3.1	Abstract	130
4.3.2	Introduction	131

4.3.3	Methods	133
4.3.4	Results	135
4.3.5	Discussion	147
4.3.6	Conclusion	149
4.3.7	References	150
4.3.8	Supplementary information	150
4.4	Overview and conclusion of the chapter 4	155
4.4.1	Main results of the French study	155
4.4.2	Main results of the Swedish study	156
4.4.3	Conclusion	157
5	IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS: AN INDIVIDUAL-LEVEL APPROACH	160
5.1	Statistical methods	161
5.1.1	Latent Class Analysis	161
5.1.2	Latent Class Mixed Models	165
5.2	Manuscript 5: Typology of online gambling behaviors during the COVID-19 pandemic: a longitudinal study based on French gambling tracking data	167
5.2.1	Abstract	167
5.2.2	Introduction	168
5.2.3	Methods	169
5.2.4	Results	173
5.2.5	Discussion	189
5.2.6	Conclusion	191
5.2.7	References	191
5.3	Manuscript 6: Typology of online gambling behaviors during the COVID-19 pandemic: Swedish national gambling tracking data from state-owned gambling sports and casino operator	192
5.3.1	Abstract	192
5.3.2	Introduction	193
5.3.3	Methods	195
5.3.4	Results	198
5.3.5	Discussion	209
5.3.6	Conclusion	211
5.3.7	References	211
5.4	Overview and conclusion of the chapter 5	212
5.4.1	Main results of the French study	212
5.4.2	Main results of the Swedish study	213
5.4.3	Conclusion	213

6	DISCUSSION AND PERSPECTIVES	217
6.1	Summary and limitations of the thesis	218
6.2	Perspectives	221
	Références bibliographiques	224

Abréviations

ADHD Attention Deficit Hyperactivity Disorder

AIC Akaike Information Criterion

ANJ Autorité Nationale des Jeux

APA American Psychiatric Association

ARJEL Autorité de Régulation des Jeux En Ligne

BIC Bayesian Information Criterion

CONGA Covid-19 and ONline GAMbling

COVID-19 Coronavirus Disease 2019

EM Expectation-Maximization

ICD-11 International Classification of Diseases (11th edition)

IFAC Institut Fédératif des Addictions Comportementales

DSM-5 Diagnostic and Statistical Manual of Mental Disorders (5th edition)

FDJ Française Des Jeux

GD Gambling Disorders

GGE Generalized Estimating Equations

GLM Generalized Linear Model

GLMM Generalized Linear Mixed Model

LM Linear Model

LMM Linear Mixed Model

MLE Maximum Likelihood Estimation

NBA National Basketball Association

OCD Obsessive-Compulsive Disorder

OFDT French Observatory for Drug and Drug Addiction

OR Odds Ratio

PMU Paris Mutuel Urbain

PGSI Problematic Gambling Severity Index

REML Restricted Maximum Likelihood

RMSE Root Mean Squared Error

SPHERE methodS in Patient-centered outcomes and HEalth ResEarch

Swelogs Swedish Longitudinal Gambling Study

WHO World Health Organization

ZIP Zero-Inflated Poisson

Liste des Tables

Table 1: Gambling practices in 2019 according to games, gender, and age among French individuals aged 18 to 75 (weighted data, %).	11
Table 2: Offline gambling practice in 2021 according to games, gender and age among Swedes individuals aged 16 to 84 (weighted data, %).	14
Table 3: Characteristics of online gambling population in Sweden in 2021, according to gender (gambling account and deposits).	16
Table 4: Diagnostic criteria of DSM-5 for GD.	19
Table 5: Prevalence of GD in France in 2019, according to PGSI.	22
Table 6: Prevalence of GD in Sweden in 2021, according to PGSI.	24
Table 7: Risk factors associated with problem gambling.	26
Table 8: Division of the COVID-19-affected periods according to each country.	87
Table 9: Reporting and timeline of Group 1 Races in 2019 and 2020.	94
Table 10: Some distributions used in GLM, link functions and corresponding types of dependent variables.	101

Liste des Figures

Figure 1: Schematic representation of the gambling offer in France before and after the law No. 2010-476.	5
Figure 2: Schematic representation of the gambling offer in Sweden before and after Swedish Gambling Act (2018:1138).	9
Figure 3: Online gambling prevalence of French gamblers in 2021.	12
Figure 4: Proportion of offline gambling frequency according to gender (%).	15
Figure 5: Online gambling prevalence of Swedish population in 2021, according to gender.	16
Figure 6: At-risk gamblers prevalence in French population in 2017, according to gambling types.	22
Figure 7: At-risk gamblers prevalence in Swedish population in 2021, according to gambling types.	24
Figure 8: First phase of the lockdown easing in France on May 11 th , 2020.	30
Figure 9: Second phase of the lockdown easing in France on June 2 nd , 2020.	31
Figure 10: Schematic representation of the COVID-19-affected periods for the French analyses.	88
Figure 11: Schematic representation of the COVID-19-affected periods for the Swedish analyses.	88
Figure 12: Timeline of sports competitions that generated the most bets in France in 2019 and 2020.	92
Figure 13: Timeline of sports competitions that generated the most bets in Sweden in 2019 and 2020.	93

Figure 14: Variations in the maximum amount of jackpot offered by FDJ for draw-based games in 2019 and 2020.

97

Chapter 1

INTRODUCTION

Table of contents

1.1	Practice of gambling in France and Sweden	1
1.1.1	Definition of gambling	2
1.1.2	History of gambling regulation and offer in France and Sweden	3
1.1.3	Practices of gambling in French and Swedish societies	10
1.1.4	The addictive power of online gambling	17
1.2	Gambling disorder	18
1.2.1	Definition and assessment of gambling disorders	18
1.2.2	Prevalence in French and Swedish population	20
1.2.3	Risk factors associated with gambling disorder	25
1.3	The coronavirus disease 2019 (COVID-19) pandemic	28
1.3.1	Public health measures implemented in France and Sweden	28
1.3.2	Impact of the pandemic restrictions on gambling offer availability	38
1.4	Justification and objectives of the thesis	39
1.4.1	Motivations	39
1.4.2	Objectives	40

1.1 Practice of gambling in France and Sweden

1.1.1 Definition of gambling

In its simplest form, gambling is defined as an activity where the outcome relies primarily or solely on chance and involves irreversible financial commitment. Gamblers make a financial sacrifice in hopes of gaining something without being able to predict the game's result (Cook, 1991). Two distinct categories of gambling are defined. Firstly, there are pure chance games, which encompass a variety of gambling activities where the outcome depends entirely on chance and is not influenced by the skills or decisions of the gambler. In these games, there is no room for strategic manoeuvring. Persisting in the game does not allow for skill improvement or increased chances of winning. Within this category of games are included:

- *Draw-based games*: Gamblers buy tickets and choose numbers on a grid, hoping that they will match the winning numbers drawn by the gambling operator. Draw-based games are part of lottery games.
- *Bingo*: Gamblers buy cards with numbered squares. A bingo caller or electronic system then randomly draws numbers and announces them. Gamblers mark the corresponding numbers on their cards, and the first one to complete a line or specific combination of numbers wins a prize. Bingo games are part of lottery games.
- *Scratch cards*: Gamblers scratch off to reveal hidden symbols on a card, checking if they have won money. Scratch games are part of lottery games.
- *Electronic Gambling Machines (EGMs)*: Gambling device that generates random symbols and pays out winnings based on the combinations of symbols shown on the machine. EGMs includes slot machines, video poker machines, etc.
- *Table games, except poker*: Gambling offered by casino operators and played on a specialized table typically overseen by a croupier. These games commonly involve cards (except poker), dice, or spinning wheels, and include popular games like blackjack, roulette, baccarat, craps, etc. Gamblers place bets on the outcome of these games, with the croupier managing the gameplay by dealing cards, spinning the roulette wheel, or rolling the dice, all while ensuring fairness and compliance with the rules.

The second category of gambling encompasses games of chance with an element of skill. While chance remains a significant factor in these games, the outcome is not solely determined by chance. Instead, the gambler's experience, knowledge, and/or skill may play integral roles in influencing the game's outcome. The result often depends on the skill gap between gamblers.

Unlike pure games of chance, where success is entirely random, these games provide opportunities for gamblers to employ strategic decisions, analyse probabilities, and use their expertise to improve their chances of winning. Within this category of games are included:

- *Sports betting*: Gamblers place a bet on the outcome of sporting competition.
- *Horse race betting*: Gamblers place a bet on the outcome of horse-race competition.
- *eSports betting*: Gamblers place a bet on the outcome of video game competition.
- *Poker*: Card games that involves betting and strategy, where gamblers compete against each other to have the best hand or to bluff their opponents into folding.

Gambling activities are offered and managed by gambling operators, who provide a wide array of gambling options and opportunities for participants. These operators establish and manage platforms like casinos, online betting websites, or betting shops, where individuals can participate in different forms of gambling. Overall, gambling operators are crucial in shaping the gambling industry, as they answer to the preferences of various audiences while adhering to regulatory standards that govern their operations.

1.1.2 History of gambling regulation and offer in France and Sweden

For centuries, gambling has been a prevalent and enduring activity in societies worldwide, continually evolving and adapting to changing times.

In recent years, online gambling has become a prominent feature of leisure pursuits, providing users with convenience, accessibility, and a plethora of gambling options. This surge in popularity can be attributed to the widespread availability of internet-connected devices and ongoing technological advancements, which have facilitated the rise of online gambling platforms. As a result, these platforms now cater to a broad spectrum of gamblers, offering a diverse range of gambling experiences to suit various preferences and interests. Consequently, both the French and Swedish governments have responded to this trend by enacting laws designed to regulate and supervise the offline and online gambling industry effectively.

French gambling regulation and offer

Offline gambling

Initially prohibited in France and for a long time clandestine, gambling gradually became legalized starting from the 18th century, notably with the establishment of the Royal Lottery (Harouel, 2011). From past years until the present day, a variety of gambling options have emerged throughout the country, such as casinos, the *Pari Mutuel Urbain* (PMU), and the National Lottery (Harouel, 2011).

Originally limited to seaside, thermal, or climate resort areas, land-based casinos expanded over time, particularly with the authorization of EGMs and the extension of their operating zones in 1987. According to the Ministry of the Interior, there are now over 200 casinos established throughout France, offering a range of gambling options including table games, poker and EGMs.

In 1930 horse racing organizations were authorized to sell horse racing bets outside of racetracks, but only in a mutualized manner. This means that the odds of bets are determined based on the bets placed by bettors and not fixed in advance by a bookmaker. The PMU was then established. In 1954, the creation of the *tiercé*, a specific type of horse-race betting where participants aim to predict the first three horses to finish a race in the correct order, marked a significant turning point in the world of horse racing betting. This innovation not only spurred a notable rise in the number of races but also fostered the diversification of betting formats within the industry. The emergence of the *tiercé* brought about a surge in interest and participation in horse-race betting, contributing to the growth and evolution of the horse-racing as a whole (PMU, 2024).

The National Lottery, descendant from the Royal Lottery, was established by the French State in 1933 to aid war invalids, veterans of the First World War, and victims of agricultural disasters. Although only a few draws were held annually initially, it wasn't until after the Second World War that draws became weekly occurrences. Draws for specific days such as Valentine's Day and Friday the 13th were also introduced. In 1976, due to the intense competition brought about by the creation of the *tiercé* by the PMU, a new draw-based game emerged: the *Loto*®. With the advancements in technology and televised draws, the *Loto*® quickly became a success. It was only in 1991 that the state-operated lottery operator was officially named *La Française Des Jeux* (FDJ). A few years later, the first scratch card games and sports betting options were introduced and the FDJ initiated a partnership with other European countries to create a new draw-based game, similar to the *Loto*® but with much higher prizes: the *EuroMillions* (FDJ, 2024).

To date, the French offline gambling market is divided into various sectors. Land-based casinos offer a variety of games, including EGMs, table games, bingo, and poker. The PMU holds a monopoly on horse racing bets, while the FDJ monopolizes draw-based games, scratch cards, and sports betting. Despite the absence of dedicated bingo halls in France (except for bingo events organized by non-profit associations), the FDJ may also organize bingo games, often in the form of scratch cards. Furthermore, the sale points for lottery games and horse race betting are subject to regulation. Offline gambling offerings by the FDJ are exclusively

available at authorized outlets, primarily located in tobacco shops, bars and shopping malls. Similarly, PMU horse racing bets are exclusively sold at outlets, including those found at racetracks. In contrast to the situation in many countries, where EGMs and other casino games are commonly found in various non-casino venues, the regulations in France are stricter. EGMs and other casino games are permitted only in approved casinos. Finally, since 2020, the *Autorité Nationale des Jeux* (ANJ) is responsible for supervising these land-based games, ensuring compliance with regulatory standards.

Online gambling

During years, only the PMU and the FDJ had been officially authorized to offer online gambling in France, holding a monopoly over online lotteries (for FDJ), online sports betting (for FDJ), and online horse races betting (for PMU), despite numerous other operators offering similar services outside the scope of the law. In terms of casinos games, only land-based casinos had been authorized, and online casino games (including poker) had been forbidden in France. With the rise of the internet, these state monopolies saw the gambling market slip away from them due to the emergence of websites offering new gambling opportunities. In response to this illegal offering, the French parliament enacted Law No. 2010-476 on May 12, 2010, aimed at opening the online gambling market to competition. This law sought to fulfil four specific objectives: regulate the online gambling to combat addiction and protect minors, ensure the integrity and transparency of gambling operations, prevent fraudulent or criminal activities (including money laundering), and ensure the balanced and equitable development of various economic sectors related to gambling. The introduction of this new legislation also allowed the French government to generate tax revenue through licenses and taxes imposed on online gambling operators. The opening of the French online gambling market to competition and regulation was desired by the European Commission to end the monopoly of the two historical operators (FDJ and PMU) on the online offering, in order to limit illegal online gambling. Thus, online gambling activities are now permitted and opened to competition in France, but only for operators with approval (licence-based market) and for the following gambling activities: horse races betting, sports betting, and poker. In parallel, the FDJ retains its monopoly on online lottery (draws-based games and scratch games) due to a special exemption. Online casinos still remain illegal in France for the time being due to their recognized addictive potential. Furthermore, e-sport betting, which involves wagering money on the outcomes of video game tournaments (League of Legends, Counter-Strike, etc.) is also illegal. The French government has entrusted the regulation of this new market to an independent administrative authority: The

Autorité de Régulation des Jeux en Ligne (ARJEL). The ARJEL was responsible for monitoring only the activities of online gambling licensed operators, offline gambling activities still being under a fragmented regulation within different ministries.

In 2020, the *Autorité Nationale des Jeux* (ANJ) was established by merging several French gambling regulatory authorities, including ARJEL. As a result, ANJ is responsible for regulating the entire gambling market, both land-based and online, in France. As of today, ANJ has granted licenses to 16 gambling operators for sports betting, horse racing, or poker, totalling 27 approvals (which means that some operators have been authorized to offer multiple types of gambling). Two operators hold exclusive rights: FDJ and PMU, due to their monopoly status for online and offline lottery games (FDJ) and offline horse race betting (PMU).

Figure 1 illustrates the evolution of French offline and online gambling offerings before and after the implementation of the new regulation in 2010.

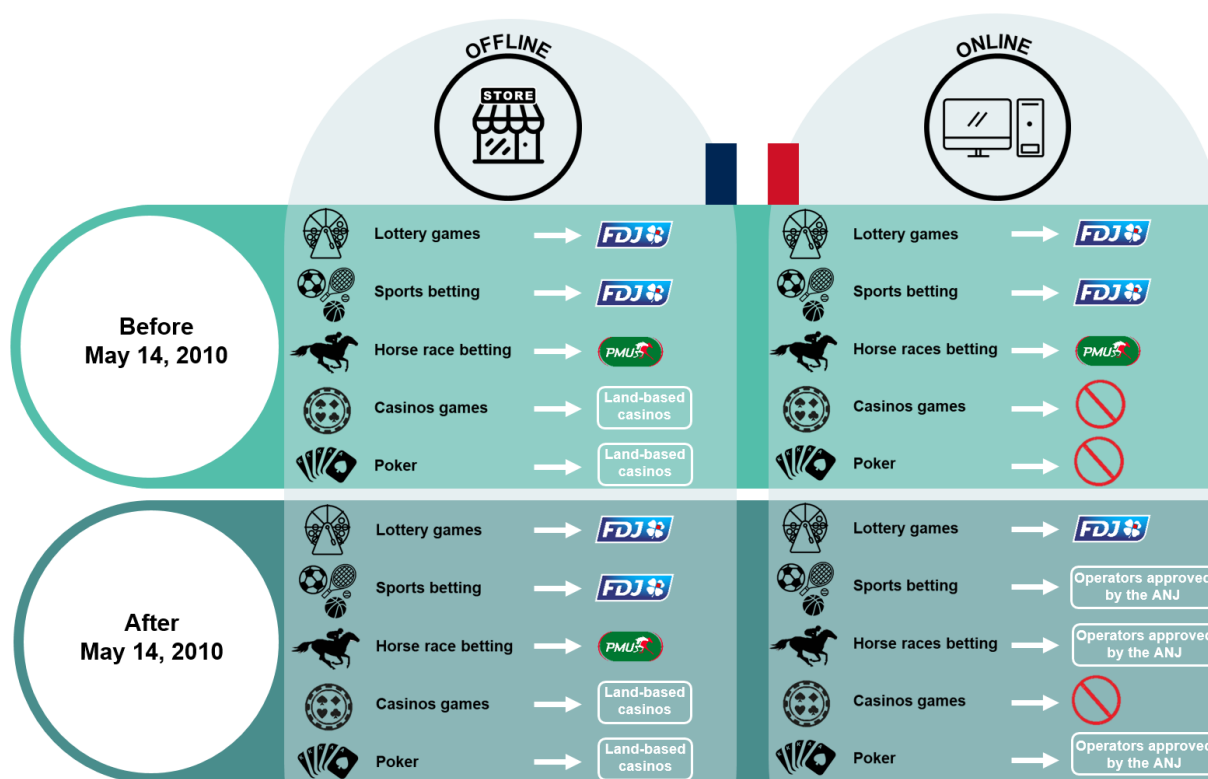


Figure 1: Schematic representation of the gambling offer in France before and after the law No. 2010-476.

Swedish gambling regulation and offer

Offline gambling

The earliest official forms of gambling in Sweden began with the opening of the *Ramlösa Brunn Casino* in the 18th century, offering primarily roulette and card games. However, despite

its initial popularity, gambling faced a significant setback a century later when authorities, influenced by the Church's condemnation of gambling as diabolic, officially banned it (Binde, 2014).

The prohibition on gambling lasted until 1897 when the Swedish government legalized commercial lottery with the establishment of *Penninglotteriet* (Matilainen, 2016). In the late 1930s and early 1940s, the government decided to regulate gambling more effectively leading to the creation of *Tipstjänst* due to widespread illegal betting related to sporting events. Operating under the supervision of the Swedish government, *Tipstjänst* offered various forms of sports betting and lottery games. Simultaneously, the Swedish state acquired ownership of the national lottery *Penninglotteriet*. For more than sixty years, *Tipstjänst* and *Penninglotteriet* jointly dominated the Swedish gambling market. During this time, the introduction of scratch card games occurred alongside the expansion of draw-based games and sports betting offerings. Notably, *Lotto* was introduced in 1980 by *Tipstjänst*, requiring gamblers to match seven numbers out of thirty-five. Additionally, in 1983, *Måltipset* was launched, challenging gamblers to predict the outcomes of eight football matches with the highest number of goals out of a selection of thirty matches (Matilainen, 2016). In 1997, *Tipstjänst* merged with *Penninglotteriet* to form the state-owned company *AB Svenska Spel* (Svenska Spel, 2024). Two years later, the Swedish parliament enacted a law on casinos, which enabled casino games to be played in accordance with international rules. *Svenska Spel*, through its new subsidiary *Casino Cosmopol*, received a permit to operate the four casinos located in Sundsvall, Stockholm, Göteborg and Malmö. Additionally, *Svenska Spel* continued to expand its offline gambling offerings, including the opening of bingo halls, the sale of scratch cards in supermarkets, and the introduction of a new *Vikinglotto* poker platform, which included the first craps table in land-based casinos.

In parallel, owing to the rise of the horse race betting market, the Swedish State established the Swedish Horse Racing Totalisator Board (ATG) in 1974. ATG is owned by Swedish horse racing associations but operates as a state-controlled entity with a monopoly over the horse race betting sector (Nikkinen & Marionneau, 2021). Furthermore, Swedish non-profit organisations (*Postkodlotteriet*, *Folkspel*, *Miljonlotteriet*, etc.) are allowed to organize lotteries and bingo activities as part of their public service initiatives. These activities aimed to raise funds to support various charitable, social, and community initiatives across country. Thus, until 2019, only *Svenska Spel* and ATG were authorized to offer gambling services for monetary gain, thereby maintaining a monopoly on gambling in Sweden. In 2017, *Svenska Spel* and ATG collectively held 76% of the regulated gambling market and 58% of the overall gambling

market. The remaining market share was divided among non-profit organisations organizations offering lotteries and bingo (comprising 22% of the regulated gambling market and 17% of the total gambling market), private operators offering casino games in restaurants (less than 1% for both), and unlicensed private operators (constituting 24% of the total market) (Nikkinen & Marionneau, 2021).

On January 1st, 2019, due to the emergence of international operators conducting gambling business (mainly online) in Sweden and using licenses obtained from other countries, the Swedish government implemented a new law, the Swedish Gambling Act (2018:1138), that brought the entire gambling industry under state control. The purpose of this legislation was to introduce competition into the market while establishing effective oversight and regulation of gambling activities. Additionally, the law mandated a distinct separation between profit-oriented gambling activities and those focused protection of gamblers. Consequently, *Svenska Spel* restructured into three subsections to adhere to the new legislation:

- *Sport & Casino*: this division encompasses offline and online activities related to sports betting and online casino games, including online bingo and poker. It focuses on profit-driven gambling activities while placing special emphasis on preventing excessive gambling.
- *Tur*: this subdivision primarily focuses on profit-driven gambling, consisting mainly of offline and online lottery games such as scratch games and draw-based games.
- *Casino Cosmopol & Vegas*: this section pertains to physical casinos and EGMs and is purely profit-driven but operates as a monopoly, i.e. the only legal operator in the country in these sub-sections of the market.

Thus, since 2019, the Swedish offline gambling market is divided into three main parts. One part includes land-based casinos and EGMs, which are supervised by the central government. Currently, only the casino in Stockholm remains operational. The casino in Sundsvall permanently closed in 2020, and those in Malmö and Göteborg closed in 2024. A recent bill proposed by the Swedish Government also is likely to lead to the closing of the last land-based casino, in Stockholm. Another part covers gambling, such as lotteries and land-based bingo. These games are available for purchase at outlets operated by *Svenska Spel*, such as tobacco shops, bars, and cafes. The third part includes sports betting, horse race betting, and online gambling which are exclusively provided by gambling operators approved by the Swedish Gambling Authority, called *Spelinspektionen*.

Online gambling

Before January 1st, 2019, *Svenska Spel* and ATG held a monopoly on legal online gambling activities in Sweden. This meant that these operators (*Svenska Spel* being owned by the state and ATG primarily by the horse racing industry) were the only authorized Swedish entities to provide online gambling services. However, the surge in unauthorized online gambling platforms prompted the Swedish government to take decisive action by introducing new regulatory measures. As mentioned above in the manuscript, before these regulations, foreign operators licensed in jurisdictions outside of Sweden had freely providing gambling services to Swedish citizens without adhering to any regulatory framework. This lack of oversight not only posed risks to the integrity of the gambling industry but also left Swedish gamblers vulnerable to potential exploitation and harm. Therefore, these new regulations aimed to address these concerns by establishing a structured framework for online gambling activities, ensuring proper oversight, and safeguarding the interests of gamblers within Sweden.

Indeed, since the new regulations, gambling operators were required to apply for gambling licenses. The key aspects of these regulations include: i) gambling operators with a license must protect gamblers from excessive gambling by monitoring behaviors and assisting gamblers in limiting their gambling if necessary, ii) bonuses can only be offered on the first occasion of gambling, iii) gamblers should be able to self-exclude from gambling with all licensed operators, iv) the Swedish Gambling Authority has the authority to request payment blocking and require online operators to display warning messages on websites that are not licensed in Sweden, and v) licensed operators are required to pay an 18% tax on the profits they generate from gambling activities in Sweden (except for non-profit organizations). Although these new regulations did not notably affect offline gambling offerings, it marked a crucial shift in the regulating of the Swedish online gambling market.

Thus, *Svenska Spel* and ATG no longer have a monopoly on online gambling in Sweden. Other entities are now permitted to offer gambling activities, but they must apply for a license to do so. This change opened up the market and allowed for more competition and diversity in the online gambling industry within Sweden.

To date, approximately 100 gambling operators, alongside *Svenska Spel* and ATG, hold active licenses for various commercial online gambling such as sports betting, horse race betting, casino games, bingo, lotteries and poker. Most of these licensed involve commercial online casino games.

Figure 2 illustrates the evolution of Swedish offline and online gambling offerings before and after the implementation of the new regulation in 2019.

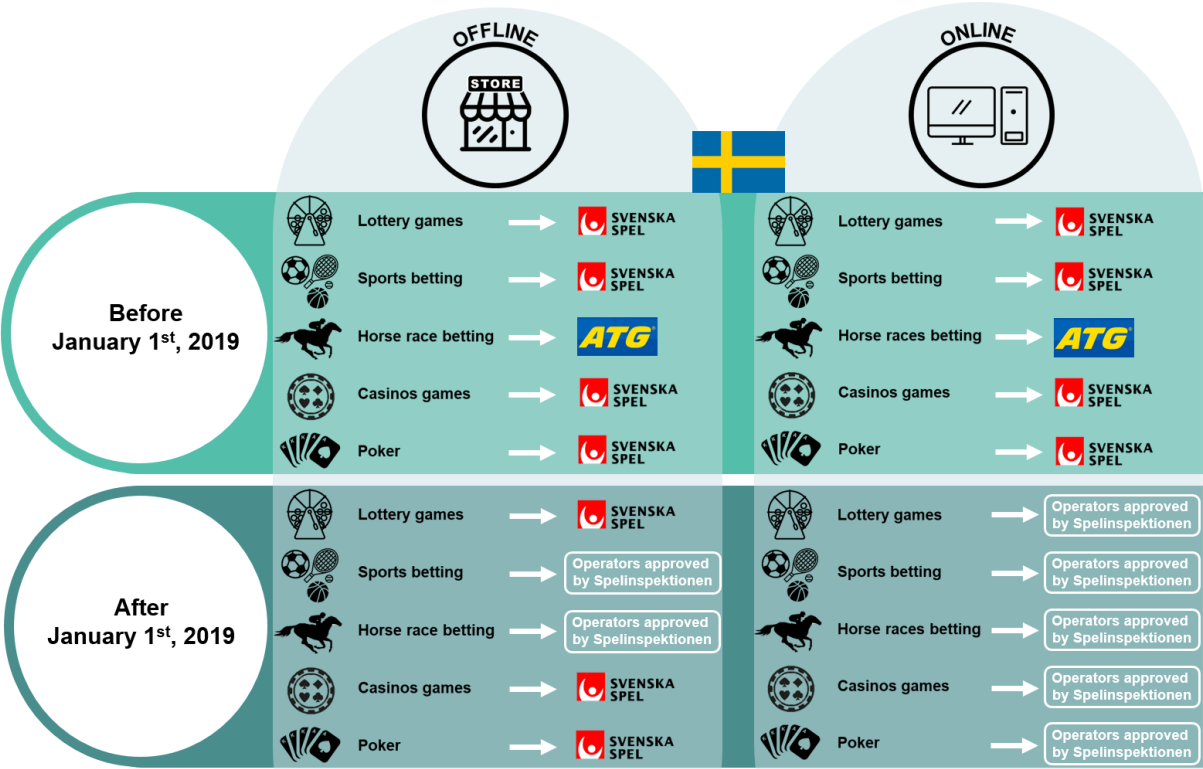


Figure 2: Schematic representation of the gambling offer in Sweden before and after Swedish Gambling Act (2018:1138).

Similarities and differences between the two countries

To resume, France and Sweden share similarities in their regulation and provision of gambling. Both countries have established regulatory bodies responsible for overseeing the gambling industry and ensuring compliance with laws and regulations. In France, this role is carried out by the ANJ, while in Sweden, it is *Spelinspektionen*, the Swedish Gambling Authority. However, despite these similarities, France and Sweden also have notable differences in their approach to gambling regulation and the structure of their gambling markets. France has historically embraced a more liberal approach to gambling, with a wide range of options available and a relatively open market. In contrast, Sweden has traditionally maintained a more monopolistic model, with state-owned operator dominating the gambling industry. Another difference lies in the availability of certain types of gambling. For instance, in France, land-based casinos are more prevalent and widespread, offering a variety of games such as roulette, blackjack, and poker compared to Sweden where the presence of land-based casino is less developed. Furthermore, a notable difference is the presence of EGMs outside of casinos in Sweden, which is strictly prohibited in France. Similarly, online casinos are strictly forbidden in France, whereas they are permitted in Sweden.

Finally, while both countries share a rich history of gambling, cultural attitudes towards gambling may differ between France and Sweden, influencing the popularity and acceptance of certain forms of gambling within each country.

1.1.3 Practices of gambling in French and Swedish societies

The gambling industry plays a crucial role in various aspects of society and the economy, in both countries. The practice of gambling is considered a popular and exciting pastime for many French and Swedish citizens. For many, playing is more than just a distraction; it's also a form of escape, entertainment, and hope.

Prevalence of gambling in France

Offline gambling

In France, there is a public interest group known as the French Observatory for Drugs and Drug Addiction (OFDT), which operates as a permanent system for observing and monitoring developments in consumption and addictive behaviors. The OFDT is tasked with collecting, analyzing, synthesizing, and disseminating knowledge regarding the entire spectrum of drugs and drug addiction, which includes gambling. Regarding gambling, the OFDT frequently publishes prevalence studies and reports on the results of surveys.

The Table 1 resulted from a study published by the OFDT in 2019. The study based on the result of the Public Health Barometer report showed that nearly half of French citizens aged 18 to 75 reported having played in any form of gambling in the past year (Costes, Richard, Eroukmanoff, et al., 2020). The most prevalent forms of gambling were lottery games, with draw games and scratch cards attracting 65.0% and 56.9% of active participants, respectively. Other popular gambling activities, listed in descending order, included sports betting (11.0%), EGMs (9.7%), horse race betting (7.7%), casino games (5.9%), and poker (2.9%). Furthermore, the study indicated that activities requiring skill, such as poker, sports betting, and horse race betting, were mainly practiced in by men. In contrast, games of pure chance, such as lottery games and EGMs, had more balanced gender distributions or even leaned towards women in some games (e.g., scratch cards).

Regarding major differences in gambling practices across age categories, the survey revealed distinct patterns. On the first hand, gamblers under the age of 25 were significantly less inclined to participate in draw-based games compared to other age groups (28.7% of gamblers versus over 57.5% for other age groups), but showed a higher propensity for other casino games (23.5% of gamblers versus less than 9.4%). On the other hand, gamblers aged 65 and older were more likely to engage in horse race betting compared to other age groups (12.2% versus less

than 8.6%). Additionally, gamblers under the age of 35 exhibited a greater inclination towards sports betting compared to other age groups (between 20.2% et 36.3% versus less than 10.9%).

Table 1: Gambling practices in 2019 according to games, gender, and age among French individuals aged 18 to 75 (weighted data, %).

	Total	Men	Women	18-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-75 years
Number of responders	9,611	4,451	5,160	785	1,274	1,653	1,973	2,029	1,897
Gamblers in 2019 (n =4,544) (%)	47.2	50.4	44.2	43.4	50.4	50.1	50.6	49.3	37.6
Draw-based games (%)	65.0	66.7	63.2	28.7	57.5	70.4	76.0	72.0	68.9
Scratch cards (%)	56.9	51.7	62.6	56.6	66.7	58.5	54.9	53.2	50.6
Horse races betting (%)	7.7	11.0	4.2	6.2	5.5	6.1	8.6	8.1	12.2
Sports betting (%)	11.0	18.4	3.0	36.3	20.2	10.9	4.7	2.4	1.3
Poker (%)	2.9	4.5	1.2	6.1	6.2	4.0	1.3	0.5	0.2
EGMs (%)	9.7	9.3	10.2	12.5	14.3	6.3	9.8	9.1	7.0
Others casino games (%)	5.9	7.5	4.2	23.5	9.4	4.8	3.1	1.2	0.3

This table is reproduced from the OFDT report: the Public Health Barometer in France in 2019 - French people and gambling (Costes, Richard, Eroukmanoff, et al., 2020).

Reading key:

47.2 % of survey respondents participated at least once in any form of gambling in 2019. 50.4% of men and 44.2% of women participated at least once in any form of gambling in 2019.

Draw-based games: 65.0% of gamblers in 2019 participated at least once in draw-based games. 66.7% of men who gambled at least once in any form of gambling in 2019 participated in draw-based games. 28.7% of gamblers aged of 18-24 in 2019 participated at least once in draw-based games.

The survey further revealed that gambling is more prevalent among employed men aged 25 to 54 compared to the non-employed. Gamblers usually had slightly lower levels of education but higher incomes than non-gamblers. The majority of gamblers only participated in gambling activities occasionally. Among those who gambled in 2019, only 28.6% engaged in gambling activities at least once per week. Daily gambling is however remained uncommon (1.2% of gamblers) and was mainly seen among sports betting and poker enthusiasts (Costes, Richard, Eroukmanoff, et al., 2020).

Online gambling

The prevalence of online gambling among the French population was 16.1% in 2019, representing a significant increase compared to 2014, when the prevalence was 7.3% (Costes, Richard, Eroukmanoff, et al., 2020). The report on gambling activities published by the OFDT

in 2022 revealed that lottery games were the most practiced forms of online gambling in 2021: nearly seven out of ten gamblers (67%) had placed a wager on this activity during the year (Eroukmanoff et al., 2022). The other activities most played online were, in descending order, sports betting (50%), eSports (33%), and poker (32%). Casino games and horse races betting were at the bottom of the list (Figure 3). It is worth noting that casino activities (excluding poker) and eSports are not subject to regulated offerings in France, which means there are no authorized online gambling operators offering these games (Figure 3).

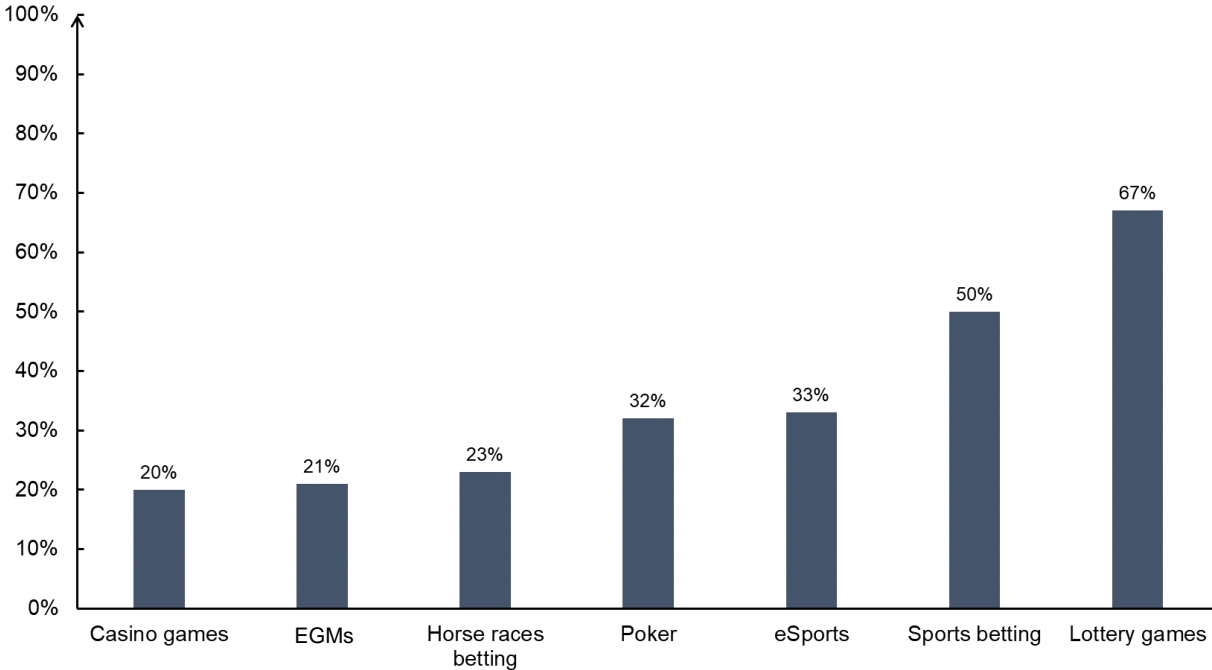


Figure 3: Online gambling prevalence of French gamblers in 2021 (Eroukmanoff et al., 2022).

The survey uncovered further findings, notably that 71% of French who engaged in online gambling in 2021 were men. Moreover, there was little disparity between gender in horse race betting practices. However, men showed a higher propensity for sports betting (57% compared to 33% of women) and poker (35% compared to 25% of women). Conversely, women exhibited a stronger involvement in lottery games: 85% of women reported participating in lottery games in 2021, compared to 60% of men.

The report on the gambling market in 2021, published by the ANJ, highlighted the youthfulness of the online gambling population. Specifically, it revealed that 38% of online gamblers were under 25, and nearly 70% were under 35 (ANJ, 2022).

Additionally, the number of active gambler accounts on gambling operators licensed by the ANJ, including sports betting, horse racing, and poker, had increased by 30.2% between 2019 and 2021. This upward trend was particularly pronounced for active gambler accounts in poker and sports betting, which increased by 38.7% and 29.9%, respectively. There was also an increase in active gambler accounts for horse race betting, although to a lesser extent (4.2% in 2021) (Eroukmanoff, 2022). Furthermore, the report highlighted a substantial growth in online betting between 2019 and 2021, suggesting an increasing number of online gamblers were opting for online platforms over traditional land-based options. Specifically, 65% of sports betting wagers were involved online in 2021, nearly matching the 2019 level of 62%. Similarly, the proportion of online wagers for horse racing increased from 14% in 2019 to 21% in 2021. Despite lottery games being predominantly sold at retail locations by FDJ (nearly 90% of wagers in 2021) there was a significant rise in online lottery bets, nearly doubling from 5.0% to 10.6% between 2019 and 2021. As for poker, no specific results were provided in the report, likely due to the limited accessibility of land-based poker options, which are mainly proposed to casinos and gambling clubs. However, OFDT published a report that indicated that 70% of poker bets were made online in 2019 (Costes, Richard, Eroukmanoff, et al., 2020).

Finally, the "e-Games France 2017" survey conducted by the OFDT revealed that in 2017, 8 out of 10 gamblers opted for licensed and regulated gambling sites, while 3 out of 10 participated in unregulated gambling activities. This indicates their involvement in games types lacking regulation in France, such as EGMs, casino games, e-sports, etc. Moreover, 1 out of 10 gamblers participated in both types of websites (regulated/unregulated) (Costes & Eroukmanoff, 2018).

Prevalence of gambling in Sweden

Offline gambling

In Sweden, the Swedish Longitudinal Gambling Study (Swelogs) is a significant longitudinal cohort study focused on understanding gambling habits and behaviors over an extended period (Romild et al., 2014). Conducted by researchers from Stockholm University, Swelogs aims to track gambling patterns and behaviors over time. The study's findings are utilized to inform public policies regarding problematic gambling in Sweden.

The results of Swelogs report published in 2023 showed that 56% of Swedes have engaged in some form of offline gambling at least once in 2021 (Folkhälsomyndigheten, 2023a). The proportion of participation was higher for men (60%) than for women (52%). Lotteries were the most popular, with 47% of Swedes having played them at least once during the year.

Additionally, 14% participated in horse race betting, 13% in bingo, 12% in sports betting, 3.4% in casino games (including EGMs), and 2.3% in poker. The proportion of gamblers among men was higher for all forms of gambling except for lotteries and bingo, where it was either similar or lower, respectively (Table 2).

In terms of gambling prevalence by age, the main findings indicated that more than 60% of Swedes aged over 45 years old participated in any form of gambling in 2021. However, the percentage of gamblers increased with age for other age categories. Specifically, 52% of Swedes aged 25-44 years old engaged in any form of gambling during the past years, compared to only 35% for those aged 18-24 years old and 13% for those aged 16-17 years old. Moreover, lottery games were the most popular type of gambling across all age categories, except for individuals aged 16-17 years old, among whom the proportion of gamblers in lotteries and sports betting was equal. However, horse races betting was more prevalent among older individuals compared to younger ones. Conversely, individuals aged 16-44 years old were more involved in poker than those aged over 45 years old.

The Swelogs report also revealed an higher proportion of gamblers gambling weekly than gambling only monthly. Additionally, 24% of men gambled at least once a month compared to 13% for women. Furthermore, the proportion of weekly gamblers was twice as high among men (16%) compared to women (8%) in 2021 (Figure 4).

Table 2: Offline gambling practice in 2021 according to games, gender and age among Swedes individuals aged 16 to 84 (weighted data, %).

	Total	Men	Women	16-17 years	18-24 years	25-44 years	45-64 years	65-84 years
Number of responders	7,343	3,711	3,632
Gamblers in 2021 (%)	56.0	60.0	52.0	13.0	35.0	52.0	68.0	60.0
Lottery games	47.0	48.0	47.0	5.1	22	43	60	52
Horse race betting	14.0	19.0	10.1	.	2.2	8.4	21	20
Sports betting	12.0	19.0	5.1	5.1	12.0	13.0	13.0	8.9
Poker	2.3	3.4	1.1	3.6	4.8	3.5	1.6	0.3
EGMs and other casino games	3.4	4.9	1.9	1.5	5.8	5.4	2.7	0.8
Bingo	13.0	12.0	15.0	2.0	9.1	13.0	14.0	15.0

This table is reproduced from the Swelogs population study report in 2021 (Folkhälsomyndigheten, 2023a).

Reading key:

Lotteries games: 47.0% of survey respondents gambled at least once in lotteries games in 2021. 48% of men and 47% of women of survey respondents gambled at least once on lotteries games in 2021.

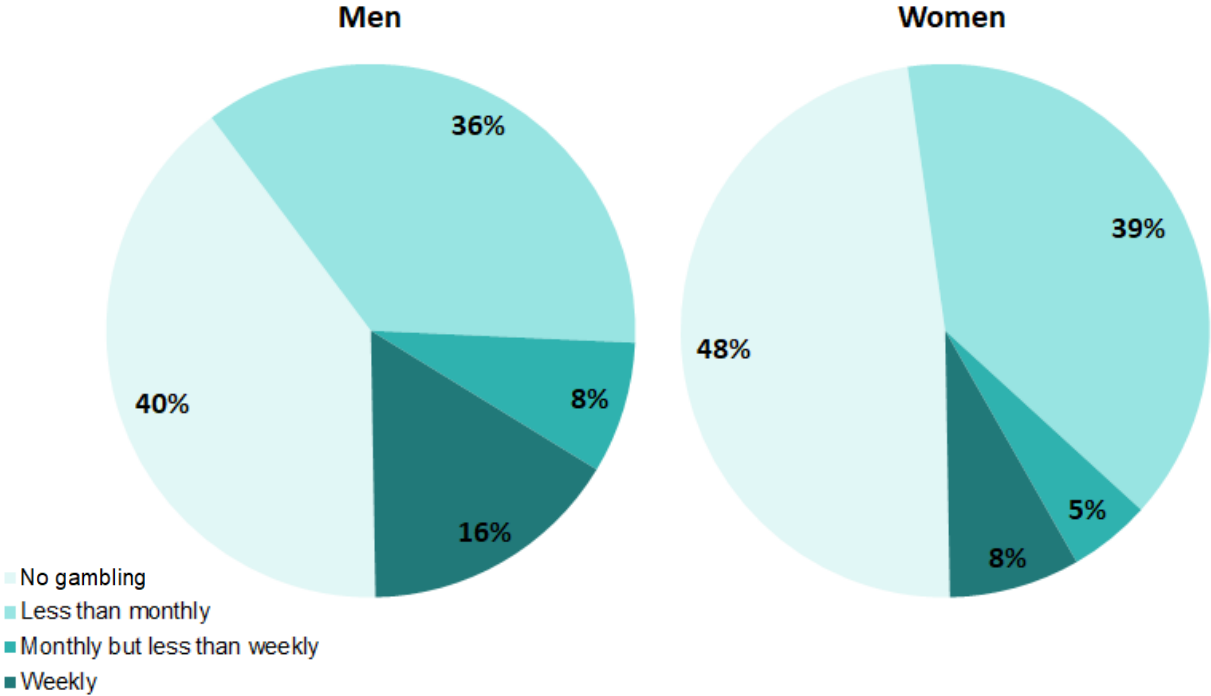


Figure 4: Proportion of offline gambling frequency according to gender (%).

Online gambling

According to the Swelogs report of 2023, 28% of Swedes participated at least once in any form on online gambling in 2021 and among them, almost 65% was men (Folkhälsomyndigheten, 2023a). As for offline gambling, the most popular online gambling type was lotteries, regardless gender. The percentage of gambler having wagered at least once during the past year was higher for men than women for all gambling types, except for bingo. Furthermore, the most popular online gambling among men were lottery games (22%), sports betting (14%) and horse racing betting (12%), while for women, it was bingo (15%) (Figure 5).

Additionally, over half of those who placed at least one wager in 2021 had no online account. Conversely, almost one-third of gamblers had only one active account, while one in ten gambled using two active accounts. Furthermore, only 3% of gamblers placed bets using three or more active accounts. As for the number of deposits from bank accounts to gambling accounts, 14.3% of gamblers had only one transaction during the last 30 days, while only 7.2% had made multiple deposits. Men tended to have more active accounts and made more deposits than women (Table 3).

Finally, the report concluded that the percentage of online gamblers has constantly increased between 2015 and 2021, across all forms of gambling (Folkhälsomyndigheten, 2023a). Additionally, it noted that 1.5% of gamblers played on websites without Swedish gambling

license. However, this figure could be higher because 5.5% of gamblers were uncertain whether their gambling activities were on websites with a Swedish gambling license or not.

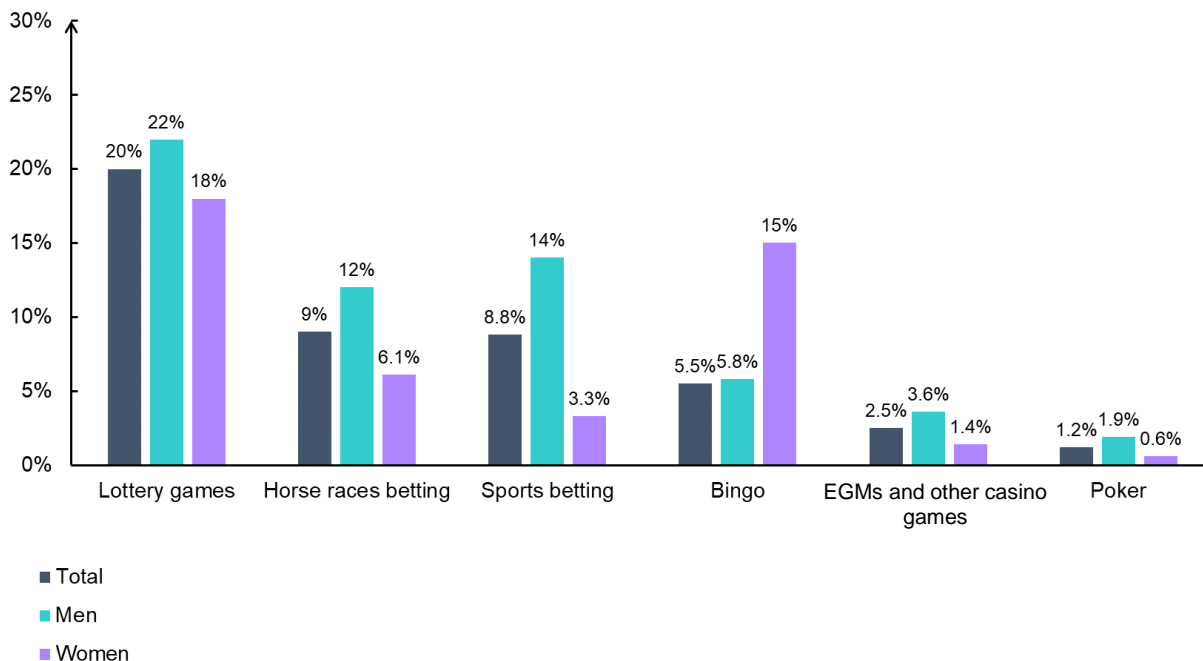


Figure 5: Online gambling prevalence of Swedish population in 2021, according to gender.

Table 3: Characteristics of online gambling population in Sweden in 2021, according to gender (gambling account and deposits).

	Total	Men	Women
Number of active gambling account during the past year (%)			
No account	56.2	45.7	69.0
One active account	31.0	35.9	25.0
Two active accounts	9.8	13.8	4.9
Three active accounts or over	3.0	4.6	1.1
Number of deposits from bank account to gambling account during the 30 last days (%)			
Never	78.5	75.2	83.6
Once	14.3	16.1	11.8
Several times	7.2	8.7	4.6

This table is reproduced from the Swelogs population study report in 2021 (Folkhälsomyndigheten, 2023a).

Reading key:

56 % of gamblers in 2021 had no active gambling account, 31.0% used only one gambling account, 9.8% used two gambling account and 3.0% used at least three gambling accounts.

Similarities and differences between the two countries

In general, French and Swedish gambling practices share many similarities. More than half of the population in each country has engaged in at least one form of offline gambling during the past year (2019 or 2021). However, online gambling is more prevalent in the Swedish population (28%) than in the French population (16%).

Additionally, men tend to gamble more than women, particularly in skill-based games such as sports betting, horse races betting, and poker. This trend was evident in both offline and online gambling practices. Furthermore, lottery games are the most popular form of gambling in both countries and for both offline and online gambling practices.

Both surveys revealed that gambling is more prevalent for men with higher salaries but lower diplomas for both countries. Additionally, online gambling is experiencing significant growth in both countries. In France and Sweden, a significant proportion of gamblers continue to gamble on unregulated sites despite regulations on online gambling offerings. This was primarily because the type of game they preferred was unavailable in their country's regulated gambling offering.

However, some differences are noticeable. Horse races betting is more popular in Sweden than in France, even surpassing sports betting. Finally, the percentage of gamblers over 45 is higher compared to other age groups. However, in France, the offline gambling prevalence is higher among individuals aged 25 to 64. Despite the importance of gambling in both societies, the OFDT and Swelogs reports indicated that the prevalence of offline gambling has steadily declined over the years, largely due to the increasing popularity of online gambling options. This trend reflects a change in gambling behaviors, with an increasing number of individuals choosing online gambling alternatives over traditional establishments.

1.1.4 The addictive power of online gambling

Gambling has become increasingly popular over the years, especially online gambling. While online gambling may not yet dominate the gambling market compared to traditional mediums, it seems that online platforms are amplifying gambling behaviors more than offline platforms.

Firstly, unlike physical gambling establishments, online platforms operate 24/7, and thus accessible at any time and from any location via the internet, facilitating gamblers access but complicating monitoring their gambling time. Moreover, online gambling offers a broader range of betting options, which can stimulate the desire to gamble more. The comfort provided by online gambling is also significant. Additionally, online payment facilities make transactions

quick and discreet, removing cash-related obstacles. The use of digital currencies in online gambling also creates a disconnection between real and virtual money, which may lead gamblers to spend more freely without feeling the direct financial impact of their actions.

Secondly, online gambling is often designed to be highly interactive, offering various inducements, such as bonuses and rewards, which keep gamblers engaged and motivated to continue playing. This constant stimulation can make it more challenging for gamblers to control their gambling practice and may lead to compulsive behaviors. Additionally, there are often incentives to play more, which further increases gambler's involvement and engagement in online gambling activities.

Lastly, on online gambling platforms, gamblers can easily conceal their real identity, which can make it more challenging to implement protective measures for vulnerable gamblers, such as minors or individuals with gambling-related disorders.

The combination of all these factors could greatly encourage gamblers to increase their gambling practice and, eventually, could lead to risky or problematic gambling behavior, potentially resulting in addiction.

1.2 Gambling disorder

1.2.1 Definition and assessment of gambling disorders

For the majority of people, gambling is a leisure activity and they engage in it in a controlled manner. However, some individuals develop an addiction, characterized by a loss of control and compulsive behaviors over their gambling practices (Wood & Griffiths, 2015). This phenomenon is referred to as Gambling Disorder (GD) or pathological gambling and lead to negatively impacts various aspects of their lives, including their finances, relationships, work or studies, and overall well-being.

In 2013, GD was officially classified as a non-substance-related addictive disorder within the "Substance-Related and Addictive Disorders" section of the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). This formalized the recognition of GD as part of the spectrum of addictive disorders. GD share with other addictions two key characteristics : i) the recurrent failure to control the behaviour (powerlessness), and ii) the continuation of the behaviour despite significant negative consequences (unmanageability) (Goodman, 1990). Several criteria have been proposed in the DSM-5 to establish the diagnosis of GD to assess its severity. These criteria are outlined in Table 4.

Table 4: Diagnostic criteria of DSM-5 for GD.

A. Persistent and recurrent problematic gambling behavior leading to clinically significant impairment or distress, as indicated by the individual exhibiting four (or more) of the following in a 12-month period:

1. Needs to gamble with increasing amounts of money in order to achieve the desired excitement.
2. Is restless or irritable when attempting to cut down or stop gambling.
3. Has made repeated unsuccessful efforts to control, cut back, or stop gambling.
4. Is often preoccupied with gambling (e.g., having persistent thoughts of reliving past gambling experiences, handicapping or planning the next venture, thinking of ways to get money with which to gamble).
5. Often gambles when feeling distressed (e.g., helpless, guilty, anxious, depressed).
6. After losing money gambling, often returns another day to get even (“chasing” one’s losses).
7. Lies to conceal the extent of involvement with gambling.
8. Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of gambling.
9. Relies on others to provide money to relieve desperate financial situations caused by gambling.

B. The gambling behavior is not better explained by a manic episode.

Thus, according to the DSM-5, the level of GD is separated into four categories:

- Absence of GD: Less than four criteria met.
- Mild GD: Between 4 and 5 criteria met.
- Moderate GD: Between 6 and 7 criteria met.
- Severe GD: Between 8 and 9 criteria met.

The 11th revision of the International Classification of Diseases (ICD-11), published by the World Health Organization (WHO) in 2019, is another classification system for diseases, including mental disorders. According to the ICD-11, GD is characterised by pattern of persistent or recurrent gambling behavior, which may be online or offline and is manifested by: i) impaired control over gambling (e.g., onset, frequency, intensity, etc.), ii) increasing priority given to gambling to the extent that gambling takes precedence over other life interests and daily activities, and iii) continuation or escalation of gambling despite the occurrence of negative consequences (World Health Organization, 2019).

Clinical evaluation using the DSM-5 and the ICD-11 is a widely accepted standard for diagnosing GD. However, beyond clinical setting, other forms of assessment methods have been proposed to screen for problematic gambling. These methods include self-administered questionnaires composed of several items where gamblers select responses from provide options. Each response is assigned a weight (e.g., never=0, sometimes=1, often=2), and then a total score is calculated. Thresholds are often defined based on the score to categorize gamblers into groups (e.g., non-problem gambler, moderate-risk gambler, high-risk gambler, etc.). These self-administered questionnaires enable the systematic and standardized assessment of the severity of GD and do not require the presence of a healthcare professional such as a psychiatrist or psychologist, as gamblers can fill out the questionnaire themselves. To date, several self-administered questionnaires are used in literature to identify problematic gamblers, with the Problematic Gambling Severity Index (PGSI) being one of the most used one (Ferris & Wynne, 2001).

The PGSI, a nine-item self-report questionnaire, is adapted from the Canadian Problem Gambling Index and is designed to assess the level of risk for excessive gambling during the past 12 months. Each of the nine items is scored on a scale from 0 (never) to 3 (almost always), and the total score is calculated by summing the scores of all nine items. According to the original scoring, a status can be derived from the total score in terms of the risk to develop GD: non-problem gambler (score of 0), low-risk gambler (score of 1 or 2), moderate-risk gambler (score between 3 and 7) and excessive gambler (score greater or equal to 8). A score of 3 was used as the threshold to define an at-risk gambler (i.e., moderate-risk or excessive gambling). However, the threshold score of 3 for the moderate-risk group was considered too low and was thought to produce high levels of false positives. Thus, several studies used a threshold score of 5 to define at-risk gamblers (Stone et al., 2015).

Thus, the term "problematic gamblers" refers to individuals who display behaviors associated with problem gambling. It's important to understand that this term doesn't refer to a diagnostic category but rather to a common description of gambling problems used in the field. Additionally, terms like "excessive gamblers" or "at-risk gamblers" are also employed in the literature to characterize individuals experiencing different levels of gambling-related issues.

1.2.2 Prevalence in French and Swedish population

A systematic review conducted in 2016 revealed significant variations in problem gambling rates among different countries worldwide. The global prevalence of problem gambling ranged from 0.12% to 5%, and in Europe, it ranged from 0.12% to 3.4% (Calado & Griffiths, 2016).

More recently, a meta-analysis conducted on empirical research from 2016 to 2022 indicated that the worldwide prevalence of moderate risk/at-risk gamblers was 2.43%, while that of excessive gamblers was 1.29% (Gabellini et al., 2023).

Prevalence of gambling problems in France

According to the study conducted by the OFDT in 2019 and the estimation founded on the PGSI, the prevalence of problematic gambling in France was 0.8% [0.6; 1.0] in 2019 (Table 5). The prevalence of at-risk gamblers, including moderate and excessive risk gamblers, was 2.9% [2.5; 3.2], corresponding to approximately 1.4 million French individuals. Interestingly, these gamblers alone accounted for almost 40% of the total gambling turnover (Costes, Richard, Eroukmanoff, et al., 2020). Among the gambling population, which comprises individuals who reported gambling in the past year, 1.6% were classified as excessive gamblers, and 6% were categorized as at-risk gamblers. The proportion of at-risk gamblers was higher among men (7.6%) than women (4.3%). Additionally, the prevalence of at-risk gamblers decreased with age. Indeed, among gamblers aged between 18-24 years old, 10.1% were at-risk gamblers, compared to 7.8% for those aged 25-34 years old, 7.5% for 35-44 years old, 4.8% for 45-54 years old, and 3.5% for 65-75 years old. The study also indicated an increase in the prevalence of at-risk gamblers between 2014 and 2019 among the gambler population. Furthermore, 0.8% of gamblers were classified as excessive gamblers in 2014, and 4.6% were at-risk gamblers, representing an increase of 0.8 and 1.4 percentage points, respectively, compared to 2019 (Costes, Richard, Eroukmanoff, et al., 2020).

The OFDT report about online gambling practices in 2017 indicated that the proportion of at-risk gamblers varied significantly depending on the type of gambling (Figure 6) (Costes & Eroukmanoff, 2018). Specifically, nearly 60% of those who participated in EGMs or other casino games were considered at-risk gamblers, with almost half of all gamblers considered as excessive gamblers. Additionally, approximately 30% of those who gambled on poker, horse race betting, or sports betting were classified as at-risk gamblers. Regarding lottery games, the proportion of at-risk gamblers was 14%. Nevertheless, while participating in lotteries carried the lowest risk individual level, it posed the highest risk collectively due to its widespread availability (Costes & Eroukmanoff, 2018).

Finally, the prevalence of excessive gambling was notably higher among unregulated forms of gambling. For instance, in 2017, the percentage of excessive gamblers was 3.6% among those participating in *Loto*®, and 9.7% among those playing scratch games *Illiko*®, compared

to 19.7% among those engaged in lotteries on unregulated websites (Costes & Eroukmanoff, 2018).

Table 5: Prevalence of GD in France in 2019, according to PGSI.

PGSI score	General population (<i>n</i> =9,619)		Gambler population (<i>n</i> =4,541)	
	%	CI _{0.95}	%	CI _{0.95}
Non gamblers	52.7	[51.7; 53.7]	/	/
Non-problem gamblers (score=0)	39.3	[38.3; 40.3]	83.3	[82.2; 84.4]
Low-risk gamblers (score =1,2)	5.1	[4.6; 5.5]	10.7	[9.8; 11.6]
Moderate-risk gamblers (score = 3,4,5,6,7)	2.1	[1.8; 2.4]	4.4	[3.8; 5.0]
Excessive gamblers (score > 7)	0.8	[0.6; 1.0]	1.6	[1.3; 2.0]
At-risk gamblers (<i>moderate</i> + <i>excessive gamblers</i>)	2.9	[2.5; 3.2]	6.0	[5.3; 6.7]

This table is reproduced from the OFDT report: the Public Health Barometer in France in 2019 - French people and gambling (Costes, Richard, Eroukmanoff, et al., 2020).

Reading key:

In 2021, 39.3% of individuals who participated at least once in any form of gambling had no risk of developing GD. 5.1% were classified as moderate-risk gamblers, 0.8% as severe-risk gamblers, and 2.9% as at-risk gamblers.

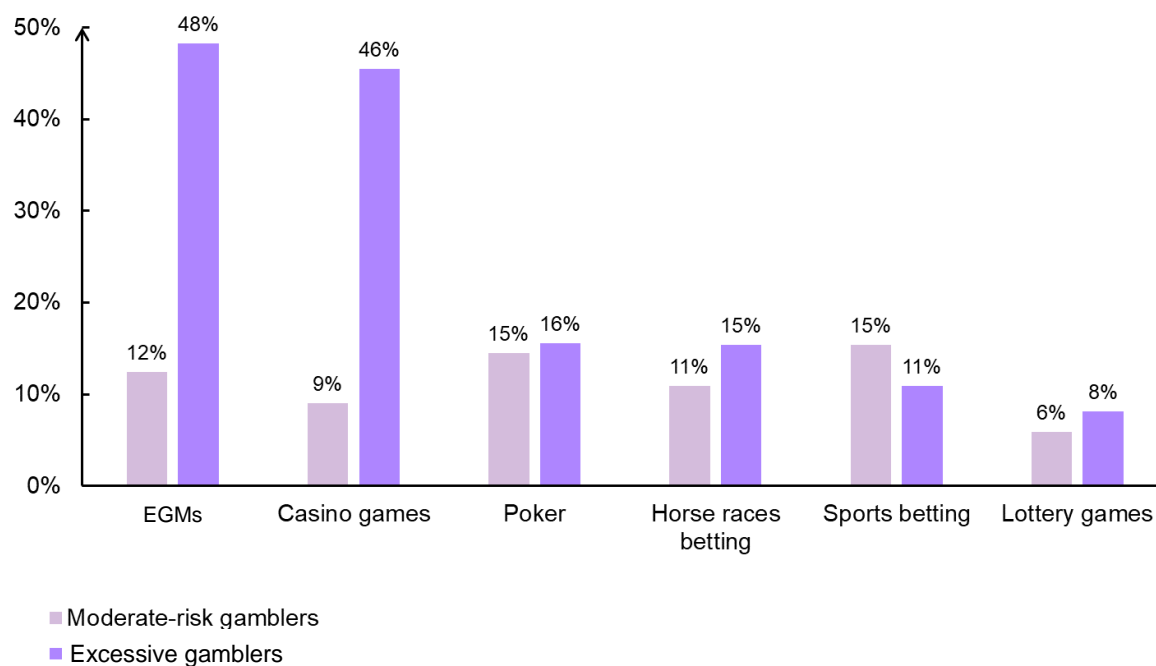


Figure 6: At-risk gamblers prevalence in French population in 2017, according to gambling types.

Prevalence of gambling problems in Sweden

According to the 2021 prevalence survey conducted by Swelogs and estimations based on the PGSI, 0.5% [0.3; 0.7] of Swedes who reported gambling in the past year were identified as excessive gamblers (Table 6). Moderate-risk gamblers represented 0.8% [0.6; 1.0] of the gambling population, while at-risk gamblers accounted for 1.3% [1.0; 1.6]. The proportion of at-risk gamblers was higher among men than women, with percentages of 1.9% [1.5; 2.3] for men and 0.7% [0.4; 1.0] for women. Individuals aged between 25 and 44 years old were found to be more susceptible to being at-risk gamblers compared to other age groups. Specifically, among gamblers in the 25-44 age range, 2.0% were at-risk gamblers, compared to 1.7% for those aged 18-24, 1.1% for 45-64, and 0.3% for 65-84.

The study also revealed that the prevalence of low-risk and moderate-risk gamblers to develop gambling problem decreased from 2015 to 2018 and remained stable in 2021. In contrast, the proportion of excessive gamblers remained consistent from 2015 to 2021 (Folkhälsomyndigheten, 2023a). The Swelogs report also highlighted that playing poker, EGMs, or casino games was associated with a higher prevalence of at-risk gambling, regardless of gender. Similarly, engaging in online gambling was more strongly linked to gambling problems compared to offline gambling (Figure 7). Additionally, individuals who began gambling for money before the age of 18 were more likely to be at risk of developing gambling problems than those who started after turning 18. Among individuals with active gambling accounts, the proportion of excessive gamblers increased as the number of active accounts they held rose. Moreover, there was a notably higher percentage of problematic gamblers among those who made deposits into their gambling accounts while gambling, particularly among those who did so multiple times within the last 30 days. Finally, the percentage of problematic gamblers was significantly higher among gamblers who gambled on sites lacking a Swedish gambling license, as well as among those doubtful of the licensing status of the sites they used (Folkhälsomyndigheten, 2023a).

Table 6: Prevalence of GD in Sweden in 2021, according to PGSI.

PGSI score	Gambler population (n=7,343)		Men (n=3,710)		Women (n=3,633)	
	%	CI _{0,95}	%	CI _{0,95}	%	CI _{0,95}
Low-risk gamblers (score =1,2)	3.0	[2.6; 3.4]	4.4	[3.7; 5.1]	1.5	[1.1; 1.9]
Moderate-risk gamblers (score = 3,4,5,6,7)	0.8	[0.6; 1.0]	1.1	[0.8; 1.4]	0.5	[0.3; 0.7]
Excessive gamblers (score > 7)	0.5	[0.3; 0.7]	0.8	[0.5; 1.1]	0.2	[0.1; 0.3]
At-risk gamblers (moderate + excessive gamblers)	1.3	[1.0; 1.6]	1.9	[1.5; 2.3]	0.7	[0.4; 1.0]

This table is reproduced from the results of the Swelogs survey report in 2021 published by the Swedish Public Health Agency (Folkhälsomyndigheten, 2023a).

Reading key:

In 2021, 3% of individuals who participated at least once in any form of gambling were classified as low-risk gamblers of developing gambling problem, 0.8% as moderate-risk gamblers, 0.5% as excessive gamblers, and 1.3% as at-risk gamblers.

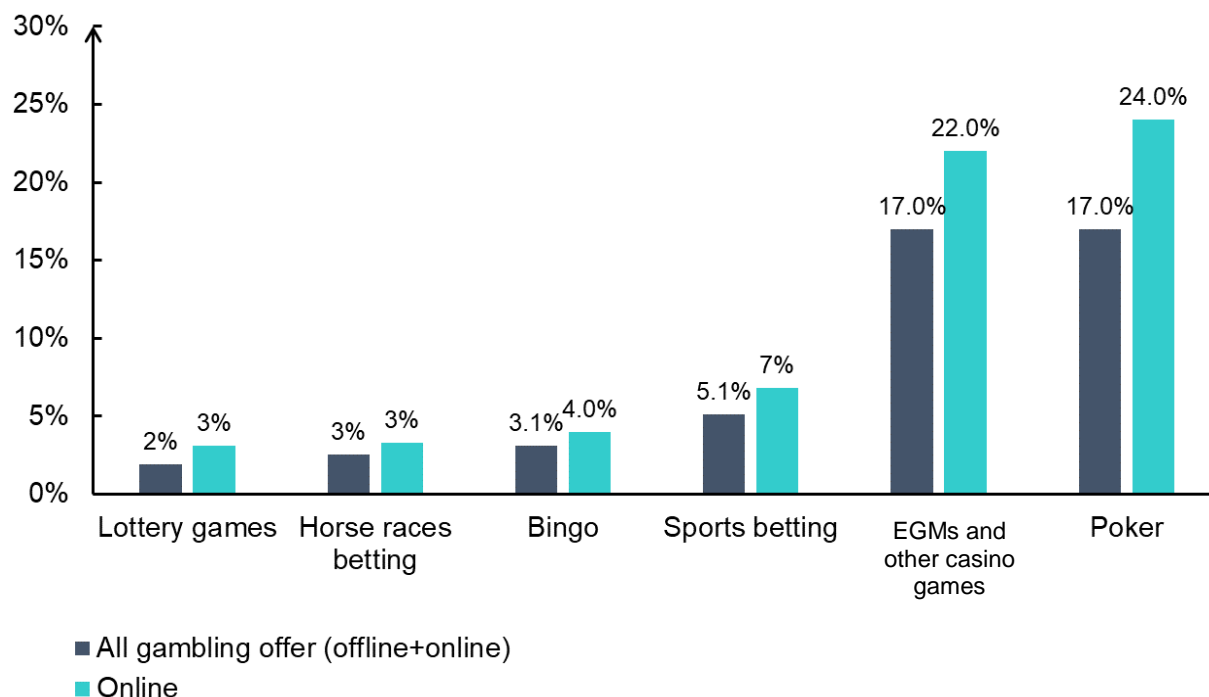


Figure 7: At-risk gamblers prevalence in Swedish population in 2021, according to gambling types.

Similarities and differences between the two countries

The main difference lies in the prevalence of at-risk gamblers, which varied between the two countries. In France, the proportion of excessive and at-risk gamblers was significantly higher compared to Sweden: in 2019, 1.6% of French gamblers were excessive gamblers, and 6% were at-risk gamblers. In contrast, Sweden had three times fewer excessive gamblers (0.5%) and five times fewer at-risk gamblers (1.3%) in 2021. Additionally, in France, young adults (18-24 years old) were more prevalent to develop gambling problem compared to other age groups, while in Sweden, the highest prevalence was found within those aged 25-44 years. Another difference was that while the prevalence of problematic gamblers in France steadily increased from 0.8% in 2014 to 1.6% in 2019, the prevalence of problematic gamblers in Sweden remained stable between 2015 and 2021.

Nevertheless, some similarities exist regarding the prevalence of GD in both countries. Firstly, men were more susceptible to gambling problems than women. Secondly, EGMs and casino games had a significantly higher proportion of excessive and at-risk gamblers than other games. Thirdly, online gambling was more prevalent among problematic gamblers than offline gambling. Lastly, gamblers who participated in unregulated online gambling were at a higher risk of developing gambling problems. These characteristics are not unique to these two countries, as they have already been identified in the literature as predictive factors of problematic gambling (Feigelman et al., 1995; Johansson et al., 2009; Miller, 2015; Hing et al., 2016; Moreira et al., 2023).

1.2.3 Risk factors associated with gambling disorder

GD can be influenced by a variety of risk factors. Understanding these risk factors is crucial for identifying individuals who may be more vulnerable to developing gambling problems and implementing targeted prevention and intervention strategies. Risk factors are defined as conditions that are associated with an increase in the likelihood of problem gambling (Kazdin et al., 1997; Kraemer et al., 1997). Over the years, numerous risk factors associated with GD have been identified in the literature and consistently confirmed, including male gender (Hing et al., 2016; Jiménez-Murcia et al., 2020), young age (Buth et al., 2017), and online gambling (Volberg et al., 2018). Systematic and scoping studies were conducted to summarize and explore the identification of these risk factors for problem gambling (Dowling et al., 2017; Johansson et al., 2009; Moreira et al., 2023). However, this is a complex task, partly due to the methodological heterogeneity of the studies included in the literature reviews. Specifically, there are variations in how gamblers are identified as problematic gamblers, with different

assessment methods and thresholds used across studies. Moreover, the characteristics of the populations studied often differ, including country of origin, socio-demographic factors, and types of gambling behaviors studied (e.g., focusing on a specific type of gambling or considering all forms of gambling). Additionally, variations in recruitment methods (e.g., recruiting from the general population, healthcare facilities, casino venues) contribute to methodological heterogeneity (Perrot, 2018). Considering these limitations, Table 7 summarizes the risk factors identified in several studies cited earlier. It is important to note that this list is not exhaustive.

Table 7: Risk factors associated with problem gambling.

Risk factors related to the individual

Socio-demographic factors

- Male gender
- Young age
- Unemployment
- Lower social-status
- Immigrants and ethnic groups
- Poor general health (diet and physical activities)
- Delinquency
- Early initiation of gambling

Psychological factors

- Impulsivity
- Low self-directness
- Low self-esteem
- Harm avoidance
- High level sensation of seeking
- Anti-social personality
- Maladaptive coping styles
- Life stress
- Low boredom tolerance

Psychiatric and addictive comorbidities

- Tobacco use
- Alcohol use disorders

Substance use

Anxiety and depression

Attention Deficit Hyperactivity Disorder (ADHD)

Obsessive-Compulsive Disorder (OCD)

Risk factors related to the environment and context (school, family, etc.)

Inconsistent parental discipline

Family problems (e.g. parental problem gambling, parental substance use, etc.)

Accessibility of gambling (e.g. live close to gambling place, such as land-based casino)

Risk factors related to the gambling practice

Online gambling

History of big prize

Early wins

Involvement (e.g. played to several type of gambling)

Advertising, inducements, bonuses

Structure of gambling (high frequency of gambling repetition, short period between bet-gain)

Cognitive distortion (erroneous perception, biased interpretation, illusion of control)

As shown in Table 7, the risk factors associated with gambling disorder can stem from various aspects, ranging from individual characteristics to the manner in which gambling is practiced, as well as the environment and context in which it occurs.

In the literature, other factors have been identified as being associated with an increase in gambling activity, which may subsequently lead to gambling problems. Among these factors are disruptive events such as economic crises, health crises, wars, and environmental disasters, which can significantly affect individuals' lives. These events, due to their unexpected nature and major impact, can lead to increased stress from financial difficulties, uncertainty about the future, and depressive symptoms linked to isolation (Olason et al., 2017; Economou et al., 2019). Additionally, these factors can change the accessibility of gambling and are considered potential risk factors for increasing gambling behaviors.

Indeed, such disruptive events can exacerbate pre-existing vulnerabilities and drive individuals to seek ways to cope with anxiety and uncertainty, sometimes turning to gambling as a coping mechanism.

1.3 The coronavirus disease 2019 (COVID-19) pandemic

The COVID-19 outbreak, caused by the novel coronavirus SARS-CoV-2, emerged in December 2019 in Wuhan, China from a cluster of severe pneumonia cases with unknown cause. Within weeks, it rapidly spread across almost the entire globe, prompting the World Health Organization (WHO) to declare a Public Health Emergency of International Concern on January 30th, 2020, and a pandemic on March 11th, 2020 (Cucinotta & Vanelli, 2020; Mahase, 2020; Wang et al., 2020). Common symptoms include fever, cough, fatigue, difficulty breathing, muscle aches, and loss of taste or smell (Huang et al., 2020). In severe cases, COVID-19 can result in pneumonia, severe acute respiratory syndrome, respiratory failure, or even death (Yang et al., 2024).

As of April 28th, 2024, the WHO has reported 7,047,396 confirmed deaths worldwide due to COVID-19. However, an analysis published in *The Lancet* in March 2022 suggested that up to 18 million lives may have been lost due to the pandemic between 2020 and 2021. These numbers encompass various factors, including deaths directly attributed to COVID-19 infections, as well as deaths resulting from healthcare system limitations and priorities, as well as reluctance among individuals to seek medical care due to fears of potential infection (COVID-19 Excess Mortality Collaborators, 2022).

1.3.1 Public health measures implemented in France and Sweden

In this section, the chronologies presented below detail the evolution of virus spread and the measures implemented by the French and Swedish governments solely during the first year of the pandemic, which is limited to the year 2020 as per the scope of the thesis.

Chronology of public health measures implemented in France in 2020

Pre-COVID-19 period: from the detection of the first cases to the lockdown on the country

The first cases of COVID-19 were officially detected and recorded on January 24th, 2020 (SPF, 2020). These cases involved three travellers who had recently visited Wuhan, the epicentre of the virus. These three individuals also marked the first confirmed cases of COVID-19 in Europe. By the end of February, 100 French individuals had been diagnosed with the virus, and two fatalities had occurred. The primary cluster of the virus was identified in the Oise department, near the Parisian area, where 36 cases were reported across various locations in the department. Consequently, gatherings were prohibited, and schools in affected towns were closed. Simultaneously, a religious gathering of 2 to 5 thousand people occurred over five days in the town of Mulhouse in the Haut-Rhin department (East of France) (Le Monde, 2020b).

This gathering was identified as the main cluster of virus propagation in France, as attendees contributed to the spread of the virus across the country upon their return home. Consequently, restrictive measures were implemented throughout the Haut-Rhin department to limit gatherings. Nationally, gatherings of more than 5,000 people in closed environments were also banned.

1st COVID-19-affected period: national lockdown due to the first epidemic peak in Europe

On March 2nd, almost 200 cases and three deaths were confirmed in Metropolitan France due to COVID-19, with new clusters emerging across the country. One week later, the number of confirmed cases surpassed 1,000. Consequently, gatherings of more than 1,000 people were banned, and only severe cases were hospitalized (Le Monde, 2020a). On March 11th, the French Health Ministry announced the prohibition of visits to nursing homes, and economic repercussions reverberated globally as stock markets crashed, with Euronext Paris experiencing its worst sessions since the 2008 subprime mortgage crisis (Cutcu & Kılıç, 2020; Tetteh et al., 2022). In a televised address, the French President announced the closure of day-care centres, schools, and universities. Employees were encouraged to work from home, and an exceptional mechanism of partial unemployment had to be implemented. Additionally, non-urgent surgical procedures were to be postponed. Furthermore, two days after the President's speech, the Prime Minister announced the closure of "non-essential" public areas. Pharmacies, banks, grocery stores, gas stations, and newsagents were the only exceptions. Subsequently, during another address a few days later, only essential travels were permitted, and any violations of these rules would be sanctioned. A system of exit permits was established to justify all journeys. Thus, starting from March 17th at noon, the entire French population was confined to their homes to halt the exponential growth of the pandemic and thereby reduce the number of infected individuals and deaths. The President reiterated multiple times the phrase "We are at war." By the end of March, the number of deaths in hospitals due to the disease had reached 1,000, and a first healthcare worker succumbed to the illness. As the spread continued to escalate, the Prime Minister announced the extension of the national lockdown until at least April 15th. Throughout April, several hundred patients passed away every day from COVID-19, with the peak occurring on April 6th with 613 deaths. An estimated 4.5% of the French population was infected between March and May, with variations across different regions (reaching 9% for those living in Paris and Haut-Rhin) (Warszawski et al., 2022). The most affected areas were Ile-de-France and Grand Est. On April 13th, the French President announced the end of the lockdown, which was partially implemented on May 11th.

2nd COVID-19-affected period: partial easing of the lockdown and decrease in the spread of the virus

On May 7th, the Prime Minister announced that the sanitary situation allowed for a progressive end of the lockdown until May 11th on the entire French territory, except for Mayotte. However, for four metropolitan areas, the conditions for the end of the lockdown were stricter. Indeed, based on three indicators (number of cases, saturation of intensive care units in hospitals, and testing capacity), Hauts-de-France, Ile-de-France, Grand Est, and Bourgogne-Franche-Comté were classified as "red" zones due to active virus spread and hospitals operating under pressure. The other areas were classified as "green" and had a more lenient easing of restrictions (Figure 8).

The first phase of the partial easing of the lockdown lasted from May 11th to June 1st. The main measures implemented during this phase included: i) lifting the requirement for exit permits, ii) mandating the use of masks in public transportation, iii) reopening stores (excluding cafes and restaurants), and iv) a slow reintroduction of in-person primary school. Travel beyond 100 kilometres remained prohibited. Additionally, parks, gardens, and middle schools remained closed in areas classified as "red". Furthermore, only individuals with an attestation issued by their employer (or in case of urgent need) were allowed to use public transportation in Île-de-France.

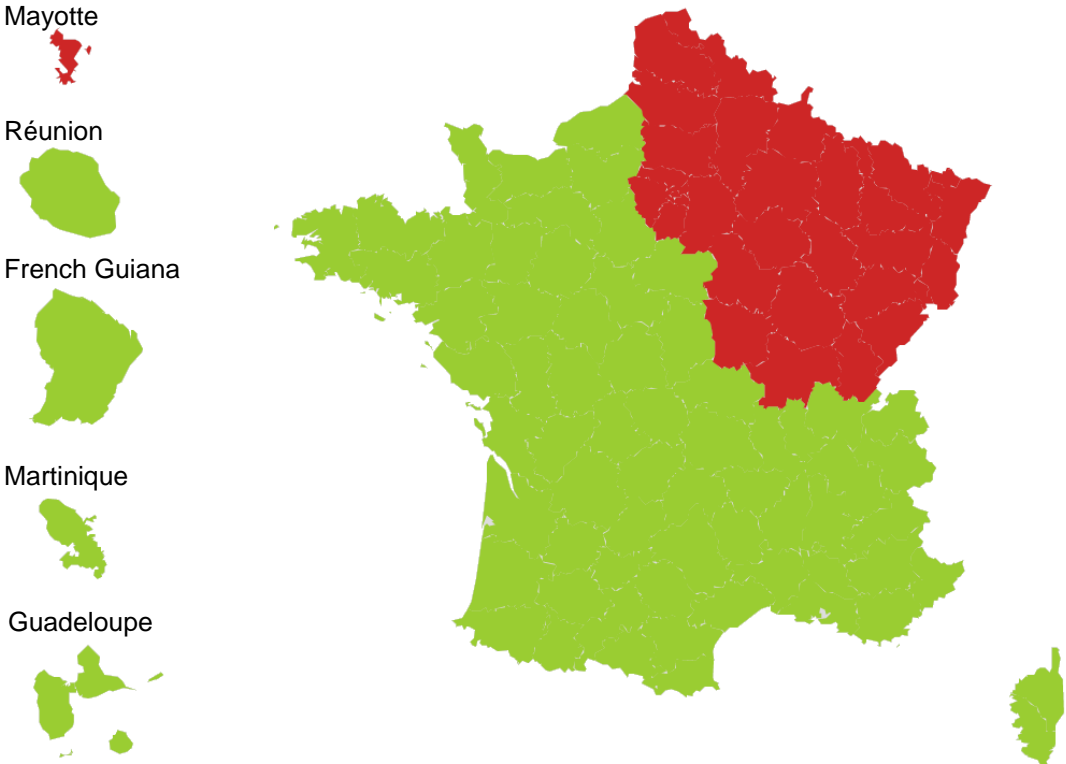


Figure 8: First phase of the lockdown easing in France on May 11th, 2020.

On June 2nd, the second phase of ending the lockdown was launched. Firstly, new French cartography was introduced, with areas designated as "green" or "orange". "Green" areas indicated a low virus spread, justifying accelerating the ending lockdown process. However, in "orange" areas, although the ending of the lockdown process was accelerated, it was accompanied by some restrictions. The "orange" zone departments were Ile-de-France, French Guiana, and Mayotte (Figure 9). Secondly, the prohibition of travel beyond 100 kilometres was lifted. However, travel between metropolitan France and overseas departments remained prohibited unless for essential reasons such as health, family, or professional matters. Thirdly, restaurants, bars, and cafes were allowed to reopen fully in "green" zones and only their outdoor terraces in "orange" zones. It's worth noting that this reopening was subject to conditions, such as limiting each table to 10 people, maintaining at least 1 meter of distance between each table, and requiring staff to wear masks. Fourthly, tourist accommodations, cultural venues, sports facilities, and theatres reopened for departments in the "green" zone, and only on June 22nd for departments in the "orange" zone. Finally, middle schools reopened with the implementation of applicable sanitary protocols. In mid-June, 239 clusters were brought under control, and the number of hospitalizations decreased. However, the spread of the virus remained active in French Guiana and Mayotte.

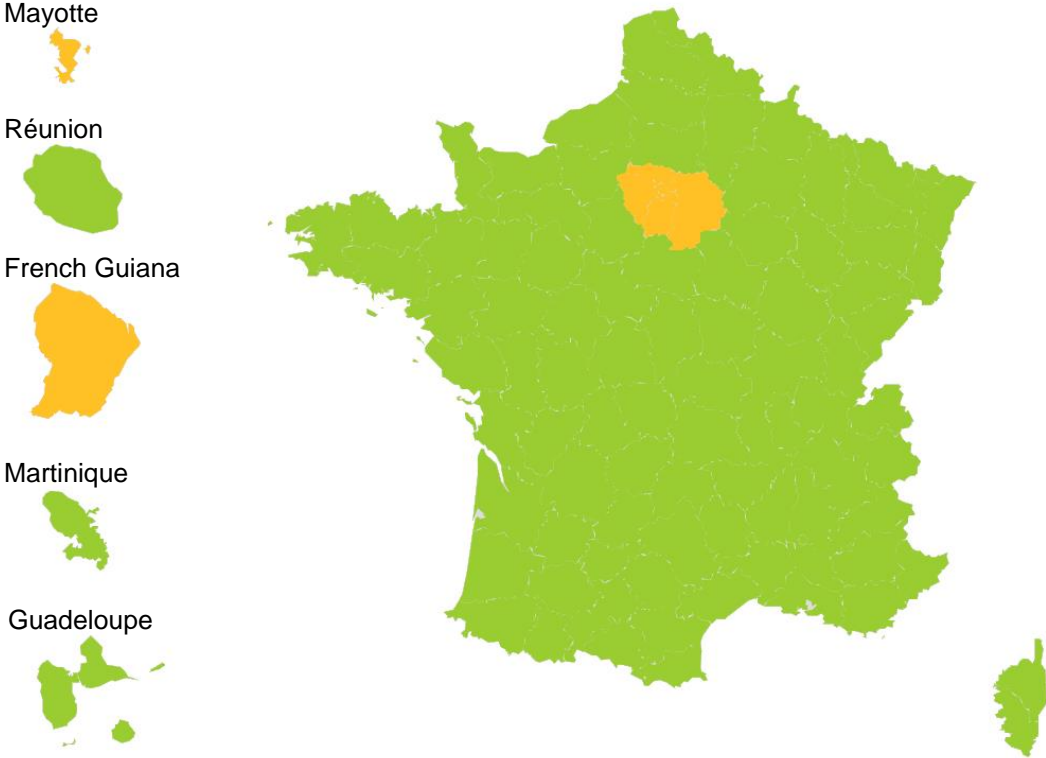


Figure 9: Second phase of the lockdown easing in France on June 2nd, 2020.

3rd COVID-19-affected period: ending of the lockdown and containment of the virus spread

On June 22nd, only French Guiana and Mayotte remained in the "orange" zone, while the transition of the Île-de-France region to the "green" zone allowed for the complete reopening of bars, cafes, and restaurants across metropolitan France. Additionally, day-care centres, schools, and middle schools were required to reopen with relaxed sanitary rules regarding physical distancing. High schools also gradually reopened, and working from home was no longer prioritized but encouraged. Furthermore, travelling between European countries and certain non-European states became possible, contingent upon the virus being controlled. The last remaining establishments that were closed, such as cinemas, casinos, and gaming halls, were able to reopen to the public. Furthermore, collective sports activities, stadiums, and racetracks were resumed. The universities reopened for the new academic year but in a hybrid format, combining in-person and distance learning in September. Although a return to normalcy seemed to occur after the lockdown period, several measures remained to prevent the virus's spread. These included observing barrier gestures, mandatory mask-wearing, and physical distancing in most public establishments and public transportation.

Moreover, testing has been ramped up, and by the end of July, insured individuals were able to request and receive COVID-19 tests free of charge and without a medical prescription. Despite a significant decrease in COVID-19 mortality and a gradual reduction in hospitalizations, the spread of the virus persisted. In mid-July, there was an epidemic resurgence due to the relaxation of basic barrier gestures, including physical distancing, among the population. Furthermore, an increasing number of asymptomatic individuals, particularly among young people, were being identified, leading to a rise in the number of cases reported weekly.

Consequently, in August, mask-wearing became mandatory in several departments in all public spaces, even outdoors. Regarding the spread of the virus, daily contamination rates increased from 2,500 cases in mid-August to 10,000 a month later, with 32 million intensive care beds occupied by COVID-19 patients. Public authorities defined the situation as a second wave of the pandemic, which was slower but present throughout the territory, unlike the first wave. On September 26th, several cities were placed under "maximum alert" and had to close their bars and restaurants for two weeks. Other ones were in the "reinforced alert" zone, which signified bars had to close before 10 pm. Increasingly restrictive measures were imposed by the government in response to the resurgence of virus infections.

4th COVID-19-affected period: national lockdown due to the second epidemic peak in Europe

On October 14th, amidst rising COVID-19 cases and concerns over public health, the French President announced the implementation of a curfew starting from October 23rd, which was set to last at least six weeks. During this period, no outings were permitted between 9 p.m. and 6 a.m. except for those presenting a valid exemption. Bars and sports facilities remained closed day and night, and telecommuting and remote learning for students were strongly recommended. However, the number of cases, hospitalizations in intensive care units, and deaths continued to increase dramatically. Thus, a second lockdown was implemented on October 29th during six weeks, which was less stringent than the first, mainly because schools were allowed to remain open. A week later, the second wave of the pandemic peaked, with daily deaths exceeding 500.

On 15th December, the number of new daily confirmed cases had decreased, and for the Christmas holidays, the national lockdown was lifted and replaced by a curfew with the same rules as in October. Cafés, bars, and restaurants remained closed until January, 2021. Meanwhile, the vaccination campaign began on December 27th.

Due to a decrease of virus spread, the curfew hour was pushed back to 7 p.m. at the end of March, 2021, to 9 p.m. in mid-May, and to 11 p.m. at the beginning of June before being definitively lifted on June 20, 2021.

Chronology of public health measures implemented in Sweden in 2020

Pre-COVID-19 period: from the detection of the first cases to the implementation of initial restrictions

On January 31st, 2020, the first case of COVID-19 was confirmed in Jönköping. It involved a woman who had travelled directly from Wuhan to Sweden. She was fully isolated, and there were no reports of the virus spreading (Folkhälsomyndigheten, 2020a). It was not until a month later that the second confirmed case was identified in Göteborg. This case involved a man who had returned from northern Italy following the outbreak there. Several days later, five more cases were confirmed, all linked to travel to high-risk areas (Folkhälsomyndigheten, 2020b). Through extensive contact tracing, over 200 cases related to travel were identified in the following weeks. Many of those who tested positive had contracted the virus while on vacation in Italy during the one-week spring break in late February. During the four-week period from February to March, coinciding with the spring break in various parts of Sweden, approximately one million Swedes, equivalent to one-tenth of the total population, travelled abroad. At this early stage, there were no clear signs of widespread disease transmission in Sweden. However, health authorities swiftly implemented surveillance and contact tracing measures to potentially

contain the spread of the virus. Consequently, testing initially targeted individuals exhibiting symptoms after traveling from heavily affected areas such as China, Iran, northern Italy, Tyrol, and South Korea, or those presenting with pneumonia of unknown origin. Towards the end of the spring break period, the number of cases increased exponentially. Stockholm County witnessed a significant surge in cases compared to other Swedish counties, including densely populated areas like Scania and Västra Götaland. The director-general of *Folkhälsomyndigheten*, the Swedish Public Health Agency, later explained that this discrepancy was partially due to Stockholm's spring break occurring later than in other regions.

1st COVID-19-affected period: First epidemic wave of the COVID-19 pandemic

On March 10th, the Swedish Public Health Agency raised the risk assessment of community spread from moderate to very high, the highest level, due to significant virus transmission in the Stockholm area and Västra Götaland. Simultaneously, in response to signs of community transmission, the Agency advised everyone with respiratory infections, even mild cases, to avoid social interactions where there's a risk of spreading the virus, both in private and professional settings. They also urged healthcare workers, particularly those in contact with vulnerable groups like nursing homes, to stay home if they showed any respiratory symptoms. Additionally, relatives of the elderly were recommended to minimize visits to hospitals and care facilities, especially if they had any respiratory symptoms. The day after, the first death was reported, as a person in their 70s from Stockholm passed away in the intensive care unit at Karolinska University Hospital. Concurrently, the government implemented its first measure: prohibiting gatherings of more than 500 people. By March 13th, after confirming the first case in Västmanland county, the disease had reached to all 21 regions in Sweden. Consequently, the Swedish Public Health Agency announced on the same day that the efforts to spot the spread of virus had entered a “new phase” necessitating different measures (Folkhälsomyndigheten, 2020c). The primary focus shifted to delaying the spread among the population and safeguarding the elderly and most vulnerable individuals against the disease. Contact tracing was no longer prioritized as part of the strategy, and testing was redirected towards individuals already hospitalized or deemed to be at higher risk of developing severe illness.

On March 17th, the Swedish Public Health Agency recommended that secondary schools, universities, and colleges switch to distance learning to prevent pupils and students from gathering in classrooms and lecture halls (Folkhälsomyndigheten, 2020d). Additionally, people aged 70 and older were invited to stay at home and travel was discouraged but not prohibited (Folkhälsomyndigheten, 2020e). By the end of March, measures intensified in Sweden.

Gatherings of more than 50 people were now prohibited, as well as visits to nursing homes. Concerning restaurants and bars, they could still accommodate guests, but they were required to implement special measures. These included prohibiting gatherings between individuals in queues, at buffets, and at bar counters. Consumers were also instructed to maintain distance from each other (Folkhälsomyndigheten, 2020f).

In mid-April, the first wave peaked with the daily death toll reaching one hundred. By that time, approximately 1,600 individuals had succumbed to the virus in the country since the beginning of the pandemic. Furthermore, health authorities estimated that between 5% to 10% of the population in Stockholm county were infected with the virus by April 9th.

2nd COVID-19-affected period: Decline in contamination and confirmed cases

In May, the Swedish government gradually expanded its testing policy for the disease. Initially focusing mainly on individuals with severe symptoms, Sweden began testing more people, including those with milder symptoms. This led to a significant increase in the number of tests conducted, rising from a relatively low level in March to a peak of 29,000 tests per week in May. Additionally, the R number, indicating infection spread, dropped below 1 for the first time at the end of April and remained low until the onset of the second wave. The number of deaths from COVID-19 decreased, reaching 20 deaths per week by the end of June and dropping below 10 deaths per week in July and August. With reduced in virus transmission, the government decided to reopen the colleges and schools after the summer vacation (Ludvigsson, 2020). Furthermore, on June 13th, the restrictions on domestic travel were lifted, permitting unrestricted travel within the country for individuals exhibiting no symptoms, provided that social distancing guidelines were adhered to. During the summer, Swedish authorities lifted travel advisories and eased entry restrictions for numerous European and Schengen area countries. Finally, by the end of September, almost all restrictions were completely lifted: the numbers of peoples that could attend public events increased from 50 to 300 and people older than 70 had been allowed to meet with family and friends (Folkhälsomyndigheten, 2023b).

3rd COVID-19-affected period: Second wave of the COVID-19 pandemic

From October to December 2020, there was a significant surge in confirmed cases and deaths in Sweden. As a result, the Swedish Public Health Agency issued several recommendations, including that individuals living with someone who is ill with COVID-19 are not allowed to go to work. Furthermore, throughout the month of November, the Swedish agency implemented stricter guidelines for the counties of Sweden, gradually introducing measures such as avoiding

the use of public transportation and refraining from staying in stores and shopping centres. Given the widespread of the virus throughout the country, on December 18th, the Prime Minister announced new and stricter measures and recommendations. These included mandating the use of face masks in public transportation and the closure of all non-essential public services. Additionally, the limit for groups at restaurants was reduced to four people per group, and alcohol sales were prohibited after 8pm. A cap on the number of people allowed in shops, shopping centres, and gyms was also introduced, with individual shops responsible for setting their own maximum limits on customer capacity. The Prime Minister cautioned that if these measures do not achieve the desired effect, the government would consider closing these businesses. Furthermore, schools for students over 16 years old continued online classes until January 24th, 2021. Additionally, all non-essential public services operated by the state, municipalities, and regions were to be closed immediately and remained closed until January 24th. This closure included facilities such as swimming pools, sports centres, and museums. Employers were strongly encouraged to allow non-essential staff to work from home. The last restriction imposed by the Swedish government was the prohibition of travel to the United Kingdom due to the emergence of the new variant of the virus. Vaccination against COVID-19 began on December 27th, with priority given to individuals aged 70 and older. The wearing of masks was also recommended on public transportation during peak hours, which are between 7am and 9am, and between 4pm and 6pm on weekdays, throughout the country (Folkhälsomyndigheten, 2023b).

Similarities and differences between the two countries

The French and Swedish governments responded differently to the challenges posed by the COVID-19 pandemic, reflecting diverse strategies and priorities in their respective approaches.

In France, stringent measures were swiftly implemented to curb the spread of the virus. These measures included imposing lockdowns, which effectively confined citizens to their homes except for essential sorties, and enforcing curfews to restrict movement during specific hours of the day. These restrictions were aimed at reducing social interactions and limiting opportunities for the virus to spread. Additionally, the French government mandated the wearing of masks in enclosed public spaces, such as workplaces and public transportation, to further mitigate transmission risks.

Conversely, Sweden opted for a less restrictive approach, avoiding widespread lockdowns and curfews and in favour on voluntary measurements and citizen responsibility (Bylund & Packard, 2021). Instead, the Swedish government relied heavily on recommendations and

targeted restrictions to contain the virus. Measures such as limitations on the maximum number of people allowed to gather and capacity restrictions in restaurants and other public venues were implemented to mitigate transmission risks while allowing a degree of societal functioning to continue. Although the Swedish government recommended mask-wearing in certain situations, it did not enforce mandatory mask mandates like those seen in France.

Furthermore, the underlying philosophies guiding these approaches differed significantly. France pursued a strategy focused on suppressing the spread of the virus and reducing the number of cases through strict containment measures. In contrast, Sweden embraced a strategy centered around achieving herd immunity, allowing controlled transmission of the virus to build immunity within the population over time.

However, despite their differing approaches, several similarities emerged in the responses of both France and Sweden to the COVID-19 pandemic. Firstly, both countries recognized the importance of implementing social distancing measures to curb the spread of the virus. They either recommended or imposed restrictions on gatherings, encouraging people to limit their interactions with others and maintain physical distance whenever possible. Additionally, both governments promoted telecommuting and remote learning arrangements to reduce the need for physical presence in workplaces and educational institutions. Moreover, both countries emphasized the importance of enhanced hygiene practices, such as frequent handwashing and sanitizing of commonly touched surfaces, to further reduce the risk of virus transmission in the community. Furthermore, France and Sweden both implemented travel restrictions in an effort to control the spread of the virus. They imposed bans on travel to high-risk areas, both domestically and internationally, and introduced quarantine requirements for travellers arriving from regions with high infection rates. These measures aimed to prevent the importation of new cases and minimize the potential for virus transmission across borders. Lastly, both countries embarked on vaccination campaigns against COVID-19 towards the end of 2020. They prioritized vaccination efforts for key demographic groups, such as healthcare workers and the elderly, who were deemed to be at higher risk of severe illness or complications from COVID-19. These vaccination campaigns represented a crucial step towards bringing an end to the pandemic and restoring normalcy to society.

In summary, while France and Sweden pursued different strategies in managing the COVID-19 pandemic, they shared common ground in their implementation of social distancing measures, travel restrictions, and vaccination efforts.

1.3.2 Impact of the pandemic restrictions on gambling offer availability

The COVID-19 pandemic has led individuals to reassess their habits and routines, often resulting in changes to their recreational and leisure activities, including gambling. Due to the restrictions implemented by governments worldwide to curb the spread of the virus, significant changes occurred in the gambling landscape in 2020, specifically during the first wave of the pandemic between March and May 2020.

One of the most notable changes occurred in sports betting. Many football, basketball, and tennis competitions, which typically generate a substantial amount of betting activity, were either cancelled or postponed during the initial epidemic peak in Europe in 2020. Most major European football leagues were suspended during this period and resumed in the summer, except for the French first league, which cancelled the remainder of the competition. In the Grand Slam tennis tournament, Wimbledon and the French Open were either cancelled or postponed. Major basketball competitions, including the National Basketball Association (NBA) and EuroLeague, were cancelled in March 2020. Thus, during the initial peak of the pandemic, the availability of sports betting was significantly reduced due to the limited number of sports competitions being held.

Like sports betting, the offer of horse race betting was significantly impacted during the initial wave of the pandemic. All horse races were cancelled in France concurrently with the announcement of the first lockdown in March 2020, a measure also taken in many other European countries. Additionally, the PMU closed all physical points of sale, making only online betting available, albeit with a reduced offering due to the limited number of horse racing events. Horse racing events gradually resumed only from mid-May 2020. In contrast to France and other European countries, Sweden continued to offer horse racing events and did not alter its gambling offerings.

The offline gambling offer of lottery games (including draw-based games, scratch games, and bingo) was not directly affected. In France, 80% of FDJ sales outlets in tobacconists and press stores remained opened during the first lockdown period. Similarly, no changes were observed in the lottery gambling offer in Sweden.

However, land-based casinos were significantly impacted. They were closed entirely in France for four months (March-June 2020). In June, casinos were allowed to resume operations, albeit with restrictions such as excluding table games. Later, they had to close again during the second wave of the epidemic at the end of October 2020. In Sweden, the government closed the four land-based casinos operated by *Svenska Spel* from March 2020 until July 2021.

As for poker, the pandemic significantly impacted offline activity, as it is traditionally played in casinos. The closure of these venues and the restrictions on social gatherings severely disrupted in-person poker games, leading to a sharp decline in participation. However, online poker platforms remained available.

1.4 Justification and objectives of the thesis

1.4.1 Motivations

This thesis project was conceived in April 2020, a period marked by intense efforts to comprehend the virus and its substantial somatic consequences. Despite this focus on understanding the virus itself and its physical effects, there was a notable gap in research concerning its impact on human behaviors, particularly those with the potential to develop into addictive disorders such as GD. Indeed, a quick bibliographic search conducted on April 20th, 2020 found only seven articles published on PubMed and dealing with the impact of COVID-19 on addictive disorders (Becker & Fiellin, 2020; Kar et al., 2020; Lippi et al., 2020; Marsden et al., 2020; Sun et al., 2020; Testino & Pellicano, 2020; Volkow, 2020). Most dealt with addictive behaviors related to substances, such as opiates or alcohol (Sun et al., 2020; Testino & Pellicano, 2020). Some dealt with the potential repercussions on behavioral addictions (Lippi et al., 2020), and in particular on pathological gambling (Marsden et al., 2020), but these were generally at this stage simply from theoretical or clinical points of view, and the actual impact remained unknown.

However, studying gambling behaviors during this period appeared crucial, given that numerous factors could contribute to changes in gambling activity due to the pandemic and the resulting restrictions. These factors might include the potential for an increase in gambling activity, both in terms of the number of participants and the intensity of engagement, as well as the longer-term risk of exacerbating gambling problems.

On the one hand, the reduction or interruption of sports and horse racing events during lockdowns may have led to a decrease in these activities, both online and offline. Additionally, the closure of certain gambling establishments and movement restrictions may have also contributed to a decline in offline gambling activities overall. Conversely, gamblers who were unable to participate in their usual gambling activities may have turned to alternative online gambling options available. Furthermore, the looming threat of a financial crisis, the negative impact on psychological well-being due to social isolation and the stress of potential infection, as well as the increase in leisure time spent online may have also played a significant role in

motivating the initiation or exacerbation of gambling activity, particularly online, among vulnerable individuals (Lippi et al., 2020).

Additionally, in July 2020, public health authorities were concerned about a potential increase in gambling activity during the acute phase of the pandemic, especially with the availability of online gambling, which is known to be more addictive than offline ones (S. M. Gainsbury, 2015). Furthermore, there was concern about individuals who shifted their gambling activity from types of games that were no longer available during the pandemic to those that remained accessible, such as online casinos, which are considered to have a higher potential for addiction than other forms of gambling (Hing et al., 2016). Finally, authorities were also worried about illegal gambling activities exacerbating the situation (Håkansson, Fernández-Aranda, et al., 2020).

When formulating the thesis topic in April 2020, the existing literature on the impacts of the COVID-19 pandemic on online gambling primarily consisted of survey-based studies (Håkansson, 2020a, 2020c) or indirect observations (Håkansson, 2020b). Additionally, every study focused on the pandemic's impact on gambling at a global level without specifically examining its effects on individuals. However, utilizing gambling tracking data, which has been widely praised in recent research on online gambling due to its ecological nature, could allow for longitudinal observation of changes in online gambling practices, including both raw gambling activity and risky behaviors. Furthermore, combining data from France and Sweden could enable a comparison between the two countries with distinct approaches to the pandemic and different gambling offer.

Thus, it appeared essential to study the impact of the pandemic on online gambling in France and Sweden i) to understand gambling behaviors during the crisis period, particularly how people reacted to restrictions and changes in their daily lives, and whether this was reflected in their gambling behaviors, ii) to identify and describe profiles of gambler who exhibited risky gambling behaviors during the acute phases of the pandemic, iii) to compare public health policies between two countries that have adopted different strategies in response to the pandemic and understand how they influenced gambling behaviors and finally, iv) to inform public policies on potential risks associated with gambling during times of crisis to develop prevention and intervention programs.

1.4.2 Objectives

This thesis aimed to evaluate the changes in online gambling activity throughout various phases of the year impacted by the COVID-19 pandemic (2020), in comparison to a baseline

year (2019), among the users of regulated online gambling platforms in France and the Swedish national lottery operator.

The first objective was i) to evaluate the changes in online gambling activity due to the pandemic at a comprehensive level, encompassing all online gamblers, and ii) to compare the changes between the two countries. The work revolved around this objective are presented in Chapter 4.

The second objective was i) to characterize individual gambling trajectories among a representative sample of gamblers, ii) to identify sub-populations of gamblers particularly susceptible to increasing their gambling activity in response to the pandemic and iii) to compare the results between the two countries. The work revolved around this objective are presented in Chapter 5.

Chapter 2

FROM MASTER'S DEGREE INTERNSHIP TO THESIS PROJECT

Table of contents

2.1	Justification and objectives of the Master's degree internship	44
2.2	The EDEIN study	45
2.2.1	Objectives of the study	45
2.2.2	Data collection	46
2.2.3	Gambling indicators	47
2.2.4	Statistical methods	48
2.3	Manuscript 1: Impact of wagering inducements on the gambling behaviors of on-line gamblers: A longitudinal study based on gambling tracking data	52
2.3.1	Abstract	52
2.3.2	Introduction	53
2.3.3	Methods	55
2.3.4	Results	58
2.3.5	Discussion	67
2.3.6	Conclusion	70
2.3.7	References	70
2.3.8	Supplementary information	70
2.4	Overview and conclusion of the chapter 2	78
2.4.1	Main results of the manuscript 2	78
2.4.2	Conclusion	79

Before starting my doctoral thesis in February 2021, I completed a six-month master's internship within the UMR SPHERE 1246 team. This internship was supervised by Dr. Gaëlle Challet-Bouju and Dr. Bastien Perrot and aimed to evaluate the impact of wagering inducements on online gambling behaviors. It marked my first experience in conducting research within the field of gambling.

2.1 Justification and objectives of the Master's degree internship

Since the legalization of online gambling in France, operators have been required to implement measures to prevent problematic gambling. For example, since March 2010, the FDJ has offered an assessment tool called *Playscan*TM, which evaluates the risk of gambling problems in a simple and engaging way using a traffic light system. Gamblers can register for this tool for free and voluntarily, and they can see their status directly on the game interface: green light (no risk), orange light (moderate risk), and red light (high risk). If a gambler receives a red light, the FDJ stops sending them commercial advertisements and suggests they contact a support organization, such as *SOS Joueurs* (Marionneau & Järvinen-Tassopoulos, 2017).

However, like in all competitive markets, gambling operators use marketing strategies to retain customers and boost sales. Wagering inducements are especially popular for keeping existing customers, encouraging more play or different playing behaviors, and attracting new gamblers (Hing et al., 2017). These gambling incentives can take various forms, such as sign-up bonuses, loyalty rewards, or compensation for losses, and are intended to encourage continued activity (Wohl, 2018). Once received, gamblers decide when to use these bonuses, as long as there is no expiration date. The amount of bonus cannot be transferred to a bank account and must be used for gambling. While some wagering inducements may seem attractive, they often come with conditions that can lead to problematic gambling, particularly for vulnerable gamblers. For example, some offers match the deposited amount with an equivalent bonus but only up to a certain limit. The issue is that the amount of the deposit cannot be withdrawn, creating a strong incentive to spend more money on gambling.

Wagering inducements have often been highlighted by addictologists as a risk factor for addictive behaviors among their patients with gambling problems (and indirectly for other gamblers) (Hing, Russell, et al., 2019). They could also represent a significant factor contributing to increased gambling behaviors (Challet-Bouju, Grall-Bronnec, et al., 2020; Russell et al., 2019). However, while some studies have explored wagering inducements in the context of online gambling, they have been predominantly qualitative, based on self-reported

subjective data from gamblers or on single gambling session with a simulation of wagering inducements (Hing et al., 2014, 2018; Rockloff et al., 2019).

At that time, no study had examined the effects of wagering inducements under real-life conditions using gambling tracking data, for instance. This could be attributed to the challenges researchers face in accessing such data, primarily due to the need for agreements and strict protocols to ensure proper usage by gambling operators. Ensuring gambler confidentiality and anonymity is also critical, as gambling data may contain sensitive personal information about gamblers. However, the use of gambling tracking data, widely acclaimed in recent years in research on online gambling given its ecological nature (Deng et al., 2019), could thus allow us to observe changes in online gambling practices (both the raw gambling activity and risky behaviors).

Thus, the objective of the internship was to investigate whether the use of wagering inducements affected gambling behaviors and to quantify this impact. The primary hypothesis was that the use of wagering inducements led to an increase in gambling activity (intensity, frequency, and risky behaviors), particularly shortly after the inducement was used.

2.2 The EDEIN study

2.2.1 Objectives of the study

The study resulting from the internship was part of the second stage of the EDEIN (Screening for Excessive Gambling Behaviors on the Internet) research program. The primary objective of the EDEIN study was to develop a screening model for identifying excessive gambling practices based on the observation of online gambling behaviors and a clinical assessment of gambling practices. The study was conducted in three phases.

The first phase was descriptive and aimed to define a typology of online gambling behaviors and identify the characteristics of gamblers who are potentially at risk of developing gambling problems (Perrot et al., 2017).

The second phase involved the development of a screening score based on gambling tracking data and a self-administered questionnaire to identify problematic gamblers: the PGSI (Problem Gambling Severity Index).

The third phase focused on validating the screening score through telephone interviews, which included a diagnostic assessment of gambling-related disorders.

2.2.2 Data collection

To respond to the objective of the internship, only data from the second phase of the EDEIN study were used. Data were provided by two sources:

One database was provided by ARJEL (now known as ANJ since 2020) and included data from gamblers registered on online platforms of licensed operators offering sports betting, horse race betting, and poker. ARJEL sent a link to an online survey to 840,797 gamblers in two successive waves, the first between December 2014 and November 2015, and the second between March 2015 and February 2016. A total of 9,306 gamblers responded to the survey, providing socio-demographic information (age and gender), data on their gambling activity (bets placed, number of deposits, etc.), and responses to the PGSI. In parallel, the ARJEL extracted the gambling tracking data (bets placed, number of deposits, etc.) from all the participants to the survey. The gambling data were aggregated weekly over 52 weeks (52 repeated observations for each gambler, resulting in a total dataset of 483,912 rows). Once collected by ARJEL, responses to the survey and gambling tracking data were aggregated together, anonymized, and then transmitted to the CHU de Nantes.

The other dataset was provided by the FDJ and included lotteries data. In the summer of 2019, FDJ sent an email containing a link to an online survey hosted by the CHU de Nantes to 303,000 of its customers. A total of 5,682 of these customers agreed to participate and completed the questionnaire, which contained the same questions as the ARJEL survey. The link included an encoded identifier from the FDJ, so that survey responses could be linked to the FDJ gambling tracking data for each participant. Gambling tracking data were also extracted weekly for one year. This database includes 5,682 gamblers with 52 repeated measures for each gambler, resulting in 295,464 rows.

Thus, both datasets contained various information on:

- **Gamblers:** gambler identifier, registration date, week number, gender, age at the time of data collection, and PGSI score.
- **Gambling days:** the number of days within a given week where at least one gambling activity was recorded*.
- **Bets:** the number of bets and amount of money wagered placed in a given week*.
- **Wins and losses:** the number and amount of wins and losses accumulated in a given week*.
- **Deposits:** the number and amount of deposits made from a bank account to a gambling account in a given week.

- **Withdrawals:** the number and amount of withdrawals made from a gambling account to a bank account in a given week.
- **Wagering inducements:** the amount of bonuses used accumulated in a given week (bonuses were attributed based on the usage rather than the acquisition date)
- **First proxy for chasing behaviors:** the number of times where three consecutive deposits were made within a rolling period of 12 hours, in a given week.
- **Second proxy for chasing behaviors:** the number of times a deposit was made within an hour following a placed bet, in a given week.

The information with * were provided according to the gambling type (ARJEL: sports betting, horse race betting and poker, FDJ: lotteries).

2.2.3 Gambling indicators

Among all the available data, five indicators of gambling behaviors were selected to measure the gambling activity of gamblers.

First, the amount of money wagered and the amount of deposits were used as indicators representing gambling intensity, with one reflecting the intensity of betting activity (bets) and the other reflecting the intensity of financial investment (deposits).

Then, the number of gambling days served as an indicator reflecting gambling frequency, ranging from 0 to 7 days per week.

Finally, the number of chasing episodes (1st proxy + 2nd proxy) and the level of involvement, defined by the number of different games played, were used as indicators of risky gambling behaviors. The FDJ offered three types of lottery games: draws-based games, scratch games, and bingo. In contrast, ARJEL-regulated operators offered ten different types of games: simple horse race bets (one race), complex horse race bets (multiple races), complex sports bets (multiple matches), live sports bets (bets placed during a sporting event), and simple bets on football, tennis, rugby, basketball, and other sports, as well as poker.

The statistical analyses in this study were conducted taking into account the gambling type (sports betting, horse race betting, poker, and lotteries), which was feasible only for two of the gambling indicators: the amount of money wagered and the number of gambling days. Indeed, ARJEL-regulated gambling operators often offer multiple types of online gambling (for example, Paris France offers its customers both sports betting and horse race betting) and when a gambler engages in multiple gambling types offered by the same operator, they use a single account. Therefore, while it is possible to differentiate bets placed for each gambling types and thus calculate the amount of gambling and number of gambling days for each gambling types,

it is not possible to distinguish deposits made into the gambling account for specific activities. Consequently, it was not feasible to calculate indicators based on deposits, chasing episodes, and gambling involvement separately according to the gambling type.

2.2.4 Statistical methods

To achieve the objective of the internship, which was to evaluate the impact of wagering inducements on online gamblers, we employed a two-step approach. The first step aimed to determine if there was a link between the use of wagering inducements and changes in gambling activity, and we visualized how long these effects lasted over time. The second step involved quantifying this impact.

Cross-correlation analysis

The statistical method used to address the first step was the cross-correlation analyse.

A cross-correlation analysis quantifies the degree of association between two-time series, at different time lags (including the no-lag case). In other words, it helps determine whether two variables are related and how that relationship evolves over time. This method quantifies the link between two-time series (in this case, amount of wagering inducement and the gambling activity through the five gambling indicators) either at the same moment (when the lag is zero) or when one time series is shifted relative to the other (positive or negative lags). Positive cross-correlation values indicate that the two time series tend to move in the same direction, while negative values suggest they move in opposite directions (Gouédard et al., 2008).

The cross-correlation function at lag k , between two time series x_1 et x_2 , is defined as:

$$\begin{aligned}\rho_{12}(k) &= \text{Corr}\{x_1(t), x_2(t+k)\} \\ &= \frac{R_{12}(k)}{\sqrt{R_{11}(0) \times R_{22}(0)}}\end{aligned}$$

Where:

- t represents time.
- $R_{11}(0)$ and $R_{22}(0)$ are the autocovariances of x_1 and x_2 , respectively at lag 0. Autocovariance measures the variability of a time series (x_1 and x_2) around its mean.
- $R_{12}(k)$ is the cross-covariance between x_1 and x_2 at lag k . Cross-covariance quantifies the extent to which variations in x_1 are associated with variations in x_2 at lag k .

The more the cross-correlation function $\rho_{12}(k)$ is close to 0, the less x_1 and x_2 are correlated at lag k .

As mentioned above, this function is not symmetric, i.e., the influence of x_1 on x_2 may differ from the influence of x_2 on x_1 . Therefore, the cross-covariance between x_1 and x_2 is not the same when the lag is reversed:

$$R_{12}(k) \neq R_{12}(-k)$$

In our analysis, we calculated cross-correlations separately for each gambling type and each gambling indicator whenever possible. Moreover, we hypothesized that the effects of wagering inducements on gambling behavior occur relatively quickly. Therefore, we limited our analysis to the following lags in weeks: $k = 0, 1, 2, 3, 4$.

- **Lag 0:** represents gambling activity during the same week that the inducement was used.
- **Lag+1:** indicates gambling activity during the week following the use of the inducement.
- ...
- **Lag+4:** reflect gambling activity four weeks after the inducement was used.

We intentionally excluded negative lags because our primary focus was on visualizing the effects of wagering inducements on gambling activity, rather than exploring how past gambling behavior might influence the use of inducements.

After calculating the cross-correlations for each gambler, and each lag, we combined these results across all gamblers to obtain an average value for each lag, along with a 95% confidence interval.

Finally, the time lag that showed the strongest effect was used as the lag of interest in the second step of our analysis.

Longitudinal Models

The second approach of the study aimed to quantify the impact of wagering inducements on gambling activity. To do this, we employed longitudinal models. Subsection 4.1.4, "Models for Longitudinal Data," describes in details the methodology and the theoretical framework behind these models. The present section provides only a brief overview of these models.

Like for cross-correlation analysis, we estimated several models for each gambling indicator and type whenever possible. For each models, the dependent variables were the gambling activity measured by each of the five specific indicators. The independent variable was the amount of wagering inducement offered to gamblers. We also included an interaction term between the PGSI status and the wagering inducement variable to investigate how the impact of inducements may differ between gamblers who are at risk of developing problem gambling

and those who are not. Additionally, our models were adjusted for previous gambling behavior, focusing on the week prior to the gambling activity. This adjustment was needed because prior behavior is a strong predictor of future gambling actions.

A significant aspect of this analysis involved selecting an appropriate model based on the characteristics of the dependent variables. We encountered several challenges in identifying suitable models:

- **Over-representation of zero observation:** Most of continuous dependent variables displayed distributions heavily skewed toward zero. This skewness was due to the fact that not all gamblers engage in gambling every week. Indeed, only a small proportion of gamblers wager at least once per week, while some might gamble only once a year. As a result, when we measured their gambling activity weekly over a year, a substantial number of observations recorded zero values. This over-representation of zero values posed challenges for linear longitudinal models, which can be not suitable for such data distributions. Thus, for the number of chasing episodes, which consisted of more than 90% zero values, was converted into a binary variable (0 = no chasing episodes, 1 = at least one chasing episode). Similarly, the level of involvement was transformed into a binary variable (0 = fewer than two different games played, 1 = at least two different games played).
- **Diverse nature of dependent variables:** The nature of dependent variables that we analyzed varied. Some were continuous variables, such as the amount of money wagered and deposits; others were count variables, such as the number of gambling days; and some were binary variables, such as chasing behavior and level of involvement. Each of these types required different modeling approaches to accurately capture the underlying relationships.

In total, we used three different types of models to quantify the impact of wagering inducements on online gambling activity.

GLMMs for binary and count data

For dependent variables with binary data, specifically those related to chasing behaviors and involvement, we employed Generalized Linear Mixed Models (GLMMs) with a logit link. GLMMs are an extension of linear mixed models suitable for non-continuous response variables. They are particularly useful when the dependent variable is binary or count data and when the data are not independent. The choice of the link function depends on the distribution of the dependent variable: for binary responses, we used a logistic link, while for count data that follows a Poisson distribution, we used a log-linear link.

Zero-Inflated Poisson models for count data with excess zeros

Although we could model the number of gambling days using a GLMM with a log-linear link, the Poisson distribution is not always appropriate when there is an over-representation of zeros in the data. This excess of zeros can violate the assumptions required for the Poisson distribution. To address this, we implemented Zero-Inflated Poisson (ZIP) models, which are specifically designed for count data that exhibit excess zeros (Giles, 2010; Hall, 2000; Lambert, 1992). ZIP models combine two distributions: a binomial distribution with a logit link to model the occurrence of zero ($Y=0$), and a Poisson distribution with a log-linear link for counting events, which can also include zeros. Both parts of the model can include explanatory variables.

We estimated both ZIP models and GLMMs with a log-linear link for the dependent variables related to the number of gambling days. To determine the most suitable model, we compared them using the Akaike Information Criterion (AIC), which helps in selecting the model that best fits the data while penalizing for complexity.

Two-part mixed models

The third type of model used is similar to the ZIP model and consists of two-part mixed models. These models are mixture distribution models, specifically designed for semi-continuous data that are zero-inflated (Farewell et al., 2017; Olsen & Schafer, 2001). This means they are suitable for bounded continuous data that include an excess of zero values. Unlike ZIP models, which focus on binary variables that are zero-inflated, two-part models treat zero and non-zero observations separately while maintaining a relationship between them. A two-part mixed model typically includes a logistic regression component to indicate whether the response variable is zero or not, along with a standard linear mixed model to handle the log transformation of non-zero responses. For response variables related to amounts of money wagered and deposits, we observed a peak at zero followed by a continuous distribution of positive values. Consequently, these variables were modeled using two-part mixed models for each type of gambling.

Finally, random effects were included on the intercept to take into account the longitudinal design of data.

2.3 Manuscript 1:

Received: 24 December 2020 | Accepted: 28 July 2021








DOI: 10.1111/add.15665

RESEARCH REPORT

ADDICTION

SSA

Impact of wagering inducements on the gambling behaviors of on-line gamblers: A longitudinal study based on gambling tracking data

Marianne Balem¹  | Bastien Perrot^{1,2}  | Jean-Benoit Hardouin^{1,2}  |
Elsa Thiabaud³  | Anaïs Saillard³  | Marie Grall-Bronnec^{1,3}  |
Gaëlle Challet-Bouju^{1,3} 

2.3.1 Abstract

Aims: To estimate whether the use of wagering inducements has a significant impact on the gambling behaviors of on-line gamblers and describe this temporal relation under naturalistic conditions. **Design:** This longitudinal observational study is part of the second stage of the Screening for Excessive Gambling Behaviors on the Internet (EDEIN) research program. **Setting:** Gambling tracking data from the French national on-line gambling authority (poker, horse race betting and sports betting) and from the French national lottery operator (lotteries and scratch games). **Participants:** A total of 9306 gamblers who played poker, horse race or sports betting and 5682 gamblers who played lotteries and scratch games completed an on-line survey. The gender ratio was largely male (between 87.1% and 92.9% for poker, horse race betting and sports betting, and equal to 65.1% for lotteries). Median age ranged from 35 (sports betting) to 53 (horse race betting and lotteries). **Measurements:** The survey used the Problem Gambling Severity Index (PGSI) to determine the status of the gamblers (at-risk or not). Gambling tracking data included weekly gambling intensity (wagers, deposits), gambling frequency (number of gambling days), proxies of at-risk gambling behaviors (chasing and breadth of involvement) and use of wagering inducements. **Findings:** The use of wagering inducements was associated with an increase of gambling intensity [β between -0.06 (-0.08 ; -0.05) and 0.57 (0.54 ; 0.60)], gambling frequency [β between 0.12 (0.10 ; 0.18) and 0.29 (0.28 ; 0.31)] and at-risk gambling behaviors [odds ratio between 1.32 (1.16 ; 1.50) and 4.82 (4.61 ; 5.05)] at the same week of their use. This effect was stronger for at-risk gambling behaviors and at-risk gamblers. **Conclusions:** Wagering inducements may represent a risk factor for developing or exacerbating gambling problems.

2.3.2 Introduction

Gambling is a widespread leisure activity that involves most of the population worldwide (Calado & Griffiths, 2016). For a proportion of gamblers, estimated to be from 0.1 to 5.8%, gambling can be addictive and have severe negative consequences (Calado & Griffiths, 2016). The internet has been consistently found to be associated with higher rates and increased severity of gambling problems (Effertz et al., 2018; Gainsbury, 2015; M. Griffiths, 2003; M. Griffiths et al., 2011; McCormack & Griffiths, 2013). In France, problem gambling has increased considerably since internet gambling was legalized in 2010 (Costes et al., 2015; Costes, Richard, & Eroukmanoff, 2020). At the same time, the internet presents a unique opportunity to monitor real-life gambling behaviors (S. Gainsbury, 2011). Indeed, the use of gambling tracking data (i.e. data extracted from user accounts, which are collected routinely by on-line gambling operators on a bet-by-bet basis) has been widely acclaimed in recent years in research into on-line gambling, given their ecological nature (Deng et al., 2019).

Marketing strategies used by gambling operators include wagering inducements, which are gambling incentives provided by a gambling company to a gambler conditional upon certain gambling-related actions and/or distributed in a form that encourages

gambling (Hing et al., 2017) (e.g. 'in case of a losing bet, you will be reimbursed'; the refunded money is generally within a predefined limit, paid into the game account and not eligible for a cash out). Little research has investigated the effects of wagering inducements on gambling behaviors, and mainly focuses upon a marketing perspective. A qualitative study demonstrated that gamblers interpret and respond to incentives differently according to their gender and age (Thomas et al., 2012). Another study highlighted that gamblers tend to underestimate the true cost of wagering inducements (Hing, Browne, et al., 2019). Wagering inducements are indeed often conceptualized as safety bets or free money, which may cause gamblers to change their gambling habits so they can obtain them (Deans et al., 2017).

According to several qualitative studies, wagering inducements may lead to impulse in-play betting patterns, especially for problem and frequent gamblers (Hing et al., 2018), increased risk-taking (Rockloff et al., 2019) and strong temptations to drop resolutions of controlled gambling in treatment-seeking gamblers (Hing et al., 2014). Using an ecological momentary assessment (EMA) design, a study on almost 600 race and sports bettors reported that more frequent and more intense betting was associated with wagering advertisements and inducements (Browne et al., 2019). This study

did not allow for causal interpretation, given that changes in betting behaviors are likely to influence exposure to certain forms of wagering advertisements and inducements. Recently, an experimental study performed on 171 on-line gamblers demonstrated that inducements had no effect on time spent gambling, but had an effect on the amount of money wagered, gambling-related expectancies and perceived loss of control (Challet-Bouju, Grall-Bronnec, et al., 2020). However, the study was based on a single gambling session and a simulation of wagering inducement, which was not conditional upon certain gambling-related actions, as is the case in the real gambling environment. As a consequence, an exploration of the impacts of wagering inducements on gambling behaviors in real-life conditions is highly needed, and gambling tracking data may offer a unique opportunity to conduct such an investigation.

To our knowledge, no study has investigated the impacts of wagering inducements based on gambling tracking data. This could be explained by the difficulty for researchers to access to gambling tracking data, but also by several methodological problems (temporality of both events (Browne et al., 2019) and specific dispersion of gambling tracking data). Regarding the temporality of event, wagering inducements attribution may depend upon gambling behavior, while gambling behavior may be

influenced by wagering inducements, leading to a close dynamic interrelation between these two events (Challet-Bouju, Grall-Bronnec, et al., 2020). As a consequence, determining the time at which an inducement has the strongest effect on gambling behavior is an important preliminary step. Regarding the distribution of gambling tracking data, they fluctuate considerably over time for a given individual and zero values are largely over-represented in the data (i.e. frequently, gamblers do not gamble at all during a given period) (Challet-Bouju, Hardouin, et al., 2020). Therefore, it is highly important to take into account zero-inflated distributions of gambling indicators.

In the present study, we hypothesized that the use of wagering inducements is followed by a change in gambling behavior (intensity, frequency and risky behaviors) that may occur quickly after the inducement has been obtained. We thus aimed to describe the temporal relation between wagering inducements and changes in gambling behavior and determine the time lag for which the inducement has the strongest effect on gambling behavior. Moreover, we hypothesized that the use of wagering inducements leads to an increase in gambling frequency, gambling intensity and the occurrence of at-risk gambling behaviors, i.e. episodes of chasing and higher involvement (Challet-Bouju, Hardouin, et al., 2020; Perrot et al., 2018b). We thus aimed to estimate whether the use of wagering inducements

impacts gambling behavior and quantify this impact. Hypotheses were preregistered prior to calculating the results (Challet-Bouju, Perrot, et al., 2020).

2.3.3 Methods

Design

This longitudinal observational study is part of the second stage of the EDEIN (Screening for Excessive Gambling Behaviors on the Internet) research program (Perrot et al., 2017).

Participants

The study participants were on-line gamblers who were recruited in two different ways. Indeed, until 2020, on-line gambling was regulated differently in France depending upon the type of gambling activity. The Regulatory Authority for On-line Gambling (*Autorité de Régulation des Jeux En Ligne*: ARJEL) regulated only gambling activities open to competition in the on-line gambling French market, i.e. poker, horse race betting and sports betting. In parallel, the national lottery operator (*Française des Jeux*: FDJ) acted as a monopoly for scratch games and lotteries (both lottery draws and daily lotteries) and was regulated separately. On-line casino games were forbidden in France before 2020 and still are. The data sets used for this study were extracted before 2020, so the two samples of on-line gamblers were generated based on the relative regulation applied.

First, a large random panel ($n = 840,797$) of on-line gamblers with an active gambling account (i.e. with at least one bet during the past 12 months) used for poker, horse race betting and sports betting were contacted by e-mail by the ARJEL in two successive waves (November 2015 and February 2016). The e-mail included information on the study and a link to an on-line survey hosted by the ARJEL. A total of 9,306 gamblers responded to the survey and had actionable data, which represents a response rate of 1.11%.

Secondly, another random panel ($n = 303,000$) of on-line gamblers with an active account used for lotteries and scratch games were contacted by e-mail by the FDJ in July 2019. The e-mail included information on the study and a link to an on-line survey hosted by the University Hospital of Nantes. A total of 5,682 gamblers responded to the survey and had actionable data, which represents a response rate of 1.88%.

For both responders' samples, data from the on-line surveys were merged by data providers (ARJEL and FDJ) with gambling tracking data at the individual level by using an encrypted identifier, with permission from the participants.

Measures

On-line survey

The content of the on-line survey was the same for gamblers in the two data sets. The participants were asked about their gambling

habits: the types of on-line gambling activities they engaged in and distribution of gambling activity both on- and off-line.

The participants also responded to the Problem Gambling Severity Index (PGSI), which is a nine-item self-report questionnaire derived from the Canadian Problem Gambling Index (Ferris & Wynne, 2001). The nine items are scored from 0 (never) to 3 (almost always), and the total score is computed as the sum of the nine items. According to the original scoring (Ferris & Wynne, 2001), a status can be derived from the total score in terms of the risk of gambling problems: non-problem gambler (score of 0), low-risk gambler (score of 1 or 2), moderate-risk gambler (score between 3 and 7) and excessive gambler (score greater or equal to 8). One limit of the PGSI is the threshold of the moderate-risk group, which was considered too low and was thought to produce high levels of false positives (Currie et al., 2013). Thus, a different categorization was proposed: non-problem gambler (score of 0), low-risk gambler (score between 1 and 4), moderate-risk gambler (score between 5 and 7) and excessive gambler (score greater or equal to 8) (Currie et al., 2013). In the present study, a score of 5 was used as the threshold to define an at-risk gambler (whether moderate-risk or excessive gambling). As in the original version, the reference period for the PGSI was the past 12 months.

Gambling tracking data

Data extracted from gambling accounts included the age and gender of gamblers and gambling tracking data for the 12 months preceding response to the on-line survey. Gambling tracking data were aggregated weekly by data providers before sending to the research team for analysis. Among all the data available, we selected five indicators of gambling behavior that were deemed to be representative of gambling intensity, gambling frequency and at-risk behaviors associated with gambling problems. Moreover, gambling tracking data included the number of bets for which a wagering inducement was used. A detailed description of the two data sets is given in the Supporting information, Table SI.1.

Gambling intensity was measured as the weekly cumulative amount of money wagered (available for each type of gambling) and the weekly cumulative amount of deposits made to the gambling account (cumulative across all types of gambling in each data set).

Gambling frequency was measured as the number of gambling days (i.e. days when the gambler placed at least one bet) in a given week for each type of gambling.

Finally, we used two indicators to measure at-risk gambling behaviors: the number of chasing episodes and breadth of involvement, which were previously identified as being able to distinguish non-problem and problem gamblers (Challet-Bouju, Hardouin, et al., 2020; Perrot et al., 2018b). The breadth of

involvement was defined as the number of different games for which at least one bet was placed during the week. The number of games played ranged from none to 10 in the ARJEL data set and from none to three in the FDJ data set. The number of chasing episodes was defined as the number of times that money was deposited into the gambling account when the following criteria were met: three or more deposits within a 12-hour period and deposits made less than 1 hour after a bet was placed (Perrot et al., 2017). These two indicators were computed globally, regardless of the type of gambling.

Analyses

The analysis plan was pre-registered (Challet-Bouju, Perrot, et al., 2020) and divided into two steps.

First, we performed a cross-correlation analysis (Gouédard et al., 2008), which allows measurement of the association between two time-series (here, the use of wagering inducements and gambling behaviors) as a function of the lag of one relative to the other. Analyses were performed separately for each gambling indicator and for each type of gambling whenever that was possible (see Supporting information). Gamblers who used no inducement at all during the year and those who did not have any gambling activity or had activity with no variations during the year were excluded (because cross-correlations cannot be computed under those circumstances). In order to observe the effect

of wagering inducements on gambling behaviors (and not the contrary), we did not include negative time lags. We hypothesized that an increase in gambling behavior may occur quickly after an inducement; thus, we limited our analysis to five time lags: 0 (gambling behavior during the same week as the use of the inducement), +1 (gambling behavior during the week following that of the use of the inducement) and so on, to +4 (gambling behavior during the week that occurred 4 weeks after that of the use of the inducement). The time lag for which the effect was the strongest was used in subsequent analyses as the lag of interest. Cross-correlations were performed using Stata software version 16.0.

Secondly, generalized linear mixed models (GLMMs) were implemented to test the strength of the association between the use of a wagering inducement and the five indicators of gambling behavior computed at the time lag of interest, and were applied to the whole sample (with no exclusion of gamblers). Random effects were included to take into account the repeated-data design. Analyses were performed separately for each indicator and for each type of gambling whenever that was possible. As we wanted to explore the differential impact of inducements on gamblers with or without gambling problems, we included the interaction between the PGSI status and inducement in the analyses. Moreover, the previous gambling behavior

(i.e. during the week before the gambling outcome) is a strong predictor of future behavior and was thus included as a confounding factor in all analyses. The type of model to be used was adapted to the specific distribution of each indicator for each type of gambling (see Supporting information Figures S1–S5). To deal with over-representation of zeroes, the number of chasing episodes and the breadth of involvement were transformed into binary variables (i.e. the presence of at least one episode of chasing or of at least two different games played during the week). Thus, GLMMs with a logit link were used for these two indicators. The other variables (money wagered, deposits and number of gambling days) were not transformed, and specific models were implemented to deal with the over-representation of zeros: (i) for the number of gambling days, GLMM with a log-linear link or zero-inflated Poisson (ZIP) models (Giles, 2010; Hall, 2000; Lambert, 1992) were used and (ii) for the amount of money wagered and deposits, two-part mixed-effects models (Farewell et al., 2017; Olsen & Schafer, 2001) were used. P-values were adjusted for multiple testing with the Benjamini & Hochberg correction (Benjamini & Hochberg, 1995a). The GLMMs were run using R Studio software version 3.6.1 (packages ‘lme4’, ‘glmmTMB’ and ‘GLMMadaptive’).

The analysis code used is provided in the Open Science Framework project attached to this study (Challet-Bouju et al., 2021).

2.3.4 Results

Description of gamblers and gambling behaviors

As described in Table 1, gamblers engaged in sports betting and poker were younger than gamblers engaged in horse race betting and lotteries. The gender ratio was largely in favor of males, but to a lesser extent for gamblers that played lotteries. At-risk gambling was present for approximately 20% of the gamblers engaged in sports betting, horse race betting and poker and 3.7% of gamblers playing lotteries.

As shown in Table 2, inducements were used only in 2–5% of observations, and there was a large over-representation of zeros for the five indicators due to inactive weeks. A flow-chart of the participants included in each analysis is provided in Figure 1.

Table 1: Description of gamblers according to the type of gambling

	Sports betting n=5,163	Horse race betting n=3,524	Poker n=4,858	Lotteries n=5,682
Gender [n (%)]				
Male	4,795 (92.9%)	3,068 (87.1%)	4,392 (90.4%)	3,698 (65.1%)
Female	320 (6.2%)	423 (12.0%)	401 (8.3%)	1,984 (34.9%)
Missing data	48 (0.9%)	33 (0.9%)	65 (1.3%)	-
Age [median (minimum - maximum)]				
	35 (18 - 94)	53 (18 - 96)	38 (18 - 96)	53 (18 - 99)
Risk category of the gambler [n (%)]				
Nonproblem gambler (score PGSI = 0)	1,379 (26.7%)	1,310 (37.2%)	1,377 (28.3%)	3,972 (70.0%)
Low-risk gambler (score PGSI between 1 and 4)	2,581 (50.0%)	1,551 (44.0%)	2,432 (50.1%)	1,502 (26.4%)
Moderate-risk gambler (score PGSI between 5 and 7)	579 (11.2%)	327 (9.3%)	493 (10.1%)	144 (2.5%)
Excessive gambler (score PGSI greater or equal to 8)	624 (12.1%)	336 (9.5%)	556 (11.5%)	64 (1.1%)
PGSI status [n (%)]				
At-risk gambler (PGSI ≥ 5)	1,203 (23.3%)	663 (18.8%)	1 049 (21.6%)	208 (3.7%)

Table 2: Description of the 5 indicators of gambling behavior and use of wagering inducements depending on the type of gambling (when possible).

Indicators	Gambling type	Number of observations*	% of zero values	Min	Max	Q1	Q2	Q3	P90	P95	P99
At least one wagering inducement used (binary)	Sports betting	483,912	97.5								
	Horse race betting	483,912	97.8								
	Poker	483,912	94.8								
	Lottery	295,464	97.9								
Amount of money wagered (quantitative)	Sports betting	483,912	82.2	0	157,430	0	0	0	23	103	759
	Horse race betting	483,912	78.3	0	30,214	0	0	0	38	123	724
	Poker	483,912	72.1	0	155,246	0	0	0	82	278	1,946
	Lottery	295,464	39.6	0	2,903	0	5	15	34	57	178
Number of gambling days (count)	Sports betting	483,912	81.8	0	7	0	0	0	2	5	7
	Horse race betting	483,912	81.4	0	7	0	0	0	4	6	7
	Poker	483,912	83.2	0	7	0	0	0	2	5	7
	Lottery	295,464	39.4	0	7	0	1	2	3	5	6
Amount of deposits (quantitative)	S/H/P**	483,912	75.7	0	14,645	0	0	0	62	150	540
	Lottery	295,464	71.0	0	1,735	0	0	10	25	45	107
At least one chasing episode (binary)	S/H/P**	483,912	91.3								
	Lottery	295,464	96.1								
At least two different games played (binary)	S/H/P**	483,912	76.5								
	Lottery	295,464	88.4								

Q1: first quartile; Q2: median; Q3: third quartile; P90: ninetieth percentile; P95: ninety-fifth percentile; P99: ninety-ninth percentile.

*The number of observations corresponds to the number of weeks observed for the total sample available for each indicator. For example, the ARJEL dataset includes 9,306 gamblers, which corresponds to $9,306 * 52 = 483,912$ observations. ** Sports betting + Horse race betting + Poker.

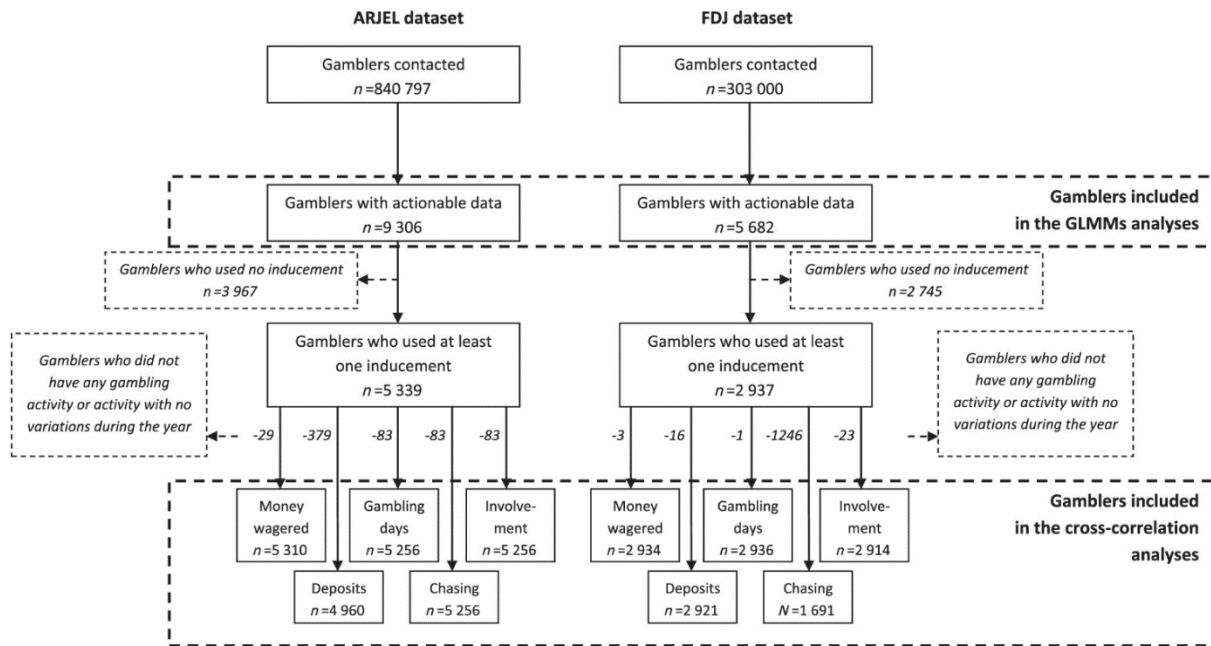


Figure 1: Flow-chart of the gamblers included in cross-correlations and generalized linear mixed-models (GLMMs) analyses.

Cross-correlations

The results of the cross-correlation analysis are depicted in Figure 2a–e. The effect of wagering inducements seemed to be the strongest for sports betting and poker, regardless of the indicator. For lotteries, the effect was close to zero for the deposit and chasing indicators, which indicates either no or a weak association between the use of wagering inducements and those two indicators. For the other conditions (other gambling types for the deposit and chasing indicators and other indicators regardless of the gambling type), an effect of wagering inducements was observed, with positive correlations ranging from 0.01 to 0.39. The effect was the strongest for lag0, seems to

partly maintain at lag+1 and then quickly decreased for subsequent weeks.

GLMMs

Lag0 was employed as the time lag of interest for GLMMs. In addition, we included results at lag+1 as an illustration of the temporal relationship between events (i.e. effect of wagering inducements on gambling behaviors, and not the contrary). The results are provided in Table 3a–e.

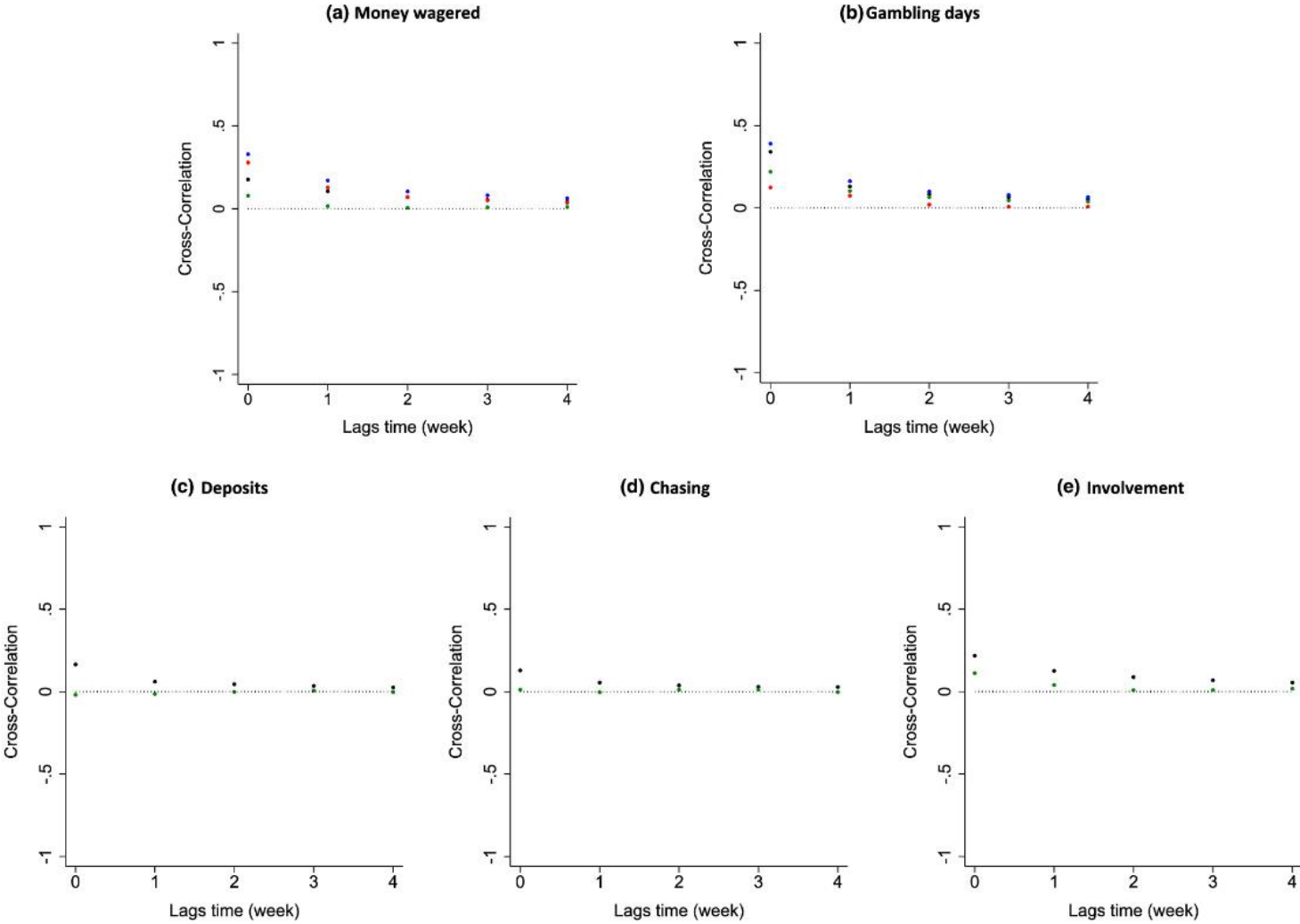
Notably, the status of the gambler ($PGSI \geq 5$) had the largest effect on the chasing and involvement indicators, which confirms that they are good proxies of gambling problems compared to intensity or frequency of gambling.

Wagering inducements were associated with a significant change of all indicators for

all types of gambling at lag0, which mainly persists, even if lower, at lag+1. The precisions of the estimated effects, either inducements' effects or the interaction with PGSI status, were good, as the confidence intervals were tightened around the predicted value.

The use of inducements seems to be associated with a weak change in gambling intensity and frequency (effects of less than €1 for money wagered and deposits and less than

0.3 gambling days), even for at-risk gamblers. Conversely, it seems to be associated with a higher change in at-risk gambling behaviors, especially for sports betting, horse race betting and poker. Except for lotteries, the interaction $\text{inducement} \times \text{PGSI} \geq 5$ was significant for all indicators, with a stronger effect of inducement for participants with gambling problems ($\text{PGSI} \geq 5$).



Legend

A and B: ● Sports betting; ● Horse race betting; ● Poker; ● Lottery
 C to E: ● Sports betting/Horse race betting/Poker; ● Lottery

Figure 2: Results of the cross-correlation for the five indicators of gambling behavior.

Table 3: Results of the GLMMs and two-part models for the five gambling indicators.

A. Money wagered (two-part mixed effects models)

		Effect at lag 0				Effect at lag +1			
Type of gambling	Effects	Excess of zeros (GLMMs with a logit link)		Values except excess of zeros (linear mixed model)		Excess of zeros (GLMMs with a logit link)		Values except excess of zeros (linear mixed model)	
		OR [CI 95%]	adj. p-value	β [CI 95%]	adj. p-value	OR [CI 95%]	adj. p-value	β [CI 95%]	adj. p-value
Sports betting	Inducement	0.05 [0.00;0.11]	<0.001	0.19 [0.16;0.23]	<0.001	0.11 [0.06;0.17]	<0.001	0.19 [0.15;0.22]	0.002
	PGSI \geq 5	0.78 [0.76;0.80]	<0.001	-0.16 [-0.17;-0.15]	<0.001	0.76 [0.74;0.78]	<0.001	-0.18 [-0.23;-0.13]	0.002
	Inducement * PGSI \geq 5	1.08 [0.95;1.21]	0.227	0.12 [0.06;0.18]	<0.001	1.78 [1.67;1.89]	<0.001	0.02 [-0.04;0.08]	0.570
	Previous behavior	0.98 [0.98;0.99]	<0.001	0.00 [-0.56;0.56]	<0.001	0.98 [0.98;0.98]	<0.001	0.00 [-0.00;0.00]	0.260
Horse race betting	Inducement	0.02 [0.00;0.14]	<0.001	0.41 [0.38;0.44]	<0.001	0.13 [0.05;0.21]	<0.001	0.16 [0.08;0.20]	0.002
	PGSI \geq 5	1.97 [1.94;2.00]	<0.001	0.56 [0.30;0.82]	<0.001	1.83 [1.80;1.85]	<0.001	0.39 [0.36;0.64]	0.004
	Inducement * PGSI \geq 5	0.50 [0.25;0.75]	<0.001	0.09 [0.03;0.16]	0.006	2.89 [2.70;3.07]	<0.001	-0.03 [-0.21;0.04]	0.403
	Previous behavior	0.96 [0.96;0.96]	<0.001	0.00 [0.00;0.00]	<0.001	0.96 [0.96;0.96]	<0.001	0.00 [0.00;0.01]	0.002
Poker	Inducement	0.04 [0.00;0.10]	<0.001	0.57 [0.54;0.60]	<0.001	0.10 [0.05;0.15]	<0.001	0.28 [0.26;0.32]	0.002
	PGSI \geq 5	1.23 [1.21;1.25]	<0.001	0.50 [0.33;0.68]	<0.001	1.17 [1.15;1.19]	<0.001	-0.01 [-0.39;-0.17]	0.937
	Inducement * PGSI \geq 5	0.73 [0.59;0.87]	<0.001	0.20 [0.14;0.25]	<0.001	1.45 [1.35;1.54]	<0.001	0.03 [-0.02;0.09]	0.333
	Previous behavior	0.99 [0.97;0.99]	<0.001	0.00 [-0.00;0.00]	<0.001	0.99 [0.99;0.99]	<0.001	0.00 [0.00;0.00]	0.002
Lotteries	Inducement	0.15 [0.05;0.25]	<0.001	-0.06 [-0.08;-0.05]	<0.001	0.56 [0.49;0.62]	<0.001	-0.03 [-0.09;-0.01]	0.002
	PGSI \geq 5	1.14 [1.10;1.19]	<0.001	-0.80 [-1.04;-0.58]	<0.001	1.14 [1.10;1.19]	<0.001	-0.12 [-0.16;0.12]	0.327
	Inducement * PGSI \geq 5	0.74 [0.17;1.32]	0.311	0.02 [-0.06;0.10]	0.634	0.97 [0.64;1.30]	<0.001	-0.10 [-0.44;0.79]	0.032
	Previous behavior	0.74 [0.74;0.74]	<0.001	0.01 [0.01;0.01]	<0.001	0.98 [0.98-0.98]	0.849	0.01 [0.01;0.01]	0.002

Notes:

Lag0: When a gambler with a PGSI score <5 uses a wagering inducement in a specific week, the money wagered during that same week on sports betting, horse race betting and poker increases by €0.19, €0.41 and €0.57, respectively, compared to €0.31, €0.50 and €0.77 respectively for gamblers with a PGSI score \geq 5. When a gambler (whatever the PGSI status) uses a wagering inducement in a specific week, the money wagered during that same week on lotteries decreases by €0.06.

Lag+1: When a gambler (whatever the PGSI status) uses a wagering inducement in a specific week, the money wagered during the following week on sports betting, horse race betting and poker increases by €0.19, €0.16 and €0.28, respectively, and decreases by €0.03 for lotteries.

B. Gambling days (GLMMs with a log-linear link or zero-inflated Poisson (ZIP) models)

ZIP models		Effect at lag 0				Effect at lag +1			
		Excess of zeros (GLMMs with a logit link)		Values except excess of zeros (GLMMs with a log-linear link)		Excess of zeros (GLMMs with a logit link)		Values except excess of zeros (GLMMs with a log-linear link)	
Type of gambling	Effects	OR [CI 95%]	adj. p-value	β [CI 95%]	adj. p-value	OR [CI 95%]	adj. p-value	β [CI 95%]	adj. p-value
Sports betting	Inducement	0.17 [0.10;0.27]	<0.001	0.12 [0.10;0.18]	0.002	1.45 [1.42;1.60]	<0.001	0.04 [0.02;0.05]	<0.001
	PGSI \geq 5	0.76 [0.52;0.96]	<0.001	0.57 [0.35;0.89]	0.002	0.89 [0.83;0.93]	<0.001	0.47 [0.35;0.59]	<0.001
	Inducement* PGSI \geq 5	0.99 [0.86;1.26]	0.479	-0.45 [-0.89;0.56]	0.512	1.11 [1.11;1.37]	0.450	-0.03 [-0.06;-0.01]	0.011
	Previous behavior	0.87 [0.71;0.97]	<0.001	0.17 [0.14;0.19]	0.002	0.11 [-0.15;0.16]	<0.001	0.11 [0.10;0.11]	<0.001
	Inducement	0.21 [0.00;0.35]	<0.001	0.16 [0.12;0.17]	0.002	2.01 [1.78;2.23]	<0.001	0.04 [0.03;0.06]	0.002
Horse race betting	PGSI \geq 5	1.25 [1.13;1.47]	<0.001	-0.21 [-0.53;0.17]	0.598	1.18 [0.99;1.37]	<0.001	-0.10 [-0.37;0.17]	0.474
	Inducement* PGSI \geq 5	1.09 [0.66;1.44]	0.570	-0.01 [-0.05;1.02]	0.602	0.98 [0.57;1.40]	0.931	-0.05 [-0.09;-0.01]	0.009
	Previous behavior	0.25 [0.07;0.46]	<0.001	0.02 [0.02;0.03]	0.002	0.08 [0.00;0.16]	<0.001	0.09 [0.08;0.09]	0.002
	Inducement	0.13 [0.05;0.22]	0.002	0.17 [0.16;0.18]	0.002	0.40 [0.32;0.48]	<0.001	-0.01 [-0.02;0.01]	0.201
Poker	PGSI \geq 5	1.07 [1.02;1.11]	0.007	0.08 [-0.10;0.25]	0.376	1.02 [0.98;1.06]	0.372	0.18 [0.02;0.33]	0.037
	Inducement* PGSI \geq 5	0.91 [0.74;1.07]	0.232	0.02 [-0.01;0.04]	0.376	0.87 [0.72;1.01]	0.073	-0.05 [-0.08;-0.02]	0.002
	Previous behavior	0.20 [0.16;0.24]	0.002	0.12 [0.11;0.12]	0.002	0.20 [0.17;0.23]	<0.001	0.12 [0.12;0.12]	0.002
	Inducement	0.13 [0.05;0.22]	0.002	0.17 [0.16;0.18]	0.002	0.40 [0.32;0.48]	<0.001	-0.01 [-0.02;0.01]	0.201
				GLMMs with a log-linear link					
				β [CI 95%]	adj. p-value			β [CI 95%]	adj. p-value
Lotteries	Inducement			0.29 [0.28;0.31]	<0.001			0.15 [0.13;0.17]	<0.001
	PGSI \geq 5			0.32 [0.18;0.45]	<0.001			0.31 [0.17;0.44]	<0.001
	Inducement* PGSI \geq 5			-0.03 [-0.11;0.06]	0.546			-0.00 [-0.09;0.08]	0.941
	Previous behavior			0.15 [0.15;0.15]	<0.001			0.15 [0.15;0.15]	<0.001
	Inducement			0.29 [0.28;0.31]	<0.001			0.15 [0.13;0.17]	<0.001

Notes:

Lag0: When a gambler (whatever the PGSI status) uses a wagering inducement during a specific week, the number of gambling days on sports betting, horse race betting, poker and lotteries increases by 0.12, 0.16, 0.17 and 0.29, respectively, during the same week.

Lag+1: When a gambler with a PGSI score <5 uses a wagering inducement during a specific week, the number of gambling days on sports betting increases by 0.04 during the following week, compared to 0.01 for gamblers with a PGSI score \geq 5.

When a gambler (whatever the PGSI status) uses a wagering inducement during a specific week, the number of gambling days on horse race betting and lotteries increases by 0.04 and 0.15, respectively, during the following week.

There was no effect of the use of the wagering inducement on the number of gambling days during the following week for poker.

C. Deposits (two-part mixed effects models)

		Effect at lag 0				Effect at lag +1			
		Excess of zeros (GLMMs with a logit link)		Values except excess of zeros (linear mixed model)		Excess of zeros (GLMMs with a logit link)		Values except excess of zeros (linear mixed model)	
Type of gambling	Effects	OR [CI 95%]	adj. p-value	β [CI 95%]	adj. p-value	OR [CI 95%]	adj. p-value	β [CI 95%]	adj. p-value
S/H/P**	Inducement	0.28 [0.27;0.29]	<0.001	0.15 [0.13;0.16]	<0.001	0.44 [0.41;0.54]	<0.001	0.03 [0.01;0.05]	<0.001
	PGSI \geq 5	0.52 [0.50;0.55]	<0.001	-1.16 [-1.29;-1.03]	<0.001	0.51 [0.50;1.01]	<0.001	-0.10 [-0.25;0.06]	0.181
	Inducement*	0.74 [0.74;0.74]	<0.001	0.10 [0.08;0.13]	<0.001	0.94 [0.89;0.97]	0.011	0.09 [0.07;0.12]	<0.001
	PGSI \geq 5	0.99 [0.97;1.01]	<0.001	0.00 [0.00;0.01]	<0.001	0.99 [0.99;0.99]	<0.001	0.00 [-0.00;0.00]	<0.001
	Previous behavior								
Lotteries	Inducement	1.00 [0.95;1.06]	0.917	-0.05 [-0.07;-0.03]	<0.001	0.84 [0.78;0.90]	<0.001	-0.02 [-0.04;-0.01]	0.020
	PGSI \geq 5	0.56 [0.52;0.60]	0.002	-1.17 [-1.48;-0.86]	<0.001	0.56 [0.52;0.60]	<0.001	-0.95 [-1.35;-0.56]	0.002
	Inducement*	0.79 [0.53;1.05]	0.108	-0.02 [-0.09;0.06]	0.672	0.37 [0.11;0.63]	0.134	-0.06 [-0.13;0.02]	0.139
	PGSI \geq 5	0.99 [0.99;0.99]	0.002	0.00 [-0.00;0.00]	<0.001	0.99 [0.99;0.99]	<0.001	0.00 [-0.00;0.01]	0.002
	Previous behavior								

** Sports betting + Horse race betting + Poker.

Note:

Lag0: When a gambler with a PGSI score <5 uses a wagering inducement during a specific week, the amount of the deposits during the same week increase by €0.15 for gamblers in the ARJEL dataset (i.e., sports betting, horse race betting, poker), compared to €0.25 for gamblers with a PGSI score \geq 5.

When a gambler (whatever the PGSI status) uses a wagering inducement during a specific week, the amount of the deposits during the same week decreases by €0.05 for gamblers in the FDJ dataset (i.e., lotteries).

Lag+1: When a gambler (whatever the PGSI status) uses a wagering inducement during a specific week, the amount of the deposits during the following week increase by €0.03 for gamblers in the ARJEL dataset (i.e., sports betting, horse race betting, poker) and decreases by €0.02 for gamblers in the FDJ dataset (i.e., lotteries).

D. Chasing (GLMMs with a logit link)

Type of gambling	Effects	Effect at lag 0		Effect at lag +1	
		OR [CI 95%]	adj. p-value	OR [CI 95%]	adj. p-value
S/H/P**	Inducement	3.31 [3.16;3.47]	<0.001	1.61 [1.56;1.66]	<0.001
	PGSI ≥ 5	6.45 [5.71;7.28]	<0.001	6.27 [6.14;6.40]	<0.001
	Inducement * PGSI ≥ 5	1.32 [1.22;1.43]	<0.001	0.86 [0.78;0.94]	<0.001
	Previous behavior	2.61 [2.53;2.69]	<0.001	2.64 [2.61;2.67]	<0.001
Lotteries	Inducement	1.32 [1.16;1.50]	<0.001	1.08 [0.95;1.22]	0.332
	PGSI ≥ 5	3.78 [2.26;6.33]	<0.001	3.75 [3.21;4.28]	0.002
	Inducement * PGSI ≥ 5	1.25 [0.79;1.97]	0.346	1.27 [1.20;1.33]	0.336
	Previous behavior	1.42 [1.33;1.51]	<0.001	1.44 [0.96;1.91]	0.002

Note:

Lag0: When a gambler in the ARJEL dataset (i.e., sports betting, horse race betting, poker) with a PGSI score <5 uses a wagering inducement during a specific week, the probability of a chasing episode during the same week increases by 3.31 times, compared to 4.63 times for gamblers with a PGSI score ≥ 5.

When a gambler in the FDJ dataset (i.e., lotteries) (whatever the PGSI status) uses a wagering inducement during a specific week, the probability of a chasing episode during the same week increases by 1.32 times.

Lag+1: When a gambler in the ARJEL dataset (i.e., sports betting, horse race betting, poker) with a PGSI score <5 uses a wagering inducement during a specific week, the probability of a chasing episode during the following week increases by 1.61 times, compared to 2.47 times for gamblers with a PGSI score ≥ 5.

There was no effect of the use of the wagering inducement on the occurrence of a chasing episode during the following week for lotteries.

E. Involvement GLMMs with a logit link)

Type of gambling	Effects	Effect at lag 0		Effect at lag +1	
		OR [CI 95%]	adj. p-value	OR [CI 95%]	adj. p-value
S/H/P**	Inducement	4.82 [4.61;5.05]	<0.001	1.47 [1.43;1.52]	<0.001
	PGSI ≥ 5	2.68 [2.33;3.09]	<0.001	2.00 [1.88;2.12]	<0.001
	Inducement * PGSI ≥ 5	1.31 [1.20;1.43]	<0.001	1.01 [0.93;1.09]	0.869
	Previous behavior	8.28 [8.10;8.46]	<0.001	8.43 [8.41;8.45]	<0.001
Lotteries	Inducement	1.99 [1.84;2.15]	<0.001	1.40 [1.32;1.47]	<0.001
	PGSI ≥ 5	6.82 [4.30;10.83]	<0.001	3.89 [3.42;4.36]	<0.001
	Inducement * PGSI ≥ 5	1.24 [0.89;1.73]	0.213	1.95 [1.60;2.29]	0.024
	Previous behavior	1.85 [1.78;1.92]	<0.001	1.49 [1.45;1.53]	<0.001

** Sports betting + Horse race betting + Poker.

Note:

Lag0: When a gambler in the ARJEL dataset (i.e., sports betting, horse race betting, poker) with a PGSI score <5 uses a wagering inducement during a specific week, the probability of playing at least 2 different games during the same week increases by 4.82 times, compared to 6.13 times for gamblers with a PGSI score ≥ 5.

When a gambler in the FDJ dataset (i.e., lotteries) (whatever the PGSI status) uses a wagering inducement during a specific week, the probability of playing at least 2 different games during the same week increases by 1.99 times.

Lag+1: When a gambler in the ARJEL dataset (i.e., sports betting, horse race betting, poker) (whatever the PGSI status) uses a wagering inducement during a specific week, the probability of playing at least 2 different games during the following week increases by 1.47 times.

When a gambler in the FDJ dataset (i.e., lotteries) with a PGSI score <5 uses a wagering inducement during a specific week, the probability of playing at least 2 different games during the following week increases by 1.40 times, compared to 3.35 times for gamblers with a PGSI score ≥ 5.

Notes for Table 3 A to E:

Bolded p-values are significant p-values < 0.05.

ZIP: Zero-Inflated Poisson; CI 95%: Confidence Interval at 95%; GLMM: Generalized Linear Mixed Models; OR: Odds Ratio.

Only significant interactions with both main effects being significant were interpreted.

2.3.5 Discussion

This study aimed to investigate the impact of wagering inducements on the gambling behaviors of on-line gamblers by describing the temporal relation between these two variables and quantifying this impact.

The socio-demographic characteristics of the two samples were similar to the source population described in the 2017 French prevalence survey dedicated only to on-line gambling (Costes & Eroukmanoff, 2018). Indeed, gamblers engaged in sports betting and poker were younger than others. Moreover, there was a global predominance of males in the two data sets. The highest proportion of females was found for lotteries, which is well known, as pure chance games are more appealing to females than skill-based games (Challet-Bouju, Hardouin, et al., 2020; McCormack et al., 2014; Perrot et al., 2018b).

The effect of wagering inducements on gambling behaviors seems to occur in the same week as their use, to maintain partly after 1 week and then to quickly decrease during subsequent weeks. This result is consistent with the EMA study, which reported an effect of inducements on intended and actual betting using a 24/48-hour interval

between surveys to conform to a weekly schedule (Browne et al., 2019).

The effect of wagering inducements on gambling behaviors was demonstrated for all types of gambling and all indicators with good accuracy of the estimated effects, but the strength of the effect varied. Indeed, the intensity and frequency of gambling were little impacted by the use of inducements when controlling for previous gambling behavior. On the contrary, inducements were associated with a large increase in at-risk gambling behaviors for gamblers engaged in sports betting, horse race betting and poker and, to a lesser extent, lotteries. Even if chasing episodes are quite rare events in the gambling activity of on-line gamblers (Challet-Bouju, Hardouin, et al., 2020; Perrot et al., 2018b), the probability of engaging in such behaviors is multiplied by more than three times for non-at-risk gamblers engaged in sports betting, horse race betting and poker and up to 4.63 times for at-risk gamblers. The increase in the probability of the occurrence of a chasing episode was smaller [odds ratio (OR) = 1.32] for lotteries, with no difference between at-risk and non-at-risk gamblers. This result is all the more worrying, because chasing was previously identified as a critical indicator of gambling problems (Challet-

Bouju, Hardouin, et al., 2020; Deng et al., 2019) and the most significant step in the development of gambling disorders (Breen & Zuckerman, 1999; Lesieur, 1979; Toce-Gerstein et al., 2003). Moreover, the breadth of involvement (i.e. the number of different games played by a gambler) was found to mediate the relationship between on-line gambling and gambling problems (Baggio et al., 2017). In a previous work on the early trajectories of on-line gamblers, we found that a greater breadth of involvement may be a key indicator for identifying gamblers at risk for future gambling problems (Challet-Bouju, Hardouin, et al., 2020). In the present study, the use of inducements increased the probability of playing at least two different games by close to five times for non-at-risk gamblers engaged in sports betting, horse race betting and poker and by more than six times for at-risk gamblers. The increase in the probability of playing at least two different games was smaller ($OR = 1.99$) for lotteries, with no difference between at-risk and non-at-risk gamblers. Therefore, inducements seem to be associated with a diversification of gambling activity, which may represent a basis for the development of future gambling problems.

The fact that inducements had a higher effect on gambling behaviors for at-risk gamblers, except for on-line lotteries, means that problem gamblers may be particularly at risk of increasing their gambling activity due

to inducements and, more worryingly, increasing their at-risk gambling behaviors. Several psychological characteristics of individuals with gambling problems can explain why at-risk gamblers may be more vulnerable to inducements. First, delay discounting is often related to problem gambling and refers to the tendency to devalue gratifications that are delayed in time compared to immediate rewards, regardless of their magnitude (Wiehler & Peters, 2015). In a recent study, delay discounting was found to be associated with chasing (Ciccarelli et al., 2019). As wagering inducements are immediate rewards, they may strengthen the inability to tolerate delayed rewards and thus contribute to the higher propensity to chase. Secondly, it could be hypothesized that inducements may favour the development of certain forms of gambling-related cognitive distortions in problem gamblers. Indeed, problem gamblers may conceptualize inducements as the recognition that they are good, competent, experienced gamblers, rather than as a marketing strategy. This may be especially the case for skill-based games, in which internal locus of control (i.e. attribution of wins to one's own personal skills) has been found to predict problem gambling (Hopley et al., 2012). Therefore, inducements may reinforce internal attribution and lead to an increase in at-risk behaviors.

Limitations and strengths

This study has several limitations. First, gambling tracking data were available in two independent data sets according to the types of gambling activity (sports betting, horse race betting and poker in the first data set and lotteries in the second data set). This was due to the specific regulation of on-line gambling in force in France until 2020. As a consequence, the results of this study may not apply to other forms of on-line gambling, such as that offered by on-line casinos. It would be interesting to replicate this work with data covering the whole gambling activity. Secondly, gambling problems were assessed through a self-report questionnaire, the PGSI. Although this scale is the most widely used for screening gambling problems in epidemiological studies, self-reported subjective data have been criticized given their numerous biases, including divergence between claimed and actual behaviors (Baumeister et al., 2007; Braverman et al., 2014; Garber et al., 2004; Rundle-Thiele, 2009). Thirdly, we had no information on the type of wagering inducements used or the distinction between inducements received and used. Future studies should further explore the differential impacts of various forms of inducements (Hing et al., 2017), as some types may convey an illusion of lower risk (Browne et al., 2019). Moreover, it would be interesting to take into account the environment when exploring the effects of inducements, as

exposure to advertising of inducements (e.g. on television) can still have an effect as a stimulus for gambling even if the inducement is not used. Fourthly, although the temporal relationship between wagering inducement and gambling behavior is clearer compared to previous studies, a causal effect could not have been tested with the current design and analyses because the reverse causal pathway (i.e. increase in gambling behavior leading to the use of wagering inducement) could not be excluded with a time lag of 0. However, the inclusion of results for time lag+1 indicate that the effect seems mainly, although partly, to maintain even after 1 week.

Conversely, this study has important strengths. First, it was based on gambling tracking data, which are currently acclaimed in gambling research because they provide access to naturalistic gambling behaviors in a real gambling environment with individuals who actually gamble (Deng et al., 2019; S. Gainsbury, 2011). Secondly, this study included all legal on-line gambling activities in France and a large probability sample of on-line gamblers that covers the full range of gambling practices (from recreational to excessive gambling). Thirdly, the indicators chosen to reflect gambling behaviors were not restricted to the intensity or frequency of gambling but extended to indicators revealing the propensity for gambling problems.

2.3.6 Conclusion

This study revealed that wagering inducements may be associated with an

immediate increase in gambling intensity, gambling frequency and at-risk gambling behaviors. This effect was stronger for at-risk gambling behaviors and at-risk gamblers, which indicates that inducements may represent a serious risk factor for developing or exacerbating gambling problems. From the perspective of responsible gambling, wagering inducements should be restricted, at least for gamblers who are identified as having gambling problems. More specifically, future studies should clarify the types of wagering inducements that present more risk and identify which gamblers are more affected. Moreover, wagering inducements should be accompanied by information messages regarding their potential impact on gambling intensity, gambling frequency and at-risk gambling behaviors, such as chasing and the breadth of involvement

weekly basis for a 12-months period, i.e. each variable was computed 52 times for each week of the 12-months period (repeated measures) and for each gambler by data providers (ARJEL for poker, horse race betting and sports betting / FDJ for scratch games and lotteries) before sending to the research team. As a consequence, each gambler in either dataset had 52 observations, so that there was 483,912 observations in the ARJEL dataset (i.e. 9,306 gamblers * 52 weeks) and 295,464 observations in the FDJ dataset (i.e. 5,682 gamblers * 52 weeks).

2.3.7 References

References are included in the References section of the thesis.

2.3.8 Supplementary information

Below is a description of the variables used in the present work. All variables from gambling tracking data were available on a

Table SI.1: Description of the datasets

Variable	Nature	Definition	Dataset specificity	Origin
Age	Continuous variable	Age of the gambler		Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ
Gender	Binary variable	Gender of the gambler		Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ
Number of wagering inducement	Count variable	Number of bets for which a wagering inducement was used		Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ
Use of a wagering inducement	Binary variable	Presence of at least one bet for which a wagering inducement was used		Computed by the authors from the original datasets
Money wagered	Continuous variable	Cumulative amount of money wagered		Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ
Deposits	Continuous variable	Cumulative amount of money deposited on the gambling account	As a gambling account may serve for various gambling activities, there was no possible differentiation between types of gambling for deposits made on the gambling account. As a consequence, the cumulative amount of money deposited was computed across all types of gambling available in each dataset.	Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ
Number of gambling days	Count variable	Number of days when the gambler placed at least one bet (range 0-7)		Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ
Number of chasing episodes	Count variable	Number of times that money was deposited into the gambling account when the following	As a gambling account may serve for various gambling activities, there was no possible differentiation between types of gambling	Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ

		criteria were met: 3 or more deposits within a 12-hour period and deposits made less than 1 hour after a bet was placed	for deposits made on the gambling account. As a consequence, the number of chasing episodes was computed across all types of gambling available in each dataset.	
Presence of a chasing episode	Binary variable	Presence of at least one episode of chasing		Computed by the authors from the original datasets
Breadth of involvement	Count variable	Number of different games for which at least one bet was placed	<p><u>ARJEL dataset:</u> The number of games played ranged from 0 to 10: “simple” (only one race) and “complex” (several races) horse race betting, “simple” sports betting (only one sporting event) on football, tennis, rugby, basketball or other sports, “complex” sports betting (several sporting events), live sports betting (betting during the sporting event) and poker</p> <p><u>FDJ dataset:</u> The number of games played ranged from 0 to 3: scratch games, lottery draws and daily lotteries.</p>	Gambling tracking data Available directly from the datasets provided by ARJEL and FDJ
Involvement	Binary variable	Presence of at least 2 different games played		Computed by the authors from the original datasets
PGSI items	Ordinal variables	Nine items from the PGSI, scored on a Lickert scale from 0 (never) to 3 (almost always)		Online survey Available directly from the dataset provided by ARJEL, and from the dataset collected by the University Hospital of Nantes for gamblers contacted by the FDJ
PGSI score	Continuous variable	Sum of the responses to the 9 items of the PGSI		Computed by the authors from the original datasets

Supplementary Information 1: Details of the statistical analysis performed.

Cross-correlation analysis

The cross-correlation analyses were performed separately for each gambling indicator.

For the amount of money wagered and number of gambling days indicators, analyses were performed independently for each type of gambling; i.e., lotteries (including lottery draws, daily lotteries, and scratch cards), sports betting, horse race betting and poker.

For the other indicators (deposits, chasing episodes and involvement), as the variables were computed at a larger scale than each type of game (see Table SI.1 above), the analyses were performed globally for each dataset.

In order to observe the effect of wagering inducements on gambling behaviors (and not the contrary), we did not include negative time lags (i.e., gambling behavior during the weeks preceding the use of the wagering inducement). We hypothesized that an increase in gambling behavior may occur quickly after an inducement, thus we limited our analysis to 5 time lags: 0 (gambling behavior during the same week as the use of the inducement), +1 (gambling behavior during the week following that of the use of the inducement), and so on, to time lag +4 (gambling behavior during the week that occurred four weeks after that of the use of the inducement). The time lag for which the effect

was the strongest was used in subsequent analyses as the lag of interest.

Cross-correlations were performed using STATA software, version 16.0.

Generalized linear mixed models (GLMMs)

Generalized linear mixed models (GLMMs) were implemented at the time lag of interest (= time lag 0), and were also applied to time lag +1 as an illustration of the temporal relationship between events (i.e. effect of wagering inducements on gambling behaviors, and not the contrary).

Random effects were included to take into account the repeated-data design. The interaction between the PGSI status and inducement was included in the analyses to explore the differential impact of inducements on gamblers with or without gambling problems. Moreover, the previous gambling behavior (i.e. during the week before the gambling outcome) was included as a confounding factor in all analyses as it is a strong predictor of future behavior.

Analyses were performed separately for each indicator and for each type of gambling when that was possible. The specific type of model (i.e., family and link function) to be used was adapted to take into account the specific distribution of each indicator for each type of gambling. Indeed, for all the indicators, there was a large overrepresentation of zeros compared to other

values because the gamblers did not wager or deposit funds into their accounts every week (see Figures S1 to S5 below for the distribution of each indicator). The only exception was for the number of gambling days for lotteries, for which zeros were predominant but not overrepresented.

This problem (overrepresentation of zeros) could be addressed by converting the indicators into binary variables when possible.

For the number of chasing episodes and the breadth of involvement, this strategy was relevant.

Indeed, chasing episodes are quite rare events (more than 90% of the values were null), and a chasing episode is an indication of at-risk behavior *per se* (Challet-Bouju, Hardouin, et al., 2020; Perrot et al., 2018a). For the breadth of involvement, a large majority of the gamblers have a single-game activity, so having multigame activity is relevant information. Therefore, these two variables were transformed into binary variables based on the presence of at least one episode of chasing during the week for the chasing indicator and whether the gambler played at least 2 different games during the week for the breadth of involvement. Thus, GLMMs with a logit link were used for these two indicators.

It was much more difficult to reduce the other variables (money wagered, deposits and number of gambling days) into binary variables, which may lead to a considerable

loss of information. Therefore, these variables were not transformed, and specific models were implemented to deal with the overrepresentation of zeros.

For the number of gambling days, which is a count variable, GLMMs with a log-linear link, in principle, could have been used. However, zero-inflated Poisson (ZIP) models allow the excess number of zeros to be modeled independently of the other values to capture the meaningfulness of this excess (Giles, 2010; Hall, 2000; Lambert, 1992). Within ZIP models, GLMMs with a logit link are used to model the excess of zero values (inflated zeros), and GLMMs with a log-linear link are used to model both non-null values and zeros that were not considered as inflated zeros. For the types of gambling for which zeroes were overrepresented, ZIP models were systematically applied. For lotteries, for which zeros were predominant but not overrepresented, the results of the ZIP models and GLMMs with a log-linear link were compared using the Akaike information criterion (AIC) to select the most suitable method.

For the amount of money wagered and deposits, which were semi continuous variables with overrepresentation of zeros, we used two-part mixed effects models (Farewell et al., 2017; Olsen & Schafer, 2001). As for the ZIP models, GLMMs with a logit link were used to model the excess of zero values, and linear mixed model were used to model

the nonnull values and zero that were not considered as inflated zeros.

P-values were adjusted for multiple testing with the Benjamini and Hochberg correction (Benjamini & Hochberg, 1995a).

The GLMMs were run using R Studio software version 3.6.1 (packages “lme4”, “glmmTMB” and “GLMMadaptive”).

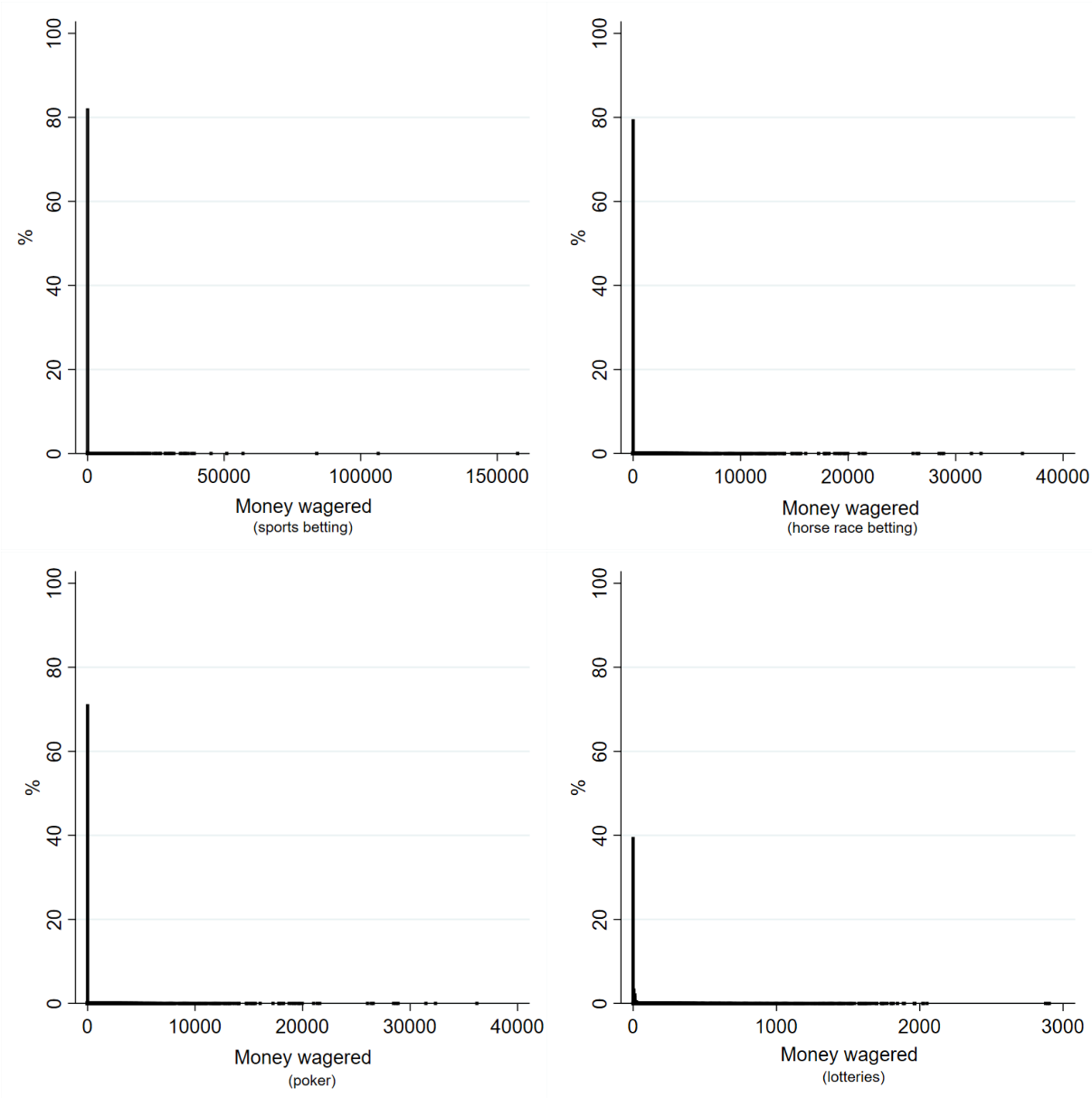


Figure SI.1: Distribution of data for the “Money wagered” indicator.

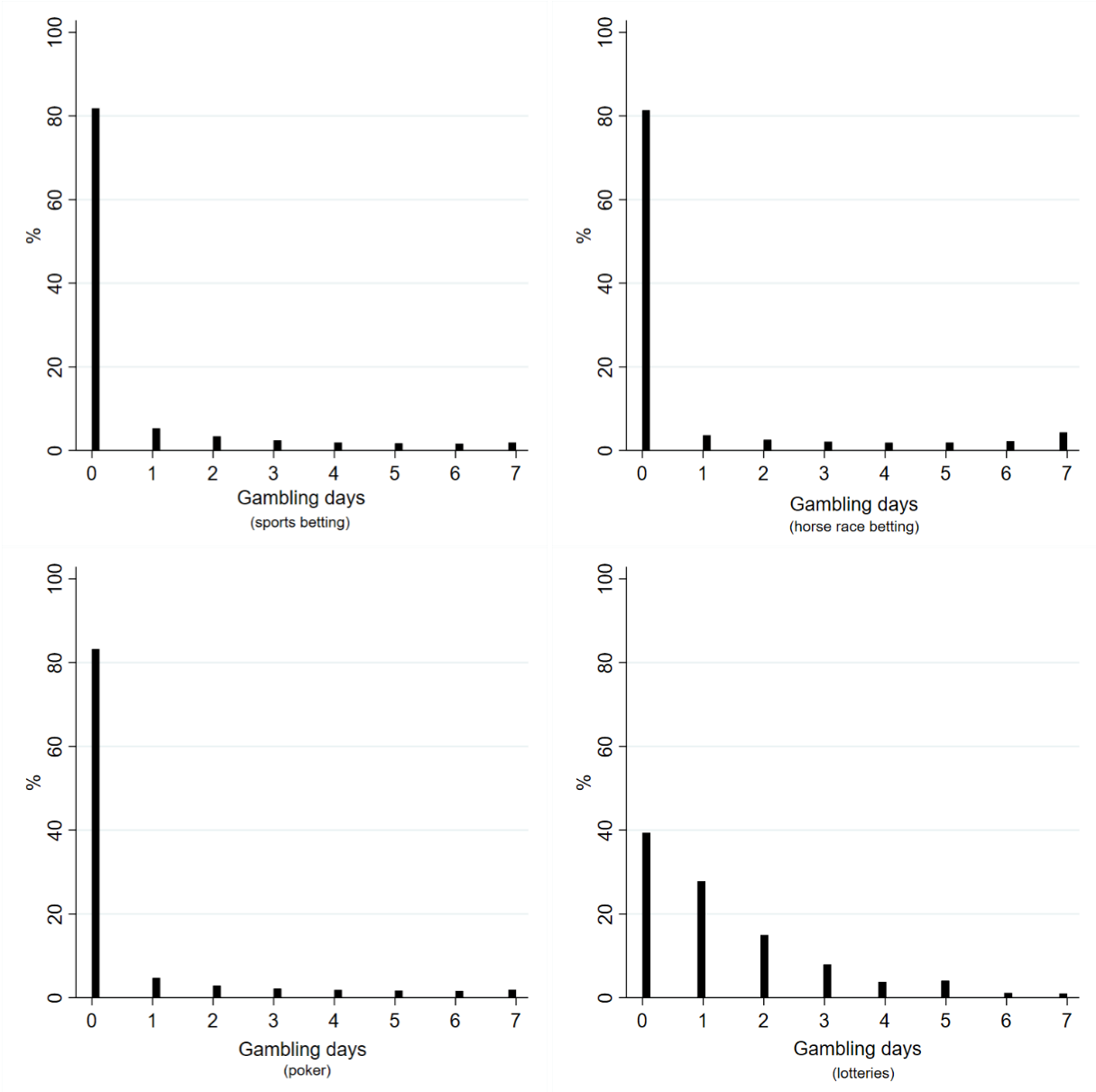


Figure SI.2: Distribution of data for the “Gambling days” indicator.

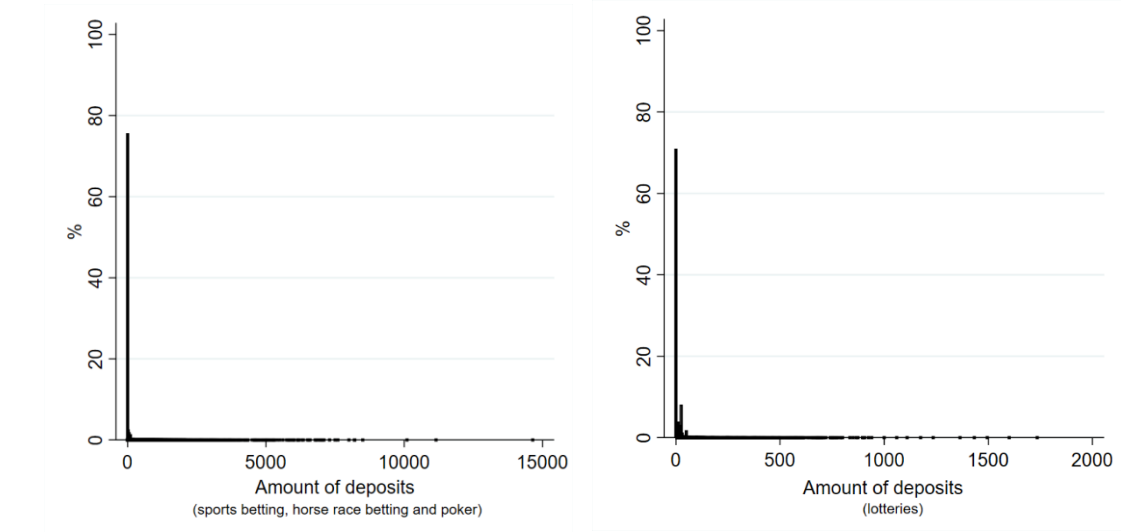


Figure S3: Distribution of data for the “Deposits” indicator.

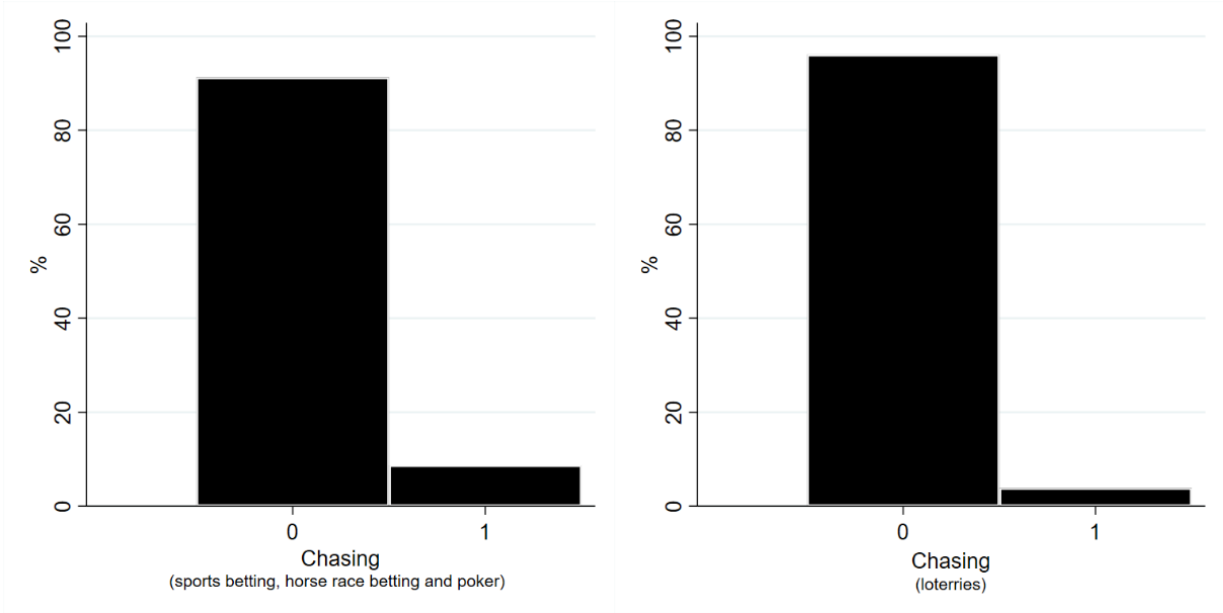


Figure SI.4: Distribution of data for the “Chasing” indicator.

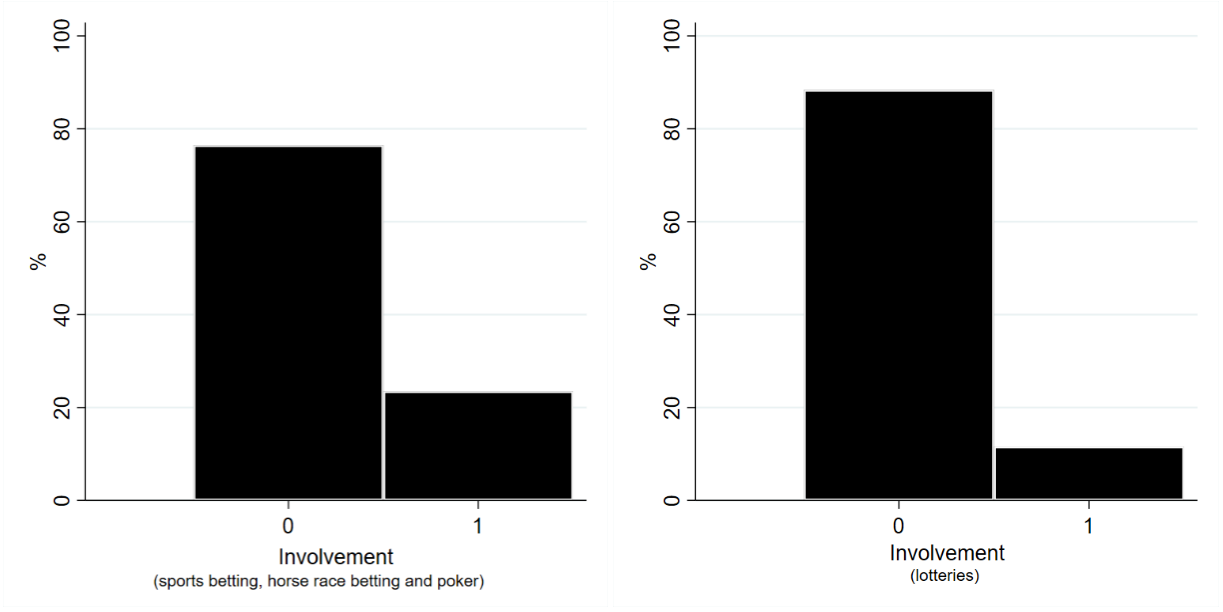


Figure SI.5: Distribution of data for the “Involvement” indicator.

2.4 Overview and conclusion of the chapter 2

In this chapter, we aimed to assess the impact of wagering inducements on gambling behaviors among online gamblers. This research is part of my second-year master's internship, during which the statistical analyses were carried out, but the publication process occurred during the first year of my doctoral thesis.

2.4.1 Main results of the manuscript 2

The study's first key finding is that the use of wagering inducements was positively correlated with the five gambling indicators for sports betting, horse-race betting, and poker, with correlation values ranging from 0.13 to 0.39. For lotteries, the correlations were also positive but lower, ranging from 0.8 to 0.12 for the amount of money wagered, the number of gambling days, and the level of involvement. However, for the number of chasing episodes and the amount of deposits, the correlations were close to zero.

Another key finding is that for all gambling indicators and all gambling types, the correlations were strongest during the same week the inducements were used (lag 0), then remained partially significant one week later (lag +1), and quickly diminished to nearly zero in the following weeks. This indicates that the impact of wagering inducements on gambling behaviors was most pronounced in the week they were used, slightly persisted during the following week, and then rapidly declined.

The findings highlighted that the use of wagering inducements appeared to increase gambling activity across the five gambling indicators, for sports betting, horse-race betting, and poker. For lotteries, the use of wagering inducements did not seem to influence gambling intensity indicators.

The changes in gambling activity due to inducements were particularly substantial for at-risk gambling behavior indicators, with odd ratios (ORs) ranging from 3.3 to 4.8. In contrast, the changes were weak for indicators of frequency and intensity of gambling. Specifically, the effects were less than €1 for money wagered and deposits, and less than 0.3 for gambling days.

Furthermore, the study revealed that at-risk gamblers were more responsive to wagering incentives, as their gambling activity increased significantly more when using a bonus compared to other gamblers. This pattern held true across all gambling indicators and types of games.

2.4.2 Conclusion

To conclude, the present study evidenced a potential link between the use of wagering inducements and an immediate increase in gambling activity, especially for gamblers with at-risk gambling behaviors. Additionally, the impact of these inducements on gambling activity appeared strongest during the week of use and diminished in subsequent weeks. This suggests that inducements may pose a potential risk factor for developing or worsening gambling problems. From this perspective, inducements should be more strictly regulated and limited, especially for at-risk gamblers. Interventions should also be proposed for all gamblers to raise awareness about the impact of bonuses on gambling behaviors.

From a personal perspective, this internship marked my first experience in the field of gambling research. This initial research work allowed me to analyze gambling tracing data for the first time. I discovered that a gambler's gambling activity cannot be measured by a single variable but requires multiple indicators that account for various factors such as intensity, frequency, etc. Moreover, these different gambling indicators are variables of different natures and distributions. Significant effort was required to find suitable modelling approaches, which often varied between the indicators. Additionally, dealing with repeated measures added complexity to the models and made the convergence process time-consuming.

Furthermore, this internship made me realize how external factors unrelated to gambling itself can deeply affect how people engage with it. Beyond the marketing strategies developed by gambling operators, such as wagering inducements and advertising, other factors like economic conditions, social influences, technological advancements, and regulatory environments play critical roles in changing gambling behaviors. For instance, economic crises or financial instability can drive individuals towards gambling as a perceived quick-fix solution to financial problems. Social influences, including peer pressure and cultural attitudes towards gambling, can also encourage or dissuade gambling activities. Technological advancements have made gambling more accessible than ever before, with online platforms and mobile applications providing easy and constant access to gambling opportunities. Changes in regulations, such as the introduction of new laws or restrictions, can either limit or expand the availability and attractiveness of gambling options. Additionally, personal factors like emotional states and mental health conditions, including stress, anxiety, and depression, can significantly influence the propensity to engage in gambling as a form of escapism or stress relief.

Thus, conducting my Master's internship during the initial period of the COVID-19 pandemic led me to question the broader impacts of such crises on gambling behaviors and addictive tendencies. The pandemic-related factors, such as increased isolation due to stay-at-home measures, heightened financial pressures, shifts in gambling offerings, and in daily routines, may significantly contribute to unusual variations in gambling behaviors. This period also highlighted emerging public health concerns related to addictive behaviors, emphasizing the necessity for comprehensive strategies to address these issues within the context of global crises.

Chapter 3

THE CONGA STUDY

Table of contents

3.1	Aim and objectives	82
3.2	Data collection	83
3.2.1	Study population and inclusion criteria	83
3.2.2	Extraction and circulation of data	83
3.2.3	Description of data	83
3.3	COVID-19-affected periods	86
3.4	Gambling-related events	89
3.4.1	Sports competitions	90
3.4.2	Horse races	94
3.4.3	Jackpots in draw-based games	96

Chapter 2 highlighted that gambling activities can be influenced by external events that seemingly have no direct connection to gambling behavior itself. The COVID-19 pandemic is a striking and unexpected example. While this global health crisis initially appeared unrelated to gambling behavior, it had significant and unexpected effects.

This chapter presents the Covid-19 and ONline GAMbling (CONGA) study, which forms the basis of this thesis. It outlines the study's purpose, objectives, data collection procedures, and methods in various subsections.

3.1 Aim and objectives

The CONGA study is an international, retrospective and observational study conducted at two centres. It analyses existing datasets to measure the impact of the COVID-19 pandemic on online gambling activity in France and Sweden. The study focused on two periods: 2019, considered as the reference period, and 2020, the year affected by the pandemic. By examining these two periods separately, the study aimed to compare the "normal" gambling activity in 2019 with the activity during the health crisis in 2020.

The CONGA study had two main objectives.

The first objective was to estimate the changes in the number of gamblers due to the pandemic at a comprehensive-level, i.e. on all French and Swedish online gamblers, across 2019 and 2020.

The second objective was to measure longitudinally the impact of the COVID-19 pandemic on gambling activity among a representative sample of French and Swedish online gamblers across 2019 and 2020. The goal was to identify trajectories of gambling behavior, highlighting subgroups of gamblers with distinct responses to the pandemic. This objective focused on two different populations of gamblers: first, active gamblers, who participated in at least one gambling activity in 2019 and 2020; second, new gamblers who registered during the first epidemic peak in Europe in 2020 (March – May 2020) and those who registered during the same period in 2019 (March – May 2019).

3.2 Data collection

3.2.1 Study population and inclusion criteria

The study population included gamblers registered on French authorized gambling platforms (FDJ and ANJ) and on the *Svenska Spel Sports & Casino* subsection website. All types of gambling were considered. In France, this included sports betting, horse betting, poker and lotteries (draw-based games, scratch games and multiplayer games). In Sweden, it covered sports betting, bingo, poker and casinos. No exclusion criteria were applied.

3.2.2 Extraction and circulation of data

The CONGA study is based on pre-existing data extracted routinely from various sources:

- **French data:** Data based on sports betting, horse racing betting, and poker were provided by ANJ. Regarding lotteries, data were extracted separately by FDJ.
- **Swedish data:** Data were extracted by *Svenska Spel*.

Regarding data transfer, in France, formal agreements were set up between the French data providers (FDJ and ANJ) and the data recipient (CHU de Nantes) to ensure the secure handling of data. Similarly, in Sweden, a data transfer agreement was established between *Svenska Spel* and Lund University, with Prof. Anders Håkansson representing the university.

3.2.3 Description of data

Multiple database exports were required from ANJ, FDJ and *Svenska Spel* to address the different objectives of the CONGA study.

To respond to the first objective, FDJ and ANJ provided databases containing weekly number of active and new French gamblers for each weeks in 2019 and 2020. However, *Svenska Spel* could not provide similar data for Swedish gamblers. To overcome this issue, we used another database from *Svenska Spel* that included weekly aggregated data of all gamblers who engaged in any form of gambling at least once from February 10, 2020, to July 19, 2020. Although this database was not part of the CONGA study, it allowed to partially address the first objective for the Swedish part of the CONGA study.

For the second objective, FDJ, ANJ, and *Svenska Spel* each provided panels of gamblers randomly selected from all active accounts between 2019 and 2020. Both ANJ and FDJ constituted panels of 40,000 gamblers who had gambled at least once in 2019 and 2020. *Svenska Spel* constituted a panel of 60,000 gamblers who had gambled at least once in 2019 or 2020. To study the early gambling behaviors of newly registered gamblers, two additional panels of

10,000 newly registered gambler accounts were established, one from ANJ and one from FDJ. These panels were randomly selected from accounts created during March-May 2019 (10,000 accounts) and March-May 2020 (10,000 accounts), with data collected for the six months following account registration. *Svenska Spel* did not provide similar data for Swedish gamblers. However, using the panel of 60,000 active gamblers, we were able to identify newly registered gamblers from 2019 and 2020 based on their account validation dates.

Finally, FDJ provided a separate database containing the history of jackpots for the draw-based games *Loto*® and *EuroMillions* in 2019 and 2020.

Data from each database and panel of gamblers were aggregated weekly to capture fine variations during the health crisis.

The databases provided by FDJ and ANJ to address the first objective contained the following variables: i) the number of gamblers, ii) the average age, and iii) its standard deviation. These variables were aggregated based on:

- **The number of weeks:** covers 105 weeks from 2019 to 2020.
- **Type of gambler:** Classified as active or new gambler.
- **Type of gambling:** Includes sports betting, horse race betting, poker (for ANJ), and draw-based games, scratch games, multiplayer games (for FDJ).
- **Gender category:** Male/Female.
- **French department:** 96 metropolitan departments and 5 overseas departments in France.
- ***Playscan™ status:** Maximum level reached per week, ranging from 0 to 6.

The panels of gamblers provided to address the second objective included the following variables, aggregated weekly:

- **General information on gamblers:** Gender, age, *home department, account seniority by age group.
- ***Responsible gambling data (FDJ only):**
 - Self-limitations (money wagered, deposits, withdrawals): Values reached at the end of the week, and the rate of reaching set limits per week (%).
 - Voluntary self-exclusion: Number of days with active self-exclusion per week.
 - *Playscan™ status: Maximum level reached per week, ranging from 0 to 6.
- **Gambling tracking data:**
 - *Number of active gambling days per week, ranging from 0 to 7.

- *Total number and amount of bets placed per week, and maximum amount of money wagered in one day, per week.
- **Total winnings per week.
- *Total losses per week (difference between money wagered and winnings).
- Total number and amounts of deposits per week, and maximum amount deposited in one day, per week.
- *Total number and amounts of withdrawals per week.
- **Total number and amounts of wagering inducements send to the gambler per week, for each type of bonus (sign-up bonus, refer-a-friend bonus, in-play bonus, deposit-related bonus, technology-related bonus, happy hours, reward programs).
- **Total number and amounts of wagering inducements used by the gambler per week, for each type of bonus.
- *Participation in specific sub-type of gambling per week (yes/no). Sub-type of gambling are as follows: i) lotteries: *EuroMillions, Loto®*, *Keno*, *Joker+*, *Bingo Live*, *Multi-joueurs*, *Illiko Grattage*, *Illiko Super Jackpot*, *Illiko Express* and *Illiko Action*, ii) sports betting: simple, live and simple, complex, live and complex, iii) horse race betting: simple and complex and iv) poker: classic, quickly (*Spin&go*, *Expresso*, etc.) and cash-game.
- *Number of chasing per week, approached through two proxies (1st proxy: three consecutive deposits over a 12-hour rolling period, and 2nd proxy: deposit made in the hour following a bet).

Note:

**Playscan*TM: The status indicates different levels of the probability of developing a gambling problem using a tricolour system: green light (value 1) = low risk, orange light (values 2, 3 and 4) = moderate risk, and red light (value 5 and 6) = high risk.

**Distinction by gambling types (overall and specific gambling types such as sports betting, horse race betting, poker for ANJ, and draw-based games, scratch games, multiplayer games for FDJ).*

**Data unavailable for the panels of Swedish gamblers.*

Finally, the database on history of jackpots provided by the FDJ were aggregately daily and included the following details:

- **Date of the draw:** Monday, Wednesday and Saturday for *Loto®* and, Tuesday and Friday for *EuroMillions*.
- **Amount of jackpots (€)**
- **Sub-type related to the draw:** *Loto®* or *EuroMillions*

3.3 COVID-19-affected periods

When we were drafting the CONGA study protocol in April 2020, the global situation with the pandemic was extremely severe, with infection and hospitalization rates reaching unprecedented highs worldwide. In France, the population was confronted with the first implementation of a nationwide lockdown, while Sweden was navigating its initial steps in imposing social distancing measures mandated by the government. At that time, both in Europe and globally, the majority of countries were struggling to contain the rapid spread of the virus. This period was marked by significant uncertainty, making it difficult for anyone to predict how events would unfold in the future. Initially, our research strategy was narrowly focused on studying the period of the first epidemic peak in Europe, specifically from March to May 2020. This approach aimed to capture the impact of the most intense phase of the pandemic on gambling behaviors.

However, as time progressed and nearly a year passed between the drafting of the protocol and the beginning of my thesis work, the pandemic continued to evolve. The emergence of subsequent waves and ongoing challenges necessitated a reassessment of our initial approach. Consequently, we opted to broaden our research strategy to encompass multiple phases of the pandemic, which we termed as "COVID-19-affected periods". By adopting this approach, we aimed to provide a deeper analysis of how gamblers have responded to the various stages of the health crisis.

To ensure a comparison between France and Sweden in our analyses, we divided the study period based on how each country responded to the virus spread in 2020. In France, where stringent governmental measures were implemented to control the pandemic, we aligned the COVID-19-affected periods in consequence to capture the impact of the phases of heightened restrictions on gambling behaviors. Conversely, Sweden opted for more relaxed governmental measures during the same period. Therefore, for the Swedish analyses, we categorized the COVID-19-affected periods based on the impact of the pandemic on the gambling opportunities rather than on governmental measures.

Furthermore, to ensure comparisons over time, we applied identical divisions from 2020 to the reference year, 2019. This enabled us to examine and contrast gambling activities between the corresponding periods in 2019 and 2020, providing insights into how the pandemic may have affected gambling behaviors relative to a pre-pandemic baseline.

Thus, we established one reference period and four COVID-19-affected periods for French analyses, and one reference period and three COVID-19 affected periods for Swedish analyses. These periods are presented in Table 8.

Table 8: Division of the COVID-19-affected periods according to each country.

France			Sweden	
Period	Date	Government restrictions due to the pandemic	Date	Gambling offerings during the pandemic
pre-C	From: 30/12/2019 To: 15/03/2020	No government restrictions implemented.	From: 30/12/2019 To: 15/03/2020	Without significant impact on gambling opportunities.
P1	From: 16/03/2020 To: 10/05/2020	Strict lockdown at home was imposed from 16/03/2020 to 11/05/2020.	From: 16/03/2020 To: 10/05/2020	<ul style="list-style-type: none"> • All sports competitions were cancelled. • On 01/04/2020, the state-owned land casinos closed.
P2	From: 11/05/2020 To: 21/06/2020	Gradual easing of the lockdown, with phases tailored to the virus spread across different French areas.	From: 11/05/2020 To: 18/10/2020	<ul style="list-style-type: none"> • Between May and June, sports events gradually began to return. • In July, all sports events reopened. • Land-based casinos remained closed.
P3	From: 22/06/2020 To: 04/10/2020	Ending of the lockdown and other restrictions.	From: 19/10/2020 To: 28/12/2020	Without significant impact on gambling opportunities.
P4	From: 05/10/2020 To: 28/12/2020	A less stringent lockdown with implementation of a curfew and closures of facilities.		

Additionally, a schematic representation of the COVID-19-affected periods is shown in Figure 11 for the French analyses and in Figure 10 for the Swedish analyses.

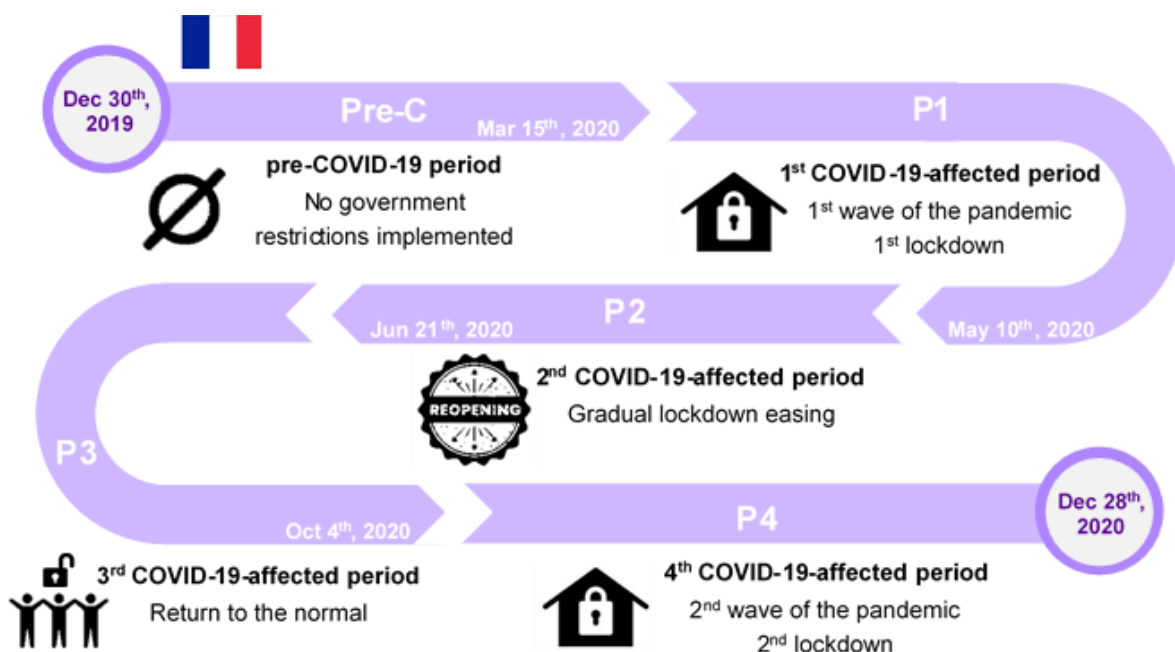


Figure 10: Schematic representation of the COVID-19-affected periods for French analyses.

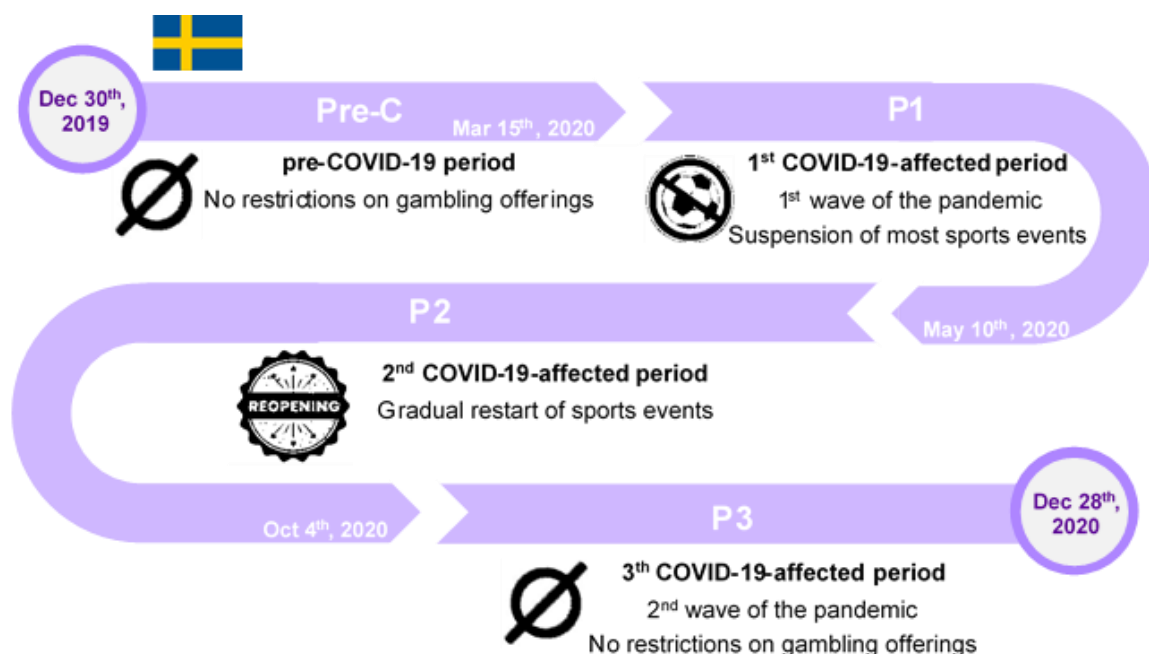


Figure 11: Schematic representation of the COVID-19-affected periods for Swedish analyses.

3.4 Gambling-related events

Beyond the profound changes in daily life, the pandemic led to substantial changes in the availability and scheduling of various gambling opportunities. Many major sports events, which typically drive gambling activity of sports bettors, were cancelled or postponed. As a result, these changes likely caused shifts in gambling habits, with many bettors adapting to the new gambling offering by exploring alternative betting options or temporarily reducing their gambling activity. Given these circumstances, it was essential to incorporate these changes into analyses, particularly when comparing gambling data from 2020 to a baseline year like 2019, which did not experience such interruptions. Consequently, a key aspect of the CONGA study focuses on examining the natural fluctuations in gambling behaviors influenced by these gambling-related events. By analyzing how the pandemic impacted the online gambling activity, in including gambling-related events, the study aims to provide an insight into the evolving landscape of gambling and the factors that drive gambler behavior in times of uncertainty.

Thus, we decided to identify variables that could represent proxies of the chronology of gambling-related events for the main types of gambling for which the pandemic may have influenced such chronology. Such variables were intended to be able to control for the changing temporal availability of gambling-related events between 2019 and 2020, so as not to wrongly attribute changes in gambling practices to gambling event calendars disrupted by the pandemic, rather than to the pandemic itself.

For the French data, we identified three types of gambling for which the calendars of gambling events were affected by the pandemic, i) for sports betting and horse-race betting: almost all competitions were suspended during the pandemic initial phase, and for some of them, postponed after the acute phase; ii) for draw-based games: while the overall availability of gambling options remained stable between 2019 and 2020, there were notable fluctuations in the weekly jackpot amounts (the evolution of jackpots always fluctuates over time, but was particularly so during the pandemic). These variations became particularly pronounced during both waves of the pandemic, as the unpredictability surrounding public events influenced the size of the jackpots. Higher jackpots typically attract more participants, creating a dynamic environment in which even slight changes can have a substantial impact on gambler engagement.

For the Swedish data, we identified only one type of gambling for which the calendar of gambling events was affected by the pandemic, i.e. sports betting.

The variables that were used as proxies of the chronology of gambling-related events were the following:

- **Sports betting: number of sports events.** This variable counts the total of major sports competitions available for betting each week.
- **Horse-race betting: number of horse races.** This variable counts the total of major horse races available for betting each week.
- **Draw-based games: amount of maximum jackpot.** This variable captures the highest amount of jackpot offered each week by the FDJ for *EuroMillions* and *Loto®* draws.

At the opposite, the availability of the other types of online gambling (poker, scratch games, multiplayer games, casinos, and bingo) remained stable during the pandemic. Therefore, we hypothesized that the gambling offering for these types of gambling remained same between 2019 and 2020 despite the pandemic, and we did not use any proxy of the chronology of gambling-related events.

3.4.1 Sports competitions

During the initial wave of the pandemic, sports competitions experienced extensive and prolonged suspensions. Many of these suspended events were major competitions that typically generate significant betting activity under normal circumstances.

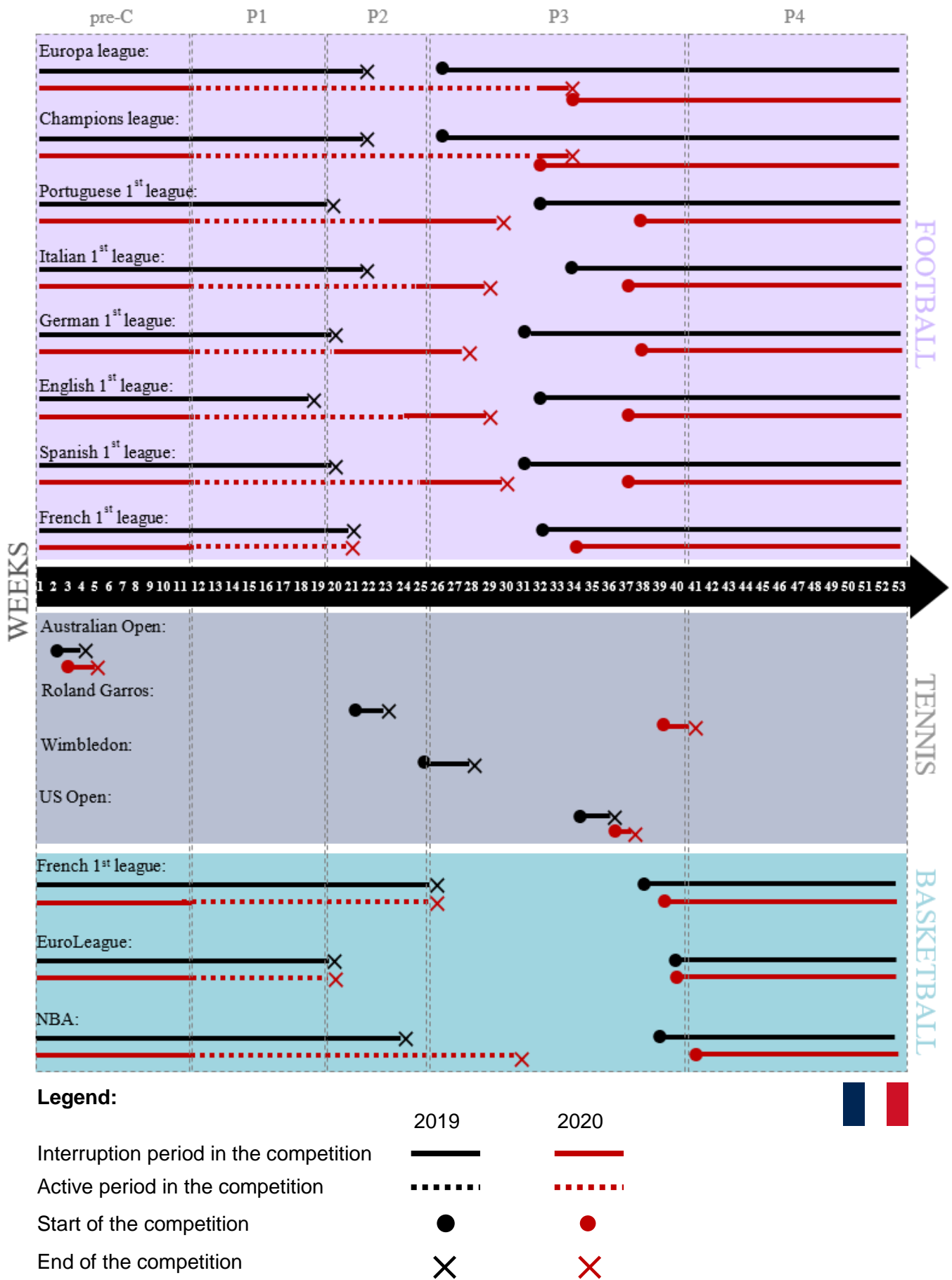
For instance, the Roland Garros tennis tournament, a major Grand Slam event known for substantial betting in France and across Europe, usually occurs in late May and early June. However, in 2020, due to the pandemic, it was rescheduled to late September and early October. This change likely altered the betting patterns of individuals who regularly wager on this event, as they had to adjust to a different timeframe. The ANJ report on the fourth quarter of 2020 announced that bets on Roland Garros generated 107 million euros in wagers, setting a new record for betting on a Grand Slam tournament (ANJ, 2021). Similarly, the NBA season, typically extending from late September to late May, was interrupted from March to late July. When matches resumed from early August to October, it marked an unconventional period compared to previous seasons. In Sweden, where hockey is a major sport and attracts substantial betting, the Champions Hockey League did not resume in 2020. Normally, this league starts in

late August and runs until February of the following year. The absence of this league for an entire season removed a significant betting opportunity for Swedish gamblers.

To summarize, the availability of sports betting during the initial phase of the pandemic was very limited, primarily restricted to Belarusian football competitions and the Korean baseball championship.

To create variables that counts the number of sports events each week in 2019 and 2020, we began by identifying the sports competitions that generate the most bets in each country. In France, the ANJ report indicated that three disciplines account for 90% of the sports betting market: football, tennis, and basketball. In Sweden, although we did not find a detailed report from *Svenska Spel* identifying the most popular sports for betting, we observed that their sports betting offerings primarily included football and ice hockey. Thus, for each type of sport, we identified the most prominent competitions and documented their schedules for 2019 and 2020.

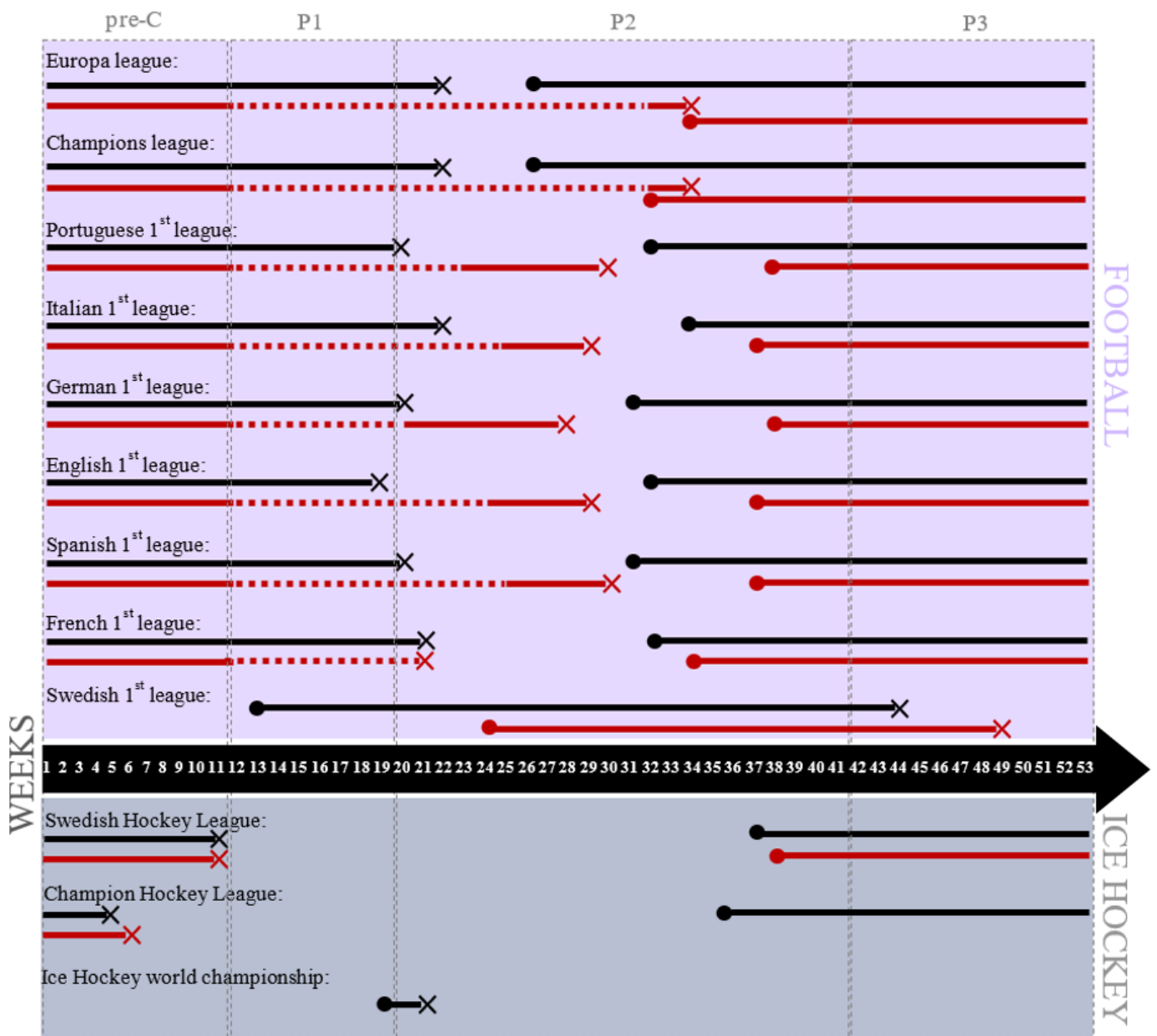
Figure 12 and Figure 13 show a timeline of the major gambling events considered in the analyses conducted for the CONGA study, for France and Sweden respectively.



Legend:

- 2019 2020
- Interruption period in the competition
- Active period in the competition
- Start of the competition
- End of the competition X X

Figure 12: Timeline of sports competitions that generated the most bets in France in 2019 and 2020.



Legend:



	2019	2020
Interruption period in the competition	—	—
Active period in the competition	⋯	⋯
Start of the competition	●	●
End of the competition	×	×

Figure 13: Timeline of sports competitions that generated the most bets in Sweden in 2019 and 2020.

3.4.2 Horse races

Horse racing was also impacted during the initial phase of the pandemic. In France, all horse races were cancelled from March 15 until early May, and then rescheduled. Although some foreign races continued, the ANJ report on the second trimester of 2020 indicated that many gamblers restricted or even halted their activity during this period of suspended French races (ANJ, 2020).

To create the variable counting the number of horse races per week, we identified the Group 1 races, which represent the highest level of competition and are the most prestigious. They attract the best horses, jockeys, and trainers from around the world and offer the highest prize money for the winners. Additionally, horses participating in these races must meet strict qualification criteria, including exceptional performances in previous races. These races are also the most publicized, generating the most betting activity in horse races. We recorded all Group 1 races for each discipline:

- **Flat Racing:** This discipline involves horses running on a flat track without obstacles, emphasizing speed. The gait of the horses is the gallop.
- **Steeplechase:** In this discipline, horses must jump over various obstacles such as hurdles, fences, and ditches. The gait of the horses is the gallop.
- **Harness Racing, and Mounted Trotting:** Both disciplines require horses to trot without galloping to avoid disqualification. In harness racing, horses pull a sulky, a lightweight two-wheeled cart with a driver seated in it. In mounted trotting, horses trot with a jockey riding on their back.

Table 9 presents the schedule of Group 1 races for 2019 and 2020.

Table 9: Reporting and timeline of Group 1 Races in 2019 and 2020.

Horse races - Group 1 Races	2019	2020
Flat Racing		
Prix du Jockey Club (French Derby)	02/06/2019	05/07/2020
Prix de Diane LONGINES (French Oaks)	16/06/2019	05/07/2020
Prix de l'Abbaye de Longchamp	06/10/2019	04/10/2020
Prix Jacques le Marois	11/08/2019	16/08/2020
Prix Maurice de Gheest	04/08/2019	09/08/2020
Poule d'Essai des Poulains (French 2000 Guineas)	12/05/2019	01/06/2020
Poule d'Essai des Pouliches (French 1000 Guineas)	12/05/2019	01/06/2020
Prix Ganay	28/04/2019	14/06/2020

Prix Saint-Alary	26/05/2019	14/06/2020
Prix Jean Prat	07/07/2019	12/07/2020
Grand Prix de Paris	14/07/2019	13/09/2020
Prix Jean-Luc Lagardère	06/10/2019	04/10/2020
Prix de la Forêt	06/10/2019	04/10/2020
Prix de l'Opéra	06/10/2019	04/10/2020
Prix Vermeille	15/09/2019	13/09/2020
Prix Morny	18/08/2019	23/08/2020
Critérium International	27/10/2019	24/10/2020
Prix de l'Arc de Triomphe du Cheval Anglo-Arabe	06/10/2019	04/10/2020
Prix Royal-Oak (French St. Leger)	27/10/2019	25/10/2020
Prix Rothschild	28/07/2019	02/08/2020
Prix Jean Romanet	18/08/2019	23/08/2020
Critérium de Saint-Cloud	26/10/2019	24/10/2020
Prix d'Ispahan	26/05/2019	19/07/2020
Grand Prix de Saint-Cloud	30/06/2019	28/06/2020
Prix du Cadran	05/10/2019	03/10/2020

Steeplechase

Grande Course de Haies d'Auteuil	18/05/2019	17/10/2020
Prix Cambacérès	03/11/2019	08/11/2020
Prix La Haye Jousselin	03/11/2019	29/11/2020
Prix Ferdinand Dufaure	19/05/2019	13/06/2020
Prix Maurice Gillois	03/11/2019	08/11/2020
Prix Renaud du Vivier	10/11/2019	15/11/2020
Prix Alain du Breil	19/05/2019	13/06/2020
Grand Steeple-Chase de Paris	19/05/2019	18/10/2020
Grand Prix d'automne	02/11/2019	09/11/2020

Harnessed trot and mounted trot

Prix d'Amérique	27/01/2019	26/01/2020
Prix de Cornulier	20/01/2019	19/01/2020
Prix de France	10/02/2019	09/02/2020
Prix de Sélection	02/03/2019	29/02/2020
Prix des Centaures	10/02/2019	09/02/2020
Prix René Ballière	23/06/2019	21/06/2020
Prix de l'Atlantique	20/04/2019	02/07/2020
Prix d'Essai	23/06/2019	21/06/2020
Prix du Président de la République	23/06/2019	21/06/2020
Prix Albert Viel	23/06/2019	21/06/2020

Prix de Vincennes	22/12/2019	27/12/2020
Critérium Continental	22/12/2019	27/12/2020
Critérium des 3 ans	15/12/2019	20/12/2020
Critérium des 4 ans	05/05/2019	29/08/2020
Critérium des 5 ans	31/08/2019	29/08/2020
Prix de l'Ile-de-France	03/02/2019	02/02/2020
Prix des Elites	29/09/2019	27/09/2020
Prix de Normandie	14/09/2019	12/09/2020
Prix Ourasi - Sulky World Cup 4 ans	30/01/2019	29/01/2020
Grand Critérium de vitesse de la Côte d'Azur	10/03/2019	08/03/2020
Prix ready Cash	14/09/2019	12/09/2020
Prix Ténor de Baune	22/12/2019	27/12/2020
Critérium des Jeunes	17/02/2019	18/02/2020
Prix de Paris Marathon Race	24/02/2019	23/02/2020
Saint-Léger des Trotteurs	15/05/2019	13/05/2020

Races highlighted in purple are those that did not occur during the same period (+/- 2 weeks) in 2020 compared to 2019.

3.4.3 Jackpots in draw-based games

As mentioned above, the gambling offerings for draw-based games were not directly impacted by the pandemic, as no pandemic-related factors prevented gamblers from purchasing tickets for draws. Unlike sports betting or horse race betting, which saw significant disruptions due to the cancellation of events, draw-based games like *EuroMillions* and *Loto*® continued to operate as usual.

However, it's important to note that other factors, such as jackpots, play a crucial role in influencing gamblers participation in these games. The size of the jackpot can greatly affect the number of tickets sold, as larger jackpots tend to attract more gamblers hoping for a substantial win. These jackpots are managed directly by the gambling operator, FDJ, which adjusts the jackpot amounts based on various factors, including the number of tickets sold and the accumulation of unclaimed prizes from previous draws.

Thus, we requested FDJ to provide details on the jackpots offered during draws in 2019 and 2020. This information was needed to: i) compare if the peak jackpot amounts differed during the periods affected by the pandemic in 2020, and ii) determine if there were significant fluctuations in jackpot amounts between 2019 and 2020. The details of these data, including how it was compiled and the specific variables it contains, are explained at the end of the subsection “3.2.3 Description of Data” in the present chapter.

Using the database provided by FDJ, we computed a variable representing the amount of jackpots, corresponding to the maximum amount of jackpot offered each week for *Loto*® and *EuroMillions* draws.

Figure 14 illustrates the changes in jackpot amounts over the weeks in 2019 and 2020. The first point we can observe is that there are several significant peaks in jackpot amounts, varying in height. These peaks did not occur at the same times in 2019 and 2020. For example, a significant peak of more than 200 million euros was observed at the end of the P3 period in 2019, a level not reached the same period of 2020. Conversely, during the P4 period in 2020, there was a notable peak, which was not as high in the same period of 2019. The second observation is that the peak in jackpot amounts in 2020 were much lower during the P1 and P2 periods and significantly higher during the P3 and P4 periods, reaching nearly twice the amounts.

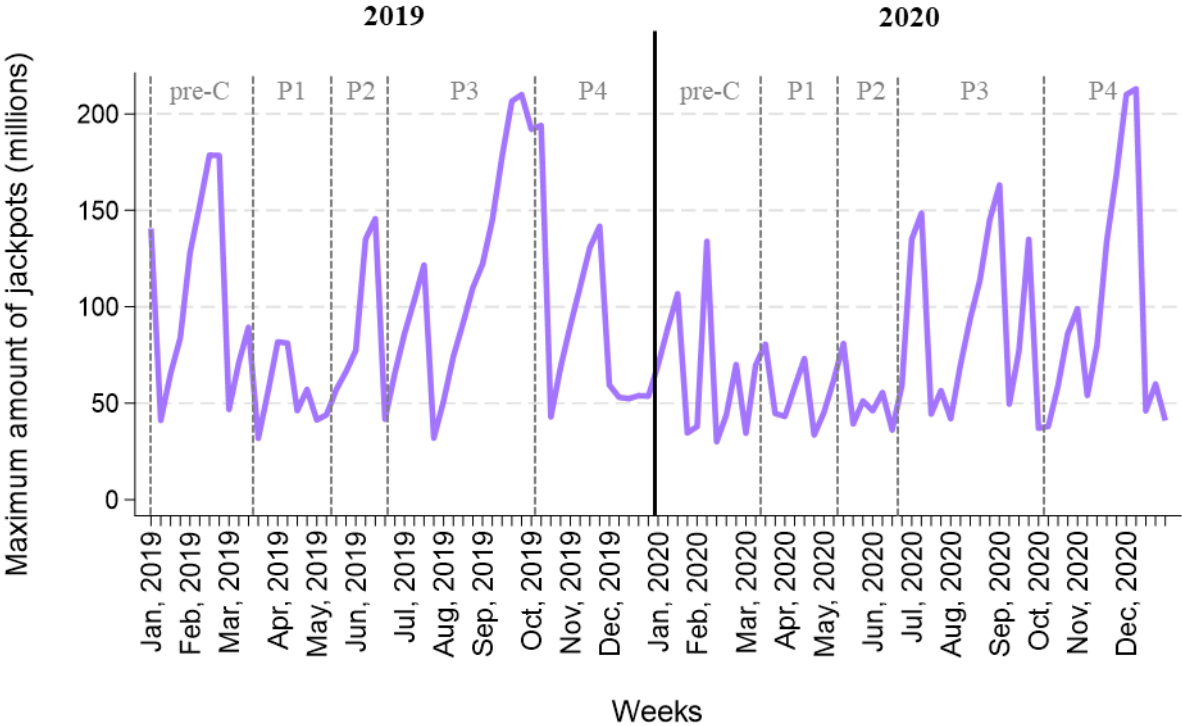


Figure 14: Variations in the maximum amount of jackpot offered by FDJ for draw-based games in 2019 and 2020.

Chapter 4

IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS: A COMPREHENSIVE-LEVEL APPROACH

Table of contents

4.1	Statistical methods	99
4.1.1	Generalized linear models	99
4.1.2	Models for longitudinal data	104
4.2	Manuscript 2: Impact of the COVID-19 pandemic on online gambling behaviors: A descriptive analysis of all legal French websites	107
4.2.1	Abstract	107
4.2.2	Introduction	108
4.2.3	Methods	110
4.2.4	Results	113
4.2.5	Discussion	121
4.2.6	Conclusion	124
4.3	Manuscript 3: Gambling and COVID-19: Swedish national gambling data from state-owned gambling sports and casino operator	130
4.3.1	Abstract	130
4.3.2	Introduction	131
4.3.3	Methods	133
4.3.4	Results	135
4.3.5	Discussion	147
4.3.6	Conclusion	149
4.4	Overview and conclusion of the chapter 4	155
4.4.1	Main results of the French study	155
4.4.2	Main results of the Swedish study	156
4.4.3	Conclusion	157

This chapter addresses the first objective of the CONGA study: to provide a comprehensive evaluation of the changes in gambling patterns among French and Swedish gamblers due to the COVID-19 pandemic.

The first subsection justifies and explains the statistical methods used in the two studies presented in the following subsections.

The second subsection focuses on a research study based in the French context, aiming to estimate the variations in the average weekly number of active and new gamblers during the year impacted by the COVID-19 pandemic (2020), compared to a reference year (2019).

The third subsection presents a Swedish study aiming to estimate the changes in the weekly gambling activity of all gamblers from the state-operated *Svenska Spel Sports & Casino* during the period from February 10 to July 19, 2020.

The fourth subsection synthesizes and discusses the results obtained in this chapter.

4.1 Statistical methods

In the context of this thesis and, primary in both studies presented in this chapter, regression analyses were used to estimate the changes in gambling activity and behaviors among French and Swedish gamblers across COVID-19-affected periods.

4.1.1 Generalized linear models

Principle of the method

In the 1970s, statisticians John Nelder and Robert Wedderburn introduced Generalized Linear Models (GLMs) as an extension of traditional LMs (Nelder & Wedderburn, 1972). Unlike the linear model, which assumes a Gaussian distribution of the dependent variable and a linearity of the relationship between independent and dependent variables, GLMs use a link function to transform the mean of the dependent variable's distribution to be linearly related to the predictors. This approach accommodates situations where the relationship between explanatory variables and the response is nonlinear or where the response variable follows a distribution other than normal.

Thus, GLMs were specifically designed to overcome the limitations of classical linear model by providing a flexible and robust framework. They can model a wide range of data types by using different distributions for the dependent variable and appropriate link functions (Jiang & Nguyen, 2021).

Distributions from the exponential family

In contrast to linear models, GLMs allow for the modeling of response variables that follow distributions beyond the Gaussian distribution. This flexibility includes distributions such as Poisson, Binomial, Gamma, and others from the exponential family.

The exponential family comprises a set of probability distributions that share common mathematical properties. A distribution of a dependent variable Y is considered to belong to the exponential family if its probability density function can be expressed in the following form:

$$f(y; \theta, \phi) = \exp \left[\frac{y\theta - b(\theta)}{a(\phi)} + c(y; \phi) \right]$$

Where:

- $f(y; \theta, \phi)$ may represent the likelihood density for a continuous quantitative variable or the likelihood $P(Y = y; \theta, \phi)$ for a discrete variable.
- y represents a specific value that the dependent variable Y can take.
- θ is the natural or canonical parameter, often directly linked to the mean of the distribution or other important characteristics. This parameter is typically chosen to simplify the mathematical expression.
- ϕ is the dispersion parameter. Some distributions within the exponential family include a dispersion parameter, which can be used to control variance or other aspects of the distribution.
- $a(\phi)$, $b(\theta)$ and $c(y; \phi)$ are specific functions that depend on the distribution of the dependent variable Y .

Link function

As mentioned above, the GLM extends the traditional linear model by relating the mean of the dependent variable to a linear combination of independent variables through a specified link function. The link function in a GLM is essential because it provides flexibility in modeling, allowing the model to adapt to the specific characteristics of the observed data while maintaining the model's desirable statistical properties.

It is essential to select a link function that aligns with the constraints of the dependent variable's distribution and accurately captures the relationship between the predictors and the mean of the dependent variable. Indeed, the choice of the link function can significantly affect the interpretability of the GLM results. For example, using a logarithmic link function involves a logarithmic transformation, thereby making the effects of independent variables on a logarithmic scale.

Additionally, the structure of residuals in a GLM differs from that in a linear model due to the specific distributions of the dependent variables and the use of link functions. In a linear model, residuals are assumed to follow a normal distribution with constant variance (homoscedasticity). In contrast, in a GLM, the distribution of the response variable can differ from normal, such as a Poisson distribution for count data or a binomial distribution for binary data. Moreover, in using a link function, GLMs introducing a potential nonlinearities relationship between predictors and the dependent variable. This transformation often results in not normally distributed residuals and may lead to heteroscedasticity, where the variance of residuals varies with the mean of the dependent variable (Hastie & Pregibon, 1992; Jiang & Nguyen, 2021; Nelder & Wedderburn, 1972).

is reproduced from *Thiele & Markussen, 2012* and lists some distributions from the exponential family used in GLMs, along with their corresponding link functions and the nature of the appropriate dependent variable (Thiele & Markussen, 2012).

Table 10: Some distributions used in GLM, link functions and corresponding types of dependent variables.

Distribution	Link function	Type of dependent variable
Gaussian or Normal	<ul style="list-style-type: none"> Identity: $g(\mu) = \eta_i = \mu$ Log: $g(\mu) = \eta_i = \log(\mu)$ 	Continuous data
Gamma	<ul style="list-style-type: none"> Log: $g(\mu) = \eta_i = \log(\mu)$ Inverse: $g(\mu) = \eta_i = \frac{1}{\mu}$ Power: $g(\mu) = \eta_i = \mu^p$ 	Continuous data that are positive and asymmetric
Beta	<ul style="list-style-type: none"> Logit: $g(\mu) = \eta_i = \log\left(\frac{\mu}{1-\mu}\right)$ Probit: $g(\mu) = \eta_i = \Phi^{-1}(\mu)$ Complementary log-log: $g(\mu) = \eta_i = \log\{-\log(1 - \mu)\}$ 	Continuous data that are bounded between 0 and 1
Exponential	<ul style="list-style-type: none"> Identity: $g(\mu) = \eta_i = \mu$ Log: $g(\mu) = \eta_i = \log(\mu)$ 	Continuous data
Poisson	<ul style="list-style-type: none"> Identity: $g(\mu) = \eta_i = \mu$ Log: $g(\mu) = \eta_i = \log(\mu)$ 	Count data
Negative Binomial	<ul style="list-style-type: none"> Identity: $g(\mu) = \eta_i = \mu$ Log: $g(\mu) = \eta_i = \log(\mu)$ 	Count data with over dispersion
Binomial	<ul style="list-style-type: none"> Logit: $g(\mu) = \eta_i = \log\left(\frac{\mu}{1-\mu}\right)$ Probit: $g(\mu) = \eta_i = \Phi^{-1}(\mu)$ 	Binary data (1/0)

- Complementary log-log: $g(\mu) = \eta_i = \log\{-\log(1 - \mu)\}$

Polytomous	<ul style="list-style-type: none"> • Cumulative logit: $g(\mu) = \eta_i = \log\left(\frac{\mu_i}{1 - \sum_{j=1}^{m-1} \mu_j}\right)$ • Ordered probit: $g(\mu) = \eta_i = \Phi^{-1}(\mu_i)$ 	Ordinal scale
------------	---	---------------

μ is the mean of the dependant variable. Φ^{-1} is the inverse function of the cumulative distribution function of the standard normal distribution. $\mu_{i,j}$ is the likelihood that the dependent variable is in the category i or j .

Specification of the model

The mathematical expression of the GLM is very similar to that of a linear model. The only difference resides in the link function. Here is the formulation for a GLM:

$$g(\mu_i) = \eta_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_p X_{ip}$$

$$g(\mu_i) = \eta_i = X_i^\top \beta$$

Where:

- Y_i is the observation of the dependant variable Y for a subject i (where $i = 1, 2, 3, \dots, n$).
- μ_i is the mean of the dependent variable pour the observation i .
- $g(\cdot)$ is the link function that transforms the mean response μ_i into the linear predictor η_i .
- The vector $\beta = (\beta_0, \beta_1, \dots, \beta_p)^\top$ of dimension $(p + 1)$ is the vector of parameters of the regression model (fixed effects). β_0 corresponds to the mathematical expected value (mean) of Y_i when $X_i = 0$.
- $X_i = (X_{i1}, X_{i2}, \dots, X_{ip})^\top$ is the vector of independent variables for a subject i .

Furthermore, the error ϵ_i are not directly mentioned in the equation in a GLM. Instead, they are implicit in the specification of the distribution of the dependent variable.

Parameter's estimation of the model

While GLMs share similarities with linear models in terms of model specification, the method for estimating parameters differs due to the specific distributions of the dependent variables and the use of link functions. Least squares estimation, typically employed in linear models, assumes that residuals follow a normal distribution with constant variance (homoscedasticity). However, this assumption may not hold in GLMs, where the response variable often follows non-normal distributions and where the variance of the response variable may vary with its mean (heteroscedasticity). Moreover, GLMs utilize a link function to model non-linear relationships between predictors and the mean of the response variable, which cannot

be adequately captured by least squares. Therefore, alternative methods such as Maximum Likelihood Estimation (MLE) is preferred for estimating parameters in GLMs. MLE accommodates the specific distributional assumptions of the dependent variable and ensure appropriate modeling of the relationship between the dependent variable and predictors (Moheghi et al., 2021). To estimate the parameters of GLM using MLE, the process typically involves three steps after the specification of the GLM:

- Step 1. Formulation of the likelihood function: The likelihood function is based on the chosen distribution and link function, and represents the probability of observing the given data under a specified model assumption.
- Step 2. Log-Likelihood: The logarithm of the likelihood function is employed to simplify computations and enhance numerical stability.
- Step 3. Maximization of the log-likelihood: The log-likelihood function is maximized using numerical algorithms such as the Expectation-Maximization (EM) algorithm (Moon, 1996). This process aims to find parameter values that maximize the probability of observing the real data according to the specified model.

To summarize, MLE involves adjusting the model parameters to achieve the best possible match between the observed data and the predictions made by the model (Myung, 2003; Patefield, 1977).

Adequacy of the model

The quality of a GLM is measured by several criteria that evaluate how well the estimated model explains the variability of the data and makes precise predictions. One of the main indicators is the coefficient of determination (\mathcal{R}^2), which quantifies the proportion of variability in the dependent variable explained by the model. The closer the \mathcal{R}^2 value is to 1, the better adequacy of the model the data. Conversely, the closer the \mathcal{R}^2 value is to 0, the poorer the adequacy of the model on the data. Additionally, the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), which quantitatively gauge how well the model explains data while considering model complexity. Lower AIC and BIC values are generally preferred to better balance model fit and complexity (Cavanaugh & Neath, 2019; Neath & Cavanaugh, 2012). Additionally, deviance plays a pivotal role in assessing model adequacy within GLMs. Finally, deviance plays a crucial role in evaluating GLM adequacy. Deviance measures how much the model's predictions differ from observed data, similar to the residual sum of squares in linear models. Lower deviance indicates a better model fit, reflecting its ability to capture underlying relationships and distributional characteristics (Sakate & Kashid, 2014).

4.1.2 Models for longitudinal data

In previous subsections, we saw that GLMs provide a robust framework for modeling relationships between variables. However, their applicability is limited when dealing with longitudinal structure data.

A longitudinal structure involves observing and measuring of data from the same subjects repeatedly over a period of time. Each unique subject is considered the grouping or level, with repeated measures over time that may be correlated, but each subject is independent of the others. The primary characteristic of longitudinal data is its ability to observe changes within individuals over time. There are several approaches to managing longitudinal structure data. One method involves aggregating all measurements from the same subject so that each subject has only one observation. Alternatively, one could estimate a model for each subject. In the first approach, aggregating limits the information utilized, while in the second approach, results would derive from many models, each not leveraging information across subjects.

Mixed models can be viewed as a middle ground between these two methods. Unlike traditional LMs and GLMs, mixed models incorporate random terms that capture the within-group variability. This enables them to effectively model complex data where observations are correlated over time, providing a more nuanced analysis of random and fixed effects within the data. As for regression models, there are several types of mixed models which depend on the structure and type of data analysed. The primary types of mixed models are Linear Mixed Models (LMMs) and Generalized Linear Mixed Models (GLMMs), which are extensions of linear models and GLMs for longitudinal design.

Specification of models

The difference in the model formulation between a LMM and GLMM compared to LM and GLM lies in the inclusion of random effects.

Here is the formulation for a LMM:

$$Y_{it} = \beta_0 + \beta_1 X_{it1} + b_{i0} + \epsilon_{it}$$

$$Y_{it} = X_{it}^T \beta + b_{i0} + \epsilon_{it}$$

Where:

- Y_{it} is the observation of the dependant variable Y for a subject i (where $i = 1, 2, 3, \dots, n$) and a time t (where $t = 1, 2, 3, \dots, n$).

- The vector $\beta = (\beta_0, \beta_1, \dots, \beta_p)^\top$ of dimension $(p + 1)$ is the vector of parameters of the regression model (fixed effects). β_0 corresponds to the mathematical expected value (mean) of Y_i when $X_i = 0$.
- b_{i0} is the random effect for the intercept for a subject i .
- $X_{it} = (X_{it1}, X_{it2}, \dots, X_{itp})^\top$ is the vector of independent variables for a subject i and a time t .
- ϵ_{it} represents the errors (or residuals) and are independent random variables distributed according to a normal distribution with a mean of zero and a variance of σ^2 : $\epsilon_i \sim \mathcal{N}(0, \sigma^2)$.

In addition to random effect for the intercept (b_{i0}), random effects for the coefficients of the independent variables can be included in the model. This allows capturing the variability in the relationship between that independent variable and the dependent variable across different subjects in a sample. variation between the time for these coefficients. Then, the model is written as:

$$Y_{it} = \beta_0 + (\beta_1 + b_{i1}) X_{it1} + b_{i0} + \epsilon_{it}$$

$$Y_{it} = X_{it}^\top (\beta + b_i) + b_{i0} + \epsilon_{it}$$

Where:

- $b_i = (b_{i1}, b_{i2}, \dots, b_{ip})^\top$ is the vector of random effects for the slopes of independent variables $X_{it} = (X_{it1}, X_{it2}, \dots, X_{itp})^\top$ respectively, for a subject i .

Hypotheses of models

LMMs and GLMM rely on several hypotheses to ensure the validity of estimations and inferences. These hypotheses are largely similar to those for LMs and GLMs, but they also include additional considerations, particularly concerning random effects:

- $b_i = (b_{i1}, b_{i2}, \dots, b_{ip})^\top$ are distributed independently and identically according to a Gaussian distribution with a mean of zero and a specific covariance matrix B .
- Fixed effects are assumed to be independent of random effects.
- The structure of the covariance matrix B must be correctly specified.

The covariance matrix B in LMMs and GLMMs, depends on how observations are organized over time and assumptions about the dependence between observations from the same subject. Typically, no specific structure is imposed on the matrix B , which means that all random effects can be correlated with each other. For instance, if random intercepts and random slopes are correlated, it implies that subjects with higher (or lower) intercepts also tend to have higher (or

lower) slopes, and vice versa. However, it is sometimes assumed that random effects are independent of each other, to reduce the number of parameters especially when the model includes multiple random effects. This assumption leads to a diagonal B matrix, where there are no off-diagonal elements representing correlations between random effects.

Estimation of model parameters

LMMs and GLMMs are primarily estimated using the Restricted Maximum Likelihood (REML) and MLE methods. The REML method maximizes the conditional likelihood of fixed effects by integrating random effects as latent variables. In contrast, MLE maximizes the likelihood of observed data with respect to all parameters of the model, without distinguishing between fixed and random effects. MLE is more general and is used for comparing different models, whereas REML is often recommended for precisely estimating fixed effects while accounting for random effects. Therefore, the choice of method varies depending on the specific objectives of the analysis and the structure of the data (Vonesh, 2006).

Adequacy of models

The measures used to assess the quality of LMMs and GLMMs are identical to those used for linear models and GLMs.

The statistical methods presented above were used in the two studies described in the following subsections. Both studies provide a comprehensive analysis of the impact of the COVID-19 pandemic on online gambling in France and Sweden.

4.2 Manuscript 2: Impact of the COVID-19 pandemic on online gambling behaviors: A descriptive analysis of all legal French websites

Marianne Balem^{1,2,3}, Bastien Perrot^{1,4}, Marie Grall-Bronnec^{1,2}, Carolina Widinghoff^{3,5}, Anna Karlsson^{3,5}, Anders Håkansson^{3,5}, Gaëlle Challet-Bouju^{1,2}

¹ Nantes Université, Univ Tours, CHU Nantes, INSERM, MethodS in Patients centered outcomes and HHealth ResEarch, SPHERE, F-44000 Nantes, France

² Nantes Université, CHU Nantes, UIC Psychiatrie et Santé Mentale, F-44000 Nantes, France

³ Faculty of Medicine, Department of Clinical Sciences Lund, Psychiatry, Lund University, Lund, Sweden

⁴ Nantes Université, CHU Nantes, Biostatistics and Methodology Unit, Department of Clinical Research and Innovation, F-44000 Nantes, France

⁵ Malmö Addiction Center, Region Skåne, Malmö, Sweden

4.2.1 Abstract

Background and Aims: To estimate the changes in gambling activity during a year impacted by the COVID-19 pandemic (2020) compared with a reference year (2019) among all French online gamblers by considering relevant gambling-related events. **Methods:** The data was provided by the French national lottery operator Française des Jeux (FDJ) (online lotteries: draw-based games, scratch games, and multiplayer games) and the French National Online Gambling Authority (ANJ) (online poker, online horse race betting, and online sports betting). The data were aggregated weekly from 01/01/2019 to 31/12/2020 and included the number of active and new gamblers who gambled at least once during the study period for each gambling type. The study period was divided into five periods according to the French government's decisions due to the level of the COVID-19 pandemic in 2020: one pre-COVID-19 period and four COVID-19-affected periods (i.e., strict lockdown, gradual reopening, interlockdown, and partial lockdown). Gambling-related events were divided into three variables: the amount of jackpots for draw-based games and the number of major sports and horse race competitions that provided the most bets. **Results:** With the reopening of sports and horse race events, online sports and online horse race betting followed a decreasing and gradual normalization pattern. In contrast, an uncommon increase in the number of active and new gamblers on online poker and online lotteries was observed during both lockdowns. **Discussion and Conclusions:** Dramatic changes in gambling behaviors due to the pandemic have diverted some gamblers and attracted new gamblers to other types of gambling.

4.2.2 Introduction

The coronavirus disease 2019 (COVID-19) pandemic has significantly threatened public health and profoundly affected all aspects of society, including mental health (Mahase, 2020; Wang et al., 2020). Gambling disorders are among the health issues that concern public health authorities due to the potential changes in gambling behaviors caused by the pandemic (S. Griffiths et al., 2020; Holmes et al., 2020). Indeed, a set of factors could explain a change in gambling activities, both in the number of gamblers and in the intensity of practices, due to the pandemic. On the one hand, the reduction or interruption of sporting and horse racing competitions during the lockdown may have induced a decrease in these activities (both online and offline) (Håkansson, 2020a, 2020b, 2020c; Otis et al., 2022). The closure of specific gambling venues and travel restrictions may also have decreased offline gambling activities in general. On the other hand, gamblers who could no longer engage in their usual gambling activities could have migrated to other available gambling activities, especially online (poker, lotteries, etc.) (Håkansson, 2020b). Online gambling has consistently been associated with higher rates of gambling problems due to the specific structural and environmental characteristics of online gambling, i.e., 24/7 accessibility, rapidness of gambling outcomes, dematerialized payment,

anonymity, etc. (M. Griffiths & Barnes, 2008; Bouju et al., 2011; Hing et al., 2015; S. M. Gainsbury, Russell, Wood, et al., 2015). In addition, the threat of a financial crisis, the negative impact on psychological well-being, and increased time freely spent online could also have very largely gambling activity, especially online and for more vulnerable individuals (Lippi et al., 2020; Marsden et al., 2020).

Four years after the beginning of the pandemic, many studies had been conducted worldwide on the impact of COVID-19 on gambling, with disparate results. In Sweden, a study on the taxation of Swedish gambling operators' revenue between January 2019 and November 2021 indicated that the gambling market grew faster during the pandemic than before its onset (Andersson et al., 2022). Another study of nearly 616,245 gamblers from the Swedish state-owned gambling operator demonstrated that gambling activity in online bingo, poker and casinos increased at the same time sports betting dramatically decreased and normalized as sports events returned (Balem, Karlsson, et al., 2023). In Italy, a web-based cross-sectional study of 6,003 participants showed that among gamblers who had already engaged in gambling activity before the lockdown, 19.7% reported a worsening of their total gambling activity during the lockdown. They also reported that the median duration of gambling activity increased from 4.5 hours per month

before the lockdown to 5.1 hours per month during the lockdown (Lugo et al., 2021). In France, the National Gambling Authority (Autorité Nationale des Jeux (ANJ)) observed a massive transfer of online gambling activity from horse racing and sports betting toward online poker during the first lockdown, especially a significant increase in the number of new gamblers and more intensive gambling practices (ANJ, 2020). However, the impact of the pandemic on lottery activities remains unknown, and no other research studies have been performed on the impact of COVID-19 on online gambling that take into account the whole online legal gambling activity (in France, only lotteries, poker, horse race and sports betting are authorized online). Moreover, no study has explored the changes in the online gambling habits of French gamblers during the health crisis (i.e., year 2020) compared to an equivalent reference year that was not impacted by the pandemic (i.e., year 2019). Furthermore, it also seems essential to consider the natural changes in the number of gamblers due to gambling-related events. Such natural changes related to gambling have never been considered in the COVID-19 literature, although they could strongly influence gambling patterns. Indeed, some of the most followed sports and horse race competitions, which generate the majority of bets in normal times, were cancelled and/or postponed due to the pandemic. Consequently, they may have

influenced gambling habits in different ways during the pandemic, especially chronologically, because they did not occur at the same time of the year in 2020 compared to 2019. Moreover, other factors could also have impacted gambling habits, independent of the pandemic. More specifically, for draw-based games, when a jackpot prize is not won in the actual draw, it is added to the next draw, and so forth. Thus, jackpots could reach large amounts as they increase weekly, possibly explaining the unusual growth in gambling activities, especially because gambling operators highly promote large jackpots, and advertising is often focused on the "life-changing" ability of such jackpots (Grant & Kim, 2001; McMullan & Miller, 2009; Ariyabuddhiphongs, 2011; Newall et al., 2019).

This study aims to estimate the potential changes in the number of gamblers participating in all French online gambling activity (all gamblers, all legal gambling types) during the different phases of the year impacted by the COVID-19 pandemic (2020) compared to a reference year (2019), controlling for the natural changes due to gambling-related events and jackpots. Our primary hypothesis was that the number of gamblers engaged in non-COVID-19-affected gambling increased during the first lockdown period in response to the interruption of sports and horse racing events and then normalized and increased again during the second

lockdown period in France. We also hypothesized that the number of new gamblers would be greater in 2020 than in 2019, mainly during the first lockdown and for non-COVID-19-affected gambling types. We assumed that some sports and horse race bettors transferred their gambling habits to available gambling types during the lockdown. Hypotheses were preregistered before calculating the results (Balem, Perrot, et al., 2023).

4.2.3 Methods

Participants

The study included data from all individuals who gambled at least once in one of the types of gambling allowed by the French State. In France, only four types of online gambling are authorized: sports betting, horse race betting, poker and lotteries. The lotteries comprise three subtypes of gambling activities: draw-based games (based on the random drawing of numbers), scratch games, and multiplayer games (where several people gamble simultaneously on the same game). The online gambling market is grounded in license-based regulations managed by the ANJ. The national lottery operator (Française Des Jeux [FDJ]) holds a monopoly for all online (and offline) lottery games. In parallel, online sports betting, horse race betting, and poker are open to competition and are offered by gambling operators licensed by the ANJ. Online casino

games (EGMs and table games, except poker) are forbidden in France.

Measures

We requested access to data from the ANJ and FDJ on the number of active and new gamblers for each type of legal online gambling activity in France. After acceptance, data were extracted and computed from gambling tracking data owned independently by the ANJ and the FDJ and aggregated weekly from 1st January 2019 to 31st December 2020 by data providers. All anonymized data were then transferred to our team through secured messaging.

Moreover, for each week, we retrospectively computed three variables related to the magnitude of gambling events to account for the impact of the pandemic on the timeline of gambling events. For draw-based games, we requested the amounts of jackpots (i.e., the maximum prizes) offered each week during the study period for Loto® and EuroMillions games from the FDJ, and we computed the variable “maximum amount of jackpots” among those offered each week. For sports and horse-race betting, we identified the main sports and horse-race events that generated the most bets for both bet types and then computed the number of events each week for each type of betting. For sports betting, only sports competitions related to football, tennis, and basketball were chosen because an activity report from the ANJ

showed that almost 90% of sports betting resulted from these three sports in 2017 (football: 57%, tennis: 21% and basketball 11%) (The French online gambling regulatory authority (ARJEL), 2018). Regarding horse race betting, all races from the “Group 1” competition level (i.e., the most prestigious competitions, with some of the best horses in the world and with the highest financial and sporting stakes) were reported for each horse racing field (gallop, steeplechase, harnessed trot and mounted trot). Conversely, we chose not to include variables related to the magnitude of gambling events for poker, scratch games, and multiplayer games because we assumed that the timeline of gambling-related events for these types of games had not been impacted by the pandemic. A detailed description of the timeline of gambling-related events is provided in Figures 1.SI, Figure 2.SI (sports betting), Table 2.SI, Figure 3.SI (horse race betting) and Figure 4.SI (draw-based games) from the supplementary information.

Five periods were isolated according to the restrictions of the French government due to the spread of the virus in 2020 (one reference period and four COVID-19-affected periods):

- Weeks 1–11 (30th December 2019 – 15th March 2020): Pre-COVID period (pre-C). Despite the detection of the first positive cases of COVID-19, no government restrictions were yet in place.
- Weeks 12–19 (16th March 2020 – 10th May 2020): First COVID-19-affected period (P1). On the 16th of March, in a live address, the French president announced strict restrictions on movement (lockdown at home) for at least two weeks. Ultimately, the lockdown was prolonged until the 11th of May. Therefore, all sports and horse race events were suspended.
- Weeks 20–25 (11th May 2020 – 21st June 2020): Second COVID-19-affected period (P2). On the 11th of May, a gradual reopening started in France. The football championships of European countries gradually started.
- Weeks 26–40 (22nd June 2020 – 4th October 2020): Third COVID-19-affected period (P3). On the 22nd of June, primary and secondary schools reopened, and the sanitary protocol was relaxed. All sports and horse racing events started.
- Weeks 41–52 (5th October 2020 – 28th December 2020): Fourth COVID-19-affected period (P4). At the end of September, hospitalizations and admissions to intensive care units due to the virus increased exponentially again. At the end of October, the French government announced a partial lockdown for at least two months. Conversely, during the 1st

lockdown, childcare centers and primary, secondary and high schools remained open. However, higher education lessons were mainly carried out via videoconference, and remote working was fully recommended for working people. On the 15th of December, the lockdown was replaced with a curfew until January 2021.

The same divisions of time were also applied during 2019 (the reference year without the COVID-19 pandemic) to compare the gambling activity between two years with the same period durations.

Statistical analysis

First, a descriptive analysis was conducted to compare the weekly average number of active and new gamblers in 2019 with 2020, according to the type of gambling and sex. Second, depending on the distribution of the dependent variable, generalized linear models with a gamma-distributed dependent variable (gamma GLMs) or linear models were used to analyze the changes in the number of gamblers over the COVID-19-affected periods (P1, P2, P3 and P4) compared with the pre-COVID-19 period (pre-C). The analyses were performed separately for each type of gambling (COVID-19-affected gambling types: sports betting and horse race betting; non-COVID-19-affected gambling types: poker, draw-based games, scratch games and multiplayer games), for each type of gambler

(active or new) and for each year (2019 and 2020). Additionally, three variables related to the magnitude of gambling events were initially tested to assess their influence on gambling activity in 2019, when there was no impact from the pandemic, with linear models and gamma GLMs (see Table 3 from the supplementary information). In the case of a significant result, they were included as adjustment variables in the final models to control for the natural evolution of the number of gamblers due to gambling-related events independent of the pandemic.

We computed the predicted means, which correspond to the average weekly number of gamblers during each period, estimated with the adjusted models. We also reported the observed means, which represent the “true” observed values averaged weekly, in Table 1 of the supplementary information.

Finally, p values were adjusted for multiple testing with Benjamini and Hochberg correction (Benjamini & Hochberg, 1995b). The models were run using StataSE software version 16.0.

Ethics

This study was approved by the local research ethics committee *Groupe Nantais d’Ethique dans le Domaine de la Santé* (GNEDS) on September 17, 2020.

4.2.4 Results

Description of the number of active and new gamblers in 2019 and 2020

As described in Table 1, draw-based games had the highest weekly average number of active gamblers in 2019, followed by sports betting, poker, horse race betting, scratch games, and multiplayer games. The results were similar for 2020, except there were more active gamblers for scratch games than for horse race betting. Regarding the new gamblers in 2019, sports betting was the gambling type with the highest weekly average number of new gamblers, followed by draw-based games, poker, scratch games, horse race betting (close numbers), and multiplayer games. The results were almost identical to those for 2020, except that there

were more new gamblers for scratch games than for poker games and fewer for horse race betting games. Men gambled more than women for all gambling types except for scratch games and multiplayer games, where the proportions were almost identical.

The average weekly number of active gamblers increased for all gambling types between 2019 and 2020, particularly for the non-COVID-19-affected gambling types: +60% for scratch games, +43% for draw-based games, +39% for poker, and +36% for multiplayer games. It also increased for new gamblers, especially for the 3 lottery games (each experiencing an increase of more than 90%). However, the number of new gamblers decreased for sports betting and horse betting.

Table 1: Description of the weekly average number of active and new gamblers in 2019 and 2020, according to type of gambling and sex.

	(1) Active gamblers		
	2019	2020	^b Δ
	Observed mean (sd)	Observed mean (sd)	n (%)
^a Number of gamblers per week			
Sports betting: Overall	567,747 (107,239)	592,674 (257,444)	+24,927 (+4%)
<i>Male</i>	91%	79%	.
<i>Female</i>	9%	21%	.
Horse race betting: Overall	139,772 (9,468)	149,732 (28,685)	+9,960 (+7%)
<i>Male</i>	88%	84%	.
<i>Female</i>	12%	16%	.
Poker: Overall	234,461 (19,308)	326,333 (54,863)	+91,872 (+39%)
<i>Male</i>	88%	89%	.
<i>Female</i>	12%	11%	.
Draw-based games: Overall	661,886 (125,474)	947,291 (235,533)	+285,405 (+43%)
<i>Male</i>	71%	70%	.
<i>Female</i>	29%	30%	.
Scratch games: Overall	128,855 (21,226)	205,865 (49,176)	+77,010 (+60%)
<i>Male</i>	55%	55%	.

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

<i>Female</i>	45%	45%	.
Multiplayer games: Overall	31,742 (4,849)	43,217 (9,062)	+11,475 (+36%)
<i>Male</i>	50%	50%	.
<i>Female</i>	50%	50%	.
(2) New gamblers			
	2019	2020	^b Δ
	Observed mean (sd)	Observed mean (sd)	n (%)
^a Number of gamblers per week			
Sports betting: Overall	136,477 (52,544)	98,007 (86,249)	-38,470 (-28%)
<i>Male</i>	97%	95%	.
<i>Female</i>	3%	5%	.
Horse race betting: Overall	5,237 (1,194)	3,302 (1,183)	-1,935 (-37%)
<i>Male</i>	82%	79%	.
<i>Female</i>	18%	21%	.
Poker: Overall	9,743 (1,814)	10,786 (8,197)	+1,043 (+11%)
<i>Male</i>	88%	86%	.
<i>Female</i>	12%	14%	.
Draw-based games: Overall	12,378 (13,447)	25,500 (26,523)	+13,122 (+106%)
<i>Male</i>	61%	59%	.
<i>Female</i>	39%	41%	.
Scratch games: Overall	5,628 (3,139)	10,872 (7,792)	+5,244 (+93%)
<i>Male</i>	60%	58%	.
<i>Female</i>	40%	42%	.
Multiplayer games: Overall	1,127 (566)	2,142 (1,469)	+1,015 (+90%)
<i>Male</i>	62%	62%	.
<i>Female</i>	38%	38%	.

^a: Represents the observed mean (i.e., “true” observed value) of the number of gamblers each week in 2019 and 2020 (only individuals who gambled at least once during a given week were included). ^b: Correspondence to the difference between the average number of gamblers in 2019 and 2020, followed by the variation rate in parentheses (2020 compared to 2019). Positive variations between 2019 and 2020 are indicated in red, and negative variations are indicated in green. sd: standard deviation.

Reading key:

(1) Sports betting: The weekly average number of active gamblers engaged in sports betting was 567,747 (91% male and 9% female) in 2019 and 592,674 (79% male and 21% female) in 2020. The raw variation was an increase of 24,927 gamblers in 2020 compared to 2019, which was 4% more gamblers in 2020 than in 2019.

(2) Sports betting: The weekly average number of new gamblers engaged in sports betting was 136,477 in 2019 and 98,007 in 2020. The raw variation decreased by 38,470 gamblers in 2020 compared to that in 2019, representing 28% fewer gamblers in 2020 than in 2019.

Comparison of changes in the number of active and new gamblers in COVID-19-affected periods in 2019 and 2020.

Table 2.SI in the supplementary information indicates that only the number of sports events and the maximum amount of jackpots influenced the number of gamblers in 2019. Figure 1.SI shows that the timeline of the number of sports events changed

drastically between 2019 and 2020, especially during the first lockdown period (P1), and Figure 3.SI shows that the timeline of jackpots also differed during the inter-lockdown and second lockdown periods (P3 and P4).

The means predicted by the models for estimating the number of active and new gamblers during the different phases related to the pandemic for both years are presented in

Table 2, with the results of the comparisons between the COVID-19-affected periods and the pre-C period.

Moreover, both the observed (full lines) and predicted (dashed lines) means of the number of active and new gamblers are illustrated in Figure 1 (COVID-19-affected gambling types) and Figure 2 (non-COVID-19-affected gambling types).

The first information that could be extracted from the comparison of observed and predicted means in Figure 1 and Figure 2 is that adjusting the models on the timeline of gambling events allowed us to avoid interpreting the "natural" peaks in the number of active and new gamblers induced by major gambling events as effects of the pandemic.

Changes in the number of active and new gamblers in 2019

Overall, in 2019, the average number of active and new gamblers either remained stable or decreased, depending on the type of gambling, during the same intervals of the COVID-19-affected periods compared to the pre-COVID-19 period.

Changes in the number of active gamblers in 2020

As expected, large decreases in the average number of active gamblers of COVID-19-affected gambling types were observed during the P1 period compared to the pre-C period due to the interruption of sports and horse race events due to the pandemic. In contrast, the average number of active gamblers increased

dramatically during the P1 period compared to the pre-C period for all non-COVID-19-affected gambling types.

During the inter-lockdown period (P2 and P3), there was a return to normal for COVID-19-affected gambling types and for multiplayer games. At the same time, the increase, albeit weaker, was maintained for non-COVID-19-affected gambling types (except for multiplayer games), especially for draw-based games (the same level of increase as for the P1 period).

During the second lockdown (the P4 period), all gambling types increased, regardless of whether they were affected by COVID-19 or not. The increase was the greatest for the 3 lottery games (+59% for scratch games, +55% for draw-based games and +41% for multiplayer games, compared to the pre-C period) and larger than for the P1 period for draw-based games and scratch games.

Changes in the number of new gamblers in 2020

A significant decrease was observed in the number of new gamblers for sports betting during the P1 period compared to the pre-C period, while there was a considerable increase for all non-COVID-19-affected gambling types, especially for poker with an increase almost three times higher ($\approx +291\%$) than in the pre-C period. These changes were followed by a return to normal for all gambling types, followed by another marked

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

increase for the 3 lottery games during the second lockdown (P4 period: draw-based games $\approx +158\%$, scratch games $\approx +153\%$, and multiplayer games $\approx +153\%$). No changes were detected in horse race betting during the entire year of 2020.

Table 2: Results of the linear models and gamma GLMs according to type of gamblers in 2019 and 2020

		(1) Active gamblers	
Gambling type	Effects	2019	2020
		Predicted mean & % [95% CI]	Predicted mean & % [95% CI]
Sports betting	Period:		
	pre-C	542,378 [488,111; 596,647] ^{ref}	616,737 [469,503; 763,970] ^{ref}
	P1	+2.3% [+1.3%; +3.2%]	-61.9% [-90.5%; -44.4%]^{***}
	P2	+6.2% [+1.9%; +9.7%]	-27.9% [-42.9%; -18.7%]
	P3	+5.3% [+4.3%; +6.5%]	+9.1% [-1.8%; +21.8%]
P4	+9.0% [+7.7%; +10.7%]	+24.6% [+17.3%; +34.6%]^{**}	
Horse race betting	Period:		
	pre-C	147,221 [143,286; 151,158] ^{ref}	152,955 [142,553; 163,357] ^{ref}
	P1	-5.6% [-6.2%; -5.1%]^{**}	-36.1% [-39.9%; -32.8%]^{***}
	P2	-10.0% [-11.2%; -8.9%]^{***}	-0.4% [-2.9%; +1.7%]
	P3	-9.3% [-9.5%; -9.1%]^{***}	+0.4% [-0.6%; +1.5%]
P4	-1.5% [-1.6%; -1.4%]	+13.3% [+12.0%; +15.0%]^{**}	
Poker	Period:		
	pre-C	242,787 [235,051; 250,523] ^{ref}	271,241 [260,563; 281,918] ^{ref}
	P1	-8.5% [-9.3%; -7.7%]^{**}	+57.0% [+56.6%; +57.4%]^{***}
	P2	-10.2% [-11.7%; -8.8%]^{***}	+23.1% [+21.1%; +24.9%]^{***}
	P3	-7.7% [-7.9%; -7.5%]^{***}	+8.8% [8.8%; +8.9%]^{**}
P4	+5.6% [+5.9%; +5.3%]	+26.9% [+26.5%; +27.3%]^{***}	
Draw-based games	Period:		
	pre-C	629,961 [585,629; 674,565] ^{ref}	755,987 [670,876; 841,098] ^{ref}
	P1	-0.7% [-1.9%; +0.2%]	+22.3% [+21.9%; +22.7%]^{**}
	P2	+0.2% [-2.2%; +2.2%]	+21.6% [+19.6%; +23.2%]^{**}
	P3	+2.8% [+2.0%; +3.5%]	+20.8% [+17.3%; +25.2%]^{***}
P4	+18.8% [+18.2%; +19.3%]^{***}	+55.4% [+49.2%; +63.2%]^{***}	
Scratch games	Period:		
	pre-C	125,166 [114,866; 135,465] ^{ref}	160,187 [138,628; 181,764] ^{ref}
	P1	-10.0% [-13.2%; -7.3%]	+41.0% [+38.1%; +44.7%]^{***}
	P2	-6.7% [-11.4%; -2.8%]	+16.7% [+13.8%; +18.9%]
	P3	+5.4% [+4.4%; +6.6%]	+20.9% [+16.7%; +26.4%][*]
P4	+16.1% [+15.1%; +17.3%][*]	+59.2% [+51.2%; +69.6%]^{***}	
Multiplayer games	Period:		
	pre-C	32,638 [30,180; 35,096] ^{ref}	35,880 [31,891; 39,868] ^{ref}
	P1	-16.9% [-19.7%; -14.4%]^{**}	+41.8% [+40.0%; +43.9%]^{***}
	P2	-15.0% [-19.2%; -11.3%][*]	+14.0% [+11.3%; +16.7%]
	P3	+3.0% [-4.4%; +1.9%]	+8.6% [+6.8%; +11.5%]
P4	+3.0% [+2.6%; +3.6%]	+41.2% [+36.9%; +47.4%]^{***}	
		(2) New gamblers	
Gambling type	Effects	2019	2020
		Predicted mean & % [95% CI]	Predicted mean & % [95% CI]

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

Sports betting	Period:		
	pre-C	153,637 [124,223; 183,051] ^{ref}	106,687 [62,312; 151,062] ^{ref}
	P1	-17.3% [-24.1%; -12.7%]	-89.9% [-94.8%; -84.9%]**
	P2	-13.6% [-27.4%; +4.3%]	-63.9% [-93.2%; -34.7%]
	P3	-15.3% [-17.6%; -13.7%]	+21.5% [+10.9%; +34.1%]
P4	-11.0% [-12.2%; -10.1%]	+26.9% [+16.7%; +37.5%]	
Horse race betting	Period:		
	pre-C	6,277 [5,763; 6,790] ^{ref}	3,416 [2,743; 4,088] ^{ref}
	P1	-20.5% [-23.8%; -17.8%]**	-20.5% [-23.8%; -17.8%]
	P2	-30.9% [-36.7%; -26.0%]***	-30.9% [-36.7%; -26.0%]
	P3	-24.0% [-24.7%; -23.3%]***	-24.0% [-24.7%; -23.3%]
P4	-12.7% [-13.4%; -12.1%]*	-12.7% [-13.4%; -12.1%]	
Poker	Period:		
	pre-C	10,974 [10,064; 11,885] ^{ref}	6,923 [5,823; 8,023] ^{ref}
	P1	-30.7% [-33.6%; -28.3%]***	+291.1% [+274.8%; +313.5%]***
	P2	-22.6% [-26.1%; -19.6%]***	+2.3% [-37.8%; +31.4%]
	P3	-14.2% [-15.1%; -13.0%]**	+0.2% [-18.4%; +13.7%]
P4	+0.9% [-0.5%; +2.6%]	+47.1% [+34.5%; +56.2%]	
Draw-based games	Period:		
	pre-C	9,777 [6,272; 13,281] ^{ref}	16,046 [10,446; 21,646] ^{ref}
	P1	+5.6% [-5.7%; -5.6%]	+132.8% [+112.3%; +154.4%]**
	P2	-3.2% [-12.5%; +6.2%]	-13.2% [-23.1%; -3.9%]
	P3	+21.3% [+20.5%; +22.9%]	-3.7% [-5.6%; -0.3%]
P4	+63.7% [+62.1%; +67.2%]	+158.3% [+152.1%; +164.0%]**	
Scratch games	Period:		
	pre-C	5,129 [3,613; 6,745] ^{ref}	6,779 [4,901; 8,657] ^{ref}
	P1	-22.5% [-20.6%; -28.1%]	+113.1% [+100.9%; +120.1%]**
	P2	+3.0% [-12.3%; +9.6%]	-18.4% [-75.5%; +25.3%]
	P3	+29.6% [+23.5%; +37.4%]	+27.9% [-8.3%; +38.9%]
P4	+18.7% [15.8%; +20.8%]	+152.8% [+139.7%; +176.1%]***	
Multiplayer games	Period:		
	pre-C	1,093 [818; 1,368] ^{ref}	1,326 [1,007; 1,646] ^{ref}
	P1	-32.8% [-55.8%; -19.0%]	+136.1% [+129.6%; +139.9%]***
	P2	-21.0% [-47.1%; -5.4%]	-13.1% [-79.4%; +27.4%]
	P3	+25.5% [+20.2%; +34.4%]	+17.4% [-4.7%; +17.4%]
P4	+14.1% [+13.4%; +14.1%]	+153.2% [+142.9%; +169.6%]***	

The predicted means correspond to the estimated values (from the models) averaged weekly for each period in 2019 and 2020. The stars correspond to the magnitude of the p- value for comparing the COVID-19-affected periods with the pre-C period. ^{ref}: reference. *: p<0.05; **: p<0.01; ***: p<0.001. The rate of the variation in predicted means compared to the pre-C period with a statistically significant p value (<0.05) are in bold. The positive rates of variation (increases) in the predicted means compared to those in the pre-C period are shown in red, and the negative rates (decreases) are shown in green.

Reading key:

(1) Sports betting: In 2019, the average weekly number of active gamblers engaged in sports betting remained the same during the four COVID-19-affected periods compared to the pre-C period (nonsignificance of the percentages). In 2020, the average weekly number of active gamblers engaged in sports betting decreased by 61.9% [44.4%; 90.5%] during the P1 period compared to the pre-C period. However, it did not change during the P2 and P3 periods but increased by 24.6% [17.3%; 34.6%] of gamblers during the P4 period.

(2) Sports betting: In 2020, the average weekly number of new gamblers engaged in sports betting decreased by 89.9% [84.9%; 94.8%] during the P1 period compared to the pre-C period. Then, it did not change during the other periods (nonsignificance of the percentages).

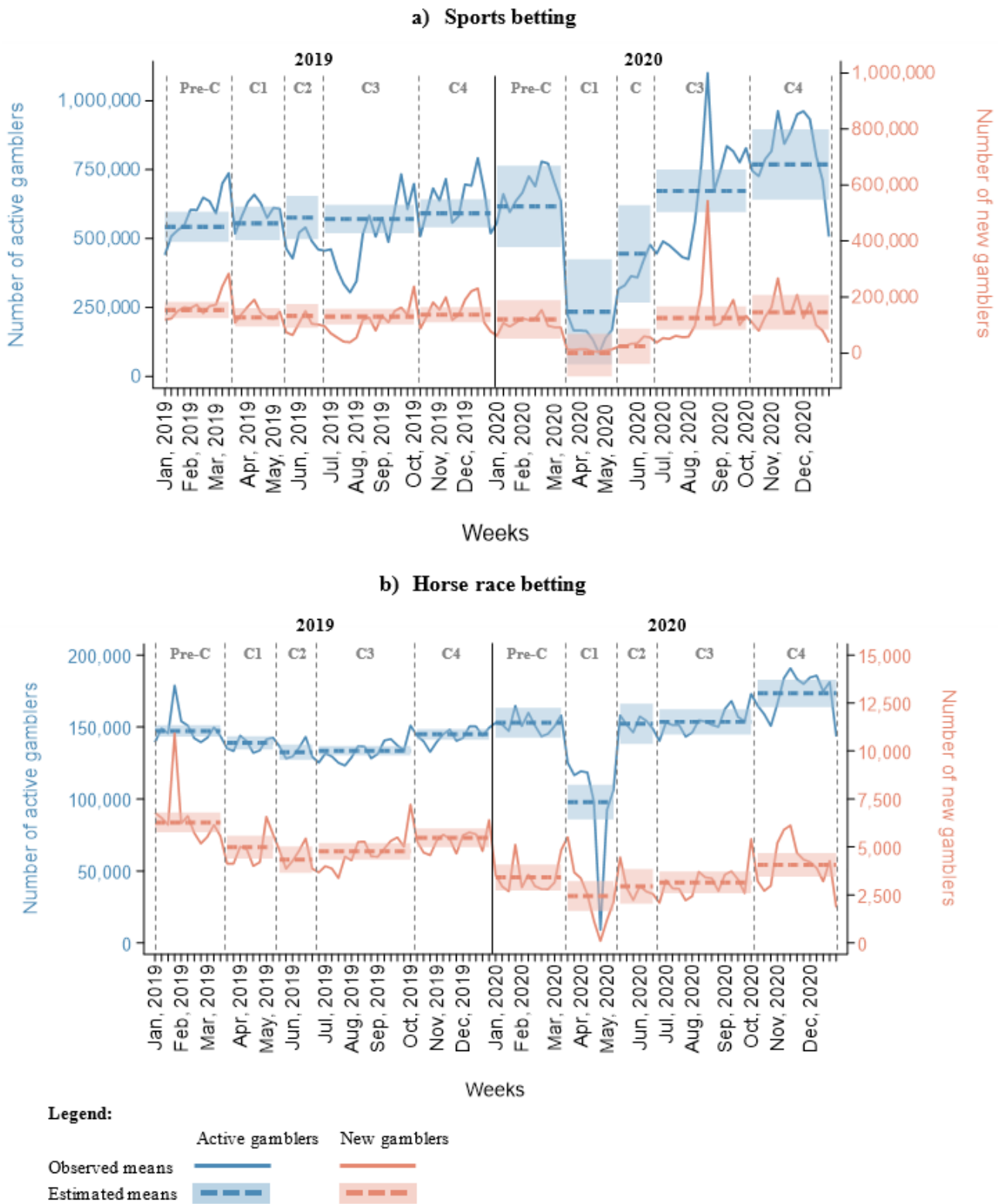


Figure 1: Representation of the observed and predicted means of the number of active and new gamblers engaged in COVID-19-affected gambling types

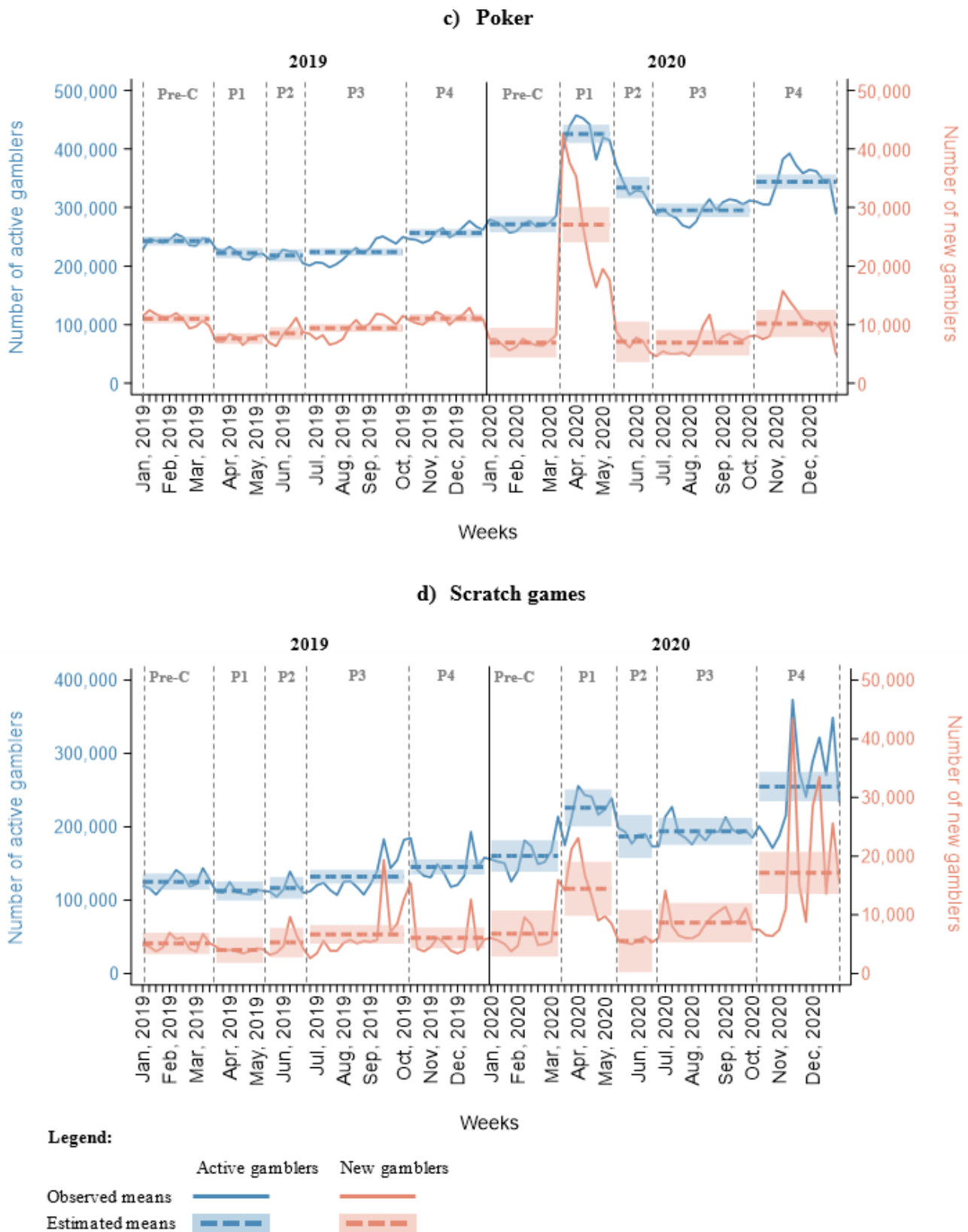
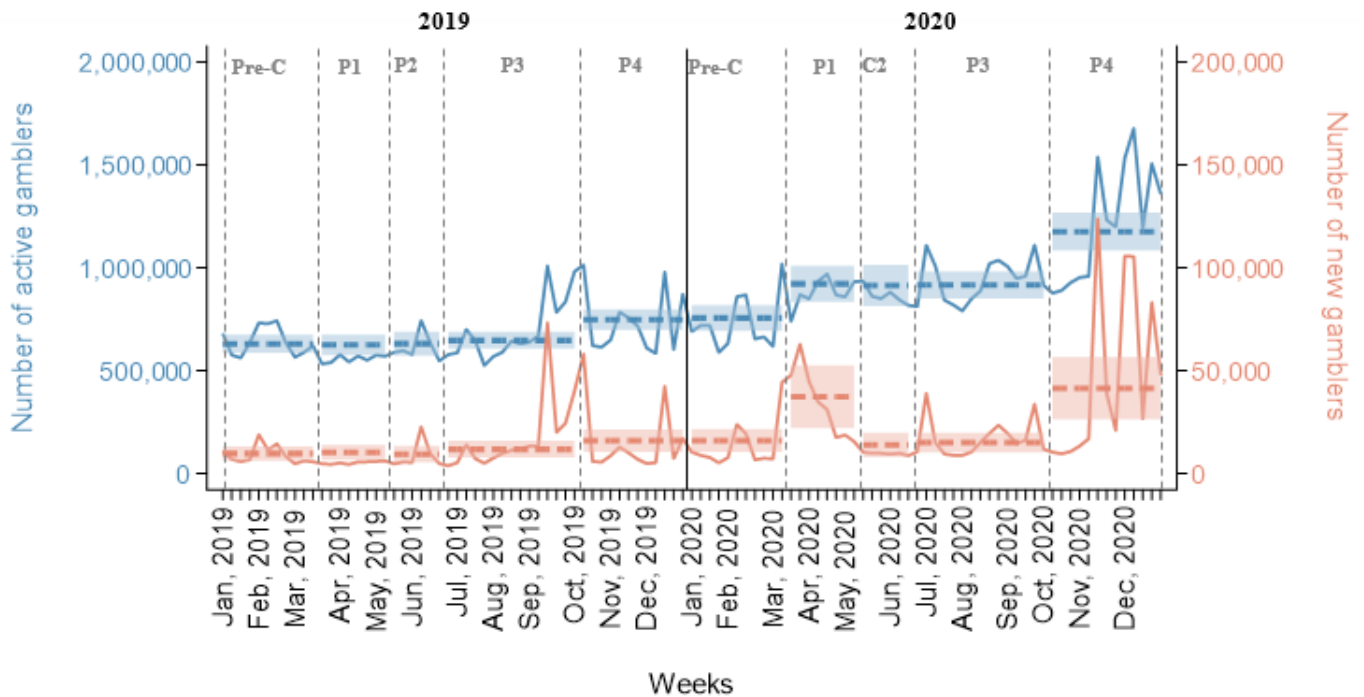
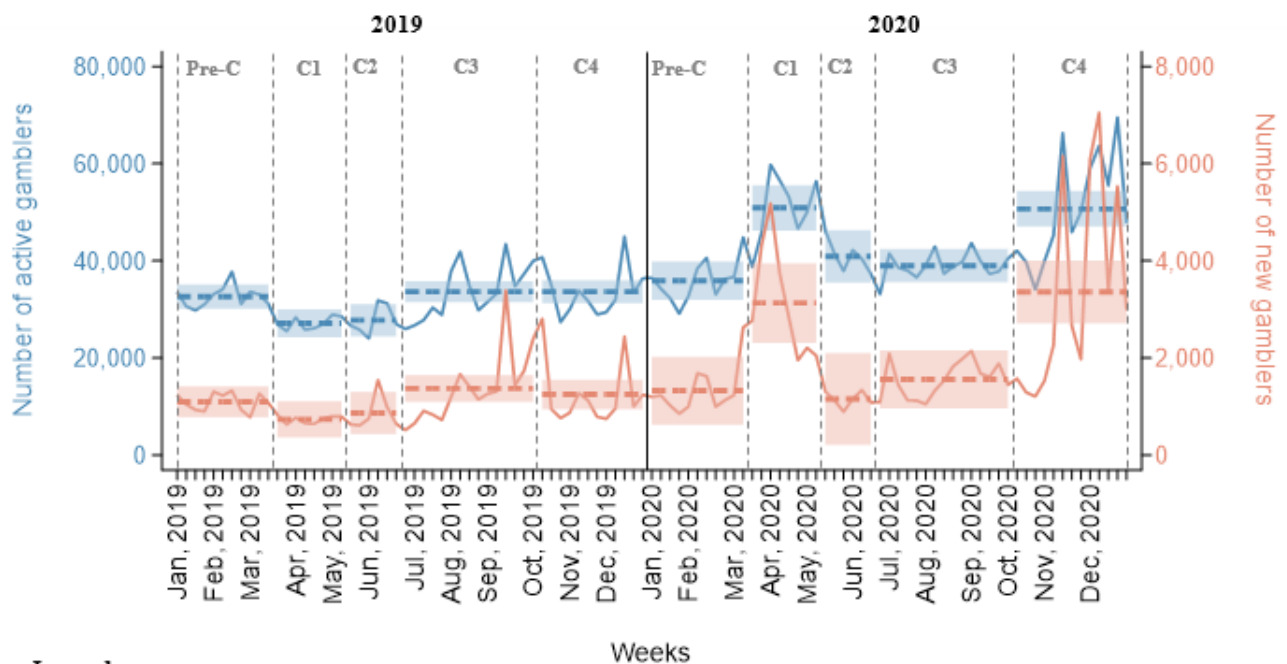


Figure 2: Representation of the observed and predicted means of the number of active and new gamblers engaged in non-COVID-19-affected gambling types.

e) Draws-based games



f) Multiplayer games



Legend:

	Active gamblers	New gamblers
Observed means		
Estimated means		

4.2.5 Discussion

The present study aimed to evaluate the changes in the number of gamblers during a year impacted by the pandemic (2020) compared to a reference year (2019) while considering the natural changes linked to major gambling-related events.

The descriptive results showed that the weekly average number of active gamblers increased between 2019 and 2020 for all gambling types, including COVID-19-affected gambling types, despite the interruption of sports and horse race events due to the pandemic in 2020.

Overall, all gambling types were impacted by the pandemic. The COVID-19-affected gambling types experienced a significant and understandable drop in the average number of active gamblers when sports and horse race events were interrupted. However, once these events resumed, the number of active gamblers returned to normal levels but increased beyond what was observed during the reference period. Conversely, the average number of active gamblers for non-COVID-19-affected gambling types significantly increased during the lockdown period and then either remained higher than in the pre-COVID period (poker and draw-based games) or normalized at pre-COVID levels (scratch games and multiplayer games). These findings align with several European studies, which showed a dramatic decrease in COVID-

19-affected gambling types during the first epidemic peak in Europe and a mirrored increase in gambling types that remained stable in response to the cancellation of sports and horse race events (Håkansson, 2020c; Lindner et al., 2020; Lugo et al., 2021; Balem, Karlsson, et al., 2023). However, contrary to these studies, our findings extended until the second epidemic peak in Europe (in France: second, but partial, lockdown). They allowed us to observe an uncommon increase in the number of active gamblers during the second lockdown for all gambling types that reached the same (multiplayer games) or even higher (draw-based and scratch games) levels for certain gambling types than during the first lockdown, despite much more flexible travel restrictions and the absence of interruption of sporting events or horse racing competitions. This means that the constraints and restrictions imposed by the government in times of crisis, even if they do not drastically restrict gambling opportunities, can lead to a significant increase in gambling activities, the sustainability of which remains to be determined.

In addition, we observed a large increase in the number of new gamblers engaged in non-COVID-19-affected gambling types during the sports and horse race interruption period. Indeed, online poker increased by 3 during the first lockdown period and by approximately 2.5 for online lotteries during both lockdown periods in 2020. These results are consistent

with the 2nd quarter 2020 report of the ANJ and confirm the hypothesis of a shift in the gambling activity of sports and horse race betting toward online poker during the first acute phase of the pandemic, together with an overall intensification in the gambling activity of active gamblers (ANJ, 2020). Our study went further by demonstrating that this shift also applied to online lotteries, which the ANJ did not yet regulate at the time of the first lockdown. Importantly, three types of online lotteries (draw-based games, scratch games and multiplayer games) were the only types of gambling that also displayed a large increase in new gamblers (approximately +150%) during the second lockdown, whereas the other types of gambling (poker, sports betting and horse race betting) remained at pre-COVID levels. Beyond the sole shift between COVID-19-affected and non-COVID-19-affected online gambling types, it is likely that there was also a shift from offline to online activity during both lockdowns due to travel restrictions and the closure of certain gambling venues. Moreover, we assume that the observed increase in the number of new gamblers reflected the initiation of nongamblers to online gambling to overcome the boredom, stress or anxiety caused by the impact of government mobility restrictions due to the pandemic (lockdown at home, social insulation and increased screen use). However, the data available in this study (restricted to online gambling only) did not

allow us to confirm this hypothesis. In the future, more studies are needed to evaluate the gambling behaviors of new gamblers to observe, in the long term, whether they maintained their gambling practices after 2020. It seems particularly important for those who already gambled before but expanded their level of involvement in several gambling types due to the pandemic. Indeed, several studies have reported that the level of involvement is positively associated with the intensity of gambling and could lead to gambling problems (Phillips et al., 2013; S. M. Gainsbury, Russell, Blaszczynski, et al., 2015; Binde et al., 2017; Mazar et al., 2020; Håkansson & Widinghoff, 2021; Balem, Karlsson, et al., 2023).

The present study also highlighted several uncommon changes in gambling-related events in 2020 compared with 2019. First, there was a clear decrease in almost all sports and horse race competitions during the first lockdown, followed by an unusual increase in jackpots during the second lockdown. These findings align with a study in the United Kingdom, which showed that gambling advertising expenditures were approximately 40% lower during the first lockdown and approximately 50% greater during the second lockdown than during the same periods in 2019 (Critchlow et al., 2022).

Thus, investigating gambling advertising during the acute phases of the pandemic seems necessary because several gambling operators

have been criticized for heavily promoting online gambling during the acute phases of the pandemic, especially because the negative influence of gambling advertising was identified as a factor associated with problem gambling (Binde & Romild, 2019; Stark & Robinson, 2021).

Limitations and strengths

This study has several limitations. First, the data analyzed were limited to the number of active and new gamblers per week for each type of gambling. Thus, we did not have details on the actual gambling activity (frequency, intensity, etc.) at the individual level over weeks. Second, the lack of available clinical data to compare the changes in gambling activity according to the problem gambling severity status of gamblers may also be a limitation. Indeed, some studies have mentioned that the evolution of gambling behaviors during the pandemic was undoubtedly not the same across different levels of problem gambling severity (Håkansson, Fernández-Aranda, et al., 2020; Brodeur et al., 2021). Finally, the models for poker, scratch games, and multiplayer games were not adjusted for gambling-related events that could impact gambling behaviors independently of the pandemic.

Conversely, this study has important strengths. First, the data included all types of online gambling activities authorized in France. This allowed us to provide an

exhaustive view of the entire legal online gambling activity in France, which was lacking in previous studies on the subject that were exclusively based on a single operator (Auer & Griffiths, 2021; Auer et al., 2020). Second, the study's time frame covered two years and allowed, on the one hand, comparing a year impacted by the pandemic (2020) with a reference year (2019) and, on the other hand, investigating the pandemic's impact beyond the acute phase of the pandemic (spring–summer 2020), which was performed in the majority of studies on this subject (Lindner et al., 2020; Donati et al., 2021; Sharman et al., 2021; Wardle et al., 2021; Sachdeva et al., 2022; Price, 2020). Finally, the statistical models were adjusted on the timeline of gambling events to take into account the natural evolution of gambling behaviors over weeks and avoid wrongly concluding an “artificial” impact of the pandemic that was due only to the postponement of certain competitions. The choice of gambling events that were included as control variables in the models can be discussed. Indeed, we isolated the main events in both sports and horse race competitions, but this selection may be affected by a certain degree of subjectivity, even if we tried to select those competitions that usually represent the large majority of bets in France. Moreover, we did not include corresponding types of gambling events for poker, scratch games or multiplayer games. If there was

undoubtedly no way to include such control variables for scratch games and multiplayer games, this choice could be questionable for poker. We chose not to include poker events as a control variable because we did not anticipate any reason that poker tournaments may have impacted gambling behaviors differently between 2019 and 2020.

4.2.6 Conclusion

The sports and horse race interruption during the first epidemic peak in Europe seems to have diverted some gamblers from their usual gambling activities and attracted new gamblers to available gambling types. Moreover, despite more flexible restrictions during the second lockdown and the lack of interruption of professional sports or horse race competitions, an increase in the number of active gamblers was still observed for all types of gambling. Thus, this study

demonstrated that a major crisis may result in a significant increase in gambling activities, even when there is no reduction in the amount of available gambling. Therefore, it seems crucial to reinforce the supervision and regulation of the gambling market and to establish a crisis plan to protect mental health and prevent problematic gambling behaviors in response to such crises in the future. Studies at the individual level are needed to visualize individual gambling trajectories due to the pandemic and determine whether certain groups of gamblers were more impacted than others, especially if their gambling activities turned to at-risk gambling behaviors.

4.2.7 References

References are included in the References section of the thesis.

4.2.8 Supplementary information

Table 1.SI: Description of the average number of active and new gamblers in 2019 and 2020, according to type of gambling and period.

Gambling type	Effects	(1) Active gamblers		(2) New gamblers	
		2019	2020	2019	2020
		Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)
Sports betting	Period:				
	pre-C	595,183 (85,845)	675,198 (68,645)	172,240 (48,724)	106,687 (23,637)
	P1	601,445 (43,820)	156,494 (40,510)	143,475 (26,130)	10,724 (3,531)
	P2	484,279 (41,929)	378,620 (61,044)	100,405 (30,099)	38,490 (15,820)
	P3	506,917 (129,532)	655,059 (203,151)	107,581 (53,942)	129,579 (125,511)
	P4	637,903 (86,316)	818,076 (129,320)	153,186 (51,236)	135,413 (59,991)

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

Horse race betting	Period:				
	pre-C	148,689 (11,080)	152,328 (6,400)	6,489 (1,550)	3,394 (835)
	P1	137,837 (4,748)	98,199 (37,697)	4,833 (911)	2,464 (1,717)
	P2	133,760 (5,840)	152,730 (4,754)	4,518 (624)	2,965 (780)
	P3	133,386 (7,427)	154,028 (8,630)	4,752 (938)	3,169 (816)
	P4	143,875 (5,292)	172,911 (14,835)	5,324 (551)	4,050 (1,252)
Poker	Period:				
	pre-C	242,787 (7,621)	271,241 (8,515)	10,974 (1,016)	6,923 (772)
	P1	222,158 (7,742)	425,812 (26,650)	7,600 (651)	27,076 (10,176)
	P2	218,039 (9,290)	333,776 (22,796)	8,491 (1,764)	7,083 (1,245)
	P3	224,008 (19,170)	295,231 (16,476)	9,420 (1,793)	6,937 (2,063)
	P4	256,307 (11,592)	344,183 (32,765)	11,074 (875)	10,181 (2,880)
Draw-based games	Period:				
	pre-C	642,705 (68,529)	730,575 (131,363)	9,161 (4,417)	13,579 (11,764)
	P1	557,855 (18,217)	877,767 (70,744)	5,357 (670)	34,154 (16,839)
	P2	615,410 (68,784)	865,243 (40,471)	8,860 (7,018)	9,745 (596)
	P3	692,479 (146,797)	941,074 (105,898)	17,424 (18,015)	17,124 (8,976)
	P4	733,820 (150,325)	1,218,492 (282,775)	15,451 (16,941)	47,196 (42,090)
Scratch games	Period:				
	pre-C	125,166 (10,991)	160,187 (23,560)	5,130 (1,143)	6,779 (3,482)
	P1	112,610 (5,339)	225,825 (25,335)	3,977 (351)	14,449 (5,539)
	P2	116,737 (12,177)	186,883 (9,638)	5,282 (2,421)	5,534 (452)
	P3	131,914 (24,458)	193,742 (14,569)	6,646 (4,249)	8,668 (2,386)
	P4	145,303 (23,208)	254,981 (64,811)	6,086 (3,850)	17,141 (11,900)
Multiplayer games	Period:				
	pre-C	32,638 (2,237)	35,880 (4,357)	1,093 (190)	1,327 (502)
	P1	27,136 (1,317)	50,876 (6,992)	735 (78)	3,130 (1,168)
	P2	27,756 (3,111)	40,902 (3,248)	863 (363)	1,152 (163)
	P3	33,625 (5,558)	38,982 (2,613)	1,372 (737)	1,557 (372)
	P4	33,631 (5,102)	50,665 (11,202)	1,247 (671)	3,357 (2,097)

sd: standard deviation.

Reading key:

(1) Sports betting: In 2019, the average number of active gamblers engaged in sports betting was 595,183 (85,845) during the pre-C period.

Table 2.SI presents the estimated effects of gambling-related events on gambling activity in 2019 calculated by the models. Only the number of sports events and the amount of jackpots seem to significantly impact the gambling activity of both active and new gamblers. Specifically, as these indicators increased, the number of gamblers also increased. Thus, only final models on sports betting and draw-based games were adjusted for gambling-related events (the number of sports events and the amount of jackpots).

The evolution of the average number of active gamblers compared to the number of major events over the weeks in 2019 and 2020

are illustrated in Figures 1.SI (for sport betting) and 2.SI (for horse race betting). First, the average number of active gamblers engaged in sports betting and the number of sports events follow the same trend, i.e., as the number of sports events decreased, so did the number of gamblers, and vice versa. In contrast, we did not observe a distinct pattern regarding the average number of active gamblers engaged in horse race betting or the number of horse race events. Another notable observation from Figures 1.SI and 2.SI is the disparity in the evolution of sports and horse race events between 2019 and 2020. The number of sports events remained constant

from January 2019 until May 2019, after which it declined during the summer months, coinciding with the conclusion of football and basketball seasons. Following the resumption of sports competitions, the situation normalized until March 2020, when the majority of sports events were cancelled due to the pandemic. Sports gradually resumed until October 2020, when stability persisted until the year's end. Concerning the progression of horse race events, major differences were not highlighted between 2019 and 2020, except for the 2020 initial lockdown period (P1), during which no events occurred due to the pandemic, while events were available in 2019.

Figure 3.SI illustrates the evolution of the average number of active gamblers engaged in draw-based games compared to the maximum amount of jackpot changes over the weeks in 2019 and 2020.

Overall, we observed peaks in the average number of active gamblers during the same weeks as the major peaks in the amount of jackpots. Thus, the average number of active gamblers increased as the amount of jackpots grew during both years. However, the intensity of the jackpot peaks differed according to the periods between 2019 and 2020.

During the pre-C periods, a considerable jackpot peaked at approximately 170 million euros in 2019, while in 2020, several lower

peaks of jackpots were observed (between 60 and 140 million euros). Conversely, the average number of active gamblers remained approximately the same during the pre-C periods between 2019 and 2020.

During the P1 period, the average number of active gamblers was greater in 2020 (approximately 0.7 million) than in 2019 (approximately 0.5 million), although the average amount of jackpot peaks nearly reached the same level during both years.

During the P2 period, the average amount of jackpot peaks and the average number of active gamblers differed significantly between 2019 and 2020. 2019 was marked by a significant jackpot peak, reaching nearly 150 million euros. Conversely, in 2020, there were several peaks, but the average amount was two times lower than that in 2019. Similarly, the average number of active gamblers was greater in 2020 (approximately 0.9 million) than in 2019 (approximately 0.6 million).

The average number of active gamblers in both years seemed to be the same during the P3 periods. However, we observed two jackpot peaks, one higher than the other (reaching more than 200 million euros) in 2019, while in 2020, there were three jackpots but fewer jackpot peaks.

Finally, the average number of active gamblers was greater during the P4 period in 2020 than in 2019. The average amount of the main jackpot peak observed in 2020 (more

than 200 million euros) was also greater than that in 2019 (150 million euros).

Table 2.SI: Estimated effects of gambling-related events on gambling activity in 2019 by linear models and gamma GLMs

Gambling	Effects	(1) Active gamblers	(2) New gamblers
		2019	2019
		β (p value)	β (p value)
Sports betting	Number of sports events	23,039 (<0.001)	9,270 (<0.001)
Horse betting	Number of horse race events	210 (0.848)	43 (0.756)
Draw-based games	Maximum amount of jackpots (million)	1,642 (<0.001)	150 (<0.001)

The beta values with a statistically significant p value (<0.05) are in bold.

Reading key:

(1) Sports betting: In 2019, when the number of sports events increased by 1, the weekly average number of active gamblers engaged in sports betting increased by 23,039 gamblers ($p < 0.001$).

(1) Horse betting: The beta values are not interpretable because the p values are not statistically significant.

(1) Draw-based games: In 2019, when the amount of jackpots increased by 1 million, the weekly average number of active gamblers engaged in draw-based games increased by 1,642 gamblers.

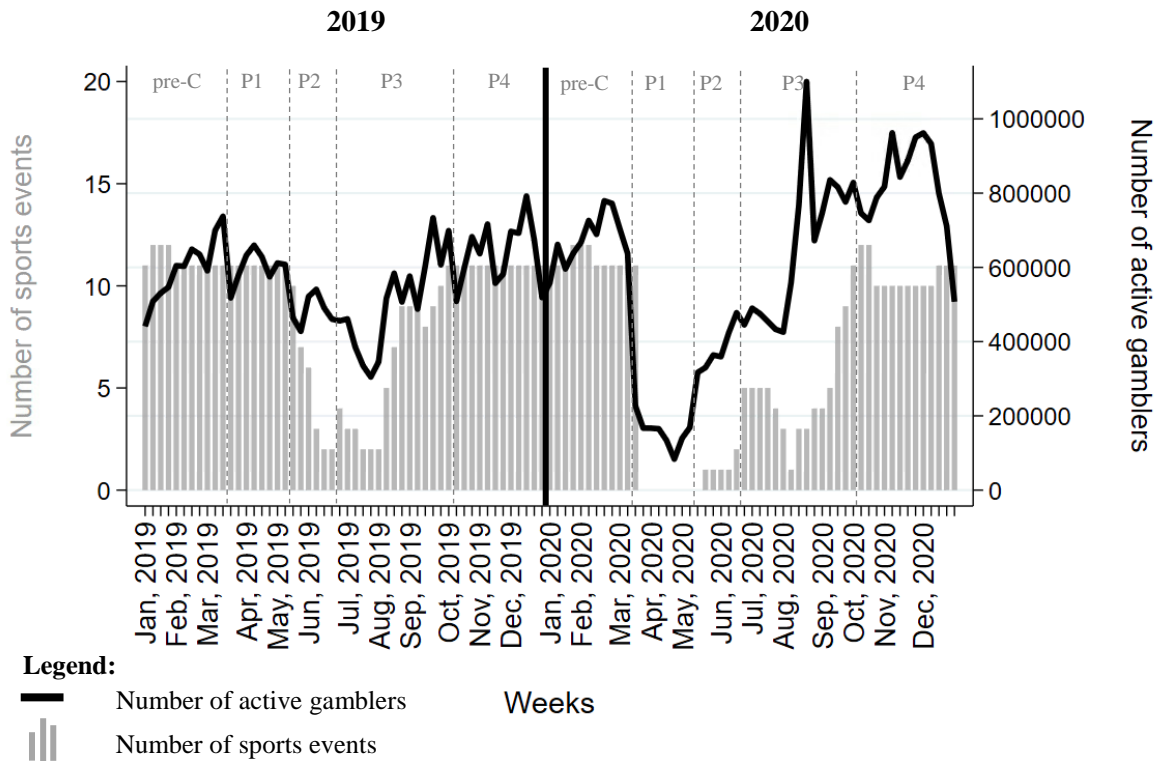


Figure 1.SI: Evolution of the average number of active gamblers engaged in sports compared to the number of major sporting events in 2019 and 2020

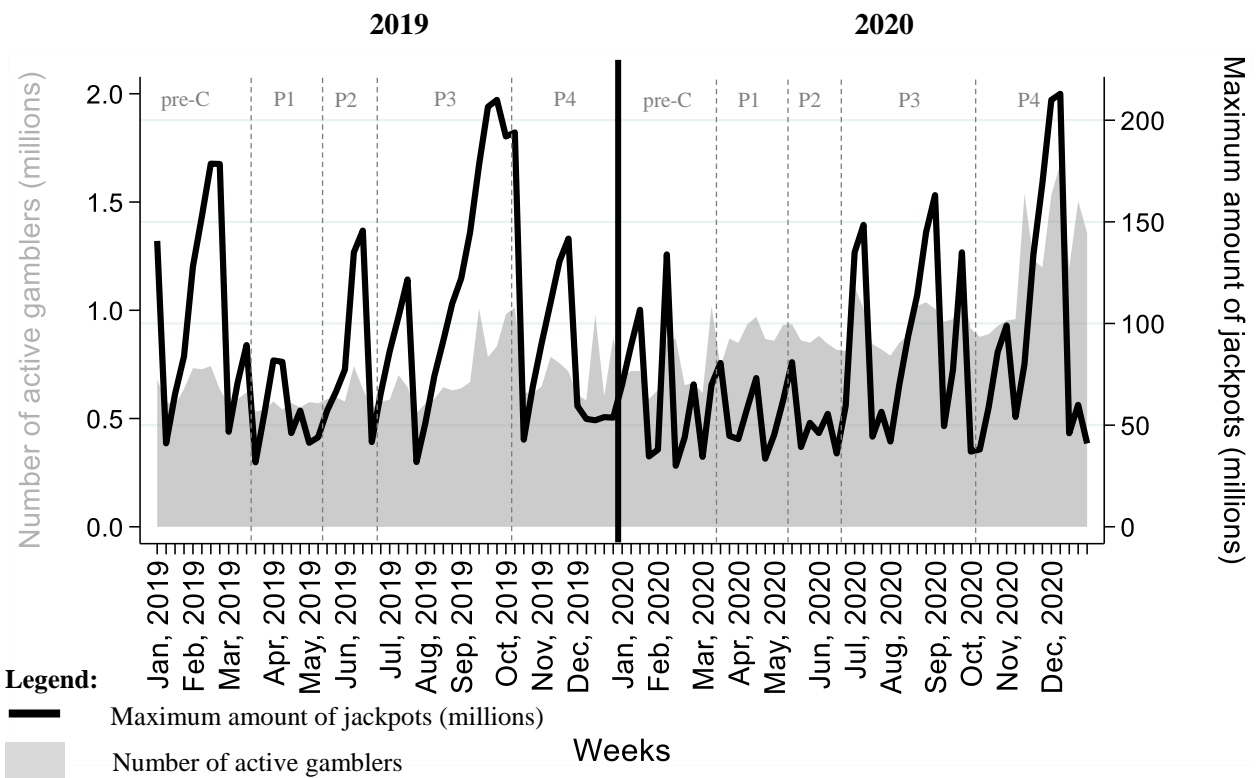


Figure 2.SI: Evolution of the average number of active gamblers engaged in horse race betting compared to the number of horse race events in 2019 and 2020

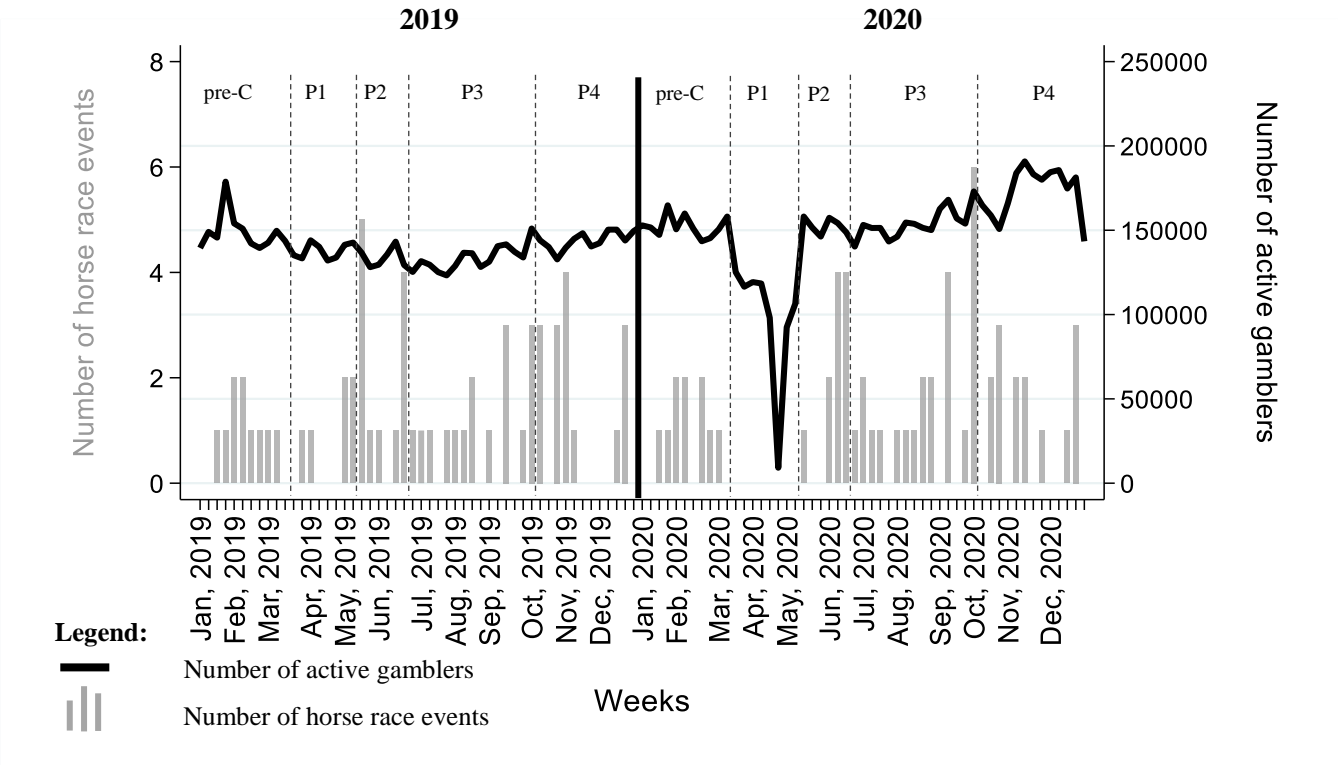








Figure 3.SI: Evolution of the average number of active gamblers engaged in draw-based games compared to the maximum amount of jackpots in 2019 and 2020.

4.3 Manuscript 3:



Gambling and COVID-19: Swedish national gambling data from a state-owned gambling sports and casino operator

Journal of Behavioral Addictions
12 (2023) 1, 230-241

MARIANNE BALEM^{1,2,3} , ANNA KARLSSON^{3,4} ,
CAROLINA WIDINGHOFF^{3,4} , BASTIEN PERROT^{1,5} ,
GAËLLE CHALLET-BOUJU^{1,2}  and ANDERS HÅKANSSON^{3,4*} 

¹ Nantes Université, CHU Nantes, UIC Psychiatrie et Santé Mentale, F-44000 Nantes, France

² Nantes Université, Univ Tours, CHU Nantes, INSERM, MethodS in Patient centered outcomes and Health ResEarch, SPHERE, F-44000 Nantes, France

³ Faculty of Medicine, Department of Clinical Sciences Lund, Psychiatry, Lund University, Lund, Sweden

⁴ Malmö Addiction Center, Region Skåne, Malmö, Sweden

⁵ Nantes University, CHU Nantes, Biostatistics and Methodology Unit, Department of Clinical Research and Innovation, F-44000, Nantes, France.

4.3.1 Abstract

Background: The lockdown of sports and gambling venues during the coronavirus disease 2019 (COVID-19) pandemic caused a fear of increased gambling on other online gambling types, with a risk for transfer to more addictive gambling than otherwise. **Aims:** This study aimed to estimate changes in gambling activity during COVID-19-affected periods among all gamblers at a Swedish state-owned gambling operator and to analyse observable sex differences. **Methods:** This study included gambling tracking data from the Swedish state-owned gambling operator Svenska Spel Sports & Casino (sports betting, bingo, casino and poker). All individuals (n = 616,245) who gambled at least once from February 10 to July 19, 2020, were included. The study period was divided into four periods according to their expected level of COVID-19 impact on gambling opportunities: one pre-COVID period and three COVID-affected periods (sports cancellation, emerging return of sports, substantial return of sports). **Findings:** Sports betting experienced an apparent decrease, followed by a gradual normalization and an end level substantially below pre-pandemic levels. For bingo, gambling levels increased upon sports interruption and then decreased with the return to normality in sports events but remained higher than baseline levels. We observed a similar trend for poker during the interruption of sports, but with a lower level than baseline levels when sports events normalized. We noticed a trend favouring casinos during the sports interruption period regarding gambling intensity but not wagering levels. **Conclusions:** Dramatic changes in the

content of the gambling market may divert some gamblers to other gambling types, but maintained effects could not be demonstrated.

4.3.2 Introduction

The global spread of SARS-CoV-2, which causes coronavirus disease 2019 (COVID-19), has posed a major threat to public health, including mental health, worldwide (Holmes et al., 2020; Mahase, 2020; Wang, Horby, Hayden, & Gao, 2020). Gambling disorder is one of the specific mental health challenges mentioned by researchers and policy-makers as potentially being associated with changes occurring during the pandemic. In the early phases of the spread of the virus, the interruption of sports events and the lockdown of gambling venues and restaurants in many countries led to a fear of increased gambling in other types of online games, with a fear of transferring to even more addictive gambling types than otherwise (Auer & Griffiths, 2021; Håkansson & al, 2020). For example, this led to special regulations in several countries to mitigate the risk of worsening gambling habits (Håkansson & Widinghoff, 2021).

Thereafter, the research experience of gambling-related behaviours in relation to the pandemic has been mixed. Auer and Griffiths studied gambling data from more than 130,000 Swedish gamblers using anonymous online commercial casino services from January through May 2020. Although almost half of the study period was not affected by

any substantial COVID-19-related changes in society, the study concluded that there was no obvious increase in online casino gambling. While the number of unique online casino gamblers increased over the study period, there was no indication of an increase in gamblers with the highest gambling levels (Auer & Griffiths, 2021). A similar study that included an anonymous commercial gambling operator for sports betting and online casino services demonstrated a decrease in sports betting during the interruption of sports and a limited increase in online casino gambling. During a study period that ended on April 8, 2020, a net decrease in gambling activity was observed for this specific operator (Lindner, Forsström, Jonsson, Berman, & Carlbring, 2020). Survey data from Australia did not detect any increase in gambling during the pandemic (Gainsbury, Swanton, Burgess, & Blaszczynski, 2021). Furthermore, among Ontario land-based casino gamblers, a shift towards online gambling was seen only in the subgroup with previous online gambling experience (Price, 2020). Altogether, gambling markets worldwide demonstrated a diverse picture with respect to COVID-19-related consequences on gambling. One important perspective is the experience of problem gamblers who reported subjective relief during lockdown measures when land-

based gambling venues were unavailable (Gainsbury et al., 2021).

On the other hand, in a nationwide study on gambling operators in Sweden using taxation records, only a moderate change was observed regarding sports betting revenues despite a substantial structural decrease in sports events worldwide (Håkansson, 2020a). Subjective self-reported data in web surveys, carried out in April/May 2020 and in November 2020, also demonstrated that a self-reported increase in gambling during the pandemic was markedly more common among problem gamblers (Håkansson, 2020b; Håkansson & Widinghoff, 2021).

Altogether, it can be concluded that overall gambling activity in society may not have increased during the early phases of the pandemic, which is in contrast to what was somewhat expected, and that the results are mixed regarding whether people with intense gambling habits and gambling problems may be at particularly high risk of increasing their gambling habits during the pandemic.

Among the studies on gambling and COVID-19 carried out thus far, few have been able to address head to head a longer course of gambling for different types of gambling, which intuitively should be affected by pandemic-related changes in society. The studies by Auer & Griffiths and Auer et al. demonstrated that a pronounced decrease in sports betting corresponded only to limited

increases in online casino gambling (Auer, Malischnig, & Griffiths, 2020; Auer & Griffiths, 2021). Additionally, studies thus far have not, to a major extent, been able to assess gambling activity in relation to different phases of the pandemic, in which gambling opportunities during the first months of COVID-19 changed dramatically over a brief period.

In addition, beyond the pandemic, there are specificities in online and offline gambling according to sex. McCormack et al. studied this contrast among online gamblers, and the results showed significant differences in the duration of gambling sessions, motivation gambling and feelings about gambling according to sex (McCormack, Shorter, & Griffiths, 2014). Additionally, gambling type preferences differ according to sex. Women tend to prefer nonstrategic gambling activities such as EGMs, scratch games and lottery activities, while men prefer strategic gambling activities such as sports betting and poker (Blanco, Hasin, Petry, Stinson, & Grant, 2006; Wenzel & Dahl, 2009). It therefore seems necessary to consider the specificities and differences according to sex in this study.

Moreover, Binde et al. demonstrated that the level of gambling involvement (i.e., participation in multiple forms of gambling) is positively associated with both the intensity of gambling and problem gambling and that this latter association is influenced by

participation in specific forms of gambling compared to others (Binde, Romild, & Volberg, 2017). Thus, it is essential to control for the level of gambling involvement when assessing changes in gambling behaviours due to the COVID-19 pandemic.

Therefore, in the present study, we aimed to assess changes in gambling behaviours for different types of gambling, all within one major gambling operator owned by the Swedish state: Svenska Spel Sports & Casino. We aimed to describe potential changes over time in relation to baseline gambling activity and to different phases of COVID-19-related effects on sports availability during the first pandemic-affected months of 2020. Our hypothesis was that gambling activity through sports betting, bingo, casinos and poker would differ in relation to the sudden and nearly total interruption of sports and would then change again with an increasing degree of the return of sports. One part of this hypothesis was that nonsports-related online gambling may have increased in response to the interruption of sports and may then have normalized upon the return of sports. Another part of the hypothesis was that the transfer of gambling activity from sports-related to nonsports-related online gambling would differ according to sex in terms of intensity and frequency. We thus aimed to estimate changes in gambling activity during the COVID-19-affected periods among all gamblers at

Svenska Spel and analyse observable sex differences. The hypotheses were defined prior to calculating the results (Balem, Karlsson, et al., 2022).

4.3.3 Methods

Participants

This study included all gambling carried out by customers of the Sports & Casino subdivision of the Swedish state-owned gambling operator Svenska Spel. Svenska Spel is owned entirely by the Swedish state. Its Sports & Casino subdivision includes gambling for which the state-owned operator is among the licenced operators in a commercial market. Other subdivisions of Svenska Spel include chance-based number games and lotteries (Svenska Spel Tur, ‘chance’) and the state monopoly of land-based electronic gambling machines and land-based casino gambling (Casino Cosmopol), the latter consisting of three land-based casinos in the three largest cities of the country. Svenska Spel offers online gambling through sports betting (live and nonlive, and for bets made either or in land-based gambling stores) and bingo, casinos and poker gambling.

Measures

Data collected from Svenska Spel included sex, age and tracked gambling data of gamblers from calendar week 7 (starting on February 10, 2020) through calendar week 29

(ending on July 19, 2020). This study included all individuals ($n = 616,245$) who gambled at least once during this period using any of the gambling services provided by the operator. Among these individuals, 499,519 (81%) were men, 116,709 (19%) were women, and sex data were missing for 18 individuals. The median age was 51 years. We described gamblers according to gambling type (Table 1). Tracked gambling data were aggregated weekly over 23 weeks, and two indicators of gambling behaviours were selected for the analysis: the amount of money wagered (gambling intensity indicator) and the number of gambling days (gambling frequency indicator) (Table 2).

The COVID-19 period assessed in the present study was divided into four periods according to the expected level of impact of COVID-19 on gambling opportunities through the Sports & Casino subdivision:

- Weeks 7–10 (February 10-March 8): Pre-COVID period (here named pre-C), without major impact on the content and possibility of gambling through the Sports & Casino subdivision.
- Weeks 11–20 (March 9-May 17): First COVID-affected period (here named P1). For example, the Italian and French soccer leagues were cancelled on March 9 and March 13, respectively, the Swedish ice hockey

league was suspended on March 15, and the country advised individuals to begin working from home on March 16 (Håkansson, 2020a). Additionally, on April 1, the state-owned land casinos were closed because of the pandemic.

- Weeks 21–24 (May 18-June 14): Second COVID-affected period (P2), when sports gradually began to return; after the start of the Korean soccer league on May 9, the first major European soccer league (Germany) started on May 16. Thereafter, the Spanish league restarted on June 11 (Håkansson, 2020a).
- Weeks 25–29 (June 15-July 19): Third COVID-affected period (P3), when sports returned substantially. The Swedish soccer league started on June 14. The common weekend soccer betting Stryktipset (a major part of sports-related betting in Sweden) opened for betting on June 17, and the first games took place on June 20.

Statistical analysis

We used linear mixed models and generalized linear mixed models (GLMMs) to analyse changes in gambling activity for each of the COVID-19-affected periods (P1, P2, P3) in comparison to the pre-COVID period (pre-C). Analyses were performed separately for each type of gambling (sports betting,

bingo, casinos and poker) and for two indicators of gambling behaviours: the amount of money wagered (in Swedish currency, SEK) and the number of gambling days.

We chose the link function according to the nature of the dependent gambling behaviour variable. For the amount of money wagered, which was a quantitative continuous variable, a log-transformation ($\log(x+1)$) was used to overcome the non-normal distribution of the data. Then, linear mixed models were estimated (West, 2021). For the number of gambling days, which was a count variable, GLMMs for the negative binomial family were implemented to take into account the overdispersion of the data (Booth, Casella, Friedl, & Hobert, 2003; Lawless, 1987). Random effects were included to consider the repeated data design. Moreover, the models included the following covariates: sex (male or female), age (years), the level of gambling involvement (from 1 to 4 different games played during the study period) and whether the individual had gambled during the last week of February 2020, in which the monthly salary is dispended in Sweden. To visualize the differential impact of COVID-19-affected periods on sex and the level of gambling involvement, we included the interaction between these variables and the COVID-19-affected periods in the analyses when Wald tests for them and the COVID-19-affected

period variables were significant in the models without interaction terms. *P* values were adjusted for multiple testing with Benjamini & Hochberg correction (Benjamini & Hochberg, 1995; Glickman, Rao, & Schultz, 2014). Analyses were performed using Stata version 16.0 (function `mixed()` and `menbreg()`). The analysis code is provided in the Open Science Framework project attached to this study (Balem, Karlsson, et al., 2022).

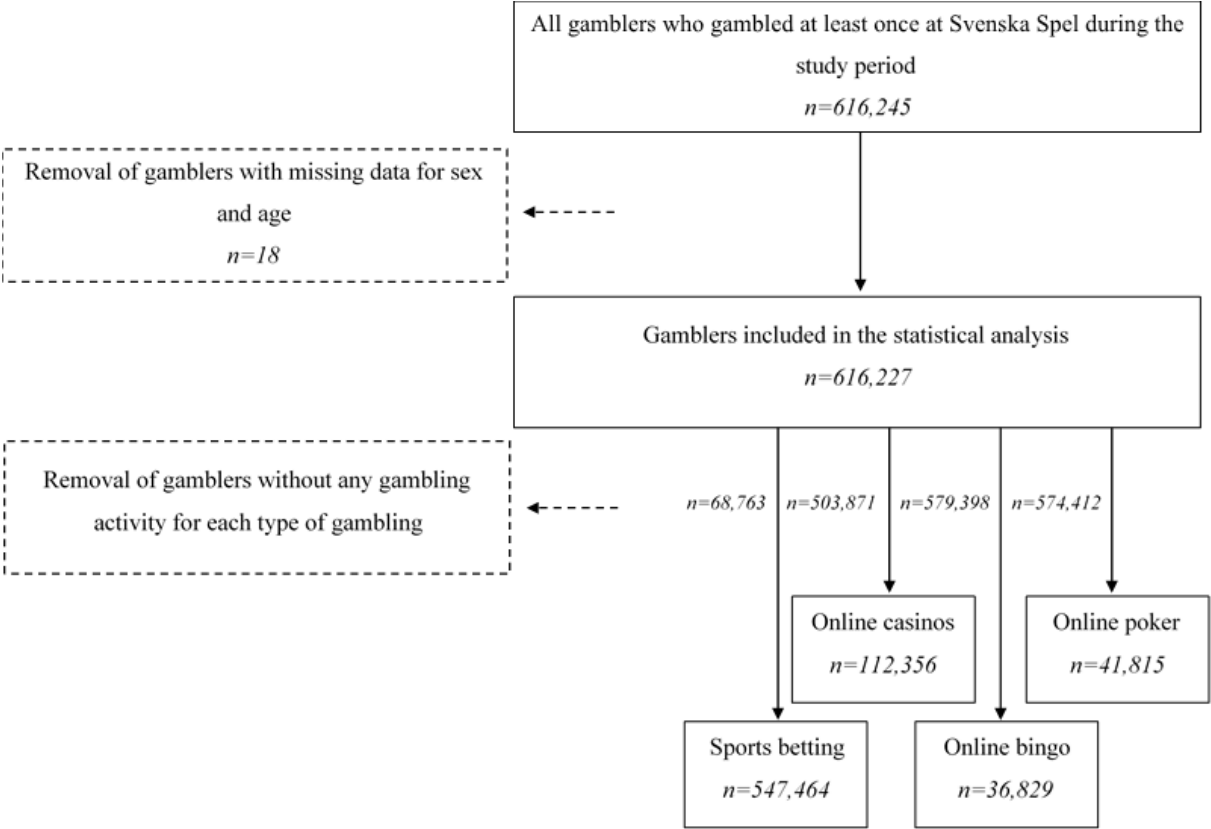
Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. The Swedish Ethical Review Authority approved this study.

4.3.4 Results

A flowchart of the selection process of the participants included in each model is provided in Figure 1.

Figure 1: Flowchart of the selection process for the gamblers included in the analyses



Description of gamblers and gambling behaviours

As described in Table 1, the population consisted predominantly of male individuals (82.8%), and this pattern was seen throughout all categories of gambling, especially for sports betting, casinos and poker. Gamblers who were engaged in casinos and poker were younger. Gambling during the salary week was markedly higher for gamblers engaged in sports betting (57.5%) than for gamblers engaged in bingo (20.7%), casinos (28%) and poker (22.8%). The customers of Svenska Spel were largely represented by sports betting gamblers. Indeed, almost 89% of the gamblers participated in sports betting at least

once during the study period, compared to 6%, 18%, and 7% who participated in bingo, casinos and poker respectively.

As shown in Table 2, the amounts of money wagered by casinos and poker gamblers were higher than those wagered by sports betting and bingo gamblers, with similar results seen for the number of gambling days.

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

Table 1: Description of gamblers according to the type of gambling

	Sports betting^a n=547,464	Bingo^a n=36,829	Casinos^a n=112,356	Poker^a n=41,815
Sex (n, %)				
<i>Men</i>	453,064 (82.8%)	21,421 (58.2%)	88,805 (79.0%)	38,698 (92.6%)
<i>Women</i>	94,400 (17.2%)	15,408 (41.8%)	23,551 (21.0%)	3,117 (7.4%)
Age (median, [min-max])	52 [18-102]	50 [18-92]	39 [18-92]	39 [18-92]
Gambling during the February salary week (n, %)				
<i>Yes</i>	314,932 (57.5%)	7,630 (20.7%)	31,413 (28.0%)	9,519 (22.8%)
<i>No</i>	232,532 (42.5%)	29,199 (79.3%)	80,943 (72.0%)	32,296 (77.2%)
Level of involvement (n, %)				
<i>Only one gambling type</i>	458,848 (83.8%)	7,047 (19.1%)	36,184 (32.2%)	14,186 (33.9%)
<i>2 different gambling type</i>	68,694 (12.6%)	16,722 (45.4%)	56,460 (50.2%)	17,226 (41.2%)
<i>3 different gambling type</i>	18,046 (3.3%)	11,184 (30.4%)	17,836 (15.9%)	8,527 (20.4%)
<i>All gambling type^b</i>	1,876 (0.3%)	1,876 (5.1%)	1,876 (1.7%)	1,876 (4.5%)

^aRepresent the number of gamblers engaged for each types of gambling. A gambler can be represented in more than one type of gambling because they can engage in several types of gambling. ^bGamblers who bet on sports and played bingo, casino games and poker at least once during the study period.

Table 2: Description of the two indicators of gambling behaviours for each type of gambling

Gambling indicators	Gambling type*	Min	Max	Q1	Q2	Q3	P90	Mean (sd)
Amount of money wagered (SEK)	Sports betting (12,591,672)*	0	739,869	0	0	0	182	132.4 (1,622)
	Bingo (847,067)*	0	41,357	0	0	0	143	89 (492)
	Casinos (2,584,188)*	0	33,075,936	0	0	3	2,445	2,170 (33,348)
	Poker (961,745)*	0	6,231,265	0	0	0	929	2,204 (37,418)
Number of gambling days	Sports betting (12,591,672)*	0	7	0	0	0	2	0.5 (1.3)
	Bingo (847,067)*	0	7	0	0	0	2	0.5 (1.3)
	Casinos (2,584,188)*	0	7	0	0	1	2	0.6 (1.4)
	Poker (961,745)*	0	7	0	0	0	3	0.7 (1.6)

Q1 = first quartile; Q2 = median; Q3 = third quartile; P90 = 90th percentile; sd = standard deviation.

*: corresponds to the total number of observations for each type of gambling. For example, there were 12,591,672 observations for the gamblers engaged in sports betting (i.e., 547,464 gamblers * 23 weeks = 12,591,672 observations).

Linear mixed models & GLMMs

The predicted means and delta coefficients for differences were estimated with each model according to sex and are presented in Table 3.

The predicted means are given for the Pre-C period, and the delta coefficients are given to represent the differences between the Pre-C and the other periods. The full results of the models are provided in the Supplementary material.

The interruption of sports events had an important impact on the frequency and intensity of the gambling activity of sports betting gamblers, particularly during the C1 period. Sports betting decreased strongly during the C1 period compared to the pre-C period; it also decreased moderately during the C2 and C3 periods. The differences among the C1, C2 and C3 periods compared to the pre-C period were higher among men than among women. For the gamblers engaged in bingo, the predicted means of the two indicators increased in the three periods compared to the pre-C period, but the increases were higher in the C1 period. Moreover, we observed that the predicted means for women were higher in the C3 period than in the pre-C period despite the return to normal for sports events. The differences among the periods were more pronounced for women than for men. Regarding the gamblers engaged in casinos,

the pandemic and the interruption of sports did not seem to impact the frequency of gambling practices. For the intensity of gambling practices, the predicted means for women were highest in the three periods compared to the pre-C period. For men, there was an increase only for the C1 period compared with the pre-C period. Finally, for the gamblers engaged in poker, the predicted means for the two indicators widely increased during the C1 period compared to the pre-C period. These means decreased in the C2 and C3 periods until they returned to the same level as those of the pre-C period for both men and women.

Table 3: Results of the predicted means and delta coefficients for differences (Δ) according to sex estimated by linear mixed models and GLMMs

(a). Money wagered (SEK)					
Gambling type	Effects	All gamblers	Men	Women	
		Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]	
Sports betting	Period:				
	<i>Pre-C</i>	280 [279; 281] ^{ref}	316 [315; 318] ^{ref}	124 [123; 125.5] ^{ref}	
	<i>P1</i>	-251 [-251; -250]***	-288 [-289; -287]***	-96 [-97; -95]***	
	<i>P2</i>	-235 [-236; -234]***	-271 [-272; -269]***	-91 [-92; -79]***	
Bingo	Period:				
	<i>Pre-C</i>	48 [47; 49] ^{ref}	42 [41; 43] ^{ref}	54 [53; 55.5] ^{ref}	
	<i>P1</i>	+10 [+10; +11]***	+8 [+8; +9]	+12 [+12; +12]***	
	<i>P2</i>	+9 [+8; +9]***	+7 [+7; +7]**	+11 [+11; +11]***	
Casinos	Period:				
	<i>Pre-C</i>	4,284 [4,231; 4,336] ^{ref}	4,271 [4,212; 4,330] ^{ref}	4,318 [4,231; 4,334] ^{ref}	
	<i>P1</i>	+220 [+216; +224]***	+197 [+192; +201]*	+311 [+288; +405]***	
	<i>P2</i>	+45 [+44; +45]	-24 [-25; -24]***	+318 [+280; +427]***	
Poker	Period:				
	<i>Pre-C</i>	1,215 [1,178; 1,251] ^{ref}	1,217 [1,180; 1,255] ^{ref}	1,187 [1,102; 1,271] ^{ref}	
	<i>P1</i>	+708 [+689; +727]***	+733 [+713; +753]***	+424 [+404; +444]***	
	<i>P2</i>	+124 [+121; +128]***	+134 [+130; +138]***	+17 [+16; +18]	
Poker	<i>P3</i>	-56 [-59; -54]***	-54 [-56; -52]	-91 [-99; -82]**	
	(b). Gambling days				
	Gambling type	Effects	All gamblers	Men	Women
			Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]
Sports betting	Period:				
	<i>Pre-C</i>	1.3 [1.3; 1.3] ^{ref}	1.3 [1.3; 1.4] ^{ref}	0.9 [0.9; 0.9] ^{ref}	
	<i>P1</i>	-1.1 [-1.1; -1.1]***	-1.1 [-1.1; -1.1]***	-0.8 [-0.8; -0.8]***	
	<i>P2</i>	-1 [-1; -1]***	-0.9 [-1; -0.9]***	-0.7 [-0.7; -0.7]***	
Bingo	Period:				
	<i>Pre-C</i>	0.4 [0.4; 0.4] ^{ref}	0.3 [0.3; 0.4] ^{ref}	0.5 [0.5; 0.5] ^{ref}	
	<i>P1</i>	+0.1 [+0.1; +0.2]***	+0.2 [+0.1; +0.2]***	+0.1 [+0.1; +0.1]***	
	<i>P2</i>	+0.1 [+0.1; +0.1]***	+0.1 [+0.1; +0.1]	+0.1 [+0.1; +0.1]***	
Casinos	Period:				
	<i>Pre-C</i>	0.6 [0.6; 0.6] ^{ref}	0.6 [0.6; 0.6] ^{ref}	0.6 [0.6; 0.6] ^{ref}	
	<i>P1</i>	0 [0; 0]	+0.1 [0; +0.1]**	+0.1 [0; +0.1]**	
	<i>P2</i>	0 [0; 0]	+0.1 [0; +0.1]***	+0.2 [+0.2; +0.2]***	
Poker	Period:				
	<i>Pre-C</i>	0.7 [0.6; 0.7] ^{ref}			
	<i>P1</i>	+0.2 [+0.2; +0.3]***			
	<i>P2</i>	+0.1 [+0.1; +0.1]***			
Poker	<i>P3</i>	-0.1 [-0.1; 0]***			

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS: A COMPREHENSIVE-LEVEL APPROACH

The stars correspond to the significance of the p value for the comparison of the periods (the pre-C period is the reference period). ref: reference. *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$. Delta coefficients for differences with a p value that was statistically significant (< 0.05) are in bold. At the time of the analysis, a currency exchange rate of 1.00 SEK = \$0.088 = €0.091 was applicable.

Reading key:

(a). Sports betting: During the P1, P2 and P3 periods, all gamblers who participated at least once in sports betting wagered, on average, 251 SEK [250; 252], 235 SEK [234; 236] and 168 SEK [167; 169] less than during the pre-C period, respectively. During the P1, P2 and P3 periods, men wagered, on average, 288 SEK [287; 289], 271 SEK [269; 272] and 194 SEK [193; 195] less than during the pre-C period, respectively, and women wagered, on average, 96 SEK [95; 97], 91 SEK [79; 90] and 66 SEK [65; 67] less than during the pre-C period, respectively.

(b). Sports betting: During the P1, P2 and P3 periods, all gamblers who participated at least once in sports betting gambled, on average, 1.1 [1.1; 1.1], 1 [1; 1] and 0.5 [0.5; 0.5] days less than during the pre-C period, respectively. During the P1, P2 and P3 periods, men gambled, on average, 1.1 [1.1; 1.1], 0.9 [0.9; 1] and 0.5 [0.5; 0.5] days less than during the pre-C period, respectively, and women gambled, on average, 0.8 [0.8; 0.8], 0.7 [0.7; 0.7] and 0.4 [0.4; 0.4] days less than during the pre-C period, respectively.

The predicted means and delta coefficients for differences were estimated with each model according to the level of gambling involvement and are presented in Table 4.

The predicted means are given for gamblers who engaged in only one gambling activity, and the delta coefficients are given to represent the differences between gamblers engaged in one activity and gamblers engaged in two, three or all other gambling activities.

The intensity and frequency of gambling seemed to correlate positively with the increase in the level of gambling involvement for gamblers engaged in sports betting and casinos. Gamblers wagered almost twice as much when they gambled on all types of gambling compared to gamblers who gambled only in sports betting or casinos.

Conversely, gamblers engaged in bingo who gambled on all types of gambling seemed to gamble with lower intensity than those who gambled only on bingo. Changes in the frequency of gambling were statistically uninterpretable.

Finally, the levels of gambling involvement for gamblers engaged in poker were statistically not interpretable for the intensity and the frequency of gambling.

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

Table 4: Results of the predicted means and delta coefficients for differences (Δ) according to the level of gambling involvement estimated by linear mixed models and GLMMs

(a). Money wagered (SEK)					
Gambling type	Effects	pre-C	P1	P2	P3
		Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]
Level of involvement:					
Sports betting	<i>Only sports betting</i>	265 [263; 266] ^{ref}	26 [26; 26] ^{ref}	40 [40; 41] ^{ref}	40 [40; 41] ^{ref}
	<i>2 different gambling types</i>	+144 [+141; +146] ^{***}	+14 [+14; +14] ^{***}	+22 [+22; +22] ^{***}	+22 [+22; +22] ^{***}
	<i>3 different gambling types</i>	+244 [+237; +252] ^{***}	+24 [+23; +25] ^{***}	+37 [+36; +38] ^{***}	+37 [+36; +38] ^{***}
	<i>All gambling types</i>	+505 [+467; +543] ^{***}	+50 [+47; +53] ^{***}	+77 [+71; +83] ^{***}	+77 [+71; +83] ^{***}
Bingo	<i>Only bingo</i>	53 [51; 55] ^{ref}	53 [51; 55] ^{ref}	63 [61; 65] ^{ref}	56 [54; 57] ^{ref}
	<i>2 different gambling types</i>	-7 [-7; -6] ^{***}	-7 [-7; -6] ^{***}	-8 [-9; -7] ^{***}	-7 [-7; -6] ^{***}
	<i>3 different gambling types</i>	-7 [-8; -7] ^{***}	-7 [-8; -7] ^{***}	-9 [-9; -8] ^{***}	-8 [-8; -7] ^{***}
	<i>All gambling types</i>	-4 [-5; -3] ^{***}	-4 [-5; -3] ^{***}	-5 [-6; -4] ^{***}	-4 [-6; -3] ^{***}
Casinos	<i>Only casinos</i>	3,786 [3,694; 3,878] ^{ref}	3,986 [3,982; 4,080] ^{ref}	3,843 [3,749; 3,936] ^{ref}	4,075 [3,977; 4,173] ^{ref}
	<i>2 different gambling types</i>	+383 [+377; +392] ^{***}	+404 [+377; +392] ^{***}	+389 [+383; +395] ^{***}	+413 [+406; +419] ^{***}
	<i>3 different gambling types</i>	+1,465 [+1,404; +1,525] ^{***}	+1,542 [+1,479; +1,605] ^{***}	+1,487 [+1,425; +1,548] ^{***}	+1,576 [+1,511; +1,548] ^{***}
	<i>All gambling types</i>	+4,201 [+3,633; +4,715] ^{***}	+4,394 [+3,823; +4,965] ^{***}	+4,236 [+3,687; +4,786] ^{***}	+4,493 [+3,909; +5,076] ^{***}
Poker	<i>Only poker</i>	1,219 [1,174; 1,264] ^{ref}	1,928 [1,859; 1,998] ^{ref}	1,343 [1,294; 1,393] ^{ref}	1,162 [1,119; 1,204] ^{ref}
	<i>2 different gambling types</i>	-4 [-6; -2]	-7 [-9; -4]	-4 [-6; -3]	-4 [-6; -2]
	<i>3 different gambling types</i>	0 [-8; +9]	0 [-13; +14]	0 [-9; +10]	0 [-8; +8]
	<i>All gambling types</i>	-48 [-95; -0]	-76 [-152; -0]	-53 [-105; -1]	-46 [-91; -0]
(b). Gambling days					
Gambling type	Effects	pre-C	P1	P2	P3
		Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]	Predicted mean & Δ [95% CI]
Sports betting	<i>Only sports betting</i>	1.2 [1.2; 1.2] ^{ref}	0.2 [0.2; 0.2] ^{ref}	0.3 [0.3; 0.3] ^{ref}	0.7 [0.7; 0.7] ^{ref}
	<i>2 different gambling types</i>	+0.6 [+0.6; +0.7] ^{***}	0 [0; 0] ^{***}	+0.2 [+0.2; +0.2] ^{***}	+0.4 [+0.4; +0.4] ^{***}
	<i>3 different gambling types</i>	+1 [+1; +1] ^{***}	+0.1 [+0.1; +0.1] ^{***}	+0.3 [+0.3; +0.3] ^{***}	+0.7 [+0.7; +0.7] ^{***}
	<i>All gambling types</i>	+1 [+1; +1] ^{***}	+0.1 [+0.1; +0.1] ^{***}	+0.3 [+0.3; +0.3] ^{***}	+0.7 [+0.7; +0.7] ^{***}

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

	<i>All gambling types</i>	+1.7 [+1.6; +1.9]***	+0.2 [+0.2; +0.2]***	+0.5 [+0.5; +0.5] ***	+1.1 [+1.1; +1.1]***
	<i>Only bingo</i>	0.4 [0.4; 0.5] ^{ref}	0.6 [0.5; 0.6] ^{ref}	0.6 [0.5; 0.6] ^{ref}	0.5 [0.5; 0.5] ^{ref}
Bingo	<i>2 different gambling types</i>	0 [0; 0]***	-0.1 [-0.1; 0]***	-0.1 [-0.1; 0]***	0 [0; +0.1]***
	<i>3 different gambling types</i>	0 [0; 0]**	-0.1 [-0.1; 0]**	-0.1 [-0.1; 0]**	+0.1 [+0.1; +0.1]**
	<i>All gambling types</i>	0 [0; +0.1]	0 [-0.1; 0]	-0.1 [-0.1; 0]	+0.1 [+0.1; +0.1]
	<i>Only casinos</i>	0.5 [0.5; 0.6] ^{ref}	0.5 [0.5; 0.5] ^{ref}	0.5 [0.5; 0.6] ^{ref}	0.6 [0.6; 0.6] ^{ref}
Casinos	<i>2 different gambling types</i>	+0.1 [+0.1; +0.1]***	+0.1 [+0.1; +0.1]***	+0.1 [+0.1; +0.1]***	+0.1 [+0.1; +0.1]***
	<i>3 different gambling types</i>	+0.3 [+0.2; +0.3]***	+0.2 [+0.2; +0.3]***	+0.3 [+0.2; +0.3]***	+0.3 [+0.3; +0.3]***
	<i>All gambling types</i>	+0.5 [+0.4; +0.5]***	+0.5 [+0.4; +0.5]***	+0.5 [+0.4; +0.5]***	+0.5 [+0.4; +0.6]***
	<i>Only poker</i>	0.7 [0.6; 0.7] ^{ref}	0.9 [0.9; 1] ^{ref}	0.7 [0.7; 0.7] ^{ref}	0.6 [0.6; 0.7] ^{ref}
Poker	<i>2 different gambling types</i>	0 [0; 0]	0 [0; 0]	0 [0; 0]	0 [0; 0]
	<i>3 different gambling types</i>	0 [0; 0]	0 [0; 0]	0 [0; 0]	0 [0; 0]
	<i>All gambling types</i>	0 [0; 0]	0 [0; 0]	0 [0; 0]	0 [0; 0]

The stars correspond to the significance of the p value for the comparison of the level of involvement (with only one gambling activity used as the reference period). ref: reference. *: p<0.05; **: p<0.01; ***: p<0.001. Delta coefficients for differences with a p value that was statistically significant (<0.05) are in bold. a: Gamblers who bet on sports and played bingo, casino games and poker at least once during the study period. At the time of the analysis, a currency exchange rate of 1.00 SEK = \$0.088 = €0.091 was applicable. Level of involvement (example for sports betting): “Only sports betting”: individuals who participated only in sports betting during the study period; “Two different types of gambling”: individuals who participated at least once in sports betting and another type of gambling (casinos, bingo or poker); “Three different types of gambling”: individuals who participated at least once in sports betting and in two other types of gambling (casinos, bingo or poker); “All types of gambling”: individuals who participated at least once in sports betting, casinos, bingo and poker.

Reading key:

(a). Sports betting: During the P1 period, gamblers who participated in two different types of gambling wagered, on average, 143.6 SEK [141; 146.1] more than gamblers who bet only on sports. Gamblers who participated in three different types of gambling wagered, on average, 244.3 [236.8; 251.6] more than gamblers who bet only on sports. Gamblers who participated in all types of gambling wagered, on average, 505.2 [466.6; 543.2] more than gamblers who bet only on sports.

(b). Sports betting: During the P1 period, gamblers who participated in two different types of gambling gambled, on average, 0.6 [0.6; 0.7] days more than gamblers who bet only on sports. Gamblers who participated in three different types of gambling gambled, on average, 1 [1; 1] day more than gamblers who bet only on sports. Gamblers who participated in all types of gambling gambled, on average, 1.7 [1.6; 1.9] days more than gamblers who bet only on sports.

Figure 2 compares the observed means and the predicted means estimated by the models over the weeks for each period according to sex. The peak observed during week 23 corresponded to a holiday jackpot with an unusually high amount for the national day in Sweden. Additionally, regarding the fluctuations for casinos, each “peak” approximately corresponded to the last week of the month and the first week of the next month, i.e., during the weeks when Swedish employees receive their salary. Figure 3 represents the observed means of gambling activity according to the gamblers' regularity over the weeks. For example, a gambler who gambled at least once through sports betting during each of the four periods was considered a regular sports betting gambler compared with a gambler who gambled only once during the entire study period. Overall, the trends were similar between regular and nonregular gamblers for all gambling types and the two indicators. However, the increase in money wagered and the number of gambling days during the C1 period for bingo and poker were more widely pronounced for regular gamblers than for others. The same pattern is seen for the increase in sports betting during the C3 period. Regarding casinos, the fluctuations were more marked for regular gamblers.

Figure 4 represents the number of gamblers for each type of gambling according

to sex. The number of gamblers engaged in poker markedly increased during the C1 period, especially among men. For bingo, the number of gamblers slightly increased during the C1 period compared to the pre-C period, and there was no marked difference according to sex. Regarding the gamblers engaged in sports betting, the number of men fully increased during the C3 period compared to the number of women. Finally, for the gamblers engaged in casinos, the number of gamblers and the fluctuations were more marked among men than among women.

Figure 2: Representation of the observed and predicted means for each type of gambling and for the two indicators of gambling behaviours

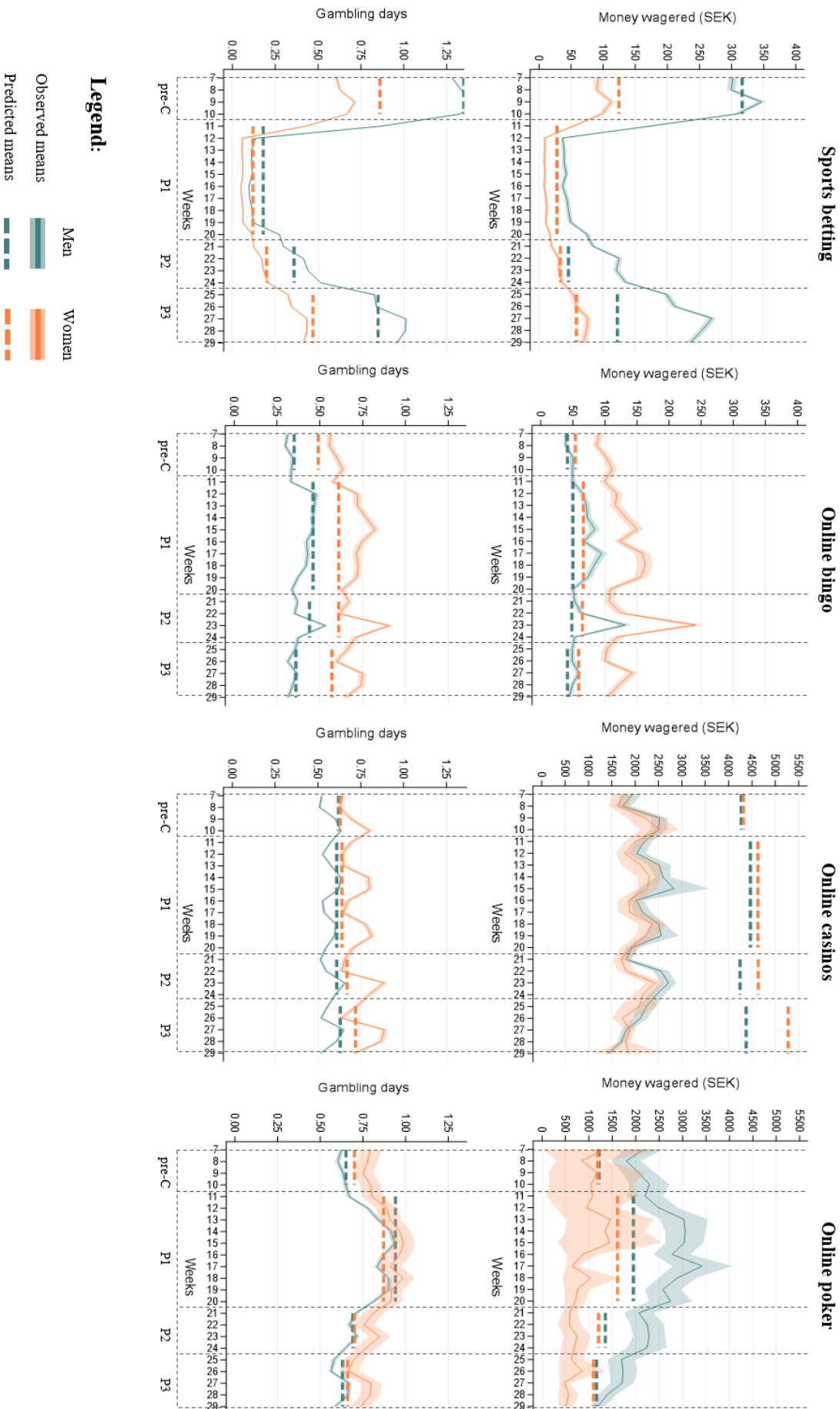


Figure 3: Representation of the observed means according to the gamblers' regularity for each gambling type and for the both indicators of gambling behaviors.

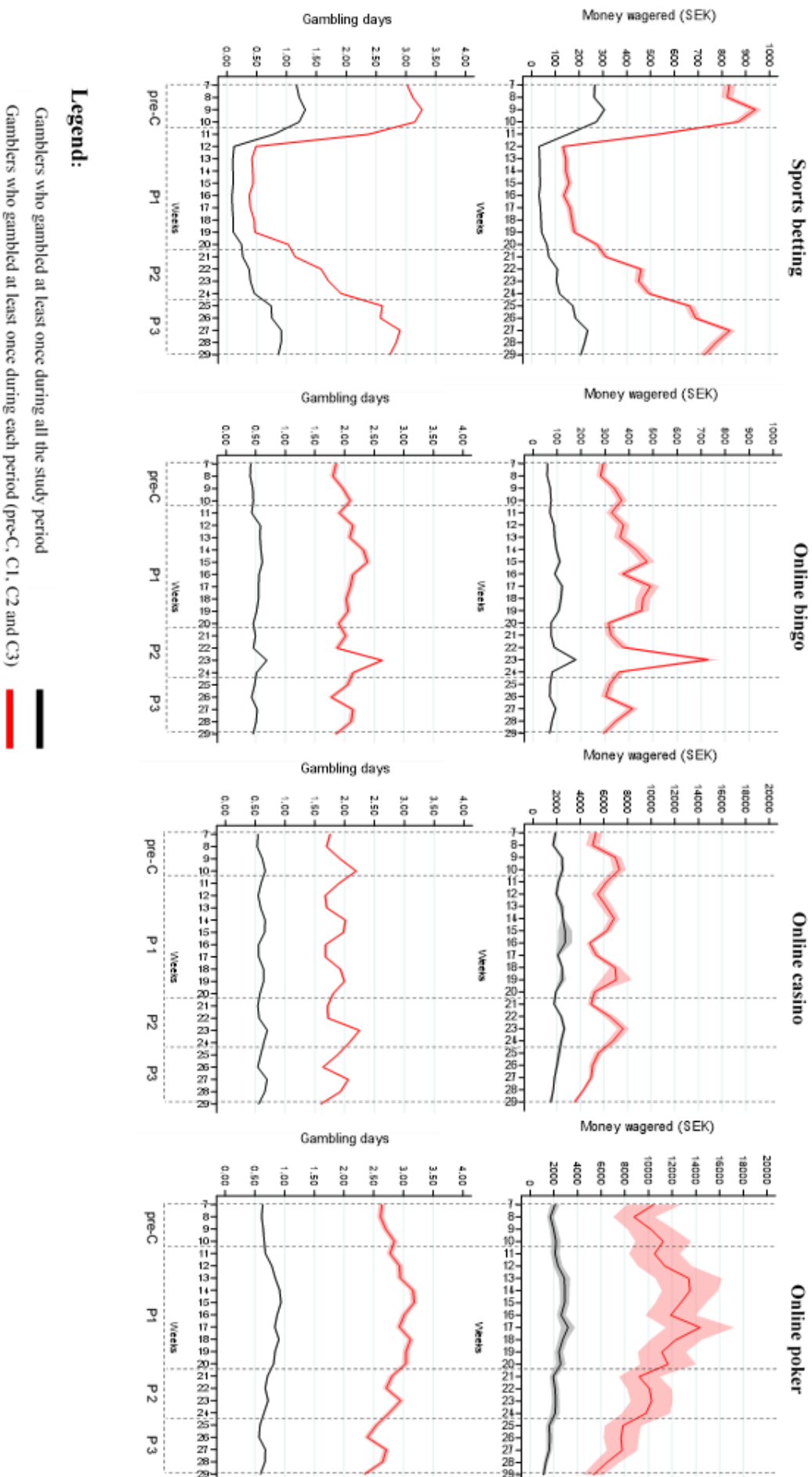
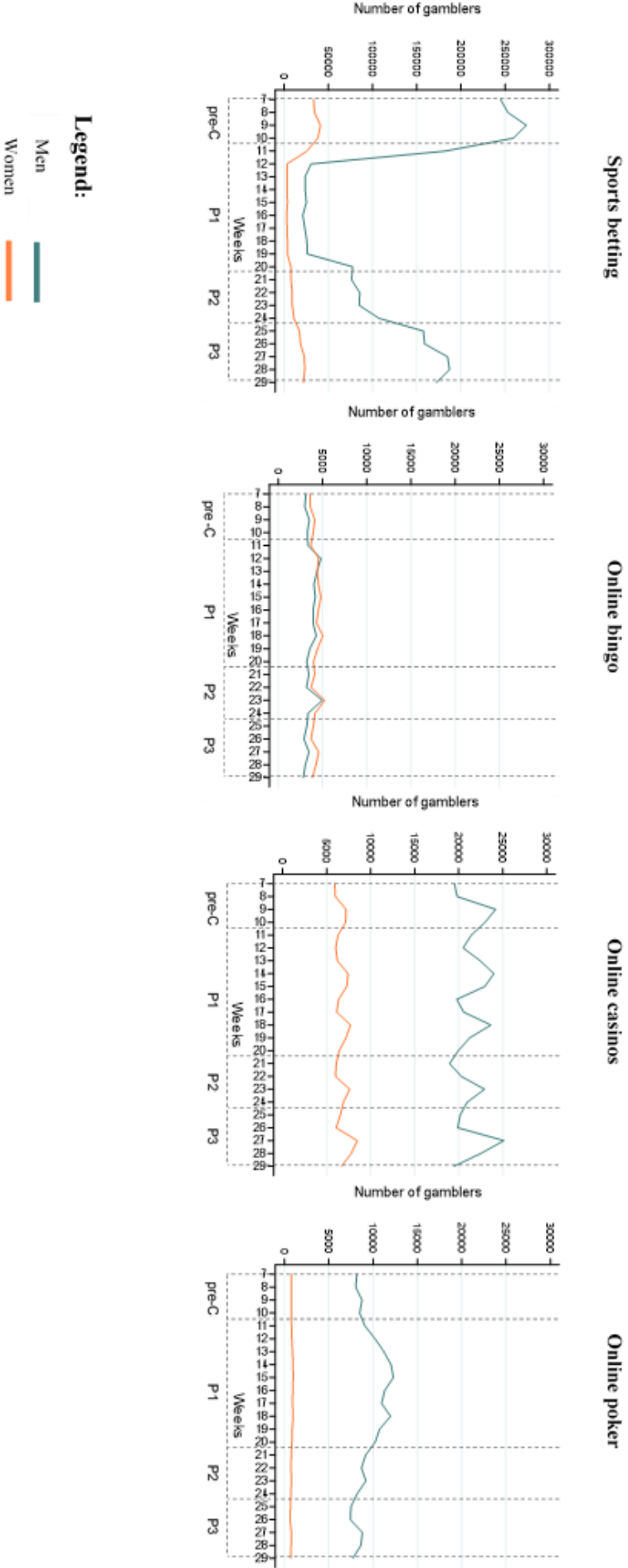


Figure 4: Representation of the number of gamblers for each gambling type according to sex and for each gambling type, for the both indicators of gambling behaviors.



4.3.5 Discussion

The present study analysed a full gambling operator's activity in the first phases of the COVID-19 pandemic. One major finding was that the patterns of distinct gambling types differed markedly. Sports betting followed an apparent decrease and ultimately reached levels that were lower than the prepandemic levels. In contrast, for bingo, gambling levels increased during the interruption of sports and then decreased with the return to normal for sports events but remained higher than the levels at baseline. We observed the same trend for poker; however, gambling stabilized at lower levels than those before the interruption of sports. Finally, an increase in casinos gambling was observed during the sports interruption period, but this was observed only for the intensity of gambling practices. Additionally, the resulting final levels for casinos gambling remained higher than those at baseline.

Thus, the general impression was that an expected and fully explainable decrease occurred in sports betting, but this was not associated with increased activity in online gambling within this gambling operator during the acute phases of the pandemic. However, as sports gambling decreased simultaneously due to the interruption of sports, an inverse trend was seen in bingo, poker and casinos gambling with rising gambling levels but normalized as sports

returned. However, the considerable increase in the number of gamblers engaged in poker could be associated with the increase in the practice intensity and frequency during the sports interruption period. Indeed, gamblers engaged in sports betting could have transferred their gambling activity to poker, particularly among men. However, the analyses seemed to show that regular gamblers (i.e., those engaged in poker throughout the periods studied) also increased their gambling activity during this same period. In contrast, we could have expected a transfer of gambling activity to bingo for gamblers engaged in sports betting, more specifically among women, but the number of gamblers engaged in bingo did not increase markedly during the interruption of sports despite the increase in gambling intensity. In contrast, regular gamblers widely increased their gambling activity both in terms of frequency and intensity compared to occasional gamblers. Regarding casinos, the number of gamblers remained relatively constant (with periodic fluctuations) during the entire period. However, the fluctuations in gambling activity in relation to the salary weeks were most marked among men and regular gamblers. Finally, the results showed that the level of involvement had much more impact in terms of intensity and frequency of gambling practices for gamblers engaged in sports betting and casinos. This is consistent

with results from other studies that reported that gambling involvement is positively associated with the intensity of gambling (Binde et al., 2017; Phillips, Ogeil, Chow, & Blaszczynski, 2013).

The present study did not demonstrate a consistent increase in gambling within the present gambling operator as a result of the COVID-19 pandemic. Therefore, this study did not confirm the fears expressed by researchers and policy-makers in the early phases of the pandemic (Håkansson et al., 2020). Instead, these findings are in line with those of European (Auer et al., 2020) and Swedish commercial online sports and casino gambling operators (Lindner et al., 2020), where the overall trend partly favoured chance-based games in the first phases of the COVID-19 pandemic but where decreases in sports betting were larger. These findings from the early phases of the pandemic, however, do not exclude a potential later and more worrisome increase in gambling in later phases of the pandemic, especially among the most vulnerable gamblers. Indeed, it can be assumed that certain profiles of gamblers may have been more affected by the pandemic and that the apparent return to normal levels of gambling activity at a global level may have hidden a dramatic and lasting increase in gambling behaviours at an individual level. Consequently, studies observing individual longitudinal variations in gambling activity

beyond the first wave of the pandemic should be performed in the future to identify those who are at higher risk for a pejorative evolution of gambling in response to the pandemic. Moreover, in addition to the dramatic changes in the actual gambling market in spring 2020, more long-term changes in society may have provoked more problematic gambling patterns, along with other public health challenges that may have followed the pandemic, such as unemployment, job insecurity and other challenges to public mental health (Håkansson et al., 2020; Price, 2020). In addition, the results could be different according to the gambling severity status of gamblers.

Limitations and strengths

The limitations of the present study include the fact that only one gambling operator was assessed and that potential changes between operators, such as a migration from sports betting to other gambling types during the interruption of sports, could not be studied here. Additionally, the time frame of the study, which covered less than six months, may also be a limitation. Further analyses with more long-term data are needed to study the potential long-term effects of COVID-19, including, for example, the potential effects of unemployment or long-term increases in poor mental health. Furthermore, the indicators chosen to reflect gambling behaviours were

restricted to the intensity and frequency of gambling with only two indicators. It would be interesting to extend the analyses to other indicators of gambling activity, such as the amount of deposits or the number of hours spent gambling per gambling day, or to indicators that reveal the propensity for gambling problems, such as the number of episodes of chasing gambling losses (Balem, Perrot, et al., 2022; Walker et al., 2006). Finally, the lack of clinical data on the status of problem gambling severity may also be a limitation. Indeed, it seems necessary to consider problem gambling severity as an indicator because the impact of the COVID-19 pandemic is undoubtedly different according to the intensity of gambling disorders.

Conversely, the strengths of the present study concern the multigame activities of one operator compared to other studies that focused only on one type of gambling. Additionally, the exhaustive list of gamblers, rather than a randomized sample, avoided selection bias and allowed us to analyse a very large sample that could produce robust results. The analysis period allowed us to consider several phases of the first wave of the COVID-19 pandemic compared to other studies that focused only on the sports interruption period. Finally, gambling activity was considered while controlling for sex, age and the salary week in February.

4.3.6 Conclusion

Investigation of the gambling activity of all clients of the state-owned gambling operator AB Svenska Spel suggests that the dramatic changes in the world of sports during the COVID-19 pandemic led to a steep decrease in sports betting, which normalized only partly during the return of sports in spring 2020, leaving a net decrease in the operator's gambling activities in the first phases of the pandemic. Modest changes were observed in online chance-based gambling when the interruption of sports occurred, but poker and bingo inversely mirrored sports betting more clearly, with an increase during the interruption of sports and a relatively rapid normalization after the return of sports. COVID-19-related effects in the early phases of the pandemic, at least within this operator, were not dramatic, but further studies of potential migration between gambling types or of long-term changes in gambling activity at an individual level in later stages of the pandemic may be warranted. Additionally, potential migration to other types of gambling operators needs further attention, especially in relation to survey data indicating a possible shift in gambling practices among high-risk gamblers, which was beyond the scope of the present study.

The present study sheds light on gambling patterns subject to some academic and political concerns. Although the overall

resulting changes during the study period may be seen as modest, they corroborate the previous impression that the types of gambling that were not technically affected by the pandemic may change because of the negative impact on other types of gambling. Thus, altogether, although many gamblers with sports betting as their preferred type of gambling may simply have reduced their gambling during the temporary lockdown, a certain proportion of gamblers may have transferred their gambling to other available types of gambling, which may have happened temporarily for horse race betting (Håkansson, 2020a). One implication of the present paper may be that health care and social service staff should pay attention to individuals' changes in gambling habits as a

maladaptive way of coping with a financial or psychosocial crisis. While such an association still cannot be concluded from the available data, another implication of the present study is to inspire more long-term studies of gambling behaviours during the COVID-19 pandemic involving more than one operator and studies that assess movements in the gambling market within and between gambling operators.

4.3.7 References

References are included in the References section of the thesis.

4.3.8 Supplementary information

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

Table 1.SI: Results of the GLMMs and LMMs

(a). Money wagered (SEK)					
Gambling type	Effects	Adjusted model without interaction		Adjusted model with interaction	
		% [95% CI]*	Adjusted p value	% [95% CI]*	Adjusted p value
Sports betting n=547,464	Period:				
	<i>pre-C</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>P1</i>	-89.56 [-89.56; -89.56]	<0.001	-77.46 [-77.46; -77.24]	<0.001
	<i>P2</i>	-83.96 [-83.96; -83.96]	<0.001	-73.29 [-73.55; -73.02]	<0.001
	<i>P3</i>	-60.15 [-60.15; -60.15]	<0.001	-53.23 [-53.70; -52.76]	<0.001
	Sex:				
	<i>Female</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>Male</i>	46.23 [44.77; 47.70]	<0.001	153.45 [150.93; 156]	<0.001
	Age	0 [0; 0]	0.990	0 [0; 0]	0.990
	Gambled during the salary week				
	<i>0</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>1</i>	238.72 [244; 249]	<0.001	238.72 [244; 249]	<0.001
	Level of involvement:				
	<i>Only sports betting</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>2 different gambling type</i>	53.73 [52.20; 55.27]	<0.001	53.73 [52.20; 55.27]	<0.001
	<i>3 different gambling type</i>	91.55 [89.65; 95.42]	<0.001	91.55 [89.65; 95.42]	<0.001
	<i>All types of gambling</i>	190.66 [177.32; 206.49]	<0.001	190.66 [177.32; 206.49]	<0.001
	Period*Gender				
	<i>Pre-C*Male</i>			<i>ref</i>	<i>ref</i>
	<i>P1*Male</i>			-60.54 [-60.85; -60.15]	<0.001
<i>P2*Male</i>			-45.66 [-46.28; -45.39]	<0.001	
<i>P3*Male</i>			-17.64 [-18.28; -17.01]	<0.001	
Bingo n=36,829	Period:				
	<i>pre-C</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>P1</i>	20.92 [19.72; 22.14]	<0.001	23.37 [20.92; 24.61]	<0.001
	<i>P2</i>	18.53 [16.18; 19.72]	<0.001	19.72 [18.53; 22.14]	<0.001
	<i>P3</i>	4.08 [3.05; 5.13]	<0.001	9.42 [7.25; 11.63]	<0.001
	Sex:				
	<i>Female</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>Male</i>	-25.17 [-27.39; -23.66]	<0.001	-22.89 [-25.17; -20.55]	<0.001
	Age	2.02 [2.02; 2.02]	<0.001	2.02 [2.02; 2.02]	<0.001
	Gambled during the salary week				
	<i>0</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>1</i>	555.35 [535.98; 575.31]	<0.001	555.35 [535.98; 575.31]	<0.001
	Level of involvement:				
	<i>Only sports betting</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>2 different gambling type</i>	-12.59 [-15.63; -9.71]	<0.001	-12.59 [-15.63; -9.71]	<0.001
	<i>3 different gambling type</i>	-13.67 [-16.72; -10.51]	<0.001	-13.67 [-16.72; -10.51]	<0.001
	<i>All types of gambling</i>	-7.85 [-13.26; -2.12]	0.008	-7.85 [-13.26; -2.12]	0.008
	Period*Gender				
	<i>Pre-C*Male</i>			<i>ref</i>	<i>ref</i>
	<i>P1*Male</i>			-1.98 [-3.92; 0]	0.053
<i>P2*Male</i>			-2.96 [-5.82; -1]	0.007	
<i>P3*Male</i>			-8.61 [-10.42; -6.76]	<0.001	
Casinos n=112,356	Period:				
	<i>pre-C</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>P1</i>	5.13 [4.08; 6.18]	<0.001	7.25 [5.13; 9.42]	<0.001
	<i>P2</i>	1.01 [0; 2.02]	0.061	7.25 [5.13; 9.42]	<0.001
	<i>P3</i>	6.18 [5.13; 7.25]	<0.001	22.14 [19.72; 24.61]	<0.001

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

	Sex:				
	Female	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	Male	-6.76 [-9.52; -4.88]	<0.001	-4.88 [-7.69; -1.98]	<0.001
	Age	3.05 [3.05; 3.05]	<0.001	3.05 [3.05; 3.05]	<0.001
	Gambled during the salary week				
	0	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	1	1,130.5 [1,106.1; 1,167.9]	0.005	1,130.5 [1,106.1; 1,167.9]	0.005
	Level of involvement:				
	Only sports betting	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	2 different gambling type	10.12 [7.59; 12.72]	<0.001	10.12 [7.59; 12.72]	<0.001
	3 different gambling type	38.68 [34.38; 43.11]	<0.001	38.68 [34.38; 43.11]	<0.001
	All types of gambling	110.22 [93.48; 127.05]	<0.001	110.22 [93.48; 127.05]	<0.001
	Period*Gender				
	Pre-C*Male			<i>ref</i>	<i>ref</i>
	P1*Male			-1.98 [-4.88; 0]	0.028
	P2*Male			-7.69 [-9.52; -4.88]	<0.001
	P3*Male			-16.47 [-18.13; -13.93]	<0.001
	Period:				
	pre-C	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	P1	58.41 [56.83; 60]	<0.001	36.34 [29.69; 41.91]	<0.001
	P2	10.52 [8.33; 11.63]	<0.001	1.01 [-3.92; 7.25]	0.622
	P3	-4.88 [-5.82; -2.96]	<0.001	-7.69 [-12.19; -2.96]	<0.001
	Sex:				
	Female	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	Male	12.75 [6.18; 19.72]	<0.001	3.05 [-3.92; 10.52]	0.501
	Age	2.02 [2.02; 2.02]	<0.001	2.02 [2.02; 2.02]	<0.001
	Gambled during the salary week				
	0	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	1	1,344 [1,287.38; 1,402.93]	<0.001	1,344 [1,287.38; 1,402.93]	<0.001
	Level of involvement:				
	Only sports betting	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	2 different gambling type	-0.30 [-3.92; 3.05]	0.855	-0.30 [-3.92; 3.05]	0.855
	3 different gambling type	0.01 [-4.30; 4.56]	0.994	0.01 [-4.30; 4.56]	0.994
	All types of gambling	-3.92 [-11.22; 3.98]	0.321	-3.92 [-11.22; 3.98]	0.321
	Period*Gender				
	Pre-C*Male			<i>ref</i>	<i>ref</i>
	P1*Male			18.53 [12.75; 23.37]	<0.001
	P2*Male			9.42 [3.05; 16.18]	0.002
	P3*Male			3.56 [-1.98; 9.42]	0.225

(b). Gambling days

Gambling type	Effects	Adjusted model without interaction	Adjusted model with interaction		
		β [95% CI]	Adjusted p value	β [95% CI]	Adjusted p value
	Period:				
	pre-C	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	P1	-2.03 [-2.03; -2.03]	<0.001	-1.99 [-2; -1.98]	<0.001
	P2	-1.35 [1.35; -1.35]	<0.001	-1.48 [-1.49; -1.48]	<0.001
	P3	-0.48 [-0.48; -0.48]	<0.001	-0.60 [-0.61; -0.60]	<0.001
	Sex:				
	Female	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	Male	0.50 [0.49; 0.51]	<0.001	0.45 [0.44; 0.45]	<0.001
	Age	0.01 [0.01; 0.01]	<0.001	0.01 [-0.01; 0.01]	<0.001
	Gambled during the salary week				

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

	0	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	1	1.56 [1.55; 1.56]	<0.001	1.56 [1.55; 1.56]	<0.001
	Level of involvement:				
	<i>Only sports betting</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>Ref</i>
	<i>2 different gambling type</i>	0.45 [0.44; 0.45]	<0.001	0.45 [0.44; 0.45]	<0.001
	<i>3 different gambling type</i>	0.65 [0.63; 0.67]	<0.001	0.65 [0.63; 0.67]	<0.001
	<i>All types of gambling</i>	0.93 [0.88; 0.98]	<0.001	0.93 [0.88; 0.98]	<0.001
	Period*Gender				
	<i>Pre-C*Male</i>			<i>ref</i>	<i>ref</i>
	<i>P1*Male</i>			-0.04 [-0.05; -0.03]	<0.001
	<i>P2*Male</i>			0.15 [0.14; 0.16]	<0.001
	<i>P3*Male</i>			0.14 [0.13; 0.14]	<0.001
	Period:				
	<i>pre-C</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>P1</i>	0.24 [0.23; 0.26]	<0.001	0.21 [0.19; 0.23]	<0.001
	<i>P2</i>	0.23 [0.22; 0.24]	<0.001	0.22 [0.20; 0.24]	<0.001
	<i>P3</i>	0.10 [0.09; 0.11]	<0.001	0.16 [0.14; 0.18]	<0.001
	Sex:				
	<i>Female</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>Male</i>	-0.33 [-0.37; -0.31]	<0.001	-0.34 [-0.37; -0.31]	<0.001
	Age	0.03 [0.03; 0.03]	<0.001	0.03 [0.03; 0.03]	<0.001
	Gambled during the salary week				
	0	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	1	1.63 [1.60; 1.66]	<0.001	1.63 [1.60; 1.66]	<0.001
	Level of involvement:				
	<i>Only sports betting</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>2 different gambling type</i>	-0.07 [-0.10; -0.03]	<0.001	-0.07 [-0.10; -0.03]	<0.001
	<i>3 different gambling type</i>	-0.05 [-0.08; -0.01]	0.020	-0.05 [-0.08; -0.01]	0.020
	<i>All types of gambling</i>	-0.01 [-0.07; 0.06]	0.842	-0.01 [-0.07; 0.06]	0.842
	Period*Gender				
	<i>Pre-C*Male</i>			<i>ref</i>	<i>ref</i>
	<i>P1*Male</i>			0.07 [0.05; 0.09]	<0.001
	<i>P2*Male</i>			0.02 [-0.01; 0.05]	0.218
	<i>P3*Male</i>			-0.13 [-0.16; -0.10]	<0.001
	Period:				
	<i>pre-C</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>P1</i>	-0.01 [-0.01; -0.01]	0.063	0.02 [0.01; 0.03]	0.006
	<i>P2</i>	-0.01 [-0.01; -0.01]	0.829	0.06 [0.04; 0.07]	<0.001
	<i>P3</i>	0.04 [0.03; 0.05]	<0.001	0.14 [0.13; 0.15]	<0.001
	Sex:				
	<i>Female</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>Male</i>	-0.07 [-0.90; -0.05]	<0.001	-0.05 [-0.07; -0.03]	<0.001
	Age	0.02 [0.02; 0.02]	<0.001	0.02 [0.02; 0.02]	<0.001
	Gambled during the salary week				
	0	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	1	1.54 [1.53; 1.56]	<0.001	1.54 [1.53; 1.56]	<0.001
	Level of involvement:				
	<i>Only sports betting</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
	<i>2 different gambling type</i>	0.12 [0.10; 0.14]	<0.001	0.12 [0.10; 0.14]	<0.001
	<i>3 different gambling type</i>	0.33 [0.30; 0.35]	<0.001	0.33 [0.30; 0.35]	<0.001
	<i>All types of gambling</i>	0.60 [0.55; 0.66]	<0.001	0.60 [0.55; 0.66]	<0.001
	Period*Gender				
	<i>Pre-C*Male</i>			<i>ref</i>	<i>ref</i>
	<i>P1*Male</i>			-0.03 [-0.05; -0.02]	<0.001
	<i>P2*Male</i>			-0.08 [-0.10; -0.06]	<0.001
	<i>P3*Male</i>			-0.13 [-0.15; -0.12]	<0.001

Bingo
n=36,829

Casinos
n=112,356

CHAPTER 4. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
A COMPREHENSIVE-LEVEL APPROACH

Poker n=41,815	Period:		
	<i>pre-C</i>	<i>ref</i>	<i>ref</i>
	<i>P1</i>	0.35 [0.34; 0.36]	<0.001
	<i>P2</i>	0.06 [0.5; 0.07]	<0.001
	<i>P3</i>	-0.04 [-0.05; -0.03]	<0.001
	Sex:		
	<i>Female</i>	<i>ref</i>	<i>ref</i>
	<i>Male</i>	0.01 [-0.04; 0.06]	0.712
	Age	0.02 [0.02; 0.02]	<0.001
	Gambled during the salary week		
	<i>0</i>	<i>ref</i>	<i>ref</i>
	<i>1</i>	1.72 [1.70; 1.75]	<0.001
	Level of involvement:		
	<i>Only sports betting</i>	<i>ref</i>	<i>ref</i>
	<i>2 different gambling type</i>	-0.02 [-0.05; 0.01]	0.122
	<i>3 different gambling type</i>	0.01 [-0.04; 0.03]	0.648
	<i>All types of gambling</i>	-0.04 [-0.10; 0.03]	0.249
	Period*Gender		
	<i>Pre-C*Male</i>		
<i>P1*Male</i>			
<i>P2*Male</i>			
<i>P3*Male</i>			

“ref”: reference. Significant p values for an alpha risk at 5% are in bold.

Reading key:

(a) Sports betting:

Adjusted model without interaction: In comparison to the pre-C period, the average percentage of money wagered during the P1, P2 and P3 periods decreased by 89.56% [89.56; 89.56], 83.96% [83.96; 83.96] and 60.15% [60.15; 60.15], respectively. Over the entire study period, men wagered, on average, 46.23% [44.77; 47.70] more money than women, and the gamblers who gambled during the salary week wagered, on average, 245.56% [244; 249] more money than the gamblers who did not gamble during the salary week. Over the entire study period, gamblers who gambled in two different gambling wagered, on average, 53.73% [52.20; 55.27] more money than gamblers who gamblers gambled only in sports. Gamblers who gambled in three gambling wagered, on average, 91.55% [89.65; 95.42] more money than gamblers gambled only in sports. Gamblers who gambled in all of gambling wagered, on average, 190.66% [177.32; 206.49] more money than gamblers gambled only in sports.

(b) Sports betting:

Adjusted model without interaction: In comparison to the pre-C period, the average numbers of gambling days during the P1, P2 and P3 periods decreased by 2.03 [2.03; 2.03], 1.35 [1.35; 1.35] and 0.48 [0.48; 0.48] days, respectively. Over the entire study period, men gambled, on average, 0.50 [0.49; 0.51] day more than women, and the gamblers who gambled during the salary week gambled, on average, 1.56 [1.56; 1.56] days more than the gamblers who did not gamble during the salary week. Over the entire study period, gamblers who gambled in two different gambling gambled, on average, 0.45 [0.44; 0.45] day more than gamblers who gamblers gambled only in sports betting. Gamblers who gambled in three gambling gambled, on average, 0.65 [0.63; 0.67] day more than gamblers gambled only in sports betting. Gamblers who gambled in all of gambling gambled, on average, 0.93 [0.88; 0.98] day more than gamblers gambled only in sports betting.

4.4 Overview and conclusion of the chapter 4

In this chapter, an analyse was conducted to estimate the overall impact of the COVID-19 on online gambling among all users of regulated online gambling platforms in France and the Swedish national lottery operator.

4.4.1 Main results of the French study

The first finding from the French study is that despite the pandemic, the average weekly number of active gamblers increased for all regulated online gambling between 2019 and 2020. This increase was particularly substantial gambling types not affected by COVID-19 (poker, draw-based games, scratch games, and multiplayer games), with growth rates ranging from 36% to 60%. Additionally, the number of new gamblers for these four non-COVID-affected types also increased, especially for lottery games, which nearly doubled between 2019 and 2020. Conversely, the number of new gamblers engaged in COVID-affected gambling types (sports betting and horse-race betting) decreased in 2020. Overall, men were more engaged than women in all types of gambling, and the male-to-female ratio remained relatively unchanged between the two years.

The analyse based on the COVID-19 affected periods in 2020 showed changes in the number of active and new gamblers compared to 2019. These changes sometimes expected and sometimes unusual, varied depending on the gambling types and whether the gamblers were active or new.

An expected finding from the present study is that the number of active sports bettors and horse race bettors decreased significantly during the first lockdown, likely due to the cancellation of sports and horse-racing events. After this period, the number of active gamblers returned to pre-pandemic levels until the second lockdown, during which the number exceeded pre-pandemic levels. Similarly, the number of new sports bettors sharply declined during the first lockdown, with a nearly 90% decrease.

Conversely, an opposite trend was observed for the non-COVID-affected gambling types. For active gamblers, the number of those engaged in poker or draw-based games continually increased during the four COVID-19 affected periods compared to the reference period, with the highest percentages occurring during both lockdown periods. For those engaged in scratch games and multiplayer games, the number of active gamblers also increased, primarily during both lockdown periods, reaching increases of 41% to 59%. Regarding new gamblers, the number of those participating in poker nearly tripled during the first lockdown and returned to

pre-pandemic levels afterward. Similarly, the number of new gamblers engaged in once of the three lottery games increased significantly during both lockdown periods, with higher levels during the second lockdown period compared to the first.

Additionally, we did not observed abnormal variations in the number of gamblers across the four periods during the reference year (2019). The only exception was an increase of less than 20% in active gamblers engaged in draw-based games and scratch games during the last period in 2019, likely due to the Christmas season when lottery gambling activity typically rises.

Finally, the French study highlighted the influence of gambling-related events on gamblers participation. For sports bettors, the number of gamblers varied with the availability of sports events. For those engaged in draw-based games, as previously noted, the number of gamblers increased drastically during the both lockdowns periods, particularly, during the second lockdown period when the amount of jackpot were unusually high compared to other periods in 2020.

4.4.2 Main results of the Swedish study

The primary finding resulting from the Swedish study is that the majority of gamblers from *Svenska Spel Sports & Casino* were men engaged in sports betting during the study period. Gamblers engaged in casinos and poker were, on average, 10 years younger than those engaged in sports betting and bingo. While the sex ratio varied between gambling types, men were consistently over-represented. Additionally, 80% of sports bettors wagered exclusively on sports, whereas for other gambling types, 66% to 81% of gamblers participated in more than one type of gambling.

The analysis based on the COVID-affected periods, using two gambling indicators (money wagered and number of gambling days), showed that while changes varied between gambling types, these gambling activity variations followed the same overall trend for both indicators. Specifically, increases in money wagered were typically accompanied by increases in the number of gambling days as well.

Furthermore, one of the main outcome identified in this study was the significant and explained decrease in gambling activity among sports bettors during the period of sports cancellations, followed by a gradual normalization during the reopening and substantial return of sports, ultimately reaching levels below those observed before the pandemic.

Conversely, an opposite trend was observed for gamblers engaged in non-COVID-affected gambling types (bingo, casino and poker). For gamblers engaged in bingo, men's gambling activity changed little throughout the study period, whereas for women, it increased slightly

across the three periods but remained modest. For casinos, women's gambling activity consistently increased throughout the study period, surpassing pre-pandemic levels noticeably. A similar trend was observed for men, albeit lower levels. For poker, gambling activity increased notably during the period of sports cancellations and remained stable thereafter, albeit slightly below pre-pandemic levels for women than men.

Additionally, although differences in the number of gambling days were minimal between women and men, there were distinct patterns in the amount wagered: women tended to wager higher amounts in bingo and casinos, while men tended to wager more in poker.

Moreover, the results showed that gambling activity of gamblers engaged in casinos and sports betting clearly increased as the level of involvement rose, for both indicators of gambling. This finding was particularly significant for casino gamblers. Indeed, those who participated in more than two different types of gambling wagered an average of 1,500 SEK more during each period compared to those who only gambled in casinos. These gamblers constituted half of the casino-engaged population.

Another important finding emerged: changes in gambling activity appeared to be more pronounced among regular gamblers compared to occasional ones. Specifically, for casino gamblers, we observed several peaks in increased gambling activity during salary weeks. This phenomenon was also notable in terms of gender, with the peak number of male gamblers being higher and more distinct than that of female gamblers.

4.4.3 Conclusion

In general, both studies showed that all types of gambling experienced changes in terms of the number of gamblers as well as the intensity of gambling activities. In both countries, these changes varied according to the type of gambling.

The overall gambling activity of those engaged in COVID-affected gambling types decreased significantly during the initial peak of the pandemic in Europe, mainly due to the cancellation of sports and horse-racing events. In response, many gamblers redirected their activity towards available options, leading to an abnormal increase in non-COVID-affected gambling types. Additionally, government restrictions to limit the spread of the virus (such as lockdowns, curfews, and stay-at-home recommendations) motivated individuals who were initially non-gamblers to start engaging in online gambling. Furthermore, while gambling behavior returned to normal with the complete reopening of sports and horse racing events, certain non-COVID-19-affected gambling types remained at higher levels than before the pandemic. This was the case for casinos in Sweden, and poker, draw-based games, and scratch

games in France. Although the studies did not extend beyond 2020, these findings could suggest that some gamblers intensified their habits due to the pandemic, potentially leading to increased gambling in the long term. These observations raise questions about the future and the potential increase in problem gambling in the coming years. The changes and new gambling practices initiated during the pandemic may have persisted over time. As gamblers adapted to new habits or intensified their activities, there is a concern that these behaviors could lead to higher rates of problem gambling.

Additionally, the French study highlighted the importance of considering gambling-related events in such research. For lottery games, which are influenced by advertising and the jackpots offered by the operator. By analyzing both lockdown periods—where the first was characterized by a strict lockdown and recommendations on advertising and jackpots, unlike the second with more relaxed health measures and recommendations—significant increases in gambling behaviors were observed during both lockdowns, with a more pronounced increase during the second lockdown. This raises questions about whether the increase in gambling behaviors was due to pandemic-related restrictions, the impact of jackpots, or a combination of both. It underscores the importance of strengthening supervision over jackpots and other forms of advertising during times of crisis. For sports betting, the chronology of sports events played a critical role in gambling behaviors. The suspension of major sports events during the pandemic significantly disrupted betting activities. However, as sports resumed, there was a noticeable rebound in sports betting. This suggests that the availability of betting opportunities directly influences gambling frequency and intensity. This observation underscores the importance of closely monitoring the scheduling and promotion of sports events, particularly during times of crisis. Understanding how the timing and availability of sports events influence gambling patterns can help in designing effective regulatory measures.

Furthermore, the findings from the Swedish study indicated that the pandemic's impact on gambling activity was different and more pronounced for certain sub-populations of gamblers. This suggests that the pandemic may have exacerbated gambling behaviors among those already engaged in frequent gambling. This was particularly evident among regular gamblers, who gambled every month, compared to those who gambled less frequently. A notable difference according to sex was also observed, especially for casino gamblers. Although more men gambled in casinos, women wagered more money and gambled more frequently. Conversely, men wagered more in poker. Then, gamblers who participated in multiple forms

of gambling engaged more frequently and intensely than those who only engaged in a single form of gambling.

Thus, although these comprehensive analyses provided an initial global overview of the impact of the COVID-19 pandemic on gambling behaviors and activity among online gamblers, they also highlighted the potential existence of sub-populations of gamblers who may be more vulnerable to the impacts of the pandemic.

Chapter 5

IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS: AN INDIVIDUAL-LEVEL APPROACH

Table of contents

5.1	Statistical methods	161
5.1.1	Latent Class Analysis	161
5.1.2	Latent Class Mixed Models	165
5.2	Manuscript 5: Typology of online gambling behaviors during the COVID-19 pandemic: a longitudinal study based on French gambling tracking data	167
5.2.1	Abstract	167
5.2.2	Introduction	168
5.2.3	Methods	169
5.2.4	Results	173
5.2.5	Discussion	189
5.2.6	Conclusion	191
5.3	Manuscript 6: Typology of online gambling behaviors during the COVID-19 pandemic: Swedish gambling data from state-owned gambling operator	192
5.3.1	Abstract	192
5.3.2	Introduction	193
5.3.3	Methods	195
5.3.4	Results	198
5.3.5	Discussion	209
5.3.6	Conclusion	211
5.4	Overview and conclusion of the chapter 5	212
5.4.1	Main results of the French study	212
5.4.2	Main results of the Swedish study	213
5.4.3	Conclusion	213

This chapter addresses the second objective of the CONGA study, which provides an individual-level analysis of changes in gambling activity among a representative sample of French and Swedish gamblers during the year impacted by the COVID-19 pandemic (2020) compared to a reference year (2019).

The first subsection justifies and explains the statistical methods used in the two studies presented in the following subsections.

The second and third subsections focus on two separate studies. Each study characterizes individual gambling trajectories of gamblers and identifies sub-populations of gamblers who were particularly susceptible to increasing their gambling activity in response to the pandemic. One study is based in the French context, and the other one in the Swedish context.

The fourth subsection synthesizes and discusses the results obtained in this chapter.

5.1 Statistical methods

In Chapter 4, we used regression models such as LMs, GLMS, LMMs and GLMMs to estimate the overall impact of the pandemic on all gamblers in 2019 and 2020. The estimates obtained from these models represented the average number of gamblers (in the French study) or the average gambling behaviors (in the Swedish study) for each affected period during COVID-19.

In this chapter, we focused on assessing the individual impact of the pandemic on gambling behaviors using a representative sample of gamblers from 2019 and 2020. This approach differs from the broader analysis presented in the previous chapter, which looked at overall trends affecting all gamblers as a whole. In the global analysis, we identified a single average trend representing the general gambling behavior across the entire sample. While this method offers a broad overview, it can obscure significant differences between various groups of gamblers. In contrast, our individual analysis aims to estimate gambling trajectories for different subgroups of gamblers over time. By categorizing gamblers into distinct classes based on their behaviors, we can better understand how different groups experienced the pandemic. Each class consists of individuals with similar gambling patterns, which helps us capture specific changes in behaviors within these subgroups.

5.1.1 Latent Class Analysis

Principle

Latent Class Analysis (LCA) is a statistical method used to identify homogeneous subgroups (or "latent classes") within a heterogeneous population based on responses to dependent

variables. LCA is founded on the assumption that differences in responses to observed variables can be explained by membership in different latent classes. Each individual in the population has an estimated probability of belonging to a specific latent class, and the observed variables serve as indicators of this membership. In its basic form, LCA is often applied to qualitative variables, but extensions of the method allow for the inclusion of quantitative variables alongside qualitative ones (Vermunt & Magidson, 2002).

Specification of the model

The modeling of LCA is based on probabilistic principles that estimate the relationships between unobservable latent classes and observed variables. Below is a detailed description of the models.

Probability of class membership:

Consider a dataset with n individuals, each evaluated on J categorical observed variables. Each variable Y_j (where $j = 1, 2, 3, \dots, J$) can take K_j possible categories. Assume there are C latent classes. For each individual i , there is a probability π_c (where $c = 1, 2, 3, \dots, C$) that this individual belongs to latent class c . The probabilities of belonging to all classes add up to 1:

$$\sum_{c=1}^C \pi_c = 1$$

Conditional probability of observed responses:

For qualitative variables:

The probability that an individual i , who belongs to latent class c , gives a specific response $y_{ij} = k$ (where $k = 1, 2, 3, \dots, K_j$) to observed variable Y_j is denoted θ_{jkc} . For each variable Y_j , the sum of these probabilities across all possible values is 1:

$$\sum_{k=1}^{K_j} \theta_{jkc} = 1$$

For quantitative variables:

The response y_{ij} for individual i on variable Y_j , given that the individual belongs to latent class c , is assumed to follow a normal distribution with mean μ_{jc} and variance σ_{jc}^2 :

$$y_{ij}|(Z_i = c) \sim N(\mu_{jc}, \sigma_{jc}^2)$$

Joint probability of responses

The joint probability of the observed responses for individual i , given their membership in latent class c , is the product of the conditional probabilities of each observed variable:

$$P(Y_{i1} = y_{i1}, Y_{i2} = y_{i2}, \dots, Y_{ij} = y_{ij} | Z_i = c) = \prod_{j \in \text{quali}} \theta_{j,y_{ij},c} \times \prod_{j \in \text{gaussian}} N(y_{ij} | \mu_{jc}, \sigma_{jc}^2)$$

Where:

- Z_i denotes the latent class membership for individual i .
- *quali* refers to qualitative variables, while *gaussian* refers to quantitative variables that follow a Gaussian distribution.

Marginal probability observed responses

The marginal probability of the observed responses for individual i across all latent classes is:

$$P(Y_{i1} = y_{i1}, Y_{i2} = y_{i2}, \dots, Y_{ij} = y_{ij}) = \sum_{c=1}^C \pi_c \prod_{j \in \text{quali}} \theta_{j,y_{ij},c} \times \prod_{j \in \text{gaussian}} N(y_{ij} | \mu_{jc}, \sigma_{jc}^2)$$

Likelihood Function

The likelihood function for the N individuals is given by:

$$\mathcal{L}(\pi, \theta) = \prod_{i=1}^N \sum_{c=1}^C \left[\pi_c \prod_{j=1}^J \theta_{j,y_{ij},c} \times \prod_{j \in \text{gaussian}} N(y_{ij} | \mu_{jc}, \sigma_{jc}^2) \right]$$

Parameter estimation

The parameter π_c , θ_{jkc} , μ_{jc} and σ_{jc}^2 are estimated using the EM algorithm. This algorithm iteratively maximizes the likelihood function to find the best-fitting parameters.

Selection of model

Latent Class Analysis (LCA) is a classification method in which the number of latent classes is unknown in advance. Therefore, multiple models need to be tested with different numbers of classes, for example, from 1 to 8. The optimal number of classes is determined using information criteria and relevance to the research question. The most commonly used criteria are the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). These criteria evaluate the adequacy of different models by comparing how well they fit the data. Both AIC and BIC provide measures of model quality while penalizing model complexity to avoid overfitting. To determine the best number of classes, these criteria are compared across different models to find a balance between model fit and simplicity. In addition to information criteria, other methods assess the "performance" or "accuracy" of the posterior classifications. These include measures such as posterior probabilities of class membership, classification error rates, and entropy. These metrics provide insights into the precision of class assignments and the associated uncertainty.

The posterior probabilities that each individual belongs to each class can be computed as follows:

$$\begin{aligned}\gamma_{ic} &= P(Z_i = c|Y_i) \\ &= \frac{\pi_c \times P(Y_i|Z_i = c)}{\sum_{c'=1}^C \pi_{c'} \times P(Y_i|Z_i = c')}\end{aligned}$$

Where:

- γ_{ic} is the probability that individual i belongs to class c , given the observations Y_i .
- $P(Y_i|Z_i = c)$ is joint probability of observing the data Y_i for individual i given that they are in class c .

The classification error rate measures the proportion of individuals for whom the most probable latent class is not the true class. For each individual i , the classification rate is defined as:

$$Error\ Rate = \frac{1}{N} \sum_{i=1}^N [1 - \max_c \gamma_{ic}]$$

Where: $\max_c \gamma_{ic}$ is the maximum posterior probability for individual i , i.e., the probability that the individual belongs to the class c with the highest posterior probability.

The classification error rate ranges from 0 to 1. The closer it is to 0, the higher the "certainty" of individual classifications. For instance, if the error rate is 0.05, each observation has a 95% chance of being correctly classified into the most probable latent class and a 5% chance of being misclassified into another class.

The last measure is entropy, which quantifies the uncertainty associated with the latent class assignments. For each individual i , entropy is defined as:

$$H_i = - \sum_{c=1}^C \gamma_{ic} \log \gamma_{ic}$$

The average entropy for all individuals is defined as:

$$H = \frac{1}{N} \sum_{i=1}^N H_i$$

Entropy measures the degree of uncertainty in the class assignments. It quantifies how well-defined the latent classes are. The closer the entropy is to 1, the better defined the clusters are. Indeed, high entropy (close to 1) implies that the model is very confident about the membership of individuals in their latent classes, reflecting precise and distinct cluster classification.

Conversely, low entropy (close to 0) suggests that the model has difficulty distinguishing between classes, resulting in less reliable classifications.

5.1.2 Latent Class Mixed Models

Principle

LCA is not well-suited for longitudinal data, which involves repeated measurements over time. LCA is primarily designed for cross-sectional data, where it identifies subgroups within a population based on observed variables at a single point in time. However, when dealing with longitudinal data, where individuals are observed at multiple time points, it is crucial to account for within-person variability and the temporal structure of the data. In such cases, Latent Class Mixed Models (LCMM), also known as the growth mixture model, are more appropriate (Proust-Lima et al., 2017). LCMMs extend the capabilities of LCA by incorporating random effects and allowing for the modeling of individual trajectories over time, providing a more accurate and nuanced understanding of how latent classes evolve and interact with time-varying covariates. This added flexibility makes LCMM a powerful tool for analyzing complex longitudinal data, as it captures both the differences between subgroups and the individual variations within those subgroups.

Specification of the model

LCMM is writing by:

$$Y_{it} = \beta_{0c_i} + \beta_{1c_i}t + \epsilon_{it}$$

Where:

- Y_{it} : value of the outcome for individual i at time t .
- β_{0c_i} : intercept specific to the latent class c_i .
- β_{1c_i} : slope specific to the latent class c_i .
- ϵ_{it} : random error term for individual i at time t .

The parameters can be decomposed into fixed and random components as follow:

$$\begin{cases} \beta_{0c_i} = \alpha_{0c_i} + r_{0c_i} \\ \beta_{1c_i} = \alpha_{1c_i} + r_{1c_i} \end{cases}$$

Where:

- α_{0c_i} : Mean intercept for the latent class c_i .
- α_{1c_i} : Mean slope for the latent class c_i .
- r_{0c_i} : Random effect on the intercept for individual i within class c_i .
- r_{1c_i} : Random effect on the slope for individual i within class c_i .

Additionally, when specifying a LCMM, several important parameters and choices needed to be considered:

- **Number of classes:** Determine the number of latent classes C to best represent the subgroups within the data.
- **Independence of errors between classes:** Ensure that the model assumptions about error independence between different classes are correct.
- **Independence of errors over time:** Address any correlation in residuals over time by incorporating appropriate structures, such as autoregressive terms, if needed.
- **Variance-covariance structure:** Choose the structure of the variance-covariance matrix of random effects based on the data and theoretical considerations.
- **Non-linear terms:** Decide whether to include non-linear terms, such as quadratic, cubic, or spline terms, to accurately capture complex trajectories within the data.

Selection of model

The model selection for Latent Class Mixed Models (LCMMs) follows a similar principle as for Latent Class Analysis (LCA). It is based on factors such as the number of classes and various criteria, including AIC, BIC, classification errors, entropy and interpretation of the classes.

The statistical methods described above were applied in the two studies detailed in the following subsections. Both studies offer an individual-level analysis of the impact of the COVID-19 pandemic on online gambling in France and Sweden. Each study used LCMMs to estimate the gambling trajectories of various subgroups of gamblers. Following this, LCA were applied on the probability of each gambler belonging to these trajectories, helping to identify gamblers with similar gambling behaviors.

5.2 Manuscript 5: Typology of online gambling behaviors during the COVID-19 pandemic: a longitudinal study based on French gambling tracking data

Marianne Balem^{1,2,3}, Bastien Perrot^{1,4}, Marie Grall-Bronnec^{1,2}, Anders Håkansson^{3,5}, Gaëlle Challet-Bouju^{1,2}

¹ Nantes Université, Univ Tours, CHU Nantes, INSERM, MethodS in Patients centered outcomes and HHealth ResEarch, SPHERE, F-44000 Nantes, France

² Nantes Université, CHU Nantes, UIC Psychiatrie et Santé Mentale, F-44000 Nantes, France

³ Faculty of Medicine, Department of Clinical Sciences Lund, Psychiatry, Lund University, Lund, Sweden

⁴ Nantes Université, CHU Nantes, Biostatistics and Methodology Unit, Department of Clinical Research and Innovation, F-44000 Nantes, France

⁵ Malmö Addiction Center, Region Skåne, Malmö, Sweden

5.2.1 Abstract

Background: Since the COVID-19 outbreak, people's habits have changed significantly. To limit the spread of SARS-CoV-2, governments implemented restrictive measures that affected individuals' daily lives. Gambling opportunities were particularly impacted, especially in terms of sports events and horse racing. **Aims:** To analyze individual gambling trajectories of representative French gamblers during the pandemic (2020) compared to 2019 and identify at-risk subpopulations likely to increase their gambling activity in response to COVID-19. **Methods:** The French National Online Gambling Authority (ANJ) (poker, horse race betting, and sports betting) and the French national lottery operator, Française des Jeux (FDJ) (online lotteries) provided us a representative sample of 40,000 gamblers each. Data comprised tracking gambling data aggregated weekly from 01/01/2019 to 31/12/2020. Latent Class Mixed Models (LCMM) were estimated to identify gambling trajectories for each type of gambling and each gambling indicator where possible. Then, Latent Class Analysis (LCA) were conducted to estimate classes of gamblers with similar trajectories in response to the COVID-19. **Findings:** The LCAs identified a particularly at-risk subgroup of sports bettors who are regular and active gamblers. This group postponed their gambling activities until sports and horse racing resumed, after which they significantly increased their gambling behaviors to levels substantially higher than before the pandemic. All gambling indicators were affected, especially those related to at-risk gambling. **Conclusions:** It seems essential to implement stricter regulations and enhance prevention measures during a crisis to limit the surge in gambling activity.

5.2.2 Introduction

During the early stages of the COVID-19 pandemic, when social distancing and restrictions were imposed around the world, concerns were raised about how the resulting changes in everyday life would have an impact on public health, including gambling habits (Håkansson, Fernández-Aranda, et al., 2020; Håkansson & Widinghoff, 2021). Indeed, a set of factors could explain a change in gambling activities, both in the number of gamblers and in the intensity of practices, due to the pandemic.

On the one hand, the reduction or interruption of sports events and horse races during the lockdown may have induced a decrease in the gambling activities (both online and offline) (Håkansson, 2020a, 2020b, 2020c; Otis et al., 2022). The closure of specific gambling venues and travel restrictions may also have decreased offline gambling activities in general. On the other hand, gamblers who could no longer engage in their usual gambling activities could have migrated to other available gambling activities, especially online (poker, lotteries, etc.) (Håkansson, 2020b). Online gambling has consistently been associated with higher rates of gambling problems due to the specific structural and environmental characteristics of online gambling, i.e., 24/7 accessibility, rapidness of gambling outcomes, dematerialized payment, anonymity, etc. (M.

Griffiths & Barnes, 2008; Bouju et al., 2011; Hing et al., 2015; S. M. Gainsbury, Russell, Wood, et al., 2015).

Four years after the beginning of the pandemic, many studies had been conducted worldwide on the impact of COVID-19 on gambling, with disparate results. Donati et al. (2021) finds that even problem gamblers reduced their gambling behaviors and gambling cravings during the pandemic, and that no “shift toward online gambling and very limited shift towards other potential addictive and excessive behaviors” were found (Donati et al., 2021). Several findings mentioned that most sports bettors significantly reduced or ceased their gambling practices due to sports cancellations during the acute phase of the pandemic (Lindner et al., 2020; Wardle et al., 2021; Auer et al., 2020). Conversely, some studies have indicated that gambling options remaining available when sporting events were cancelled (e.g. online casino, online bingo, online poker and horse betting) experienced a notable increase in activity during the same period, suggesting a shift or migration of gambling activity between different types of games (Balem, Karlsson, et al., 2023; Emond et al., 2022; Håkansson, 2020a). Moreover, research has demonstrated that starting a new form of gambling during the pandemic was linked to gambling-related problems (Wardle et al., 2021). Finally, numerous studies have highlighted that the minority of gamblers who increased their

gambling practices during the pandemic were primarily regular gamblers before the outbreak and constituted a subpopulation of gamblers who were more vulnerable, either due to their younger age or pre-existing gambling problems (S. M. Gainsbury et al., 2021; Lugo et al., 2021; Quinn et al., 2022).

The impact of the pandemic on gambling behaviors has been widely studied around the world. However, there are few longitudinal studies based on tracking gambling data, likely due to challenges for researchers in accessing this type of data. To our knowledge, none have specifically assessed the pandemic's impact on individual gambling habits over an extended period beyond the initial wave of the COVID-19 pandemic.

Nevertheless, although the pandemic and the associated restrictive measures are now in the past, the lessons learned on the impact of a global crisis of this type can be particularly useful in proposing better regulation, better prevention and better care management of gambling activities and associated gambling problems in crisis situations.

Thus, the present study aimed i) to characterize individual gambling trajectories of representative French gamblers over a year impacted by the pandemic (2020) and a reference year (2019) and ii) to identify subpopulations of gamblers, particularly at-risk to increase their gambling activity in response to the COVID-19 pandemic.

5.2.3 Methods

Participants

The present study included a representative sample of gamblers who had participated at least once in one of the gambling types permitted by the French state. In France, only four types of online gambling are allowed: sports betting, horse racing betting, poker, and lotteries. The online gambling market has been regulated by the National Gambling Authority (Autorité Nationale des Jeux, ANJ) since 2020. Online sports betting, horse racing betting, and poker are provided by licensed operators approved by the ANJ, while online lottery games are exclusively offered by the national lottery operator, Française Des Jeux (FDJ), which holds a monopoly on all lottery games (draw-based games, scratch games) both online and offline. Additionally, online casino games (such as EGMs and table games, except poker) are prohibited in France.

Data collection

ANJ and FDJ each provided dataset of gamblers randomly selected from all active accounts between 2019 and 2020. The dataset from FDJ included 40,000 gamblers who participated at least once in online lotteries during this period. The dataset from ANJ included 40,000 gamblers who engaged in online sports betting, horse racing betting, or poker at least once in 2019 and 2020. For both datasets, the data were aggregated weekly from January 1, 2019, to December 31, 2020,

and included socio-demographic information such as gender and age, along with gambling tracking data specific to each gambling type. From the gambling tracking data, we selected five key indicators to measure gambling activity. The amount of money wagered and deposits were selected to represent the intensity of gambling. Gambling frequency was measured by the number of gambling days. Finally, the number of chasing behavior episodes and the level of involvement were used as at-risk gambling indicators linked to gambling problems. The number of chasing episodes was defined as the number of times that money was deposited into the gambling account when the following criteria were met: three or more deposits within a 12-hour period and deposits made less than 1 hour after a bet was placed. The level on involvement corresponded to the number of different gambling activities used by gamblers (Mazar et al., 2020; Perrot et al., 2017). These indicators have been previously identified as effective in distinguishing between non-problem and problem gambling behaviors. The amount of money wagered and the number of gambling days were given for each gambling types. Conversely, the amount of deposits, the number of chasing episodes and the level of involvement were computed globally, regardless of the gambling type. Characteristics of the gamblers and the five indicators of gambling behaviors are detailed in Tables 1 and 2.

Additionally, to account for natural changes in gambling behaviors due to gambling-related events/opportunities, we retrospectively calculated three variables related to the time schedule of gambling events. The first two variables pertained to sports and horse racing bets. We identified the main competitions that generated the most bets and reported the weekly number of bets for each type of betting throughout the study period. For sports betting, we focused on football, tennis, and basketball, as an ANJ report indicated that nearly 90% of sports betting in 2017 came from these three sports (football: 57%, tennis: 21%, basketball: 11%). For horse racing, we included all races from the " Group 1 Races " level, which features the most prestigious competitions with top horses and high stakes. For lotteries, we obtained the jackpot amounts (i.e., the maximum prizes) offered each week for both Loto® and EuroMillions® from the FDJ, from which we calculated the variable "maximum jackpot amount" for each week. In this study, we focused solely on online gambling and, therefore, on the timing of events that might have changed due to the pandemic. This includes sports and horse racing competitions, which only occur in person, as well as events with fluctuating prize amounts from week to week. Consequently, we did not include variables related to poker tournaments and scratch games, as we hypothesized that the pandemic did not affect the schedule of these

types of online gambling. Furthermore, the study period was divided into five phases based on the measures taken by the French government to limit the spread of the virus:

- Week 1-11 (30th December 2019 – 15th March 2020): Pre-COVID period (pre-C). The first cases appeared in France, but no restrictions were implemented yet.
- Week 12-19 (16th March 2020 – 10th May 2020): 1st COVID-affected period (P1). A lockdown was implemented in France from March 17, 2020, to May 11, 2020. Gatherings, cultural activities, and leisure activities were strictly prohibited. Only outings for essential shopping, medical appointments, and similar needs were allowed. Additionally, physical activity was permitted for one hour per day within a 1 km radius of home, provided individuals had an official attestation. Furthermore, the majority of sports competitions and horse races were suspended.
- Week 20-25 (11th May 2020 – 21th June 2020): 2nd COVID-affected period (P2). In May, a gradual easing of the lockdown was implemented, depending on the region in France and the level of infection. Football championships in several European

countries began to resume, and horse racing also restarted.

- Week 26-40 (22nd June 2020 – 4th October 2020): 3th COVID-affected period (P3). The lockdown has ended, allowing gatherings to resume, but with strict protocols in place (social distancing). Restaurants and bars were also allowed to reopen. Additionally, travel was once again permitted. Regarding sports events and horse races, all activities had resumed.
- Week 41-52 (5th October 2020 – 28th December 2020): 4th COVID-affected period (P4). A second lockdown, from October 30 to December 15, 2020, was implemented due to a resurgence of cases but allowed some businesses to operate. Remote work is still recommended.

The same divisions of time were also applied during 2019 (the reference year without the COVID-19 pandemic) to facilitate a comparison of the gambling activity between 2019 and 2020.

Statistical analysis

Firstly, we conducted a descriptive analysis of the gamblers and their gambling indicators based on the gambling type (see Tables 1 & 2). Then, we implemented a two-step approach to identify profiles of gamblers and their gambling trajectories during the COVID-19 pandemic year (2020) compared

to a reference year (2019). This two-step analysis approach was similar to one employed in previous study (Brédart et al., 2016; Montourcy et al., 2018; Perrot et al., 2018b).

First step: characterisation of gambling individual trajectories

The first step of the procedure was to estimate and compare classes of individual trajectories of gambling by using latent class mixed models (LCMM). The LCMM assumes that the population of interest is heterogeneous and composed of non-observed and unknown subgroups of subjects called latent classes, which are characterized by mean trajectories (Lin et al., 2002; Proust-Lima et al., 2013, 2014). In the present study, the LCMMs were composed of two submodels. Submodel 1 was a multinomial logistic regression estimating the membership probabilities of each gambler to each latent class, and submodel 2 was a class-specific mixed model estimating the mean gambling trajectory of each class over weeks from 2019 to 2020. We conducted LCMMs with varying numbers of classes, ranging from one to eight. We determined the optimal model using several criteria: the Akaike Information Criteria (AIC) and the Bayesian Information Criteria (BIC) to assess the goodness of fit, entropy to evaluate the quality of the classification (values closer to one indicating better classification) and the interpretability of classes. This process was carried out

separately for the four gambling indicators and each gambling type, whenever applicable. Additionally, LCMMs were adjusted on the three variables related to the magnitude of the gambling events (number of sports events, number of horse races and maximum amount of jackpots) to control for the natural evolution of gambling behaviors.

We aggregated data over two weeks' periods instead of one (53 weeks instead of 105 weeks) to optimize the analysis and improve models estimation efficiency and duration.

To deal with the non-normal distribution of the four gambling indicators, we estimated LCMMs using a quadratic I-splines function and adjusted the combination of knots to optimize the fit to the data based on the AIC. Additionally, we used natural cubic splines with three inner knots, positioned at quartiles of the distribution of weeks 13, 26, and 39. This adjustment aimed to accommodate the sudden and abnormal changes in individual gambling trajectories resulting from the pandemic's impact on gambling opportunities (Elhakeem et al., 2022; Lévêque et al., 2020; Marcoulides & Khojasteh, 2018; Perperoglou et al., 2019). As the I-splines function failed to converge for the models related to the amount of money wagered and the number of deposits, likely due to the wide range of the data (see Table 2), we additionally opted for a $\log(x+1)$ transformation to address the range issue.

Second step: classification of gamblers with similar gambling trajectories

The second step consisted of conducting a Latent Class Analysis (LCA) to classify gamblers with similar gambling trajectories. The LCA was carried out on the membership probabilities (as observed variable) derived from the trajectories estimated in the first step. We estimated several models whose number of classes ranged from 1 to 8 and determined the optimal number of classes using the same criteria as in the first step. The classes were described by the trajectory membership probabilities of each indicators and each gambling type (whenever applicable), covariates.

LCMMs were performed with the `lcmm()` package on R 4.2.2 version (Proust-Lima et al., 2017).

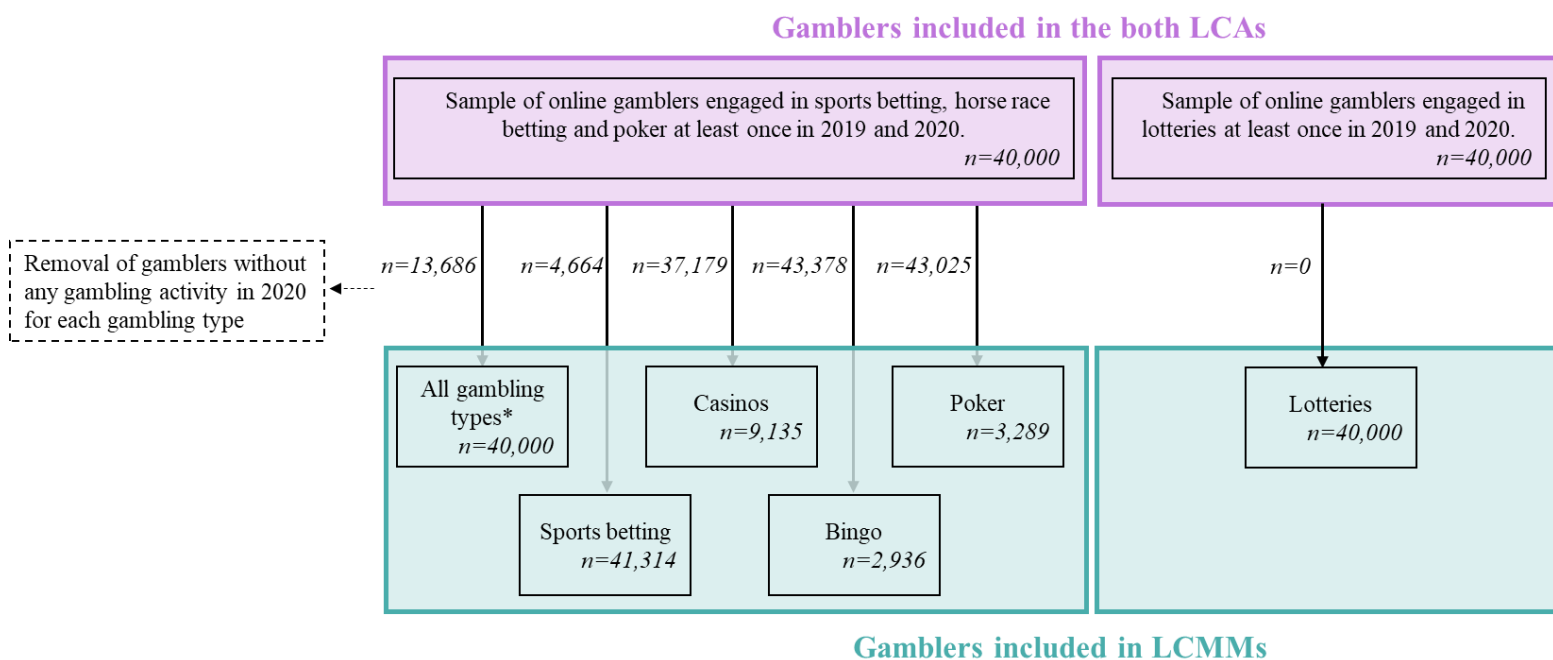
reflected in the amounts deposited. Furthermore, lottery gamblers tended to diversify their gambling activities more by participating in multiple types of lottery games, compared to sports bettors, horse race bettors, and gamblers engaged in poker.

5.2.4 Results

The flow-chart of the study is presented in Figure 1.

Description of gamblers and gambling indicators

As shown in Table 1, males predominated across all types of gambling. Additionally, gamblers involved in online sports betting and poker tended to be younger than those participating in horse race betting and lotteries. Table 2 indicates that lottery gamblers placed bets more frequently but at lower amounts than those involved in other types of gambling. This trend was also



*: The analyses on the amount of deposits, the number of chasing and the level of involvement were realized across all types of gambling (sports betting, horse race betting and poker) in the sample without distinguish them separately. Since a gambling account could be used for various gambling activities, it wasn't possible to differentiate between types of gambling for the deposits made into the account.

Figure 1: Flow-chart of the study

Table 1: Description of gamblers according to the gambling type

n=40,000	Gamblers engaged in sports betting ^{a,b} n=25,106	Gamblers engaged in horse race betting ^{a,b} n=8,642	Gamblers engaged in poker ^{a,b} n=10,219	Gamblers engaged in lotteries ^a n=40,000
Covariates (n,%) or (med, min-max)				
Gender				
<i>Male</i>	20,372 (81%)	5,772 (67%)	7,596 (74%)	28,278 (71%)
<i>Female</i>	4,734 (19%)	2,870 (33%)	2,623 (26%)	11,722 (29%)
Age				
	30 (20-92)	57 (20-100)	36 (20-91)	48 (20-96)

^a: Represents the number of gamblers who gambled at least once in 2019 and 2020 for the specified gambling type. ^b: A gambler can be represented in more than one gambling type if he gambled at several gambling types during the study period.

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

Table 2: Description of the five gambling indicators according to the gambling type

Gambling indicators	Gambling types	n*	Mean (sd)	Min	Max	Q1	Q2	Q3	P90
Amount of money wagered	Sports betting	1,330,618	27 (373)	0	119,415	0	0	0	27
	Horse race betting	458,026	66 (581)	0	113,140	0	0	18	109
	Poker	541,607	390 (7,2007)	0	1,631,047	0	0	2	98
	Lotteries	2,120,000	24 (97)	0	5,390	0	7	21	46
Number of gambling day	Sports betting	1,330,618	1 (2)	0	14	0	0	1	3
	Horse race betting	458,026	2 (4)	0	14	0	0	2	8
	Poker	541,607	1 (3)	0	14	0	0	1	5
	Lotteries	2,120,000	3 (3)	0	14	0	1	4	8
Amount of deposits	S/H/P ^a	1,310,637	26 (233)	0	90,000	0	0	0	40
	Lotteries	1,977,006	16 (63)	0	36,025	0	0	20	40
Chasing	S/H/P ^a	156,403	0 (2)	0	169	0	0	0	1
	Lotteries	553,744	0 (3)	0	144	0	0	0	1
Level of involvement	S/H/P ^a	2,120,000	1 (2)	0	18	0	0	1	3
	Lotteries	2,120,000	2 (2)	0	18	0	1	3	4

sd= standard deviation; Q1 = first quartile; Q2 = median; Q3 = third quartile; P90 = 90th percentile. *: Corresponds to the total number of observations for each gambling type (e.g. for sports betting: 25,106 gamblers engaged in sports betting * 53 weeks = 1,330,618 observations). ^a: Corresponds to Sports betting, Horse race betting and Poker.

LCMMs

Figure 2, 3, 4, 5 and 6 illustrated the trajectories of the selected LCMMs, for each gambling indicators and each gambling types, when it was possible.

Sports betting

Six trajectories were identified for gambling days and seven for money wagered. Trajectory 6 (3.2%) for gambling days and trajectory 3 (60.9%) for money wagered were characterized by active and stable gambling activity in 2019, with a slight decrease at the end of 2020. The number of gambling days decreased from 4 days every 2 weeks to 3

days, while the money wagered dropped from €30 to below €10. Trajectory 2 (4.8%) for gambling days and trajectory 1 (4.2%) for money wagered showed a decrease in gambling activity during the P1 and P2 periods in 2020, followed by an exponential increase during the P4 period. Gambling activity increased from nearly zero to an average of €100 wagered and 6 gambling days every 2 weeks. The other trajectories were characterized by varying levels of gambling activity in 2019, which dropped to close to zero in 2020.

Horse race betting

Five trajectories were estimated for gambling days and eight for money wagered. Trajectories 1 (8.2% - 9.7%) and Trajectories 3 (5.3% - 6.3%) for gambling days and money wagered showed a significant increase in gambling activity towards the end of 2019 for Trajectories 1 and the beginning of 2020 for Trajectories 3. Once they reached a peak of 6 gambling days and around €40-€50 wagered per 2 weeks, all four trajectories experienced a drastic decline in 2020, eventually dropping to nearly zero gambling activity. Trajectory 2 (7.3%) for gambling days and trajectory 8 (3.8%) for money wagered illustrated a significant decrease in gambling activity at the end of 2019, followed by a resurgence during the P1 and P2 periods. These trajectories reached 2 gambling days and €10 wagered per 2 weeks, levels that were lower than those of 2019. Trajectory 6 (9.5%) for money wagered was characterized by higher levels than other trajectories, averaging €70 per 2 weeks. This trend slightly decreased in early 2020 during the pre-C and C1 periods but then increased again, reaching levels higher than those in 2019, peaking at almost €90. Finally, the remaining trajectories were characterized by active gambling activity in 2019, which then dropped to almost nothing in 2020.

Poker

Eight trajectories for gambling days and seven trajectories for money wagered were identified. Trajectory 1 (3.0%) for gambling

days and trajectory 2 (3.9%) for money wagered were characterized by a significant increase in gambling activity, peaking during the P1 period in 2020. Gambling days increased from 2.5 to 6 per 2 weeks, and money wagered rose from €70 to €325 per 2 weeks. After reaching this peak, the trend drastically decreased, returning to levels similar to or lower than those in 2019.

Trajectory 7 (4.7%) for gambling days and trajectory 1 (4.6%) for money wagered showed a similar trend to trajectories 1 and 2 but at lower levels. Trajectory 6 (3.6%) for gambling days was characterized by stable and active gambling frequency, with a slight decrease in 2019, followed by an increase during the P1 and P2 periods in 2020, and a subsequent decrease at the end of 2020, returning to 2019 levels.

Sports betting, Horse race betting and poker

Seven trajectories were estimated for the three gambling indicators. Trajectory 2 (4.7%) for deposits and trajectories 1 (1.3% - 6.0%) for chasing and involvement were characterized by stable trends throughout 2019 at higher levels than other trajectories, followed by a substantial increase during P3 and P4 periods in 2020. Deposits rose from €30 to €70, chasing episodes increased from 2 to 14, and the level of involvement went from 2.5 to 3 different games played per 2 weeks. Trajectories 6 (3.4% - 4.9%) for deposits and involvement and trajectory 7 (3.2%) for

chasing showed stable gambling activity in 2019, an increase during the P1 and P2 periods in 2020, and then a decrease, ending the year at levels lower than those in 2019. Other trajectories for the three gambling indicators showed a decline in gambling activity from 2020, becoming nearly zero. An exception was Trajectory 6 for chasing, which showed no chasing episodes throughout the study period until the P4 period in 2020, where it reached 3 episodes of chasing per 2 weeks.

Lotteries

Models with five, six, seven, and four trajectories were identified for gambling days, chasing, money wagered, involvement, and deposits, respectively. Trajectories 1 (0.6% - 7.7%) for deposits and chasing and trajectories 2 (18.9% - 35.2%) for gambling days and involvement were characterized by an increase in gambling activity during the P1 and P2 periods in 2019, reaching 6.5 gambling days, €35 in deposits, 2.5 different games played, and 16 chasing episodes per 2 weeks. This trend continued until the P2 period in 2020, after which gambling activity decreased in the P3 and P4 periods, returning to levels similar to those in 2019, except for deposits, which remained stable after the initial increase in 2019. Trajectories 1 (1.9% - 3.6% - 5.1%) for involvement, gambling days, and money wagered showed a similar trend. Gambling activity increased starting in the P2 period in

2019, peaking during the pre-C and P1 periods in 2020 with gambling days rising from 2 to 5.5, money wagered from €5 to €40, and different games played from 2.5 to 5 per 2 weeks. However, from the P2 period, gambling activity decreased, returning to levels similar to those at the beginning of 2019. Trajectories 3 (4.1% - 4.4% - 5.3%) for money wagered, involvement, and gambling days and trajectories 2 (1.7% - 2.7%) for chasing and deposits were characterized by weak and stable gambling activity in 2019, followed by an increase in 2020 during the P2 and P3 periods. Although levels decreased in the P4 period, they remained higher than those in 2019, except for gambling days and money wagered.

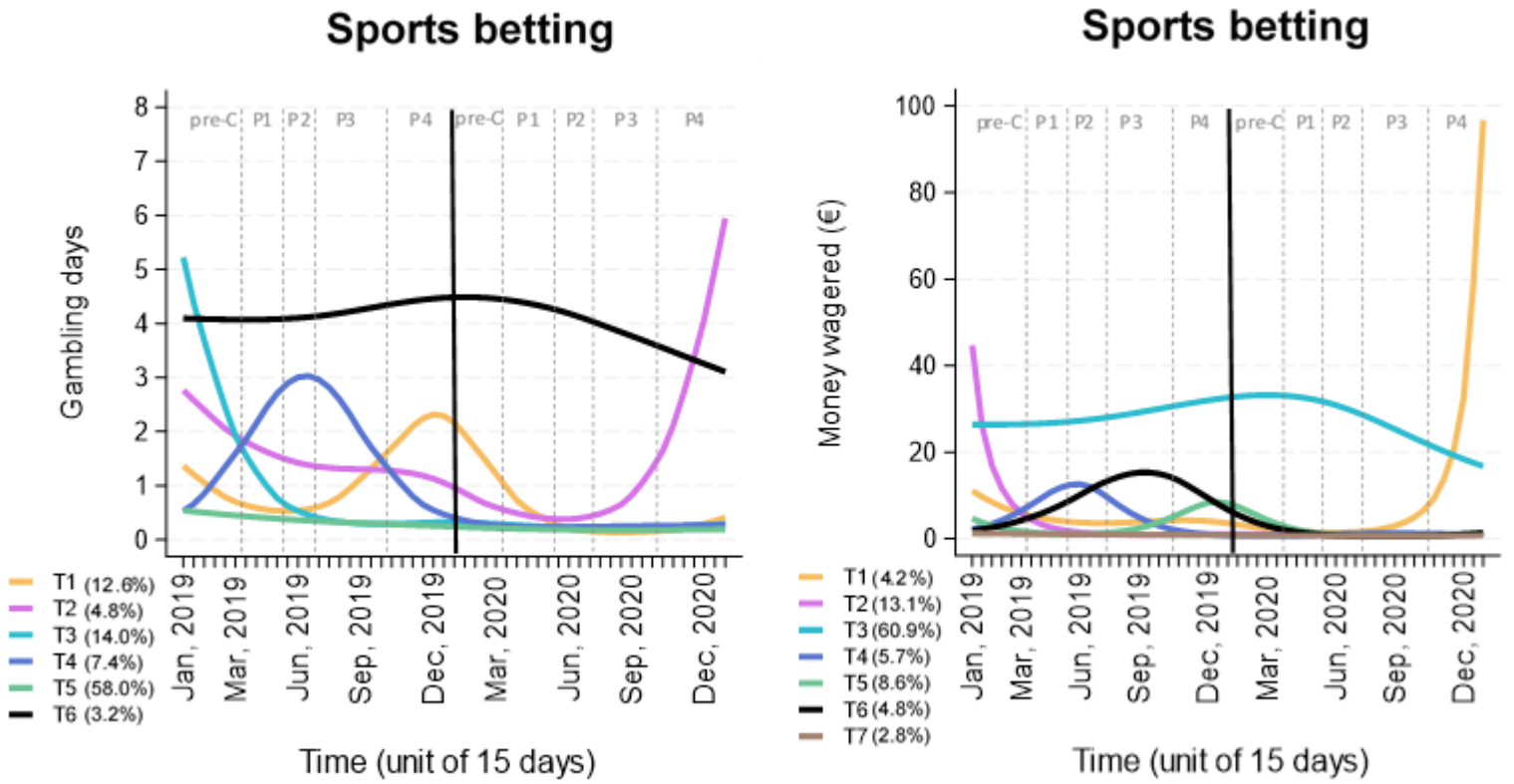
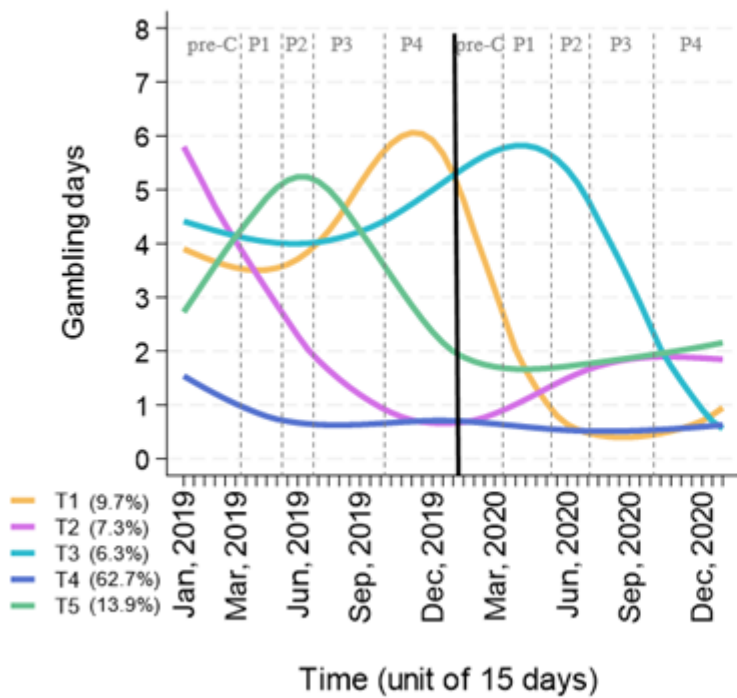


Figure 2: Gambling trajectories of sports bettors for the number of gambling days and money wagered.

Horse race betting



Horse race betting

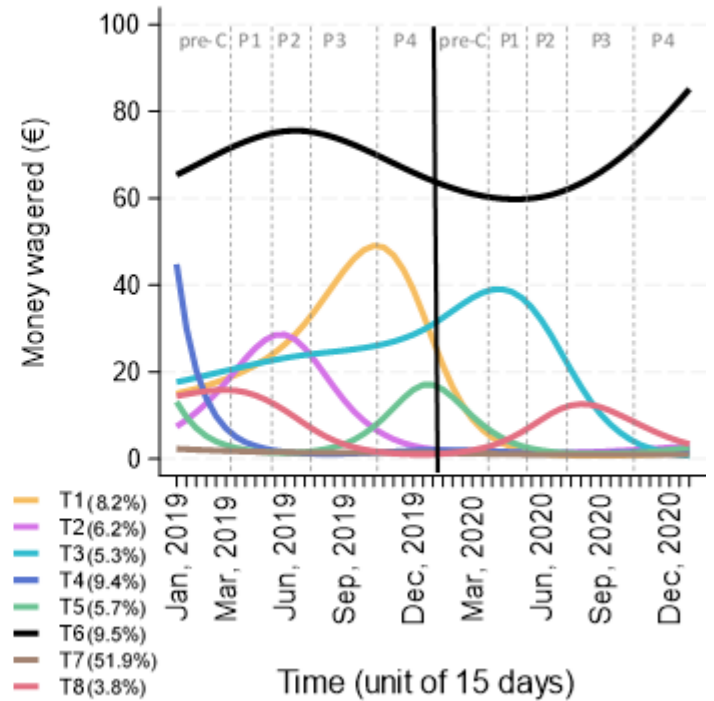
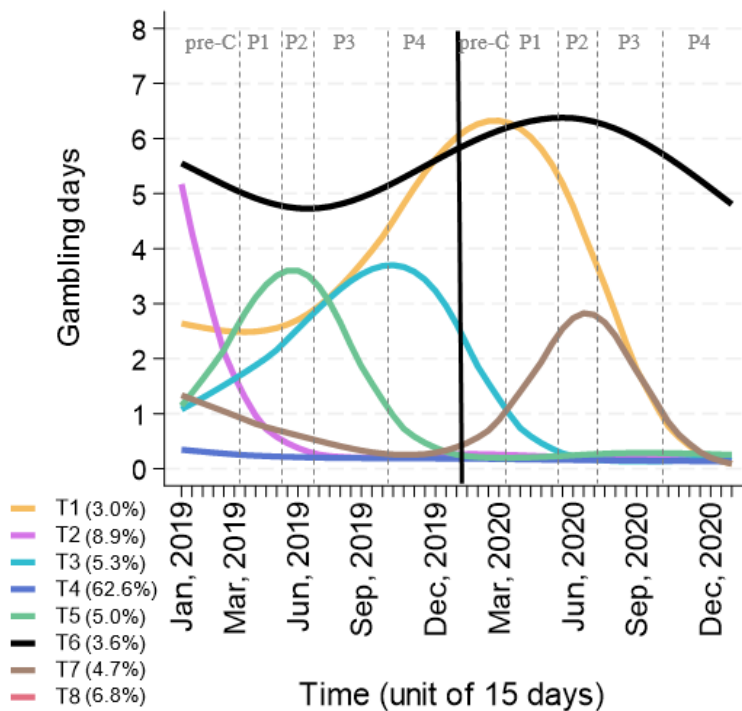


Figure 3: Gambling trajectories of horse race bettors for the number of gambling days and money wagered.

Poker



Poker

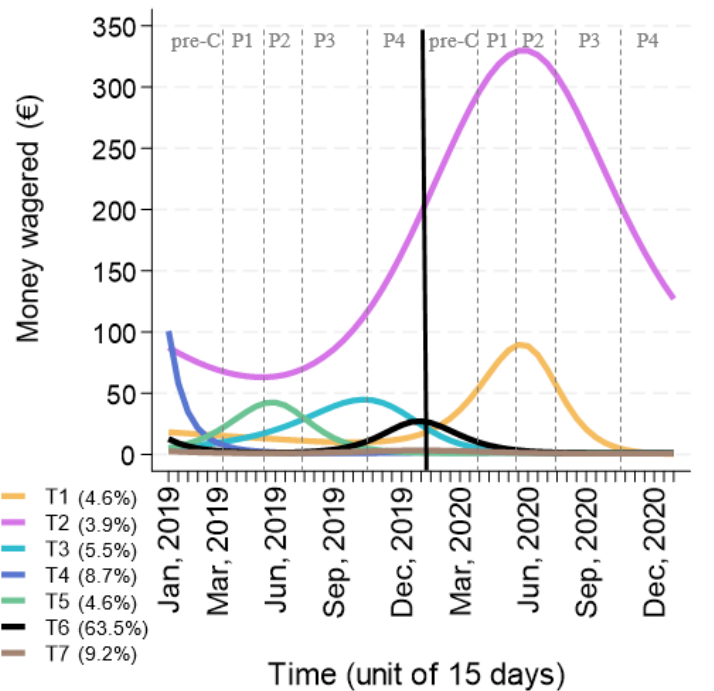
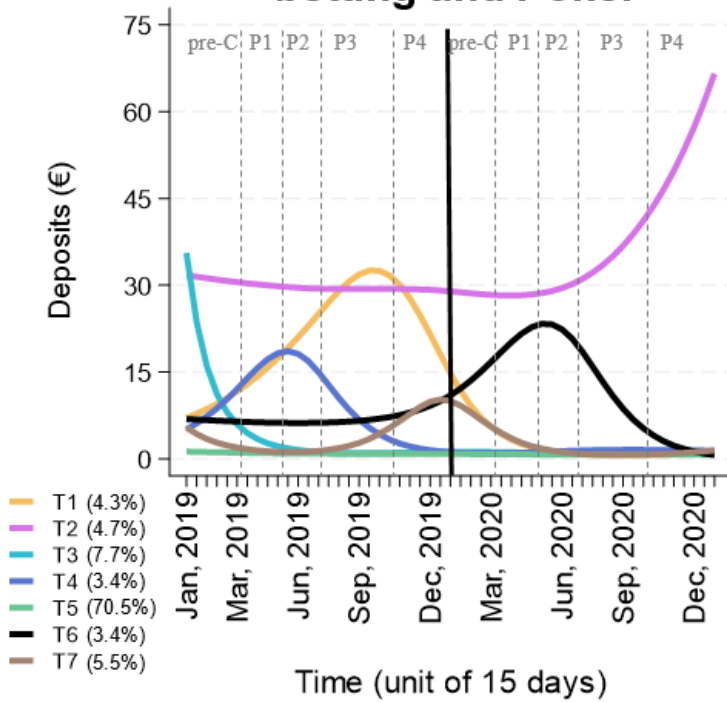
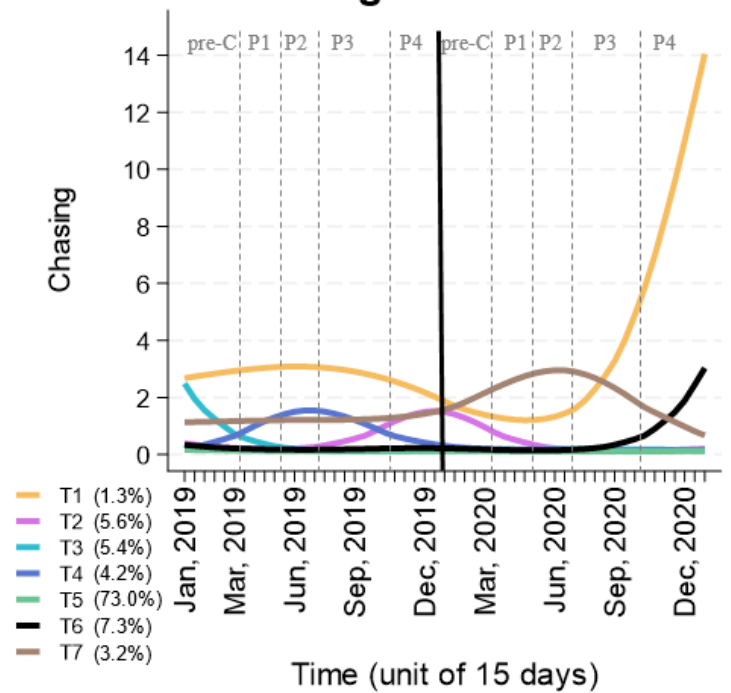


Figure 4: Gambling trajectories of gamblers engaged in poker for the number of gambling days and money wagered.

Sports betting, Horse race betting and Poker



Sports betting, Horse race betting and Poker



Sports betting, Horse race betting and Poker

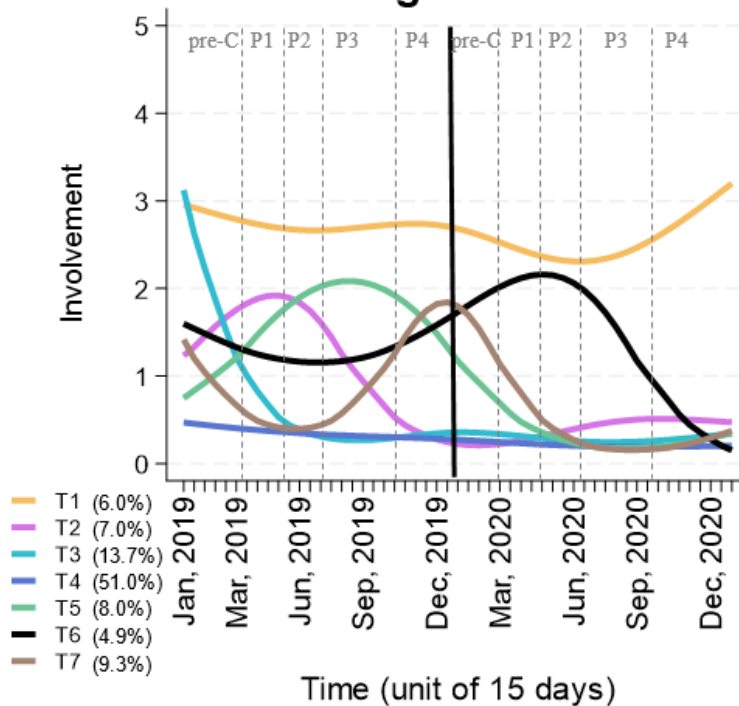
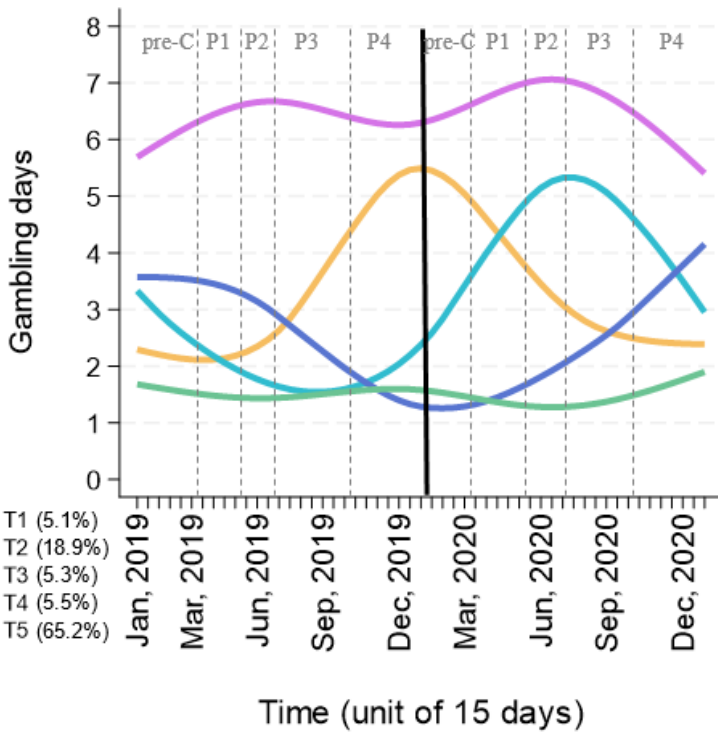
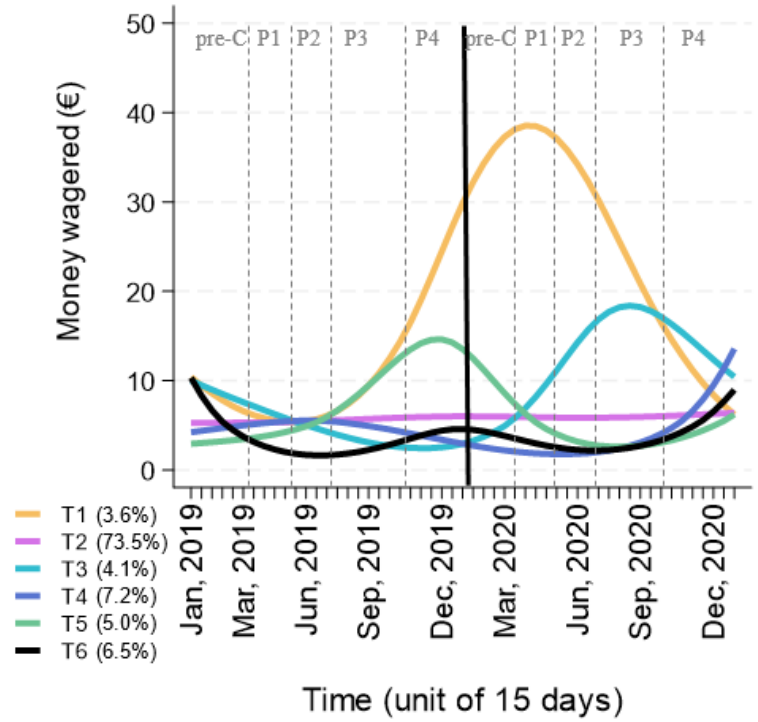


Figure 5: Gambling trajectories of gamblers engaged in sports betting, horse race betting and poker for the amount of deposit, number of chasing episode and level of involvement.

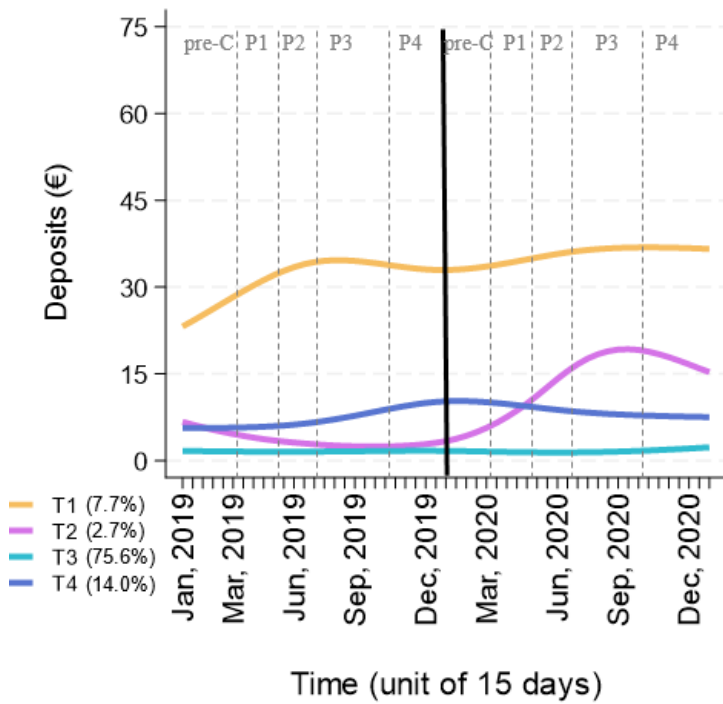
Lotteries



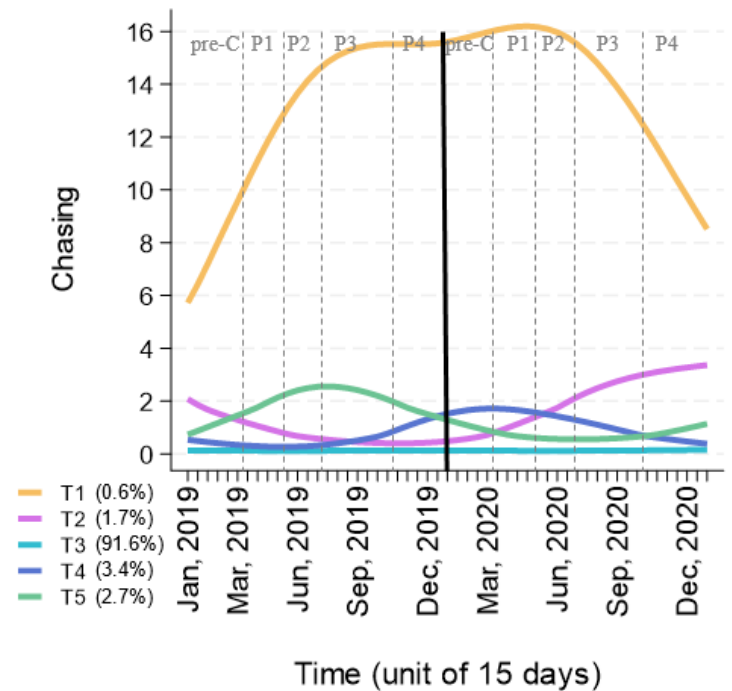
Lotteries



Lotteries



Lotteries



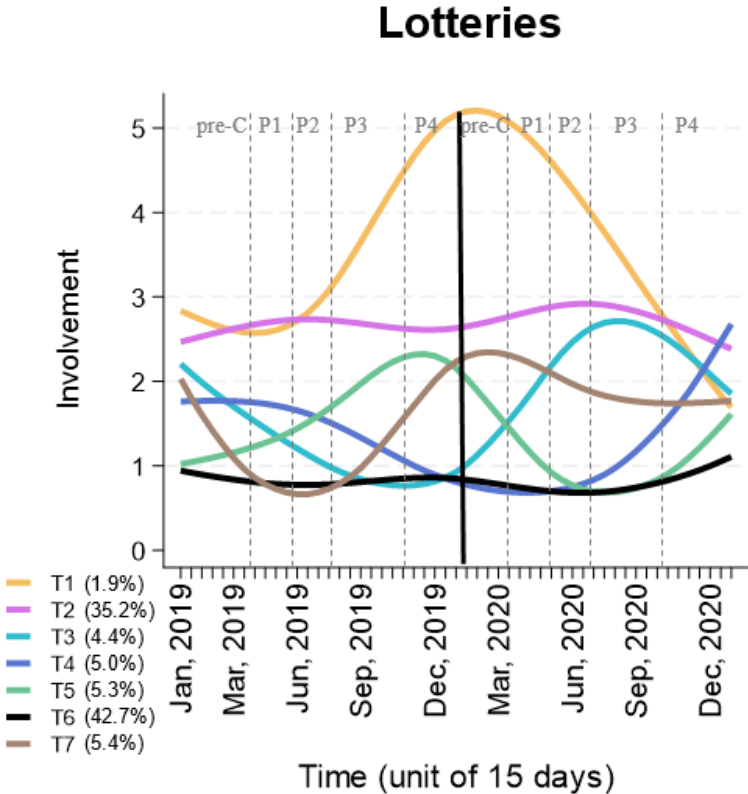


Figure 6: Gambling trajectories of gamblers engaged in lotteries for the five gambling indicators.

LCAs

The fit indices for the 1 to 8 classes solutions tested in the LCAs are provided in Table 3. For LCAs involving gamblers engaged in sports betting, horse race betting, and poker, the five-class solution was selected due to its higher entropy and lower BIC. For the LCA involving gamblers engaged in lotteries, the five-class solution was chosen because it had the highest entropy. The classification error rate was low for both LCAs (2% – 3%), indicating that the LCAs were well-distinguished and class membership probabilities were accurately predicted.

Gamblers engaged in sports betting, horse-race betting and poker

Table 4 presents results of the eLCA for 5 solutions for gamblers engaged in sports betting, horse race betting and poker.

Class 1 (58.6%) consisted primarily of sports bettors, with 77% being male and an average age of 37. Some individuals exhibited low gambling activity throughout the study period, while others maintained a stable gambling intensity in 2019, wagering about €25 per two weeks. This amount slightly decreased starting from the P1 period in 2020, eventually dropping to below €20 by the end of the year. Additionally, individuals in this

class gambled less than once per two weeks, deposited very little money into their gambling accounts, and did not engage in chasing episodes. A few gamblers also placed bets on poker (€25 every two weeks), but only between late 2019 and early 2020.

Class 2 (13.9%) consisted entirely of sports bettors, primarily male (82%), with an average age of 33. Some individuals showed high intensity and frequency of gambling at the start of 2019, but this significantly declined, leading to almost no gambling activity in 2020. Others maintained stable gambling levels from 2019 until the P1 period in 2020, after which their activity dropped but then increased sharply in the P4 period to levels much higher than those in 2019. Additionally, some individuals were more involved in 2019, gambling 2 to 3 different games, whereas their involvement dropped to nearly zero in 2020.

Class 3 (10.1%) comprised gamblers involved in sports betting and poker, primarily male, with an average age of 40. Sports bettors showed stable gambling intensity in 2019, but this decreased in 2020. Those engaged in poker participated during various periods in 2019 but did not gamble at all in 2020. Additionally, individuals in this class had a higher level of involvement in 2019, playing 1 to 2 different games, compared to 2020, when they either did not play or played only one game. Furthermore, they did not deposit

much money into their gambling accounts and did not engage in chasing episodes.

Class 4 (10.0%) was characterized by sports bettors and horse race bettors, primarily men with an average age of 35. Sports bettors decreased their gambling activity in terms of frequency and intensity in 2020 compared to 2019. Horse race bettors were active gamblers, wagering between €70 and €80 every two weeks in 2019. During the P1 period in 2020, their gambling intensity decreased to €60 per two weeks, but then increased to over €80 per two weeks during the P4 period. In contrast, their frequency of gambling remained stable over the two years, staying at less than one day of gambling per two weeks. For individuals in Class 4, the level of involvement was around two different games played in 2019 but dropped to zero in 2020.

Class 5 (7.4%) was characterized by predominantly male gamblers (72%) with an average age of 54. Gamblers in this class were regular participants in sports betting, horse race betting, and poker. For sports betting and horse race betting, the gambling activity remained stable in 2019 but decreased during the P1 period in 2020. It then substantially increased, reaching higher levels in the P4 period than those observed in 2019, especially for sports betting. For instance, the amount wagered increased from an average of €10 in 2019 to €100 per two weeks in the P4 period in 2020, and the number of gambling days

rose from 2 days to 6 days per two weeks. Regarding poker, both the intensity and frequency of play increased significantly during the P1 and P2 periods in 2020, with the amount wagered rising from €75 to nearly €325. However, the gambling activity returned to normal levels in the P4 period. For deposits, some gamblers had stable deposit amounts in 2019, followed by a significant increase starting in the P3 and P4 periods in 2020, rising from €30 to nearly €70. Others saw a substantial increase in deposits during the P1 and P2 periods but returned to normal levels afterward. Both trends were also observed for the level of involvement. Finally, individuals in this class exhibited a stable trend of chasing episodes close to zero, or another trend where chasing episodes were stable in 2019 but increased drastically during the P3 and P4 periods in 2020, rising from 3 episodes per two weeks to 14.

Gamblers engaged in lotteries

Table 5 presents results of the LCA for 5 solutions for gamblers engaged in lotteries.

Class 1 (46.2%) was predominantly composed of males (68.20%) with an average age of 47. These gamblers had low and stable gambling activity throughout the study period, wagering an average of €5, gambling 1.5 days, and participating in one type of game every two weeks. The trends for deposits and chasing episodes were close to zero.

Class 2 (30.1%) comprised gamblers, primarily male, with an average age of 40. Gamblers in this class had stable gambling activity until the P1 and P2 periods in 2020, where their activity increased significantly: gambling days rose from 2 to 5, money wagered from €5 to €20, money deposited from €5 to €20, and different games played from 1.5 to 2.5, all per two weeks. However, during P4 period the gambling activity decreased. The number of chasing episodes remained close to zero throughout the study period.

Class 3 (14.0%) was characterized predominantly by males aged 54. The gambling activity of these gamblers increased at the end of 2019, peaked during the P1 and P2 periods in 2020, and then decreased in the P3 and P4 periods to levels similar to those in 2019. Their gambling activity rose from €5 to €40 in money wagered and from 2 to 5.5 gambling days per two weeks before returning to normal levels. Additionally, the amount of deposits and level of involvement increased slightly during the same periods.

Class 4 (7.5%) was characterized primarily by males aged 48. The gambling activity for most of these gamblers decreased from the end of 2019 to the beginning of 2020, then increased during the P4 period, reaching the same levels as in 2019. These gamblers wagered and deposited weak sums of money (around €5 per two weeks) and played

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

between 1 to 4 days per week, varying changes occurred: the amount wagered between 1 and 2 different games. increased from €5 to €20, gambling days rose

Class 5 (2.3%) was primarily composed of from 2 to 5, deposits grew from €5 to €20, and males aged 49. This class is characterized by chasing episodes increased from 1 to 3. stable gambling activity, except during the P2 and P3 periods in 2020 when the following

Table 3: Fit indices of the 1-to 8-class models for both LCAs.

Number of class	Log-likelihood	BIC	Classification errors	Entropy
<i>LCA on gamblers engaged in sports betting, horse-race betting and poker</i>				
1-Class	-287,868.38	576,298.40	0.000	1.000
2-Class	-260,524.18	522,182.20	0.023	0.902
3-Class	-243,829.96	489,365.98	0.026	0.930
4-Class	-232,258.32	466,794.93	0.034	0.926
5-Class	-224,397.81	431,256.13	0.026	0.949
6-Class	-218,605.93	451,646.13	0.028	0.941
7-Class	-213,630.59	440,634.59	0.029	0.945
8-Class	-210,330.34	425,227.84	0.044	0.926
<i>LCA on gamblers engaged in lotteries</i>				
1-Class	-173,787.04	347,807.21	0.000	1.000
2-Class	-165,707.79	331,712.29	0.011	0.966
3-Class	-161,183.06	322,726.41	0.070	0.794
4-Class	-158,210.31	316,844.50	0.010	0.905
5-Class	-155,120.36	310,728.18	0.016	0.953
6-Class	-154,333.46	312,217.96	0.079	0.867
7-Class	-151,414.58	303,443.78	0.023	0.912
8-Class	-149,342.16	299,362.51	0.045	0.887

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

Table 4: Results of the LCA on gamblers engaged in sports betting, horse race betting and poker.

LCA	Class 1	Class 2	Class 3	Class 4	Class 5
Probabilistic class size, in %	58.6	13.9	10.1	10.00	7.4
Probabilities, p					
Amount of money wagered					
<i>Sports betting</i>					
Trajectory 1	0.00	0.64	0.00	0.02	0.78
Trajectory 2	0.01	0.12	0.01	0.01	0.01
Trajectory 3	0.63	0.13	0.13	0.17	0.08
Trajectory 4	0.01	0.10	0.01	0.03	0.01
Trajectory 5	0.01	0.01	0.00	0.48	0.02
Trajectory 6	0.00	0.00	0.00	0.28	0.01
Trajectory 7	0.34	0.00	0.86	0.00	0.09
<i>Horse race betting</i>					
Trajectory 1	0.00	0.00	0.00	0.01	0.07
Trajectory 2	0.00	0.00	0.00	0.00	0.02
Trajectory 3	0.00	0.00	0.00	0.04	0.06
Trajectory 4	0.00	0.01	0.00	0.01	0.74
Trajectory 5	0.00	0.00	0.00	0.02	0.03
Trajectory 6	0.00	0.00	0.00	0.73	0.00
Trajectory 7	1.00	0.99	1.00	0.18	0.07
Trajectory 8	0.00	0.00	0.00	0.01	0.01
<i>Poker</i>					
Trajectory 1	0.00	0.00	0.09	0.00	0.03
Trajectory 2	0.00	0.00	0.00	0.00	0.78
Trajectory 3	0.00	0.00	0.12	0.02	0.02
Trajectory 4	0.00	0.02	0.19	0.00	0.00
Trajectory 5	0.00	0.00	0.10	0.00	0.00
Trajectory 6	0.22	0.05	0.33	0.07	0.04
Trajectory 7	0.78	0.93	0.17	0.91	0.13
Number of gambling days					
<i>Sports betting</i>					
Trajectory 1	0.01	0.00	0.00	0.74	0.02
Trajectory 2	0.00	0.61	0.00	0.02	0.63
Trajectory 3	0.00	0.15	0.01	0.01	0.01
Trajectory 4	0.01	0.16	0.00	0.18	0.01
Trajectory 5	0.98	0.07	0.99	0.04	0.09
Trajectory 6	0.00	0.00	0.00	0.01	0.24

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

Horse race betting

Trajectory 1	0.00	0.00	0.00	0.01	0.29
Trajectory 2	0.00	0.01	0.00	0.00	0.20
Trajectory 3	0.00	0.00	0.00	0.00	0.02
Trajectory 4	0.99	0.99	0.98	0.98	0.27
Trajectory 5	0.01	0.00	0.00	0.01	0.23

Poker

Trajectory 1	0.00	0.00	0.07	0.00	0.03
Trajectory 2	0.00	0.02	0.36	0.00	0.00
Trajectory 3	0.00	0.00	0.14	0.02	0.00
Trajectory 4	1.00	0.96	0.12	0.94	0.15
Trajectory 5	0.00	0.01	0.14	0.00	0.00
Trajectory 6	0.00	0.00	0.01	0.00	0.77
Trajectory 7	0.00	0.01	0.00	0.00	0.02
Trajectory 8	0.00	0.00	0.16	0.03	0.02

Amount of deposits

*S/H/P**

Trajectory 1	0.00	0.00	0.06	0.10	0.04
Trajectory 2	0.00	0.54	0.00	0.00	0.56
Trajectory 3	0.00	0.18	0.10	0.01	0.02
Trajectory 4	0.00	0.06	0.05	0.01	0.03
Trajectory 5	1.00	0.20	0.68	0.72	0.05
Trajectory 6	0.00	0.00	0.05	0.01	0.30
Trajectory 7	0.00	0.02	0.08	0.15	0.00

Number of chasing

*S/H/P**

Trajectory 1	0.00	0.21	0.00	0.00	0.45
Trajectory 2	0.00	0.00	0.01	0.02	0.02
Trajectory 3	0.00	0.01	0.01	0.00	0.02
Trajectory 4	0.00	0.00	0.01	0.01	0.01
Trajectory 5	1.00	0.65	0.97	0.97	0.40
Trajectory 6	0.00	0.13	0.00	0.00	0.05
Trajectory 7	0.00	0.00	0.00	0.00	0.03

Level of involvement

*S/H/P**

Trajectory 1	0.00	0.02	0.00	0.00	0.70
Trajectory 2	0.02	0.26	0.00	0.00	0.01
Trajectory 3	0.03	0.58	0.01	0.01	0.00
Trajectory 4	0.93	0.10	0.05	0.05	0.01
Trajectory 5	0.01	0.02	0.36	0.36	0.00
Trajectory 6	0.01	0.01	0.03	0.03	0.28

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

Trajectory 7	0.01	0.01	0.54	0.54	0.00
Covariates					
Gender, %					
<i>Male</i>	77.09	81.57	72.23	82.04	75.92
<i>Female</i>	22.89	18.43	27.27	17.96	24.08
Age, years					
	36.65	32.99	40.18	35.11	51.32

*: Corresponds to Sports betting, Horse races betting and Poker.

Table 5: Results of the LCA on gamblers engaged in lotteries.

LCA	Class 1	Class 2	Class 3	Class 4	Class 5
Probabilistic class size, in %	46.2	30.1	14.0	7.5	2.3
Probabilities, p					
Amount of money wagered					
<i>Lotteries</i>					
Trajectory 1	0.01	0.09	0.72	0.49	0.19
Trajectory 2	0.71	0.21	0.14	0.07	0.07
Trajectory 3	0.05	0.68	0.05	0.21	0.58
Trajectory 4	0.10	0.02	0.05	0.04	0.04
Trajectory 5	0.06	0.05	0.0	0.19	0.11
Trajectory 6	0.07	0.03	0.4	0.00	0.01
Number of gambling days					
<i>Lotteries</i>					
Trajectory 1	0.00	0.09	0.62	0.17	0.16
Trajectory 2	0.01	0.10	0.23	0.49	0.11
Trajectory 3	0.01	0.59	0.08	0.09	0.68
Trajectory 4	0.03	0.07	0.07	0.05	0.00
Trajectory 5	0.95	0.15	0.00	0.19	0.05
Amount of deposits					
<i>Lotteries</i>					
Trajectory 1	0.01	0.00	0.05	0.15	0.01
Trajectory 2	0.03	0.65	0.01	0.07	0.84
Trajectory 3	0.92	0.00	0.05	0.51	0.15
Trajectory 4	0.04	0.35	0.89	0.27	0.15
Number of chasing					
<i>Lotteries</i>					
Trajectory 1	0.00	0.00	0.00	0.00	0.00
Trajectory 2	0.01	0.00	0.00	0.00	0.56
Trajectory 3	0.98	0.98	0.93	0.97	0.25
Trajectory 4	0.01	0.01	0.02	0.01	0.15

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

Trajectory 5	0.00	0.01	0.05	0.02	0.04
Level of involvement					
<i>Lotteries</i>					
Trajectory 1	0.00	0.05	0.05	0.02	0.00
Trajectory 2	0.00	0.01	0.00	0.35	0.00
Trajectory 3	0.00	0.94	0.09	0.04	0.72
Trajectory 4	0.00	0.00	0.19	0.05	0.00
Trajectory 5	0.01	0.00	0.16	0.05	0.02
Trajectory 6	0.92	0.00	0.51	0.43	0.26
Trajectory 7	0.07	0.00	0.00	0.05	0.00
Covariates					
Gender, %					
<i>Male</i>	68.20	75.30	68.55	72.10	69.15
<i>Female</i>	31.80	24.70	31.45	27.90	30.85
Age, years					
	46.70	51.54	47.58	54.41	48.88

5.2.5 Discussion

The present study aimed to identify subpopulations of gamblers with distinct gambling behavior during the COVID-19 pandemic, using individual gambling trajectories from a representative sample covering all authorized gambling types in France. We identified five distinct subpopulations of online gamblers engaged in sports betting, horse betting, and poker, and five distinct subpopulations of online gamblers engaged in lotteries, based on their gambling trajectories during the pandemic year (2020) compared to a reference year (2019).

The findings reveal distinct patterns in gambling behaviors across five classes of gamblers engaged in sports betting, horse race betting and poker and five classes of gamblers engaged in lotteries.

The results indicate that most gamblers in the ANJ dataset are primarily sports bettors who engage in gambling infrequently, with activity levels close to zero. Since these individuals are not heavily invested in regular betting, the disruptions caused by the pandemic did not significantly alter their habits or engagement levels. Furthermore, the finding that 46% of gamblers involved in lotteries exhibited stable and weak activity further emphasizes the trend of low-frequency participation among many gamblers. These results are consistent with findings from many studies conducted on the general population, which indicate that most people did not change their gambling habits during the period of restrictive measures. They either maintained their usual gambling frequency or did not gamble at all, both before and after the pandemic. (Amerio et al., 2022; Catalano et

al., 2024; Salerno & Pallanti, 2021; Shaw et al., 2022)

A specific group of bettors, who maintained stable gambling activity in 2019, completely ceased their betting in 2020. This cessation can likely be attributed to the cancellation of sports and horse racing events, indicating a strong reliance on these specific activities for their gambling engagement. The fact that these bettors did not shift to other forms of gambling suggests a limited versatility in their gambling habits, reflecting a commitment to sports betting as their primary interest. Similar results are found in several studies, which show that a majority of sports bettors either stopped participating or reduced their gambling habits due to the smaller sports betting offering (Håkansson, Jönsson, et al., 2020; Månsson et al., 2021; Wardle et al., 2021).

In contrast, another group of gamblers experienced a decline in their betting activity during the initial lockdown. However, this group later showed a remarkable resurgence, with their activity surpassing pre-pandemic levels during the second lockdown. This rebound may highlight an enthusiasm to engage more intensely once opportunities became available again. Their ability to return to higher levels of activity could also suggest a stronger emotional or social investment in gambling compared to those who completely stopped.

The findings indicate that gamblers with the highest levels of gambling activity were significantly impacted by the pandemic. For sports and horse race bettors, the decline in activity during sports and horse race interruptions led many to temporarily shift to poker, demonstrating some adaptability in their gambling behaviors as they sought alternatives to stay engaged. Once sports events resumed, these bettors returned to their original games. However, despite this return, there was a concerning increase in gambling intensity, frequency, and indicators of at-risk behaviors. The rise in chasing episodes from 3 to 14 highlights a troubling trend, suggesting the psychological impacts of the pandemic on gamblers, as the need to chase losses could indicate a deeper struggle with gambling addiction or maladaptive coping mechanisms (Banerjee et al., 2023; S. M. Gainsbury et al., 2014; Linnet et al., 2006). Furthermore, the findings indicate that some gamblers engaged in lotteries experienced an increase in activity during the first lockdown period, suggesting that many turned to lotteries as a form of entertainment when other gambling options were unavailable. Several studies have shown a potential shift in gambling activity from unavailable types of gambling to available types during the period of sports cancellations (Balem, Karlsson, et al., 2023; Emond et al., 2022; Håkansson, 2020b).

Limitation and strengths

The present study has several limitations.

Firstly, the lack of a third year after the pandemic-related year prevented to evaluate the effect at more long term, especially after the second lockdown. Secondly, a significant limitation is the absence of clinical data to assess changes in gambling activity based on the severity of problem gambling or gambling-related harms among participants. Research suggests that gambling behaviors during the pandemic likely differed according to varying levels of problem gambling severity (Håkansson, 2020c, 2020a; Lindner et al., 2020).

Conversely, this study has important strengths. The data included all types of online gambling activities authorized in France. This allowed us to provide an exhaustive view of the entire legal online gambling activity in France, which was lacking in previous studies on the subject that were exclusively based on a single operator or gambling type (Auer et al., 2020; Otis et al., 2022). The study spanned two years, allowing for a comparison between the pandemic-affected year (2020) and a reference year (2019). This timeframe also enabled the investigation of the pandemic's impact beyond the initial acute phase (spring–summer 2020), which is often overlooked in similar studies. Statistical models were

adjusted to account for the timeline of gambling events, ensuring that any observed effects were not mistakenly attributed solely to the postponement of competitions. Finally, By analyzing individual profiles, this study reveals detailed insights into how various classes of gamblers responded to the pandemic, uncovering behavioral variations that broader analyses might miss (Auer et al., 2020; Balem, Karlsson, et al., 2023; S. M. Gainsbury et al., 2021). This approach provides a more comprehensive understanding of the pandemic's diverse effects on gambling habits.

5.2.6 Conclusion

This study highlights the impact of a crisis that, at first glance, seems unrelated to gambling behavior (in this case, a viral pandemic). However, it may involve restrictions or concerns that indirectly affect gambling activities and lead some vulnerable groups to gamble more, even beyond the acute phase of the crisis. Preventive or regulatory measures should be strongly recommended if such situations occur again, whether it is a health crisis like COVID-19 or other types of crises (economic, war, internal security, etc.).

5.2.7 References

References are included in the References section of the thesis.

5.3 Manuscript 6: Typology of online gambling behaviors during the COVID-19 pandemic: Swedish national gambling tracking data from state-owned gambling sports and casino operator

Marianne Balem^{1,2,3}, Bastien Perrot^{2,4}, Gaëlle Challet-Bouju^{1,2}, Anders Håkansson^{3,5}.

¹ Nantes Université, CHU Nantes, UIC Psychiatrie et Santé Mentale, F-44000 Nantes, France

² Nantes Université, Univ Tours, CHU Nantes, INSERM, MethodS in Patient centered outcomes and HEalth ResEarch, SPHERE, F-44000 Nantes, France

³ Faculty of Medicine, Department of Clinical Sciences Lund, Psychiatry, Lund University, Lund, Sweden

⁴ Nantes University, CHU Nantes, Biostatistics and Methodology Unit, Department of Clinical Research and Innovation, F-44000, Nantes, France.

⁵ Malmö Addiction Center, Region Skåne, Malmö, Sweden

5.3.1 Abstract

Background: The COVID-19 pandemic has profoundly impacted daily life, increasing isolation and online activity, which affected gambling behaviors. The interruption of sports events led some gamblers to halt their activities while others intensified their gambling. **Aims:** To analyze individual gambling trajectories of representative Swedish gamblers during the pandemic (2020) compared to 2019 and identify at-risk subpopulations likely to increase their gambling activity in response to COVID-19. **Methods:** Gambling tracking data were provided from the Swedish state-owned gambling operator Svenska Spel Sports & Casino (sports betting, bingo, casinos and poker). A representative sample of 60,000 online gamblers were randomly selected. Gamblers must have gambled at least once from January 1st 2019 to December 31th, 2020. The first step was to estimate and compare classes of individual gambling trajectories using Latent Class Mixed Models (LCMM). The second step involved conducting a Latent Class Analysis (LCA) on the membership probabilities derived from the LCMM to classify gamblers with similar gambling trajectories. **Findings:** The study identified seven distinct classes of gamblers. The majority of them were mostly inactive and minimally impacted by the pandemic, while other classes, primarily sports bettors, showed varied responses such as significant declines during sports interruptions, shifting to other gambling types, and substantial increases in activity when sports resumed at the end of 2020. The results also highlighted differing impacts based on gambling type and gender. **Conclusions:** The study demonstrated the need for increased regulation and targeted prevention strategies during crises to limit abnormal changes in gambling behavior in response to fluctuations in gambling options.

5.3.2 Introduction

The coronavirus disease 2019 (COVID-19) pandemic has profoundly altered the day-to-day lifestyles of the global population (Ammar et al., 2020; Giallonardo et al., 2020). Public health measures (social distancing guidelines, home quarantine, work in-home, etc.), while necessary for containing the spreading virus, have increased feelings of isolation, anxiety and time spent online among people worldwide (Chauhan et al., 2020; Chen et al., 2021). Gambling, much like other forms of leisure, has faced significant disruptions due to the pandemic. One of the most notable effects for gamblers has been the total interruption of major sporting events for several months during the initial wave of the pandemic in 2020 (March–May 2020), disrupting their usual betting patterns and routines (Otis et al., 2022). Moreover, the closure of numerous land-based gambling establishments, including casinos, bingo halls, betting shops, poker rooms, etc., compelled gamblers to halt their gambling activities or shift to online platforms (Håkansson, 2020b). Then, the changes in gambling behaviors due to the pandemic could have varied among gamblers. While some may have reduced their gambling activity, others may have begun or intensified their habits, potentially leading to the development of problematic gambling behaviors (Claesdotter-Knutsson &

Håkansson, 2021; Håkansson & Widinghoff, 2021).

As a result of the pandemic's effects on psychological well-being and gambling opportunities during its early stages, researchers have called for investigations into how the COVID-19 pandemic has influenced gambling habits and potentially worsened gambling problems (Håkansson, Fernández-Aranda, et al., 2020). To date, numerous studies have been conducted worldwide since the beginning of the pandemic. Several findings mentioned that most sports bettors significantly reduced or ceased their gambling practices due to sports cancellations during the acute phase of the pandemic (Lindner et al., 2020; Wardle et al., 2021; Auer et al., 2020). Conversely, Håkansson highlighted that sports bettors who continued gambling during the period of limited sports betting occasions had significantly higher levels of gambling problems and were more likely to have a history of financial debt (Håkansson, 2020c). Additionally, some studies have indicated that gambling options remaining available when sporting events were cancelled (e.g. online casino, online bingo, online poker and horse betting) experienced a notable increase in activity during the same period, suggesting a shift or migration of gambling activity between different types of games (Balem, Karlsson, et al., 2023; Emond et al., 2022; Håkansson, 2020a). Moreover, research has demonstrated that starting a new form of

gambling during the pandemic was linked to gambling-related problems (Wardle et al., 2021). Then, a noticeable transition in gambling practices from land-based venues to online platforms during the first wave of the pandemic was observed in Germany (Smith et al., 2023). The authors raised concerns about the potential long-term effects, given that online gambling is more addictive than traditional offline gambling (Bouju et al., 2011; S. M. Gainsbury et al., 2013). Finally, numerous studies have highlighted that the minority of gamblers who increased their gambling practices during the pandemic were primarily regular gamblers before the outbreak and constituted a subpopulation of gamblers who were more vulnerable, either due to their younger age or pre-existing gambling problems (S. M. Gainsbury et al., 2021; Lugo et al., 2021; Quinn et al., 2022).

The impact of the pandemic on gambling activity across the global population was thoroughly studied worldwide. However, as of now, few longitudinal studies based on tracking gambling data have been conducted, and none, to our knowledge, has specifically evaluated the impact of the pandemic on individual gambling habits over a more extended period than just the initial wave of the pandemic.

Additionally, it's important to take into account the natural fluctuations in gambling behaviors in function of the availability of sports events. These fluctuations have not

been addressed in the existing COVID-19 research, even though they could significantly impact gambling trends. Many of the most popular sports leagues, which typically account for a large portion of bets, were either cancelled or postponed during the pandemic. As a result, these changes likely affected gambling habits in various ways throughout the pandemic, particularly in terms of timing, since events in 2020 did not align with those of 2019.

Thus, the present study aimed i) to characterize individual gambling trajectories of representative Swedish gamblers over a year impacted by the pandemic (2020) and a reference year (2019) and ii) to identify subpopulations of gamblers, particularly at-risk to increase their gambling activity in response to the COVID-19 pandemic.

Our first hypothesis was that a subpopulation of sports bettors may have shifted their gambling habits towards available forms of gambling and have maintained this activity despite the resumption of sports events, resulting in increased level of involvement. Our second hypothesis was that certain gamblers who had stable and controlled gambling behaviors before the pandemic would cease their gambling activity during the initial wave of the pandemic and would not resume it later. Our final hypothesis was that gamblers who engaged in more intense gambling behaviors before the pandemic compared to those who

gambled less (such as a high level of involvement, gambling more than once a week or a higher amount of money wagered etc.) would be more likely to increase their gambling habits in response to the pandemic.

5.3.3 Methods

Participants

The present study included gamblers who participated in the Svenska Spel's Sports & Casino subdivision. AB Svenska Spel is entirely owned by the Swedish state and is divided into three subdivisions: Sports & Casino (which included online sports betting, casino, bingo and poker), Svenska Spel Tur (which included lotteries and chance-based number games), and Casino Cosmopol (which included land-based casinos and land-based electronic gambling machines).

Measures

Svenska Spel provided a dataset of 60,000 online gamblers who engaged in sports betting, casinos, bingo, or poker at least once. The data were collected and aggregated weekly from January 1st, 2019, to December 31st, 2020, and included socio-demographic information such as sex and age and gambling tracking data of gamblers. Among the gambling tracking data available, three specific indicators of gambling behaviors were selected to illustrate gambling intensity and gambling frequency. We used two indicators to measure the gambling intensity: the weekly amount of money wagered and the

weekly amount of deposits made from the bank account to the gambling account. Gambling frequency was measured by the weekly number of gambling days (i.e., the number of days in a week when at least one bet was made). Importantly, all data were fully anonymized to protect the individuals' privacy.

Furthermore, to account for natural changes in gambling behaviors due to the gambling-related events, we calculated a variable related to the number of sports-related gambling events. We focused exclusively on football and ice hockey competitions, based on the hypothesis that most sports betting through the gambling operator was concentrated on these sports due to the wide range of betting options available on the site. We considered gambling-related events only for gambling types where the event timeline was impacted by the pandemic. This includes bets on competitions requiring physical presence, such as sports. Conversely, gambling events related to other forms of games, like casino games, bingo, and poker, were not included in our analysis because these events primarily take place online and were able to continue as usual during the pandemic, unlike in-person competitions.

To compare the different stages of the impact of the COVID-19 pandemic on the gambling opportunities within the Svenska Spel in 2020, four periods were defined,

comprising one reference period and three COVID-affected periods:

- Week 1-11 (30th December 2019 – 15th March 2020): Pre-COVID period (pre-C). The first official positive case in Sweden was identified on 31/01/2020, followed by the first death on 11/03/2020. There were no restrictions on gambling opportunities within Svenska Spel Sports & Casino.
- Week 12-19 (16th March 2020 – 10th May 2020): 1st COVID-affected period (P1). The peak of the first wave of contamination arrived in April, reaching an average of 100 deaths per day. The Swedish government implemented some restrictions (limiting gatherings to 50 people, closing secondary schools and colleges, etc.) and strongly urged people to practice social distancing and work from home. Most of European sports competitions were suspended and the state-owned land casinos were closed.
- Week 20-43 (11th May 2020 – 18th October 2020): 2nd COVID-affected period (P2). In May, the number of contaminations decreased gradually, and several football leagues began planning their return. The Bundesliga in Germany resumed matches without fans. In June, most of the top European football leagues restarted. By August,

all major sports competitions had resumed, including the NBA and tennis.

- Week 44-52 (19th October 2020 – 28th December 2020): 3th COVID-affected period (P3). In November, with the emergence of the second wave of COVID-19, the Swedish government tightened restrictions compared to the first wave. This included limiting alcohol sales and closing all public institutions. People were strongly encouraged to stay home and reduce contact. While casinos remained closed, sports competitions continued as scheduled.

To facilitate a comparison of the gambling behaviours between the two years, the same period division was applied to the year 2019.

Statistical analysis

Firstly, a descriptive analysis of the gamblers and the gambling indicators according to the gambling type was conducted, as presented in Tables 1 & 2. Then, we used a two-step approach to identify profiles of gamblers and their gambling trajectories during a year impacted by the COVID-19 pandemic (2020) and a reference year (2019). A two-step analysis approach was similar to the one employed in previous studies (Brédart et al., 2016; Montourcy et al., 2018; Perrot et al., 2018b).

First step: characterisation of gambling individual trajectories

The first step of the procedure was to estimate and compare classes of individual trajectories of gambling by using latent class mixed models (LCMM). The LCMM assumes that the population of interest is heterogeneous and composed of non-observed and unknown subgroups of subjects called latent classes, which are characterized by mean trajectories (Lin et al., 2002; Proust-Lima et al., 2013, 2014). In the present study, the LCMMs were composed of two submodels. Submodel 1 was a multinomial logistic regression estimating the membership probabilities of each gambler to each latent class, and submodel 2 was a class-specific mixed model estimating the mean gambling trajectory of each class over weeks from 2019 to 2020. We conducted LCMMs with varying numbers of classes, ranging from one to eight. We determined the optimal model using several criteria: the Akaike Information Criteria (AIC) and the Bayesian Information Criteria (BIC) to assess the goodness of fit, entropy to evaluate the quality of the classification (values closer to one indicating better classification) and the interpretability of classes. This process was carried out separately for the four gambling indicators and each gambling type, whenever applicable.

Additionally, the LCMMs for sports betting were adjusted according to the number of sports events, to account for natural

changes in gambling behaviors that occurred due to the differences in sports schedules between 2019 and 2020. Moreover, we aggregated data over two weeks instead of one (53 weeks instead of 105 weeks) to optimize the analysis and improve models estimation efficiency and duration.

To deal with the non-normal distribution of the four gambling indicators, we estimated LCMMs using a quadratic I-splines function and adjusted the combination of knots to optimize the fit to the data based on the AIC. Additionally, we used natural cubic splines with three inner knots, positioned at quartiles of the distribution of weeks 13, 26, and 39. This adjustment aimed to accommodate the sudden and abnormal changes in individual gambling trajectories resulting from the pandemic's impact on gambling opportunities (Elhakeem et al., 2022; Lévêque et al., 2020; Marcoulides & Khojasteh, 2018; Perperoglou et al., 2019). As the I-splines function failed to converge for the models related to the amount of money wagered and the number of deposits, likely due to the wide range of the data (see Table 2), we additionally opted for a $\log(x+1)$ transformation to address the range issue.

Second step: classification of gamblers with similar gambling trajectories

The second step consisted of conducting a Latent Class Analysis (LCA) to classify gamblers with similar gambling trajectories. The LCA was carried out on the membership

probabilities (as observed variable) derived from the trajectories estimated in the first step. We estimated several models whose number of classes ranged from 1 to 8 and determined the optimal number of classes using the same criteria as in the first step. The classes were described by the trajectory membership probabilities of each indicators and each gambling type (whenever applicable), covariates. LCMMs and LCA were performed with the `lcmm()` package on R 4.2.2 version (Proust-Lima et al., 2017).

5.3.4 Results

The flow-chart of the study is presented in Figure 1.

Description of gamblers and gambling indicators

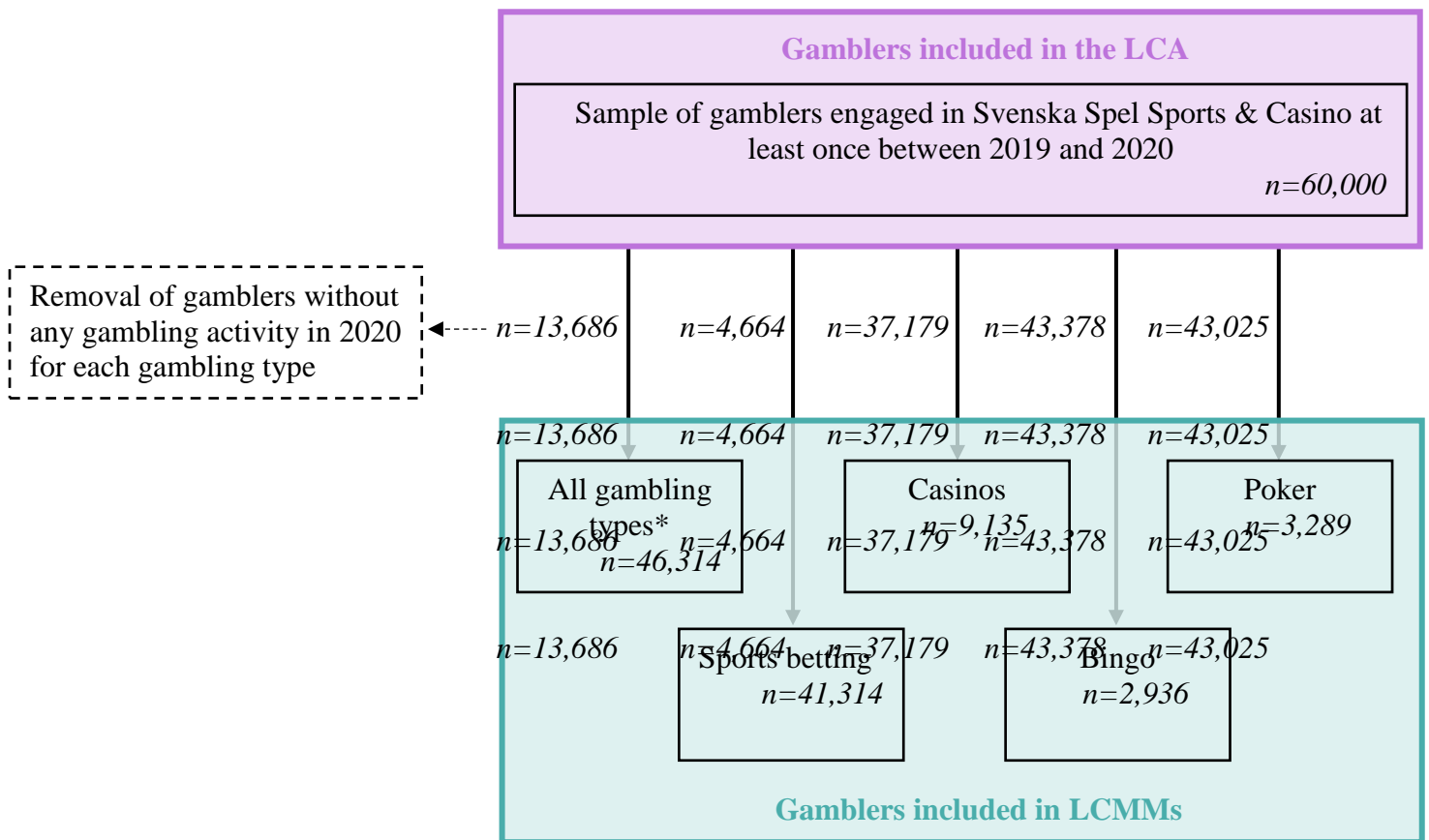
As described in Table 1, males predominated across all gambling types, although to a lesser extent among those playing online bingo. Additionally, gamblers engaged in online poker and online casinos tended to be younger than sports bettors and bingo gamblers.

As indicated in Table 2, gamblers engaged in online casinos and online poker wagered larger amounts than gamblers engaged in other forms of gambling. However, sports bettors tended to participate more frequently than gamblers involved in other types of gambling.

Table 1: Description of gamblers according to the gambling type.

n=46,314	Gamblers engaged in sports betting^a n=41,650	Gamblers engaged in casino^a n=9,135	Gamblers engaged in bingo^a n=2,936	Gamblers engaged in poker^a n=3,289
Covariates (n,%) or (med, min-max)				
Gender				
<i>Male</i>	33,450 (80%)	7,180 (79%)	1,704 (58%)	3,045 (93%)
<i>Female</i>	8,200 (20%)	1,955 (21%)	1,232 (42%)	244 (7%)
Age	51 (19-95)	38 (19-85)	48 (19-85)	38 (19-80)

^a: Represents the number of gamblers who gambled at least once in 2020 for the specified gambling type. A gambler can be represented in more than one gambling type if he gambled at several gambling types during the study period.



*: The analyses on the amount of deposits were realized across all types of gambling in the sample without distinguish them separately. Since a gambling account could be used for various gambling activities, it wasn't possible to differentiate between types of gambling for the deposits made into the account.

Figure 1: Flow-chart of the study

Table 2: Description of the four gambling indicators according to the gambling type.

Gambling indicators	Gambling types	<i>n</i> *	Mean (sd)	Min	Max	Q1	Q2	Q3	P90
Amount of money wagered	Sports betting	2,207,450	283 (2,524)	0	401,609	0	0	96	444
	Casino	484,155	2,279 (23,555)	0	5,206,827	0	0	0	1,970
	Bingo	155,608	87 (542)	0	24,629	0	0	0	95
	Poker	174,317	1,974 (35,030)	0	3,162,120	0	0	0	556
Number of gambling day	Sports betting	2,207,450	1.2 (2.6)	0	14	0	0	1	4
	Casino	484,155	0.7 (2.0)	0	14	0	0	0	2
	Bingo	155,608	0.6 (1.8)	0	14	0	0	0	2
	Poker	174,317	0.8 (2.4)	0	14	0	0	0	2
Amount of deposits	All gambling types	1,650,261	241 (1,617)	0	466,300	0	0	55	464

sd= standard deviation; Q1 = first quartile; Q2 = median; Q3 = third quartile; P90 = 90th percentile. *: corresponds to the total number of observations for each gambling type (e.g. for sports betting: 41,650 gamblers engaged in sports betting * 53 weeks = 2,207,450 observations).

LCMMs

Figure 2,3,4,5 and 6 illustrated the trajectories of the best LCMM, for each gambling indicators and each gambling types, when it was possible.

On the whole, the graphs reveal that for each type of gambling and each gambling indicator, there is one trajectory representing a large majority of gamblers, which shows nearly zero gambling activity throughout the entire study period.

Sports betting

Seven trajectories were identified for both gambling indicators. Most trajectories showed a decrease in gambling frequency and intensity in 2020, particularly during the P1 and P2 periods. Specifically, trajectories 1 (13.3%), 3 (8.7%), and 5 (6.6%) for gambling days, and trajectories 1 (15.2%), 3 (8.2%), and 4 (6.5%) for money wagered, all exhibited a decrease in gambling frequency and intensity during the P1 and P2 periods. This was followed by a significant increase in the P3 period, reaching higher levels than those observed in 2019.

Casinos

Seven trajectories were identified for gambling days and eight for money wagered. Trajectories 1 and 6 for both gambling indicators showed a significant increase in gambling activity during the P2 period in 2019. Trajectory 1 reached 5 gambling days and 1,500 SEK wagered per two weeks, while

trajectory 6 reached 2.5 gambling days and 1,750 SEK wagered per two weeks. These levels decreased in 2020, with trajectory 6 dropping to nearly zero gambling activity and trajectory 1 experiencing a slight decline. Trajectory 4 (7.4%) for gambling days and trajectory 2 (7.5%) for money wagered showed no gambling activity until the P3 period in 2020, when activity increased, peaking at 3 gambling days and 1,000 SEK wagered per two weeks. Trajectories 3 and 2 showed an increase in gambling days during the P1 period in 2020, peaking in the P2 period, and then decreasing in the P3 period.

Bingo

Eight trajectories were identified for both gambling days and the amount of money wagered. Trajectories 1 for both gambling indicators, representing about 5% of gamblers, were characterized by the highest levels of gambling frequency and intensity, with 5 gambling days and 230 SEK per two weeks, compared to the other trajectories. Trajectory 3 (4.0%) for gambling days and trajectory 7 (4.3%) for money wagered showed a similar trend, with no gambling activity until the P3 period, reaching 3 gambling days and 100 SEK wagered on average per two weeks. Trajectories 2 (2.9%), 4 (1.8%), and 7 (4.0%) showed an increase in gambling days in 2020 compared to 2019. The highest levels were reached during the P2

period. For trajectories 4 and 7, these levels decreased afterward, but they remained the same for trajectory 2. Trajectory 3 for money wagered exhibited a significant increase in 2020, reaching 200 SEK money wagered per two weeks between the P1 and P2 periods, then decreasing to less than 50 SEK per two weeks in the P3 period.

Poker

Seven trajectories were identified for gambling days and eight for money wagered. Trajectory 4, representing between 5% and 6% of gamblers, had the highest levels of gambling activity, reaching 6.5 gambling days and 1,000 SEK wagered per two weeks at the end of 2019. These levels then decreased in 2020. As seen with bingo, two trajectories showed no gambling activity until the P3 period in 2020. Specifically, trajectory 6 (6.5%) for gambling days and trajectory 2 (6.9%) for money wagered increased during the P3 period in 2020, reaching nearly 3 gambling days and 150 SEK wagered per two weeks. Trajectory 1 (6.0%) for gambling days and trajectory 5 (2.7%) for money wagered exhibited an increase, peaking during the pre-C period in 2020, and then decreasing to levels close to zero. Trajectories 2 (3.6%) and 3 (3.8%) for gambling days increased during the P1 period in 2020, peaking during the P2 period with between 1.5 and 2.5 gambling days per two weeks, and then decreasing.

All gambling types

Six trajectories were identified for deposits. Trajectories 1 (9.0%), 4 (10.6%) and 5 (8.3%) were characterized by a significant increase of amount of deposits during the P3 period in 2020 reaching levels largely higher than those observed before. Trajectory 3 (3.4%) exhibited an increase during the P1 period in 2020 reaching a peak of 120 SEK of deposits in P2 period, and decreased then in P3 period, reaching amounts close to zero.

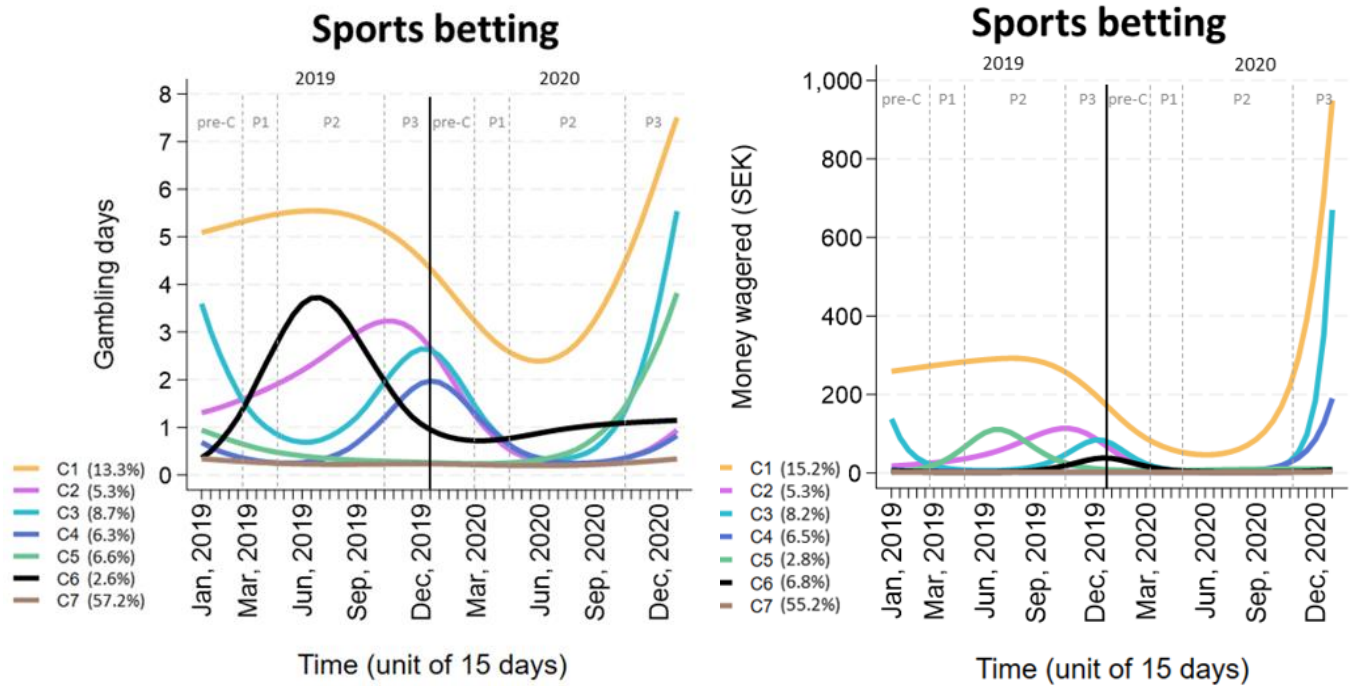


Figure 2: Gambling trajectories of sports bettors according to the gambling type.

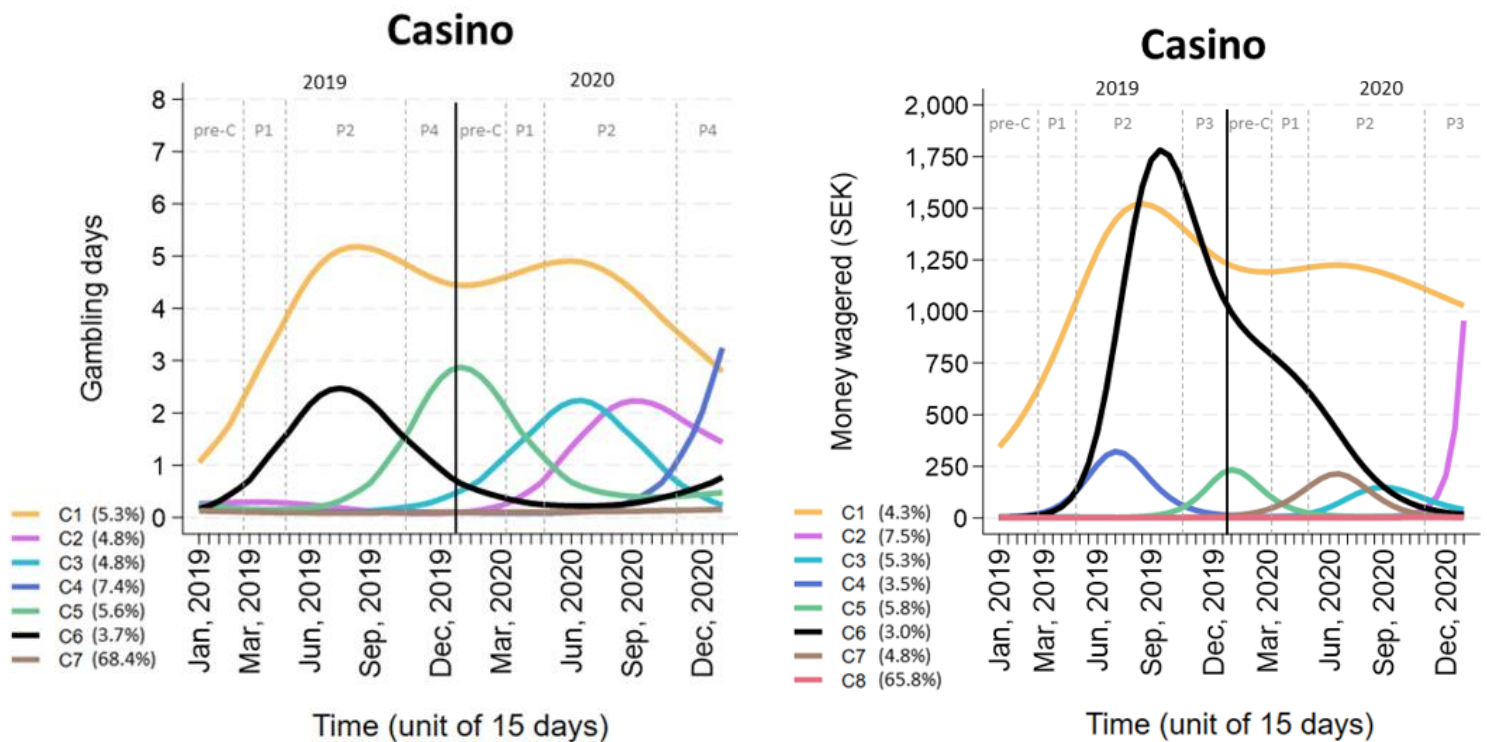


Figure 3: Gambling trajectories of gamblers engaged in casinos according to the gambling type.

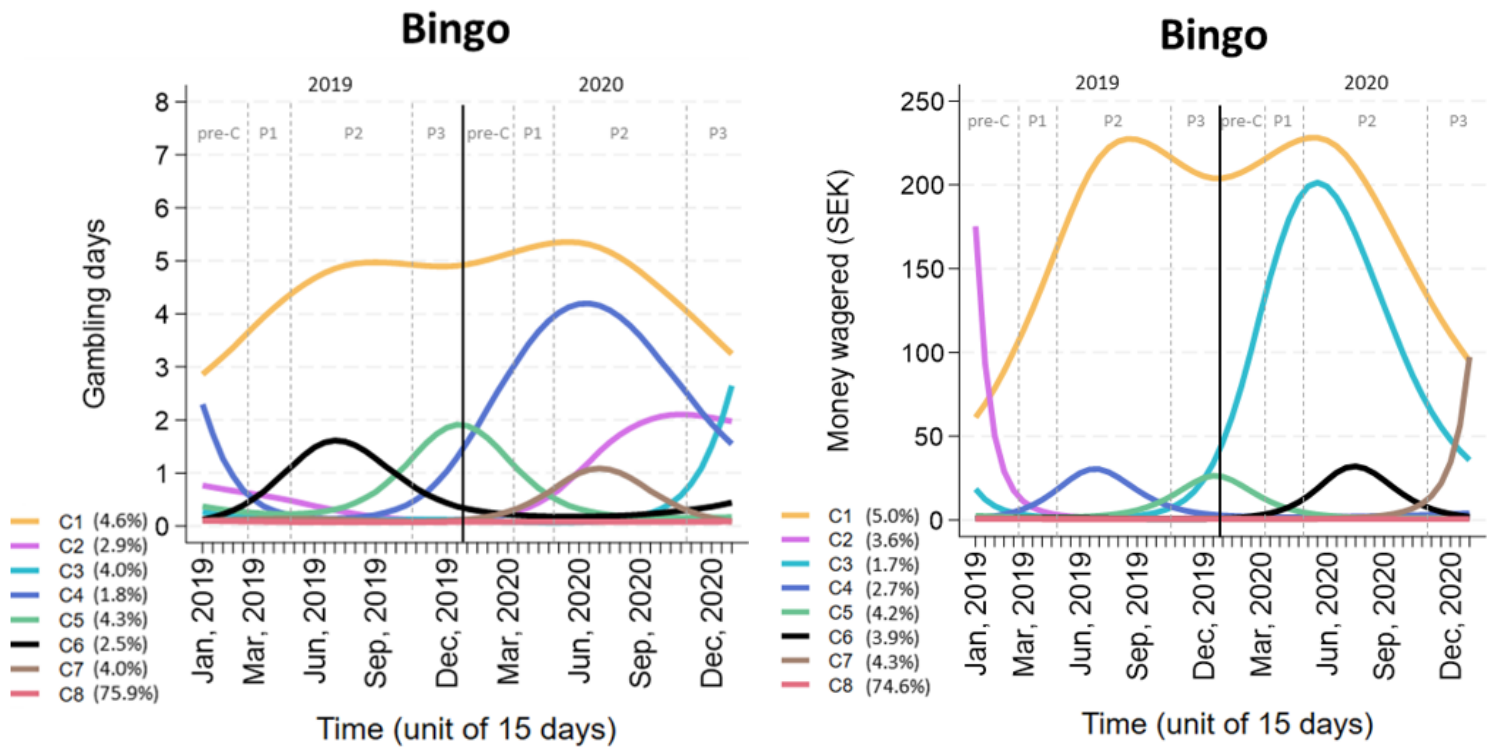


Figure 4: Gambling trajectories of gamblers engaged in bingo according to the gambling type.

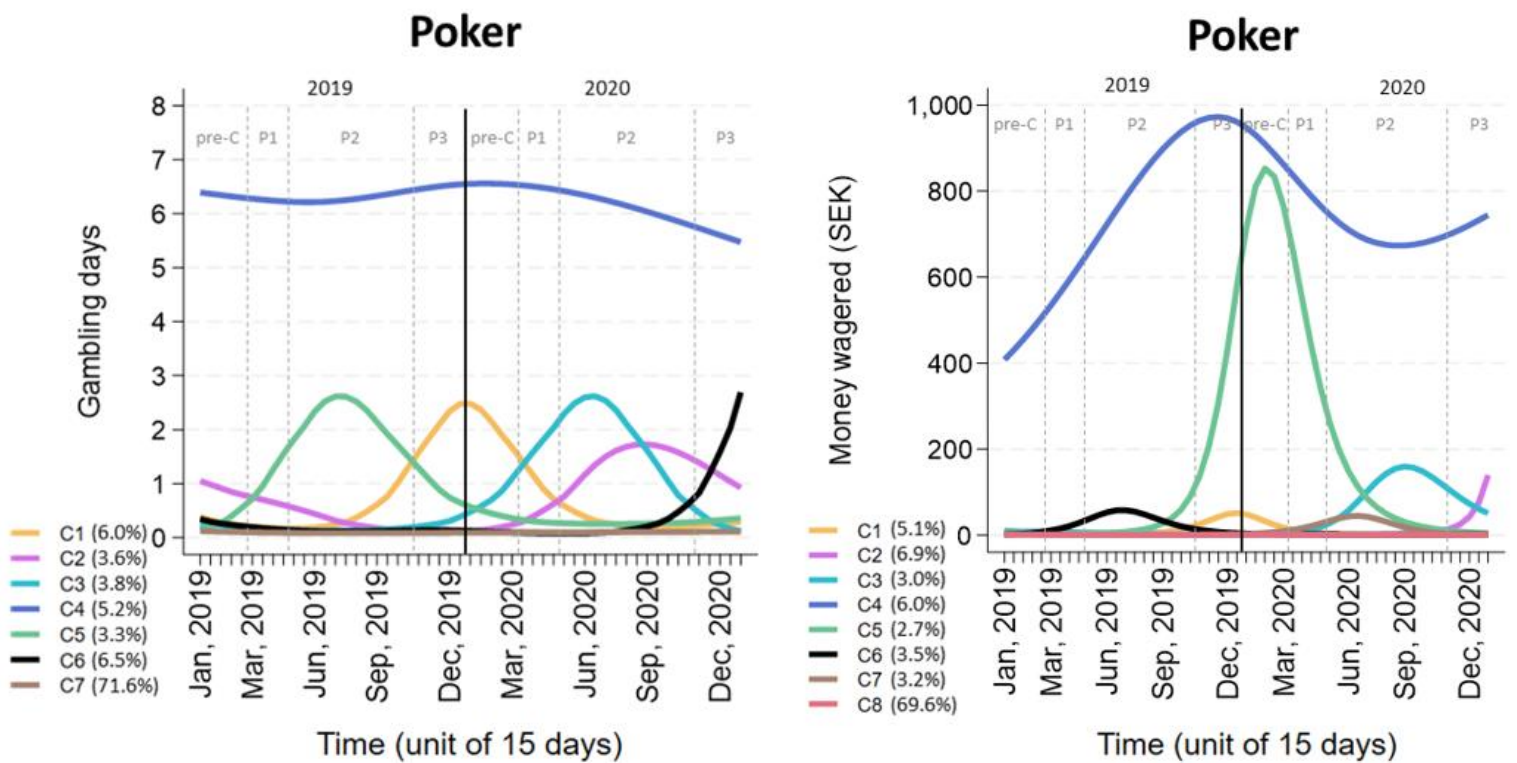


Figure 5: Gambling trajectories of gamblers engaged in poker according to the gambling type.

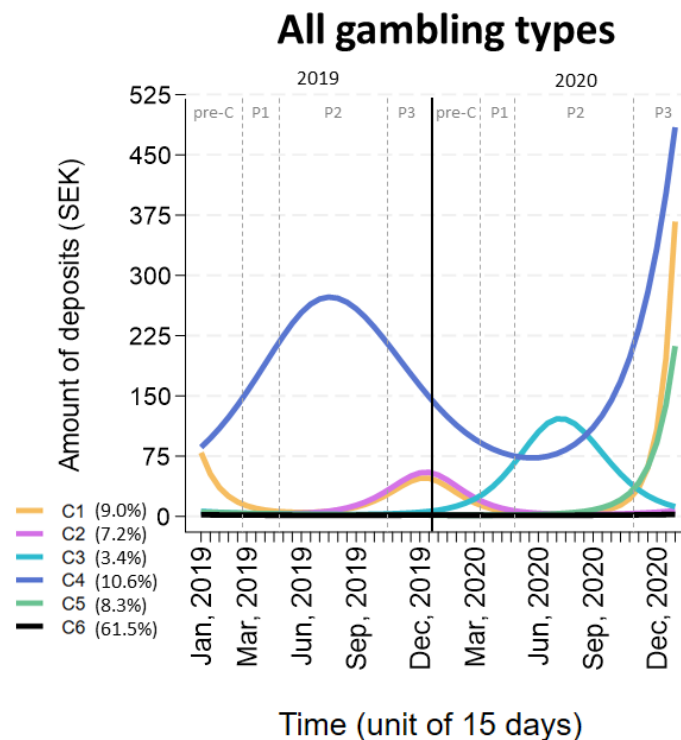


Figure 6: Gambling trajectories on amount of deposits for all gamblers.

LCA

Table 3 presents the fit indices for the 1 to 8 classes solutions tested in the LCA. The seven-class solution was chosen due to its higher entropy and lower BIC. The classification error rate was low (1%), indicating that the LCA was well-distinguished and class membership probabilities were accurately predicted.

Table 4 presents the results of the LCA with 8 classes solutions.

Class 1 (65%) consisted mainly of males, averaging 48 years old, who primarily engaged in only one type of gambling during the study period (85%). This class was characterized by very low gambling activity,

nearly zero across all types of gambling and indicators.

Class 2 (9.09%) was predominantly composed of men (92%) with an average age of 56 years, mainly engaged in a single form of gambling during the study period (78%). These individuals were involved in sports betting and had an active and stable gambling pattern in 2019. Their gambling activity decreased during the P1 and P2 periods in 2020 but then increased until the P3 period, reaching significantly higher levels than in 2019. Specifically, the amount wagered increased from 250 SEK to 950 SEK, and the number of gambling days rose from 5 to 7.5 days per two weeks. A similar trend was observed for the amount of deposits, which

increased from around 200 SEK to 500 SEK per two weeks.

Class 3 (8.69%) consisted primarily of males (85%) with an average age of 49 years, who engaged in one form of gambling during the study period (78%). These gamblers were mainly involved in sports betting, with most of their gambling activity occurring in 2019. Some of these sports bettors increased their gambling activity at the end of 2019 until the beginning of 2020, after which it returned to the same level as in 2019.

Class 4 (5.71%) consisted of 84% men with an average age of 48 years. Most gamblers in this class engaged in only one form of gambling (70%), while the rest engaged in 2 to 3 forms of gambling during the study period (29%). For sports betting, there was no gambling activity in 2019 and 2020 until the P3 period, where an increase was observed, with money wagered rising from 0 to 200 SEK and gambling days increasing from 0 to 4 days per two weeks. A similar trend was observed for casino gambling, with no activity until the P3 period in 2020, when it increased from 0 to 3 gambling days and from 0 to 200 SEK wagered. Regarding deposits, some gamblers deposited almost nothing during the study period, while others increased their deposits during the P3 period, rising from no deposits to over 200 SEK per two weeks.

Class 5 (5.69%) consisted predominantly of males (93%) with an average age of 44, with 76% engaged in only one form of gambling

during the study period. Most gamblers in this class participated in sports betting. Their gambling activity increased at the end of 2019, decreased at the beginning of 2020, and then increased again drastically during the P3 period. The changes were particularly notable in the frequency of gambling, which went from 3.5 gambling days at the beginning of 2019 to 1 day during the P2 period in 2019, then to 2.5 days in January 2020, dropped to zero in the P2 period, and finally increased to 5.5 days per two weeks during the P3 period. For deposits, some gamblers followed this same trend, while others deposited very little, close to zero, throughout the entire study period.

Class 6 (3.5%) was primarily composed of men (78%) with an average age of 45. About half of these gamblers were involved in two different types of gambling, while 30% engaged in three types. Some gamblers in this class were active sports bettors who reduced their gambling activity during the P1 and P2 periods in 2020, then reached higher levels in the P3 period than those observed in 2019. A similar trend was observed for deposits. Another group within this class was involved in casino gambling and poker. These gamblers exhibited two distinct trends: one group increased their gambling activity during the pre-C, P1, and P2 periods, returning to normal levels in the P3 period, while the other group had no gambling activity until the P3 period in

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

2020, where their gambling activity increased drastically.

Class 7 (1.08%) was characterized by a majority of women (60%) with an average age of 56, who primarily engaged in 2 or 3 different types of gambling during the study period. These gamblers were mainly involved in bingo and casino games. For bingo, there were two observed trends: one group significantly increased their gambling activity during the P1 and P2 periods in 2020, returning to normal levels in the P3 period.

The second trend involved gamblers who increased their activity during the P3 period in 2020, going from no gambling activity to 100 SEK wagered and from 0 to 2.5 gambling days per two weeks. For casinos, both same trends were observed: one group increased their gambling activity during the P1 and P2 periods in 2020 and returned to normal levels in the P3 period, while another group increased their gambling activity during the P3 period.

Table 3: Fit indices of the 1-to 8-class models for the LCA

Number of class	Log-likelihood	BIC	Classification errors	Entropy
1-Class	-242,462.78	485,552.68	0.000	1.000
2-Class	-204,671.15	410,607.56	0.013	0.945
3-Class	-190,137.56	382,178.48	0.009	0.968
4-Class	-179,526.42	361,594.34	0.011	0.969
5-Class	-173,261.78	349,703.17	0.012	0.970
6-Class	-169,182.89	342,183.52	0.014	0.969
7-Class	-165,341.60	331,048.21	0.012	0.973
8-Class	-162,977.12	335,139.06	0.012	0.971

Table 4: Results of the LCA

LCA	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Probabilistic class size. in %	64.96	9.09	8.69	5.71	5.69	3.50	1.08

Probabilities. p

Amount of money wagered

Sports betting

Trajectory 1	0.00	0.99	0.00	0.02	0.06	0.19	0.07
Trajectory 2	0.00	0.00	0.37	0.00	0.00	0.06	0.03
Trajectory 3	0.00	0.00	0.00	0.00	0.91	0.06	0.01
Trajectory 4	0.00	0.00	0.00	0.74	0.01	0.03	0.02

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

Trajectory 5	0.00	0.00	0.17	0.00	0.00	0.03	0.00
Trajectory 6	0.01	0.00	0.45	0.01	0.01	0.08	0.02
Trajectory 7	0.99	0.01	0.00	0.23	0.01	0.56	0.85
<i>Bingo</i>							
Trajectory 1	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Trajectory 2	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Trajectory 3	0.00	0.00	0.00	0.00	0.00	0.00	0.78
Trajectory 4	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Trajectory 5	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Trajectory 6	0.00	0.00	0.00	0.00	0.00	0.00	0.06
Trajectory 7	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Trajectory 8	1.00	1.00	1.00	1.00	1.00	1.00	0.00
<i>Casino</i>							
Trajectory 1	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Trajectory 2	0.00	0.01	0.00	0.14	0.01	0.40	0.51
Trajectory 3	0.00	0.00	0.00	0.02	0.00	0.01	0.02
Trajectory 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 6	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Trajectory 7	0.00	0.00	0.00	0.00	0.00	0.58	0.02
Trajectory 8	1.00	0.99	1.00	0.84	0.99	0.00	0.36
<i>Poker</i>							
Trajectory 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 2	0.00	0.00	0.00	0.00	0.00	0.19	0.00
Trajectory 3	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Trajectory 4	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Trajectory 5	0.00	0.00	0.00	0.00	0.00	0.71	0.00
Trajectory 6	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Trajectory 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 8	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Number of gambling days							
<i>Sports betting</i>							
Trajectory 1	0.00	0.90	0.00	0.01	0.01	0.16	0.07
Trajectory 2	0.00	0.02	0.36	0.00	0.01	0.06	0.03
Trajectory 3	0.00	0.02	0.01	0.00	0.92	0.07	0.05
Trajectory 4	0.00	0.00	0.41	0.00	0.02	0.08	0.04
Trajectory 5	0.00	0.01	0.00	0.73	0.01	0.03	0.03
Trajectory 6	0.00	0.01	0.16	0.00	0.00	0.03	0.03
Trajectory 7	1.00	0.04	0.05	0.26	0.03	0.58	0.74
<i>Bingo</i>							
Trajectory 1	0.00	0.00	0.00	0.00	0.00	0.00	0.01

CHAPTER 5. IMPACT OF THE COVID-19 PANDEMIC ON GAMBLING BEHAVIORS:
AN INDIVIDUAL-LEVEL APPROACH

Trajectory 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 3	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Trajectory 4	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Trajectory 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 7	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Trajectory 8	1.00	1.00	1.00	1.00	1.00	1.00	0.10
<i>Casino</i>							
Trajectory 1	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Trajectory 2	0.00	0.00	0.00	0.02	0.00	0.05	0.01
Trajectory 3	0.00	0.00	0.00	0.00	0.00	0.36	0.29
Trajectory 4	0.00	0.01	0.00	0.14	0.01	0.59	0.56
Trajectory 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 7	1.00	0.99	1.00	0.85	0.99	0.00	0.10
<i>Poker</i>							
Trajectory 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 2	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Trajectory 3	0.00	0.00	0.00	0.00	0.00	0.67	0.00
Trajectory 4	0.00	0.01	0.00	0.00	0.01	0.02	0.00
Trajectory 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trajectory 6	0.00	0.00	0.00	0.00	0.00	0.31	0.00
Trajectory 7	1.00	0.99	1.00	1.00	0.99	0.00	1.00
Amount of deposits							
<i>All gambling types</i>							
Trajectory 1	0.00	0.09	0.04	0.02	0.50	0.01	0.02
Trajectory 2	0.00	0.02	0.24	0.00	0.04	0.00	0.00
Trajectory 3	0.00	0.02	0.01	0.02	0.00	0.24	0.42
Trajectory 4	0.00	0.68	0.04	0.00	0.01	0.69	0.00
Trajectory 5	0.00	0.08	0.01	0.47	0.06	0.00	0.51
Trajectory 6	1.00	0.11	0.65	0.48	0.40	0.06	0.05
Covariates							
Gender. %							
<i>Male</i>	71	92	85	84	93	78	40
<i>Female</i>	29	8	15	16	7	22	60
Age. years							
	48	56	49	44	48	45	56
Level of involvement. %							
<i>One gambling type</i>	0.85	0.78	0.78	0.70	0.76	0.13	0.11
<i>Two different gambling type</i>	0.12	0.16	0.16	0.22	0.17	0.50	0.40
<i>Three different gambling type</i>	0.03	0.06	0.05	0.07	0.06	0.30	0.41
<i>All gambling type*</i>	0.00	0.00	0.01	0.01	0.00	0.7	0.07

*: Corresponds to online gamblers who participated at least once in sports betting, bingo, casinos and poker during the study period.

5.3.5 Discussion

The present study aimed to identify subpopulations of gamblers with different gambling behavior during the COVID-19 pandemic, using individual gambling trajectories from a representative sample of gamblers from the state-owned gambling operator in Sweden. We identified seven distinct subpopulations of online gamblers based on their gambling trajectories during the pandemic year (2020) and a reference year (2019).

The results show that the majority of Svenska Spel gamblers, had an occasional approach to gambling and exhibit low activity levels. Thus, the impact of the pandemic was minimal for them. This indicates a certain resilience among these individuals in response to changes in the gambling landscape. Furthermore, findings indicated that many sports bettors reduced or stopped their betting altogether and did not switch to other gambling options. Even after sports resumed, their activity did not recover. These results align with several studies indicating that online gambling, particularly sports betting, decreased during the initial phase of the pandemic, and there was no overall increase in online gambling (Auer et al., 2020; Lindner et al., 2020; Wardle et al., 2021).

Conversely, some sports bettors, despite experiencing a decline in activity during the

interruptions, showed a strong rebound at the end of 2020, indicating a compensatory response. This significant resumption can be seen as an attempt to make up for missed opportunities. Not only did these bettors resume their wagering, but they also tended to increase their bets, reaching levels higher than those before the pandemic. This pattern of behavior raises questions about gamblers' psychology: the urge to "catch up" on lost gambling opportunities may lead to intensified gambling thereafter. These results align with the findings on compensatory gambling behavior during the COVID-19 pandemic (Rossi et al., 2020; Santomauro et al., 2021).

Additionally, findings show that some gamblers demonstrated low activity throughout the study but showed a significant increase at the end of 2020. This may indicate that certain gamblers only engage during specific periods, possibly in response to promotions or major events outside of gambling, such as holidays, Christmas, etc. Furthermore, it could involve new gamblers who created their accounts at the end of 2020 with the resumption of sports events.

The results revealed significant differences in gambling behaviors between sexes. In our sample from Svenska Spel, men tended to shift their focus toward poker and casino

games during the suspension of sports events. In contrast, women primarily played bingo and casino games. This suggests that men are more likely to seek competitive forms of gambling, while women may prefer games of chance that provide a different kind of engagement. These findings are consistent with a broader study of all gamblers from Svenska Spel, which highlighted differences in gambling behaviors during the acute phase of the pandemic based on gender (Balem, Karlsson, et al., 2023).

Finally, the results confirm previous studies that suggest some sports bettors shifted to other forms of gambling due to the cancellation of sports events (Brodeur et al., 2021; Catalano et al., 2024). This behavior indicates an instability in their gambling habits, as they may temporarily engage in different types of gambling but tend to revert to their original preferences once sports events resume. This pattern raises concerns about the potential for developing risky gambling behaviors. When bettors switch to alternative gambling forms, they may engage more frequently or at higher wagers, which can lead to problematic gambling pattern (Claesdotter-Knutsson & Håkansson, 2021; Håkansson, 2020b, 2020c; Håkansson & Widinghoff, 2021).

Limitations and strengths

The present study has several limitations. Firstly, the sample only includes gamblers

from the Svenska Spel operator, which does not encompass the entire online gambling activity in Sweden. As a result, this limits the study's ability to provide a comprehensive view of legal online gambling in the country. Secondly, the lack of clinical data to compare changes in gambling activity based on the severity of problem gambling among participants is a significant limitation. Research indicates that gambling behaviors during the pandemic likely varied across different levels of problem gambling severity (Claesdotter-Knutsson & Håkansson, 2021; Håkansson & Widinghoff, 2020). Finally, the study's timeframe ends in 2020 and does not account for subsequent years, preventing an assessment of long-term effects related to the pandemic.

Conversely, this study has important strengths. First, data encompassed multiple types of gambling from a major operator from Sweden, unlike other studies that focused on only one type of gambling (Auer et al., 2020; Auer & Griffiths, 2021). Additionally, the randomized sample of 60,000 gamblers allowed us to analyse a very large sample that could produce robust results. Third, the study's time frame covered two years and allowed, on the one hand, to compare a year impacted by the pandemic (2020) with a reference year (2019) and, on the other hand, to investigate the pandemic's impact beyond the acute phase of the pandemic (spring–summer 2020), which was performed in the

majority of studies on this topic (Lindner et al., 2020; Donati et al., 2021; Sharman et al., 2021; Wardle et al., 2021; Sachdeva et al., 2022; Price, 2020). Finally, studying individual gambler profiles rather than observed overall trends is a significant advantage of this research. Most studies on online gambling and COVID-19 tend to focus on the effects on the general gambling population, which can overlook important nuances in behaviors (Balem, Karlsson, et al., 2023; Månsson et al., 2021; Wardle et al., 2021). By examining individual profiles, this study provides deeper insights into how different sub-population of gamblers responded to the pandemic, highlighting variations in behaviors that might be missed in broader analyses. This approach enhances our understanding of the diverse impacts of the pandemic on gambling habits.

5.3.6 Conclusion

This study underscores the importance of monitoring gambling behaviors during crises. The observed increase in gambling after interruptions or changes in options highlights the need for targeted prevention strategies that address these dynamics. Additionally, these strategies should consider gender differences in gambling behaviors.

Finally, the COVID-19 pandemic, though not directly related to gambling, has shown that such crises can indirectly impact gambling activities and lead vulnerable

groups to gamble more. This emphasizes the need for preventive and regulatory measures to manage these effects, whether the crisis is health-related, economic, or involves other issues like war or security.

5.3.7 References

References are included in the References section of the thesis.

5.4 Overview and conclusion of the chapter 5

In this chapter, we conducted an individual-level analysis to estimate changes in gambling activity among a representative sample of French and Swedish gamblers during the year impacted by the COVID-19 pandemic (2020) compared to a reference year (2019).

5.4.1 Main results of the French study

Five distinct profiles were identified for gamblers involved in sports betting, horse race betting, and poker. Additionally, five others profiles were identified for gamblers involved in lotteries.

Results based on gamblers engaged in sports betting horse races and poker showed that 58% of them were sports bettors who had low and stable gambling activity throughout the study period. Another significant part, representing 14% of gamblers, were primarily male sports bettors who showed high gambling activity in early 2019, which then dropped significantly in 2020, resulting in minimal gambling that year. However, some of these gamblers maintained their activity until the sports interruption in 2020, after which their gambling decreased sharply and peaked at the end of the year, surpassing 2019 levels. Another group, comprising 10% of gamblers, was involved in both sports betting and poker, showing weak and unstable activity in 2019 that nearly disappeared in 2020. There was also a group of sports and horse race bettors, making up 10% of the sample, where sports bettors had stable activity in 2019 that decreased in 2020, while horse race bettors experienced a decline during the sports interruption but increased their activity by the end of the year, reaching higher levels than before the pandemic. Finally, 7% of gamblers exhibited regular, moderate to high activity in sports betting, horse race betting, and poker. Their sports and horse race betting activities declined during the lockdown but surged post-reopening, with sports betting even surpassing pre-pandemic levels. Horse race betting remained low in 2020, while poker activity increased during the lockdown and returned to normal afterward. For some gamblers, the number of chasing episodes remained stable and close to zero, while for others, it dramatically increased by the end of 2020. Despite these changes, the level of involvement remained consistent throughout the study period, with gamblers participating in 2 or 3 different games.

Results based on gamblers engaged in lotteries showed about 46% of gamblers exhibited low and stable gambling activity throughout the pandemic. Another significant group, comprising 30% of gamblers who were predominantly male, had stable activity in 2019, which rose significantly during the lockdown and sports interruption but declined during the second

lockdown. A smaller class, representing 14%, experienced increased gambling activity at the end of 2019, peaking during the lockdown, and then returning to 2019 levels by the end of 2020. There was also a group whose activity decreased from late 2019 to early 2020, followed by an increase during the second lockdown period, eventually returning to 2019 levels. Lastly, a very small group (2%) showed stable gambling activity except during the first lockdown in 2020 when all indicators rose sharply, before decreasing again to pre-pandemic levels during the second lockdown.

5.4.2 Main results of the Swedish study

Seven distinct profiles were identified for gamblers who participated in any form of gambling in *Svenska Spel Sports & Casino* during the study period. The majority of gamblers displayed low activity levels, engaging minimally in any gambling form, and were largely unaffected by the pandemic. While some sports bettors showed moderate activity in 2019, their engagement nearly disappeared in 2020 due to the interruption of sports events, leading many to stop betting altogether without exploring other gambling options. Conversely, other class of sports bettors initially experienced a decline in activity during the sports interruption but significantly increased their gambling at the end of 2020, surpassing pre-pandemic levels without shifting to other types of gambling. A smaller class of gamblers involved in both sports betting and casinos showed little activity throughout the study but also saw a notable increase at the end of 2020. Additionally, some sports bettors reduced their gambling during the sports cancellations but later switched to casino and poker games before returning to sports betting once events resumed. Lastly, a group primarily consisting of women engaged in bingo and casino games showed a significant rise in activity during the sports cancellation period, returning to pre-pandemic levels once sports resumed.

5.4.3 Conclusion

Both studies aimed to understand how different profiles of gamblers responded to the pandemic, revealing varied reactions among these classes. The majority of gamblers across all categories—those engaged in sports betting, horse race betting and poker in France, those engaged in lotteries in France, and those engaged in *Svenska Spel Sports and Casino* in Sweden—showed gambling activity levels close to zero for all indicators. This finding suggests that these individuals were occasional gamblers whose gambling habits remained unaffected by the pandemic, as their activity levels did not change between 2019 and 2020. The stability in gambling activity among occasional gamblers highlights their resilience to external disruptions

like the pandemic. Unlike more frequent gamblers, occasional gamblers likely engage in gambling sporadically, meaning they gamble infrequently and irregularly. Their consistently low activity levels suggest that the availability of gambling opportunities or external stressors, such as the pandemic, did not influence their behaviors.

Additionally, both studies showed that some gamblers who were active in 2019 completely stopped gambling in 2020. This was likely due to lockdown measures and the suspension of sports and horse racing. Furthermore, these gamblers did not shift their activity to other available games. This lack of transition highlights several potential factors. First, many gamblers may be gambling event-driven, finding motivation primarily in the excitement of live sports or horse racing. Without these gambling events, their interest in gambling diminished significantly. Additionally, the stress and uncertainty caused by the pandemic may have led some individuals to withdraw from gambling altogether rather than to seek alternative options. Thus, the profiles of these gamblers indicate that their gambling behaviors are deeply link with gambling offering and external circumstances. The pandemic served as a significant disruptor, resulting in a complete halt in gambling for some.

Conversely, another common result from the French and Swedish analyses is that a portion of gamblers shifted their activities during the sports and horse race interruption. In both contexts, this class of gamblers primarily consisted of regular and active sports or horse race bettors who redirected their desire to gamble towards available gambling. During the first lockdown, casinos, bingo, poker, and lotteries saw significant increases in participation, but this activity decreased once sports and horse racing reopened, returning to levels similar to those before the pandemic. Additionally, most of these gamblers resumed their betting activities, but did so with much greater intensity. The rise in participation in alternative games during the lockdown indicates a strong desire to maintain a connection to gambling, even when preferred options were unavailable. This significant increase may reflect a coping mechanism for some individuals. Interestingly, while one might expect these gamblers to continue their new gambling activities alongside their original betting habits, they seemed to stop or significantly reduce their play in these alternative games once sports and horse racing resumed. In contrast, a surprising trend emerged: they resumed their initial activities but with much greater intensity than before the pandemic. This heightened engagement may reflect a desire to make up for lost time or an attempt to recapture the excitement that was missing during the lockdown. Such behaviors raise concerns about the potential for increased gambling-related risks among these individuals.

Finally, a notable finding from the Swedish study is the observed difference between genders in gambling behaviors. While men who shifted their gambling activities during the suspension of sports and horse racing predominantly turned to poker, a specific group of women redirected their gambling towards different types of games, such as bingo. These gender-specific behaviors underscore the importance of understanding the diverse motivations behind gambling. Male gamblers often seek to replicate the competitive nature of sports betting through games like poker, which require skill and strategy. This preference indicates a desire for the thrill and engagement that comes with competitive play (McCormack et al., 2014; Wong et al., 2013).

Regarding the statistical methods employed in this analysis, estimating trajectories proved to be a lengthy and complex task. Initially, we tested two-part models within the framework of LCMM using Mplus software. While these models can provide valuable insights into heterogeneous populations, they also presented several challenges. First, the implementation of two-part models was often time-consuming, requiring extensive computational resources and long processing times. Additionally, convergence issues frequently arose, with the models rarely reaching stable solutions. This lack of convergence made it difficult to obtain reliable and interpretable results, raising concerns about the robustness of the findings. Furthermore, two-part models have inherent limitations in capturing the complexity of time-varying gambling behaviors. They often struggle to accurately represent changes in trajectories over time, particularly in dynamic environments such as gambling. As a result, these models might provide an oversimplified view of the data, potentially missing critical fluctuations and trends that could inform understanding of gambling behaviors during the study period.

Given these challenges, I decided to explore an alternative method for modeling the gambling activity of gamblers, specifically focusing on time-varying variables. After evaluating various modeling options, I concluded that using splines provided the best balance between flexibility and accuracy. Implementing LCMM with splines enabled a more detailed examination of the factors influencing changes in gambling activity over time. The spline implementation allowed for a more refined representation of data compared to previous approaches, which often only captured changes in curves imprecisely. However, we noted that the smoothing effect inherent in splines led to some loss of precision in the estimated trajectories. This smoothing can obscure sharp transitions and subtle fluctuations in gambling activity that are important for a comprehensive analysis.

Additionally, I opted to change the time unit from one week to two weeks for data aggregation. While this decision aimed to reduce computational demands and streamline the

modeling process, it also introduced trade-offs. The longer aggregation period helped stabilize the analysis, making it more manageable. However, this adjustment also diminished the precision of trajectory changes, as longer intervals can mask short-term variations in gamblers activity.

Chapter 6

DISCUSSION AND PERSPECTIVES

Table of contents

6.1	Summary and limitations of the thesis	218
6.2	Perspectives	221

6.1 Summary and limitations of the thesis

In this thesis, we first estimated the overall changes in gambling activity due to the pandemic among all active online gamblers on the legal gambling platforms in France and among all gamblers participating in *Svenska Spel*, the state-operated gambling provider in Sweden. Subsequently, the thesis conducted an individual approach to identify sub-populations of gamblers who were more at-risk of increasing their gambling activity because of the pandemic.

During global events like a pandemic, the immediate effects on health, the economy, and social life dominate public attention. However, less consideration is given to other areas that are indirectly affected. One such area is gambling, which, while not immediately linked to the core issues of a pandemic, experiences significant changes. This work thesis aimed to highlight these changes and to identify how gamblers responded to the evolving circumstances.

The pandemic led to an increase in all online gambling activities in 2020 compared to 2019, despite the reduced availability of some gambling. The closure of physical gambling venues accelerated the digitization of gambling practices. With physical casinos, betting shops, and other venues closed to prevent the spread of COVID-19, many gamblers transitioned to online platforms. This marked a significant shift from traditional, in-person gambling to digital environments. The convenience of online gambling attracted a larger audience, including individuals who might not have gambled otherwise. The ease of access, combined with increased free time during lockdowns, led to higher participation rates. However, the increased accessibility and convenience of online platforms also raised concerns about higher instances of gambling addiction. Online gambling is identified as more likely to develop or exacerbate problematic gambling behaviors compared to offline gambling (Chóliz, 2016; S. M. Gainsbury, 2015; Mora-Salgueiro et al., 2021).

Additionally, the impact of the pandemic on French and Swedish gamblers appeared to be quite similar. For a large majority of gamblers, the pandemic did not significantly change their gambling habits, as they are occasional gamblers. However, some gamblers experienced a marked decline or even a total cessation of their activities in 2020. Others significantly reduced their gambling during the suspension of sports and horse racing but returned to their previous levels once these activities resumed. The main difference between the two countries lies in the behaviors of regular and active gamblers, who had to postpone their gambling activities during the sports and horse race interruption and the initial lockdown period. While there was a massive increase in gambling activity with the return of sports, reaching levels much higher than before the pandemic by the end of 2020, this surge seemed particularly pronounced among

French gamblers compared to Swedish ones. Indeed, the increases were significantly more marked in France, affecting all gambling indicators, including intensity, frequency, and at-risk behaviors.

The heightened response among French gamblers may be attributed to differing regulations, government measures implemented during the pandemic, and cultural factors.

The sense of stress and isolation caused by the lockdown measures in France may explain some of these differences, especially since Sweden did not implement similar measures. In France, the strict lockdown policies forced individuals to stay home for extended periods, leading to increased feelings of anxiety and social disconnection. This environment may have prompted some gamblers to turn to gambling as a coping mechanism, seeking distraction or an escape from their circumstances. In contrast, Sweden's approach during the pandemic was notably different. The Swedish government opted against strict lockdowns, allowing more freedom of movement and social interaction. This decision likely mitigated some of the stress and isolation that French gamblers faced, maybe leading to a more stable gambling behaviors among Swedish gamblers.

Additionally, the regulatory environment may have played a significant role. In Sweden, online gambling regulations during the pandemic were much stricter than in France. During the initial peak of the outbreak, Sweden had no specific regulations in place, but authorities closely monitored online gambling activities due to concerns about potential increases in problem gambling. Operators were encouraged to promote responsible gambling and monitor gamblers' behaviors more closely. From July 2020 to November 2021, specific regulations were introduced in Sweden, including: i) weekly deposit limit for online casino games: set at 5,000 SEK (\approx 476€), ii) restricted inducements: operators could offer a maximum bonus of 100 SEK (\approx 10€) to gamblers, iii) time limits for gambling sessions: gamblers were required to set time limits before playing, iv) enhanced monitoring: stricter controls to ensure operators complied with regulations, v) awareness campaigns: launched by the government to inform the public about gambling risks and vi) advertising restrictions: limitations on promotions to prevent encouraging excessive gambling (Håkansson & Widinghoff, 2021). In contrast, France's measures were less stringent, focusing more on ongoing monitoring rather than specific regulations.

These differences are also seen in how responsible gambling is approached in both countries. In France, the regulation model in place mainly relies on actions from the gamblers themselves. It often appears that individuals are responsible for choosing whether to use responsible gambling measures, such as setting limits or opting for self-exclusion, even though setting

limits is mandatory when opening an account. This framework places the responsibility primarily on the gamblers themselves, which can lead to inconsistent engagement with these measures. In contrast, Sweden's approach to responsible gambling is much more proactive. The state imposes stricter regulations and requirements on gambling operators to promote responsible behaviors among gamblers. Swedish regulations include mandatory tools for gamblers, such as time restrictions, and self-exclusion options that are integrated into the gambling platforms. This regulatory framework creates a supportive environment where responsible gambling is not merely an option but a fundamental aspect of the gambling experience. The differences in these approaches highlight broader cultural attitudes toward gambling. In Sweden, there is a strong emphasis on protecting gamblers and minimizing harm, reflecting a more collective responsibility. The government actively intervenes to ensure that gambling remains a safe activity, whereas in France, the focus is more on individual choice and personal accountability. Moreover, the differences between France and Sweden in changes on gambling activity due to the pandemic can be also attributed to the varying scope of data available for analysis. In Sweden, data we obtained were limited to information from *Svenska Spel*, which represents approximately half of the regulated online gambling market. This narrow dataset may not accurately reflect the full spectrum of gambling behaviors across the country, leading to potential gaps in understanding how different subpopulation of gamblers engaged with gambling.

In the same way, our analysis is not exhaustive because it does not account for offline gambling activities or unregulated gambling. This lack of data is important because offline gambling makes up a significant part of the overall gambling landscape. Additionally, not having information on unregulated activities complicates our understanding, as these activities often involve risky behaviors that are not reflected in regulated environments (S. M. Gainsbury et al., 2018). To improve research in the gambling field, governments should make data access easier for research teams. By providing more comprehensive gambling data, researchers could conduct deeper analyses that consider a wider range of factors. This would reduce the need for researchers to request multiple datasets out of caution, including data they might not ultimately use. When certain data elements are missing, it becomes challenging to efficiently obtain the necessary information from gambling operators. As a result, researchers often find themselves requesting the same information repeatedly, as they typically focus on similar indicators to measure gambling activity. Furthermore, having more accessible data for years like 2021 would have allowed for comparisons over a longer period, particularly during times when gambling behaviour was returning to normal. Overall, improving data accessibility would streamline

research efforts and contribute to a more thorough understanding of gambling trends and behaviors.

To conclude, given events that significantly impact the gambling landscape, such as the pandemic, it's important to consider what we can learn and what measures should be taken if a similar situation occurs in the future. First, specific interventions and restrictions should be implemented to protect gamblers while and after such crises, to limit potential engagement in risky gambling behaviors. These measures could include setting mandatory temporary limits on gambling activities and tailored interventions (especially preventive interventions) based on gamblers engagement, age, and gender. Second, conducting qualitative studies to understand gamblers experiences during the pandemic could provide valuable insights. For instance, it's crucial to determine whether changes in gambling habits were driven by boredom, stress and loneliness, or the desire to win within financial incertitude times. Additionally, interact with problematic gamblers can help clarify their expectations from the government and regulatory authorities regarding restrictions and the marketing strategies used by operators. By gathering this information, we could develop more effective policies to promote a healthier gambling environment during future crises.

6.2 Perspectives

After this thesis, future directions for this gambling research will focus both on the finalization of the CONGA project, but also the implementation of new projects still linked to the analysis of gambling tracking data.

First, I will finalise the CONGA project by performing analyses for the final objective, which consisted in completing individual analyses and identifying subpopulations of new gamblers to understand their reactions to the pandemic in both France and Sweden. To achieve this, we may consider alternative methods for estimating gamblers' trajectories. In our previous analyses, we estimated several models for each gambling indicator and type. To enhance research efficiency, we could use joint latent class models that assess multiple factors simultaneously. This approach would allow us to combine indicators such as frequency and intensity into a single analysis, enabling us to account for a broader range of variables while reducing the number of separate model estimations required. Utilizing joint models would not only streamline the analytical process but also provide a more comprehensive understanding of gambling behaviors. By examining the interplay between different indicators, we could identify more nuanced insights into how various factors influence gambling activity. This method can lead to more robust findings and improve the quality of research.

Furthermore, as part of the CONGA project, an analysis will compare the gambling habits of women between two countries, independent of COVID-19's impact. A similar analysis will also be conducted based on age groups.

Additionally, I will be working on a new project led by *the Institut Fédératif des Addictions Comportementales* (IFAC) at the CHU de Nantes. This project aims to measure the impact of temporary self-exclusion on online gambling activities and to describe the profiles of gamblers who choose to self-exclude, including their demographic information and gambling behaviors in the weeks leading up to exclusion. This study will enhance our understanding of the actual effects of temporary self-exclusion on gambling behaviors. Specifically, it will help identifying the characteristics of self-excluded gamblers, investigate whether they continue to gamble on other sites from which they are not excluded, and evaluating if self-exclusion is associated with a reduction in gambling behaviors, particularly concerning high-risk behaviors (e.g., chasing episode).

Finally, we are establishing a research project in collaboration with Prof. Sally Gainsbury at the University of Sydney with the idea to undertake a two-year postdoctoral position at her university, where I aim to deepen my research in the gambling research field. This project is particularly appealing because I seek to transition my focus towards more intervention-based research, moving away from the primarily observational studies that characterized my thesis. While observational research provides valuable insights, I believe that developing and implementing interventions can lead to more meaningful change in the field of gambling behaviors and responsible practices. My recent observations of the differences in responsible gambling practices between France and Sweden have further motivated me to critically examine the concept of responsible gambling in France. In Sweden, there are comprehensive strategies and proactive measures in place that effectively promote safer gambling behaviors. This contrast has raised important questions about the adequacy of current responsible gambling initiatives in France and the potential for implementing similar interventions. That's why I am particularly interested in studying the gambling-related harm associated with online gambling activities, and how to minimise them by setting up preventive and care actions. My goal is to gain a comprehensive understanding of the specific needs of gamblers in order to provide tailored interventions that effectively address these needs. To be able to join the University of Sydney within the team of Prof. Sally Gainsbury, and to perform this stimulating project, I will apply to a Marie Curie Sklodowska Global Fellowship. In the event of failure to obtain this fellowship, it is planned that I will remain at IFAC to carry out both statistical activities (analysis of data from clinical trials carried out by IFAC) but also that I will be able to continue

my research activities in biostatistics around the above projects and possibly nevertheless lead a remote collaboration with Prof. Sally Gainsbury on gambling-related harms and associated interventions.

Références bibliographiques

- Amerio, A., Stival, C., Lugo, A., Fanucchi, T., Gorini, G., Pacifici, R., Odone, A., Serafini, G., & Gallus, S. (2022). COVID-19 lockdown: The relationship between trait impulsivity and addictive behaviors in a large representative sample of Italian adults. *Journal of Affective Disorders*, 302, 424–427. <https://doi.org/10.1016/j.jad.2022.01.094>
- Ammar, A., Chtourou, H., Boukhris, O., Trabelsi, K., Masmoudi, L., Brach, M., Bouaziz, B., Bentlage, E., How, D., Ahmed, M., Mueller, P., Mueller, N., Hsouna, H., Aloui, A., Hammouda, O., Paineiras-Domingos, L. L., Braakman-Jansen, A., Wrede, C., Bastoni, S., ... On Behalf Of The Eclb-Covid Consortium, null. (2020). COVID-19 Home Confinement Negatively Impacts Social Participation and Life Satisfaction: A Worldwide Multicenter Study. *International Journal of Environmental Research and Public Health*, 17(17), 6237. <https://doi.org/10.3390/ijerph17176237>
- Andersson, M. J., Balem, M., & Håkansson, A. (2022). An interrupted time series analysis of gambling behavior based on gambling operator revenue-based taxation during the COVID-19 pandemic in Sweden. *Public Health*, 211, 14–20. <https://doi.org/10.1016/j.puhe.2022.07.003>
- ANJ. (2020). *Analyse trimestrielle du marché des jeux en ligne—2ème trimestre 2020*.
- ANJ. (2021). *Analyse trimestrielle du marché des jeux en ligne—4ème trimestre 2020*.
- ANJ. (2022). *Analyse du marché des jeux d'argent—Année 2021*.
- Ariyabuddhipongs, V. (2011). Lottery Gambling: A Review. *Journal of Gambling Studies*, 27(1), 15–33. <https://doi.org/10.1007/s10899-010-9194-0>
- Auer, M., & Griffiths, M. D. (2021). Gambling Before and During the COVID-19 Pandemic Among Online Casino Gamblers: An Empirical Study Using Behavioral Tracking Data. *International Journal of Mental Health and Addiction*. <https://doi.org/10.1007/s11469-020-00462-2>

- Auer, M., Malischnig, D., & Griffiths, M. D. (2020). Gambling Before and During the COVID-19 Pandemic Among European Regular Sports Bettors: An Empirical Study Using Behavioral Tracking Data. *International Journal of Mental Health and Addiction*, 1–8. <https://doi.org/10.1007/s11469-020-00327-8>
- Baggio, S., Dupuis, M., Berchtold, A., Spilka, S., Simon, O., & Studer, J. (2017). Is gambling involvement a confounding variable for the relationship between Internet gambling and gambling problem severity? *Computers in Human Behavior*, 71, 148–152. <https://doi.org/10.1016/j.chb.2017.02.004>
- Balem, M., Karlsson, A., Widinghoff, C., Perrot, B., Challet-Bouju, G., & Håkansson, A. (2023). Gambling and COVID-19: Swedish national gambling data from a state-owned gambling sports and casino operator. *Journal of Behavioral Addictions*, 12(1), 230–241. <https://doi.org/10.1556/2006.2022.00089>
- Balem, M., Perrot, B., Grall-Bronnec, M., Karlsson, A., Håkansson, A., & Challet-Bouju, G. (2023). *Impact of the COVID-19 pandemic on online gambling behaviors: A comprehensive analysis on all legal French websites*. <https://osf.io/ewmnh/>
- Banerjee, N., Chen, Z., Clark, L., & Noël, X. (2023). Behavioural expressions of loss-chasing in gambling: A systematic scoping review. *Neuroscience & Biobehavioral Reviews*, 153, 105377. <https://doi.org/10.1016/j.neubiorev.2023.105377>
- Baumeister, R. F., Vohs, K. D., & Funder, D. C. (2007). Psychology as the Science of Self-Reports and Finger Movements: Whatever Happened to Actual Behavior? *Perspectives on Psychological Science: A Journal of the Association for Psychological Science*, 2(4), 396–403. <https://doi.org/10.1111/j.1745-6916.2007.00051.x>
- Becker, W. C., & Fiellin, D. A. (2020). When Epidemics Collide: Coronavirus Disease 2019 (COVID-19) and the Opioid Crisis. *Annals of Internal Medicine*, 173(1), 59–60. <https://doi.org/10.7326/M20-1210>
- Benjamini, Y., & Hochberg, Y. (1995a). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society. Series B (Methodological)*, 57(1), 289–300. <https://www.jstor.org/stable/2346101>

- Benjamini, Y., & Hochberg, Y. (1995b). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society. Series B (Methodological)*, 57(1), 289–300.
- Binde, P. (2014). Gambling in Sweden: The cultural and socio-political context. *Addiction (Abingdon, England)*, 109(2), 193–198. <https://doi.org/10.1111/add.12103>
- Binde, P., & Romild, U. (2019). Self-Reported Negative Influence of Gambling Advertising in a Swedish Population-Based Sample. *Journal of Gambling Studies*, 35(2), 709–724. <https://doi.org/10.1007/s10899-018-9791-x>
- Binde, P., Romild, U., & Volberg, R. A. (2017). Forms of gambling, gambling involvement and problem gambling: Evidence from a Swedish population survey. *International Gambling Studies*, 17(3), 490–507. <https://doi.org/10.1080/14459795.2017.1360928>
- Bouju, G., Grall-Bronnec, M., Landreat-Guillou, M., & Venisse, J.-L. (2011). Jeu pathologique: Facteurs impliqués. *L'Encéphale*, 37(4), 322–331. <https://doi.org/10.1016/j.encep.2011.01.003>
- Braverman, J., Tom, M. A., & Shaffer, H. J. (2014). Accuracy of self-reported versus actual online gambling wins and losses. *Psychological Assessment*, 26(3), 865–877. <https://doi.org/10.1037/a0036428>
- Brédart, A., Merdy, O., Sigal-Zafrani, B., Fiszer, C., Dolbeault, S., & Hardouin, J.-B. (2016). Identifying trajectory clusters in breast cancer survivors' supportive care needs, psychosocial difficulties, and resources from the completion of primary treatment to 8 months later. *Supportive Care in Cancer*, 24(1), 357–366. <https://doi.org/10.1007/s00520-015-2799-1>
- Breen, R. B., & Zuckerman, M. (1999). 'Chasing' in gambling behavior: Personality and cognitive determinants. *Personality and Individual Differences*, 27(6), 1097–1111. [https://doi.org/10.1016/S0191-8869\(99\)00052-5](https://doi.org/10.1016/S0191-8869(99)00052-5)
- Brodeur, M., Audette-Chapdelaine, S., Savard, A.-C., & Kairouz, S. (2021). Gambling and the COVID-19 pandemic: A scoping review. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 111, 110389. <https://doi.org/10.1016/j.pnpbp.2021.110389>

- Browne, M., Hing, N., Russell, A. M. T., Thomas, A., & Jenkinson, R. (2019). The impact of exposure to wagering advertisements and inducements on intended and actual betting expenditure: An ecological momentary assessment study. *Journal of Behavioral Addictions*, 8(1), 146–156. <https://doi.org/10.1556/2006.8.2019.10>
- Buth, S., Wurst, F. M., Thon, N., Lahusen, H., & Kalke, J. (2017). Comparative Analysis of Potential Risk Factors for at-Risk Gambling, Problem Gambling and Gambling Disorder among Current Gamblers—Results of the Austrian Representative Survey 2015. *Frontiers in Psychology*, 8, 2188. <https://doi.org/10.3389/fpsyg.2017.02188>
- Bylund, P. L., & Packard, M. D. (2021). Separation of power and expertise: Evidence of the tyranny of experts in Sweden’s COVID-19 responses. *Southern Economic Journal*, 87(4), 1300–1319. <https://doi.org/10.1002/soej.12493>
- Calado, F., & Griffiths, M. D. (2016). Problem gambling worldwide: An update and systematic review of empirical research (2000-2015). *Journal of Behavioral Addictions*, 5(4), 592–613. <https://doi.org/10.1556/2006.5.2016.073>
- Catalano, A., Milani, L., Franco, M., Buscema, F., Giommarinia, I., Sodano, B., Gilcrease, W., Mondo, L., Marra, M., Di Girolamo, C., Bena, A., & Ricceri, F. (2024). The impact of COVID-19 pandemic on gambling: A systematic review. *Addictive Behaviors*, 108037. <https://doi.org/10.1016/j.addbeh.2024.108037>
- Cavanaugh, J. E., & Neath, A. A. (2019). The Akaike information criterion: Background, derivation, properties, application, interpretation, and refinements. *WIREs Computational Statistics*, 11(3), e1460. <https://doi.org/10.1002/wics.1460>
- Challet-Bouju, G., Grall-Bronnec, M., Saillard, A., Leboucher, J., Donnio, Y., Péré, M., & Caillon, J. (2020). Impact of Wagering Inducements on the Gambling Behaviors, Cognitions, and Emotions of Online Gamblers: A Randomized Controlled Study. *Frontiers in Psychiatry*, 11. <https://doi.org/10.3389/fpsyg.2020.593789>
- Challet-Bouju, G., Hardouin, J.-B., Thiabaud, E., Saillard, A., Donnio, Y., Grall-Bronnec, M., & Perrot, B. (2020). Modeling early gambling behavior using indicators from online lottery gambling tracking data: Longitudinal analysis. *Journal of Medical Internet Research*, 22(8), e17675. <https://doi.org/10.2196/17675>

- Challet-Bouju, G., Perrot, B., & Balem, M. (2020). Impact of wagering inducements on the gambling behaviors of online gamblers: A study based on gambling tracking data—Analysis plan [internet]. *Open Science Framework*. osf.io/h465z
- Challet-Bouju, G., Perrot, B., & Balem, M. (2021). Impact of wagering inducements on the gambling behaviors of online gamblers: A study based on gambling tracking data—Analysis code [internet]. *Open Science Framework*. osf.io/m5k8a
- Chauhan, V. S., Chatterjee, K., Chauhan, K. S., Prakash, J., & Srivastava, K. (2020). Impact on Anxiety of COVID-19 and Lockdown. *Journal of Marine Medical Society*, 22(Suppl 1), S78. https://doi.org/10.4103/jmms.jmms_96_20
- Chen, P. J., Pusica, Y., Sohaei, D., Prassas, I., & Diamandis, E. P. (2021). An overview of mental health during the COVID-19 pandemic. *Diagnosis (Berlin, Germany)*, 8(4), 403–412. <https://doi.org/10.1515/dx-2021-0046>
- Chóliz, M. (2016). The Challenge of Online Gambling: The Effect of Legalization on the Increase in Online Gambling Addiction. *Journal of Gambling Studies*, 32(2), 749–756. <https://doi.org/10.1007/s10899-015-9558-6>
- Ciccarelli, M., Cosenza, M., D'Olimpio, F., Griffiths, M. D., & Nigro, G. (2019). An experimental investigation of the role of delay discounting and craving in gambling chasing behavior. *Addictive Behaviors*, 93, 250–256. <https://doi.org/10.1016/j.addbeh.2019.02.002>
- Claesdotter-Knutsson, E., & Håkansson, A. (2021). Changes in Self-Reported Web-Based Gambling Activity During the COVID-19 Pandemic: Cross-sectional Study. *JMIR Serious Games*, 9(4), e30747. <https://doi.org/10.2196/30747>
- Cook, P. J. (1991). [Review of *Review of Gambling and Speculation: A Theory, a History, and a Future of Some Human Decisions.*, by R. Brenner & G. A. Brenner]. *Contemporary Sociology*, 20(1), 70–71. <https://doi.org/10.2307/2072088>
- Costes, J.-M., & Eroukmanoff, V. (2018). *Les pratiques de jeux d'argent sur Internet en France en 2017*. Observatoire Des Jeux (ODJ).

- Costes, J.-M., Eroukmanoff, V., Richard, J.-B., & Tovar, M.-L. (2015). *Les jeux d'argent et de hasard en France en 2014. Les notes de l'Observatoire des jeux*. (6; pp. 1–9).
- Costes, J.-M., Richard, J.-B., & Eroukmanoff, V. (2020). *Les problèmes liés aux jeux d'argent en France, en 2019*.
- Costes, J.-M., Richard, J.-B., Eroukmanoff, V., Le Nézet, O., & Philippon, A. (2020). *Les Français et les jeux d'argent et de hasard—Résultat du Baromètre de Santé publique France 2019* (Tendances OFDT, 2020, n°138).
- COVID-19 Excess Mortality Collaborators. (2022). Estimating excess mortality due to the COVID-19 pandemic: A systematic analysis of COVID-19-related mortality, 2020–21. *Lancet (London, England)*, 399(10334), 1513–1536. [https://doi.org/10.1016/S0140-6736\(21\)02796-3](https://doi.org/10.1016/S0140-6736(21)02796-3)
- Critchlow, N., Hunt, K., Wardle, H., & Stead, M. (2022). Expenditure on Paid-for Gambling Advertising During the National COVID-19 ‘Lockdowns’: An Observational Study of Media Monitoring Data from the United Kingdom. *Journal of Gambling Studies*, 1–15. <https://doi.org/10.1007/s10899-022-10153-3>
- Cucinotta, D., & Vanelli, M. (2020). WHO Declares COVID-19 a Pandemic. *Acta Bio-Medica: Atenei Parmensis*, 91(1), 157–160. <https://doi.org/10.23750/abm.v91i1.9397>
- Currie, S. R., Hodgins, D. C., & Casey, D. M. (2013). Validity of the Problem Gambling Severity Index interpretive categories. *Journal of Gambling Studies*, 29(2), 311–327. <https://doi.org/10.1007/s10899-012-9300-6>
- Cutcu, I., & Kılıç, Y. (2020). *Stock Market Response to Coronavirus (COVID-19) Pandemic*. 10, 207–220.
- Deans, E. G., Thomas, S. L., Derevensky, J., & Daube, M. (2017). The influence of marketing on the sports betting attitudes and consumption behaviours of young men: Implications for harm reduction and prevention strategies. *Harm Reduction Journal*, 14(1), 5. <https://doi.org/10.1186/s12954-017-0131-8>

- Deng, X., Lesch, T., & Clark, L. (2019). Applying Data Science to Behavioral Analysis of Online Gambling. *Current Addiction Reports*, 6(3), 159–164. <https://doi.org/10.1007/s40429-019-00269-9>
- Donati, M., Cabrini, S., Capitanucci, D., Primi, C., Smaniotto, R., Avanzi, M., Quadrelli, E., Bielli, G., Casini, A., & Roaro, A. (2021). Being a Gambler during the COVID-19 Pandemic: A Study with Italian Patients and the Effects of Reduced Exposition. *International Journal of Environmental Research and Public Health*, 18, 424. <https://doi.org/10.3390/ijerph18020424>
- Dowling, N. A., Merkouris, S. S., Greenwood, C. J., Oldenhof, E., Toumbourou, J. W., & Youssef, G. J. (2017). Early risk and protective factors for problem gambling: A systematic review and meta-analysis of longitudinal studies. *Clinical Psychology Review*, 51, 109–124. <https://doi.org/10.1016/j.cpr.2016.10.008>
- Economou, M., Souliotis, K., Malliori, M., Peppou, L. E., Kontoangelos, K., Lazaratou, H., Anagnostopoulos, D., Golna, C., Dimitriadis, G., Papadimitriou, G., & Papageorgiou, C. (2019). Problem Gambling in Greece: Prevalence and Risk Factors During the Financial Crisis. *Journal of Gambling Studies*, 35(4), 1193–1210. <https://doi.org/10.1007/s10899-019-09843-2>
- Effertz, T., Bischof, A., Rumpf, H.-J., Meyer, C., & John, U. (2018). The effect of online gambling on gambling problems and resulting economic health costs in Germany. *The European Journal of Health Economics: HEPAC: Health Economics in Prevention and Care*, 19(7), 967–978. <https://doi.org/10.1007/s10198-017-0945-z>
- Elhakeem, A., Hughes, R. A., Tilling, K., Cousminer, D. L., Jackowski, S. A., Cole, T. J., Kwong, A. S. F., Li, Z., Grant, S. F. A., Baxter-Jones, A. D. G., Zemel, B. S., & Lawlor, D. A. (2022). Using linear and natural cubic splines, SITAR, and latent trajectory models to characterise nonlinear longitudinal growth trajectories in cohort studies. *BMC Medical Research Methodology*, 22(1), 68. <https://doi.org/10.1186/s12874-022-01542-8>
- Emond, A., Nairn, A., Collard, S., & Hollén, L. (2022). Gambling by Young Adults in the UK During COVID-19 Lockdown. *Journal of Gambling Studies*, 38(1), 1–13. <https://doi.org/10.1007/s10899-021-10029-y>

- Eroukmanoff, V. (2022). *Les jeux d'argent et de hasard en France en 2021*. OFDT.
- Eroukmanoff, V., Brissot, A., Philippon, A., & Spilka, S. (2022). *Pratiques de jeux d'argent et de hasard sur internet* [Tendances OFDT, 2022]. OFDT.
- Farewell, V., Long, D. L., Tom, B., Yiu, S., & Su, L. (2017). *Two-Part and Related Regression Models for Longitudinal Data*. <https://doi.org/10.17863/CAM.12107>
- FDJ. (2024). *FDJ, une histoire de cœur avec les Français*. Groupe FDJ. <https://www.groupefdj.com/en/history/>
- Feigelman, W., Kleinman, P. H., Lesieur, H. R., Millman, R. B., & Lesser, M. L. (1995). Pathological gambling among methadone patients. *Drug and Alcohol Dependence*, 39(2), 75–81. [https://doi.org/10.1016/0376-8716\(95\)01141-k](https://doi.org/10.1016/0376-8716(95)01141-k)
- Ferris, J., & Wynne, H. (2001). The Canadian Problem Gambling Index. *Canadian Centre on Substance Abuse*.
- Folkhälsomyndigheten. (2020a, January 31). *Confirmed case of novel coronavirus in Jönköping (2019-nCoV)—The Public Health Agency of Sweden*. <https://web.archive.org/web/20200328040657/https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/januari/bekraftat-fall-av-nytt-coronavirus-i-sverige/>
- Folkhälsomyndigheten. (2020b, February 27). *Invitation to press conference: Additional cases of COVID-19 in several regions — The Public Health Agency of Sweden*. <https://web.archive.org/web/20200510151437/https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/februari/inbjudan-till-presstraff-ytterligare-fall-av-covid-19-i-flera-regioner2/>
- Folkhälsomyndigheten. (2020c, March 13). *New phase requires new measures against COVID-19—The Public Health Agency of Sweden*. <https://web.archive.org/web/20200327132011/https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/ny-fas-kraver-nya-insatser-mot-covid-19/>
- Folkhälsomyndigheten. (2020d, March 19). *Consider whether the trip is really necessary—The Public Health Agency of Sweden*.

- <https://web.archive.org/web/20200327222047/https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/tank-over-om-resan-verkligen-ar-nodvandig/>
- Folkhälsomyndigheten. (2020e, March 24). *New rules for restaurants and pubs—Folkhälsomyndigheten*.
<https://web.archive.org/web/20200327222034/https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/nya-regler-for-restauranger-och-krogar/>
- Folkhälsomyndigheten. (2020f, March 30). *Higher education institutions and upper secondary schools are now encouraged to conduct distance education—The Public Health Agency of Sweden*.
<https://web.archive.org/web/20200330143645/http://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/mars/larosaten-och-gymnasieskolor-uppmanas-nu-att-bedriva-distansundervisning/>
- Folkhälsomyndigheten. (2023a). *Tabellsammanställning för Swelogs prevalens-undersökning 2021*.
- Folkhälsomyndigheten. (2023b, June 13). *When did what happen during the pandemic?*
<https://www.folkhalsomyndigheten.se/smittykydd-beredskap/utbrott/aktuella-utbrott/covid-19/nar-hande-vad-under-pandemin/>
- Gabellini, E., Lucchini, F., & Gattoni, M. E. (2023). Prevalence of Problem Gambling: A Meta-analysis of Recent Empirical Research (2016–2022). *Journal of Gambling Studies*, 39(3), 1027–1057. <https://doi.org/10.1007/s10899-022-10180-0>
- Gainsbury, S. (2011). Player account-based gambling: Potentials for behaviour-based research methodologies. *International Gambling Studies*, 11(2), 153–171. <https://doi.org/10.1080/14459795.2011.571217>
- Gainsbury, S. M. (2015). Online Gambling Addiction: The Relationship Between Internet Gambling and Disordered Gambling. *Current Addiction Reports*, 2(2), 185–193. <https://doi.org/10.1007/s40429-015-0057-8>
- Gainsbury, S. M., Russell, A., Blaszczynski, A., & Hing, N. (2015). Greater involvement and diversity of Internet gambling as a risk factor for problem gambling. *European Journal of Public Health*, 25(4), 723–728. <https://doi.org/10.1093/eurpub/ckv006>

- Gainsbury, S. M., Russell, A., Hing, N., Wood, R., & Blaszczynski, A. (2013). The impact of internet gambling on gambling problems: A comparison of moderate-risk and problem Internet and non-Internet gamblers. *Psychology of Addictive Behaviors: Journal of the Society of Psychologists in Addictive Behaviors*, 27(4), 1092–1101. <https://doi.org/10.1037/a0031475>
- Gainsbury, S. M., Russell, A. M., Hing, N., & Blaszczynski, A. (2018). Consumer engagement with and perceptions of offshore online gambling sites. *New Media & Society*, 20(8), 2990–3010. <https://doi.org/10.1177/1461444817738783>
- Gainsbury, S. M., Russell, A., Wood, R., Hing, N., & Blaszczynski, A. (2015). How risky is Internet gambling? A comparison of subgroups of Internet gamblers based on problem gambling status. *New Media & Society*, 17(6), 861–879. <https://doi.org/10.1177/1461444813518185>
- Gainsbury, S. M., Suhonen, N., & Saastamoinen, J. (2014). Chasing losses in online poker and casino games: Characteristics and game play of Internet gamblers at risk of disordered gambling. *Psychiatry Research*, 217(3), 220–225. <https://doi.org/10.1016/j.psychres.2014.03.033>
- Gainsbury, S. M., Swanton, T. B., Burgess, M. T., & Blaszczynski, A. (2021). Impacts of the COVID-19 Shutdown on Gambling Patterns in Australia: Consideration of Problem Gambling and Psychological Distress. *Journal of Addiction Medicine*, 15(6), 468–476. <https://doi.org/10.1097/ADM.0000000000000793>
- Garber, M. C., Nau, D. P., Erickson, S. R., Aikens, J. E., & Lawrence, J. B. (2004). The concordance of self-report with other measures of medication adherence: A summary of the literature. *Medical Care*, 42(7), 649–652. <https://doi.org/10.1097/01.mlr.0000129496.05898.02>
- Giallonardo, V., Sampogna, G., Del Vecchio, V., Luciano, M., Albert, U., Carmassi, C., Carrà, G., Cirulli, F., Dell’Osso, B., Nanni, M. G., Pompili, M., Sani, G., Tortorella, A., Volpe, U., & Fiorillo, A. (2020). The Impact of Quarantine and Physical Distancing Following COVID-19 on Mental Health: Study Protocol of a Multicentric Italian Population Trial. *Frontiers in Psychiatry*, 11, 533. <https://doi.org/10.3389/fpsy.2020.00533>

- Giles, D. (2010). *Notes on the Zero-Inflated Poisson Regression Model*. University of Victoria. <http://web.uvic.ca/~dgiles/downloads/count/zip.pdf>
- Goodman, A. (1990). Addiction: Definition and implications. *British Journal of Addiction*, 85(11), 1403–1408. <https://doi.org/10.1111/j.1360-0443.1990.tb01620.x>
- Gouédard, P., Stehly, L., Brenguier, F., Campillo, M., Verdière, Y. C. de, Larose, E., Margerin, L., Roux, P., Sánchez-Sesma, F. J., Shapiro, N. M., & Weaver, R. L. (2008). Cross-correlation of random fields: Mathematical approach and applications. In K. Wapenaar, D. Draganov, J. O. A. Robertsson, & M. A. Pelissier (Eds.), *Seismic Interferometry: History and Present Status* (Vol. 26, p. 0). Society of Exploration Geophysicists.
- Grant, J. E., & Kim, S. W. (2001). Demographic and clinical features of 131 adult pathological gamblers. *The Journal of Clinical Psychiatry*, 62(12), 957–962. <https://doi.org/10.4088/jcp.v62n1207>
- Griffiths, M. (2003). Internet gambling: Issues, concerns, and recommendations. *Cyberpsychology & Behavior: The Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society*, 6(6), 557–568. <https://doi.org/10.1089/109493103322725333>
- Griffiths, M., & Barnes, A. (2008). Internet Gambling: An Online Empirical Study Among Student Gamblers. *International Journal of Mental Health and Addiction*, 6(2), 194–204. <https://doi.org/10.1007/s11469-007-9083-7>
- Griffiths, M., Wardle, H., Orford, J., Sproston, K., & Erens, B. (2011). Internet Gambling, Health, Smoking and Alcohol Use: Findings from the 2007 British Gambling Prevalence Survey. *INTERNATIONAL JOURNAL OF MENTAL HEALTH AND ADDICTION*, 9(1), 1–11. <https://doi.org/10.1007/s11469-009-9246-9>
- Griffiths, S., Reith, G., Wardle, H., & Mackie, P. (2020). Pandemics and epidemics: Public health and gambling harms. *Public Health*, 184, 1–2. <https://doi.org/10.1016/j.puhe.2020.06.022>
- Håkansson, A. (2020a). Changes in Gambling Behavior during the COVID-19 Pandemic—A Web Survey Study in Sweden. *International Journal of Environmental Research and Public Health*, 17(11). <https://doi.org/10.3390/ijerph17114013>

- Håkansson, A. (2020b). Effects on Gambling Activity From Coronavirus Disease 2019-An Analysis of Revenue-Based Taxation of Online- and Land-Based Gambling Operators During the Pandemic. *Frontiers in Psychiatry*, *11*, 611939. <https://doi.org/10.3389/fpsy.2020.611939>
- Håkansson, A. (2020c). Impact of COVID-19 on Online Gambling – A General Population Survey During the Pandemic. *Frontiers in Psychology*, *11*. <https://doi.org/10.3389/fpsyg.2020.568543>
- Håkansson, A., Fernández-Aranda, F., Menchón, J. M., Potenza, M. N., & Jiménez-Murcia, S. (2020). Gambling During the COVID-19 Crisis—A Cause for Concern. *Journal of Addiction Medicine*, *14*(4), e10–e12. <https://doi.org/10.1097/ADM.0000000000000690>
- Håkansson, A., Jönsson, C., & Kenttä, G. (2020). Psychological Distress and Problem Gambling in Elite Athletes during COVID-19 Restrictions—A Web Survey in Top Leagues of Three Sports during the Pandemic. *International Journal of Environmental Research and Public Health*, *17*(18). <https://doi.org/10.3390/ijerph17186693>
- Håkansson, A., & Widinghoff, C. (2020). Gambling Despite Nationwide Self-Exclusion-A Survey in Online Gamblers in Sweden. *Frontiers in Psychiatry*, *11*, 599967. <https://doi.org/10.3389/fpsy.2020.599967>
- Håkansson, A., & Widinghoff, C. (2021). Changes of Gambling Patterns during COVID-19 in Sweden, and Potential for Preventive Policy Changes. A Second Look Nine Months into the Pandemic. *International Journal of Environmental Research and Public Health*, *18*(5). <https://doi.org/10.3390/ijerph18052342>
- Hall, D. B. (2000). Zero-inflated Poisson and binomial regression with random effects: A case study. *Biometrics*, *56*(4), 1030–1039. <https://doi.org/10.1111/j.0006-341x.2000.01030.x>
- Harouel, J.-L. (2011). From Francis I to Online Betting: The History of Gambling in France. *Pouvoirs*, *139*(4), 5–14.
- Hastie, T. J., & Pregibon, D. (1992). Generalized Linear Models. In *Statistical Models in S*. Routledge.

- Hing, N., Browne, M., Russell, A. M. T., Greer, N., Thomas, A., Jenkinson, R., & Rockloff, M. (2019). Where's the Bonus in Bonus Bets? Assessing Sports Bettors' Comprehension of their True Cost. *Journal of Gambling Studies*, 35(2), 587–599. <https://doi.org/10.1007/s10899-018-9800-0>
- Hing, N., Cherney, L., Blaszczynski, A., Gainsbury, S. M., & Lubman, D. I. (2014). Do advertising and promotions for online gambling increase gambling consumption? An exploratory study. *International Gambling Studies*, 14(3), 394–409. <https://doi.org/10.1080/14459795.2014.903989>
- Hing, N., Cherney, L., Gainsbury, S. M., Lubman, D. I., Wood, R. T., & Blaszczynski, A. (2015). Maintaining and losing control during internet gambling: A qualitative study of gamblers' experiences. *New Media & Society*, 17(7), 1075–1095. <https://doi.org/10.1177/1461444814521140>
- Hing, N., Russell, A. M. T., Li, E., & Vitartas, P. (2018). Does the uptake of wagering inducements predict impulse betting on sport? *Journal of Behavioral Addictions*, 7(1), 146–157. <https://doi.org/10.1556/2006.7.2018.17>
- Hing, N., Russell, A. M. T., Thomas, A., & Jenkinson, R. (2019). Wagering Advertisements and Inducements: Exposure and Perceived Influence on Betting Behaviour. *Journal of Gambling Studies*, 35(3), 793–811. <https://doi.org/10.1007/s10899-018-09823-y>
- Hing, N., Russell, A., Tolchard, B., & Nower, L. (2016). Risk Factors for Gambling Problems: An Analysis by Gender. *Journal of Gambling Studies*, 32, 511–534. <https://doi.org/10.1007/s10899-015-9548-8>
- Hing, N., Sproston, K., Brook, K., & Brading, R. (2017). The Structural Features of Sports and Race Betting Inducements: Issues for Harm Minimisation and Consumer Protection. *Journal of Gambling Studies*, 33(2), 685–704. <https://doi.org/10.1007/s10899-016-9642-6>
- Holmes, E. A., O'Connor, R. C., Perry, V. H., Tracey, I., Wessely, S., Arseneault, L., Ballard, C., Christensen, H., Silver, R. C., Everall, I., Ford, T., John, A., Kabir, T., King, K., Madan, I., Michie, S., Przybylski, A. K., Shafran, R., Sweeney, A., ... Bullmore, E. (2020). Multidisciplinary research priorities for the COVID-19 pandemic: A call for

- action for mental health science. *The Lancet Psychiatry*, 7(6), 547–560. [https://doi.org/10.1016/S2215-0366\(20\)30168-1](https://doi.org/10.1016/S2215-0366(20)30168-1)
- Hopley, A. A. B., Dempsey, K., & Nicki, R. (2012). Texas Hold'em Online Poker: A Further Examination. *International Journal of Mental Health and Addiction*, 10(4), 563–572. <https://doi.org/10.1007/s11469-011-9353-2>
- Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., Zhang, L., Fan, G., Xu, J., Gu, X., Cheng, Z., Yu, T., Xia, J., Wei, Y., Wu, W., Xie, X., Yin, W., Li, H., Liu, M., ... Cao, B. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet (London, England)*, 395(10223), 497–506. [https://doi.org/10.1016/S0140-6736\(20\)30183-5](https://doi.org/10.1016/S0140-6736(20)30183-5)
- Jiang, J., & Nguyen, T. (2021). *Linear and Generalized Linear Mixed Models and Their Applications*. Springer. <https://doi.org/10.1007/978-1-0716-1282-8>
- Jiménez-Murcia, S., Granero, R., Giménez, M., Del Pino-Gutiérrez, A., Mestre-Bach, G., Mena-Moreno, T., Moragas, L., Baño, M., Sánchez-González, J., de Gracia, M., Baenas-Soto, I., Contaldo, S. F., Valenciano-Mendoza, E., Mora-Maltas, B., López-González, H., Menchón, J. M., & Fernández-Aranda, F. (2020). Moderator effect of sex in the clustering of treatment-seeking patients with gambling problems. *Neuropsychiatrie: Klinik, Diagnostik, Therapie Und Rehabilitation: Organ Der Gesellschaft Osterreichischer Nervenarzte Und Psychiater*, 34(3), 116–129. <https://doi.org/10.1007/s40211-020-00341-1>
- Johansson, A., Grant, J. E., Kim, S. W., Odlaug, B. L., & Gøtestam, K. G. (2009). Risk factors for problematic gambling: A critical literature review. *Journal of Gambling Studies*, 25(1), 67–92. <https://doi.org/10.1007/s10899-008-9088-6>
- Kar, S. K., Arafat, S. M. Y., Sharma, P., Dixit, A., Marthoenis, M., & Kabir, R. (2020). COVID-19 pandemic and addiction: Current problems and future concerns. *Asian Journal of Psychiatry*, 51, 102064. <https://doi.org/10.1016/j.ajp.2020.102064>
- Kazdin, A. E., Kraemer, H. C., Kessler, R. C., Kupfer, D. J., & Offord, D. R. (1997). Contributions of risk-factor research to developmental psychopathology. *Clinical Psychology Review*, 17(4), 375–406. [https://doi.org/10.1016/S0272-7358\(97\)00012-3](https://doi.org/10.1016/S0272-7358(97)00012-3)

- Kraemer, H. C., Kazdin, A. E., Offord, D. R., Kessler, R. C., Jensen, P. S., & Kupfer, D. J. (1997). Coming to Terms With the Terms of Risk. *Archives of General Psychiatry*, 54(4), 337–343. <https://doi.org/10.1001/archpsyc.1997.01830160065009>
- Lambert, D. (1992). Zero-Inflated Poisson Regression, with an Application to Defects in Manufacturing. *Technometrics*, 34(1), 1–14. <https://doi.org/10.2307/1269547>
- Le Monde. (2020a, March 8). Coronavirus: Les rassemblements de plus de 1 000 personnes interdits en France. *Le Monde.fr*. https://www.lemonde.fr/planete/article/2020/03/08/coronavirus-le-bilan-passe-a-19-morts-en-france-1-126-cas-confirmes_6032265_3244.html
- Le Monde. (2020b, March 27). Deux mille pèlerins, cinq jours de prière et un virus: À Mulhouse, le scénario d'une contagion. *Le Monde.fr*. https://www.lemonde.fr/societe/article/2020/03/27/mulhouse-scenario-d-une-contagion_6034722_3224.html
- Lesieur, H. R. (1979). The compulsive gambler's spiral of options and involvement. *Psychiatry*, 42(1), 79–87. <https://doi.org/10.1080/00332747.1979.11024008>
- Lévêque, E., Lacourt, A., Philipps, V., Luce, D., Guénel, P., Stücker, I., Proust-Lima, C., & Leffondré, K. (2020). A new trajectory approach for investigating the association between an environmental or occupational exposure over lifetime and the risk of chronic disease: Application to smoking, asbestos, and lung cancer. *PLoS ONE*, 15(8), e0236736. <https://doi.org/10.1371/journal.pone.0236736>
- Lin, H., Turnbull, B. W., McCulloch, C. E., & Slate, E. H. (2002). Latent Class Models for Joint Analysis of Longitudinal Biomarker and Event Process Data: Application to Longitudinal Prostate-Specific Antigen Readings and Prostate Cancer. *Journal of the American Statistical Association*, 97(457), 53–65. <https://doi.org/10.1198/016214502753479220>
- Lindner, P., Forsström, D., Jonsson, J., Berman, A. H., & Carlbring, P. (2020). Transitioning Between Online Gambling Modalities and Decrease in Total Gambling Activity, but No Indication of Increase in Problematic Online Gambling Intensity During the First Phase of the COVID-19 Outbreak in Sweden: A Time Series Forecast Study. *Frontiers in Public Health*, 8, 554542. <https://doi.org/10.3389/fpubh.2020.554542>

- Linnet, J., Røjskjær, S., Nygaard, J., & Maher, B. A. (2006). Episodic chasing in pathological gamblers using the Iowa gambling task. *Scandinavian Journal of Psychology*, *47*(1), 43–49. <https://doi.org/10.1111/j.1467-9450.2006.00491.x>
- Lippi, G., Henry, B. M., Bovo, C., & Sanchis-Gomar, F. (2020). Health risks and potential remedies during prolonged lockdowns for coronavirus disease 2019 (COVID-19). *Diagnosis (Berlin, Germany)*, *7*(2), 85–90. <https://doi.org/10.1515/dx-2020-0041>
- Ludvigsson, J. F. (2020). The first eight months of Sweden’s COVID-19 strategy and the key actions and actors that were involved. *Acta Paediatrica (Oslo, Norway: 1992)*, *10.1111/apa.15582*. <https://doi.org/10.1111/apa.15582>
- Lugo, A., Stival, C., Paroni, L., Amerio, A., Carreras, G., Gorini, G., Mastrobattista, L., Minutillo, A., Mortali, C., Odone, A., Pacifici, R., Tinghino, B., & Gallus, S. (2021). The impact of COVID-19 lockdown on gambling habit: A cross-sectional study from Italy. *Journal of Behavioral Addictions*, *10*(3), 711–721. <https://doi.org/10.1556/2006.2021.00033>
- Mahase, E. (2020). China coronavirus: WHO declares international emergency as death toll exceeds 200. *BMJ (Clinical Research Ed.)*, *368*, m408. <https://doi.org/10.1136/bmj.m408>
- Månsson, V., Wall, H., Berman, A. H., Jayaram-Lindström, N., & Rosendahl, I. (2021). A Longitudinal Study of Gambling Behaviors During the COVID-19 Pandemic in Sweden. *Frontiers in Psychology*, *12*. <https://www.frontiersin.org/article/10.3389/fpsyg.2021.708037>
- Marcoulides, K. M., & Khojasteh, J. (2018). Analyzing Longitudinal Data Using Natural Cubic Smoothing Splines. *Structural Equation Modeling: A Multidisciplinary Journal*, *25*(6), 965–971. <https://doi.org/10.1080/10705511.2018.1449113>
- Marionneau, V., & Järvinen-Tassopoulos, J. (2017). Consumer protection in licensed online gambling markets in France: The role of responsible gambling tools. *Addiction Research & Theory*, *25*(6), 436–443. <https://doi.org/10.1080/16066359.2017.1314464>
- Marsden, J., Darke, S., Hall, W., Hickman, M., Holmes, J., Humphreys, K., Neale, J., Tucker, J., & West, R. (2020). Mitigating and learning from the impact of COVID-19 infection

- on addictive disorders. *Addiction (Abingdon, England)*, 115(6), 1007–1010.
<https://doi.org/10.1111/add.15080>
- Matilainen, R. (2016). Cultural and Social Meanings of Gambling in Finland and Sweden: A Historical Perspective. In *Random Riches*. Routledge.
- Mazar, A., Zorn, M., Becker, N., & Volberg, R. A. (2020). Gambling formats, involvement, and problem gambling: Which types of gambling are more risky? *BMC Public Health*, 20(1), 711. <https://doi.org/10.1186/s12889-020-08822-2>
- McCormack, A., & Griffiths, M. D. (2013). A Scoping Study of the Structural and Situational Characteristics of Internet Gambling. *International Journal of Cyber Behavior, Psychology and Learning (IJCPL)*, 3(1), 29–49.
<https://doi.org/10.4018/ijcbpl.2013010104>
- McCormack, A., Shorter, G. W., & Griffiths, M. D. (2014). An Empirical Study of Gender Differences in Online Gambling. *Journal of Gambling Studies*, 30(1), 71–88.
<https://doi.org/10.1007/s10899-012-9341-x>
- McMullan, J. L., & Miller, D. (2009). Wins, winning and winners: The commercial advertising of lottery gambling. *Journal of Gambling Studies*, 25(3), 273–295.
<https://doi.org/10.1007/s10899-009-9120-5>
- Miller, H. (2015). *Risk factors for problem gambling: Environmental, geographic, social, cultural, demographic, socio-economic, family and household*. Victorian Responsible Gambling Foundation, Melbourne.
- Moheghi, H. R., Noorossana, R., & Ahmadi, O. (2021). GLM profile monitoring using robust estimators. *Quality and Reliability Engineering International*, 37(2), 664–680.
<https://doi.org/10.1002/qre.2755>
- Montourcy, M., Hardouin, J.-B., Caillon, J., Leboucher, J., Rousselet, M., Grall-Bronnec, M., & Challet-Bouju, G. (2018). Typology of patients with behavioral addictions or eating disorders during a one-year period of care: Exploring similarities of trajectory using growth mixture modeling coupled with latent class analysis. *PLoS ONE*, 13(11), e0207398. <https://doi.org/10.1371/journal.pone.0207398>

- Moon, T. K. (1996). The expectation-maximization algorithm. *IEEE Signal Processing Magazine*, 13(6), 47–60. IEEE Signal Processing Magazine. <https://doi.org/10.1109/79.543975>
- Mora-Salgueiro, J., García-Estela, A., Hogg, B., Angarita-Osorio, N., Amann, B. L., Carlbring, P., Jiménez-Murcia, S., Pérez-Sola, V., & Colom, F. (2021). The Prevalence and Clinical and Sociodemographic Factors of Problem Online Gambling: A Systematic Review. *Journal of Gambling Studies*, 37(3), 899–926. <https://doi.org/10.1007/s10899-021-09999-w>
- Moreira, D., Azeredo, A., & Dias, P. (2023). Risk Factors for Gambling Disorder: A Systematic Review. *Journal of Gambling Studies*, 39(2), 483–511. <https://doi.org/10.1007/s10899-023-10195-1>
- Myung, I. J. (2003). Tutorial on maximum likelihood estimation. *Journal of Mathematical Psychology*, 47(1), 90–100. [https://doi.org/10.1016/S0022-2496\(02\)00028-7](https://doi.org/10.1016/S0022-2496(02)00028-7)
- Neath, A. A., & Cavanaugh, J. E. (2012). The Bayesian information criterion: Background, derivation, and applications. *WIREs Computational Statistics*, 4(2), 199–203. <https://doi.org/10.1002/wics.199>
- Nelder, J. A., & Wedderburn, R. W. M. (1972). Generalized Linear Models. *Journal of the Royal Statistical Society. Series A (General)*, 135(3), 370–384. <https://doi.org/10.2307/2344614>
- Newall, P. W. S., Moodie, C., Reith, G., Stead, M., Critchlow, N., Morgan, A., & Dobbie, F. (2019). Gambling Marketing from 2014 to 2018: A Literature Review. *Current Addiction Reports*, 6(2), 49–56. <https://doi.org/10.1007/s40429-019-00239-1>
- Nikkinen, J., & Marionneau, V. (2021). On the efficiency of Nordic state-controlled gambling companies. *Nordisk Alkohol- & Narkotikatidskrift: NAT*, 38(3), 212–226. <https://doi.org/10.1177/1455072520968024>
- Olason, D. T., Hayer, T., Meyer, G., & Brosowski, T. (2017). Economic Recession Affects Gambling Participation But Not Problematic Gambling: Results from a Population-Based Follow-up Study. *Frontiers in Psychology*, 8. <https://doi.org/10.3389/fpsyg.2017.01247>

- Olsen, M. K., & Schafer, J. L. (2001). A Two-Part Random-Effects Model for Semicontinuous Longitudinal Data. *Journal of the American Statistical Association*, 96(454), 730–745. <https://www.jstor.org/stable/2670310>
- Otis, E., Kim, A. J., Stewart, S. H., Sherry, S. B., & Yakovenko, I. (2022). Changes in sports gambling behavior during the COVID-19 pandemic in Canada. *Frontiers in Psychiatry*, 13, 1018234. <https://doi.org/10.3389/fpsyt.2022.1018234>
- Patefield, W. M. (1977). On the Maximized Likelihood Function. *Sankhyā: The Indian Journal of Statistics, Series B (1960-2002)*, 39(1), 92–96.
- Perperoglou, A., Sauerbrei, W., Abrahamowicz, M., & Schmid, M. (2019). A review of spline function procedures in R. *BMC Medical Research Methodology*, 19(1), 46. <https://doi.org/10.1186/s12874-019-0666-3>
- Perrot, B. (2018). *Repérérage des problèmes liés à la pratique des jeux de hasard et d'argent sur Internet*. Nantes Université.
- Perrot, B., Hardouin, J.-B., Costes, J.-M., Caillon, J., Grall-Bronnec, M., & Challet-Bouju, G. (2017). Study protocol for a transversal study to develop a screening model for excessive gambling behaviours on a representative sample of users of French authorised gambling websites. *BMJ Open*, 7(5), e014600. <https://doi.org/10.1136/bmjopen-2016-014600>
- Perrot, B., Hardouin, J.-B., Grall-Bronnec, M., & Challet-Bouju, G. (2018a). Typology of online lotteries and scratch games gamblers' behaviours: A multilevel latent class cluster analysis applied to player account-based gambling data. *International Journal of Methods in Psychiatric Research*, 27(4), e1746. <https://doi.org/10.1002/mpr.1746>
- Perrot, B., Hardouin, J.-B., Grall-Bronnec, M., & Challet-Bouju, G. (2018b). Typology of online lotteries and scratch games gamblers' behaviours: A multilevel latent class cluster analysis applied to player account-based gambling data. *International Journal of Methods in Psychiatric Research*, 27(4), e1746. <https://doi.org/10.1002/mpr.1746>
- Phillips, J. G., Ogeil, R., Chow, Y.-W., & Blaszczynski, A. (2013). Gambling Involvement and Increased Risk of Gambling Problems. *Journal of Gambling Studies*, 29(4), 601–611. <https://doi.org/10.1007/s10899-012-9325-x>

- PMU. (2024). *PMU - Notre histoire*. Groupe PMU. <https://entreprise.pmu.fr/notre-histoire>
- Price, A. (2020). Online Gambling in the Midst of COVID-19: A Nexus of Mental Health Concerns, Substance Use and Financial Stress. *International Journal of Mental Health and Addiction*, 1–18. <https://doi.org/10.1007/s11469-020-00366-1>
- Proust-Lima, C., Amieva, H., & Jacqmin-Gadda, H. (2013). Analysis of multivariate mixed longitudinal data: A flexible latent process approach. *The British Journal of Mathematical and Statistical Psychology*, 66(3), 470–487. <https://doi.org/10.1111/bmsp.12000>
- Proust-Lima, C., Philipps, V., & Liqueur, B. (2017). Estimation of Extended Mixed Models Using Latent Classes and Latent Processes: The R Package lamm. *Journal of Statistical Software*, 78, 1–56. <https://doi.org/10.18637/jss.v078.i02>
- Proust-Lima, C., Séne, M., Taylor, J. M., & Jacqmin-Gadda, H. (2014). Joint latent class models for longitudinal and time-to-event data: A review. *Statistical Methods in Medical Research*, 23(1), 74–90. <https://doi.org/10.1177/0962280212445839>
- Quinn, A., Grant, J. E., & Chamberlain, S. R. (2022). COVID-19 and resultant restrictions on gambling behaviour. *Neuroscience and Biobehavioral Reviews*, 143, 104932. <https://doi.org/10.1016/j.neubiorev.2022.104932>
- Rockloff, M. J., Browne, M., Russell, A. M. T., Hing, N., & Greer, N. (2019). Sports betting incentives encourage gamblers to select the long odds: An experimental investigation using monetary rewards. *Journal of Behavioral Addictions*, 8(2), 268–276. <https://doi.org/10.1556/2006.8.2019.30>
- Romild, U., Volberg, R., & Abbott, M. (2014). The Swedish Longitudinal Gambling Study (Swelogs): Design and methods of the epidemiological. *International Journal of Methods in Psychiatric Research*, 23(3), 372–386. <https://doi.org/10.1002/mpr.1449>
- Rönnerberg, S., Volberg, R. A., Abbott, M. W., Moore, W. L., Andréén, A., Munck, I., Jonsson, J., Nilsson, T., & Svensson, O. (n.d.). *Gambling and problem gambling in Sweden*.
- Rossi, R., Soggi, V., Talevi, D., Mensi, S., Nioiu, C., Pacitti, F., Di Marco, A., Rossi, A., Siracusano, A., & Di Lorenzo, G. (2020). COVID-19 Pandemic and Lockdown

- Measures Impact on Mental Health Among the General Population in Italy. *Frontiers in Psychiatry*, 11. <https://doi.org/10.3389/fpsy.2020.00790>
- Rundle-Thiele, S. (2009). Bridging the gap between claimed and actual behaviour: The role of observational research. *Qualitative Market Research: An International Journal*, 12(3), 295–306. <https://doi.org/10.1108/13522750910963818>
- Russell, A. M. T., Hing, N., & Browne, M. (2019). Risk Factors for Gambling Problems Specifically Associated with Sports Betting. *Journal of Gambling Studies*, 35(4), 1211–1228. <https://doi.org/10.1007/s10899-019-09848-x>
- Sachdeva, V., Sharma, S., & Sarangi, A. (2022). Gambling behaviors during COVID-19: A narrative review. *Journal of Addictive Diseases*, 40(2), 208–216. <https://doi.org/10.1080/10550887.2021.1971942>
- Sakate, D. M., & Kashid, D. N. (2014). A deviance-based criterion for model selection in GLM. *Statistics*, 48(1), 34–48. <https://doi.org/10.1080/02331888.2012.708035>
- Salerno, L., & Pallanti, S. (2021). COVID-19 Related Distress in Gambling Disorder. *Frontiers in Psychiatry*, 12. <https://doi.org/10.3389/fpsy.2021.620661>
- Santomauro, D. F., Mantilla Herrera, A. M., Shadid, J., Zheng, P., Ashbaugh, C., Pigott, D. M., Abbafati, C., Adolph, C., Amlag, J. O., Aravkin, A. Y., Bang-Jensen, B. L., Bertolacci, G. J., Bloom, S. S., Castellano, R., Castro, E., Chakrabarti, S., Chattopadhyay, J., Cogen, R. M., Collins, J. K., ... Ferrari, A. J. (2021). Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *The Lancet*, 398(10312), 1700–1712. [https://doi.org/10.1016/S0140-6736\(21\)02143-7](https://doi.org/10.1016/S0140-6736(21)02143-7)
- Sharman, S., Roberts, A., Bowden-Jones, H., & Strang, J. (2021). Gambling in COVID-19 Lockdown in the UK: Depression, Stress, and Anxiety. *Frontiers in Psychiatry*, 12. <https://doi.org/10.3389/fpsy.2021.621497>
- Shaw, C. A., Hodgins, D. C., Williams, R. J., Belanger, Y. D., Christensen, D. R., el-Guebaly, N., McGrath, D. S., Nicoll, F., Smith, G. J., & Stevens, R. M. G. (2022). Gambling in Canada During the COVID Lockdown: Prospective National Survey. *Journal of Gambling Studies*, 38(2), 371–396. <https://doi.org/10.1007/s10899-021-10073-8>

- Smith, E., Michalski, S., Knauth, K. H. K., Kaspar, K., Reiter, N., & Peters, J. (2023). Large-Scale Web Scraping for Problem Gambling Research: A Case Study of COVID-19 Lockdown Effects in Germany. *Journal of Gambling Studies*, 39(3), 1487–1504. <https://doi.org/10.1007/s10899-023-10187-1>
- SPF. (2020, March 5). *First cases of coronavirus disease 2019 (COVID-19) in the WHO European Region, 24 January to 21 February 2020*. <https://www.santepubliquefrance.fr/import/first-cases-of-coronavirus-disease-2019-covid-19-in-the-who-european-region-24-january-to-21-february-2020>
- Stark, S., & Robinson, J. (2021). Online gambling in unprecedented times: Risks and safer gambling strategies during the COVID-19 pandemic. *Journal of Gambling Issues*. <https://doi.org/10.4309/jgi.2021.47.17>
- Stone, C. A., Romild, U., Abbott, M., Yeung, K., Billi, R., & Volberg, R. (2015). Effects of Different Screening and Scoring Thresholds on PGSI Gambling Risk Segments. *International Journal of Mental Health and Addiction*, 13(1), 82–102. <https://doi.org/10.1007/s11469-014-9515-0>
- Sun, Y., Bao, Y., Kosten, T., Strang, J., Shi, J., & Lu, L. (2020). Editorial: Challenges to Opioid Use Disorders During COVID-19. *The American Journal on Addictions*, 29(3), 174–175. <https://doi.org/10.1111/ajad.13031>
- Svenska Spel. (2024). *Vår historia*. Svenska Spel. <https://om.svenskaspel.se/om-oss/var-historia/>
- Testino, G., & Pellicano, R. (2020). Alcohol consumption in the COVID-19 era. *Minerva Gastroenterologica E Dietologica*, 66(2), 90–92. <https://doi.org/10.23736/S1121-421X.20.02698-7>
- Tetteh, J. E., Amoah, A., Ofori-Boateng, K., & Hughes, G. (2022). Stock market response to COVID-19 pandemic: A comparative evidence from two emerging markets. *Scientific African*, 17, e01300. <https://doi.org/10.1016/j.sciaf.2022.e01300>
- The French online gambling regulatory authority (ARJEL). (2018). *Activity report on 2017-2018*. <https://anj.fr/sites/default/files/2019-12/rapport-activite-Arjel%202018.pdf>

- Thiele, J., & Markussen, B. (2012). Potential of GLMM in modelling invasive spread. *CAB Reviews Perspectives in Agriculture Veterinary Science Nutrition and Natural Resources*, 7, 1–10. <https://doi.org/10.1079/PAVSNNR20127016>
- Thomas, S. L., Lewis, S., McLeod, C., & Haycock, J. (2012). ‘They are working every angle’. A qualitative study of Australian adults’ attitudes towards, and interactions with, gambling industry marketing strategies. *International Gambling Studies*, 12(1), 111–127. <https://doi.org/10.1080/14459795.2011.639381>
- Toce-Gerstein, M., Gerstein, D. R., & Volberg, R. A. (2003). A hierarchy of gambling disorders in the community. *Addiction (Abingdon, England)*, 98(12), 1661–1672. <https://doi.org/10.1111/j.1360-0443.2003.00545.x>
- Vermunt, J. K., & Magidson, J. (2002). Latent class cluster analysis. In J. Hagenaars & A. McCutcheon (Eds.), *Applied latent class analysis* (pp. 89–106). Cambridge University Press.
- Volberg, R. A., McNamara, L. M., & Carris, K. L. (2018). Risk Factors for Problem Gambling in California: Demographics, Comorbidities and Gambling Participation. *Journal of Gambling Studies*, 34(2). <https://doi.org/10.1007/s10899-017-9703-5>
- Volkow, N. D. (2020). Collision of the COVID-19 and Addiction Epidemics. *Annals of Internal Medicine*, 173(1), 61–62. <https://doi.org/10.7326/M20-1212>
- Vonesh, E. F. (2006). Mixed Models: Theory and Applications. *Journal of the American Statistical Association*. <https://doi.org/10.1198/jasa.2006.s146>
- Wang, C., Horby, P. W., Hayden, F. G., & Gao, G. F. (2020). A novel coronavirus outbreak of global health concern. *Lancet (London, England)*, 395(10223), 470–473. [https://doi.org/10.1016/S0140-6736\(20\)30185-9](https://doi.org/10.1016/S0140-6736(20)30185-9)
- Wardle, H., Donnachie, C., Critchlow, N., Brown, A., Bunn, C., Dobbie, F., Gray, C., Mitchell, D., Purves, R., Reith, G., Stead, M., & Hunt, K. (2021). The impact of the initial Covid-19 lockdown upon regular sports bettors in Britain: Findings from a cross-sectional online study. *Addictive Behaviors*, 118, 106876. <https://doi.org/10.1016/j.addbeh.2021.106876>

- Warszawski, J., Beaumont, A.-L., Seng, R., de Lamballerie, X., Rahib, D., Lydié, N., Slama, R., Durrleman, S., Raynaud, P., Sillard, P., Beck, F., Meyer, L., Bajos, N., Warszawski, J., Bajos, N., Barlet, M., Beck, F., Counil, E., Jusot, F., ... The EPICOV study group. (2022). Prevalence of SARS-Cov-2 antibodies and living conditions: The French national random population-based EPICOV cohort. *BMC Infectious Diseases*, 22(1), 41. <https://doi.org/10.1186/s12879-021-06973-0>
- Wiehler, A., & Peters, J. (2015). Reward-based decision making in pathological gambling: The roles of risk and delay. *Neuroscience Research*, 90, 3–14. <https://doi.org/10.1016/j.neures.2014.09.008>
- Wohl, M. J. A. (2018). Loyalty programmes in the gambling industry: Potentials for harm and possibilities for harm-minimization. *International Gambling Studies*, 18(3), 495–511. <https://doi.org/10.1080/14459795.2018.1480649>
- Wong, G., Zane, N., Saw, A., & Chan, A. K. K. (2013). Examining Gender Differences for Gambling Engagement and Gambling Problems Among Emerging Adults. *Journal of Gambling Studies / Co-Sponsored by the National Council on Problem Gambling and Institute for the Study of Gambling and Commercial Gaming*, 29(2), 171–189. <https://doi.org/10.1007/s10899-012-9305-1>
- Wood, R. T. A., & Griffiths, M. D. (2015). Understanding Positive Play: An Exploration of Playing Experiences and Responsible Gambling Practices. *Journal of Gambling Studies*, 31(4), 1715–1734. <https://doi.org/10.1007/s10899-014-9489-7>
- World Health Organization. (2019). *International Classification of Diseases 11th Revision (ICD-11)*. <https://icd.who.int/en/>
- Yang, C., Tan, Y., Li, Z., Hu, L., Chen, Y., Zhu, S., Hu, J., Huai, T., Li, M., Zhang, G., Rao, D., Fei, G., Shao, M., & Ding, Z. (2024). Pulmonary redox imbalance drives early fibroproliferative response in moderate/severe coronavirus disease-19 acute respiratory distress syndrome and impacts long-term lung abnormalities. *Annals of Intensive Care*, 14(1), 72. <https://doi.org/10.1186/s13613-024-01293-3>

Titre : Impact de la pandémie du COVID-19 sur l'activité de jeu de hasard et d'argent en ligne en France et en Suède.

Mots clés : COVID-19, données de suivi de jeu, France, jeux de hasard et d'argent en ligne, jeu problématique, Suède.

Résumé : La pandémie du COVID-19 a bouleversé les modes de vie, accroissant l'isolement, l'anxiété et le temps passé en ligne. Les jeux de hasard et d'argent (JHA) ont été fortement perturbés par l'arrêt des événements sportifs et hippiques ainsi que par la fermeture des établissements de jeu terrestres. Les comportements de jeu ont pu varier en conséquence : certains joueurs ont pu réduire leur activité, tandis que d'autres ont pu l'intensifier, augmentant ainsi les risques de problèmes de jeu. Cette thèse visait à évaluer les changements dans les pratiques de jeu en ligne au cours de l'année impactée par la pandémie (2020), par rapport à une année de référence (2019), parmi les joueurs de plateformes de jeux en ligne réglementées en France et ceux de l'opérateur de jeu public suédois, Svenska Spel. Des modèles linéaires

généralisés et des modèles mixtes, estimés sur les données de jeu à un niveau global, ont montré que les changements dus à la pandémie ont détourné certains joueurs et attiré de nouveaux vers d'autres types de JHA. De plus, des modèles de trajectoires ont caractérisé des trajectoires de jeu des joueurs français et suédois en 2019 et 2020, et des modèles à classes latentes ont identifié des sous-populations de joueurs ayant augmenté leur activité de jeu durant les phases aiguës de la pandémie. Certains profils identifiés pourraient correspondre à des joueurs à risque de développer des problèmes de jeu à plus long terme. Des mesures préventives ou réglementaires devraient être fortement recommandées si de telles situations se reproduisent, qu'il s'agisse d'une crise sanitaire ou d'autres types de crises.

Title: Impact of the COVID-19 pandemic on online gambling in France and Sweden.

Keywords: COVID-19, gambling disorder, gambling tracking data, France, online gambling, Sweden.

Abstract: The COVID-19 pandemic has disrupted lifestyles, increasing isolation, anxiety, and time spent online. Gambling opportunities were significantly by the interruption of sports and horse races events, and the closure of land-based gambling establishments. Consequently, gambling behaviors may have changed: some gamblers might have reduced their gambling activity, while others may have intensified it, increasing the risk of gambling problems. This thesis aimed to assess changes in online gambling practices during the pandemic year (2020) compared to a reference year (2019), among gamblers of regulated online gambling platforms in France and the Swedish public gambling operator, Svenska Spel. Generalized linear models and mixed models, based on

comprehensive gambling data, showed that pandemic-related changes caused some gamblers to shift their habits and attracted new gamblers to different types of gambling. Additionally, trajectory models mapped the gambling patterns of French and Swedish gamblers, while latent class models identified sub-populations that increased their gambling activity during the acute phases of the pandemic. Some of these profiles may correspond to gamblers at risk of developing long-term gambling problems. Preventive or regulatory measures should be strongly recommended if such situations occur again, whether due to a health crisis or other types of crises.