Individuals' perceptions of their cancers' risks stemming from environmental factors : overview, relationships with adoption of health-related behaviors and determinants

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Abstract

Objectives: (1) To explore and analyze individuals' perceptions of their own cancers' risks in general and stemming from environmental factors. (2) To investigate their relationships with individuals' adoption of health-related behaviors. (3) To identify and analyze the determinants of these perceptions.

Methods: A theoretical and an empirical literature reviews, an exploratory qualitative study among individuals with and without personal cancer history and a confirmatory quantitative study among a representative sample of the French population have been conducted.

Results: (1) Cancers' risks stemming from environmental factors are a subject of concern among French people. In particular, more than half of our sample perceived themselves at risk to develop cancers stemming from outdoor air pollution, pesticides and stress. (2) Individuals' adoptions of health-related behaviors can be associated with their risk perceptions, but are more associated with their endorsement of prevention-related beliefs, and their time and risk preferences. Endogeneity strongly impacts the significance of associations between perceptions and behaviors. (3) Endorsement of cancers-related beliefs and salience of cancers' risks stemming from environmental factors determine more strongly individuals' risk perceptions than availability and affect heuristics, knowledge, perceived control and voluntariness of risk exposures, personal health history and socio-demographic characteristics.

Discussion: Our results, consistent with the literature, bring new outcomes helpful to better understand individuals' risk perceptions and to design targeted public health policies.

Keywords: individuals' risk perceptions; health-related behaviors; cancers; environmental factors; literature review; qualitative study; quantitative study

Titre en français

Perceptions individuelles des risques de cancers liés aux facteurs environnementaux : état des lieux, liens avec l'adoption de comportements en santé et déterminants

Résumé

Objectifs : (1) Explorer et analyser les perceptions individuelles des risques de cancers toutes causes confondues et liés aux facteurs environnementaux. (2) Investiguer les liens entre ces perceptions et l'adoption de comportements en santé. (3) Identifier et analyser les déterminants de ces perceptions.

Méthodes : Revues de la littérature empirique et théorique, étude qualitative auprès de personnes avec et sans antécédent(s) de cancer, étude quantitative auprès d'un échantillon représentatif de la population française.

Résultats : (1) Les risques de cancers liés aux facteurs environnementaux sont un sujet de préoccupation. Une part importante des participants se percoit notamment à risque de développer des cancers liés à la pollution de l'air, aux pesticides et au stress. (2) Les adoptions de comportements en santé sont parfois associées aux perceptions des risques mais sont plus souvent associées à l'adhérence à des croyances relatives à la prévention et aux préférences vis-à-vis du temps et du risque. Prendre en compte l'endogénéité impacte fortement la significativié des associations entre perceptions et comportements. (3) L'adhérence à des croyances relatives aux cancers et la saillance des risques de cancers liés à l'environnement déterminent plus fortement les perceptions que les heuristiques d'affect et de disponibilité, la connaissance, le contrôle perçu et la volonté perçue des expositions aux risques, l'histoire personnelle de santé et les caractéristiques sociodémographiques.

Discussion : Nos résultats, cohérents avec la littérature, permettent de mieux comprendre les perceptions individuelles des risques et peuvent servir de support au développement de politiques ciblées de santé publique.

Mots-clés: perceptions individuelles des risques; comportements en santé; cancers; facteurs environnementaux; revue de la littérature; étude qualitative; étude quantitative

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Introduction et objectifs

Les cancers sont l'une des premières causes de morbidité et de mortalité dans le monde, 1 décès sur 6 leur sont attribuables. En France, en 2015, le nombre de nouveaux cancers étaient estimés à 385 000 et le nombre de décès à 149 500. Les cancers sont le résultat de plusieurs étapes de transformation des cellules normales en cellules tumorales issues d'interactions entre des facteurs génétiques individuels et des agents extérieurs. L'une des missions du Centre International de Recherche sur le Cancer (CIRC) est notamment de maintenir à jour une classification des facteurs environnementaux pouvant augmenter le risque de cancer chez l'homme, i.e. *« produits chimiques, mélanges complexes, expositions professionnelles, agents physiques, agens biologiques et facteurs comportementaux ».*

Ce rôle des facteurs environnementaux dans la survenue des cancers est devenu un sujet de préoccupation tant parmi la population que parmi les décideurs de santé publique. Par exemple, des études ont montré que leurs participants percevaient entre autres, le tabagisme, les pesticides et produits chimiques dans l'alimentation ainsi que la pollution comme des facteurs favorisant la survenue de cancers. Tout comme, le manque d'exercice et le stress. Cependant, les perceptions des individus quant à leur propre risque de développer des cancers en lien avec ces facteurs restent peu étudiées. En effet, alors que de nombreuses études ont analysé les perceptions individuelles des risques de cancers toutes causes confondues, peu d'études se sont intéressées à analyser comment les individus perçoivent leurs propres risques de développer des cancers liés aux facteurs environnementaux. (1) Le premier objectif de cette thèse est donc d'explorer et analyser ces perceptions individuelles des risques de cancers toutes causes confondues et liés aux facteurs environnementaux.

S'intéresser aux perceptions des risques soulève également la question de l'influence de ces perceptions sur l'adoption de comportements en santé, une association soutenue par de nombreux modèles en sciences sociales. Ces modèles font l'hypothèse qu'une personne percevant un risque faible ou élevé pour elle-même d'être confrontée à un évènement négatif va déterminer son adoption ou non de comportements en santé. Cette hypothèse est intéressante pour le décideur public lorsque l'on sait que 30 à 50% des cancers seraient évités si les connaissances actuelles sur les facteurs de risques étaient traduites en actions de prévention efficaces au niveau individuel et collectif. Cependant, les données empiriques ne soutiennent pas de façon incontestable cette hypothèse d'association entre perceptions et comportements. Certaines études ont en effet montré que les perceptions individuelles n'influençaient pas l'adoption de comportements. D'autres ont également souligné que l'adoption de comportements en santé conduit les individus à réévaluer leur risque sur la base de leur nouveau mode de vie mettant ainsi en lumière l'existence d'un lien double entre perceptions et comportements. En outre, des limites méthodologiques et conceptuelles ont été identifiées dans l'analyse de cette association motivant ainsi notre second objectif : (2) investiguer les liens entre adoption de comportements en santé et perceptions individuelles des risques de cancers toutes causes confondues et liés aux facteurs environnementaux.

Enfin, le troisième objectif de nore travail est (3) d'identifier et analyser les déterminants de ces perceptions individuelles.

Afin de répondre à ces trois objectifs, ce travail a été divisé en trois phases structurant les chapitres de cette thèse.

Chapitre 1 - Revues des littératures empirique et théorique

Afin d'appréhender l'ensemble du contexte empirique et théorique dans lequel s'inscrit notre recherche, nous avons réalisé deux revues de la littérature : l'une théorique et l'autre empirique. Notre revue de la littérature théorique s'est basée sur une méthode de recherche opportuniste guidée principalement par les pairs et la recherche documentaire en bibliothèque. Notre revue de la littérature empirique a quant à elle été basée sur une procédure de recherche systématique réalisée à partir d'équations de recherche sur des bases de données (cf. Appendix 1.2.)

Nos principaux résultats sont les suivants :

1. Etat des lieux :

L'analyse des facteurs environnmentaux en tant que facteurs de risque de cancers, ou d'autres pathologies, perçus par les individus est un sujet de recherche croissant. Cependant, plus de la moitié des études publiées porte sur le tabagisme, limitant de fait les informations disponibles sur les autres facteurs environnementaux tels que l'exposition au soleil ou les pesticides. En outre, la plupart des études interroge les individus sur leurs perceptions des risques de cancers toutes causes confondues et non pas liés à un ou plusieurs facteurs environnementaux.

2. Liens avec l'adoption de comportements en santé

Les liens entre adoptions de comportements en santé et perceptions des risques sont analysés dans peu d'études par rapport au même facteur environnemental limitant ainsi la prise en compte des effets de contexte. De plus, les résultats empiriques de certaines études confirment que les perceptions des risques sont liées à l'adoption de comportements tandis que d'autres confirment que l'adoption de comportements est liée à la perception des risques. Ce constat soulève la nécessité de prendre en compte l'endogénéité potentielle de la perception des risques lorsque celle-ci est analysée en lien avec l'adoption de comportements. Par ailleurs, si la littérature économique théorique et empirique souligne l'importance des préférences individuelles vis-à-vis du temps et du risque dans l'adoption de comportements, ces concepts sont très peu étudiés dans notre terrain de recherche appliquée. Des problématiques méthodologiques sont également associées à la mobilisation des ces concepts notamment concernant leur mesure. Enfin, l'influence sur l'adoption de comportements en santé de l'histoire personnelle de santé des individus (antécédent(s) de cancer(s) et/ou de maladie(s) chronique(s), état de santé perçu) et de leurs caractéristiques sociodémographiques est confirmée dans de nombreuses études.

3. Déterminants des perceptions individuelles des risques

Les perceptions individuelles des risques de cancers toutes causes confondues et liés aux facteurs environnementaux sont apparues déterminées par les heuristiques, en particulier d'affect et de disponibilité, la connaissance, l'adhérence à des croyances, le contrôle perçu, la volonté perçue, l'inquiétude d'avoir un cancer et la saillance des risques de cancers liés à l'environnement. Les résultats restent cependant limités et demandent à être confirmés. En outre, les résultats de nombreuses études soulignent que l'histoire personnelle de santé des individus et leurs caractéristiques sociodémographiques sont des déterminants de leurs perceptions individuelles des risques de cancers toutes causes confondues et liés aux facteurs environnementaux.

Bien que nos revues de littérature soient limitées par les bases de données et les mots-clés utilisés, ce travail nous a permis d'identifier les variables pertinentes à inclure dans nos analyses ainsi que les limites méthodologiques à dépasser lors de celles-ci.

Chapitre 2 - Etude qualitative exploratoire

Plus de la moitié de notre littérature étant issue d'Amérique du Nord, nous avons donc choisi de réaliser une étude qualitative afin de confirmer la pertinence de nos objectifs dans le contexte français, de valider la compréhension de nos principaux concepts au sein d'une population non spécialiste et d'affiner nos questions de recherche. Nous avons donc réalisé, sur la base d'un guide d'entretien identique, des entretiens semi-directifs, individuels et de groupes, avec respectivements des personnes ayant un ou des antécédent(s) de cancer(s) et des personnes sans antécédént(s) de cancers.

Nos principaux résultats sont les suivants :

1. Etat des lieux :

Tout d'abord, la cohérence des réponses entre les participants renseigne de façon positive la compréhension de nos principaux concepts au sein d'une population non-spécialiste. Ensuite, un grand nombre de facteurs (n=19) a été cité par nos participants comme causes perçues de cancers incluant des facteurs comme le tabagisme, la consommation d'alcool, la pollution de l'air, les radiofréquences ou encore le vieillissement et le patrimoine génétique. Ce constat montre que les risques de cancers liés aux facteurs environnementaux sont un sujet de préoccupation parmi la population.

2. Liens avec l'adoption de comportements en santé

Les participants à notre étude ont déclaré avoir adopté des comportements relatifs à leur alimentation, leur niveau d'activité physique, leur achat et usage de produits cosmétiques ou d'entretien, leur consommation de tabac et leur exposition aux radiofréquences. De façon intéressante, on note que les facteurs liés à ces comportements sont en cohérence avec leurs risques perçus de cancers. Il est également ressorti de nos verbatims que l'adhésion à des croyances relatives à la prévention est un élément important à considérer dans l'analyse de l'adoption de comportements en santé tels que la motivation d'adopter des comportements pour prévenir le cancer ou les barrières perçues à cette adoption de comportements.

3. Déterminants des perceptions individuelles des risques

En cohérence avec les résultats de la revue de la littérature, l'analyse des verbatims montre que l'expérience de cancer, la connaissance relative aux facteurs de risques de cancer et le contrôle perçu ainsi que la volonté perçue de l'exposition aux risques sont des déterminants à considérer dans nos analyses des perceptions individuelles des risques de cancers liés aux facteurs environnementaux.

Notre étude présente certaines limites. Tout d'abord, les personnes ont probablement accepté de participer du fait de leur intérêt pour la thématique impliquant un biais de sélection. De plus, la moitié de notre population avec antécédent(s) de cancers a déclaré une expérience de lymphome limitant la comparabilité de nos résultats avec d'autres études mais soulignant l'importance de cette thématique pour cette catégorie de personnes. En dépit de ces limites, notre étude qualitative a apporté des connaissances intéressantes à la fois cohérentes et originales au regard de la littérature dans le champ. Par ailleurs, nous avons mobilisé nos verbatims afin de construire certaines variables de notre questionnaire (cf. chapitres 3 et 4) comme les items liés aux facteurs environnementaux, à l'adhérence à des croyances relatives à la prévention, et au score d'heuristique d'affect, pour lequel nous proposons notamment une mesure intuitive. Ainsi, notre étude qualitative nous a permis de construire un questionnaire à la fois compréhensible et accessible au plus grand nombre. Enfin, les résultats nous ont permis d'affiner notre cadre d'analyse et de formuler des hypothèses quant aux relations entre nos variables.

Chapitre 3 et 4- Etude quantitative confirmatoire

Afin de tester nos hypothèses, nous avons réalisé une étude quantitative confirmatoire. Le développement de notre questionnaire auto-complété a été basé sur les résultats de nos deux premières étapes (revues de la littérature et étude qualitative exploratoire) ainsi que sur les questionnaires de grandes études transversales françaises. Il durait environ 35 minutes et contenait 278 questions réparties dans 43 catégories, les items dans les catégories étaient distribués au hasard afin d'éviter un effet d'ordre. Une vingtaine de pré-tests ont été réalisés auprès d'experts et de personnes non-spécialistes. Le questionnaire a été administré en Octobre 2016 par un institut de sondage national (IPSOS) sur un échantillon représentatif de la population française composé de 1500 personnes.

Les associations entre l'adoption de comportements en santé et les perceptions des risques, les préférences vis-à-vis du temps, l'impulsivité, les préférences vis-à-vis du risque et les croyances relatives à la prévention ont été estimé par des régressions logistiques ajustées sur l'histoire personnelle de santé des individus et leurs caractéristiques sociodémographiques. Afin de contrôler l'endogénéité potentielle des perceptions, ces associations, ajustées sur les mêmes variables, ont aussi été estimées par une procédure en deux étapes (2SRI : two-stage residual inclusion).

Une Analyse des Correspondances Multiples a été réalisé afin d'identifier des tendances de réponses sur les 24 perceptions des risques recueillies dans cette enquête. 3 tendances de réponses sont ressorties dont les déterminants ont été analysés par le biais de régressions ZIP. Enfin, l'observation d'Alphas de Cronbach élevés a conduit à la construction de 4 scores de perceptions des risques de développer des cancers : liés aux comportements, liés aux expositions environnementales, liés aux produits de consommation et liés aux émotions négatives. Les déterminants de ces scores ont été analysés par des régressions OLS. Les déterminants des perceptions des risques de cancers toutes causes confondues et liés au patrimoine génétique ainsi que liés au fait de prendre la pilule ont été analysé par des régressions logistiques.

Nos principaux résultats sont les suivants :

1. <u>Etat des lieux :</u>

Prés de la moitié des répondants ont déclarés percevoir, au regard de leurs modes de vie, leurs risques de développer des cancers liés à la pollution de l'air extérieur, aux pesticides par le biais de l'alimentation ou de l'air respiré, et au stress au cours de leur vie élevés ou très élevés. A l'inverse, plus de 60% des participants ont déclarés percevoir, au regard de leurs modes de vie, leurs risques de développer des cancers liés aux produits cosmétiques, aux produits d'entretien et à une consommation excessive d'alcool au cours de leur vie faibles ou presque nuls. Enfin, 43% des répondants ont déclarés ne pas savoir comment percevoir leurs risques de développer des cancers toutes causes confondues au cours de leur vie, sur la base de leur mode de vie. La même proportion de répondre « je ne sais pas » est observée pour les risques de cancers liés à l'exposition domestique au radon. De façon intéressante, on observe que ces deux proportions sont les plus élevées de réponses « je ne sais pas », proportion qui descend au plus haut à 21% pour les autres facteurs environnementaux et le patrimoine génétique.

2. <u>Liens avec l'adoption de comportements en santé</u>

Notre hypothèse selon laquelle percevoir au regard de son mode de vie son risque de développer des cancers toutes causes confondues, liés à son patrimoine génétique ou liés aux facteurs environnementaux au cours de sa vie, élevé par rapport à faible décroit la vraissemblance d'avoir adopté des comportements en santé associés à ces mêmes facteurs est très peu confirmée. Lorsque l'endogénéité n'est pas prise en compte, un tiers des adoptions de

comportements en santé sont significativement associées aux perceptions des risques. Lorsque l'endogénéité est prise en compte, seule une adoption de comportements en santé est significativement associée à la perception du risque et une sous-estimation de l'impact des perceptions des risques sur l'adoption de comportements en santé (résidus FSE significatifs dans SSE) n'est confirmée que dans deux cas, le tagagisme et le stress.
Notre hypothèse selon laquelle une préférence pour le présent, une impulsivité et une préférence pour le risque croissante décroit la vraissemblance d'adopter des comportements en santé est partiellement confirmée. Ainsi, une préférence pour le futur, une patience et une aversion pour le risque dans des contextes de prévention croissante est significativement associée à l'adoption de certains comportements en santé tout comme une préférence pour le risque croissante dans des contextes risqués.
Notre hypothèse selon laquelle l'adhérence à des croyances relatives à la prévention accroit la vraissemblance d'adopter des comportements en santé, à l'exception des barrières perçues qui décroit cette vraissemblance, est fortement confirmée. Ainsi, toutes les adoptions de comportements en santé sont significativement associées avec l'adhérence à au moins une croyance relative à la prévention.
L'histoire personnelle de santé des individus et leurs caractéristiques sociodémographiques ressortent peu associées à l'adoption de comportements en santé, à l'exception pour certains comportements d'un effet genre positif chez les femmes.

3. Déterminants des perceptions individuelles des risques

Les tendances de réponses sont apparues fortement déterminées par le niveau de connaissance sur les facteurs environnementaux et leurs liens avec les cancers ainsi que pas l'adhérence à des croyances relatives aux cancers et à leurs causes.
Les scores de perceptions des risques apparaissent quant à eux déterminés fortement par l'adhérence à des croyances relatives aux cancers et à leurs causes ainsi que la saillance des risques de cancers liés à l'environnement. De façon intéressante, le score de perceptions des risques de cancers liés aux émotions négatives ressort également déterminé par une partie de l'heuristique de disponibilité.
Les perceptions des risques de cancers toute causes confondues et liés au patrimoine génétique sont ressortis déterminés par une partie de l'heuristique de disponibilité notamment l'expérience indirecte de cancers parmi les proches et l'inquiétude d'avoir un cancer un jour au cours de son existence.
Contrairement à nos hypothèses, le contrôle perçu et la volonté perçue de l'exposition aux risques ne sont pas ressortis comme des déterminants des perceptions des risques. De plus, les perceptions des risques apparaissent peu déterminées par l'histoire personelle de santé des individus et leurs caractéristiques sociodémographiques contrairement aux résultats de la littérature et aux résultats de notre phase qualitative.

Notre étude présente des limites. Tout d'abord, il s'agit d'une enquête transversale auto-administrée en ligne. Aussi, l'exactitude des réponses est dépendante de la bonne volonté des participants. Ensuite, notre mesure des perceptions des risques repose sur une échelle qualitative en 4 points avec en plus « je ne sais pas ». Cette limite peut cependant aussi être considérée comme une force car ces modalités de réponses limitent l'impact potentiel d'un faible niveau de « numéracie » des individus.

En dépit de ces limites, notre étude quantitative apporte des connaissances cohérentes et originales au regard de la littérature dans le champ notamment de part l'utilisation de mesures de certains items et de méthodes d'analyse encore peu utilisées dans le champ.

Conclusion

Nos résultats montrent que les risques de cancers liés aux facteurs environnementaux sont un sujet de préoccupation au sein de la population française. En particulier, près de la moitié de nos participants ont déclaré se percevoir à risque de développer au cours de leur vie des cancers liés à la pollution de l'air extérieur, aux pesticides et au stress. A contrario, plus de la moité de nos particpants ont déclaré ne pas savoir comment percevoir leurs risques de développer des cancers toutes causes confondues au cours de leur vie. Ainsi, les individus ont plus de facilité à évaluer un risque lorsque le contexte est clairement précisé.

Nos résultats montrent également que les adoptions de comportements en santé sont parfois associées aux perceptions des risques, mais sont plus associées à l'adhérence à des croyances relatives à la prévention et aux préférences vis-à-vis du temps et du risque. Prendre en compte l'endogénéité impacte fortement la significativié des associations entre perceptions des risques et adoption de comportements en santé appelant donc à la prudence quant aux analyses conduites et aux interprétations faites. En outre, l'histoire personnelle de santé des individus et leurs caractéristiques sociodémographiques ressortent peu associées à leur adoption de comportements en santé, à l'exception pour certains comportements d'un effet genre positif chez les femmes.

Enfin, nos résultats montrent que l'adhérence à des croyances relatives aux cancers et à leurs causes ainsi que la saillance des risques de cancers liés à l'environnement déterminent plus fortement les perceptions des risques de cancers que les heuristiques d'affect et de disponibilité, la connaissance, le contrôle et la volonté perçue des expositions aux risques, l'histoire personnelle de santé et les caractéristiques sociodémographiques.

Nos résultats, cohérents avec la littérature, permettent de mieux comprendre les perceptions individuelles des risques et d'aider à concevoir des politiques ciblées de santé publique. De futurs travaux permettront d'affiner nos analyses et nos résultats.

Table of Content

List of Figures

List of Tables

INTRODUCTION

Cancers are one of the leading worldwide severe diseases with 8.8 million estimated associated deaths in 2015 (World Health Organization 2017). Cancers involving the higher number of casualties worldwide are cancers located in lung, liver, colon/rectum, stomach and breast (World Health Organization 2017). In France, 150 000 deceases were estimated to be due to cancers in 2015 and especially to lung and colorectal cancers among both French men and women as well as prostate cancers among men and breast cancers among women. These cancers are also the most frequent ones among the French population (INCa 2016).

Cancers is a generic term used to describe a group of diseases resulting from a rapid growth of abnormal cells beyond their usual boundaries in any part of the body which can then invade adjoining parts and spread to other organs (World Health Organization 2017). The transformation of normal cells into tumor cells is a multistage process generally progressing from a pre-cancerous lesion to a malignant tumor. These changes are the result of interactions between individuals' genetic features and external agents (World Health Organization 2017). One of the mission of the International Agency for Research on Cancer (IARC), the WHO's cancer research agency, is to maintain a classification of environmental agents that can increase the risk of human cancer.

IARC includes in environmental factors *"chemicals, complex mixtures, occupational exposures, physical agents, biological agents, and lifestyle factors"* (IARC 2017 Jan 26). This is an important point because, depending on whether the environment is defined according to a narrow *"air, water, soils and food pollutants"* or a broad *"all non-genetic factors"* definition, the implications of findings differ and especially the proportion of cancers attributed to environmental factors (McGuinn et al. 2012). As an illustration, one fifth of cancers are estimated to be attributable to air, water, soil, and food pollutants (World Health Organization 2011) and one third to high body mass index, low fruit and vegetable intake, lack of physical activity, tobacco use and alcohol consumption (World Health Organization 2017).

The IARC has classified so far as carcinogenic to humans 120 agents, meaning that sufficient evidence was available to support a causal relationship between exposure to the agent and human cancer. As shown in Table 1, a large number of factors are classified probably or possibly carcinogenic meaning that available evidence is not sufficient to conclude on these factors' carcinogenicity and an even larger number of factors are not classifiable as their carcinogenicity to humans because of inadequate evidence.

Table 1 Agents classified by the *IARC Monographs*, volumes 1–118. Source: IARC website, http://monographs.iarc.fr/, last update: 19 May 2017

Group 1	Carcinogenic to humans	120 agents
Group 2A	Probably carcinogenic to humans	81
Group 2B	Possibly carcinogenic to humans	294
Group 3	Not classifiable as to its carcinogenicity to humans	505
Group 4	Probably not carcinogenic to humans	1

Along with these epidemiological data, the role of environmental factors in inducing cancers has also become a subject of concern among the population worldwide. For instance, almost all the respondents from a French representative sample perceived smoking, sun exposure, pesticides in food and air pollution as factors inducing cancers (Beck and Gauthier 2012). In the same survey, living near a nuclear plant or a cell-phone antenna was perceived at least probably carcinogenic by more than two third of respondents (Beck and Gauthier 2012). Two Australian studies also found smoking, alcohol consumption, diet-related factors such as overweight, unbalanced diet and lack of physical activity perceived as leading causes of cancers by their respondents (Jones et al. 2011; Adams et al. 2013). Finally, the majority of a sample of African American US adults perceived the environment as playing an important role in cancers' occurrence (Rice et al. 2015).

These results show that individuals perceive the risks of cancers stemming from environmental factors at the population level. But, do individuals perceive their own cancers' risks stemming from these environmental factors?

Few studies have actually investigated whether individuals perceive, i.e think and feel about (Renner, Gamp, et al. 2015), themselves at risk to develop cancers stemming from environmental factors in their remaining lifetime. In a survey conducted among a representative sample of the French population, around half of the sample estimated rather or very high their risk of developing a cancer stemming from environmental factors (Ménard et al. 2008). Some

studies also showed that individuals tend to perceive their risks of cancers stemming from environmental factors as a threat for others but not for themselves. For instance, current smokers were found to display an optimistic bias, i.e. they perceive their own risk of developing lung cancer to be low or (Lin and Sloan 2015) or lower than others (Hahn and Renner 1998; Weinstein et al. 2005; Shiloh et al. 2009; Persoskie et al. 2014). Individuals living beyond 30 km from a nuclear power plant were also found to perceive higher cancers' risks for people living within 30 km from a nuclear power plant (Ho et al. 2014). In addition, around half of US respondents were found to perceive their skin cancer's risks to be low or lower than other people (US National Cancer Institute 2017). On the contrary, other studies supported that individuals perceived these risks as salient. Current smokers were indeed found in some studies to perceive their risk to have cancer or lung cancer high (Ford et al. 2014; Peretti-Watel et al. 2014) or higher than others (Chen and Kaphingst 2011). They were also found to display high risk perceptions of smoking-related health problems if they continue to smoke (Stewart et al. 2013). Some individuals were also found to perceive their risk to have skin cancer to be high or higher than others rather than low or lower than others (Bränström et al. 2006).

A first observation regarding these studies is that the majority of them are focused on smoking (see Appendix 1 for a review). Few findings can thus be found regarding other environmental factors such as radon, air pollution, pesticides, unbalanced diet, etc.

Moreover, perceptions of risks to develop cancers stemming from environmental factors have not been always directly elicited. For instance, respondents were asked about their risk perceptions to develop cancers in general and their answers were related with environmental factors through data analyses (Chen and Kaphingst 2011; Kiviniemi and Ellis 2014). More precisely, participants were not asked whether they perceive themselves at risk of lung or skin cancers stemming from smoking or sun exposure while they can display different perceptions whether they are asked to consider risks of cancers in general or stemming from these specific environmental factors. The importance of this issue lies in self-relevance and the extent to which individuals are able to picture themselves in a given context (Knuth et al. 2014). It thus appears important to explicitly asked respondents about their perceptions of their own risks to develop cancers in general and cancers stemming from selected environmental factors to actually elicit them.

Based on this statement, the first objective of this thesis is to explore and to analyze individuals' perceptions of their own cancers' risks in general and stemming from environmental factors.

According to the WHO, cancers' burden can be lessening by 30% to 50% through early detection, appropriate treatments and avoidance of risk factors (World Health Organization 2017). Consistent with this objective, national public health initiatives have been established last decade in western countries to promote adoption of preventive health-related behaviors against smoking, unbalanced diet, obesity, physical inactivity, etc. However, these initiatives struggle to achieve their objectives in terms of health-related behaviors actually adopted (Morgan and Peters 2015; Schüz et al. 2015). Three studies conducted respectively in South Korea, USA and France found that less than half of their respondents met dietary recommendations to eat at least three vegetables a day (Park et al. 2009; Malon et al. 2010; Redmond et al. 2010). Redmond et al. (2010) also showed that only one fifth of a representative sample of the US population met recommendations for exercise. One explanation may be due to the fact that these public health campaigns rely on a too broad information dissemination and people's unconditional acceptance of public health recommendations (Armitage 2015). These public health policies may have thus reached their limits in terms of impact on individuals' decisions to adopt preventive health-related behaviors and show the gap between collective recommendations and individual preferences.

Interestingly, individuals' perceptions of their own risks to develop cancers have been shown to influence individuals' decisions to adopt health-related behaviors from an empirical and a theoretical point view. Unfortunately, findings are sparse in the context of cancers' risks stemming from environmental factors. Individuals perceiving their risks to develop cancers stemming from sun exposure or smoking as high were found to adopt preventive health-related behaviors (Weinstein et al. 2005; McCool et al. 2009; Kiviniemi and Ellis 2014) or to reduce risk-taking health-related behaviors regarding these risks (Johnson et al. 2002; Lundborg and Lindgren 2004; Bränström et al. 2006; Hay et al. 2007; Lundborg and Andersson 2008; Denny-Bas et al. 2014; Lin and Sloan 2015). Nonetheless, individual risk perceptions were also found to be influenced by adoption of health-related behaviors since individuals adopting preventive health-related behaviors were found to perceive their risks of cancers stemming from smoking, radon or from a various set of hazards as low (Smith and Johnson 1988; Hay et al. 2007; Rice et al. 2015).

Moreover, studies conducted in this field did not analyze direct relationships between perceptions and behaviors. For instance, Bränström and colleagues analyzed the association between readiness to change behaviors and risk perception of skin cancer, but did not provide

findings regarding the relationship with sunbathing habits (Bränström et al. 2006). Similarly, Peretti-Watel and colleagues underlined that the majority of respondents in their study declared to plan quitting smoking but the authors did not give findings regarding relationship with perceptions of cancers' risks stemming from smoking (Peretti-Watel et al. 2007).

In addition, very few studies have investigated relationships between individuals' perceptions of their risks to develop cancers and adoption of health-related behaviors when both are related to specific environmental factors. Our idea behind this concern is that individuals' perceptions of their risks to develop cancers stemming from, for example, alcohol consumption may be associated with individuals' adoption of health-related behaviors regarding alcohol consumption, but not regarding physical activity or sun exposure. To the best of our knowledge, no study has ever investigated these relationships with such a focus on context and considering a large set of environmental factors.

Based on this statement, the second objective of this thesis is to investigate the relationships between individuals' adoption of health-related behaviors and perceptions of their own risks to develop cancers when both are elicited regarding cancers in general and stemming from environmental factors.

Quite a few studies searched to identify determinants of individuals' perceptions of their cancers' risks. These studies highlighted the role played by knowledge, beliefs, perceived control, perceived voluntariness, experience with cancer, worry, salience and sociodemographic characteristics (for a review see Article #1 in Appendix 1 Section 1.2). However, few have focused on identifying determinants of individuals' perceptions of their own risks to develop cancers stemming from environmental factors.

Based on this statement, the third objective of this thesis is to identify and to analyze the determinants of individuals' perceptions of their own risks to develop cancers in general and stemming from environmental factors.

Answering these three objectives may help in the design and establishment of a more talkative structure of cancer prevention for individuals such as targeted prevention on one environmental factor and on one type of health-related behavior. More generally, the identification of the determinants of individuals' perceptions of their own risks to develop

cancers in general and stemming from environmental factors might help to produce public health policies better adapted to them.

This thesis deliberately does not propose any action to change individuals' health-related behaviors as its first objective is to analyze and understand the complexity of individuals' perceptions of risks to develop cancers in general and stemming from environmental factors as well as their relationships with adoption of health-related behaviors.

Finally, improving knowledge and understanding of perceptions and behaviors towards risk factors of cancers is an objective of the 2014-2019 Cancer Plan (INca 2014). More specifically, this thesis is consistent with Action 11.13 – to improve the knowledge of perceptions and behaviors regarding risk factors of cancers. It also brings valuable data for Action 11.12 – to enlighten individuals' decisions by clarifying the hierarchy between cancer risk factors.

In order to reach these objectives, this thesis is structured into three parts.

First, we conducted a theoretical literature review and an empirical one to allow the analysis of the entire context in which our objectives are settled, as well as to support the construction of our research questions. Findings from these literature reviews are summarized in Chapter 1. While the theoretical literature review has been conducted following a convenient process guided by peer advices and hand search in libraries, the empirical literature review has been conducted following a systematic procedure and led to the writing of an article under submission (Authors' draft available in Appendix 1, Section 1.2).

Then, we conducted an exploratory qualitative study, described in Chapter 2. Perceptions of cancers' risks in general and cancers' risks stemming from environmental factors as well as adoption of health-related behaviors were explored in individual and group semi-structured interviews conducted respectively with individuals with and without personal cancer history (Article submitted and under review in Health, Risk & Society). Findings from the qualitative study contributed to the refinement of our research questions and to the construction of our questionnaire. In particular, while genetics is not included in the IARC's definition of the environment, it appeared as a widely perceived cancer risk factor in the population and thus important to take into account in our elicitation of individuals' perceptions of cancers' risks.

Finally, we conducted a confirmatory quantitative study, described in Chapter 3 and Chapter 4 to test the assumptions we made on the relationships between our variables based on findings from the literature reviews and qualitative analysis. A representative survey of the French

population aged between 18 and 75 year-old, recruited by a survey institute, completed online an auto-administrated questionnaire in October 2016.

In chapter 3, we describe whether respondents perceive themselves at risk to develop cancers in general and cancers stemming from genetics as well as from environmental factors. Then, we investigate the relationships between individuals' adoption of health-related behaviors and their perceptions of their cancers' risks in general as well as stemming from genetics and environmental factors, their time preference, their impulsivity, their risk preference and their endorsement of prevention-related beliefs taking into account the endogeneity of risk perceptions. These analyses took into account personal health history and sociodemographic characteristics.

In chapter 4, we then analyze whether the determinants we identified, namely affect heuristic, availability heuristic, knowledge, beliefs' endorsement related to cancers and cancers' causes, cancer-related worry, salience, perceived voluntariness and perceived control of risks' exposure determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors. These analyses took into account personal health history and sociodemographic characteristics.

Following these four chapters, we discuss our results and propose future issues in lights of our research questions and we finally conclude.

1 Individuals' perceptions of risks in general, in cancers and cancers stemming from environmental factors

"Danger is real but risk is socially constructed" (Slovic 1999). With this statement, Slovic put in perspective the basic definition of the concept of risk: probability of occurrence x severity. In classic economics, only these objective and calculated risks are considered, and individual agents are conceptualized as *"homo economicus"*, calculated and unemotional agent. In this context, rational individuals weigh each possible consequences with their probabilities of occurrence and act in order to maximize their subjective expected utility.

However, in situations of *"unmeasurable uncertainty"* [1] where *"uncertainties are not reducible to risks"* because of the lack of information regarding the probabilities' distribution (Ellsberg 1961), assessing risks accurately becomes very difficult if not impossible. As a consequence, people rely on the subjective probabilities they construct to take decisions and make judgments in their everyday life (Tversky and Kahneman 1974). Subjective risk perceptions have been indeed found as better predictors of adoption of health-related behaviors than objective risk estimations (Lipkus et al. 2000; Carman and Kooreman 2014). Individuals may be thus perceived as taking irrational decisions whereas they make their choices according to their own subjective estimates of probabilities (Eiser et al. 1979).

Based on their numerous research's findings, Kahneman and Tversky developed the (cumulative) Prospect Theory and showed that individuals overestimate small probabilities, underestimate large ones, consider prospects as gains and losses regarding their specific reference point and are averse to losses but seek gains (Kahneman and Tversky 1979; Tversky and Kahneman 1992). The adoption by individuals of a subsequent number of behaviors denied

[1] As shown in Table 1, there is still a lot of uncertainty regarding cancers' risks induced by environmental factors from an epidemiological perspective (IARC 2017 Jan 26), this notion of unmeasurable uncertainty is especially important in our applied field.

by the classic economic theory of expected utility found explanation thanks to the Prospect Theory.

Regarding more precisely individuals' perceptions of risks in the context of cancers, studies have suggested several mechanisms. In particular, the Precaution Adoption Process suggested that an individual goes through three stages of risk perception before actually perceiving himself at risk enough to adopt preventive health-related behaviors (Weinstein 1988). At the first stage, he becomes aware of the disease risk at the population level like individuals perceiving smoking, alcohol consumption, diet-related factors and lack of physical activity as leading cancers' causes (Jones et al. 2011; Adams et al. 2013). At the second stage, he perceives the disease as a threat for others but not for himself like current smokers who perceive their own risk of developing lung cancer to be lower than others (Weinstein et al. 2005). And, finally, at the third stage, he perceives the disease as a threat for himself. Another mechanism is the existence of a *"second-order risk"* meaning that individuals, when considering whether they are themselves at risk, simplify the probability of a threat's occurrence, even when it is an individualized information, to a binary situation: whether or not they might be sick themselves (Han et al. 2009; Lee 2010).

In our thesis, we aim to explore whether individuals perceive themselves at risk when faced to cancers' risks in general and cancers' risks stemming from environmental factors. Thus, mechanism such as the precaution adoption model is not tested because we rather focus on whether individuals perceive themselves at risk or not. Consistent with Han and colleagues' assumption, we assume a second-order risk where individuals assimilate epidemiological data to define in a simple way whether or not they are at risk because of a specific threat.

In addition, among empirical data, few studies asked individuals about their perceptions of their own risks to develop cancers stemming from environmental factors and, half of them are focused on cancers' risks stemming from smoking. Moreover, in most studies, authors rather elicited individuals' perceptions of their own risks to develop cancers in general. This point may appear as a trivial concern but that is not actually the case because different people in different contexts may have a different meaning of *"risk"* (Codern et al. 2010), whether a subjective definition of risk perception is adopted, *"how individuals think and feel about the risks they face"* (Renner et al. 2015), or an objective one, *"perceived likelihood of personally encountering a hazard and the possibility of incurring negative consequences"* (Knuth et al. 2014). One solution to overcome this issue of self-relevance in risk research is to ask explicitly

participants about their perceived likelihood of becoming a victim of the events (Knuth et al. 2014).

Research Question 1: Which environmental factors French individuals perceive as cancers' risk factors for themselves? Which environmental factors they do not perceive as cancers' risk factors for themselves?

2 Relationships with adoption of health-related behaviors in general, in cancers and cancers stemming from environmental factors

According to the model proposed by Grossman in 1972, an individual's health can be defined as a capital. When born, each person has a certain amount of health capital that can be increased using health services and endorsing preventive behaviors (balanced eating, regular exercising, etc.) or depreciated through aging and endorsing risk-taking behaviors (regular smoking and alcohol consumption, unbalanced eating, etc.). Following this model, a rational agent can increase his positive investment (adoption of preventive behaviors) and/or decrease his negative investment (avoidance of risk-taking behaviors) (Grossman 1972; Cawley and Ruhm 2012).

Individuals are assumed to make prior assessments of their beliefs (probabilities) and values (preferences) in order to evaluate the available options they have, leading to choices maximizing their utility (van der Pligt 2015). Thus, individuals compute their own subjective probabilities, construct their own rationality and adopt health-related behaviors consistent with it. As a consequence, individuals overestimating their risk of cancer may excessively endorse preventive health-related behaviors whereas individuals underestimating their risk of cancer may endorse no preventive health-related behaviors at all (Peters et al. 2006). In addition, an individual can simultaneously adopt risk-taking health-related behaviors and be rational according to his own point of view (Eiser et al. 1979).

Few empirical studies investigating the relationship between individuals' adoption of health-related behaviors and cancer risk perceptions appeared related to conceptual frameworks. The most quoted conceptual framework are the Health Belief Model (Vaughan 1993; Bowen et al. 2004; Silk et al. 2006; Wang et al. 2009; Chen and Kaphingst 2011), the Self-Regulatory Model (Bowen et al. 2004; Shiloh et al. 2009; Chen and Kaphingst 2011; Kelly et al. 2012), the Trans-theoretical Model of Behavioral change (McCoy et al. 1992; Bränström et al. 2006; Stewart et al. 2013) and the Bayesian updating process (Lundborg and Lindgren 2004; Lundborg and

Andersson 2008; Lin and Sloan 2015) (more details regarding these models can be found in Appendix 1, Section 1.1).

All these models, whether coming from economics or psychology, underline the complexity of individuals' risk perceptions and thus, the necessity to conduct multi-disciplinary research including concepts from both economics and psychology to understand individuals' risk perceptions and their relationship with adoption of health-related behaviors. Interestingly, while none of these numerous models appeared to outperform, leaving space to conduct studies, there is a transversal agreement on a positive relationship between increasing individuals' risk perceptions and adoption of preventive health-related behaviors as well as a negative relationship with adoption of risk-taking health-related behaviors (Prochaska and DiClemente 1982; Rosenstock et al. 1988; Viscusi 1991). However, empirical data do not always support this relationship and, from a methodological point of view, correlations between risk perceptions and adoption of behaviors are sometimes improperly used to answer two key and easily confused questions (Weinstein and Nicolich 1993) :

The first one is whether individuals' perceptions of their personal risks are correctly reflecting their adoption of health-related behaviors. In this case, a negative correlation is expected between increasing risk perceptions and individuals' adoption of preventive health-related behaviors. Some empirical evidence supports this assumption since individuals adopting preventive health-related behaviors were found to perceive their cancers' risks in general and stemming from environmental factors as low (Smith and Johnson 1988; Hay et al. 2007; Robb et al. 2007; Rice et al. 2015).

The second one is whether individuals who recognized their high personal risk adopt health-related behaviors to reduce that risk. In this case, a positive correlation is expected between increasing risk perceptions and adoption of preventive health-related behaviors. Consistent with this assumption, individuals perceiving their cancers' risks in general and stemming from environmental factors as high were found to adopt preventive health-related behaviors regarding these risks (Weinstein et al. 2005; Fagerlin et al. 2007; Moser et al. 2007; McCool et al. 2009; Spector et al. 2009; Kiviniemi and Ellis 2014).

This double-sense relationship supported by empirical evidence raises basically two methodological issues. First, choices in methods of elicitation of individuals' risk perceptions is necessary in order to disentangle these relationships from one another and clarify the sense of the relationship analyzed. Second, the endogeneity of risk perception might be an issue to consider in empirical strategy.

Research Question 2.1.: Is there a relationship between individuals' adoption of health-related behaviors and their perceptions of their cancers' risks in general and stemming from environmental factors when both are elicited regarding the same factor and taking into account the endogeneity of risk perceptions?

Individuals' time preferences may as well influence their adoption of health-related behaviors. Consuming goods today or tomorrow has indeed the same value for time-consistent individuals because their marginal rate of substitution for consumption in any period is constant. However, time-inconsistent individuals have inconstant marginal rates of substitution for consumption over time, meaning that consuming today has a higher value than consuming tomorrow. In this case, future consumption is discounted and individuals prefer an amount of utility today than an amount of utility in the future (Cawley and Ruhm 2012). A preference enhanced by the fact that benefits from preventive health-related behaviors are delayed whereas costs are immediate (Chapman 2005). Furthermore, individuals were found to endorse hyperbolic discounting meaning that the discount rate is higher for intertemporal trade-offs in the near future compared with a longer time horizon (Cawley and Ruhm 2012). In other words, consuming today has a higher value than consuming tomorrow which has a higher value than consuming the day after tomorrow. Thus, individuals may have present-biased preferences to consume today. According to these theoretical assumptions, individuals who tend to be future-oriented are assumed to think more about investments in health and thus to adopt more health-related behaviors perceived as risk-reducing than individuals who tend to be present-oriented.

From a methodological point of view, discounting a delayed over an immediate benefit of the same magnitude is motivated by the waiting cost but also the risk of not receiving the delayed reward (Sozou and Seymour 2003) in particular because of the uncertainty surrounding the continuity of an individual's life (Arrondel and Masson 2014). Differentiating the time delay from its associated uncertainty is a critical issue (Gafni and Torrance 1984). Assessing both individuals' time and risk preferences may answer in part this issue as it allows to capture at least both concepts.

Time and risk preferences were found to influence a variety of health-related behaviors (Anderson and Mellor 2008; Lawless et al. 2013). Nonetheless, expected relationships between measures of time and risk preferences and adoption of health-related behaviors were found in some but not all studies. For instance, some studies found drinker-drivers and smokers to discount long-term events more than short-term events (Sloan et al. 2014; Harrison et al. 2015)

while others found no significant difference of time discounting by smoking status (Khwaja et al. 2007). Regarding risk preferences, some studies found risk-averse individuals to be less likely to smoke, to have heavy episodic drinking and to be more overweight than others (Anderson and Mellor 2008) while others found risk-prone individuals to report more physical activity than others (Leonard et al. 2013) and other studies found no significant difference of risk preference by smoking status (Harrison et al. 2015).

Interestingly, among cross-sectional surveys, current smokers were found to have shorter financial planning horizon and to be more impulsive than people who never smoked (Khwaja et al. 2007). Consistently, drinker drivers were found to be less likely to engage in financial planning and more likely to be impulsive than non-drinker drivers (Sloan et al. 2014). These results suggest that individuals adopting risk-taking behaviors tend to be more present-oriented in their financial choices and more impulsive than those who do not adopt these risk-taking behaviors.

The extent to which individuals are oriented towards present-preference, impulsivity and risk-prone-preference may thus influence their adoption of health-related behaviors.

Research Question 2.2: Is there a relationship between individuals' adoption of health-related behaviors and their time preference, their impulsivity and their risk preference?

Conventional wisdom suggests that an individual's personal health history may impact his/her adoption of health-related behaviors. For instance, individuals with chronic disease(s) or disorder may adopt risk-reducing behaviors to have healthier lifestyles or to prevent the occurrence of a second chronic disease. However, this assumption was not always supported (Williams et al. 2013; Mowls et al. 2016). In addition, the extent to which individuals perceive their current health status as poor, good, or fair, may also have an impact on adoption of health-related behaviors. In particular, Pasanen et al. (2014) found a positive association between perceived general health status and physical activity indoor and outdoor. Personal health history appears important to take into account when analyzing adoption of health-related behaviors.

Finally, socio-demographic characteristics were found to influence adoption of health-related behaviors associated with environmental factors. Women tend to adopt more preventive health-related behaviors regarding sun exposure than men (Bränström et al. 2006; McCool et al. 2009). Results were more mitigated regarding age: sometimes youngers were found to adopt more preventive health-related behaviors than elders (Lundborg and Lindgren 2004) while

sometimes elders were found to adopt more preventive health-related behaviors than youngers (McCool et al. 2009; Dantzker et al. 2010). Being socioeconomically disadvantaged was also found associated with increasing odds of engaging in health-related risk-taking behaviors (Adams et al. 2013). Sociodemographic variables appear also important to take into account when analyzing adoption of health-related behaviors.

3 Determinants of individuals' perceptions of risks in general, of general cancers' risks and cancers' risks stemming from environmental factors

Heuristics

As stated before, faced with the task's complexity, individuals tend to rely on heuristics to assess probabilities of events' occurrence rather than objectively computing them (Tversky and Kahneman 1974). In particular, Kahneman and Tversky emphasized three heuristics: availability heuristic, i.e. tendency to judge the likelihood of an event by the ease with which its instances come to mind, representativeness heuristic, i.e. tendency to judge the likelihood of an event by the extent to which it resembles to the typical case, and adjustment and anchoring, i.e. tendency to judge the likelihood of an event from a perceived starting point (Tversky and Kahneman 1974). The affect heuristic was also found as an important determinant of individuals' risk perceptions with positive affect impacting negatively perceived risks and positively perceived benefits (Fischhoff et al. 1978; Finucane et al. 2000). Although they can be perceived as a way to save time and cognitive faculties, heuristics are often presented as origins of errors and biases in individuals' judgments (Tversky and Kahneman 1974).

Gigerenzer and Gaissmaier conducted a review on research testing formal models of heuristic inference. One of their findings is that individuals often rely on simple heuristics in an adaptive way and that ignoring part of the information can lead to more accurate judgments especially for low predictability and small samples (Gigerenzer and Gaissmaier 2011). They thus defined heuristics as strategies ignoring *"part of the information, with the goal of making decisions more quickly, frugally, and/or accurately than more complex methods"* (Gigerenzer and Gaissmaier 2011).

Peters and colleagues applied these concepts to cancer risk perception and used heuristics to explain how and why individuals misperceived their own risk of cancer (Peters et al. 2006). According to the authors and consistently with Gigerenzer and Gaissmaier, *"relying on affective impressions can be simpler and more efficient than using deliberative processes such*

as weighting pros and cons" especially because, based on these heuristics, individuals build strong embodied responses to risk estimations allowing them to save a lot of time. However, one drawback is that these constructions may become strong enough to lead to insensitivity towards objective data (Peters et al. 2006).

Heuristics thus appear as determinants of individuals' perceptions of their own cancers' risks in general, especially affect and availability heuristics. Therefore, affect and availability heuristics might be relevant determinants of individuals' perceptions of their cancers' risks stemming from environmental factors.

Affect heuristic refers in this context to the *"specific feeling of "goodness"* or *""badness" evoked by a stimulus"* used by individuals as a cue to determine their ow risk such as stronger feelings enhance personal risk estimation (Peters et al. 2006). Among empirical studies, cancers were found associated with negative words and feelings across several years and countries (Klein and Stefanek 2007; Beck et al. 2009; Han et al. 2009; Lemal and Van den Bulck 2009; Lipworth et al. 2010; Moser et al. 2014) as well as perceived as the most severe disease across a range of serious chronic diseases such as heart diseases, stroke, diabetes, etc. (Wang et al. 2009; Shiloh et al. 2013; Klein et al. 2014). It can be assumed from these findings that cancer might be a stimulus evoking a feeling of badness and that it may have an impact on whether individuals perceive themselves at risk to develop cancers in general and cancers stemming from environmental factors in particular.

Availability heuristic refers to the judgment of an event's likelihood based on the ease with which its instances come to mind (Tversky and Kahneman 1974). Thus, the more people with cancer experience an individual can recall, the more it enhances personal risk estimation (Peters et al. 2006). Cancer history among family, friends or colleagues, compared to none, has indeed been found associated with higher perceptions of cancers' risks (Montgomery et al. 2003; Robb et al. 2004; Katapodi et al. 2005; Haber et al. 2012; Walker et al. 2013; Kye et al. 2015; Peipins et al. 2015). Among the few studies conducted in the context of cancers' risks stemming from environmental factors, results were less straightforward. Some studies found cancer history among family, friends or acquaintances associated with higher perceptions of lung cancer's risk stemming from smoking (Chen and Kaphingst 2011; Lin and Sloan 2015) while others found no impact of cancer family history on risk perceptions to have skin cancer in context of sun exposure (Kiviniemi and Ellis 2014). Relationships between availability heuristic and risk perceptions in context of cancers' risks in general and stemming from environmental factors

still need to be clarified as the positive relationship between these variables seems to be not always supported.

Research Question 3.1: Do affect heuristic and availability heuristic determine individuals' perceptions of their cancers' risks in general and stemming from environmental factors in particular?

Knowledge

Individuals were found to use pre-existing knowledge and information to update their risk assessment (Smith and Johnson 1988; Katapodi et al. 2005; Lipworth et al. 2010) and to evaluate their own level of risk using information coming from others as an indicator (Fagerlin et al. 2007; Klein et al. 2014). High knowledge of cervical cancer was thus found associated with high risk perception of developing cervical cancer (Kelly et al. 2012). Increase in knowledge related to environmental factors was also found associated with higher awareness (Poortinga et al. 2008) and risk perception (Kim et al. 2015).

However, information spreading was also found associated with increasing worry and anxiety without necessarily accurate updating of risk perception (García et al. 2005; Klein and Stefanek 2007; Lemal and Van den Bulck 2009; Sessa et al. 2010; Matthew et al. 2011). Individuals' knowledge may also be impacted by the information disseminated by the media which can create a *"social amplification of risk"* phenomenon. According to Kasperson et al. (1988), public risk perception is shaped, amplify or attenuate, by information processes, institutional structures, social-group behaviors and individual responses.

Finally, some studies reported no association between individuals' level of knowledge and perceptions of cancers' risks (Absetz et al. 2000; Harrison et al. 2004) or environmental issues (Elias and Shiftan 2012).

Relationships between individuals' knowledge regarding environmental factors and risk perceptions appeared thus still unclear, in particular in the context of cancers' risks stemming from environmental factors where few studies have been conducted.

Research Question 3.2: Does knowledge determine individuals' perceptions of their cancers' risks in general and stemming from environmental factors in particular?

Beliefs

Individuals' endorsement of beliefs related to cancers or environmental factors has been found to influence individuals' risk perceptions. Depending on the beliefs, the relationship may be positive such as pro-environmental beliefs associated with greater risk perception related the environment (Carlton and Jacobson 2013), or negative such as feeling that chance or fate could influence prostate cancer occurrence associated with lower individual's prostate cancer risk perception (Matthew et al. 2011) or positive beliefs towards pesticides in food associated with less perceived risks (Saba and Messina 2003).

Beliefs were found to have especially a strong influence on risk perceptions in smoking context where current smokers hold beliefs minimizing smoking risks and helping them to maintain their smoking-behaviors (Johnson et al. 2002; Weinstein et al. 2005; Peretti-Watel et al. 2007; Peretti-Watel et al. 2014; Viscusi 2015).

However, their influence in other contexts has been sparsely studied. Bränström and colleagues, for instance, found individuals in their survey to endorse realistic beliefs about the contribution to skin cancer of sun exposure but did not cross this data with risk perception of developing skin cancer (Bränström et al. 2006).

Additional data on the relationship between individuals' endorsement of beliefs, related to cancers and cancers' causes, and perceptions of their cancers' risks stemming from environmental factors may thus add knowledge in this area.

Research Question 3.3: Does endorsement of beliefs related to cancers and cancers' causes determine individuals' perceptions of their cancers' risks in general and stemming from environmental factors in particular?

Worry and salience

Theoretical studies supported the role played by an affectively-based component of risk perception on individuals' decisions. For instance, Denes-Raj and Epstein found their respondents to prefer a jar containing a higher number of wining beans with a lower actual chance of winning than a jar containing a lower number of wining beans but with a higher actual chance of winning (Denes-Raj and Epstein 1994). Participants felt they had a better chance of winning by choosing the jar with more wining beans. They, thus, relied on intuition rather than cognition. Slovic and colleagues made also this distinction by disentangling *"risk as analysis"*

from *"risk as feeling"* (Slovic et al. 2004). According to these authors, *"risk as analysis"* is a construct based on cognitive processing of risk judgments through probabilities' evaluation and numeracy skills whereas *"risk as feeling"* is based on heuristics and individual's affective pool gathering all positive and negative somatic markers associated with images (Slovic et al. 2004). According to Loewenstein and O'Donogue, this interaction between a cognitive sophisticated deliberative system and a rapidly responding affective system may explain why individuals can simultaneously do one thing while wishing to do another one (Loewenstein and O'Donoghue 2004). Janssen and colleagues tested the relevance to distinguish cognitive and affective components in the measure of cancer risk perception and found positive correlations between affective likelihood and worry with cognitive measure of risk perception (Janssen et al. 2012).

The extent to which individuals may be worried about cancers' occurrence has been shown to be a specific, affectively-based, risk component distinct from other constructs such as absolute or comparative risk perception (Slovic et al. 2004). A range of empirical studies also supported a positive relationship between a high level of worry and high risk perceptions of cancers or health risks (Robb et al. 2004; Robb et al. 2007; Kelly et al. 2012; Shiloh et al. 2013; Denny-Bas et al. 2014; Kiviniemi and Ellis 2014; Peipins et al. 2015; Rice et al. 2015). Cancer-related worry might thus be a relevant determinant of cancers' risk perceptions.

Some studies conducted in the context of environmental factors also analyzed, along risk perceptions, the extent to which people felt concern about health/cancer risks stemming from environmental factors, i.e the extent to which this issue is salient to them, and found a positive association (Dantzker et al. 2010; Ho et al. 2014; Orita et al. 2015). For instance, high level of concern regarding pesticides was associated with high risk perceptions (Dantzker et al. 2010). These few studies showed consistent results that still have to be confirmed on other environmental factors.

Research Question 3.4: Do cancer-related worry and salience of cancers' risks stemming from environmental factors determine individuals' perceptions of their cancers' risks in general and stemming from environmental factors in particular?

Perceived voluntariness and perceived control of risks' exposure

Psychometric studies showed that risks' characteristics have an impact on individuals' risk perceptions (Starr 1969; Fischhoff et al. 1978; Slovic 1987; Siegrist et al. 2005).

Voluntariness of exposure to risks was found to be negatively correlated with risk perceptions such as individuals displayed lower (higher) risk perceptions for a risk perceived as voluntarily (involuntarily) vs. involuntarily (voluntarily) endorsed (Starr 1969; Fischhoff et al. 1978; Slovic 1987; Slovic 1999; Bickerstaff 2004; García et al. 2005; Siegrist et al. 2005; Denny-Bas et al. 2014).

In addition, the extent to which individuals' perceive cancers' occurrence or environmental factors' exposure as something they can control at their individual level was also found to influence their risk perceptions. A negative relationship was especially supported across empirical studies, meaning that individuals displayed lower (higher) risk perception for a risk perceived as controllable (uncontrollable) vs. uncontrollable (controllable) (Vaughan 1993; Brenot et al. 1998; Rowe et al. 2005; Bränström et al. 2006; Robb et al. 2007; Spector et al. 2009; Wang et al. 2009; Dantzker et al. 2010; Leiter 2011; Matthew et al. 2011; Denny-Bas et al. 2014).

Not taking into account environmental factors' characteristics such as perceived voluntariness and control of risks' exposure may neglect a facet of perceptions of cancers' risks in general and stemming from environmental factors in particular as an individual construction.

Research Question 3.5: Do perceived voluntariness and control of risks' exposure determine individuals' perceptions of their cancers' risks in general and stemming from environmental factors in particular?

Personal history of cancer was found positively associated with individuals' perceptions of their risk to develop cancers in general such as individuals with personal cancer history, compared to those without cancer history, displayed higher perceptions of cancers' risks (Lipworth et al. 2010). Few studies have analyzed this relationship in the context of cancers' risks stemming from environmental factors. One study found personal history of cancer to enhance perceptions of environmental health risks (Rice et al. 2015). More generally, individuals with personal history of chronic diseases may perceive their cancers' risks as high because of proven or supposed link with cancer's occurrence. For instance, sufficient evidence in humans supported causal relationship between Hepatitis B and C virus and liver and bile duct cancers, and between HIV type 1 and uterine cervix cancer and Kaposi sarcoma (IARC 2017 Jan 26). Second, individuals with personal experience of benign diseases or symptoms were found to perceive higher, than those without this personal experience, their own risk of

developing breast cancer (Park et al. 2009), colorectal cancer (Robb et al. 2004) and prostate cancer (Matthew et al. 2011). Moreover, the extent to which individuals perceive their current health status as poor, good, or fair, may also have an impact on perceptions of general cancers' risks and cancers' risks stemming from environmental factors. For example, perceiving oneself as overweight was found associated with greater perceived risk for diabetes and heart disease (Darlow et al. 2012).

As a consequence, taking into account personal health history appear important when analyzing individuals' perceptions of their cancers' risks in general and stemming from environmental factors in particular.

Taking into account sociodemographic characteristics appear important as well when analyzing individuals' perceptions of their cancers' risks in general and stemming from environmental factors in particular (for a review see Article #1 in Appendix 1 Section 1.2). Women were found to display higher perceptions of cancers' and environmental risks as well as cancers' risks stemming from environmental factors than men. Findings were more contrasted regarding age with studies supporting lower risk perception among youngers compared to elders, others supporting the contrary and others from which conclusions could not be drawn regarding the impact of age. Findings were also contrasted regarding the impact of education and income.

To summarize, this first chapter allowed us to state and analyze the entire context in which our objectives are settled and to construct our research questions related to these objectives.

But, because most of the outcomes driven from our literature reviews come from studies conducted in North America thus potentially displaying a cultural bias, and because few studies have been conducted on individuals' risk perceptions of cancers' risks stemming from environmental factors, we decided to conduct a qualitative study to test the understanding of our concepts and topics among a lay population as well as to refine our research questions (see Chapter 2).

1 Introduction

The literature reviews presented in Chapter 1 showed that few findings are available regarding individuals' perceptions of cancers' risks stemming from environmental factors and adoption of health-related behaviors. In addition, the majority of studies are oriented toward smoking and conducted in North America.

We thus decided to conduct a qualitative analysis (i) to explore our research topics in a French context allowing us to test their relevance and thus the relevance of our research objectives in our country, (ii) to validate the understanding of our main concepts and topics in the lay population, (iii) to refine our research questions, and (iv) to provide inputs for the questionnaire's construction administered in the national survey (Chapter 3 and 4).

A qualitative design allows participants to speak freely but following a topic guide. Thus, participants were asked to express their cancer risk perceptions and adoption of health-related behaviors. To the best of our knowledge, no qualitative study has yet investigated these issues. Thus, it may bring some valuable insights regarding specifically two of our research questions:

Research Question 1: Which environmental factors French individuals perceive as cancers' risk factors for themselves? Which environmental factors they do not perceive as cancers' risk factors for themselves?

Research Question 2.1.: Is there a relationship between individuals' adoption of health-related behaviors and their perceptions of their cancers' risks in general and stemming from environmental factors when both are alicited regarding the same factor and taking into account the endogeneity of risk perceptions?

This chapter is structured as follows: we first present the methods, results and discussion of the qualitative analysis[2]. We then discuss the contribution of our findings to our research questions.

2 Methods

2.1 Sampling and data collection

Participants were aged between 18 and 75 years-old, spoke and understood French and were living in the Rhône-Alpes Region. Previous studies showed that personal cancer history may alter individuals' perceptions of cancers' risks and adoption of health-related behaviors (Mowls et al. 2016). Thus, individuals with and without personal cancer history were recruited. Participants could have relatives, friends, or peers with cancer history. Written informed consent was obtained from participants before the interviews. Data gathered have been declared to the National Commission for Data Protection and Liberties.

Two group interviews were conducted respectively with 9 and 7 volunteers, without personal cancer history, identified through social networks and snowball sampling, in convenient and accessible locations downtown, during 150 minutes. Twenty-three individual interviews were conducted with 23 volunteers, with personal cancer history, identified by a GP practicing in a community health centre or the responsible of patient library located at the regional cancer centre, mainly at participants' homes, between 53 and 85 minutes. Two interviews were excluded because of bad recording quality. Volunteers with personal cancer history were interviewed in individual sessions because some of them were still receiving treatment or did not feel comfortable to discuss these issues in group sessions.

Data regarding sociodemographic characteristics are displayed in Table 2. Interviews, whether in group or individual session, were conducted with the same topic guide. Participants were asked (i) to define the concepts of risk, cancer and environment according to their own point of view; (ii) to point out all environmental factors they perceive as cancers' causes, (iii) to mention health-related behaviors adopted if they did so. Volunteers with personal cancer history were also asked to point out environmental factor(s) they perceive as their own cancer's cause. As group interviews are believed to reveal more ideas than individual interviews

[2] An article related to this qualitative study is under review in Health, Risk & Society: Genton MC, Carretier J, Gafni A, Médina P, Charles C and Moumjid N. "Exploring individuals' perceptions of risks and adoption of health-related behaviours in cancers induced by environmental factors".

(Coenen et al. 2012), discrepancy in hours of data collection between both methods do not mean discrepancies in amount of information gathered. Anonymized interviews were recorded and transcribed.

Table 2 Sociodemographic characteristics of the participants in the qualitative study

	16 individuals without personal cancer history (CFI)		21 individuals with personal cancer history (CP)	
	N	(%)	N	(%)
Gender				
Men	7	(44)	8	(38)
Women	9	(56)	13	(62)
Age, years old				
Median [min,max]	47	[22,70]	59	[25,74]
Cancer diagnoses				
Lymphoma	.		11	(52)
Breast cancer	.		5	(24)
Kidney cancer	.		2	(9)
Bowel / colorectal cancer	.		2	(9)
Prostate cancer	.		1	(5)
Treatments after 2011	.		13	(62)
Occupational status category				
Independent professions	2	(12)	1	(5)
Employees	7	(44)	7	(33)
Managers	4	(25)	9	(43)
Students, unemployed and retirees	3	(19)	4	(19)
Level of education				
Below high-school	1	(6)	3	(14)
High school diploma	1	(6)	3	(14)
1st degree level (eq. bachelor)	8	(50)	6	(29)
2nd degree level (eq. graduate)	6	(38)	8	(38)
3rd degree level (eq. doctor)	0	.	1	(5)
Marital situation				
Single	6	(38)	3	(14)
In couple	2	(12)	1	(5)
Married	7	(44)	13	(62)
Divorced	1	(6)	3	(14)
Widow	0	.	1	(5)
Location				
Urban area	13	(81)	9	(42)
Suburban area	1	(6)	6	(29)
Rural area	2	(13)	6	(29)

2.2 Data analysis

Transcripts were imported into NVivo software and coded following the topic guide and emerging themes. Data analysis of the corpus was progressive and iterative. A thematic content analysis was first conducted on each sample separately. General ideas raised on each topic by individuals with and without personal cancer history were combined to highlight similarities and differences. The COREQ checklist was used to control for consistent data reporting (Tong et al. 2007).

3 Results

3.1 Perceptions of risk, cancer and environment

The concept of risk was mainly associated with words such as “danger” and “loss” among both Cancer-Free Individuals (CFI) and Cancer Patients (CP) highlighting the negative side of taking risk. The positive side of taking risks related to excitement and benefits was also pointed out but in a lesser extent and especially among CFI. In both samples, many participants underlined risk as inseparable from life. A majority of CP highlighted that exposure to risk factors could be involuntary, a fact only mentioned by few CFI. Several participants in both samples, whether they were parents or not, saw the fact of having children as a determinant of negative risk perception and as having deterrent effect on personal risk-taking behaviors. The following quotes illustrate these points.

> “For me, a risk is something negative.” CP, lymphoma, woman aged 42.
>
> “Living is risky.” CFI, woman aged 70
>
> “There are risks on which we cannot act … that one undergoes.” CP, breast cancer, woman aged 59
>
> “You take risks more lightly when you are young and don’t have a family.” CFI, woman aged 52

Around half CFI and majority of CP made associations between the word “cancer” and words such as “death”, “suffering” and “serious disease”. Among both samples, but especially among CP, associations between the word “cancer” and word such as “cure”, “recovery” and “survival” were also made. The word “cancer” was perceived among both samples as a global term covering too many diseases to be meaningful.

> “To call it « cancer » doesn’t mean anything, I think, because there are so many of them.” CP, lymphoma, woman aged 53

Around two third of CFI defined “the environment” in a broad and neutral way. One third of CP defined “the environment” as their living environment including their occupation and family. Among both CP and CFI, participants made associations between the word “environment” and words such as “nature”, “fresh air” but also “air pollution” and “nuisances”.

3.2 Perceptions of cancers’ risks stemming from environmental factors

Participants’ perceptions of cancers’ risks stemming from environmental factors are displayed in Table 3. Overall, CP and CFI perceived the same environmental factors as potential cancers’ causes, especially pesticides and smoking. Genetics were also cited among both samples whereas it was not included in the broad definition of the environment. Nonetheless, while CFI emphasized the role of radiofrequencies (mobile phones and Wi-Fi) and sun exposure on cancers’ occurrence, CP emphasised the role of unbalanced diet, stress or negative emotions, pollution, nuclear pollution or radioactivity, chemical products, air pollution and occupational exposures. In addition, CP mentioned factors not mentioned by CFI: ageing, asbestos and X-rays associated with imagery. Interestingly, some participants questioned pesticides and radiofrequencies as cancers’ causes as illustrated by the following quotes.

> “Electromagnetic waves are the demonized think of the moment because we are told that it can be used to treat but at the same time that it is dangerous.” CFI, woman aged 26

> “Everything depends on how pesticides are used… I do not perceive an absolute link between pesticides and cancer.” CFI, man aged 50

Table 3 Perceptions of cancers' risks stemming from environmental factors among the participants of the qualitative study

		Ageing	Air pollution	Alcohol consumption	Asbestos	Chemical products	Cosmestic products	Drugs / Pill	Genetics	Home care products	X-rays (imagery)	Lifestyle
CP1*	F,25**			X	X	X		X	X		X	
CP2	F,65		X									
CP3	H,57				X				X	X	X	
CP4	H,50		X			X						
CP5	F,37						X	X				
CP6	H,74			X		X			X			
CP7	F,57		X	X				X	X			
CP8	H,68					X						
CP9	F,68	X			X	X	X	X		X	X	
CP10	H,59	X	X	X	X	X			X		X	
CP11	F,61		X		X		X			X		X
CP12	F,61		X			X			X			
CP13	F,47			X		X	X					X
CP14	H,64		X		X							X
CP15	F,64		X				X			X		
CP16	H,61	X	X			X						
CP17	H,55											X
CP18	F,42				X				X			X
CP19	F,53				X		X		X		X	
CP20	F,59		X		X	X						X
CP21	F,30		X	X	X	X			X			X
CFI1	H,28			X				X	X			
CFI2	F,24			X				X	X			
CFI3	H,47					X						
CFI4	H,50											X
CFI5	F,64			X		X				X		
CFI6	F,70		X									
CFI7	H,30		X									
CFI8	H,46											X
CFI9	F,48											
CFI10	F,26									X		
CFI11	F,52											
CFI12	F,22					X						X
CFI13	F,42		X			X	X					
CFI14	H,51					X						
CFI15	F,52			X			X					
CFI16	H,31											
∑		3	14	10	10	16	8	6	11	6	5	10

		Nuclear pollution / Radioactivity	Occupational exposures	Paints	Peticides	Pollution	Radiofre-quencies	Smoking	Sun exposure	Stress / Negative emotions	Unbalenced diet	∑
CP1	F,25	X	X		X	X	X	X	X	X	X	15
CP2	F,65			X	X	X		X			X	6
CP3	H,57	X			X	X		X			X	9
CP4	H,50	X			N***	X		X	X	X	X	8
CP5	F,37	X			R***		X	X	X	X	X	8
CP6	H,74	X			X			X	X	X	X	9
CP7	F,57	X			X	X		X		X	X	10
CP8	H,68		X	X	X	X					X	6
CP9	F,68	X	X			X	X	X		X	X	14
CP10	H,59	X	X		X		X	X		X	X	14
CP11	F,61		X			X					X	8
CP12	F,61	X	X		X	X	X	X		X	X	11
CP13	F,47			X	X			X		X	X	9
CP14	H,64		X		X					X		6
CP15	F,64				X		X			X	X	7
CP16	H,61				X	X						5
CP17	H,55							X		X	X	4
CP18	F,42	X			X	X	X				X	8
CP19	F,53	X	X		X	X				X	X	10
CP20	F,59		X		X		X	X		X	X	10
CP21	F,30	X			X			X		X	X	11
CFI1	H,28		X		X	X		X				7
CFI2	F,24				X	X	X	X	X			8
CFI3	H,47				X	X		X	X		X	6
CFI4	H,50				R			X	X	X		4
CFI5	F,64			X	X			X				6
CFI6	F,70				R			X	X			3
CFI7	H,30					X		X				3
CFI8	H,46	X					X					3
CFI9	F,48	X						X				2
CFI10	F,26				R		N	X	X			3
CFI11	F,52	X			X		X	X	X		X	6
CFI12	F,22				X		X	X	X			6
CFI13	F,42				X		X	X	X	X		8
CFI14	H,51	X		X			X	X	X	X		7
CFI15	F,52				X			X	X		X	6
CFI16	H,31				X		X	X				3
∑		16	10	5	25	16	15	29	14	18	22	7,3

* Cancer Patients / Cancer-Free Individuals

** Gender, sexe *** N: do not perceive associated cancers' risks / R: no cancers' risks associated with reasonable

3.3 Perceived cancers' cause(s) among cancer patients

More than half CP perceived a potential link between their cancer and the environment, but most of them did not identify a specific factor. CP also mentioned strong negative emotions or shocks as causes of their cancer, especially stress, but often in association with other factors such as genetics. Around one-fifth of CP identified occupational exposures, especially chemical products, as the leading cause of their cancer. Among CP who did not perceive links between their cancer and environmental factors, "I don't know" was the main answer, followed by genetics. Around a quarter of CP pointed out at least two causes for their cancer. These points are illustrated by the following quotes.

> "I looked for answers … today I'm convinced that it's the environmental conditions of my life that explain why I got cancer." CP, lymphoma, man aged 68

> "I think that stress at work had a lot to do with me getting cancer." CP, breast cancer, woman aged 37

> "I was working in a paint laboratory. I worked for twenty years in a toxic environment. It [the cancer] was linked to my occupational activity." CP, lymphoma, woman aged 47

> "I think there is a genetic reason. I don't think it is linked to my environment." CP, bowel cancer, man aged 57

3.4 Adoption of health-related behaviors

Most CP emphasized their perceived importance of adopting health-related behaviors against cancer, a point of view shared by few CFI, but at the same time of enjoying life to the fullest. Half CP declared to have change or increase their adoption of healthier behaviors after their cancer experience. However, most of them underlined that they were mainly motivated by taking better care of their health in general. The desire to prevent a second cancer only came as a second motivation. Only few CFI linked their health-related behaviors with cancer prevention.

> "As far as possible you put more chances on your side to avoid getting cancer … I try to promote a healthy environment, as much as possible, at all levels." CP, lymphoma, women aged 61

A balanced diet and regular physical activity were declared adopted by all CP and very few CFI. Around half CP and one CFI declared to pay close attention to purchase and use of cosmetic and home care products. Around half CP and one CFI declared to have stopped smoking. A quarter of CP reported to have never smoked, a status not reported among CFI. Very few participants declared themselves as current smokers. Moreover, a third of CP reported they had adopted preventive measures regarding their exposure to radiofrequencies, especially through their use of mobile phones and Wi-Fi. No CFI mentioned this precaution. Around one

third of CP said they had suggested their adopted preventive health-related behaviors to their families in order to protect them or to inform them about how they can protect themselves against cancer. No CFI mentioned this.

The following quotes illustrated the adoption of preventive health-related behaviors among CP.

> "We try to have a balanced diet and I do sport every week." CP, lymphoma, man aged 55

> "We are careful about the use of products [against vermin]." CP, kidney cancer, man aged 50

> "I was worried at one time because I smoked a lot. So I stopped smoking nine years ago." CP, lymphoma, woman aged 65

> "I switch off the waves of my phone at night. I put it in airplane mode." CP, kidney cancer, woman aged 25

> "You explain to them a bit of what you know… But now, they are old enough … I tried to make them aware." CP, lymphoma, man aged 59

It is noteworthy that limitations to these preventive health-related behaviors were pointed out in both samples. It was particularly supported by a quarter of CFI and one third of CP that adopting preventive health-related behaviors is not an absolute protection against cancer as illustrated by the following quote.

> "You can adopt the best behaviour and still end up getting cancer." CFI, man aged 46

4 Discussion

In this qualitative study, we explored individuals' perceptions of cancers' risks stemming from environmental factors and investigated associated adoption of health-related behaviors among CP and CFI. First, these perceptions appeared related to personal cancer history. CP and CFI displayed similarities and differences in their perceptions of risk, cancer, and environment. Both samples perceived the same environmental factors as potential cancers' causes with additional environmental factors mentioned only by CP. Furthermore, the emphasis of cancers' causes within both samples was different. Smoking and pesticides were emphasized as cancers' causes among the entire sample but, among CFI only, the emphasis was on radiofrequencies and sun exposure whereas, among CP only, it was on diet and stress or negative emotions. In addition, all CP reported at least one change towards healthier behaviors, something only sparsely mentioned by CFI. These decisions were mentioned to be firstly motivated by taking care of health and secondly by cancer prevention. These results lead us to discuss several points.

4.1 General concepts of risk, cancer, and environment

Among both samples, the concept of risk was perceived as something negative but also neutral inscribed in the notion of life. This duality in risk perceptions was also found by Lupton and Tulloch (Lupton and Tulloch 2002). Nonetheless, CFI in our study also perceived the concept of risk as something positive associated with excitement. This was not as much the case among CP. We thus assume that cancer experience may have changed CP's reference point for decisions involving risk (Kahneman and Tversky 1979), leading them to perceive risk more negatively than CFI (Lacey et al. 2006).

Associations between "cancer" and terms related to death and suffering were made among both samples as well as associations, especially among CP, with "hope" and "recovery". CP we interviewed were in treatments or in remission explaining maybe why they did not necessarily perceive cancers as life-threatening diseases.

Both samples displayed rather the same definition of 'the environment' consistent with broad ones (McGuinn et al. 2012): a neutral concept including all non-genetic factors.

4.2 Perceptions of cancers' risks stemming from environmental factors

CP mentioned more environmental factors perceived as cancer causes than did CFI. Because the question "why did I get it?" occurs when cancer strikes, CP may start to think about, ask questions and search for information on potential causes of their cancer (Mayer et al. 2007). During this search, CP may find information about environmental factors and their links (proven or not) with cancer, leading them to construct different beliefs than CFI.

Smoking and unbalanced diet, mentioned by almost all participants, have proven links with cancers' occurrence (IARC 2017 Jan 26). This accurate knowledge about cancer risk factors may be related to our participants' level of education: more than half had a college degree. This finding could also result from public health campaigns promoting adoption of preventive health-related behaviors (Lemon et al. 2004) such as the most cited factors might be the most publicized (Kasperson et al. 1988).

Our results also showed different emphasis of environmental factors perceived as cancer causes among CP and CFI. For instance, air pollution, occupational exposure and negative emotions were perceived as cancers' causes by most CP but only few CFI. Thomson et al. (2014) also found different emphasis of breast cancer perceived causes by women with and without breast cancer history.

Pesticides and radiofrequencies were perceived as cancers' causes by a significant number of participants but some of them also questioned this position. These factors have common features that may explain differences in individuals' perceptions. First, scientific evidence regarding the carcinogenicity of radiofrequencies and some pesticides is still limited (IARC 2017 Jan 26). Furthermore, exposure to radiofrequencies or pesticides is perceived less controllable and voluntary at individual level than other factors like smoking (Slovic 1987). More generally, individuals display lower perceptions for a risk perceived as controllable or voluntary endorsed than one perceived uncontrollable or involuntary endorsed (Starr 1969; Fischhoff et al. 1978; Bickerstaff 2004; Siegrist et al. 2005).

4.3 Perceived cancers' causes among cancer patients

Majority of CP declared they did not know their cancer's cause. According to Dumalaon-Canaria et al. (2014), CP may lack awareness about cancer's causes or may know about them but feel confused or may not want to think about it.

"Don't know" responses aside, CP identified stress or negative emotions, occupational exposures and genetics as their cancer's cause. Dumalaon-Canaria et al. (2014) found similar causal attributions among breast cancer survivors but ranked differently: genetics, environmental factors, stress and fate. The type of cancer may play a role: more than half of our CP had lymphoma and pointed out environmental factors while breast cancer survivors mainly attributed their cancer to genetics and family history. Other studies found stress or negative emotions (Thomson et al. 2014) and occupational exposure (Wold et al. 2005) perceived by CP as their cancer's cause. It is noteworthy that no CP perceived smoking as their cancers' cause. A significant number of CP reported to have stopped or never started smoking, they may thus not consider smoking as a salient cancer's cause (Chen and Kaphingst 2011).

4.4 Adoption of health-related behaviors

All CP reported at least one change towards healthier behaviors whereas it was the case among few CFI. Most CP and one CFI reported the wish to take better care of their health as their main motivation to adopt health-related behaviors. The desire of primary or tertiary cancer prevention came later. Interestingly, cancer occurrence appeared as a trigger for changes in adoption of health-related behaviors among CP: more than half of them declared to have change after their cancer experience.

These decisions appeared also to be influenced by participants' beliefs about cancers' causes (Lemon et al. 2004; Ford and Kaphingst 2009): unbalanced diet was the most cited factor among CP and all of them declared to have adopted balanced diet. Rabin and Pinto also found a significant positive association between beliefs and changes in associated behaviors among breast cancer patients (Rabin and Pinto 2006). Nonetheless, adoption of healthier behaviors by CP is not always supported (Mowls et al. 2016).

Finally, some CP declared to have extended their preventive health-related behaviors to their relatives. CP may indeed be worried that their first-degree relatives would be at higher cancer risk because of their cancer history (Eisinger et al. 2011). Consistently, having children seems to increase risk perceptions (Lupton and Tulloch 2002) and decrease risk-taking behaviors (Dohmen et al. 2011).

The identification of relationship between individuals' perceptions of cancers' risks stemming from environmental factors and adoption of health-related behaviors appears challenging. Brewer and colleagues indeed proposed several assumptions consistent with our findings: behavior motivation assumption, i.e. people with higher vs. lower risk perceptions adopt preventive behaviors, and accuracy assumption i.e. people who have adopted vs. not adopted preventive behaviors correctly perceive their cancer risk lower (Brewer et al. 2004). Our data do not allow us to conclude on the most relevant assumption. However, it is noteworthy that CP tended to perceive environmental factors as cancers' causes and to adopt preventive health-related behaviors regarding these risks more than CFI.

Our qualitative design and number of CP with lymphoma history limit our results' generalizability. However, qualitative studies are not meant to be representative and our population was diversified. In addition, CP with lymphoma had high interest for this topic suggesting future researches based on cancer locations. Finally, individuals' perceptions of cancers' risks may vary according to sociodemographic characteristics (Waters et al. 2011) and psychometric features (Fischhoff et al. 1978; Slovic 1987) such as perceived control and voluntariness of exposure. These links are analyzed in the third step of our work through a national representative survey.

5 Conclusion

Our study showed a different emphasis of environmental factors perceived as potential cancers' causes depending on the sample considered. Thus, smoking and pesticides were perceived the most as cancers' causes among the entire sample while cancer-free individuals

emphasized the role of radiofrequencies and sun exposure in inducing cancers and cancer patients emphasized the importance of diet and stress or negative emotions. We assumed similarities and differences in individuals' risk perceptions to be due to knowledge as well as perceived control and voluntariness of exposure to environmental factors. In addition, all cancer patients reported at least one change towards healthier behaviors while few cancer-free individuals reported these behaviors. Health-related behaviors declared adopted were related to diet, physical activity, smoking as well as cosmetic and home-care products and radiofrequencies. Finally, personal cancer history may influence individuals' perceptions of cancers' risks stemming from environmental factors as well as adoption of health-related behaviors.

6 Contributions of this qualitative study to our research project

As a reminder, this exploratory qualitative study was conducted (i) to ensure the relevance of our objectives within the French context, (ii) to validate the understanding of our main concepts and topics in the lay population (iii) to bring valuable insights regarding our research questions 1 and 2.1. and to refine them and (iv) to provide inputs for the questionnaire's construction which will be administered in the national survey.

Our findings showed that cancers' risks stemming from environmental factors are a subject of public interest as lots of environmental factors were cited as potential cancers' causes by the participants. Thus, our interest in perceptions of cancers' risks stemming from environmental factors appears relevant in the French context.

Our participants expressed their own subjectivity and seemed to have understood the questions similarly because answers were consistent with each other. We can thus expect that our main concepts will be well understood by a large sample of lay individuals.

Then, the following environmental factors were perceived as potential cancers' causes by our participants: air pollution, alcohol consumption, asbestos, chemical products, cosmetic products, drugs, hormonal contraceptives (pill), home care products, imagery (X-rays), lifestyle, nuclear pollution, occupational exposure, paints, pesticides, pollution, radiofrequencies (mobile phones and Wi-Fi), smoking, sun exposure, stress or negative emotions and unbalanced diet. Our participants also emphasized the role of genetics. While genetics is not included in our definition of the environment, it was found in previous research to be one of the most widely perceived cancer risk factor (Absetz et al. 2000; Silk et al. 2006; Robb et al. 2007; Spector et al. 2009; Jones et al. 2011). On the contrary, indoor radon exposure

is an environmental factor carcinogenic to humans (IARC 2017 Jan 26) but it was not perceived as such by our participants. Thus, we decided to elicit in our quantitative survey individuals' perceptions of cancers' risks in general as well as cancers' risks stemming from genetics and from the environmental factors mentioned in this paragraph. Moreover, we found an emphasis on smoking, pesticides, radiofrequencies, sun exposure, diet and stress or negative emotions as potential cancers' causes giving thus some first insights on the environmental factors that French individuals might perceive themselves at cancers' risks from (*Research Question 1*).

Participants declared to have adopted a balanced diet and a regular physical activity, to be careful in their purchase and use of cosmetic and home care products, to have stopped smoking or to have never smoked and to be careful about exposure to radiofrequencies, especially through their use of mobile phones and Wi-Fi. These findings do not directly bring insight on the relationship between individuals' adoption of health-related behaviors and their perceptions of their cancers' risks in general and stemming from environmental factors taking into account the endogeneity of risk perceptions (*Research Question 2.1*). However, it shows the importance of context as individuals declared to have adopted specific health-related behaviors associated to specific environmental factors. This is consistent with our objective to investigate the relationships between individuals' adoption of health-related behaviors and perceptions of their cancers' riskss when both are elicited in the same context (cancers in general or stemming from genetics as well as from environmental factors). Thus, we decided to elicit adoption of health-related behaviors related to cancers' risks in general and to cancers' risks stemming from genetics as well as from the set of environmental factors mentioned above.

Participants' answers also enlighten the importance of beliefs' endorsement related to cancers' prevention as well as motivations and perceived barriers at the individual level to adopt preventive health-related behaviors. These elements are of first importance, especially in the Health Belief Model, in which individuals' intrinsic motivations, perceived barriers, and perceived efficacy of taking action were suggested to motivate or restrain individuals from adopting health-related behaviors at their individual level (Rosenstock et al. 1988). Other studies highlighted the importance of individuals' perceived barriers to adoption of health-related behaviors (Weinstein and Nicolich 1993; Hambach et al. 2011). We may thus integrate in our analysis, as determinants of individuals' adoption of health-related behaviors, whether individuals have the motivation to prevent cancer, whether they perceived barriers at their level to adopt health-related behaviors, their perceived efficacy of these behaviors and their perceived importance of cancer prevention. The construction of these variables was based on verbatim expressed in group or individual interviews.

All participants with personal cancer history reported at least one change towards healthier behaviors while very few participants without personal cancer history reported these kinds of behaviors. Personal cancer history might thus also influence adoption of health-related behaviors in addition of individuals' perceptions of cancers' risks stemming from environmental factors. This is consistent with our findings in Chapter 1 that personal health history might influence individuals' adoption of health-related behaviors and perceptions of cancers' risks in general and stemming from environmental factors.

Participants' verbatim were also used to construct variables related to affect heuristic. Our aim is to propose and test an intuitive approach to capture the affect heuristic associated with cancers by using words associated with cancers in group and individual interviews.

Despite its limitations, our qualitative study brought several valuable insights supported by the literature but others appeared to be original ones. In addition, it allows us to improve the potential understandability and accessibility of our questionnaire within a representative sample of French population.

Finally, it allowed us to expend our framework with *Research Question 2.3: Is there a relationship between individuals' adoption of health-related behaviors and their endorsement of prevention-related beliefs?*

All these contributions as well as findings from our literature reviews allowed us to make assumptions on the relationships between our variables. These assumptions are presented in the next methodological section.

ASSUMPTIONS ON RELATIONSHIPS BETWEEN VARIABLES

Based on the findings from the literature reviews and the qualitative analysis, we made the following assumptions on the relationships between our variables (summarized in Figure 1).

Individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors and adoption of health-related behaviors

Individuals' risk perceptions and adoption of health-related behaviors influence each other in an iterative process. This complexity raised an important methodological issue regarding the analysis of relationships between risk perceptions and adoption of behaviors which cannot solely rely on correlations (Weinstein and Nicolich 1993). Brewer et al. (2004) suggested three hypotheses to define these relationships. (1) High risk perception to face a negative health outcome motivates adoption of risk-reducing behaviors while low risk perceptions do not motivate adoption of risk-reducing behaviors; (2) High risk perception is observed among individuals who do not adopt risk-reducing behaviors while low risk perception is observed among individuals adopting risk-reducing behaviors; (3) Adoption of risk-reducing behaviors is associated with low risk perception while non-adoption of risk-reducing behaviors is associated with high risk perception. The second assumption suggests that individuals construct, at a given time, their risk perception to face a negative health outcome based on their lifestyle. Thus, rather than analyzing the dynamic relationship between risk perceptions and adoption of health-related behaviors, we focus on the association at a given time between individuals' adoption of health-related behaviors and their perceptions of their cancers' risks based on their lifestyle.

We assume that individuals displaying high risk perceptions to develop cancers in general and stemming from genetics as well as from environmental factors, based on their lifestyle, are less likely to declare adoption of health-related behaviors related to the same factor than those displaying low risk perceptions.

Time preferences, impulsivity, risk preferences and adoption of health-related behaviors

The economic theory predicts that present-oriented individuals would be less likely to adopt risk-reducing health-related behaviors than future-oriented individuals but empirical studies have found mixed results. For instance, Chapman (2005) found in her literature review significant differences in adoption of addictive behaviors like smoking according to time preference but did not found significant differences in adoption of preventive health related behaviors like vaccination. On the contrary, Khwaja et al. (2007) found no significant difference of time discounting by smoking status.

Mixed results were also found regarding relationships between risk preference and adoption of health related behaviors. Some studies found risk-averse individuals to adopt less risk-taking behaviors (Anderson and Mellor 2008) while other studies found risk-prone individuals to adopt risk-reducing behaviors such as physical activity (Leonard et al. 2013; Conell-Price and Jamison 2015) and other studies found no significant difference of risk preference by smoking status (Harrison et al. 2015).

Interestingly, among cross-sectional surveys, alternative measures of intertemporal choices used to assess time preferences were found to be associated with adoption of health-related behaviors (Picone et al. 2004; Khwaja et al. 2007; Becker et al. 2012). Consistently, drinker drivers were found to be less likely to engage in financial planning and more likely to be impulsive than non-drinker drivers (Sloan et al. 2014).

We assume that individuals displaying present-oriented preferences, being impulsive and displaying risk-prone-oriented preferences are less likely to adopt health-related behaviors than those displaying future-oriented preferences, being thoughtful and displaying risk-aversion-oriented preferences.

Prevention-related beliefs and adoption of health-related behaviors

As mentioned in the previous chapter, intrinsic motivations, perceived barriers, and perceived efficacy of taking action at the individual level may also motivate or restrain individuals from adopting preventive health-related behaviors (Rosenstock et al. 1988; Weinstein and Nicolich 1993).

We assume that individuals' adoption of health-related behaviors is positively associated to the motivation to prevent cancer, the perceived importance of cancer prevention and the perceived efficacy of risk-reducing behaviors, while it is negatively associated with perceiving barriers to adopt health-related behaviors.

Empirical data showed the importance to control for personal health history (personal history of cancer, personal history of chronic disease(s) or disorder, perceived current health status) and sociodemographic variables (age, gender, education, income) when analyzing relationships with adoption of health-related behaviors.

Affect and availability heuristic and individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

Cancers were found associated with negative words and feelings across several years and countries (Klein and Stefanek 2007; Beck et al. 2009; Han et al. 2009; Lemal and Van den Bulck 2009; Lipworth et al. 2010; Moser et al. 2014) as well as perceived as the most severe diseases across a range of serious chronic diseases such as heart diseases, stroke, diabetes, etc. (Wang et al. 2009; Shiloh et al. 2013; Klein et al. 2014). Cancers might thus be a stimulus evoking a feeling of badness for individuals.

We assume that affect heuristic is a determinant of high risk perceptions. Thus, an increasing negative affect is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

According to the availability heuristic, the more people with cancer experience an individual can recall, the more it enhances personal risk estimation (Peters et al. 2006). Cancer history among family, friends or colleagues, compared to none, has been found associated with higher perceptions of cancers' risks (Montgomery et al. 2003; Robb et al. 2004; Katapodi et al. 2005; Haber et al. 2012; Walker et al. 2013; Kye et al. 2015; Peipins et al. 2015).

We assume that availability heuristic is a determinant of high risk perceptions. Thus, strong indirect experience with cancers is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

Knowledge and individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

High knowledge of cervical cancer was found associated with high risk perception of developing cervical cancer (Kelly et al. 2012). Increase in knowledge related to environmental factors was also found associated with higher awareness (Poortinga et al. 2008) and risk perception (Kim et al. 2015). Some studies reported no association between individuals' level

of knowledge and perceptions of cancers' risks (Absetz et al. 2000; Harrison et al. 2004) or environmental issues (Elias and Shiftan 2012).

We assume that knowledge is a determinant of perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors but we do not assume the sense of this relationship because of a lack of empirical evidence.

Beliefs' endorsement related to cancers' and cancers' causes and individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

Individuals' endorsement of beliefs related to cancers or environmental factors was found to influence individuals' risk perceptions but, depending on the beliefs, relationships may be positive or negative. Pro-environmental beliefs were found associated with greater risk perception related the environment (Carlton and Jacobson 2013), while feeling that chance or fate could influence prostate cancer occurrence was found associated with lower individual's prostate cancer risk perception (Matthew et al. 2011) or positive beliefs towards pesticides in food were found associated with less perceived risks (Saba and Messina 2003).

We assume that endorsement of beliefs related to cancers and cancers' causes is a determinant of perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors but we do not assume the sense of this relationship because of a lack of empirical evidence.

Worry, salience and individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

A range of empirical studies supported a positive relationship between a high level of worry and high risk perceptions of cancers or health risks (Robb et al. 2004; Robb et al. 2007; Kelly et al. 2012; Shiloh et al. 2013; Denny-Bas et al. 2014; Kiviniemi and Ellis 2014; Peipins et al. 2015; Rice et al. 2015).

We assume that worry is a determinant of high risk perceptions. Thus, being worried about having a cancer one day in remaining lifetime is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

The extent to which people felt concern about health/cancer risks stemming from environmental factors, i.e. the extent to which this issue is salient to them, was found positively associated with risk perceptions (Dantzker et al. 2010; Ho et al. 2014; Orita et al. 2015).

We assume that salience is a determinant of high risk perceptions. Thus, the extent to which people feel concerned about the issue of cancers' risks stemming from environmental factors is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

Perceived voluntariness and perceived control of risks' exposure and individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

Perceived voluntariness of risks' exposure was found negatively associated with risk perception such as individuals displayed lower (higher) risk perceptions for a risk perceived as voluntarily (involuntarily) vs. involuntarily (voluntarily) endorsed (Starr 1969; Fischhoff et al. 1978; Slovic 1987; Slovic 1999; Bickerstaff 2004; García et al. 2005; Siegrist et al. 2005; Denny-Bas et al. 2014).

We assume that perceived voluntariness of risks' exposure is a determinant of low risk perceptions. Thus, perceiving risks' exposure as avoidable is associated with low rather than high perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

Perceived control of exposure to risks was found negatively associated with risk perception such as individuals displayed lower (higher) risk perception for a risk perceived as controllable (uncontrollable) vs. uncontrollable (controllable) (Vaughan 1993; Brenot et al. 1998; Rowe et al. 2005; Bränström et al. 2006; Robb et al. 2007; Spector et al. 2009; Wang et al. 2009; Dantzker et al. 2010; Leiter 2011; Matthew et al. 2011; Denny-Bas et al. 2014).

We assume that perceived control of risks' exposure is a determinant of low risk perceptions. Thus, perceiving risks' exposure as controllable is associated with low rather than high perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

Empirical data showed the importance to control for personal health history (personal history of cancer, personal history of chronic disease(s) or disorder, perceived current health status)

and sociodemographic variables (age, gender, education, income) when analyzing relationships with individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

All these assumptions on relationships between variables are summarized in the following Figure 1.

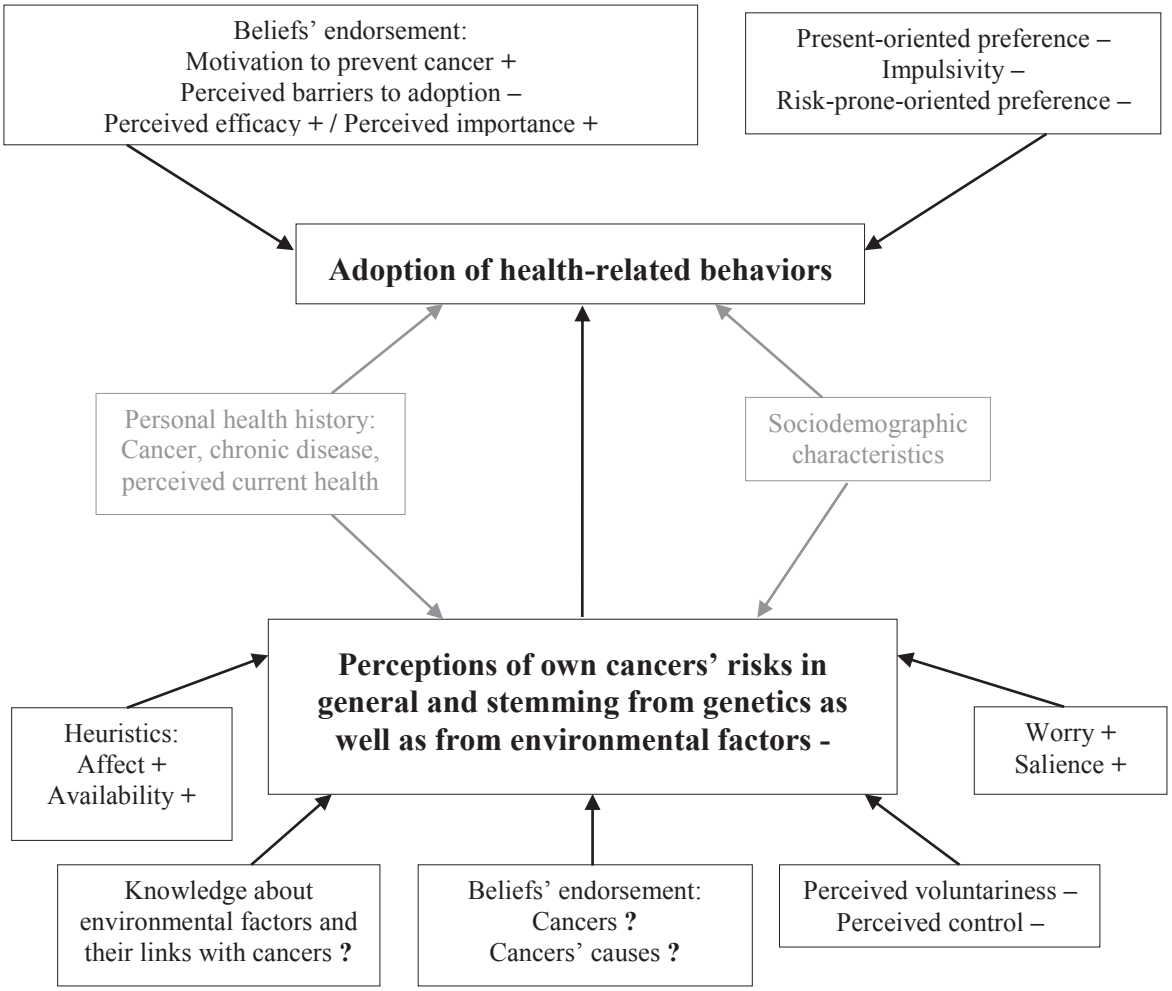

Figure 1 Assumptions on relationships between variables

The next and final part of our work consisted in testing these hypotheses. We thus conducted an online cross-sectional survey on a representative sample of the French population. The next two chapters present the analyses conducted on the collected data.

In Chapter 3, we analyzed individuals' perceptions of their own cancers' risks in general and stemming from genetics as well as from environmental factors. We also investigated the relationships between individuals' adoption of health-related behaviors and their perceptions of their cancers' risks in general as well as stemming from genetics and environmental factors, time preference, impulsivity, risk preference and endorsement of prevention-related beliefs taking into account the endogeneity of risk perceptions as well as personal health history and sociodemographic characteristics

In Chapter 4, we analyzed whether the determinants we indentified namely affect heuristic, availability heuristic, knowledge, beliefs' endorsement related to cancers and cancers' causes, cancer-related worry, salience, perceived voluntariness and perceived control of risks' exposure determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors taking into account personal health history and sociodemographic characteristics.

CHAPTER 3 CONFIRMATORY QUANTITATIVE STUDY: Adoption of health-related behaviors

1 Introduction

In this third chapter, we describe individuals' perceptions of their own cancers' risks in general and stemming from genetics as well as from environmental factors. Then, we investigate the relationships between individuals' adoption of health-related behaviors and their perceptions of their own cancers' risks in general and stemming from genetics as well as environmental factors, their time preference, their impulsivity, their risk preference and their endorsement of prevention-related beliefs taking into account the endogeneity of risk perceptions as well as personal health history and sociodemographic characteristics.

More precisely, the objective of this chapter is to answer the following research questions and to test the associated assumptions:

Research Question 1: Which environmental factors French individuals perceive as cancers' risk factors for themselves? Which environmental factors they do not perceive as cancers' risk factors for themselves?

Research Question 2.1: Is there a relationship between individuals' adoption of health-related behaviors and their perceptions of their cancers' risks in general and stemming from environmental factors when both are elicited regarding the same factor and taking into account the endogeneity of risk perceptions?

Assumption: Individuals displaying high risk perceptions to develop cancers in general and stemming from genetics as well as from environmental factors, based on their lifestyle, are less likely to declare adoption of health-related behaviors related to the same factor than those displaying low risk perceptions.

Research Question 2.2: Is there a relationship between individuals' adoption of health-related behaviors and their time preference, their impulsivity and their risk preference?

Assumption: Individuals displaying present-oriented preference, being impulsive and displaying risk-prone-oriented preference are less likely to adopt health-related behaviors than

those displaying future-oriented preference, being thoughtful and displaying risk-aversion-oriented preference.

Research Question 2.3: Is there a relationship between individuals' adoption of health-related behaviors and their endorsement of prevention-related beliefs?

Assumption: Individuals' adoption of health-related behaviors is positively associated to their motivation to prevent cancer, their perceived importance of cancer prevention and their perceived efficacy of risk-reducing behaviors while it is negatively associated with perceiving barriers to adopt health-related behaviors.

This chapter is structured as follows. In the following section, we present the methods developed in our survey, i.e. the development of our questionnaire, our sample and data collection as well as the ethical requirements. We then present our measurements of the variables included in these analyses as well as the empirical strategy we used to test our hypotheses. Then, we present the results. Finally, we discuss the results and conclude[3].

2 Methods

2.1 The questionnaire development

The development of our auto-administrated questionnaire was supported by findings from our literature reviews and qualitative study as well as questionnaires from French cross-sectional surveys (Guilbert et al. 2006; Ménard et al. 2008; Beck and Gauthier 2012) [4].

Our questionnaire contains 278 questions divided into 43 categories with 4 additional questions whether individuals declared personal cancer history or cancer history among family, friends or acquaintances. Items among categories of questions were randomly displayed to avoid an order effect. It took on average 35 minutes to complete.

Based on findings from the qualitative study, adoption of health-related behaviors and individuals' perceptions of cancers' risks were elicited regarding the following factors: genetics, smoking, passive smoking, excessive alcohol consumption, asbestos, outdoor air pollution, pesticides in air breathing, indoor radon exposure, unprotected sun exposure, pesticides in food, diet rich in fat and sugar, diet rich in red meat, low physical activity, radiofrequencies associated with use of mobile phones and Wi-Fi, stress in daily life, negative

[3] Draft article: Genton MC, Carretier J, Gafni A and Moumjid N. "Adoption of health-related behaviors: The role of cancer risk perceptions, time preference, impulsivity, risk preference and prevention-related beliefs."

[4] Guilbert et al. 2006: Baromètre Cancer 2005 - Beck and Gauthier 2012: Baromètre Cancer 2010
Ménard et al. 2008: Baromètre Santé Environnement 2007

emotional shocks, paints not labeled as ecological, cosmetic products, home care products and taking hormonal contraceptive (pill) among women[5]. We selected the factors mentioned by more than three individuals to ensure it is not mostly unknown among our respondents and refined some of them to have more specific answer. For instance, unbalanced diet was specified by diet rich in fat and sugar and diet rich in red meat.

The questionnaire was pre-tested among a panel of lay individuals and experts (20 pre-tests were conducted). Most of the pre-tests' feedbacks led to small rephrasing to enhance questions' understanding, it thus did not undergo important changes.

2.2 Sample and data collection

Recruitment of participants for this online cross-sectional survey was performed by a national survey institute in October 2016 which handled also their payment (points to get gift voucher).

To ensure that our sample would be representative of the French population aged between 18 and 75 years-old, a quota sampling procedure was used. The quota variables are displayed in Table 4 and included gender, age, regional distribution and socioeconomic status. Sociodemographic characteristics of individuals who stopped the questionnaire were also collected for sample comparison when available (see Table 17 in Appendix 2 for details).

Overall, 4811 individuals started the questionnaire and 2115 individuals completed the questionnaire (response rate 44%). The representative sample of the French population included 1500 individuals since 500 individuals were included in a subsample in the AURA Region and 115 individuals were out of quotas. Both of these subpopulations were excluded from the following analyses.

[5] No health-related behaviors were asked regarding the presence of nuclear industries and taking hormonal treatments. Perceptions of cancers' risks related with these environmental factors are thus only included in Chapter 4.

Table 4 Quotas used to ensure the construction of a sample representative of the French population

	General population sample
Total	1500
Gender	
Man	49%
Woman	51%
Age (years old)	
18-29	22%
30-39	19%
40-49	20%
50-59	19%
60-75	20%
Regional distribution	
Agglomeration of Paris	19%
Parisian Basin West/East	17%
North	6%
West	9%
East	13%
South West	11%
South East	12%
Mediterranean Region	13%
Socioeconomic status	
Farmer	1%
Independent profession	3%
Executive	9%
Intermediate profession	14%
Office worker	16%
Skilled/unskilled worker	12%
Retired	32%
Unemployed	12%

2.3 Ethics and consent

This questionnaire was registered at the National Commission for Data Protection and Liberties (declaration n°1993982). Respondents were informed that their data are anonymous and analyzed in a research perspective.

Their specific consent was asked before answering questions related to personal history of chronic diseases (whether they have personal history, identification of the disease, whether they had treatment during the last year, whether the disease was diagnosed 10 years ago, 5 years ago or less than 1 year ago).

2.4 Variables' measurements

Adoption of health-related behaviors

Questionnaires asking for specific past behaviors' frequency appeared the most commonly used method to assess adoption of health-related behaviors (Renner, Klusmann, et al. 2015). However, this type of questionnaire raises methodological issues. Firstly, it is based on the fact that respondents understood the questions, identified the behavior, retrieved its instances and converted them into the format of the questions, for instance twice a week or 30 minutes per day. Secondly, individuals may consciously or unconsciously over-report healthy behaviors and under-report risky behaviors to appear with a healthier lifestyle than their actual one (Renner, Klusmann, et al. 2015).

To limit these biases, respondents were asked the extent to which they have adopted a set of 25 various health-related behaviors integrating widespread simple behaviors, such as ventilate home every day, and more complex ones, such as consuming organic products, on 5-point scales ("not at all", "not really", "somewhat", "absolutely", "not concerned"). Dummy variables were created to indicate if respondents declared to have somewhat or absolutely adopted each of these health-related behaviors.

Perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

Questions to elicit individuals' perceptions of their own cancers' risks in general and stemming from genetics as well as from environmental factors were adapted from previous research conducted in the field (Han et al. 2011).

Respondents were first asked about their risk perceptions to develop cancers in general and then about their risk perceptions to develop cancers stemming from genetics and environmental factors: "Based on your lifestyle, how would you describe your risk of developing a cancer [stemming from the different factors presented below] during your remaining lifetime? Would you say your risk of developing a cancer [stemming from genetics and each of the 20 environmental factors)] is…?" Respondents choose one answer among "almost none", "somewhat low", "somewhat high", "very high", and "I don't know".

If a respondent declared a personal experience of cancer, questions were rephrased to ask for their risk perception of second cancer to ensure that respondents displayed their perceived cancers' risks and not causes.

Dummy variables were created to indicate if respondents declared to perceive their own risks to develop cancers as high (1=somewhat or very high) or low (0=somewhat low or almost none). Don't know answers were considered missing.

Time preferences, impulsivity and risk preferences

To elicit individuals' time preferences, it is common to ask respondents to choose between smaller/sooner monetary rewards and larger/later ones (Eckel and Grossman 2008) whether studies are experiments (Leonard et al. 2013; Harrison et al. 2015) or cross sectional surveys (Khwaja et al. 2007; Sloan et al. 2014). The measure of individuals' time preference in this case is the average switching point over both lists of choices from the early to the delayed amount. A first methodological issue regarding these elicitations of time preferences mentioned in our first chapter is that it contains also a risk component (Sozou and Seymour 2003). However, it is technically difficult to evaluate exogenous and 'pure' individual time preferences because other effects and mechanisms, not distinguishable from time preferences, may be at play (Gafni and Torrance 1984; Arrondel and Masson 2014). For instance, "*individuals' responses to time-preference-type questions may represent not only their attitudes toward the timing of events but also their attitudes toward other things such as sequences of events"* (Gafni 1995).

Regarding individuals' risk preferences, their elicitation is often realized through respondents' choice between lotteries in studies with experimental designs (Anderson and Mellor 2008; Leonard et al. 2013; Harrison et al. 2015). Relying on experimental designs allows to answer a main concern among the literature related to assessment of time and risk preferences that choices made in hypothetical scenarios, like those proposed in cross-sectional surveys, may not reflect actual behaviors when real money is at stake (Anderson and Mellor 2008). Nonetheless, this type of study design can be difficult to establish especially among national representative samples. Like time preferences, risk preferences are often elicited regarding the financial domain.

These issues motivated our use of the methodology developed by Arrondel and Masson in the PATER study to generate time preferences, impulsivity and risk preferences as individual general characteristics, not only related to the financial domain (Arrondel et al. 2002; Arrondel and Masson 2014). This method consists in asking individuals the extent to which they endorse a large number of statements directly linked with their choices in real life and related respectively with their time preference, impulsivity and risk preference (Arrondel et al. 2002; Arrondel and Masson 2014). Two strengths of this method can be identified. First, questions are related to individuals' choices in real life, thus, limitations associated with hypothetical

scenarios stressed in studies not using experimental design are thus a lessen subject of concern. Comparing their score with common survey and experimental measures, Arrondel and Masson found their score to perform better (Arrondel et al. 2002; Arrondel and Masson 2014). Second, it may allow us to have a starting point in disentangling time and risk preferences.

Respondents were thus asked to display the extent to which they endorse 19, 7 and 31 statements directly linked with their choices in real life and related respectively with their time preference, impulsivity and risk preference. Most of the answers were on 4-point scales from "not at all" to "absolutely". Few of them required an answer on 4-point scales from "never" to "often". Respondents' answers were then coded: + 1 = present / impulsive / risk-prone -oriented answer versus – 1 = future / thoughtful / risk-averse -oriented answer while 0 = neutral-oriented answer. Scores of time preference, impulsivity and risk preference were then constructed based on a selective procedure using Cronbach alphas and item-rest correlations. Variables with item-rest correlations lower than 0.05 were excluded. Four simple additive scores were computed with satisfying Cronbach alphas. Raw score of time preference varied from -12, very future-oriented, to 17, very present-oriented (α=0.62). Raw score of impulsivity varied from -9, very thoughtful, to 9, very impulsive (α=0.46). Raw score of risk preference in context of risk-taking behaviors varied from -19, very risk-averse, to 19, very risk-prone (α=0.75) and raw score of risk preference in context of protective behaviors varied from -13, very risk-averse, to 13, very risk-prone (α=0.69). Details regarding scores' construction are available in Appendix 2, Section 2.3.1 for time preferences, Section 2.3.2 for impulsivity and Section 2.3.3 for time preferences).

Prevention-related beliefs

Respondents were proposed a list of motivations to have somewhat or absolutely adopted health-related behavior(s) and could pick as many motivations they wanted. A dummy variable was created to indicate if respondents selected the motivation "to prevent cancer occurrence".

Respondents were also proposed a list of motivations to have not at all or not really adopted health-related behavior(s). A dummy variable was created to indicate if respondents selected the motivations "I would like to but don't have the money/the will to do so".

Perceiving adoption of preventive health-related as effective to prevent cancers' occurrence was elicited by asking respondents the extent to which they think "it is possible to prevent cancer occurrence with our daily behaviors" on a 4-point scale "not at all", "not really", "somewhat", or "absolutely". A dummy variable was created to indicate if respondents somewhat or absolutely agreed to this statement.

Respondents were then asked the extent to which they think "it is important for me to establish actions in my daily life in order to prevent cancer" on the same 4-point scale from "not at all" to "absolutely". A dummy variable was created to indicate if respondents somewhat or absolutely agreed to this statement.

Personal health history and sociodemographic characteristics

Respondents were asked whether they perceived their current health status to be "very poor", "poor", "fair", "good", or "very good". One dummy variable was created to indicate if respondents perceived their current health status very poor or poor and another one to indicate if respondents perceived their current health status good or very good.

Personal history of cancer(s) and chronic disease(s) or disorder was elicited by asking respondents if they have, or had, at least one history of chronic disease or disorder in their lifetime. A dummy variable was created to indicate if respondents answered "yes". Another dummy variable was created to indicate if respondents selected "cancer" in the proposed list of chronic disease(s) or disorder(s).

Gender, age, highest degree completed, socio-professional category, marital status, number of children, number of children living in the household (more or less than 18 years-old), net annual household income category and degree of urbanization of the living area were collected.

2.5 Empirical strategy

Chi-square tests were computed to investigate bivariate relationships between adoption/non adoption of health-related behaviors and perceptions of risks to develop cancers associated to the same context (cancers in general, cancers stemming from genetics, cancers stemming from environmental factors).

Kendall's pairwise correlation coefficients, displayed in Table 8, showed significant but low agreement among respondents between adoptions of health-related behaviors. In some cases, adoptions of health-related behaviors were even independent from each other. We thus decided to analyze each adoption of health-related behaviors independently.

The association between individuals' perceptions of their risks to develop cancers rkp_{ij} and adoption of health-related behaviors b_adp_{ij} was analyzed using logistic regressions where "i" refers to the individual and "j" refers to the context, i.e. cancers in general, cancers stemming from genetics, cancers stemming from an environmental factor.

First, these relationships were analyzed without taking account the endogeneity. We thus estimated the following model with logistic regressions integrating robust standard errors (as a remainder b_adp_{ij} is a binary variable).

$$b\_adp_{ij} = \zeta_0 + \zeta_1 rkp_{ij} + \zeta_2 X_{1i} + \zeta_3 X_{2i} + \zeta_4 X_{3i} + \nu_{ij}$$

Where X_{1i} is a vector of individual variables including time preferences, impulsivity and risk preferences, X_{2i} prevention-related beliefs, X_{3i} personal health history and sociodemographic characteristics.

Then, a two-stage residual inclusion procedure was followed in order to take into account potential endogeneity issues. This procedure has been shown to perform better in health economics applications involving nonlinear models with endogenous regressors than two-stage predictor substitution (Terza et al. 2008).

An instrument rkp_{ik} is consistent if it is strongly correlated with the regressor rkp_{ij}. Thus, Kendall's pairwise correlation coefficients were computed between perceptions of cancers' risks in general, cancers' risks stemming from genetics as well as from environmental factors, displayed in Table 7, to identify the strongest correlation (Cameron and Trivedi 2010). The instrument has also to be uncorrelated with unobservable parameters affecting adoption of behaviors (Cameron and Trivedi 2010). This exogeneity restriction cannot be directly tested. However, to ensure at least that the candidate instrument rkp_{ik} was not correlated with adoption of health-related behavior b_adp_{ij}, bivariate analyses were conducted. rkp_{ik} was considered a good instrument for rkp_{ij} if the associated parameter was not significant. If it was, we get back at pairwise correlations and re-tested both conditions with the second most correlated risk perception with rkp_{ij}. This procedure was replicated until both conditions were respected.

Our first-stage equation was given by

$$rkp_{ij} = \alpha_0 + \alpha_1 rkp_{ik} + \alpha_2 X_{1i} + \alpha_3 X_{2i} + \alpha_4 X_{3i} + \varepsilon_{ij}$$

Where X_{1i} is a vector of individual variables including time preferences, impulsivity and risk preferences, X_{2i} prevention-related beliefs, X_{3i} personal health history and sociodemographic characteristics. Ordinary least squares regressions integrating robust standard errors were computed even if rkp_{ij} was binary (i.e. almost none and low answers vs. high and very high answers). As a reminder, don't know answers were considered missing. Residuals ε_{ij} were estimated and then integrated in the second stage equation to control for endogeneity.

The second-stage equation was given by

$$b\_adp_{ij} = \beta_0 + \beta_1 rkp_{ij} + \beta_2 \varepsilon_{ij} + \beta_3 X_{1i} + \beta_4 X_{2i} + \beta_5 X_{3i} + \upsilon_{ij}$$

Where X_{1i} is a vector of individual variables including time preferences, impulsivity and risk preferences, X_{2i} prevention-related beliefs, X_{3i} personal health history and sociodemographic characteristics. Logistic regressions integrating robust standard errors were computed (b_adp_{ij} is a binary variable).

Regression results are reported as odd-ratios and exponentiated form to allow effects' comparisons. Because of the multiple tests conducted, only results with $p<0.01$ are interpreted. All statistical analyses were conducted using Stata 11 (Stata, College station, Texas). Schwarz's Bayesian Information Criterion was computed for logistic regressions and second-stage equations from the 2SRI procedure to compare data fit (Cameron and Trivedi 2010).

Sociodemographic characteristics integrated as covariates were the following: gender, age and age-squared, living in a couple, having children, secondary school completed, professional degree, (ref. high school completed), college degree lower than graduation or equivalent completed, college degree at least equal to graduation or equivalent completed, net annual household income category not declared, (ref. 25% lowest net annual household income category declared adjusted on household consumption units), 25%-50% adj-NAHI, 50%-75% adj-NAHI, 25% highest adj-NAHI, living in rural area or with less than 20 000 inhabitants, (ref. living in area comprising between 20 000 and 199 999 inhabitants) and living in area comprising 200 000 inhabitants and more.

3 Results

3.1 Descriptive statistics

Sociodemographic characteristics are displayed in Table 5 and show that our sample was representative of the French population aged between 18 and 75 years-old according to the selected quotas. Nonsensical responses or unreasonable response time were checked leading to delete answers from 22 respondents. Half of the sample declared a level of education higher than high school. The majority of respondents (62%) declared to be in a couple or married and more than half of the sample (55%) declared to have children. Around half of the sample declared to be full-time (44%) or part-time (8%) employed. Around one fifth of respondents preferred not to declare their household's net annual income.

Very few respondents declared a personal history of cancer (3%) while the proportion of respondents who declared a personal history or chronic illness of disorder was much higher

(30%). Around half of respondents perceived their current health status as very good or good (46%), four over ten perceived their current health state as fair and few (13%) perceived their current health status as poor.

Table 5 Socio-demographic characteristics of respondents in the cross-sectional survey

Sociodemographic characteristics		**n= 1478** N	%
Gender	Man	720	49
	Woman	758	51
Age	18-29	326	22
	30-39	273	18
	40-49	295	20
	50-59	282	19
	60-75	302	20
Regional distribution	Agglomeration of Paris	282	19
	Parisian Basin West/East	252	17
	North	89	6
	West	133	9
	East	191	13
	South-East	159	11
	South-West	178	12
	Mediterranean Region	194	13
Socio-professional category	Farmer	15	1
	Independent profession	60	4
	Executive	158	11
	Intermediate profession	242	16
	Office worker	277	19
	Skilled/unskilled worker	178	12
	Retired	354	24
	Unemployed	194	13
Marital status	Single	441	30
	Living in a couple	201	14
	Married	704	48
	Divorced / Widowed	132	9
Having children	Yes	814	55
	No	664	45
Number of consumption units in the household [a]	1	228	15
	] 1 – 2]	916	62
	] 2 – 3]	311	21
	] 3 – 4.1]	23	2
NAIH adjusted on consumption units [b]	First quarter (25% with lowest adj-NAHI)	325	22
	Second quarter	300	20
	Third quarter	279	19
	Fourth quarter (25% with highest adj-NAHI)	326	22
	Prefer to not answer	248	17
Level of education	Secondary school completed	95	6
	Professional degree	328	22
	High school completed	331	22
	1st college degree or eq. (HSD + 2 years)	340	23
	2nd college degree or eq. (HSD + 3/4 years)	232	16
	3rd college degree or eq. (HSD + 5 years and more)	152	10
Self-rated health	Poor/very poor	193	13
	Fair	601	41
	Very good/good	684	46
Personal health history	Chronic disease(s) or disorder(s)	444	30
	Cancer	37	2
Living area	Rural or less than 20 000	590	40
	Between 20000 and 200 000	274	19
	More than 200 000	614	41

[a] Weight attributed to consumption units in the household: 1 for the respondent, 0.5 for each additional adult or child aged more than 18 years-old, 0.4 for each child aged less than 18 year-old

[b] Net Annual Income of the Household category

As showed in Table 6, almost half of our respondents answered that they do not know how to perceive their risks to develop cancers in general in their remaining lifetime (risks of cancers in general: 43% DK). The same level of DK answers was found on perceptions of risks to develop cancers stemming from indoor radon exposure (42% DK). The lowest level of DK answers was found on perceptions of risks to develop cancers stemming from smoking (6% DK).

High perceived risks to develop cancers in remaining lifetime were the highest for cancers stemming from outdoor air pollution (53%), pesticides through food consumption (49%) or air breathing (46%) and stress in everyday life (46%). It is noteworthy that between 53% and 44% of our respondents perceived their risks to develop cancers stemming from outdoor air pollution, pesticides, stress, smoking and sun exposure high or very high. On the contrary, low perceived risks to develop cancers in remaining lifetime were the highest for cancers stemming from use of cosmetic products (69%), alcohol consumption higher than daily public health recommendations (65%) and use of home care products (64%). Around half of the sample perceived their risks to develop cancers stemming from cleaning products, diet rich in red meat and low physical activity somewhat low.

Too few cancer patients participated in our study to compare their perceptions with cancer-free individuals.

Kendall's pairwise correlation coefficients, displayed in Table 7 showed that perceptions of risks to develop cancers in general, cancers stemming from genetics and from environmental factors are positively related and not independent from each other ($p<0.000$ in all cases). Besides, all the coefficients are positive. However, it also shows low agreement between these perceptions among respondents since few coefficients were higher than 0.5.

Almost all respondents declared to ventilate their home every day, to be careful about having regular physical activity, to be non-smoker and to be careful about eating fruits and vegetables every day. Kendall’s pairwise correlation coefficients between adoptions of health-related behaviors were low (see Table 8), except for a high correlation between consumption of organic fruits and vegetables and consumption of other organic products (0.65).

Chi2 tests showed that individuals’ perceptions of cancers’ risks in general and stemming from genetics as well as from environmental factors differ according to their adoption of health-related behaviors. However, this does not hold in all cases.

Table 6 Respondents' declared adoption of health-related behaviors and perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors

Perceptions of cancers' risks stemming from …		**Almost none**		**Low**		**High**		**Very high**		**Don't know**		**Total**		
Health-related behaviors		N	%	N	%	N	%	N	%	N	%	N	%	*P*
General cancers' risks		15	1	263	18	470	32	97	7	633	43	1478	100	
Taking part, or intend to, in national screening campaigns	No	9	1	98	16	189	30	53	8	281	45	630	43	*0,013*
	Yes	6	1	165	19	281	33	44	5	352	42	848	57	
Careful about eating fruits and vegetables every day	No	4	1	61	14	146	34	29	7	186	44	426	29	*0,249*
	Yes	11	1	202	19	324	31	68	6	447	42	1052	71	
Genetics		133	9	553	37	375	25	164	11	253	17	1478	100	
Asked about family history about severe diseases	No	49	10	190	38	108	22	36	7	113	23	496	34	*0,000*
	Yes	84	9	363	37	267	27	128	13	140	14	982	66	
Smoking		590	40	160	11	275	19	370	25	83	6	1478	100	
Being non-smoker	No	24	6	53	12	168	39	154	36	32	7	431	29	*0,000*
	Yes	566	54	107	10	107	10	216	21	51	5	1047	71	
Having reduced cigarettes' consumption	No	542	45	104	9	191	16	296	25	64	5	1197	81	*0,000*
	Yes	48	17	56	20	84	30	74	26	19	7	281	19	
Using an e-cigarette / Vaping	No	584	42	151	11	247	18	336	24	76	5	1394	94	*0,000*
	Yes	6	7	9	11	28	33	34	40	7	8	84	6	
Adopting at least one protective behavior against smoking	No	23	9	23	9	102	38	101	38	18	7	267	18	*0,000*
	Yes	567	47	137	11	173	14	269	22	65	5	1211	82	
Secondhand smoking		350	24	512	35	324	22	188	13	104	7	1478	100	
Avoiding smoke from others	No	92	17	186	34	155	28	66	12	46	8	545	37	*0,000*
	Yes	258	28	326	35	169	18	122	13	58	6	933	63	
Excessive alcohol consumption (higher than recommendations)		548	37	410	28	284	19	127	9	109	7	1478	100	
Careful about not drinking more than the daily recommendations	No	193	35	124	22	131	24	47	8	62	11	557	38	*0,000*
	Yes	355	39	286	31	153	17	80	9	47	5	921	62	
Asbestos exposure		440	30	382	26	172	12	286	19	198	13	1478	100	
Careful to not expose oneself to asbestos	No	193	27	184	26	99	14	109	15	121	17	706	48	*0,000*
	Yes	247	32	198	26	73	9	177	23	77	10	772	52	
Outdoor air pollution		73	5	463	31	585	40	197	13	160	11	1478	100	
Limiting one exposition to outdoor air pollution	No	46	4	327	31	420	40	126	12	121	12	1040	70	*0,075*
	Yes	27	6	136	31	165	38	71	16	39	9	438	30	
Pesticides in air		131	9	477	32	442	30	240	16	188	13	1478	100	
Ventilating home every day	No	13	9	42	31	39	28	22	16	21	15	137	9	*0,894*
	Yes	118	9	435	32	403	30	218	16	167	12	1341	91	
Indoor radon exposure		242	16	336	23	188	13	87	6	625	42	1478	100	
Searching for information regarding the radon concentration in soils	No	238	17	318	22	175	12	79	6	616	43	1426	96	*0,000*
	Yes	4	8	18	35	13	25	8	15	9	17	52	4	
Having done radon concentration measures in your house	No	238	17	328	23	172	12	82	6	616	43	1436	97	*0,000*
	Yes	4	10	8	19	16	38	5	12	9	21	42	3	
Unprotected sun exposure		197	13	588	40	381	26	203	14	109	7	1478	100	
Using protections in case of sun exposure	No	62	13	164	35	150	32	51	11	47	10	474	32	*0,000*

	Yes	135	13	424	42	231	23	152	15	62	6	1004	68	
Pesticides in food		84	6	468	32	468	32	244	17	214	14	1478	100	
Eating only fruits and vegetables labelled as organic or not treated with pesticides	No	63	5	357	31	379	33	182	16	177	15	1158	78	*0,089*
	Yes	21	7	111	35	89	28	62	19	37	12	320	22	
Consuming only products (other than fruits and vegetables) labelled as organic	No	68	6	387	31	397	32	198	16	186	15	1236	84	*0,404*
	Yes	16	7	81	33	71	29	46	19	28	12	242	16	
Diet rich in fat and sugar		125	8	618	42	472	32	109	7	154	10	1478	100	
Careful about having a diet low in fat and sugar	No	25	4	200	34	246	42	39	7	79	13	589	40	*0,000*
	Yes	100	11	418	47	226	25	70	8	75	8	889	60	
Diet rich in red meats		217	15	707	48	317	21	62	4	175	12	1478	100	
Careful about having a diet low in red meat	No	77	10	354	46	186	24	29	4	117	15	763	52	*0,000*
	Yes	140	20	353	49	131	18	33	5	58	8	715	48	
Low physical activity		256	17	657	44	337	23	78	5	150	10	1478	100	
Careful about being active every day or having a regular physical activity	No	31	8	163	40	126	31	23	6	66	16	409	28	*0,000*
	Yes	225	21	494	46	211	20	55	5	84	8	1069	72	
Mobiles phones use without hand-free kit		264	18	604	41	305	21	91	6	214	14	1478	100	
Using mobile phone without a hand-free kit sparsely	No	158	15	418	40	248	24	61	6	160	15	1045	71	*0,000*
	Yes	106	24	186	43	57	13	30	7	54	12	433	29	
Wi-Fi		184	12	576	39	372	25	93	6	253	17	1478	100	
Using the Wi-Fi sparsely	No	134	11	453	38	317	26	77	6	217	18	1198	81	*0,001*
	Yes	50	18	123	44	55	20	16	6	36	13	280	19	
Stress in everyday life		126	9	524	35	509	34	173	12	146	10	1478	100	
Limiting stress induced by one daily life	No	63	8	230	29	296	37	111	14	90	11	790	53	*0,000*
	Yes	63	9	294	43	213	31	62	9	56	8	688	47	
Negative emotional shocks		190	13	595	40	399	27	117	8	177	12	1478	100	
Limiting the feeling of strong negative emotions during one lifetime	No	121	14	320	36	252	28	71	8	126	14	890	60	*0,000*
	Yes	69	12	275	47	147	25	46	8	51	9	588	40	
Paints not labeled as ecological		315	21	549	37	228	15	71	5	315	21	1478	100	
Using paints labelled as ecological	No	225	22	375	36	145	14	25	2	262	25	1032	70	*0,000*
	Yes	90	20	174	39	83	19	46	10	53	12	446	30	
Cosmetic products		419	28	612	41	178	12	55	4	214	14	1478	100	
Careful about buying and using cosmetic products	No	253	36	250	35	68	10	19	3	115	16	705	48	*0,000*
	Yes	166	21	362	47	110	14	36	5	99	13	773	52	
Home care products		194	13	747	51	284	19	53	4	200	14	1478	100	
Careful about buying and using home care products	No	90	13	338	50	122	18	20	3	104	15	674	46	*0,239*
	Yes	104	13	409	51	162	20	33	4	96	12	804	54	
Pill: women only		219	29	250	33	142	19	53	7	94	12	758	51	
Stopping or stopped to take the pill: women only (no pregnancy wish or menaupose)	No	108	25	143	33	88	20	22	5	78	18	439	30	*0,000*
	Yes	111	35	107	34	54	17	31	10	16	5	319	22	

Table 7 Kendall's pairwise correlation coefficients between perceptions of cancers' risks in general and stremming from genetics as well as from environmental factors

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
General cancers' risks	1	1.00																						
Genetics	2	0.33	1.00																					
Smoking	3	0.15	0.29	1.00																				
Secondhand smoking	4	0.14	0.26	0.56	1.00																			
Alcohol consumption	5	0.13	0.31	0.46	0.39	1.00																		
Asbestos exposure	6	0.12	0.33	0.48	0.47	0.44	1.00																	
Outdoor air pollution	7	0.17	0.30	0.31	0.37	0.34	0.36	1.00																
Pesticides in air	8	0.13	0.28	0.35	0.41	0.37	0.46	0.55	1.00															
Radon indoor exposure	9	0.13	0.25	0.24	0.26	0.27	0.39	0.29	0.27	1.00														
Sun exposure	10	0.15	0.34	0.43	0.44	0.43	0.49	0.46	0.44	0.29	1.00													
Pesticides in food	11	0.16	0.31	0.35	0.38	0.34	0.45	0.56	0.57	0.26	0.42	1.00												
Diet high in fat and sugar	12	0.17	0.31	0.33	0.35	0.40	0.36	0.55	0.38	0.27	0.37	0.38	1.00											
Diet high in red meats	13	0.13	0.30	0.28	0.28	0.37	0.29	0.49	0.33	0.22	0.32	0.31	0.47	1.00										
Low physical activity	14	0.15	0.25	0.28	0.27	0.30	0.27	0.53	0.29	0.21	0.28	0.27	0.44	0.36	1.00									
Mobiles phones use	15	0.15	0.26	0.19	0.27	0.27	0.23	0.44	0.29	0.23	0.26	0.28	0.31	0.35	0.27	1.00								
Wi-Fi	16	0.12	0.23	0.13	0.18	0.19	0.14	0.47	0.28	0.21	0.18	0.30	0.26	0.33	0.26	0.51	1.00							
Stress	17	0.19	0.32	0.22	0.25	0.25	0.24	0.51	0.35	0.18	0.30	0.33	0.35	0.30	0.34	0.36	0.33	1.00						
Negative emotional shocks	18	0.19	0.29	0.16	0.21	0.24	0.20	0.48	0.31	0.19	0.26	0.28	0.34	0.31	0.37	0.32	0.34	0.59	1.00					
Paints not labeled as ecological	19	0.14	0.27	0.24	0.29	0.33	0.36	0.42	0.37	0.41	0.36	0.38	0.34	0.34	0.30	0.34	0.30	0.28	0.29	1.00				
Cosmetic products	20	0.12	0.28	0.24	0.32	0.35	0.35	0.41	0.35	0.32	0.33	0.37	0.33	0.34	0.30	0.38	0.34	0.35	0.36	0.44	1.00			
Cleaning products	21	0.16	0.29	0.28	0.34	0.38	0.38	0.48	0.44	0.34	0.38	0.40	0.35	0.38	0.33	0.37	0.32	0.39	0.37	0.48	0.37	1.00		
Presence of nuclear indiustries	22	0.16	0.28	0.37	0.38	0.35	0.48	0.43	0.47	0.28	0.38	0.44	0.37	0.28	0.29	0.29	0.26	0.30	0.29	0.35	0.35	0.37	1.00	
Pill: women only	23	0.12	0.30	0.30	0.29	0.31	0.35	0.29	0.33	0.31	0.36	0.31	0.35	0.32	0.28	0.37	0.31	0.31	0.26	0.31	0.38	0.35	0.29	1.00

Table 8 Kendall's rank pairwise correlations between adoptions of health-related behaviors

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Adopting at least one protective behavior against smoking	1	1.00																								
Avoiding smoke from others	2	0.39	1.00																							
Careful to not expose oneself to asbestos	3	0.07	0.17	1.00																						
Ventilating home every day	4	0.09	0.07	0.15	1.00																					
Searching for information regarding the radon concentration in soils	5	0.03	0.06	0.11	0.00	1.00																				
Having done radon concentration measures in your house	6	0.02	0.03	0.09	0.02	0.40	1.00																			
Eating only F&V labelled as organic products or not treated with pesticides	7	0.09	0.11	0.19	0.12	0.19	0.14	1.00																		
Consuming only products (other than F&V) labelled as organic products	8	0.08	0.10	0.16	0.09	0.18	0.14	0.64	1.00																	
Using mobile phone without a hand-free kit sparsely	9	0.07	0.06	0.14	0.10	0.07	0.13	0.11	0.10	1.00																
Using the Wi-Fi sparsely	10	0.04	0.04	0.06	0.04	0.11	0.08	0.11	0.08	0.16	1.00															
Using protections in case of sun exposure	11	0.17	0.20	0.14	0.15	0.02	0.03	0.13	0.12	0.06	0.03	1.00														
Careful about eating fruits and vegetables every day	12	0.19	0.19	0.21	0.23	0.06	0.02	0.23	0.19	0.12	0.06	0.20	1.00													
Careful about having a diet low in fat and sugar	13	0.15	0.15	0.22	0.18	0.06	0.03	0.19	0.16	0.14	0.13	0.19	0.37	1.00												
Careful about having a diet low in red meat	14	0.15	0.16	0.22	0.14	0.10	0.07	0.21	0.21	0.12	0.07	0.14	0.28	0.31	1.00											
Careful about being active every day or having a regular physical activity	15	0.15	0.13	0.15	0.19	0.02	0.03	0.13	0.12	0.07	0.07	0.15	0.27	0.28	0.20	1.00										
Limiting stress induced by one daily life	16	0.08	0.09	0.19	0.07	0.07	0.08	0.17	0.14	0.16	0.10	0.07	0.23	0.21	0.20	0.15	1.00									
Limiting the feeling of strong negative emotions during one lifetime	17	0.06	0.08	0.17	0.03	0.11	0.10	0.19	0.18	0.14	0.10	0.11	0.18	0.20	0.19	0.14	0.50	1.00								
Limiting one exposition to outdoor air pollution	18	0.06	0.18	0.29	0.08	0.13	0.10	0.27	0.22	0.16	0.12	0.12	0.16	0.23	0.21	0.11	0.23	0.25	1.00							
Asking around family about cancer family history	19	0.03	0.06	0.21	0.08	0.08	0.06	0.11	0.13	0.08	0.06	0.11	0.17	0.11	0.17	0.08	0.11	0.10	0.15	1.00						
Taking part, or intent to, in national screening campaigns	20	0.16	0.17	0.14	0.16	0.00	0.01	0.11	0.10	0.06	0.05	0.17	0.28	0.20	0.19	0.13	0.14	0.12	0.15	0.22	1.00					
Using paints labelled as ecological	21	0.07	0.14	0.32	0.09	0.16	0.12	0.30	0.35	0.13	0.06	0.14	0.17	0.18	0.19	0.15	0.14	0.16	0.26	0.16	0.11	1.00				
Careful about not drinking more than the daily recommendations	22	0.12	0.13	0.21	0.07	0.03	0.00	0.06	0.09	0.12	0.05	0.12	0.15	0.18	0.17	0.14	0.11	0.13	0.12	0.13	0.18	0.12	1.00			
Careful about buying and using cosmetic products	23	0.12	0.17	0.26	0.20	0.06	0.03	0.27	0.26	0.11	0.10	0.29	0.27	0.34	0.26	0.19	0.16	0.18	0.24	0.17	0.26	0.20	0.14	1.00		
Careful about buying and using cleaning products	24	0.11	0.15	0.28	0.20	0.10	0.08	0.34	0.30	0.13	0.08	0.20	0.31	0.31	0.24	0.18	0.18	0.18	0.25	0.14	0.24	0.29	0.13	0.47	1.00	
Stopping or stopped to take the pill: women only	25	0.04	0.05	0.16	0.08	0.07	0.08	0.09	0.11	0.10	0.07	0.02	0.06	0.07	0.04	0.04	0.06	0.11	0.20	0.12	0.07	0.19	0.07	0.13	0.14	1.00

Table 9 reports descriptive statistics on additional variables included in the model to analyze adoption of health-related behaviors. Mean time preference is -0.51. Most future-oriented respondents (first quartile) have scores ranging from -11 to -3 while most present-oriented respondents (last quartile) have scores ranging from 2 to 15. Mean impulsivity is -1.37. Most thoughtful respondents have scores ranging from -9 to -3 while most impulsive respondents have scores ranging from 0 to 9. Mean risk preferences in context of risk-taking is -7.32. Most risk-averse respondents in context of risk-taking behaviors have scores ranging from -19 to -10 while most risk-prone respondents have scores ranging from -5 to 4. Mean risk-preference in context of protective behaviors is -0.86. Most risk-averse respondents in context of protective behaviors have scores ranging from -13 to -3 while most risk-prone respondents have scores ranging from 1 to 13.

Around one third of respondents declared to be motivated by cancer prevention when they adopt health-related behaviors (25%). The same proportion of respondents declared they would like to adopt health-related behaviors but do not have the money or the will to do so (29%). On the contrary, the double of respondents endorsed positively that it is possible to prevent cancer occurrence with their daily behaviors (68%) and that it is important for them to establish actions in their everyday life to prevent cancer (62%).

Table 9 Additional expected predictors of adoption of health-related behaviors

Additional expected predictors of health-related behaviors declared adopted	Yes		No	
	N	%	N	%
Time preference, impulsivity, risk preference				
Time preference: mean -0.51 (sd. 3.6)				
Most future-oriented respondents: 1st quartile [-11;-3]	275	19	1203	81
Respondents with time preference around the mean: 2nd and 3rd quartile [-3;2]	949	64	529	36
Most present-oriented respondents: 4th quartile]2;15]	254	17	1224	83
Impulsivity: mean -1.37 (sd. 2.54)				
Most thoughtful respondents: 1st quartile [-9;-3[	284	19	1194	81
Respondents with impulsivity around the mean: 2nd and 3rd quartile [-3;0]	879	60	599	40
Most impulsive respondents: 4th quartile]0;9]	315	21	1163	79
Risk preference in context of risk-taking behaviors: mean -7.32 (sd. 4.24)				
Most risk-averse respondents in context of risk-taking behaviors: 1st quartile: [-19;-10[	339	23	1139	77
Risk preference in context of risk-taking behaviors around the mean: 2nd and 3rd q. [-10;-5]	803	54	675	46
Most risk-prone respondents in context of risk-taking behaviors: 4th quartile]-5;4]	336	23	1142	77
Risk preference in context of protective behaviors: mean -0.86 (sd. 3.32)				
Most risk-averse respondents in context of protective behaviors: 1st quartile [-13;-3[	339	23	1139	77
Risk preference in context of protective behaviors around the mean: 2nd and 3rd q. [-3;1]	894	60	584	40
Most risk-prone respondents in context of protective behaviors: 4th quartile]1;13]	303	21	1175	79
Prevention-related beliefs				
Cancer prevention as a motivation to adopt preventive health-related behaviors	375	25	1103	75
Would like to but don't have the money/the will to do so	435	29	1043	71
It is possible to prevent cancer occurrence with our daily behaviors	1004	68	474	32
It is important for me to establish actions in my daily life in order to prevent cancer	923	62	555	38

3.2 Econometric analyses

Results from logistic regressions when endogeneity is not taken into account and when endogeneity is taken into account (two-stage residual inclusion procedure) are reported in Table 10, Table 11, Table 12 and Table 13. As a reminder, only parameters significant at 1% level are interpreted in this results' section.

The following interpretations have to be considered all other things being equal.

Relationship between adoption of health-related behaviors and perceptions of cancers' risks

Some, but not all, odd-ratios associated with perceptions of cancers' risks are significant.

When the endogeneity is not taken into account,

- Perceiving high versus low risks to develop cancers stemming from smoking, passive smoking, excessive alcohol consumption, diet rich in fat and sugar, diet rich in red meats, low physical activity, use of mobile phones without hand-free kit and stress in everyday life decreases significantly the respective likelihood to declare to have adopted at least one protective behavior against smoking, to avoid smoke from others, to have a mindful alcohol consumption, to have a diet low in fat and sugar, to have a diet low in red meat, to be careful about level of physical activity, to declare using mobile phones without a hand-free kit sparsely and to limit stress in everyday life.

When the endogeneity is taken into account (2SRI),

- Perceiving high versus low risks to develop cancers stemming from smoking decreases significantly the likelihood to declare to have adopted at least one protective behavior against smoking.
- Parameters associated with residuals were significant at a 1% level in the cases of smoking and stress. Both parameters were negative meaning that the effect of risk perceptions on adoption of these health-related behaviors was underestimated.

No other relationships significant at a 1% level were observed between adoption of health-related behaviors and perceptions of cancers' risks when both are related to the same context (cancers' risks in general and stemming from genetics as well as 20 environmental factors).

Our assumption that perceiving high versus low risks to develop cancers in general and cancers stemming from genetics as well as from environmental factors, based on lifestyle, decreases the

likelihood to declare adoption of associated health-related behaviors is thus very partially supported. When the endogeneity is not taken into account, one third of adoptions of health-related behaviors (8/25) are significantly associated with risk perceptions. When the endogeneity is taken into account, only one adoption of health-related behaviors is significantly associated with risk perceptions and the underestimation of the effect of risk perceptions on adoption of health-related behaviors is supported in two cases, smoking and stress.

Relationship between adoption of health-related behaviors and time preference, impulsivity and risk preference

Some, but not all, odd-ratios associated with time preferences, impulsivity and risk preferences are significant.

When the endogeneity is not taken into account,

- The more an individual displays a present-oriented preference, the less likely he is to declare avoiding smoke from others and to be careful about his level of physical activity.
- The more an individual shows an orientation towards impulsivity, the less likely he is to declare to consume fruits and vegetables every day, to eat organic fruits and vegetables, to eat organic products (other than fruits and vegetables), to have a diet low in fat and sugar, to be careful about level of physical activity, to use Wi-Fi sparsely, to limit stress in everyday life, to limit negative emotional shocks, to use paints labeled as ecological and to have a mindful consumption of cosmetic products.
- The more an individual displays a risk-prone-oriented preference in context of risk-taking behaviors, the more likely he is to declare to consume fruits and vegetables every day, to consume organic products (other than fruits and vegetables), to be careful about level of physical activity and to limit negative emotional shocks.
- The more an individual displays a risk-prone-oriented preference in context of protective behaviors, the less likely he is to declare to take part, or intend to, in screening campaigns, to have asked about family history of severe diseases, to have adopted at least one protective behavior against smoking, to avoid smoke from others, to protect oneself in case of sun exposure, to be careful about level of physical activity and to be Wi-Fi sparsely.

When the endogeneity is taken into account (2SRI),

- The more an individual displays a present-oriented preference, the less likely he is to declare to have a diet low in fat and sugar and to be careful about his level of physical activity.
- The more an individual shows an orientation towards impulsivity, the less likely he is to declare to eat organic fruits and vegetables, to eat organic products (other than fruits and vegetables), to have a diet low in fat and sugar, to be careful about level of physical activity, to use Wi-Fi sparsely, to limit stress in everyday life, to limit negative emotional shocks, to use paints labeled as ecological, to have a mindful consumption of cosmetic products as well as home care products.
- The more an individual displays a risk-prone-oriented preference in context of risk-taking behaviors, the more likely he is to declare to consume fruits and vegetables every day, to consume organic products (other than fruits and vegetables), to be careful about level of physical activity, to limit negative emotional shocks and, for women, to stop taking hormonal contraceptives (pill).
- The more an individual displays a risk-prone-oriented preference in context of protective behaviors, the less likely he is to declare to take part, or intend to, in screening campaigns, to consume fruits and vegetables every day, to have asked about family history of severe diseases, to avoid smoke from others, to be careful about level of physical activity and to be Wi-Fi sparsely.

Our assumption that increasing present-oriented preference, impulsivity and risk-prone-oriented preference decreases the likelihood to declare adoption of health-related behaviors is partially supported. Two third of adoption of health-related behaviors (17/25) are significantly associated with at least one variable related to time and risk preference but association between adoption of health-related behaviors and risk-prone-oriented answers in context of risk-taking behaviors contradicted our assumption.

Relationship between adoption of health-related behaviors and prevention-related beliefs

When the endogeneity is not taken into account,

- Motivation to prevent cancer increases the likelihood to declare to have asked about family history of severe diseases, to be careful about exposure to asbestos, to ventilate

home every day, to consume organic fruits and vegetables and to have a mindful consumption of cosmetic products.

- Perceiving barriers to adopt health-related behaviors at the individual level decreases the likelihood to declare to have adopted at least one protective behavior against smoking and to consume organic products.
- Perceiving adoption of preventive health-related as effective prevent cancers' occurrence increases the likelihood to declare to have a mindful alcohol consumption, to limit exposure to outdoor air pollution, to consume organic products (other than fruits and vegetables), to have diet low in red meat, to limit stress in everyday life and to use paints labeled as ecological.
- Perceiving cancer prevention as important increases the likelihood to declare to have asked about family history of severe diseases, to have adopted at least one protective behavior against smoking, to avoid smoke from others, to be careful about exposure to asbestos, to protect oneself in case of sun exposure, to consume organic fruits and vegetables, to have a diet low in fat and sugar, to have a diet low in red meat, to be careful about level of physical activity, to limit stress in everyday life and negative emotional shocks. Odd-ratios showed a particular strong association between perceiving cancer prevention as important and increasing odds to declare to consume fruits and vegetables every day, to limit exposure to outdoor air pollution, to have done radon measurement in home, to consume organic products (other than fruits and vegetables), to use paints labeled as ecological, to have a mindful consumption of cosmetic products and home care products as well as to stop taking the pill for women

When the endogeneity is taken into account (2SRI),

- Motivation to prevent cancer increases the likelihood to declare to take part, or intend to, in organized screening campaigns, to have asked about family history of severe diseases, to be careful about exposure to asbestos, to limit exposure to outdoor air pollution, to ventilate home every day, to consume organic fruits and vegetables and to have a mindful consumption of cosmetic products.
- Perceiving barriers to adopt health-related behaviors at the individual level decreases the likelihood to declare to have adopted at least one protective behavior against smoking and to consume organic products.
- Perceiving adoption of preventive health-related as effective prevent cancers' occurrence increases the likelihood to declare to have a mindful alcohol consumption,

to limit exposure to outdoor air pollution, to consume organic products (other than fruits and vegetables), to have diet low in red meat, to limit stress in everyday life as well as negative emotions, to use paints labeled as ecological and to have a mindful consumption of home care products.

- Perceiving cancer prevention as important increases the likelihood to declare to have asked about family history of severe diseases, to avoid smoke from others, to be careful about exposure to asbestos, to protect oneself in case of sun exposure, to have a diet low in fat and sugar, to have a diet low in red meat, to be careful about level of physical activity, to limit stress in everyday life and negative emotional shocks. Odd-ratios showed a particular strong association between perceiving cancer prevention as important and increasing odds to declare to consume fruits and vegetables every day, to limit exposure to outdoor air pollution, to have done radon measurement in home, to consume organic fruits and vegetables, to consume organic products (other than fruits and vegetables), to use paints labeled as ecological, to have a mindful consumption of cosmetic products and home care products as well as to stop taking the pill for women.

Our assumption that endorsement of prevention-related beliefs increases the likelihood to declare adoption of health-related behaviors is thus well supported. Almost all adoptions of health-related behaviors (22/25) are significantly associated with at least one prevention-related belief. The exceptions were searching information about radon domestic exposure, using mobile phones without hand-free kit sparsely and using Wi-Fi sparsely. In addition, results were very consistent across the different methods of estimation.

Relationship between adoption of health-related behaviors and personal health history as well as socio-demographic characteristics

Few results are significant regarding personal health history and sociodemographic variables.

None of the odd-ratios associated with personal history of cancer(s) and chronic disease(s) or disorder are significant whether endogeneity was controlled or not.

When the endogeneity is not taken into account,

- Perceiving current health status as poor increases significantly the likelihood to declare to have asked about family history of severe diseases.

- Perceiving current health status as good increases the likelihood to declare to protect oneself in case of sun exposure, to be careful about level of physical activity, to limit stress in everyday life and negative emotional shocks.
- Being woman increases the likelihood to declare to consume fruits and vegetables every day, to avoid smoke from others, to consume organic fruits and vegetables, consuming organic products (other than fruits and vegetables), to have a diet low in fat and sugar, to have a diet low in red meat and to have a mindful consumption of home-care products. Odd-ratios showed a particular strong association between being woman and increasing likelihood to declare to take part, or intend to, in organized screening campaigns, to protect oneself in case of sun exposure and to have a mindful consumption of cosmetic products.
- A quadratic effect of age is significantly associated with taking pill among women. Increasing age is associated with higher likelihood to stop taking the pill. However, after 51 years-old, increasing age is associated with lower likelihood to stop taking the pill. No other significant quadratic effect of age is observed.
- Compared to being single, being in a couple is associated with increasing likelihood to declare using paints labeled as ecological.
- Compared to having an adj-NAHI in the first quartile, having an adj-NAHI in the second quartile decreases the odds to declare to have a diet low in red meat, and having an adj-NAHI in the fourth quartile decreases the likelihood to have a diet low in red meat and to stop taking the pill among women.
- Compared to living in a suburban urea, living in a rural area decreases the likelihood to ventilate home every day.

When the endogeneity is taken into account (2SRI),

- Perceiving current health status as poor increases significantly the likelihood to declare to have asked about family history of severe diseases.
- Perceiving current health status as good increases the likelihood to declare to protect oneself in case of sun exposure, to be careful about level of physical activity, to limit stress in everyday life and negative emotional shocks.
- Being woman increases the likelihood to declare to consume fruits and vegetables every day, to consume organic fruits and vegetables, consuming organic products (other than fruits and vegetables), to have a diet low in fat and sugar, to have a diet low in red meat and to have a mindful consumption of home-care products. Odd-ratios showed a

particular strong association between being woman and increasing likelihood to declare to take part, or intend to, in organized screening campaigns, to protect oneself in case of sun exposure and to have a mindful consumption of cosmetic products.

- A quadratic effect of age is significantly associated with taking pill among women. Increasing age is associated with higher likelihood to stop taking the pill. However, after 51 years-old, increasing age is associated with lower likelihood to stop taking the pill. In the cases of mindful alcohol consumption and diet low in red meat, the parameter associated with the simple age effect is not supported at a 1% level but at a 5% level, while the parameter associated with age-squarred is significant at a 1% level. In both cases, increasing age is associated with lower likelihood to declare to have mindful alcohol consumption and to have a diet low in red meat. However, after an age threshold respectivelly 40 and 37 years-old, respective, increasing age is associated with higher likelihood to declare to have mindful alcohol consumption and to have a diet low in red meat.
- Compared to those who completed high school, individuals who have additional years of education are more likely to declare to have a diet low in red meat.
- Compared to those who completed high school, individuals who completed secondary school and those with professional degree have a higher likelihood to declare to stop taking the pill.
- Compared to being single, being in a couple is associated with increasing likelihood to declare using paints labeled as ecological.
- Compared to having an adj-NAHI in the first quartile, preferring to not declare NAHI category is associated with increasing likelihood to declare to protect oneself in case of sun exposure and to have a mindful consumption of home care products. In addition, compared to having an adj-NAHI in the first quartile, having an adj-NAHI in the fourth quartile decreases the likelihood to declare having a diet low in red meat, using paints labeled as ecological and stopping to take the pill among women.
- Compared to living in a suburban urea, living in a rural area decreases the likelihood to ventilate home every day.

None of the odd-ratios associated with having children and very few associated with education level are significant whatever the method of estimation used.

Table 10 Regression results: relationships between adoption of health-related behaviors and individuals' risk perceptions, time preferences, impulsivity, risk preferences, endorsement of prevention-related beliefs, personal health history and sociodemographic characteristics (1st table)

Model	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE
Type RKP	binary	OLS	binary	binary	OLS	binary	binary	OLS	binary	binary	OLS	binary	binary	OLS	binary	binary	OLS	binary
Behavior	Screening campaigns			F&V everyday			Asking family history			Prevention smoking			Avoiding passive smoking			Mindful alcohol cons.		
Risk perception	Cancer			Cancer			Genetics			Smoking			Passive smoking			Excessive alcohol cons.		
VI Risk perception	Genetics			Genetics			Sun exposure			Asbestos exposure			Asbestos exposure			Passive smoking		
N	845	778	778	845	778	778	1225	1192	1192	1395	1257	1257	1374	1245	1245	1369	1328	1328
High risk perception vs. low	0.783	1.393**	0.353*	0.654*	1.393**	0.598	1.241	1.414**	0.695	0.147**	1.873**	0.425**	0.615**	1.784**	0.894	0.646**	1.571**	0.959
Residuals FSE			2.240			1.044			1.827			0.184**			0.594			0.578
Time preference	0.974	1.002	0.989	0.979	1.002	0.989	0.976	1.002	0.980	0.991	1.008*	0.978	0.946**	0.999	0.947*	0.960	1.005	0.961
Impulsivity	0.981	1.019**	0.979	0.907**	1.019**	0.922*	0.993	1.016**	0.993	1.009	1.004	1.019	0.950	1.000	0.947	0.989	0.997	0.990
Risk pref.: risk-taking behav.	1.011	1.000	1.016	1.068**	1.000	1.062**	0.993	0.999	1.000	0.978	1.007*	0.960	0.970	1.002	0.966*	1.011	1.008**	1.004
Risk pref.: protective behav.	0.912**	1.002	0.902**	0.926*	1.002	0.910**	0.927**	1.002	0.926**	0.921**	1.004	0.924*	0.933**	0.996	0.923**	0.957	1.004	0.960
Motivation: cancer prevention	1.546*	1.060	1.676**	1.081	1.060	1.071	1.679**	1.028	1.658**	1.128	1.003	1.092	1.139	1.024	1.176	1.276	0.997	1.254
Barriers at indiv. Level	1.471*	1.026	1.592*	1.048	1.026	1.042	1.109	1.021	1.142	0.622**	1.093**	0.534**	0.754*	1.030	0.766	1.290	0.966	1.326*
Perceived efficacy of prev.	1.149	0.968	1.166	1.282	0.968	1.396	1.426*	1.004	1.384*	1.171	0.991	1.172	1.267	0.985	1.275	1.598**	1.037	1.611**
Perc. Importance of prev.	1.107	1.023	1.128	2.784**	1.023	2.728**	1.530**	1.015	1.624**	1.844**	1.015	1.535*	1.579**	1.033	1.469**	1.309*	1.013	1.301*
History of cancer	0.646	1.116	0.584	0.820	1.116	0.908	1.004	0.943	1.227	2.160	0.900	2.681	1.774	0.922	1.789	1.086	1.023	1.048
History of disease or disorder	1.036	1.001	1.192	1.234	1.001	1.323	1.354	1.038	1.397	0.981	1.023	1.037	0.825	0.983	0.809	1.284	1.007	1.282
Positive perceived health	1.217	0.968	1.133	1.467	0.968	1.419	0.818	0.923*	0.796	1.277	0.964	1.459*	1.036	0.940*	1.042	1.308	0.982	1.372*
Negative perceived health	1.195	1.084*	1.306	1.157	1.084*	1.097	2.983**	1.147**	3.085**	0.698	1.060	0.624	0.982	1.056	0.946	0.837	1.018	0.834
Being woman	2.655**	0.992	2.708**	1.836**	0.992	1.928**	1.136	1.048	1.192	1.312	0.977	1.388	1.412**	1.020	1.336*	1.042	0.973	1.039
Age	1.033	1.016*	1.026	0.982	1.016*	0.979	1.034	1.007	1.038	1.042	1.002	1.043	0.993	0.987*	1.004	0.943*	1.000	0.937*
Age-squarred	1.000	1.000*	1.000	1.000	1.000*	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.001*	1.000	1.001**
Being in a couple	1.101	1.015	1.190	1.142	1.015	1.207	1.155	1.029	1.132	1.136	1.030	1.380	0.973	1.043	0.936	1.154	0.958	1.225
Having children	1.106	1.053	1.132	1.030	1.053	0.921	1.034	1.034	0.982	1.148	0.987	1.238	0.868	0.931**	0.857	0.925	0.997	0.929
Secondary school completed	1.549	0.904	1.336	1.177	0.904	1.159	0.565	0.957	0.589	0.863	1.020	0.719	1.066	0.965	0.946	0.800	0.985	0.793
Professional degree	1.045	0.987	1.038	1.249	0.987	1.167	0.713	0.936	0.751	0.702	0.983	0.615*	1.037	0.988	0.904	0.727	1.030	0.741
HSD + 2/3/4 years	1.160	1.079	1.300	1.646*	1.079	1.800*	1.151	1.011	1.173	1.192	0.976	1.173	1.112	0.947	1.081	1.051	0.983	1.122
HSD ≥ 5 years	1.318	1.066	1.375	1.796	1.066	1.985*	0.833	0.985	0.908	1.754	0.920*	1.770	1.691*	0.919*	1.756*	1.316	0.981	1.421
NoNAHIdeclared	0.838	0.996	0.987	0.980	0.996	0.959	1.478	0.958	1.403	0.902	0.973	0.925	1.567*	0.995	1.604*	1.123	0.963	1.200
2nd quarter	0.993	1.020	1.124	1.461	1.020	1.424	1.450	0.981	1.409	0.879	0.992	0.873	1.055	0.984	1.102	1.203	1.034	1.224
3rd quarter	1.144	1.001	1.276	0.990	1.001	1.040	0.957	0.952	0.881	0.947	0.974	0.881	1.131	0.947	1.106	1.361	0.991	1.399
4th quarter	1.132	0.983	1.207	1.009	0.983	0.976	1.654*	0.977	1.509	0.781	0.988	0.810	1.056	0.938	1.075	1.077	1.044	1.112
Rural or < 20 000	0.882	1.106*	0.966	0.746	1.106*	0.615	1.013	0.991	1.031	0.920	1.003	0.900	1.304	0.992	1.284	1.232	1.022	1.241
>200 000	0.846	1.075	0.865	1.016	1.075	0.807	0.820	0.972	0.819	1.133	1.027	1.020	1.276	1.029	1.216	1.010	1.062*	0.978
Pseudolikelihood	-502.9	-426.7	-457.7	-432.7	-426.7	-389.3	-683.2	-741.7	-661.8	-532.4	-569.5	-468.7	-828.4	-580.1	-751.3	-832.9	-649.4	-806.6
R2 / Pseudo R2	0.1221	0.2056	0.1314	0.1418	0.2056	0.1528	0.1022	0.1756	0.10017	0.1864	0.4192	0.2145	0.0799	0.3709	0.0820	0.701	0.2559	0.0722
BIC	1201		1115	1061		978	1573		1536	1275		1151	1866		1716	1875		1828

Exponentiated coefficients; * Significant at 5%, ** Significant at 1%

FSE: First-Stage Equation / SSE: Second-Stage Equation

Table 11 Regression results: relationships between adoption of health-related behaviors and individuals' risk perceptions, time preferences, impulsivity, risk preferences, endorsement of prevention-related beliefs, personal health history and sociodemographic characteristics (2nd table)

Model	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE
Type RKP	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary
Behavior	Avoiding asbestos exp.			Limiting exp. to air poll.			Ventilate home everyday			Search info. Radon			Radon measures in home			Protected sun exposure		
Risk perception	Asbestos exposure			Outdoor air pollution			Pesticides in air			Indoor radon exposure			Indoor radon exposure			Unprotected sun exposure		
VI Risk perception	Sun exposure			Pesticides in air			Pesticides in food			Outdoor air pollution			Outdoor air pollution			Asbestos exposure		
N	1280	1244	1244	1318	1236	1236	1290	1209	1209	853	827	827	853	827	827	1369	1244	1244
High risk perception vs. low	0.988	1.770**	0.794	1.001	1.648**	1.239	0.961	1.775**	0.802	1.384	1.374**	2.372	2.472*	1.374**	4.478	0.752*	1.872**	0.703
Residuals FSE			1.454			0.785			1.213			0.561			0.528			1.138
Time preference	0.960*	1.018**	0.962	0.989	1.004	0.987	0.947	1.006	0.951	1.055	1.006	1.051	1.154*	1.006	1.156*	0.973	0.993	0.958
Impulsivity	1.015	1.003	1.016	0.969	1.007	0.964	0.965	0.993	0.947	1.021	1.000	1.020	1.032	1.000	1.037	0.969	0.998	0.984
Risk pref.: risk-taking behav.	0.979	1.005	0.982	1.010	1.007*	1.007	1.048	1.001	1.045	1.101*	1.011**	1.093	1.130*	1.011**	1.122*	0.983	1.003	0.982
Risk pref.: protective behav.	0.961	0.993	0.960	0.959	0.998	0.965	0.949	1.001	0.942	0.971	0.998	0.974	0.959	0.998	0.959	0.934**	1.003	0.934*
Motivation: cancer prevention	1.627**	0.973	1.640**	1.429*	0.973	1.493**	2.477**	1.015	2.651**	1.896	1.045	1.912	0.741	1.045	0.772	1.172	1.026	1.247
Barriers at indiv. Level	1.038	1.006	1.060	1.279	0.990	1.244	0.858	1.005	0.866	0.619	0.991	0.622	0.383*	0.991	0.386*	0.919	0.974	0.912
Perceived efficacy of prev.	1.324*	1.016	1.314*	1.532**	0.966	1.544**	1.490	1.066*	1.472	1.637	1.024	1.528	0.797	1.024	0.746	1.279	0.986	1.215
Perc. Importance of prev.	1.873**	1.069**	1.933**	2.372**	1.079**	2.426**	1.557	1.058*	1.588	3.503*	1.080*	3.265*	6.666**	1.080*	6.088**	1.966**	1.007	1.990**
History of cancer	0.809	1.031	0.817	1.083	1.086	0.966	0.959	0.996	0.821	1.773	1.020	1.708	4.075	1.020	3.906	0.892	1.017	0.898
History of disease or disorder	0.960	1.021	0.997	1.143	1.007	1.075	0.967	1.005	1.067	0.663	0.987	0.655	0.626	0.987	0.617	1.156	0.992	1.220
Positive perceived health	0.853	0.976	0.886	1.213	1.017	1.243	1.369	0.992	1.390	1.093	0.926*	1.135	0.620	0.926*	0.661	1.577**	1.006	1.837**
Negative perceived health	0.800	0.971	0.803	0.968	1.076	0.990	1.008	0.972	1.133	1.115	0.924	1.160	1.814	0.924	1.815	1.094	1.046	1.143
Being woman	0.814	0.990	0.841	1.055	1.009	1.029	1.299	1.005	1.244	1.081	1.026	1.049	1.433	1.026	1.354	2.658**	1.029	2.673**
Age	1.011	1.004	1.005	0.970	1.010	0.955	0.970	0.988*	0.964	1.082	0.997	1.084	0.967	0.997	0.973	1.052	0.994	1.071*
Age-squarred	1.000	1.000	1.000	1.000	1.000*	1.001	1.001	1.000*	1.001	0.999	1.000	0.999	1.000	1.000	1.000	0.999*	1.000	0.999*
Being in a couple	1.032	0.959	1.048	1.119	0.974	1.136	1.403	0.987	1.314	1.008	1.022	1.012	1.136	1.022	1.167	0.972	1.031	0.891
Having children	0.909	1.009	0.886	1.157	0.999	1.149	1.358	1.000	1.353	1.244	1.016	1.248	1.456	1.016	1.494	0.939	0.993	1.007
Secondary school completed	1.118	0.992	1.129	1.698	0.958	1.514	0.726	1.044	0.624	2.204	0.952	2.351	0.592	0.952	0.604	0.545*	1.054	0.566*
Professional degree	1.243	1.021	1.302	1.198	0.962	1.207	0.691	1.061	0.640	1.418	1.065	1.328	1.843	1.065	1.700	0.619*	1.048	0.625*
HSD + 2/3/4 years	1.037	0.961	1.068	1.020	0.964	1.067	0.715	1.015	0.697	1.368	0.914*	1.467	0.988	0.914*	1.071	0.987	1.021	0.922
HSD ≥ 5 years	1.041	0.953	1.086	1.153	1.000	1.145	0.514	1.009	0.492	1.392	0.896	1.510	0.185	0.896	0.191	0.973	0.995	0.966
NoNAHIdeclared	1.197	1.016	1.190	1.136	1.002	1.075	1.587	0.942	1.800	0.489	0.997	0.474	0.512	0.997	0.484	1.602*	0.946	1.870**
2nd quarter	1.033	0.981	0.996	0.849	0.972	0.859	0.922	0.913**	0.964	0.293*	0.964	0.326	1.529	0.964	1.604	1.009	0.981	1.077
3rd quarter	1.033	0.994	1.030	0.873	0.993	0.894	0.760	0.914*	0.905	0.559	0.962	0.584	1.084	0.962	1.127	1.133	0.966	1.107
4th quarter	0.816	0.980	0.785	0.930	1.030	0.925	0.690	0.908*	0.742	0.371*	0.943	0.383	1.132	0.943	1.150	1.026	0.950	1.174
Rural or < 20 000	1.095	1.000	1.096	1.130	0.944	1.172	0.321**	1.035	0.285**	2.334	1.018	2.327	0.735	1.018	0.731	1.173	0.955	1.155
>200 000	0.979	1.018	0.994	0.737	1.153**	0.718	0.473*	1.007	0.438*	3.911*	1.032	3.712*	1.323	1.032	1.278	1.260	1.014	1.316
Pseudolikelihood	-827.7	-536.1	-801.9	-745.0	-618.2	-696.9	-343.1	-614.0	-321.4	-146.5	-464.2	-145.2	-110.5	-464.2	-109.5	-743.2	-594.2	-667.9
Pseudo R2	0.0621	0.3973	0.0649	0.0757	0.3355	0.0803	0.1204	0.3505	0.1278	0.1402	0.1786	0.1406	0.2086	0.1786	0.2100	0.1252	0.3826	0.1331
BIC	1862		1817	1702		1607	894		855	489		492	417		420	1695		1549

Exponentiated coefficients; * Significant at 5%, ** Significant at 1%
FSE: First-Stage Equation / SSE: Second-Stage Equation

Table 12 Regression results: relationships between adoption of health-related behaviors and individuals' risk perceptions, time preferences, impulsivity, risk preferences, endorsement of prevention-related beliefs, personal health history and sociodemographic characteristics (3rd table)

Model	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE
Type RKP	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	binary
Behavior	Consuming organic F&V			Consuming organic prod.			Diet low in fat and sugar			Diet low in red meat			Being active everyday			Using hand-free kit		
Risk perception	Pesticides in food			Pesticides in food			Diet rich in fat and sugar			Diet rich in red meat			Low physical acitivity			Use mobile phones		
VI Risk perception	Pesticides in air			Pesticides in air			Excessive alcohol cons.			Excessive alcohol cons.			Neg. emotional shocks			Wi-Fi		
N	1264	1209	1209	1264	1209	1209	1324	1301	1301	1303	1282	1282	1328	1254	1254	1264	1165	1165
High risk perception vs. low	0.819	1.754**	1.140	0.833	1.754**	1.371	0.443**	1.531**	0.810	0.638**	1.478**	1.061	0.444**	1.310**	0.454	0.674**	1.577**	1.141
Residuals FSE			0.631			0.482*			0.490*			0.564			0.983			0.495
Time preference	0.997	0.997	0.988	0.955	0.997	0.935*	0.951*	1.003	0.944**	0.974	1.001	0.975	0.916**	1.002	0.916**	0.978	1.006	0.971
Impulsivity	0.907**	1.005	0.905**	0.890**	1.005	0.884**	0.900**	1.008	0.899**	0.953	1.004	0.948*	0.872**	1.008	0.871**	0.950	1.009	0.945
Risk pref.: risk-taking behav.	1.044*	1.004	1.038	1.075**	1.004	1.069**	1.024	1.006	1.011	1.007	1.013**	0.996	1.079**	1.000	1.086**	0.993	1.010**	0.981
Risk pref.: protective behav.	0.983	1.001	0.991	1.014	1.001	1.028	0.952*	1.000	0.951*	0.967	1.003	0.964	0.937**	1.001	0.932**	0.953	0.994	0.954
Motivation: cancer prevention	1.539**	1.000	1.543**	1.370	1.000	1.399	1.338	1.039	1.333	1.111	1.007	1.123	1.284	0.957	1.349	1.001	0.980	1.004
Barriers at indiv. Level	0.688*	0.998	0.646*	0.508**	0.998	0.478**	0.902	1.047	0.900	1.026	1.053	1.035	0.879	1.038	0.875	1.166	0.980	1.187
Perceived efficacy of prev.	1.248	0.965	1.173	1.918**	0.965	1.778**	1.294	0.967	1.336*	1.771**	1.018	1.748**	1.165	1.043	1.147	1.430*	0.950*	1.473*
Perc. Importance of prev.	1.994**	1.026	2.110**	3.393**	1.026	3.454**	1.874**	0.988	1.872**	1.953**	1.035	1.909**	1.885**	1.036	1.860**	1.389*	1.040	1.297
History of cancer	0.809	1.040	0.916	0.709	1.040	0.785	0.702	0.948	0.703	0.689	1.049	0.617	0.616	0.855*	0.707	1.686	1.063	1.449
History of disease or disorder	1.007	1.009	1.006	1.010	1.009	0.978	1.471*	1.028	1.409*	1.135	0.960	1.167	0.948	1.014	0.942	0.917	0.980	0.918
Positive perceived health	1.035	0.949*	1.059	0.710	0.949*	0.716	1.214	0.929*	1.247	1.174	0.998	1.198	1.697**	0.967	1.705**	0.893	0.983	0.898
Negative perceived health	1.032	1.033	0.924	1.376	1.033	1.357	0.926	1.007	0.892	1.151	1.026	1.120	0.945	1.067	0.916	0.725	1.005	0.717
Being woman	1.715**	1.051*	1.716**	1.706**	1.051*	1.632**	1.592**	0.993	1.541**	1.864**	0.956	1.911**	1.244	0.987	1.301	1.086	1.033	1.017
Age	0.955	1.012*	0.950	0.999	1.012*	0.999	0.946	1.000	0.947	0.956	1.009	0.942*	0.959	0.995	0.944	1.012	1.009	1.020
Age-squarred	1.001	1.000**	1.001*	1.000	1.000**	1.000	1.001*	1.000	1.001*	1.001*	1.000	1.001**	1.001	1.000	1.001*	1.000	1.000*	1.000
Being in a couple	1.306	0.990	1.374	1.300	0.990	1.286	1.006	1.030	0.961	0.875	1.042	0.894	1.069	1.045	1.107	0.956	0.985	0.857
Having children	1.253	0.952	1.316	1.411	0.952	1.453	0.993	0.960	1.015	0.983	1.033	0.978	1.214	1.066*	1.293	1.049	0.982	1.071
Secondary school completed	0.683	0.974	0.703	0.636	0.974	0.551	1.042	1.019	1.034	0.993	1.011	0.981	0.776	0.947	0.803	1.019	1.080	0.765
Professional degree	0.728	0.989	0.739	0.928	0.989	0.968	0.891	0.985	0.817	0.894	1.007	0.876	0.886	0.933	0.894	0.915	1.072	0.737
HSD + 2/3/4 years	1.210	1.006	1.270	1.248	1.006	1.374	1.086	0.933*	1.120	1.499*	0.981	1.531**	1.002	0.923*	1.022	0.814	1.001	0.722
HSD ≥ 5 years	1.216	1.030	1.303	0.953	1.030	1.062	1.037	0.966	1.059	1.425	0.985	1.467	0.927	0.923	0.898	0.844	1.036	0.742
NoNAHIdeclared	0.935	1.009	0.901	1.528	1.009	1.483	1.110	1.017	1.076	0.643*	0.985	0.678	0.897	0.918*	1.017	0.758	0.983	0.776
2nd quarter	0.672	1.032	0.666	0.745	1.032	0.746	0.983	1.010	1.021	0.599**	0.952	0.635*	1.001	0.938	0.981	0.932	0.968	0.931
3rd quarter	0.907	1.047	0.881	1.037	1.047	1.062	0.969	1.017	0.977	0.672*	0.991	0.711	0.828	0.928	0.857	0.811	0.958	0.905
4th quarter	0.981	1.004	0.927	1.324	1.004	1.242	0.913	1.025	0.916	0.549**	0.960	0.564**	0.785	0.932	0.767	0.912	0.975	0.990
Rural or < 20 000	1.069	0.952	1.086	1.287	0.952	1.270	0.947	1.003	0.937	0.749	0.998	0.791	1.186	1.006	1.251	1.302	1.030	1.231
>200 000	1.001	1.007	1.076	1.152	1.007	1.159	0.955	0.998	0.906	1.033	0.960	1.069	1.352	1.050	1.449	1.218	1.085**	1.199
Pseudolikelihood	-617.6	-601.2	-586.7	-498.0	-601.2	-471.0	-779.1	-793.7	-762.6	-814.9	-667.3	-800.5	-664.1	-731.2	-627.0	-717.0	-548.2	-657.3
Pseudo R2	0.0811	0.3559	0.0898	0.1336	0.3359	0.1441	0.1172	0.1929	0.1205	0.0977	0.1936	0.0990	0.1246	0.1241	0.1324	0.0712	0.3045	0.0769
BIC	1442		1386	1203		1154	1767		1740	1838		1815	1537		1468	1641		1526

Exponentiated coefficients; * Significant at 5%, ** Significant at 1%

FSE: First-Stage Equation / SSE: Second-Stage Equation

Table 13 Regression results: relationships between adoption of health-related behaviors and individuals' risk perceptions, time preferences, impulsivity, risk preferences, endorsement of prevention-related beliefs, personal health history and sociodemographic characteristics (4th table)

Model	Simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	simple	FSE	SSE	Simple	FSE	SSE
Type RKP	Binary	binary	binary	binary	binary	binary	binary	binary	binary	binary	Binary	binary	binary	binary	binary	binary	binary	binary	Binary	binary	binary
Behavior	Sparse use of Wi-Fi			Limiting everyday stress			Limiting neg. emo. shocks			Using eco paints			Cosmetics: mindful cons.			Home care prod.: mindful cons.			Stop the pill		
Risk perception	Wi-Fi			Stress everyday			Neg. Emotional shocks			Paints no eco label			Cosmetic products			Home care products			Pill		
VI Risk perception	Use mobile phones			Home care products			Low physical activity			Home care products			Paints no eco label			Paints no eco label			Home care products		
N	1225	1165	1165	1332	1238	1238	1301	1254	1254	1163	1114	1114	1264	1103	1103	1278	1114	1114	664	618	618
High risk perception vs. low	0.698*	1.640**	0.623	0.559**	1.375**	1.775	0.726*	1.328**	1.123	0.871	1.670**	1.066	1.329	1.486**	1.554	1.017	1.691**	1.217	0.675	1.324**	1.066
Residuals FSE			1.195			0.277**			0.630			0.756			0.806			0.793			0.580
Time preference	1.011	0.997	1.007	0.980	1.000	0.986	0.992	1.000	0.992	0.951	1.003	0.956	0.993	1.003	0.990	0.976	1.001	0.985	0.958	0.994	0.964
Impulsivity	0.910**	1.006	0.900**	0.905**	1.009	0.889**	0.930**	1.000	0.928**	0.918**	1.005	0.916**	0.923**	0.991*	0.915**	0.944*	0.998	0.926**	0.959	1.013	0.937
Risk pref.: risk-taking behav.	1.032	0.998	1.027	1.041*	1.002	1.043*	1.053**	1.001	1.050**	1.021	1.000	1.023	1.036*	1.012**	1.034	1.038*	1.004	1.040*	1.061*	1.007	1.074**
Risk pref.: protective behav.	0.924**	1.004	0.925**	0.958	0.996	0.956	0.976	0.994	0.986	0.966	0.996	0.966	0.965	1.003	0.965	0.971	1.001	0.966	1.012	1.005	1.011
Motivation: cancer prevention	1.356	0.956	1.358	1.033	1.046	1.060	1.233	1.041	1.161	1.223	1.017	1.175	1.490**	1.001	1.631**	1.230	0.997	1.236	1.174	0.975	1.119
Barriers at indiv. Level	0.859	1.028	0.847	1.116	1.009	1.158	0.988	1.002	0.984	0.928	0.983	0.968	1.073	0.986	1.042	0.895	0.970	0.926	1.155	1.018	1.152
Perceived efficacy of prev.	1.027	1.098**	1.039	1.551**	1.031	1.503**	1.374*	0.977	1.455**	1.599**	1.023	1.649**	1.307	1.030	1.313	1.363*	0.987	1.506**	1.071	1.033	1.017
Perc. Importance of prev.	1.280	1.059*	1.252	1.744**	1.042	1.511**	1.808**	1.075*	1.768**	2.560**	1.058*	2.554**	2.241**	1.013	2.208**	2.252**	1.070**	2.351**	2.175**	0.991	2.217**
History of cancer	1.111	0.938	1.078	1.691	0.942	2.958*	2.236*	0.974	2.319*	0.567	0.906	0.497	0.483	1.088	0.612	0.835	1.023	0.917	1.855	1.173	2.989
History of disease or disorder	1.130	1.039	1.029	1.301	1.014	1.220	1.377*	1.033	1.345*	1.343	1.034	1.403	1.160	0.980	1.164	1.014	1.006	1.093	0.998	0.934	1.004
Positive perceived health	0.936	1.025	0.980	1.482**	0.873**	1.767**	1.766**	0.884**	1.862**	1.133	1.010	1.233	1.114	0.967	1.103	0.870	0.961	0.865	0.752	0.988	0.764
Negative perceived health	1.201	1.033	1.269	1.082	1.082	0.949	0.999	1.097*	0.941	1.007	1.065	0.995	0.940	0.974	1.019	0.884	0.984	0.835	0.573	1.077	0.599
Being woman	0.827	1.031	0.780	0.927	1.090**	0.793	1.069	1.117**	1.010	1.045	1.003	1.109	3.968**	1.084**	3.708**	1.813**	1.034	1.718**	1	1	1
Age	1.050	0.994	1.063	0.955	1.018**	0.945	1.014	1.019**	1.011	1.051	0.996	1.043	1.063*	1.000	1.062	1.068*	1.005	1.065*	1.364**	0.983*	1.371**
Age-squarred	1.000	1.000	1.000	1.001*	1.000**	1.001*	1.000	1.000**	1.000	1.000	1.000	1.000	0.999	1.000	0.999	0.999	1.000	1.000	0.996**	1.000	0.996**
Being in a couple	0.688*	1.061*	0.708	0.875	0.962	0.911	0.820	0.923**	0.868	1.633**	0.981	1.711**	0.959	0.984	1.016	1.030	1.014	0.993	1.218	1.072	1.223
Having children	1.247	0.995	1.249	0.917	0.996	0.872	0.850	0.943	0.891	0.898	1.039	0.968	1.134	0.977	1.235	1.022	0.964	1.029	0.904	1.008	0.985
Secondary school completed	1.373	0.973	1.233	0.695	0.921	0.692	0.864	0.999	0.970	0.787	0.891*	0.634	1.462	1.014	1.533	0.858	1.167**	0.793	2.501*	0.887	2.183
Professional degree	1.354	0.936	1.264	0.969	1.039	0.913	0.935	1.037	0.932	1.196	1.062	1.210	1.056	0.972	1.022	0.976	1.003	0.993	1.944*	0.999	1.833
HSD + 2/3/4 years	1.051	1.033	1.060	0.901	1.018	0.859	1.095	1.020	1.084	1.299	1.000	1.324	1.322	0.962	1.229	1.405*	0.995	1.436*	1.742*	0.948	1.809*
HSD ≥ 5 years	0.851	0.986	0.799	0.858	1.103	0.798	1.032	1.126*	0.972	1.113	1.037	1.129	1.124	0.916*	0.951	1.392	0.980	1.276	1.131	0.937	1.394
NoNAHIdeclared	0.574*	0.982	0.539*	1.228	1.042	1.273	1.096	0.995	1.160	1.560	0.923*	1.396	1.351	1.011	1.424	1.469	0.957	1.817**	0.752	0.946	0.783
2nd quarter	0.778	1.020	0.766	1.240	1.015	1.274	0.885	0.947	0.948	0.912	0.947	0.836	1.430	1.002	1.508	1.164	0.993	1.396	0.817	0.911	0.852
3rd quarter	0.565*	0.984	0.561*	1.025	0.975	1.174	1.052	0.943	1.142	0.769	0.928	0.696	1.036	1.020	1.056	1.051	0.970	1.246	0.872	0.935	0.904
4th quarter	0.576*	0.956	0.538*	0.949	0.996	0.999	0.840	0.968	0.906	0.576*	0.932	0.509**	1.304	0.984	1.338	0.977	0.965	1.158	0.431**	0.905	0.414**
Rural or < 20 000	1.058	1.004	1.065	1.139	1.044	1.093	1.116	1.067	1.141	1.361	1.025	1.542	1.029	0.986	1.050	1.129	0.975	1.142	0.859	0.987	0.822
>200 000	1.527	0.967	1.481	1.160	1.061	1.035	0.940	1.029	0.928	1.520	1.040	1.671*	0.800	1.025	0.847	0.895	0.997	0.943	0.860	0.998	0.772
Log-likelihood	-571.4	-596.2	-536.9	-848.6	-777.6	-781.8	-829.5	-763.6	-801.5	-578.7	-450.8	-550.6	-739.8	-389.0	-646.2	-795.3	-464.0	-685.7	-372.7	-335.1	-347.1
Pseudo R^2	0.0658	0.3097	0.0655	0.0792	0.1773	0.0874	0.0594	0.1716	0.0580	0.1016	0.3154	0.1058	0.1530	0.2392	0.1521	0.0946	0.3156	0.1034	0.1260	0.1663	0 .1280
BIC	1349		1285	1906		1777	1867		1817	1362		1311	1687		1502	1798		1581	927		880

Exponentiated coefficients; * Significant at 5%, ** Significant at 1%

FSE: First-Stage Equation / SSE: Second-Stage Equation

4 Discussion

In this quantitative study, we described individuals' perceptions of their own cancers' risks in general and stemming from genetics as well as from environmental factors. We then investigated the relationships between individuals' adoptions of health-related behaviors and their perceptions of their own cancers' risks in general and stemming from genetics as well as from environmental factors when both were related to the same factor and taking into account the potential endogeneity of risk perceptions. We also investigated the relationships between individuals' adoptions of health-related behaviors and their time preference, their impulsivity, their risk preference and their endorsement of prevention-related beliefs. Analyses took into account individuals' personal health history and sociodemographic characteristics.

First, related to *Research Question 1*, we found the highest proportion of high perceived risks to develop cancers in remaining lifetime associated with cancers stemming from outdoor air pollution (53%), pesticides through food consumption (49%) or through air breathing (46%) and stress in everyday life (46%). On the contrary, we found the highest proportion of low perceived risks to develop cancers in remaining lifetime associated with cancers stemming from use of cosmetic products (69%), alcohol consumption higher than daily public health recommendations (65%) and use of home care products (64%). In addition, don't know answers on perceptions of cancers' risks in general and stemming from indoor radon exposure were reported by around half of the sample. Unfortunately, too few cancer patients participated in our study to compare their perceptions with cancer-free individuals.

Then, related to Research Questions on adoption of health-related behaviors, we found mixed and partial support to our *Assumption* related to *Research Question 2.1* especially because results were not always consistent across the methods of estimation. When the endogeneity was not taken into account, perceiving high versus low risks to develop cancers in general and stemming from genetics as well as from environmental factors, based on lifestyle, decreases the likelihood to declare adoption of some but not all associated health-related behaviors. When the endogneity was taken into account, this assumption was only supported for smoking. The significant parameters associated with residuals in the cases of smoking and stress supported an underestimation of the impact of risk perceptions on adoption of associated health-related behaviors when endogeneity is not taken into account.

We also found partial support to our *Assumption* related to *Research Question 2.2* since increasing present-oriented preference, impulsivity and risk-prone-oriented preference in context of protective behaviors decreases the likelihood to declare adoption of some but not all health-related behaviors while increasing risk-prone oriented preference in context of risk-

taking behaviors increases the likelihood to declare adoption of some health-related behaviors. Finally, we found good support to our *Assumption* related to *Research Question 2.3* since almost all adoptions of health-related behaviors are associated with at least one prevention-related belief. In addition, when significant, perceiving barriers to adoption was associated with lower likelihood to adopt health-related behaviors.

These results lead us to discuss several points.

4.1 Perceptions of individuals' own cancers' risks in general and stemming from genetics as well as from environmental factors

The majority of respondents answered that they do not know how to perceive their risk to develop cancers in their remaining lifetime (43%). Among these respondents, some may do not want to think about it. Emanuel et al. (2015) found that 39% of a sample of US adults did not want to know their risk of cancer. However, we did not find such a result among our sample [6]. We may thus assume that these individuals are simply uncertain about their risk to develop cancers in their remaining lifetime. This finding reflects Weinstein's statement that research on risky behaviors should not assume that people know what illnesses or disabilities may result from exposure to environmental hazards (Weinstein 1999).

Interestingly, for perceptions of cancers' risks stemming from genetics and from environmental factors, the proportion of DK answers was lower. This finding could support the notion of self-relevance we stressed and the fact that it may be easier for people to define their cancers' risks when associated with a specific factor rather than their general disease risks.

Our data show that between 53% and 44% of our respondents perceived their risks to develop cancers stemming from outdoor air pollution, pesticides (whatever the source of exposure: food consumption or air breathing), stress, smoking and sun exposure high or very high.

Outdoor air pollution, smoking, sun exposure and some kinds of pesticides' components were classified Group 1 carcinogenic to humans by the IARC (IARC 2017 Jan 26). Thus, individuals might base their risk perceptions on these published and accessible data. Bearth et al. (2017) also found that individuals rely on experts' judgments when they construct their perceptions of dangerousness of cleaning products.

[6] We tabulated perceptions of cancers' risks in general with answers to the question « I don't think about it in my daily life and I do not want to » and test of Chi2 was not significant.

4.2 Adoption of health-related behaviors and perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

Support to our assumption that perceiving high versus low risks to develop cancers in general and cancers stemming from genetics as well as from environmental factors, based on lifestyle, decreases the likelihood to declare adoption of associated health-related behaviors is very partial and depends on the method of estimation used.

The second-stage residual inclusion procedure allows to control the endogeneity but also to test whether risk perception is an endogenous variable when it comes to analyze adoption of its associated health-related behavior. Among our results, endogeneity of perceptions of cancers' risks was supported in the context of smoking and stress since parameters associated with residuals were significant at the 1% level. We expected risk perceptions as endogenous variables when analyzed in relationships with adoption of associated health-related behaviors to be more supported.

Nevertheless, our findings are similar from those of Lin and Sloan (2015) and Lloyd-Smith et al. (2016) who found an endogeneity associated with risk perceptions. Lin and Sloan (2015) included in their second-stage equation an estimation of smoking risk perceptions based on proximity to lung cancer patient. This procedure is different from ours but their findings also supported endogenous risk perceptions when analyzed in relationships with smoking-related behaviors. Lloyd-Smith et al. (2016) used the same method, thus, second-stage residual inclusion procedure. Like in our results in the context of smoking and stress, they found an underestimation of the influence of risk perceptions on individuals' adoption of behaviors when endogeneity was not taken into account. These similar findings are interesting because two points might have caused variations between our results. First, research fields are different. Lloyd-Smith et al. (2016) investigated relationships between averting expenditures / choices and perceived health risks associated with tap water, home filtered tap water and bottle water while we investigated relationships between adoption of health-related behaviors and perceptions of cancers' risks. Secondly, our method to elicit individuals' risk perceptions was different. Lloyd-Smith et al. (2016) used an online interactive risk-ladder showing several numerical annual death risks based on Canadian data on which respondents used a sliding mechanism to choose their perceived risk level for each water source, while we asked respondents to indicate their perceived cancers' risks by choosing among qualitative options (almost none, low, etc.). In light of these elements, our choice to rely on this method seems to find some external support.

However, caution has to be taken because endogeneity is not well supported among other contexts raising concern regarding the instruments we used. Rigorous precautions have been taken to make sure instruments were technically appropriate according to theoretical guidelines. In addition, Schwarz's Bayesian Information Criterion (BIC) computed for each model showed second-stage equations from the 2SRI procedure to perform better on our data than logistic regressions (BIC are smaller) (Cameron and Trivedi 2010). The only exception was in the context of indoor radon exposure for which BIC from logistic regressions and second-stage equations are almost equal.

We mainly discussed the "control of endogeneity"-side of the inclusion of residuals in the second-stage equation. But, when considered as a test of endogeneity, our results might show that perceptions of risks to develop cancers in general and cancers stemming from genetics as well as from some environmental factors (excluding smoking and stress) are less endogenous with adoption of associated health-related behaviors. Two elements might support this assumption. First, asking individuals clearly to elicit their risk perceptions according to their lifestyle might decrease the simultaneity bias. Second, risk perceptions might be more endogenous in some context than others, in particular smoking and stress. Caution as however to be taken regarding implications from these findings because we used OLS estimations in the first-stage equation in order to be able to estimate residuals whereas risk perceptions' variables were binary. Additional research appears thus necessary to add to this field of research.

These considerations taken into account, it appears that individuals adopting health-related behaviors associated with specific factors perceive their risks to develop cancers stemming from these factors as low while those who do not adopt these health-related behaviors perceive their associated risks to develop cancers as high. This outcome is consistent with previous research conducted in the field (Hahn and Renner 1998; Honda and Neugut 2004; Robb et al. 2004; Jones et al. 2011; Matthew et al. 2011; Kelly et al. 2012).

Interestingly, all the factors for which we found a significant relationship in the logistic regressions taking not into account the endogeneity, except stress, are associated with preventive recommendations in the European Code against Cancer (Schüz et al. 2015). Our findings may thus reflect awareness of cancer risk factors and actions taken to act upon by respondents to reduce their cancer risks (Llewellyn et al. 2017).

It is also noteworthy that perceiving cancers' risks in general as well as stemming from unprotected sun exposure and indoor radon exposure as high rather than low were not significantly associated respectivelly with taking part, or intending to, in organized screening campaigns, consumption of fruits and vegetables every day, protecting oneself in case of sun

exposure, searching information about radon and having done measures in home. Most of the respondents perceived their risks to develop cancers in general and stemming from unprotected sun exposure as low and have actually declared to take part, or intend to, in screening campaigns, to consume fruits and vegetables every day and to protect oneself in case of sun exposure. As expected concerning indoor radon exposure, around half of respondents declared to not know how to perceive their risks to develop cancers stemming from indoor radon exposure. In addition, almost all of respondents living in a department classified at risk for indoor radon exposure (see Figure 2 for the associated map of France) did not search for information regarding radon's concentration in soils. Work is thus still needed to reach widespread awareness and knowledge on this cancer risk factor in public health prevention campaigns.

4.3 Adoption of health-related behaviors and time preferences, impulsivity and risk preferences

Our assumption that increasing present-oriented preference, impulsivity and risk-prone-oriented preference decreases the likelihood to declare adoption of health-related behaviors is partially supported. While adoptions of health-related behaviors are significantly associated with increasing future-oriented preference, thoughtfulness and risk-aversion oriented preference in context of protective behaviors, it is also associated with increasing risk-prone oriented preference in context of risk-taking behaviors. In addition, significant odd-ratios displayed small size-effects ranging from 0.9 to 1.1.

Our results regarding time preferences, impulsivity and risk preferences in context of protective behaviors are consistent with other studies (Granö et al. 2004; Chapman 2005; Anderson and Mellor 2008; Chiteji 2010; Scharff and Viscusi 2011; Leonard et al. 2013; Conell-Price and Jamison 2015; Goldzahl 2017) especially for health-related behaviors associated with diet and physical activity. Individuals may value short-terms benefits of health-related behaviors such as smoking despite the long-term associated costs (Chapman 2005; Codern et al. 2010). Conell-Price and Jamison (2015) found also that more present-oriented individuals tend to declare to exercize more. Similarly, we found increasing risk-prone-oriented preference in context of risk-taking behaviors positively associated with being careful about daily level of physical activity and moreover eating fruits and vegetables every day, consuming organic products other than fruits and vegetables, limiting negative emotional shocks, and stopping to take the pill for women only. Apart from taking the pill, other health-related behaviors are associated with well-being and taking care of oneself. This relationship might be

explained by the immediate gratification associated with the adoption of these behaviors (Conell-Price and Jamison 2015; Kirk and Greenfield 2017).

This result might also be a consequence of our elicitation's method and question's framing that led us to construct two scores of risk preferences. However, even if unexpected, it shows some interesting features (see Figure 5 displaying the scores' distribution) that might be consistent with Kanheman and Tversky's assumption that individuals are more averse to losses than to gains (Kahneman and Tversky 1979).

Implications from our results have to be taken with cautious because no significant relationships were found between adoption of health-related behaviors related to active smoking, alcohol consumption, asbestos exposure, outdoor air pollution, home's ventilation, indoor radon exposure, sun exposure, diet low in red meat and use of mobile phones and time preference, impulsivity, risk preference. Since no other studies analyzed these relationships on these specific behaviors, discussion of this finding is limited and underlines the need for additional studies investigating these points.

Finally, we may underline that our method of elicitation is not specific to health context but rather reflected individuals' general time preference, impulsivity and risk preference (Arrondel et al. 2002; Arrondel and Masson 2014). Weber et al. (2002) found their respondents to be not consistently risk-averse or risk-seeking across all content domains supporting the use of specific methods to elicit individuals' time preference, impulsivity and risk preference in health context. However, the true elicitation of individual's risk attitude in health would require identifying the three effects at play: quantity effect, time preference effect and gambling effect (Gafni and Torrance 1984). The method we used has thus its drawbacks but also its strengths. It is accessible to respondents regardless of their level of education or numeracy because they only have to think about what they do, or will do, in their life when they face this situation. In addition, except for impulsivity, Cronbach alphas were satisfying showing thus the consistency in respondents' answers (ranging from 0.62 to 0.74).

4.4 Adoption of health-related behaviors and endorsement of prevention-related beliefs

Our assumption that endorsement of prevention-related beliefs increases the likelihood to declare adoption of health-related behaviors is well supported as almost all adoptions of health-related behaviors are significantly associated with, at least, the endorsement of one prevention-related belief. Our findings thus support the general statement established in the literature

showing that beliefs influence adoption of health-related behaviors (Vaughan 1993; Katapodi et al. 2004; Lundborg and Andersson 2008; Dantzker et al. 2010; Viscusi 2015), but are nonetheless original in our research field.

Interestingly, we found that respondents who perceived barriers at individual level to adopt health-related behaviors were less likely to declare to adopt at least one preventive behavior against smoking and to consume organic products (other than fruits and vegetables). This result points out that some respondents significantly would like to adopt these behaviors, but do not have the means to do so. Additional analyses showed that answers to question "I would like to but do not have the will to do so" significantly contributed to non-adoption of at least one preventive behavior against smoking, whereas "I would like to but do not have the money to do so" significantly contributed to non-consumption of organic products (other than fruits and vegetables). These findings could have implications in terms of preventive public health campaigns. The first one highlights that some individuals may not stop smoking because they cannot rather than because they do not want to. The second one highlights the perceived financial barriers existing towards the access to organic products.

Similarly, additional analyses showed that 59% of our participants declared they would like to establish actions in their daily life to prevent cancer but do not know what to do at their individual level while 42% declared they cannot establish actions in their daily life to prevent cancer because they do not have the possibility to do so. Thus, our respondents seem to lack knowledge about actions they can adopt at their individual level rather than feeling powerless because of barriers perceived too big to overcome at the individual level (Bickerstaff 2004).

Concerning perceived efficacy of cancer prevention, we found that a moderate consumption of alcohol, consuming organic products (other than fruits and vegetables), limiting outdoor air pollution, limiting consumption of red meat, avoiding stress and negative emotional shocks, using paints labeled as ecological and having a mindful consumption of home care products were associated with perceiving adoption of preventive health-related towards cancers' occurrence efficient. Similarly, Sullivan et al. (2008) found that individuals eating plenty of fruits and vegetables were more likely to report that good nutrition could prevent cancer. Perceived efficacy of cancer prevention was stressed as an important component in models analyzing adoption of health-related behaviors (Rosenstock et al. 1988; Rimal and Real 2003). Conducting analyses according to the Risk Perception Attitude Framework, Sullivan et al. (2008) found also that individuals perceiving their risk to have cancer as high and perceiving high cancer prevention efficacy reported more nutrition-related behavioral intentions than those perceiving low cancer prevention efficacy. But, no differences in behavioral intentions

according to perceived cancer prevention efficacy was found among individuals perceiving their risk to have cancer as low. Testing this interaction between perception of risk and cancer prevention efficacy among our set of data could be an interesting future issue.

Perceived importance of cancer prevention was also found to be strongly associated with adoption of health-related behaviors within our sample since, when significant, the effect on adoption of health-related behaviors was the highest.

4.5 Adoption of health-related behaviors: personal health history and sociodemographic characteristics

Previous research suggested that experience of significant medical events influences adoption of health-related behaviors (Llewellyn et al. 2017). However, we did not find such a result at a 1% level. Nonetheless, at a 5% level, we found that individuals with a personal history of cancer, compared to those without, were twice more likely to declare to limit negative emotional shocks. Individuals with personal history of chronic disease, compared to those without, were also more likely to declare to limit diet rich in fat and sugar. Interestingly, seventy respondents declared to have diabetes or digestive disorder, chronic diseases or disorders requiring diet management. Further analyses could thus be conducted to investigate whether different conditions lead to different adoption of health-related behaviors.

Perceiving current health status as poor increases by a factor of three the odds to declare to ask about family history of severe diseases. We may assume that when individuals have notice a deterioration of their health, they start to think about the potential reasons for this change and, thus, ask their family about family history of severe diseases. This finding shows the importance among our respondents of genetics as a health risk factor. Perceiving current health status as good increases the likelihood to declare using protections in case of sun exposure, being active every day and limiting stress as well as negative emotional shocks. Adopting these health-related behaviors may be associated with general health-caring lifestyles allowing individuals to perceive their current health status as good.

Consistent with previous studies (Wardle et al. 2004; Bränström et al. 2006; McCool et al. 2009), we found women to be more likely than men to adopt health-related behaviors associated with diet, sun exposure, screening but also with cosmetic and home care products. An interesting analysis would be to investigate interaction between gender and age. For instance, young women were found to think about quitting smoking in association with plans of motherhood (Codern et al. 2010).

Concerning age, we found one significant quadratic effect: as age increases, women are more likely to declare to stop taking the pill until 51 years-old after which it decreases. This finding associated with declaration to stop taking the pill seem to support wish of motherhood even if we explicitly asked women to consider themselves out of context of pregnancy or menopause. However, additional analyses showed that significantly more women who agreed that "taking pills for many years increases the risk of cancer" declare to stop taking the pill than those who did not agree to this statement. Discussion regarding this point is very limited because very few studies investigated women's perceptions of health risks stemming from taking the pill. One study found an increasing perceived risk of breast and uterine cancer stemming from taking the pill on average by around one third of women (20%-40% and 25%-50%) (Grubb 1987). Another study found women who never took the pill to perceive high health risk associated with taking the pill while those who did take the pill had the lowest estimates (Emmett and Ferguson 1999). None of these two studies found an effect of age but they also did not include age in its quadratic form. Our findings allow a small updating of these data, but additional research on this topic would be necessary to draw more actual implications.

Moreover, our results showed two partially significant quadratic effect of age at a 1% level but significant at a 5% level. Increasing age was found associated with lower likelihood to declare mindful consumption of alcohol and to have a diet low in red meat, until respectively 40 and 37 years-old, after which increasing age is associated with higher likelihood to declare mindful alcohol consumption and to have a diet low in red meat. These findings tend to support the assumption that individuals might become more concerned about their health risks at a time in their life.

Concerning education, contrary to Cawley and Ruhm (2012), we did not find a significant relationship between education and adoption of health-related behaviors meaning that individuals with education higher than high school did not significantly adopt more health-related behaviors than individuals who completed secondary school or those who had a professional degree at a 1% level. Nonetheless, at a 5% level of significance, those who completed secondary school and those who have professional degree are less likely than individuals who completed high school to declare to protect themselves from sun exposure. Individuals who have additional education than high school are more likely than those who completed high school to declare to eat fruits and vegetables every day and to limit their consumption of red meat. Finally, individuals who graduated from college are more likely than those who completed high school to declare to avoid passive smoking.

Interestingly, even if not significant and whatever the method of estimation used, we can observe that individuals who completed secondary school and those who have professional degree were less likely than those who completed high school to declare to have adopted at least one protective behavior against smoking, to have a mindful consumption of alcohol, to eat organic fruits and vegetables, to limit their consumption of read meat and to have a mindful consumption of home care products while individuals with additional years of education were more likely to declare adoption of these health-related behaviors. Additional analyses need to be conducted to support or reject the existence of a gradient effect of education regarding the adoption of these health-related behaviors. Even if not clearly identified, we found some support that education is a determinant of adoption of health-related behaviors.

Economic literature suggests that individuals' level of education impacts their health and thus their adoption of health-related behaviors because both are partly determined by individuals' time and risk preferences (Fuchs 1982; Cutler and Lleras-Muney 2010). Consistently, we found that individuals perceiving their current health status to be good were more likely to declare to protect themselves from sun exposure, to be careful about daily level of physical activity and to limit stress in their everyday life. We investigated further this point and found that increasing in level of education was significantly associated with an increase towards positive perception of current health status[7]. Individuals who completed secondary school and those who have professional degree significantly rated more than others their perceived current health status as very or rather bad. Reciprocally, individuals who declared an education level higher than high school significantly rated more than others their perceived current health status as very or rather good. No significant difference was found for individuals who completed high school[8]. These findings suggest that education and health might be related within our sample. Further analyses may thus be conducted. We could especially analyze whether these differences actually reflect differences in investments towards health, as suggested by Grossman (1972), mediated by time and risk preferences (Cawley and Ruhm 2012).

[7] Bivariate analysis showed a significant and positive association at a 1% level.
[8] We tabulated perceived current health status with reported level of education. Chi2 tests were significant at a 5% level for individuals who completed secondary school, those who have professional degree and those who graduated from college while it was significant at a 10% for individuals who declared education higher than high school but did not graduated.

4.6 Limitations

Some limitations in our study have to be acknowledged.

First, data are self-reported and our survey is cross-sectional limiting the reliability of our findings. However, caution in the questionnaire's development has been taken to limit in particular the desirability bias and the influence of questions on each other.

Second, we elicited individuals' perceptions of cancers' risks by using absolute qualitative categories rather than numerical answers. Previous studies have raised the issue of individuals' difficulties to assess risks especially as their ability to deal with numerical issues is related to their level of numeracy (Klein and Stefanek 2007; Dave et al. 2010) and sensitivity to questions' framing (Tversky and Kahneman 1974). Our study was conducted in a French representative sample, thus, relying on qualitative answers allowed the use of a tool accessible to the greatest number of people. In addition, our participants were asked about a lot of environmental factors, and, even if these factors were chosen through a qualitative study among lay people, some factors may still be unfamiliar to respondents.

5 Conclusion

Through this first quantitative study, we focused on our first research questions related to cancers' risks in general and stemming from genetics as well as from environmental factors French individuals perceived salient to themselves and adoption of health-related behaviors.

In the following chapter, we now focus on the set of research questions analyzing the identified determinants of individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors.

CHAPTER 4 CONFIRMATORY QUANTITATIVE STUDY: Determinants of individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors

1 Introduction

In this fourth chapter, we analyze whether the determinants we identified, namely affect heuristic, availability heuristic, knowledge, beliefs' endorsement related to cancers and cancers' causes, cancer-related worry, salience, perceived voluntariness and perceived control of risks' exposure, determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors. Analyses include also personal health history and sociodemographic characteristics.

More precisely, the objective of this chapter is to answer the following research questions and to test the associated assumptions:

Research Question 3.1: Do availability heuristic and affect heuristic determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular?

Assumption: Increasing negative affect is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

Assumption: Strong indirect experience with cancers is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

Research Question 3.2: Does knowledge about environmental factors and their link with cancers determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular?

Assumption: Knowledge is a determinant of perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors but no specific assumption on the relationship with risk perceptions is proposed.

Research Question 3.3: Does endorsement of beliefs related to cancers and cancers' causes determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular?

Assumption: Endorsement of beliefs related to cancers and cancers' causes is a determinant of perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors but no specific assumption on the relationship with risk perceptions is proposed.

Research Question 3.4: Do cancer-related worry and salience of the issue of cancers' risks stemming from environmental factors determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular?

Assumption: Being worried about having a cancer one day in remaining lifetime is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

Assumption: People for whom the issue of cancers' risks stemming from environmental factors is salient perceive high rather than low their cancers' risks in general and stemming from genetics as well as from environmental factors.

Research Question 3.5: Do perceived voluntariness and control of the risks' exposure determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors?

Assumption: Perceiving risks' exposure as voluntary is associated with low rather than high perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

Assumption: Perceiving risks' exposure as controllable is associated with low rather than high perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

This chapter is structured as follows. We first present our measurements of the variables included in the analyses and the empirical strategy we use to test our hypotheses since the methods related to the survey have been already detailed in Chapter 3, Section 2. We then present the results, discuss them and conclude.

2 Methods

2.1 Variables' measurements

Perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors

Questions to elicit individuals' perceptions of their own cancers' risks in general and stemming from genetics as well as from genetics, smoking, passive smoking, excessive alcohol consumption, asbestos, outdoor air pollution, pesticides in air breathing, indoor radon exposure, unprotected sun exposure, pesticides in food, diet rich in fat and sugar, diet rich in red meat, low physical activity, radiofrequencies associated with use of mobile phones and Wi-Fi, stress in daily life, negative emotional shocks, paints not labeled as ecological, cosmetic products, home care products, presence of nuclear industries, taking hormonal treatments and taking hormonal contraceptive (pill) among women were adapted from previous research conducted in the field (Han et al. 2011) as described in Chapter 3, Section 2.4.

Heuristics

Affect heuristic: cancers' perception

First, respondents were asked to rank among a list of 15 chronic diseases the three diseases they perceived as the most serious. This question was adapted from Guilbert et al. (2006) and Beck and Gauthier (2012). A dummy variable was created to indicate if a respondent selected *"cancer"* as one of the three most serious diseases.

Second, because we had in our qualitative analysis verbatim associated to cancers, we took them as an opportunity to test an intuitive approach to capture the affect heuristic associated with cancers. Our idea was to elicit individuals' cancers' perceptions through their association of words with cancers. In order to create a variable with enough variability to have meaning as a proxy of affect, we asked our respondents to rank the words representing the most cancers according to them with the possibility to choose a maximum of 6 words among a list of 29 words.

Negative-valence words conveying a negative affect were the followings: chemotherapy, death, fatality, fear, frequent, hair loss, hospitalization, incurable, loneliness, metastases, misfortune, mortal, suffering, upheaval. They were associated with a negative coefficient. While positive-valence words conveying a positive affect were the followings: bravery, combativeness,

healing, medical research, prevention, remission, screening, socially accepted, support, survival, to treat. They were associated with a positive coefficient.

Then, we calculated a simple additive score of cancers' perception taking into account the individuals' words' ranking as well as the valence associated with the words as displayed by the following formula: scr_perc_cancer = (+/-)×word1×6 + (+/-)×word2×5 + (+/-)×word3×4 + (+/-)×word4×3 + (+/-)×word5×2 + (+/-) ×word6×1.

Availability heuristics: experience of cancers among family, friends, etc.

Respondents were asked whether they have, or had, someone or several persons among their relatives, friends, colleagues, or acquaintances who have or had cancer (yes/no).

Those who answered "yes" were asked additional questions to take into account different aspects of this indirect experience with cancer. For each aspect, two dummy variables were created to indicate:

(1) Intensity: (i) very strong experience with cancer (respondents experienced the hospital and the everyday life with people who have/had cancers), (ii) strong experience with cancer (respondents experienced the hospital or the everyday life with people who have/had cancers) – Reference: respondents neither experienced the hospital nor the everyday life with people who have/had cancers;

(2) Distance: the closest person to respondents with cancer was (i) a close family member, (ii) a friend – Reference: another link;

(3) Valence: (i) negative valence (the closest person to respondents with cancer is deceased because of cancer or still undergoing treatments); (ii) positive valence (the closest person to respondents with cancer is cured or in remission) – Reference: the closest person to respondents with cancer is neither deceased or undergoing treatments, nor cured or in remission.

Knowledge about environmental factors and their link with cancers

Respondents were asked to answer with *"true"* or *"false"* to 20 statements about environmental factors and their link with cancer. Then, their answers were assessed to be *"right"* or *"wrong"* (cf. Appendix 2, Section 2.2). A simple additive score of knowledge was calculated for each participant. A right answer gave +1 and a wrong answer 0. A simple additive score was then

computed to construct an indicator of cancer-related knowledge with raw scores ranging from 0 to 20.

Endorsement of beliefs related to cancers and cancers' causes

To elicit their beliefs related to cancers and cancers' causes, respondents were asked the extent to which they endorsed 20 statements on a 4-point scale "not at all", "not really", "somewhat" or "absolutely". The 10 first statements were related to cancers as diseases and the 10 last statements were related to cancers' causes. These questions were adapted from Guilbert et al. (2006) and Beck and Gauthier (2012).

Our objective here was to construct a score of beliefs' endorsement. However, the Cronbach alpha associated with cancers' related beliefs questions showed low scale reliability (α=0.41). Thus, we analyzed item-rest correlations and conducted a Multiple Correspondence Analysis (MCA) to improve the meaning of our score. Details can be found in Appendix 2, Section 2.3.4. Results showed a consistent pattern of answers among respondents answering "absolutely" to the following cancer-related beliefs:

- It is possible to prevent cancer occurrence by our daily behaviors.
- Cancer is a disease affecting only elderly.
- Cancer is a chronic disease among others.
- It is possible to have a similar life before and after a cancer.
- Cancer is a disease which can nowadays be cured.

Consequently, a score, with raw values ranging from 0 to 5, was created taking the value 1 for each "absolutely" answer to these 5 beliefs. This variable is used in multivariate analyses and the associated Cronbach alpha is acceptable (α=0.52).

The same procedure was followed regarding beliefs related to cancers' causes.

First, "I don't know" answers were analyzed separately because DK answers appeared to be really consistent with each other. The associated Cronbach alpha showed a high scale reliability (α=0.83) and MCA results showed a very consistent pattern of answers among respondents answering "I don't know" to the 10 beliefs related to cancers' causes. Consequently, a score, ranging from 0 to 10, was created taking the value 1 for each "I don't know" answer to these 10 beliefs.

Then, a Cronbach alpha on other modalities of answer was computed showing an acceptable scale reliability (α=0.60) and a multiple correspondence analysis was conducted. Details can be found in Appendix 2, Section 2.3.5. Results showed a consistent pattern of answers among respondents answering "absolutely" to 8 beliefs related to cancers' causes:

- Breathing the air in cities is worse for health than smoking cigarettes daily.
- Keeping a healthy weight using diet is more important than being physically active.
- Drinking alcohol, even moderately, increases significantly the risk of developing cancer.
- Eating 5 fruits and vegetables per day has a significant protective effect on the risk of cancer.
- Living in the periphery of large cities near a highway increases significantly the risk of cancer.
- Drinking sodas and eating hamburgers is as bad for the health as drinking alcohol.
- Eating industrial-cooked dishes is as good for the health as eating self-cooked dishes.
- Taking the pill for many years increases significantly the risk of some cancers.

Consequently, a score, ranging from 0 to 8, was created taking the value 1 for each *"absolutely"* answer to these 8 beliefs. This variable is used in multivariate analyses and the associated Cronbach alpha is slightly improved (α=0.63).

Worry and Salience

Cancers-related worry was elicited by asking respondents if they "never", "sometimes", "from time to time" or "often" happen to be or have ever been worried about having a cancer one day in their lifetime. A dummy variable was created to indicate if a respondent declared to be "from time to time" or "often" worried.

Regarding salience of the issue of cancers stemming from environmental factors, respondents were asked if they "not at all", "not really", "somewhat", or "absolutely" feel personally concerned about the issue of cancers stemming from environmental factors. A dummy variable was created to indicate if a respondent declared to feel "somewhat" or "absolutely" personally concerned.

Perceived voluntariness and control of risks' exposure

Perceived voluntariness of exposure was defined as the extent to which an individual perceives his exposure to a specific risk chosen or imposed. Respondents were thus asked the extent to which they think they can choose to be or not be personally exposed to environmental factors in general, as well as the extent to which they think they can avoid to be exposed to each of the 22 environmental factors on 4-point scales ("not at all", "not really", "somewhat" or

"absolutely"). Dummy variables were created to indicate if a respondent perceived each exposure as somewhat or absolutely avoidable.

Perceived control was elicited by asking respondents the extent to which they think they can control cancers' occurrence in their remaining lifetime and the extent to which they can control their exposure to each of the 22 environmental factors on 4-point scales ("not at all", "not really", "somewhat" or "absolutely"). Dummy variables were created to indicate if a respondent perceived each exposure as somewhat or absolutely controllable.

Personal health history and sociodemographic characteristics

Respondents were asked whether they perceived their current health status to be "very poor", "poor", "fair", "good", or "very good". One dummy variable was created to indicate if respondents perceived their current health status very poor or poor and another one to indicate if respondents perceived their current health status good or very good.

Personal history of cancer(s) and chronic disease(s) or disorder was assessed by asking respondents if they have, or had, at least one history of chronic disease or disorder in their lifetime. A dummy variable was created to indicate if respondents answered "yes". Another dummy variable was created to indicate if respondents selected "cancer" in the proposed list of chronic disease(s) or disorder(s).

Gender, age, highest degree completed, socio-professional category, marital status, number of children, number of children living in the household (more or less than 18 years-old), net annual household income category and degree of urbanization of the living area were collected.

2.2 Empirical strategy

MCA were conducted to identify common pattern of answers among respondents (Roux and Rouanet 2010). Contribution of each item's modalities to the first axis was compared to the mean inertia to identify the significantly contributing variables. All contributive-modalities were also checked for positive correlation between themselves and for negative or no correlation on the second axis. Three patterns of answers were pointed out: answering "don't know", answering "almost none" and answering "very high". After checking for internal-consistency reliability, three simple additive scores were calculated and varied from 1 to 22 (α_{dk} = 0.94, α_{an} = 0.88, α_{vh} = 0.88). Perceptions of cancers' risks in general were excluded because modalities were not significantly contributive. Besides, perceptions of cancers' risks stemming

from taking the pill were also kept aside as only women were concerned by this question. Dummy variables were thus created to indicate when individuals answered DK, Almost None or Very High to questions related to risk perceptions. Three simple additive scores were then computed to count respondents' number of DK, AN and VH answers. Relationships between independent variables and these three scores were estimated with Zero-Inflated Poisson (ZIP) regressions integrating robust standard errors (Cameron and Trivedi 2010).

Based on findings from another study (Peretti-Watel et al. 2016) and correlations between risk perceptions, four groups of perceptions were constructed:

- The first one gathered respondents' perceptions of their risks to develop cancers stemming from health-related behaviors, i.e. smoking, passive smoking, alcohol consumption, sun exposure, diet rich in fat and sugar, diet rich in red meats and low physical activity ($\alpha_{behav} = 0.84$).
- The second group includes perceptions of cancers' risks stemming from environmental exposures, i.e. asbestos, indoor radon exposure, pesticides through food consumption, pesticides through air breathing, air pollution and presence of nuclear industries ($\alpha_{expo\_env} = 0.84$).
- The third group includes perceptions of cancers' risks stemming from consumption's products, i.e. mobile phones, Wi-Fi, paints without ecological label, cosmetic products, home care products and taking hormonal treatments ($\alpha_{cons} = 0.82$).
- The fourth group includes perceptions of cancers' risks stemming from negative emotions, i.e. stress in daily life and negative emotional shocks ($\alpha_{emo\_neg} = 0.78$).

Perceptions of cancers' risks in general were excluded because correlations with other risk perceptions were poor. Perceptions of cancers' risks stemming from genetics were also analyzed apart because genetics is considered as a specific factor since it is not included in the definition of the environment. In addition, Cronbach's alpha between these variables was not high enough to combine them ($\alpha = 0.42$). Like in the first multivariate analysis, risk perceptions of cancers' risks stemming from taking the pill were kept aside as only women were concerned.

These four scores of perceptions of cancers' risks stemming from health-related behaviors, environmental exposures, consumption products and negative emotions were constructed by summing respondents' answers to the associated risk perception questions. Relationships between independent variables and these four scores were estimated with Ordinary Least Squared (OLS) regressions integrating robust standard errors (Cameron and Trivedi 2010). Corresponding scores of perceived control and voluntariness of associated risks' exposure were also calculated.

Relationships between independent variables and perceptions of cancers' risks in general and cancers' risks stemming from genetics as well as from taking the pill among women were estimated with Ordered Logistic regressions integrating robust standard errors with almost none (=1), low (=2), high (=3), very high (=4) (Cameron and Trivedi 2010), while answering "I don't know" to these questions was analyzed with simple logistic regressions integrating robust standard errors.

Independent variables integrated in the regressions were related to affect heuristic (cancers' perceptions), availability heuristic (indirect experience of cancer), knowledge, beliefs related to cancers and cancers' causes, worry, salience, perceived voluntariness and perceived control.

Personal health history was integrated as covariate and included personal history of chronic disease(s) or disorder vs. none, history of cancer vs. none, good perceived health status, (ref. neutral perceived health status), poor perceived health status.

Sociodemographic characteristics integrated as covariates were the following: gender, age and age-squared, living in a couple, having children, secondary school completed, professional degree, (ref. high school completed), college degree lower than graduation or equivalent completed, college degree at least equal to graduation or equivalent completed, net annual household income not declared, (ref. 25% lowest net annual household income declared adjusted on household consumption units), 25%-50% adj-NAHI, 50%-75% adj-NAHI, 25% highest adj-NAHI, living in rural area or with less than 20 000 inhabitants, (ref. living in area comprising between 20 000 and 199 999 inhabitants) and living in area comprising 200 000 inhabitants and more.

Regression results are reported as exponentiated coefficients and odd-ratios to allow effects'comparison. Because of the multiple tests conducted, only results with $p<0.01$ are interpreted. All statistical analyses were conducted using Stata 11 (Stata, College station, Texas).

3 Results

3.1 Descriptive statistics

Sociodemographic characteristics and personal health history have been displayed in Chapter 3, Section 3.1 and thus are not detailed here.

Respondents' perceptions of their cancers' risks in general and cancers stemming from genetics as well as from environmental factors are displayed in Table 14. This table also displays perceived control and perceived voluntariness of risks' exposure.

As shown in Chapter 3, high perceived risks to develop cancers in remaining lifetime were the highest for cancers stemming from outdoor air pollution (53%), pesticides through food consumption (49%) or air breathing (46%) and stress in everyday life (46%). On the contrary, low perceived risks to develop cancers in remaining lifetime were the highest for cancers stemming from use of cosmetic products (69%), alcohol consumption higher than daily public health recommendations (65%) and use of home care products (64%). Almost half of respondents declared to not know their own risk of developing a cancer during their remaining lifetime (general cancers' risks: 43% DK). The same level of DK answers was found on perception of cancers' risks stemming from indoor radon exposure (42% DK).

Regarding perceived voluntariness and control of risks' exposure, they are the highest for excessive alcohol consumption (91%, 93%), diet rich in fat and sugar (90%, 90%) and rich in red meats (88%, 91%) whereas perceived involuntariness and un-control of exposure are the highest for outdoor air pollution (76%, 80%), pesticides exposure through breathing air (75%,80%) and presence of nuclear industries (70%,74%). Cancers' occurrence in general is perceived uncontrollable by a majority of respondents (86%) and in a lesser extent perceived avoidable (58%).

Table 14 Respondents' perceptions of their cancers' risks in general and cancers stemming from genetics as well as from environmental factors, perceived control, and perceived voluntariness, ranked by the decreasing proportion of high perceived risk

	Perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors															Perceived voluntariness of risks' exposure				Perceived control of risks' exposure			
	Almost none		Low		High		Very high		DK		Total	High RK		Low risk		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	N	%	N	%	N	%	N	%	N	%	N	%
Outdoor air pollution	73	5	463	31	585	40	197	13	160	11	1478	782	53	536	36	351	24	1127	76	292	20	1186	80
Pesticides through food consumption	84	6	468	32	468	32	244	17	214	14	1478	712	48	552	37	667	45	811	55	608	41	870	59
Pesticides through air breathing	131	9	477	32	442	30	240	16	188	13	1478	682	46	608	41	370	25	1108	75	299	20	1179	80
Stress	126	9	524	35	509	34	173	12	146	10	1478	682	46	650	44	593	40	885	60	581	39	897	61
Smoking	590	40	160	11	275	19	370	25	83	6	1478	645	44	750	51	1237	84	241	16	1237	84	241	16
Unprotected sun	197	13	588	40	381	26	203	14	109	7	1478	584	40	785	53	1130	76	348	24	1147	78	331	22
Diet rich in fat and sugar	125	8	618	42	472	32	109	7	154	10	1478	581	39	743	50	1328	90	150	10	1328	90	150	10
Cancers	15	1	263	18	470	32	97	7	633	43	1478	567	38	278	19	617	42	861	58	202	14	1276	86
Genetics	133	9	553	37	375	25	164	11	253	17	1478	539	36	686	46	.	.	.	.	.	.	.	.
Presence of nuclear industries	294	20	462	31	311	21	220	15	191	13	1478	531	36	756	51	440	30	1038	70	378	26	1100	74
Negative emotional shocks	190	13	595	40	399	27	117	8	177	12	1478	516	35	785	53	584	40	894	60	536	36	942	64
Secondhand smoking	350	24	512	35	324	22	188	13	104	7	1478	512	35	862	58	953	64	525	36	923	62	555	38
WIFI	184	12	576	39	372	25	93	6	253	17	1478	465	31	760	51	542	37	936	63	514	35	964	65
Asbestos	440	30	382	26	172	12	286	19	198	13	1478	458	31	822	56	823	56	655	44	673	46	805	54
Physical inactivity	256	17	657	44	337	23	78	5	150	10	1478	415	28	913	62	1129	76	349	24	1189	80	289	20
Excessive alcohol consumption	548	37	410	28	284	19	127	9	109	7	1478	411	28	958	65	1340	91	138	9	1373	93	105	7
Mobile phones without hand-free kit	264	18	604	41	305	21	91	6	214	14	1478	396	27	868	59	583	39	895	61	568	38	910	62
Taking the pill : women only	219	29	250	33	142	19	53	7	94	12	758	195	26	469	62	556	73	202	27	591	78	167	22
Diet rich in red meats	217	15	707	48	317	21	62	4	175	12	1478	379	26	924	63	1303	88	175	12	1340	91	138	9
Cleaning products	194	13	747	51	284	19	53	4	200	14	1478	337	23	941	64	998	68	480	32	1160	78	318	22
Paints not labeled as ecologial	315	21	549	37	228	15	71	5	315	21	1478	299	20	864	58	872	59	606	41	773	52	705	48
Indoor radon exposure	242	16	336	23	188	13	87	6	625	42	1478	275	19	578	39	489	33	989	67	408	28	1070	72
Hormonal treatments	610	41	338	23	211	14	64	4	255	17	1478	275	19	948	64	1170	79	308	21	1179	80	299	20
Cosmetic products	419	28	612	41	178	12	55	4	214	14	1478	233	16	1031	70	1179	80	299	20	1263	85	215	15

Affect and availability heuristics, score of knowledge, score of absolute endorsement of beliefs related to cancers and cancers' causes, cancer-related worry and salience of the issue of cancers' risks stemming from environmental factors are reported in Table 15.

Cancer is perceived as one of three most serious diseases by the majority of respondents (86%). The mean score of cancers' perception is negative (-10.8) and data dispersion shows that 75% of the sample had a score lower that -6 implying a general negative affect heuristic associated with cancers among our sample. The majority of our sample (78%) declared indirect experience with cancer, concerning a close family member (54%) or a friend (11%). One fourth declared a very strong experience (25%) and for half of the sample the outcome had a negative valence (53%).

The mean score of knowledge is 12.54 meaning that respondents gave on average two third (between 12 and 13) of right answers. No respondent is fully unaware or knowledgeable as number of right answers varied between 4 and 18.

On average, respondents absolutely endorsed 2.17 (sd. 1.19) beliefs related to cancers. It is noteworthy that one third of them endorsed at least one statement (31%). Regarding cancers' causes related beliefs, on average, respondents absolutely endorsed 4.04 (sd. 1.96) statements and two third endorsed strongly at least one statement (63%). On average, respondents answered I don't know to 1.67 (sd. 2.31) beliefs related to cancers' causes and two third answered I don't know to at least one statement (66%).

Fewer respondents declared to be worried (42%) about having a cancer one day in their lifetime than respondents declaring to be not worried (58%). Inversely, more respondents declared to feel concerned (59%) about the issue of cancers stemming from environmental factors than respondents feeling not concerned about this issue (41%).

Table 15 Additional determinants of perceptions of cancers' risks

	Yes		No	
	N	%	N	%
Heuristics				
Affect heuristic				
Cancer as 1 of the three most serious diseases	1267	86	211	14
Score of cancers' perception	Mean (sd): -10.76 (8.75)			
Q1 (<25%) [-21 ; -15[	340	23	1138	77
Q2 (25%-50%) [-15 ; -15]	458	31	1020	69
Q3 (50-75%)]-15 ; -6]	342	23	1136	77
Q4 (75%-100%)]-6 ; 15]	327	22	1152	78
Availability heuristic				
Moderate indirect cancer experience	320	22	1158	78
Strong indirect cancer experience	454	31	1424	69
Very strong indirect cancer experience	376	25	1102	75
Negative indirect cancer experience	782	53	696	47
Neutral indirect cancer experience	51	3	1427	97
Positive indirect cancer experience	317	21	1161	79
Someone indirect cancer experience	190	13	1288	87
Close family indirect cancer experience	801	54	677	46
Friend indirect cancer experience	169	11	1299	89
Knowledge				
Score of knowledge	Mean (sd): 12.54 (2.23)			
Q1 (<25%) [4 ; 11[	240	16	1238	84
Q2 (25%-50%) [11 ; 12]	433	29	1045	71
Q3 (50-75%) [13 ; 14]	544	36	934	63
Q4 (75%-100%)]14 ; 17]	261	18	1217	82
Endorsement of beliefs related to cancers and cancers' causes				
Score of endorsement of cancers-related beliefs	Mean (sd): 0.45 (0.82)			
Absolute endorsement of none of the beliefs	1026	69	452	31
Absolute endorsement of one belief	311	21	1167	79
Absolute endorsement of two beliefs and more	141	10	1337	90
Score of endorsement of cancers' causes-related beliefs	Mean (sd): 1.41 (1.56)			
Absolute endorsement of none of the beliefs	556	37	922	63
Absolute endorsement of one belief	340	23	1138	77
Absolute endorsement of two beliefs	266	18	1212	82
Absolute endorsement of three beliefs	172	12	1306	88
Absolute endorsement of four beliefs and more	144	10	1334	90
Score of DK answers to cancers' causes-related beliefs	Mean (sd) : 1.67 (2.31)			
DK answers to none of the beliefs	648	44	830	56
DK answers to one of the beliefs	292	20	1186	80
DK answers to two of the beliefs	160	11	1318	89
DK answers to three of the beliefs	145	10	1333	90
DK answers to four beliefs and more	233	15	1245	85
Worry and salience				
Being worried about having a cancer one day in their lifetime	617	42	861	58
Feeling concerned about issue of cancers stemming from environmental factors	875	59	603	41

3.2 Econometric analyses

Results are displayed in Table 16.

The following interpretations have to be considered all other things being equal.

Relationship between risk perceptions and affect heuristic, availability heuristic

All parameters associated with variables related to affect heuristic are not significant and most of parameters with variables related to availability heuristic were also not significant.

Regarding availability heuristic, a very strong experience with cancers, compared to a moderate experience, increases significantly the odds of perceiving increasing own cancers' risks in general and stemming from genetics. Compared to a moderate indirect experience with cancers, a very strong or a strong experience with cancers significantly decreases the odds of answering "I don't know" to questions related to own cancers' risks stemming from genetics. In addition, the score of perceptions of cancers' risks stemming from negative emotions is significantly higher for individuals with very strong indirect experience of cancers. Having a first-degree relative with cancer history also increases significantly the odds of perceiving increasing own cancers' risks stemming from genetics.

Our assumption that increasing negative affect is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors is not supported. However, we found a weak support to our assumption that strong indirect experience with cancers is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics, but not from environmental factors.

Relationship between risk perceptions and knowledge

Our analyses show that the higher an individual's knowledge score is, the fewer are the number of expected DK answers to risk perceptions questions and the less likely an individual is a certain zero Almost none answers to risk perceptions questions.

Other parameters associated with knowledge were not significant.

We found very weak support to our assumption that knowledge is a determinant of perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

However, we found a relationship between tendencies to answers I don't know and almost none and knowledge related to environmental factors and their link with cancers.

Relationship between risk perceptions and absolute endorsement of beliefs

Our analyses show that the higher an individual's score of absolute endorsement of cancers-related beliefs, the higher is the expected number of Almost None and Very High answers to risk perceptions questions.

In addition, the higher an individual's score of absolute endorsement of cancers' causes-related beliefs, the higher is the expected number of Very High answers to risk perception questions and the less likely an individual is a certain zero Very High answers to risk perceptions questions. Increasing score of absolute endorsement of cancers' causes-related beliefs is significantly associated with higher score of perceptions of cancers' risks stemming from environmental exposures, consumption products and negative emotions.

On the contrary, the higher an individual's score of DK answers to cancers' causes-related beliefs, the less likely an individual is a certain zero DK answers to risk perceptions questions but the higher is the expected number of DK answers to risk perception questions and the more likely he is a certain zero Very High answers to risk perceptions questions. Increasing score of DK answers to cancers' causes-related beliefs is significantly associated with lower score of perceptions of cancers' risks stemming from behaviors, environmental exposures, consumption products and negative emotions. On the contrary, increasing score of DK answers to cancers' causes-related beliefs is significantly associated with higher likelihood to answer "I don't know" to questions related to own cancers' risks in general and stemming from genetics as well as stemming from taking the pill for women only.

Our assumption that endorsement of beliefs related to cancers and cancers' causes is a determinant of perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors is well supported.

Relationship between risk perceptions and worry, salience

Being worried about having a cancer one day in remaining lifetime increases significantly the odds of perceiving increasing own cancers' risks in general and stemming from genetics.

Compared to not feeling personally concerned about the issue of cancers stemming from environmental factors, feeling personally concerned significantly decreases the expected number of Almost None answers while it significantly increases the expected number of Very High answers to risk perceptions questions. It also increases significantly the odds of being in the zero Almost None answers group. The scores of perceptions of cancers' risks stemming from behaviors, environmental exposures, consumption products and negative emotions were significantly higher for individuals feeling personally concerned about the issue of cancers stemming from environmental factors than those who did not. Feeling personally concerned rather than feeling not concerned about the issue of cancers stemming from environmental factors also increases significantly the odds of perceiving increasing own cancers' risks in general.

We found moderate support to our assumption since being worried about having a cancer one day in remaining lifetime is associated with high rather than low perceptions of cancers' risks in general and stemming from genetics but not from environmental factors. We found a good support to our assumption related to salience since salience of the issue of cancers stemming from environmental factors is significantly associated with high rather than low perceptions of cancers' risks in general and stemming from environmental factors but not from genetics.

Relationship between risk perceptions and perceived voluntariness, perceived control

All parameters associated with perceived voluntariness of risks' exposure are not significant.

Perceiving cancers' occurrence as controllable rather than uncontrollable decreases significantly the odds of perceiving increasing own cancers' risks in general. Other parameters associated with perceived control of risks' exposure are not significant.

We found no support to our assumption that perceiving risks' exposure as avoidable is associated with low rather than high perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors. However, we found very weak support to our assumption related to perceived control since perceiving risks' exposure as controllable is associated with low rather than high perceptions of cancers' risks in general but neither with cancers' risks stemming from genetics nor from environmental factors.

Risk perceptions and personal health history and sociodemographic characteristics

All parameters associated with personal history of cancer and of history chronic disease(s) or disorder are not significant with one exception. Compared to none, having a personal history of cancer significantly increases the odds of answer "I don't know" to perception of own cancers' risks stemming from taking the pill. In addition, individuals perceiving their current health status as good are more likely than those perceiving current health status as fair to be in the zero Very High answers group. Moreover, perceiving current health status as poor rather than fair increases significantly the odds of perceiving increasing own general cancers' risks. The score of perceptions of cancers' risks stemming from negative emotions is also significantly higher for individuals perceiving current health status as poor rather than fair.

Regarding gender, only two associations are significant. The scores of perceptions of cancers' risks stemming from consumption products and negative emotions are significantly higher for women than for men. Regarding age, no quadratic associations are significant at a 1% level. The only significant result is that increasing age is significantly associated with lower score of perceptions of cancers' risks stemming from behaviors. All parameters associated with living in a couple, having children and education level were not significant.

The score of perceptions of cancers' risks stemming from consumption products is significantly lower for individuals who preferred to not declare their household income than those who declared it. These individuals have also higher odds to answer "I don't know" to question related to perceptions of cancers' risks in general. In addition, parameters associated with net annual household income category adjusted on the number of consumption units in the household show that increasing adj-NAHI decreases the expected number of DK answers to risk perceptions questions. Compared to having an adj-NAHI in the first quartile, having an adj-NAHI in the second quartile, third quartile and fourth quartile decreases respectively by a factor of 0.76, 0.72 and 0.70 the expected number of DK answers to risk perceptions questions.

Table 16 Multivariable regressions results: determinants of individuals' perceptions of their own general cancers' risks and cancers' risks stemming from behaviors, environmental exposures, consumption products, negative emotions, genetics and, among women, taking the pill

	DK answers		Almost none answers		Very high answers		Behaviors	Environmental exposures	Consumption products	Negative emotions	Cancers' risks in general		Genetics		Taking the pill	
Models	Zero-inflated poisson		Zero-inflated poisson		Zero-inflated poisson		OLS	OLS	OLS	OLS	Ologit	Logit	Ologit	Logit	Ologit	Logit
Format y	Continuous	Zero	Continuous	Zero	Continuous	Zero	Continuous	Continuous	Continuous	Continuous	Categorical (1-4)	Binary (DK)	Categorical (1-4)	Binary (DK)	Categorical (1-4)	Binary (DK)
N	874	604	1066	412	753	725	1478	1478	1478	1478	845	1478	1225	1478	664	758
Cancer: 1 of 3 serious	0.941	1.228	0.968	0.985	0.928	1.115	1.089	1.430	0.845	1.143	0.769	1.163	0.873	0.905	0.845	1.471
Cancers' perception	0.999	1.000	1.007*	1.004	1.003	1.014*	0.981	0.976	0.994	0.993	0.985	1.012	0.996	1.009	0.987	0.986
Very strong intensity	0.940	1.544*	1.091	1.016	1.086	0.728	1.760	1.600	1.445	1.545**	1.803**	0.585**	1.726**	0.827	1.062	0.845
Strong intensity	1.005	1.231	0.961	0.925	0.938	0.865	1.335	0.926	0.969	1.279	1.231	0.643**	1.310	0.800	0.848	0.496*
Moderate intensity	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FDR	0.986	0.786	0.983	0.950	1.093	0.938	1.123	0.784	0.748	1.077	1.473	0.976	2.066**	1.217	0.838	1.431
Friend	0.857	0.747	0.968	0.799	1.233	1.073	0.940	0.733	1.231	1.256	1.449	0.956	1.280	1.310	1.025	2.293
Other link	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Positive valence	0.804	0.846	0.920	0.919	0.846	0.786	1.803	1.507	2.078	0.964	1.237	0.875	0.825	0.852	1.504	0.567
Neutral valence	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Negative valence	0.860	0.731	0.991	0.861	0.966	0.946	1.235	1.355	1.078	0.885	1.213	0.986	0.892	0.962	1.322	0.813
Knowledge	0.959**	0.953	1.002	0.932**	0.979	1.041	0.975	0.968	1.030	1.031	0.984	1.019	0.982	0.972	0.952	0.881*
Cancers-related beliefs	0.944	0.967	1.103**	1.119	1.154**	0.961	1.059	1.293	1.050	0.950	0.936	0.962	0.973	1.072	1.072	0.846
Cancers' causes related beliefs	0.932*	0.967	1.015	0.905*	1.068**	0.832**	1.228*	1.318**	1.279**	1.142**	1.115*	0.984	1.013	0.990	1.059	0.942
DK answers to beliefs	1.129**	0.758**	1.013	1.052	1.010	1.083**	0.554**	0.506**	0.524**	0.808**	1.064	1.145**	1.003	1.277**	0.937	1.347**
Worry	0.958	0.913	0.911	1.032	1.060	0.730*	1.619	1.155	1.226	1.222	2.118**	0.803	1.595**	0.837	1.367	1.375
Salience	1.011	0.984	0.786**	1.594**	1.328**	0.811	2.980**	7.845**	2.018**	1.498**	1.532**	0.915	1.330*	1.205	1.317	0.882
Perceived voluntariness	1.065	1.038	1.015	1.133	0.977	0.750*	1.132	1.036	1.224*	1.012	1.035	1.043	1.231	1.124	0.761	0.765
Perceived control	1.188	1.125	1.102	1.379	1.105	1.275	0.804	0.979	0.877	0.859*	0.466**	0.881	0.732	0.936	0.664	0.530
History of cancer	1.272	0.916	0.982	0.452	0.869	0.877	0.373	0.673	0.366	0.759	1.379	0.822	0.659	1.077	1.688	5.098**
Hystory of chronic disease	0.911	0.944	0.935	0.865	1.095	1.000	1.557	1.543	1.362	1.321*	0.922	0.874	1.216	0.838	0.777	0.786
Good perceived health	0.942	1.042	1.066	0.914	1.004	1.515**	0.670	0.858	1.130	0.808	0.814	1.240	0.750*	0.888	0.821	0.867
Fair perceived health	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Poor perceived health	0.870	1.158	0.962	1.026	1.025	0.650*	2.752*	2.046	1.557	1.724**	1.861**	0.848	1.539*	0.885	1.227	0.930
Being woman	0.919	0.951	0.939	1.160	1.085	0.944	0.927	1.218	2.410**	1.511**	1.073	1.145	1.199	0.839	1	1
Age	1.030	0.988	0.998	0.998	0.982	1.038	0.842**	0.873*	0.934	1.016	1.075*	1.000	1.006	1.096*	0.951	1.013
Age-squarred	1.000	1.000	1.000	1.000	1.000	1.000	1.002*	1.001	1.000	1.000	0.999*	1.000	1.000	0.999*	1.000	1.000
Living in a couple	1.053	1.310	1.044	1.075	0.955	1.062	0.768	0.730	1.222	0.990	0.984	0.928	1.064	0.863	1.337	0.921
Having children	0.940	1.026	1.043	1.022	0.897	0.884	0.863	0.971	0.968	0.989	1.155	1.086	1.133	0.857	0.848	0.925
Secondary school completed	1.015	0.648	1.062	0.937	1.008	1.224	0.465	0.693	0.694	0.704	0.844	1.394	0.751	1.239	0.745	0.681
Professional degree	1.022	0.907	1.033	1.320	1.071	0.992	1.004	1.666	0.828	0.972	0.872	1.357	0.894	0.905	1.133	0.485
High school degree	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HSD + 2/3/4 years	0.930	0.914	0.947	0.812	0.884	1.082	0.523	0.681	1.147	1.057	1.270	1.001	1.045	0.837	0.745	0.932
HSD ≥ 5 years	0.840	0.785	0.937	0.549*	0.958	1.366	0.437	0.754	1.048	1.425	1.572	0.813	1.034	1.654	0.801	0.499
NoNAHIdeclared	1.013	0.615*	1.013	0.785	0.785*	1.336	0.498	0.333*	0.284**	0.831	0.778	1.664**	0.817	1.527	0.572*	1.006
1st 25% adj-NAHI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2nd quarter	0.760**	0.768	0.911	0.725	0.872	0.985	1.628	1.042	0.984	1.003	1.007	1.200	0.971	1.002	0.665	0.909
3rd quarter	0.718**	0.760	1.023	0.635*	0.848	1.028	0.951	0.927	0.637	0.861	0.807	1.428*	0.861	0.756	0.648	0.589
4th quarter	0.700**	0.875	1.040	0.752	0.919	1.472*	1.363	0.956	0.675	0.975	0.685	1.149	0.769	0.753	0.586*	0.728
rural_less20000	0.931	0.920	0.952	0.877	1.171	1.034	0.952	1.179	1.353	1.163	1.240	0.871	0.954	1.128	0.853	0.875
Area (20 000 -199 999)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
urban_200000_more	0.971	0.839	0.931	1.276	1.245*	0.743	1.708	1.794	1.702	1.132	1.184	0.883	0.934	0.882	1.107	1.637
Log-likelihood	-3693.8		-3985.0		-2949		-4506.2	-4474.4	-4199.8	-2945.7	-766.6	-952.5	-1419.7	-612.9	-722.9	-230.9
McFadden (adj) / R^2 /Peuso R^2	0.146		0.031		0.063		0.1346	0.1868	0.2020	0.2009	0.1014	0.0562	0.0590	0.0940	0.0800	0.1873
BIC	7913		8495		6424		9275	9211	8662	6154.16	1789	2168	3110	1489	1786	693.91

Exponentiated coefficients; * $p < 0.05$, ** $p < 0.01$

4 Discussion

In this chapter, we analyzed whether affect heuristic, availability heuristic, knowledge, beliefs, worry, salience, perceived voluntariness and perceived control of risks' exposure are determinants of individuals' perceptions of their own cancers' risks in general and stemming from genetics as well as from environmental factors.

Interestingly, we found three tendencies of answers among our respondents to questions related to perceptions of cancers' risks: answering "I don't know", "Almost None" and "Very High". Then, apart from endorsement of beliefs related to cancers and cancers' causes, we did not find strong support to our assumptions related to the determinants of individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

However, some of our findings raise interesting issues and lead us to discuss them.

4.1 Perceptions of cancers' risks and don't know answers

Among perceptions of cancers' risks stemming from genetics and from environmental factors, the proportion of DK answers is lower than for perceptions of cancers' risks in general. This finding highlight the fact that it may be easier for people to define their cancers' risks when associated with a specific factor rather than with a general disease and thus support the importance of self-relevance in risk research. In addition, the association with specific environmental factors polarized individuals' risk perceptions since we found two opposed patterns of answers, "Almost none" and "Very high" when we conducted our MCA. The third pattern is related to don't know answers. The extent to which respondents answered "I don't know" to questions related to their perceptions of their cancers' risks stemming from genetics as well as from environmental factors seem to be significantly influenced by their level of knowledge and their endorsement of beliefs as well as their household income level. Interestingly, don't know answers were shown to be often displayed by vulnerable populations (Hay et al. 2015; Waters et al. 2016). Consistently, we found that increasing household income is associated with decreasing number of DK answers for questions related to risk perceptions. In addition, respondents who preferred not to declare their income were more likely to not know their own risk to develop cancers in general. Further analyses should thus be conducted regarding the extent to which DK answers are influenced by income levels and find a better way to handle the influence of education and income levels since we did not find the expected effect of education on DK risk perceptions answers.

4.2 Relationships between perceptions of cancers' risks and heuristics

Regarding affect heuristic, cancers were perceived as the most severe diseases across a range of serious illness and were associated with negative words and feelings within our sample. This is consistent with previous research conducted in the field (Klein and Stefanek 2007; Beck et al. 2009; Han et al. 2009; Lemal and Van den Bulck 2009; Wang et al. 2009; Lipworth et al. 2010; Shiloh et al. 2013; Klein et al. 2014; Moser et al. 2014). However, our assumption that individuals for whom cancers evoked strong negative feelings may perceive their own cancer's risk to develop cancers in general and cancers stemming from genetics as well as from environmental factors as high rather than low was not supported. Nonetheless, even if non-significant, we can observe that increasing negative affect is associated with higher scores of perceptions of cancers' risks stemming from behaviors, environmental exposures, consumption products and negative emotions. Despite the lack of significance, our intuitive measure of affect towards cancers shows promising implications and consistent link with theoretical assumption (Tversky and Kahneman 1974; Finucane et al. 2000; Slovic et al. 2004). Using this measure in other studies, on other sample of respondents, in order to test its validity might be a step for future research.

Regarding availability heuristic, we did not find like previous research that cancer history among family, friends or colleagues, compared to none, is associated with higher perceptions of cancers' risks in general (Montgomery et al. 2003; Robb et al. 2004; Katapodi et al. 2005; Haber et al. 2012; Walker et al. 2013; Kye et al. 2015; Peipins et al. 2015). However, our result is consistent with the assumption of Llewellyn et al. (2017) suggesting that family history provides a working model to estimate risk of hereditary disease. We actually found that individuals who have a first-degree relative with an experience of cancer are significantly twice more likely, than those who have not, to perceive their risk to develop cancers stemming from genetics as high rather than low. Moreover, we found that very strong or strong indirect experience with cancer decreases one's likelihood to answer that he/she does not know his/her own risk to have cancer and increases one's likelihood to perceive his/her own risks to develop cancers in general as high rather than low, as well as stemming from negative emotions. Interestingly, genetics and negative emotional shocks were stressed by cancer patients in our qualitative study as potential causes of their cancers. As very strong indirect experience with cancer means that respondents experienced the hospital and the everyday life with people who have/had cancers, we may think that respondents were close enough to the person(s) to talk with them about potential causes of their cancer(s). They may have thus talked about the role played by genetics and negative emotions. Fate of loved ones thus may have influenced

individuals' perceptions of cancers' risks in general as well as stemming from genetics and from negative emotions consistently with the mechanism of availability and representativeness heuristics (Tversky and Kahneman 1974; Peters et al. 2006; Pachur et al. 2012; Llewellyn et al. 2017).

4.3 Relationships between perceptions of cancers' risks and knowledge

Previous studies suggested that individual's level of knowledge about cancer and its risk factors is an important determinant of cancer risk perceptions as individuals use information to construct their perception of their own risk of cancer (Smith and Johnson 1988; Fagerlin et al. 2007; Lipworth et al. 2010; Kelly et al. 2012; Klein et al. 2014; Knuth et al. 2014). Among our analyses, we did not find support to this assumption since most relationships between knowledge and risk perceptions were not significant. One explanation may be that individuals may have knowledge about risks at the population level but have difficulties to estimate their own personal risks (Cawley and Ruhm 2012).

4.4 Relationships between perceptions of cancers' risks and endorsement of beliefs related to cancers and cancers' causes

Weinstein stressed that it is important to determine whether people recognize factors altering their risk but also the importance to discover the myths individuals hold about risk factors (Weinstein 1999). Our results actually support the importance of beliefs in determining individuals' perceptions of their risks to develop cancers in general and stemming from genetics as well as from environmental factors.

In addition, Orita et al. (2015) suggest that beliefs about health effects from radiation polarized their respondents' risk perceptions of acute radiation syndrome. We found a similar pattern among our sample: the extent to which individuals endorse or not beliefs related to cancer and cancers' causes polarized their risk perceptions. Increasing number of DK answers to cancers' causes-related beliefs was indeed associated with higher DK answers to risk perceptions questions and lower perceptions of risks. On the contrary, increasing absolute endorsement of beliefs was associated with higher perceptions of risks.

Rather than being associated with individuals' denials of their cancers' risks, individuals' absolute endorsement of beliefs seems on the contrary to be associated with individuals' increasing perceptions of risks. Beliefs may thus work as a potential source of knowledge. This assumption has still to be tested.

4.5 Relationships between perceptions of cancers' risks and worry and salience

Our findings related to worry about developing cancer and concern about the issue of cancers' risks stemming from environmental factors are in line with previous research showing worry (Robb et al. 2004; Robb et al. 2007; Kelly et al. 2012; Shiloh et al. 2013; Denny-Bas et al. 2014; Kiviniemi and Ellis 2014; Peipins et al. 2015; Rice et al. 2015; Chien et al. 2016) and concern about health risks stemming from environmental factors (Dantzker et al. 2010; Ho et al. 2014; Orita et al. 2015) as important determinants of risk perceptions. Nonetheless, our results allow us to go further since cancer-related worry and salience of the issue of the issue of cancers' risks stemming from environmental factors do have a positive influence on perceptions of risks to develop cancers in general. However, while worry increases likelihood to perceive high rather than low risks to develop cancers stemming from genetics, salience increases likelihood to perceive high rather than low risks to develop cancers' stemming from behaviors, environmental exposures, consumption products and negative emotions.

Salience of the issue of cancers' risks stemming from environmental factors is not a widely studied concept unlike worry about cancers but our findings show that it might be promising to integrate salience in studies. It may allow in particular the identification of a specific profile of individuals for whom these issues are salient and thus may have specific risk perceptions as well as may adopt specific health-related behaviors.

4.6 Relationships between perceptions of cancers' risks and perceived voluntariness and control of risks' exposure

Neither perceived voluntariness nor perceived control of risks' exposure were found negatively associated with risk perceptions unlike supported in previous research (perceived voluntariness: Starr 1969; Fischhoff et al. 1978; Slovic 1987; Slovic 1999; Bickerstaff 2004; García et al. 2005; Siegrist et al. 2005; Keller et al. 2009; Denny-Bas et al. 2014; Knuth et al. 2014) (perceived control: Vaughan 1993; Brenot et al. 1998; Rowe et al. 2005; Bränström et al. 2006; Robb et al. 2007; Spector et al. 2009; Wang et al. 2009; Dantzker et al. 2010; Leiter 2011; Matthew et al. 2011; Denny-Bas et al. 2014). The only exception is that perceiving cancers' occurrence as controllable rather than uncontrollable decreases significantly the odds of perceiving increasing own cancers' risks in general.

We may explain our nonsignificant results by our aggregation of factors. We could observe on our data that the proportion of respondents who perceived their exposure to smoking, sun, passive smoking, excessive alcohol consumption, diet rich in fat and sugar, hormonal

contraceptives for women, physical activity, paints not labelled as ecological, hormonal treatments, diet rich in red meats, cosmetic products and cleaning products as controllable and voluntary was higher than the proportion of respondents who perceived their exposure to these factors as uncontrollable and involuntary. The first group of variables we created included smoking, secondhand smoking, alcohol consumption sun exposure, diet rich in fat and sugar, diet rich in red meat and physical activity. In this group, on average, around 80% of respondents perceived their exposure to these factors voluntary and controllable. Inversely, the second group we created gathered asbestos' exposure, indoor radon exposure, pesticides through food consumption, pesticides through air breathing, air pollution and presence of nuclear industries. In this group, on average, around 70% of respondents perceived their exposure to these factors involuntary and uncontrollable. It is thus likely that these too similar positions in variables' groups explain the non-significance of our results. As a consequence, we may have a confounding effect between perceived voluntariness and control of exposure to environmental factors. Thus, in future research we should take into account this issue and create an indicator to whether or not individuals perceive their risks' exposure to these factors voluntary and controllable.

4.7 Perceptions of cancers' risks and personal health history as well as sociodemographic characteristics

Among previous research, personal history of cancer was found in some but not all studies positively associated with enhanced perceptions of cancers' risks (Lipworth et al. 2010; Klein et al. 2014; Moser et al. 2014; Rice et al. 2015). We did not find such an association. As we have few individuals with personal experience of cancer among our sample (n= 37), we may lack the statistical power to find significant associations. In addition, our data are self-reported and not cross-checked with medical records[9]. The only significant association was that women who have a personal experience of cancer, compared to those who do not, are five times more likely to answer that they do not know their risk to develop cancers stemming from taking the pill. At a 5% level, the score of perceptions of cancers' risks stemming from negative emotions is higher for individuals with personal history of chronic disease than those who do not. We can suppose that individuals feeling distress from going through chronic diseases may perceive this distress as a potential cancers' cause. Exploratory additional analyzes tend to support this

[9] We thus acknowledge that our database may contain some inaccuracies regarding respondents' reporting of chronic diseases such as diseases not recognized in the official list of "Assurance Maladie" (Ameli 2017). However, we may assume this as strength rather than weakness since we are analyzing individuals' subjective and not objective appraisals (risk perceptions, perceived control, perceived voluntariness of exposure, etc.).

assumption since individuals with personal history of chronic illness perceived significantly more than individuals without their own risk to develop cancers stemming from stress as very high raising issues regarding the well-being of this category of people.

According to previous research, current health status provides individuals' information about the likelihood of future health outcomes (Carbone et al. 2005). Accordingly, we found that perceiving current health state as poor increases the likelihood to perceive high compared to low risks to develop cancers in general and stemming from negative emotions. Contrarily to the suggestion proposed by Tseng et al. (2013), we did not find that individuals with poor physical health have higher levels of perceived health risks for environmental sources because none of the associations was significant at a 1% level. However, we do find at a 5% level a positive association between perceiving current health status as poor and perceiving high risks to develop cancers stemming from genetics and behaviors. This second point is interesting and calls for further analyses especially on interaction between adoption of health-related behaviors and perceived current health status as well as perceived current health status and conditions because we might be concerned by a high correlation between both.

The findings of our literature review supported a clear gender effect on perceptions of risk. A gender effect also found outside the cancer area (Tseng et al. 2013; Wiedemann et al. 2013; Knuth et al. 2014). However, while we found that women tend to perceive their risks to develop cancers stemming from consumption products and negative emotions significantly higher than men, no other relationship is significant. Interestingly, being woman was associated with higher likelihood to consume fruits and vegetables every day, to avoid passive smoking, to consume organic fruits, vegetables and other products, to limit diet rich in fat and sugar, to limit diet rich in red meat and to protect themselves in case of sun exposure. Thus, woman may not perceive themselves at higher risks of cancers stemming from behaviors than men because they have lifestyles they perceive as not risk-increasing if not protective. Even if the relationship was not significant, it appeared that women tend to perceive their risks to develop cancers stemming from behaviors lower than men. Conducting additional research to analyze the relationships between gender, risk perception and adoption of behaviors might reveal valuable insights in terms of public health policy. Following this focus on women, personal history of cancer among women was found to multiply by five their probability to answer that they do not know their risk of cancer associated with taking the pill. In addition, 49% of our sample somewhat or absolutely agreed that taking the pill for many years increases significantly the risk of developping some cancers. Combining these data may bring valuable insights in the literature available in this field.

Ageing is a fundamental factor in the development of cancer and incidence of cancer increases with age (World Health Organization 2017). Nonetheless, we did not find a significant quadratic effect of age on individuals' perceptions to develop cancers in general and stemming from genetics as well as from environmental factors at a 1% level.

Other sociodemographic characteristics were not found as important determinants of individuals' perceptions of risks.

The limitations related to this quantitative study are already mentioned in Chapter 3.

5 Conclusion

We found three tendencies of answers among our respondents to questions related to perceptions of cancers' risks: answering "I don't know", "Almost None" and "Very High". These tendencies of answers were determined by beliefs' endorsement related to cancers and cancers' causes and knowledge in a lesser extent. Beliefs' endorsement related to cancers and cancers' causes determined also perceptions of cancers' risks stemming from behaviors, environmental exposures consumption products and negative emotions, along with salience of issue of cancers' risks stemming from environmental factors. Perceptions of cancers' risks in general and stemming from genetics were determined by worry about having a cancer one day in remaining lifetime, as well as availability heuristic in a lower extent. Finally, personal health history and sociodemographic characteristics were not found to be major determinants of perceptions of cancers 'risks in general and stemming from genetics as well as from environmental factors.

We now discuss as a whole the work conducted in this thesis and propose future research issues.

GENERAL DISCUSSION

Our thesis first aimed to explore and to analyze individuals' perceptions of their own cancers' risks in general and stemming from environmental factors. The second objective was to investigate the relationships between individuals' adoption of health-related behaviors and perceptions of their own risks to develop cancers when both are elicired regarding cancers in general and stemming from environmental factors. Finally, the third objective was to identify and to analyze the determinants of individuals' perceptions of their own risks to develop cancers in general and stemming from environmental factors.

To meet these objectives, we conducted first, a theoretical and an empirical literature reviews described in Chapter 1 to allow the analysis of the entire context in which our objectives are settled as well as to support the construction of our research questions. While the theoretical literature review has been conducted following a convenience process guided by peer advices and hand search in libraries, the empirical literature review has been conducted following a systematic procedure and led to the writing of an article currently under submission (Authors' draft available in Appendix 1, Section 1.2).

Then, we conducted an exploratory qualitative study, described in Chapter 2, to explore our research topics in a French context allowing us to test their relevance, to validate the understanding of our main concepts in the lay population, to refine our research questions, and to provide inputs for the questionnaire's construction. We conducted individual and group semi-structured interviews conducted respectively with individuals with and without personal cancer history (Article under review in Health, Risk & Society). Findings from this qualitative study showed that cancers' risks stemming from environmental factors were a subject of public interest as 19 environmental factors were cited as potential cancers' causes by the participants. In particular, genetics appeared as an important cancer risk factor to take into account in our analysis while it is not included in the IARC's definition of the environment; it is a widely perceived cancer risk factor in the population. Thus, we decided to elicit in our quantitative survey individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors. Moreover, our participants seemed to have understood the questions similarly, thus, we could expect that our main concepts will be understood among a

representative sample of the French population. Participants' verbatim were used to construct several variables. In particular, we constructed and tested an intuitive approach to capture the affect heuristic associated with cancers by using words associated with cancers in group and individual interviews as multiple choice question's items. Finally, it allowed us to expend our framework related to adoption of health-related behaviors through the integration of prevention-related beliefs.

Finally, we conducted a quantitative study to answer our research questions and to test their related assumptions based on the findings from the literature reviews and the qualitative analysis. A representative survey of the French population aged between 18 and 75 year-olds, recruited by a national survey institute, completed an online auto-administrated questionnaire. Firstly, we explored and analyzed individuals' perceptions of their own risks to develop cancers in general and stemming from genetics as well as from environmental factors. Secondly, we investigated the relationships between individuals' adoptions of health-related behaviors and their perceptions of their cancers' risks in general as well as stemming from genetics and environmental factors, their time preference, their impulsivity, their risk preference and their endorsement of prevention-related beliefs taking into account the endogeneity of risk perceptions as well as personal health history and sociodemographic characteristics (Article under preparation). Thirdly, we analyzed whether the determinants we indentified namely affect heuristic, availability heuristic, knowledge, beliefs' endorsement related to cancers and cancers' causes, cancer-related worry, salience, perceived voluntariness and perceived control of risks' exposure determine individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors. Analyses include also personal health history and sociodemographic characteristics.

Concerning environmental factors French individuals perceive and do not perceive as cancers' risk factors for themselves:

In both the qualitative and the quantitative study, outdoor air pollution and exposure to pesticides were emphasized as potential cancers' causes. In particular, in the quantitative study, cancers stemming from outdoor air pollution and exposure to pesticides were those with the more important proportions of participants who perceived their risks to develop cancers as high.

Participants in the qualitative study mentioned also ageing and genetics whilst genetics is not included in the broad definition of environment (IARC 2017 Jan 26). Moreover, slightly less than half of participants in the quantitative study, perceived their cancers' risks stemming from genetics as high or very high. Consistently with our assumption and international studies

published in the empirical field (Absetz et al. 2000; Silk et al. 2006; Robb et al. 2007; Spector et al. 2009; Jones et al. 2011), genetics thus appear as a widely perceived cancer risk factor within the French population too.

Additionally, in our quantitative study, we found three tendencies of answers on questions related to perceptions of cancers' risks stemming from environmental factors: "Almost None", "Very High" and "I don't know". These tendencies might highlight first, that perceptions of cancers' risks stemming from environmental factors are polarized with individuals perceiving a lot of risks and others perceiving none. This finding is consistent with findings from other studies conducted in France (Beck and Gauthier 2012). Secondly, these tendencies were mainly determined by beliefs' endorsement related to cancers and cancers' causes and knowledge about environmental factors and their link with cancers.

Concerning the relationship between individuals' adoptions of health-related behaviors and their perceptions of their cancers' risks in general and stemming from environmental factors when both are elicited regarding the same factor and taking into account the endogeneity of risk perceptions:

We found partial support to our assumption that perceiving high versus low risks to develop cancers in general and cancers stemming from genetics as well as from environmental factors, based on lifestyle, decreases the likelihood to declare adoption of associated health-related behaviors. However, significance of results was very variable according to the method of estimation used, except for smoking for which results were consistent.

When the endogeneity was not taken into account, we found a significant negative relationship between perceiving high versus low risks to develop cancers stemming from smoking, passive smoking, excessive alcohol consumption, diet rich in fat and sugar, diet rich in red meats, low physical activity and stress in everyday life and adoption of health-related behaviors associated with the same factors, i.e. to declare to have adopted at least one protective behavior against smoking, to avoid smoke from others, to have mindful alcohol consumption, to have diet low in fat and sugar, to have diet low in red meat, to be careful about level of physical activity and to limit stress in everyday life. Howerver, when the endogeneity was taken into account, we found a significant negative relationship only between perceiving high versus low risks to develop cancers stemming from smoking and to declare to have adopted at least one protective behavior against smoking. In addition, we found support that not taking into account the endogeneity of risk perceptions underestimate the effect of risk perceptions on adoption of health-related behaviors, especially in the context of smoking and stress.

Perceptions of cancers' risks might be less endogenous with adoption of health-related behaviors related to the same factors when individuals are asked to picture themselves in their lifestyle, thus potentially limiting the simultaneous bias. However, we expected the endogeneity of risk perceptions to be more supported, thus, caution as to be taken regarding the implications of our results.

An interesting research perspective could consist in analyzing whether individuals use their perceived risk to develop cancers in general as an anchor and adjustment heuristic (Tversky and Kahneman 1974) to assess their perceptions of cancers' risks stemming from environmental factors. The same question could also be studied regarding perceptions of cancers' risks stemming from genetics since Llewellyn et al (2017) found that their respondents evaluated the salience of a risk factor based on family history, environment and lifestyle, and lived experience.

Concerning the relationship between individuals' adoption of health-related behaviors and their time preference, their impulsivity and their risk preference:

We found that increasing present-oriented preference, impulsivity and risk-prone-oriented preference in context of protective behaviors were associated with lower likelihood to declare adoption of health-related behaviors, especially for smoking, diet and physical activity. These results are consistent with other studies conducted in the field (Granö et al. 2004; Chapman 2005; Anderson and Mellor 2008; Chiteji 2010; Scharff and Viscusi 2011; Leonard et al. 2013; Conell-Price and Jamison 2015; Goldzahl 2017). But, we also found increasing risk-prone-oriented preference in context of risk-taking behaviors positively associated with eating fruits and vegetables every day, consuming organic products other than fruits and vegetables, being careful about daily level of physical activity, limiting negative emotional shocks, and stopping to take the pill among women only. Apart from taking the pill, other health-related behaviors are related to well-being and taking care of oneself. These behaviors were actually also reported by participants in our qualitative study who justified their adoption by the wish to take care of their health in general (Chapter 2, Section 3). One fifth of our sample indeed declared to have adopted health-related behaviors because they wanted to have a healthier lifestyle and another fifth to feel well every day. Relationships between these motivations, adoption of health-related behaviors, time and risk preferences might thus be interesting to investigate.

Concerning the relationship between individuals' adoption of health-related behaviors and their endorsement of prevention-related beliefs:

Our findings support strongly that endorsement of beliefs related to prevention determine individuals' adoption of health-related behaviors. More precisely, adoption of health-related behaviors is highly influenced by perceiving cancer prevention as important when the association is significant. Interestingly, some of these health-related behaviors such as searching for information on radon concentration and doing radon measures in home, using ecological paints, having a mindful consumption of cosmetic and home care products, were declared adopted by a minority of respondents. We may thus assume that a specific profile of individuals is concerned by these types of behaviors. In our qualitative study, cancer patients particularly emphasized their perceived importance of cancer prevention. However, we did not find a significant difference in perceived importance of cancer prevention among cancer patients compared to respondents without personal cancer history at a 5% level[10].

In addition, several studies stressed the implications of believing that *"nothing can be done to avoid cancer"* or that "*there's not much you can do to lower your chances of getting cancer"* (Han et al. 2007; Emanuel et al. 2015; Peretti-Watel et al. 2016) on individuals' adoption of health-related behaviors. This belief was actually integrated in the score of cancers-related beliefs suggesting that endorsement of beliefs related to cancers and cancers' causes may also be important determinants of individuals' adoption of health-related behaviors. This assumption is supported in several studies. For instance, Kirk and Greenfield (2017) found that individuals who viewed deepened skin color as a protection against sun burn tend to lower their sunscreen use. Emanuel et al. (2015) found individuals to display greater information avoidance when they believe the outcome is uncontrollable and health behaviors do not influence health outcomes and cancers' occurrence. Analyzing the relationships between endorsement to beliefs' related to cancers and causes' causes and risk perceptions on adoption of health-related behaviors is thus as an interesting future research issue. Similarly, analyzing relationships between endorsement of beliefs' related to cancers and causes' causes and risk perceptions on non-adoption of health-related behaviors is also an interesting future research issue.

[10] We tabulated perceived importance of cancer prevention with personal history of cancer and test of Chi2 was not significant at a 5% level. At a 10% level, individuals with personal cancer history tended more to stressed the importance of cancer prevention than individuals without personal cancer history.

We did not find that personal health history and socio-demographic characteristics were strongly associated with individuals' adoptions of health-related behaviors.

Concerning availability heuristic and affect heuristic as determinants of individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular:

We did not find significant relationship between increasing negative affect heuristic and perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors. This result is surprising in light of findings from our qualitative study and data from our empirical literature review showing that cancers were associated with negative words. We nonetheless found that a very strong indirect experience with cancer (availability heuristic) determines increasing perceptions of cancers' risks in general and stemming from genetics. This result is consistent with the literature in the field (Montgomery et al. 2003; Robb et al. 2004; Katapodi et al. 2005; Haber et al. 2012; Walker et al. 2013; Kye et al. 2015; Peipins et al. 2015) showing that cancer history among close relatives appear as an important determinant of perceptions of cancers' risks in general and stemming from genetics, but not from environmental factors. We may assume that environmental factors are perceived as external elements from the individuals while genetics are perceived as internal elements, and that they do not influence each other.

Concerning knowledge as a determinant of individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular:

We found a relationship between tendencies to answers "I don't know" and "almost none" and knowledge on environmental factors and their link with cancers. In particular, increasing knowledge was associated with decreasing "don't know" answers but did not impact perceptions of cancers' risks in general and stemming from genetics and from environmental factors. One explanation might be that individuals who have this knowledge may know risk factors salient to them, adopt risk-reducing behaviors and thus do not anymore perceive these factors as salient. On the other side, individuals' lack of knowledge has been suggested and shown to explain non adoption of preventive health-related behaviors (Vaughan 1993; Buxton et al. 2003; Honda and Neugut 2004; Spector et al. 2009; Lipworth et al. 2010; Beck et al. 2013; Haluza and Cervinka 2013), while other studies showed that knowledge and information alone were not sufficient to positively influence the adoption of preventive health-related behaviors(Codern et al. 2010; Morgan and Peters 2015; Wang et al. 2017), but are associated

with increase in worry (García et al. 2005; Klein and Stefanek 2007; Lemal and Van den Bulck 2009; Sessa et al. 2010; Matthew et al. 2011). Investigating these interactions between knowledge, worry and risk perceptions on adoption of health-related behaviors is an interesting research issue, especially since risk perception was recently found to mediate the relationship between knowledge and adoption of risk-reducing health-related behaviors regarding pesticides residues (Wang et al. 2017).

Concerning endorsement of beliefs related to cancers and cancers' causes as a determinant of individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular:

We found that beliefs' endorsement is a strong determinant of perceptions of cancers' risks. More precisely, these was a relationship between tendencies to answers "I don't know", "Almost None" and "Very High" to questions related to perceptions of cancers' risks and beliefs' endorsement. Perceptions of cancers' risks stemming from behaviors, environmental exposures consumption products and negative emotions were also determined by beliefs' endorsement. Beliefs might be an embodiment of knowledge, an assumption that still has to be tested. In addition, endorsement of these beliefs might also determine adoption of health-related behaviors as discussed above.

Concerning cancer-related worry and salience to issue of cancers' risks stemming from environmental factors as determinants of individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors in particular:

We found that cancer-related worry and salience of the issue of the issue of cancers' risks stemming from environmental factors do have a positive influence on perceptions of risks to develop cancers in general. However, while worry increases likelihood to perceive high rather than low risks to develop cancers stemming from genetics, salience increases likelihood to perceive high rather than low risks to develop cancers' stemming from behaviors, environmental exposures, consumption products and negative emotions. Previous studies showed the mediating role played by worry between perceptions of cancers' risks and adoption of health-related behaviors (Buxton et al. 2003; Bowen et al. 2004; Kiviniemi and Ellis 2014). Analyzing the mediating effect of worry and concern of perceptions of cancers' risks in general and stemming from environmental factors might thus be an interesting future research issue.

Concerning perceived voluntariness and control of the risks' exposure as determinants of individuals' perceptions of their cancers' risks in general and stemming from genetics as well as from environmental factors:

We found no significant relationships between perceived voluntariness and perceived control of risks' exposure. But perceiving the occurrence of cancers as controllable was associated with low rather than high perceptions of cancers' risks in general. Previous research also emphasized that individuals who perceived the occurrence of cancer as something they can control tended to endorse healthier behaviors as compared to people who perceived cancer's occurrence as something uncontrollable (Vaughan 1993; Katapodi et al. 2004; Rowe et al. 2005; Klein and Stefanek 2007; Robb et al. 2007; Spector et al. 2009; Lipworth et al. 2010; Matthew et al. 2011). From a more general perspective, perception of control have been found to be a predictor of intentions to adopt risk-protective behavior (Chien et al. 2016), to adopt health promoting behaviors (Llewellyn et al. 2017), to adopt preventive and disinhibited health behaviors (Conell-Price and Jamison 2015). Integrating perception of control might help to understand adoption, as well as non-adoption, of health-related behaviors among our sample.

Personal health history was found to have only some minor implications and, except for gender, sociodemographic variables were not found as major determinants of individuals' perceptions of cancers' risks in general and stemming from genetics as well as from environmental factors.

The findings of our literature review supported a clear gender effect on perceptions of risk, also found outside the cancer area (Tseng et al. 2013; Wiedemann et al. 2013; Knuth et al. 2014). However, while we indeed found that women tend to perceive their risks to develop cancers stemming from consumption products and negative emotions significantly higher than men, no other relationship was significant.

Ageing is a fundamental factor in the development of cancer and incidence of cancer increases with age, most likely because of the accumulation of risk factors over life. Nonetheless, we did not find a significant quadratic effect of age on individuals' perceptions to develop cancers in general and stemming from genetics as well as from environmental factors at a 1% level. We nonetheless observed a quadratic effect of age on mindful consumption of alcohol such as adopting a mindful consumption of alcohol decreases until 40 years-old after which it increases. Two hypotheses may explain these observations:

First, taking all these observations together, it may be assumed that individuals start to be aware of their cancer risks and implications on their lifestyle in their 40's and 50's. Unconcern about cancer at younger age was indeed found in previous studies as an explanation of low perceived risk and sometimes also with adoption of risk-taking behaviors (Honda and Neugut 2004; Lundborg and Lindgren 2004; Lundborg and Andersson 2008; Shepherd et al. 2012; Rice et al. 2015). Lundborg and Lindgren (2004) suggested that young adults aged between 12 and 18 who smoke may plan to quit smoking before facing lung cancer risk. Similarly, Carbone et al. (2005) suggested that people endowed with longer life expectancy may smokes more in their first part of life because they think about making things right when they will be older. To test this assumption among our sample, we could as a next step analyze whether individuals who perceive their life expectancy as high adopt less health-related behaviors than those who do not.

Second, individuals may start to gather some information about their risk by taking part in cancer screening campaigns. The quadratic effect of age we observed on DK answers may support this assumption since we observed a higher likelihood of DK answers regarding perceive risks to develop cancers stemming from genetics as age increases until 51 years-old, then, increasing age is associated with a lower likelihood of DK answers. As we asked our respondents whether they take part or intent to in screening campaigns, we can test this hypothesis in further analysis.

Concerning education and income, surprisingly, but like Katapodi et al. (2004) and Rowe et al. (2005), we did not find as strong impact of education and income on risk perceptions as expected. However, we found some interesting relationships between number of DK answers to risk perceptions and income. This finding is consistent with findings from Hay et al. (2015) and Waters et al. (2016) that DK answers are more likely among vulnerable populations. Even if not significant, education displays a similar pattern since high school appeared as a threshold with higher level of education decreasing expected number of DK answers and lower level of education increasing expected number of DK answers. A similar non-significant pattern can be observed for expected number of 'Almost None' and 'Very High' answers. In addition, we can observe that the education gradient seems to be positively, but not significantly, associated with perceptions of risks to develop cancers in general and stemming from consumption products, negative emotions and genetics. Observations showed less clear pattern with the income gradient. The only consistent observation is that individuals who preferred to not declare their category of income tend to be the least likely to perceive their risks to develop cancers stemming from behaviors, environmental exposures, consumption products and negative emotions as high rather than low. Low correlation among our sample between education and income ($\rho = 0.28$)

lead us to keep both gradients in our analyses. However, these observations may call for further analyses such as creating a variable of socioeconomic situation including both level of education and income as done in some studies (Flynn et al. 1994; Brenot et al. 1998; García et al. 2005; Adams et al. 2013).

In addition to education, the concept of health literacy was found associated in some studies with adoption of health-related behaviors such as individuals with less health literacy were found more likely to adopt risk-taking health-related behaviors (Adams et al. 2013; Stewart et al. 2013). In particular, Adams et al. (2013) suggested and found that health literacy partially mediates the relationship between socioeconomic staus, perceptions of cancers' risks and adoption of health-related behaviors. Thus taking into account health-literacy when analyzing relationships between adoption of health-related behaviors and individuals' perceptions of their own cancers' risks stemming from environmental factors might be an interesting research perspective. In addition, in both studies, health literacy was found associated with several sociodemographic characteristics such as age, gender, education and income (Adams et al. 2013; Stewart et al. 2013) suggesting other interactions to take into account.

Unlike previous studies (Lupton and Tulloch 2002; Dohmen et al. 2011) and results from our qualitative study, we did not find a significant effect of having children neither on perceptions of risks not on adoption of health-related behaviors. Additional analyzes stressing a confounding effect between being in a couple and having children may help in the understanding of this result.

CONCLUSION

Our results show that cancers' risks in general, stemming from genetics as well as from environmental factors are a subject of concern among the French population. In particular, we found that more than half of our sample perceives themselves to be at risk to develop cancers stemming from outdoor air pollution, pesticides and stress. On the contrary, more than half of our sample declared to not know how to perceive their own risk to develop cancers in general in their remaining lifetime. Thus, individuals were more concrete in their elicitation of risks when the context was particular rather than general.

Our results also showed that individuals' adoptions of health-related behaviors were associated in some cases to their cancers' risk perceptions but were more associated with their endorsement of prevention-related beliefs and time and risk preferences. Taking into account the endogeneity of risk perceptions had an important impact on the relationships' significance between perceptions of cancers' risks and adoption of health-related behaviors behaviors. In adidition, personal health history and socio-demographic characteristics were not found to be strongly associated with adoptions of health-related behaviors, except for a small gender effect.

Finally, endorsement of cancers-related beliefs and salience of cancers' risks stemming from environmental factors determined more strongly individuals' risk perceptions than availability and affect heuristic, knowledge, perceived control and voluntariness of risk exposures, personal health history and socio-demographic characteristics.

Our results are consistent with those published in the field and bring new outcomes that are helpful in our research field (i) to better understand individuals' risk perceptions; and (ii) to design targeted public health policies. Additional analyses should be conducted to test further relationships between our variables as well as their interactions.

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1 Appendix 1: Additional information on the literature reviews

To construct our research questions and hypotheses we conducted two literature reviews: an empirical and a theoretical one. This appendix presents in his first part the behavioral models mentioned in the introductive chapter found through the theoretical literature review. The second part contains the draft of the article presenting the empirical literature review.

1.1 Theoretical literature review: risk perceptions and behavioral models

Models used in empirical studies attempt to include these two types of factors and four of them especially stood out in our empirical literature review: the Health Belief Model (Vaughan 1993; Bowen et al. 2004; Silk et al. 2006; Wang et al. 2009; Chen and Kaphingst 2011); the Self-Regulatory Model (Bowen et al. 2004; Shiloh et al. 2009; Chen and Kaphingst 2011; Kelly et al. 2012); the Trans-theoretical Model of Behavioral change (McCoy et al. 1992; Bränström et al. 2006; Stewart et al. 2013); and the Bayesian updating process (Lundborg and Lindgren 2004; Lundborg and Andersson 2008; Lin and Sloan 2015).

The Health Belief Model was cooperatively developed by Hochbaum, Kegeles, Leventhal and Rosenstock in the 1950's and attempts to explain and predict health-related behaviors by individual's motivation to adopt it under the assumption that *"diseases are regarded as negatively valent regions to be avoided"* (Rosenstock 1974). Following the changes brought by other authors, the HBM includes three/four components: (1) perceived susceptibility: belief that one is likely to be affected by a particular disease; (2) perceived seriousness: belief regarding disease's seriousness including emotional arousal created by the disease's thought; (3) perceived benefits of and perceived barriers to taking action: beliefs regarding alternatives' effectiveness in reducing disease's susceptibility or seriousness; (4) perceived efficacy – sometimes included in perceived benefits and barriers: belief that disease can be avoided or controlled (Rosenstock et al. 1988).

The Self-Regulatory Model was developed by Leventhal and colleagues in the 1980's. It examines the relationship between individual's cognitive representation of his health-related

behavior and his subsequent coping behavior. SRM encompasses three dynamic stages: (1) interpretation: development of illness beliefs through disease perception – how an individual interprets the illness's problem – and social messages – the individual becomes aware that something deviates from the norm; (2) coping: an individual develops coping strategies – approach or avoidance coping – to meet again the norm; (3) appraisal: an individual evaluates if his adopted coping strategy is effective and continues with it if it is, indeed, effective or searches for alternative strategy if it was found ineffective. This model integrates five dimensions of illness beliefs identified by Leventhal and colleagues: (i) identity: label given to the disease, (ii) perceived cause of the disease, (iii) time line: beliefs about the disease's length, (iv) consequences: perceptions of the possible effects of the disease on one's life, (v) curability and controllability: beliefs about whether the illness can be treated and cured and the outcome controllable. According to Uskul and Horn, SRM can be appreciated as a parallel-response framework combining a cognitive and an emotional path. The objective health-threat's representation covering coping procedures and evaluative processes are related to the cognitive path while the subjective processing system covering feeling states, coping procedures, and appraisal rules are related to the subjective path (Uskul and Horn 2015).

The Transtheoretical Model of Behavior was initially developed by Prochaska and DiClemente (1982). It includes five dynamic stages which do not always mandatorily occur one after another and are associated with different behavior's levels of costs and benefits: (1) precontemplation: the individual does not intent to take action whether knowing or not the deleterious effect of his behavior, (2) contemplation: the individual thinks about taking action because he begins to consider the deleterious effect of his behavior (3) preparation: the individual intents to take action and may even starts to take small ones (4) action: the individual takes actions and changes his behavior towards a non-deleterious one, (5) maintenance: the individual steaks with his new non-deleterious behavior (Prochaska and DiClemente 1982).

The Bayesian updating process was applied to individual's risk perception and health-related behaviors by W. Kip Viscusi in the context of smoking and smoking decisions in 1990 and 1991 (Viscusi 1990; Viscusi 1991). Following his work, other authors used similar conceptual frameworks to explain individual's risk perception of lung cancer or other disease related to smoking and smoking behaviors (Lundborg and Lindgren 2004; Lundborg and Andersson 2008; Lin and Sloan 2015). According to these authors, the individual has at start a prior set of beliefs on links between choices and outcomes reflecting information obtained from different sources. As this individual is a Bayesian updater, he updates his set of beliefs when he receives new information. W. Kip Viscusi identified three information sources (Viscusi 1991): (1)

individual's prior risk assessment p associated with information content ψ_0, (2) experiential risk assessment q associated with information content γ_0 based on individual's direct and indirect experience, (3) information-transfer-based risk assessment r associated with information content ξ_0 based on information communicated to the individual by the government or industries. Based on the information received, the individual updates his subjective belief regarding the probability of specific adverse health outcomes due to a specific choice. Individual's risk perception π function takes the following simple additive form: $\pi = \frac{\psi_0 p + \gamma_0 q + \xi_0 r}{\psi_0 + \gamma_0 + \xi_0}$. According to the Bayesian learning process, an increase of the subjective belief regarding the probability of developing a specific adverse health outcome, for instance smoking-related disease, decreases the individual's propensity to continue the associated behavior, for instance smoking (Lin and Sloan 2015).

A less used, but not less interesting, model regarding our research is the Precaution Adoption Model proposed by Weinstein in 1988 as an alternative model of adoption of preventive health-related behavior against a specific disease as well as other precautions (Weinstein 1988). This model considers that an individual has to go through five stages before actually adopting this behavior knowing that each stage's transition acts as a barrier that has to be overcome. The three first stages are related to perceived personal susceptibility: (1) the individual becomes aware of the general disease risk, (2) the individual perceives the disease as a threat for others but not for himself, (3) the individual is aware that the disease represents a risk for himself and this act to reduce his risk; the two last are related to health-related behaviors: (4) the individual decides and intents to take precaution taking into account beliefs regarding personal susceptibility, personal severity, threat seriousness, short and long term threat's and costs' salience, precaution's effectiveness, barriers to adoption, and social behavioral norm; (5) the individual actually takes precaution taking into account strength of intention to act, precaution's complexity, information availability, time and effort and resources, and reminders.

1.2 Authors' draft of the article associated with the empirical literature review

Perceptions of cancers' risks stemming from environmental factors, determinants and impact on adoption of health-related behaviors: a literature review

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Abstract

Background. Cancers are one of the worldwide leading causes of morbidity and mortality but 30-50% could be prevented if current knowledge about cancer risk factors was translated into effective public health strategies. Individuals' perceptions of risks were suggested to have a dynamic relationship with their adoption of preventive health-related behaviors.

Objectives. First, to summarize the available research findings on individuals' perceptions of cancers' risks stemming from environmental factors (i.e. all non-genetic factors). Second, to analyze relationships between these perceptions and adoption of health-related behaviors. Third, to identify the determinants of individuals' perceptions of cancers' risks stemming from environmental factors.

Data sources. Business Source Complete, EconLit, PubMed, PsycInfo, Sciende Direct.

Study eligibility criteria. Individuals' perception of risks was the main topic. Cancer and/or environmental factors in general or specific cancer and/or environmental factors.

Study appraisal and synthesis methods. Personalized extraction sheet.

Results. We observed an increase in the number of papers published on environmental factors and a focus on breast cancer and smoking-related diseases. Smoking was also the most studied environmental factor. Among our 101 selected studies, 42 analyzed relationships between risk perceptions and adoption of health-related behaviors. Two third found a positive relationship between high risk perceptions and adoption of preventive health-related behaviors or non-adoption of risk-taking health-related behaviors. One fourth found a negative relationship between high risk perceptions and adoption of preventive health-related behaviors or non-adoption of risk-taking health-related behaviors. The remainders found no significant association. Individuals' perceptions of cancers' risks stemming from environmental factors appeared to variable extent to be shaped by individuals' level of knowledge, endorsement of beliefs, perceived control, perceived voluntariness of exposure, experience with cancer, worry, concern about environmental factors and sociodemographic characteristics.

Limitations. Selection of keywords, only results relevant for our scope were included in this article

Conclusions and implications. We observed an increased interest in environmental factors as a research subject and an understudying of some cancers and environmental factors giving perspectives for future research. Individuals' perceptions of cancers' risks stemming from environmental factors were rarely assessed compared to cancers' risks in general. Data suggested that risk perceptions motivate individuals to adopt health-related behaviors rather than be the result of an assessment based on lifestyle. However, caution has to be taken because, in most studies, the endogenous relationship between risk perceptions and behaviors was not taken into account in the analyses.

Key-words. Cancers, Environmental factors, Risk perceptions, Health-related behaviors

1 Introduction

Cancers are one of the worldwide leading causes of morbidity and mortality with 14 million new cases estimated in 2012 and 8.8 million deaths in 2015 (1). The transformation of normal cells into tumor cells is a multi-step process, the steps of which are interactions between individuals' genetic features and external agents 1. One of the mission of the International Agency for Research on Cancer (IARC), the WHO's cancer research agency, is to maintain a classification of environmental factors that can increase the risk of human cancer. According to the definition of the environment adopted, the narrow one including "air, water, soils and food pollutants" or the broad one including "all non-genetic factors" (2), the proportion of cancers estimated to be attributable to environmental factors varies. IARC defines environmental factors as "chemicals, complex mixtures, occupational exposures, physical agents, biological agents, and lifestyle factors" 3 and estimated that around 30-50% of cancers could be prevented if current knowledge about cancer risk factors was translated into effective public health strategies (3,4).

In order to reduce cancer burden, national public health initiatives were thus established, especially in high-income countries last decades, to promote adoption of preventive health-related behaviors such as smoking avoidance or non-initiation, moderate alcohol consumption, balanced diet with five servings of fruit and vegetable a day, regular physical activity, etc. However, these initiatives struggle to achieve their objectives in terms of actual adoption of preventive health-related behaviors among the population (4,5). One explanation may be that these campaigns, relying on broad information dissemination and people's unconditional acceptance of public health recommendations (6), reached their limits in terms of impact on individuals' decisions.

Several behavioral models from social sciences, such as the Health Belief Model (7), the Precaution Adoption Model (8), the Risk Perception Attitude Framework (9), supported that individuals' perceptions of health risks influence their adoption of preventive health-related behaviors. However, once individuals perceiving their health risks as high have adopted preventive health-related behaviors, they might perceive their risk as low. Brewer and colleagues highlighted, through the identification of thee mechanisms, this dynamic relationship (10). Thus, identifying the relationship between individuals' risk perceptions and adoption of health-related behaviors might be challenging since they seem to impact each other.

Similarly to what has been done regarding screening behaviors (11) and vaccination (12), we aimed a synthesis of the available research findings on the relationships between individuals' perceptions of cancers' risks and adoption of health-related behaviors with a focus on cancers'

risks stemming from environmental factors according to the IARC definition, i.e. all external factors not related to genetics.

Furthermore, according to Weinstein's Precaution Adoption Model, an individual has to go through five stages before actually adopting a preventive behavior and the three first stages are related to perceived risk (8). (1) The individual becomes aware of the general disease risk. (2) The individual perceives the disease as a threat for others but not for himself. (3) The individual is aware that the disease represents a risk for him and thus thinks to act to reduce his risk. It thus appeared important, in order to understand the relationships between perceptions and behaviors, to have an overview of individuals' perceptions of cancers' risks stemming from environmental factors as well as to identify the determinants shaping these perceptions at the individual level.

In this context, the first objective of this literature review was to summarize the available research findings on individuals' perceptions of cancers' risks stemming from environmental factors (i.e. all non-genetic factors). The second one, to analyze relationships between these perceptions and adoption of health-related behaviors. And finally, to identify the determinants of individuals' perceptions of cancers' risks stemming from environmental factors.

2 Methods

This literature review was conducted following the PRISMA guidelines and the PRISMA checklist was used to control for consistent data reporting (13).

2.1 Search strategy

Five international bibliographical databases were searched from January 2014 to June 2016: PubMed, PsycINFO, Science Direct, Business Source Complete, and EconLit. A google scholar alert was computed to not miss grey literature. These databases allowed gathering references from a multidisciplinary approach.

In order to have a comprehensive overview of individuals' perceptions of cancers' risks stemming from environmental factors, research of articles dealing with individuals' perceptions of cancer risks in general and perceptions of risks stemming from environmental factors were also conducted.

The search strategy used combinations of the following search terms *"risk perception* / perceived risk* / perception of risk*", "neoplasms / cancer*" and "environment*"* with

Equation 1 focused on perceptions of cancers' risks stemming from environmental factors, Equation 2a on perceptions of cancer risks in general and Equation 2b on perceptions of risks stemming from environmental factors. The search was limited to titles or abstracts and limited to studies conducted on human subjects. Research equations were developed on PubMed database and adapted to the specificities of each of the other databases.

Two reasons motivated our choice to not include key-words related to health-related behaviors in our research equations. (1) The cornerstone of this literature review is to have an overview of individuals' perceptions of cancers' risks stemming from environmental factors. Thus, relevant articles could have been excluded because they did not analyze relationships with health-related behaviors. (2) We had an interest in health-related behaviors related to primary prevention (smoking, alcohol consumption, exercise, diet, etc.). Thus, studies could have been missed due to lack of comprehensiveness in the selected keywords. Screening behaviors, included in secondary prevention, were analyzed independently and meta-analyses regarding relationships between individuals' risk perceptions and screening behaviors were searched. The same position was taken regarding risk communication in health which appeared as an additional area of interest in the context of this research.

2.2 Study selection and data analysis

We selected articles published in peer-reviewed journals with abstract and full-text available when individuals' perception of risks was the main topic and when it added a contribution in terms of data or knowledge. No specific restriction was imposed on methods, applied field, country, year of publication, study design or study population. Thus, we included without distinction literature reviews, mixed-design studies, qualitative and quantitative studies. The applied field could also be cancer and/or environmental factors in general or specific cancer and/or environmental factors such as prostate or breast cancer, smoking or sun exposure. If several publications used data from the same study, we included the most recent publication unless each of them presented complementary data.

We excluded articles not written in English or French as well as when the main topic was public perception of risks. In addition, we excluded studies conducted on individuals in specific context of genetic testing or at risk because of family history based on the assumption that these respondents would have specific perceptions and knowledge received from healthcare professionals.

We first selected possibly relevant articles through assessment of titles (MG) and abstracts (MG and NM), and further through the full article (MG). Reference lists of selected articles were also screened to identify additional studies.

In absence of a standardized extraction sheet for the analyses, we used a personalized extraction sheet including (i) context: first author, year of publication, journal, title, country; (ii) method: study design, population studied, main objective, method used; (iii) results: individuals' risk perceptions, determinants of individuals' risk perceptions, relationships with behaviors.

3 Results

Overall, 3698 references were gathered by the research equations. After the first screening, 950 potential relevant abstracts were screened. Around 200 full-texts potential relevant articles were obtained, read, and analyzed. In fine, 101 were kept for the analysis (see Figure 1 for the flowchart related to the literature review process).

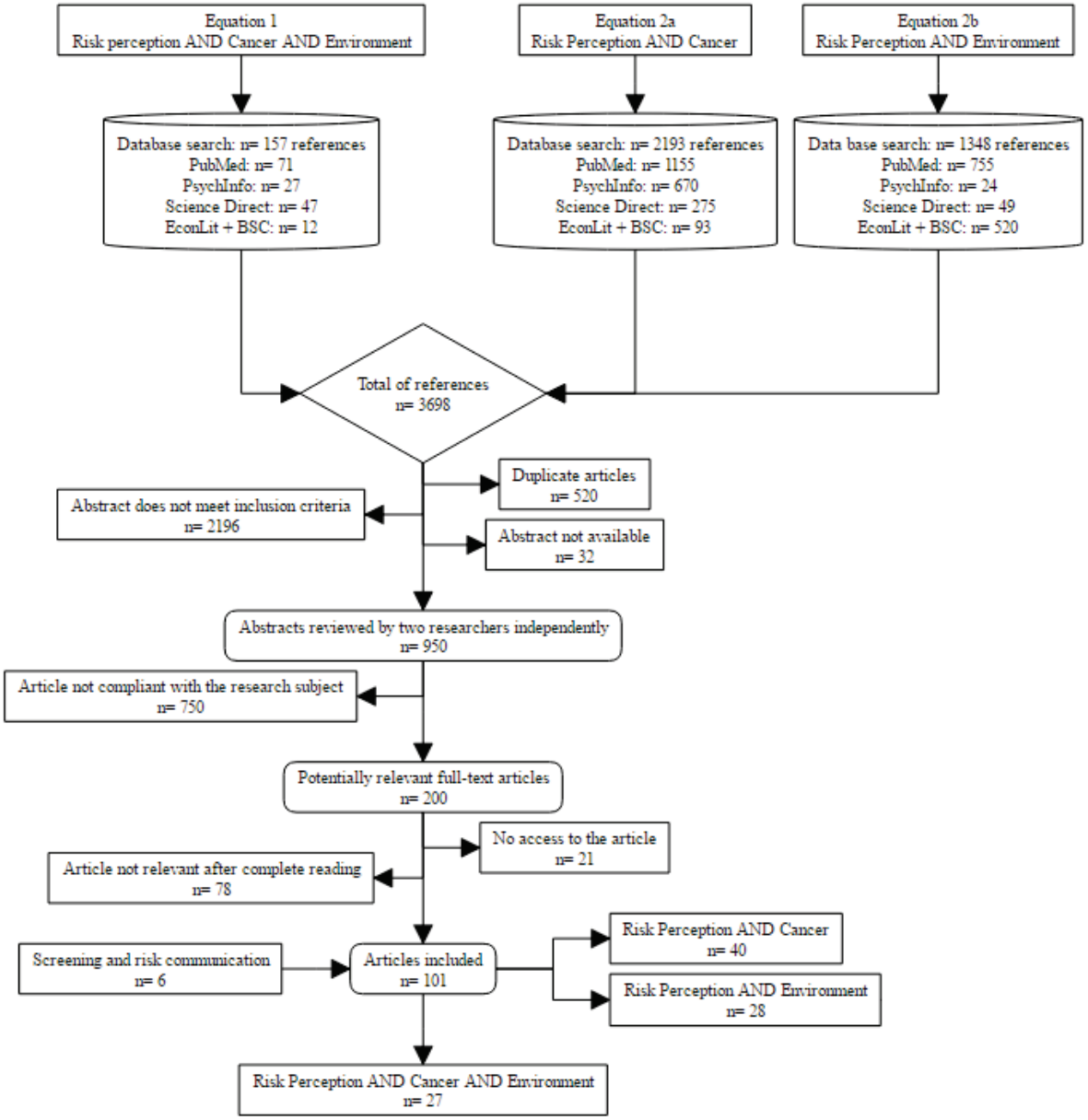

Figure 1 Flowchart of the literature search and article selection process

3.1 Description of included studies

We included 27 articles analyzing individuals' perceptions of cancers' risks stemming from environmental factors, 40 analyzing individuals' perceptions of cancer risks in general, 28 analyzing individuals' perceptions of risks stemming from environmental factors and 6 literature reviews related to screening practices and risk communication in health. Description of the characteristics of these selected studies are available in Table 1.

3.1.1 Study designs, methods, and populations

The majority of studies were cross-sectional surveys (n=82), 7 studies had a qualitative design and 3 studies a mixed design. We further identified 9 literature reviews.

Among the cross sectional surveys, 51 articles were conducted within the general population with 18 studies conducted in national representative samples and 33 in convenient sample of adults. The remaining quantitative studies (n=32) were conducted within specific populations: 14 studies were conducted in women, 8 in individuals potentially exposed to environmental risks (smoking included), 5 in young adults and/or teenagers, 3 in cancer patients and 2 in workers in specific occupational groups.

Among the qualitative studies, focus groups were conducted in four studies with adults aged between 50 and 74 years-old (14–16) and with female adolescents aged from 9 to 15 years-old and women aged 21 to 55 years-old (17). In three studies, individual semi-structured interviews were conducted with women with experience of abnormal breast symptoms (18), with men with no personal history of prostate cancer but with FDR with prostate cancer (19) and with women with at least one sister with breast cancer (20).

Studies with mixed-method design used a combination of cross-sectional quantitative surveys and qualitative approaches, i.e. focus groups (21), individual interviews (22) and field observations (23).

Literature reviews were conducted in 9 studies. Three literature reviews were related to our main subject. Wandersman and Hallman searched to understand the public responses to environmental risks through a focus on risk perceptions of cancers (24). Lipworth and colleagues mobilized 87 articles to provide information on lay individuals' constructs and experiences of their individual risk of cancer given by medical and public health practitioners based on epidemiological data (25). Finally Greene and colleagues synthetized the available evidence related to health-related psychological responses of two or more communities experiencing the same public health threat (26).

Three literature reviews were dealt with risk communication in health. S. Vernon synthesized findings from 27 research papers on relationships between cancer screening behaviors and risk perceptions and communication (27). Fitzpatrick-Lewis and colleagues analyzed effectiveness of communication strategies on environmental health risks and factors impacting communication uptake in 24 articles (28). Edwards and colleagues assessed with 41 articles the effects of personalized risk communication on informed decision making regarding screening (29). Finally, three literature reviews were related to screening behaviors. Katapodi and

colleagues synthesized research findings from 42 articles analyzing the association between breast cancers' risk perceptions and screening 11. Walker and colleagues examined also these relationships but among women with family history of breast cancer in 20 articles (30). Atkinson and colleagues analyzed 58 articles to determine the association between colorectal cancers' risk perceptions and screening behaviors (31).

3.1.2 Countries of origin and years of publication

Half of articles (n=50) came from the United States followed by studies conducted in France (n=10), Australia (n=5), United Kingdom (n=5), Canada and Sweden (n=4), Italy and South Korea (n=3), China, Israel and Japan (n=2), Austria, Belgium, Finland, Germany, Mexico, New Zealand, Pakistan, Spain, Switzerland, and Taiwan. One study was conducted on samples from both Italy and USA.

All studies were published between 1988 and 2016: two articles were published before 1990, nine between 1990 and 1999, 43 published between 2000 and 2010, and 47 articles published since 2011. This was particularly the case regarding articles focused on risks stemming from environmental factors with six articles published between 2000 and 2010, and 17 articles published since 2011.

Table 1 Characteristics' description of the 101 selected studies

Author	Country	Method	Sample	Applied field	Environmental factors	Measures of Risk perception: Absolute RKP (ARKP), Comparative RKP (CRKP) NR: not reported
Cancer and Environmental factors						
Bränström et al. (2006)	Sweden	Quantitative study	722 visitors to mobile skin cancer screening unit aged more than 16 years-old	Skin cancer (SC)	Sun exposure	ARKP: personal risk of developing skin cancer. Very high, rather high, neither high nor low, rather low, and very low SC incidence: how many people in Sweden do you think will get a skin cancer diagnosed during a year? < 1,000; 1,000-2,000; 2,000-5,000; 5,000-10,000; 10,000 -20,000; > 20,000 CRKP: own risk compared with other's in the same age as oneself. Much lower, somewhat lower, same, much higher
Chen and Kaphingst (2011)	USA	Quantitative study	National representative sample 5105	Lung cancer (LC)	Smoking	ARKP: how likely do you think it is that you will develop lung cancer in the future? 5-point Likert scale from very low to very high CRKP: compared to the average person your age, would you say that you are more likely, about as likely, or less likely to get lung cancer?
Dantzker et al. (2010)	USA	Mixed design: qualitative study + quantitative study	Current pesticide applicators + supervisors or managers: 31 participants (10 in Albany focus group, 10 in Ithaca, 11 in Buffalo) / 104 participants aged 20 to 72 years (96% men)	Cancer (C)	Pesticides	NR
Ford et al. (2014)	USA	Quantitative study	374 survivors had to be diagnosed with cancer before age 35, currently be between ages 18 and 55, out of treatment for at least 2 years, mentally able to provide informed consent, reachable by telephone, able to speak English, and be current smoker	Cancer Heart diseases Serious health threat	Smoking	ARKP: rate the chance that they thought they would experience any serious health problem in the future. 6-point scale: no chance to certain to happen CRKP: rate the chances, compared to individuals the same age and gender, that they would be diagnosed with cancer or have heart problems in the future. 5-point scale: much less to much more likely
Hahn and Renner (1998)	Germany	Quantitative study	154 residents of Berlin aged between 16 and 85 years old	Smoking-related diseases	Smoking	ARKP: what do you think are your chances of developing lung cancer during your life? Other's ARKP: how likely do you think it is that someone else -same sex and age as yourself- will develop lung cancer during his/her life? 7-point Likert-scales from extremely unlikely (-3) to extremely likely (+3) CRKP: compared to other people -same sex and age as yourself- what do you think are your chances of developing lung cancer during your lifetime? Much below average (-3) to much above average (+3) RK stereotype: imagine a person who has a particularly high chance of developing lung cancer. Please characterize the smoking behavior of that person ... a person has a high chance of developing lung cancer, if he or she has smoked at least for .. years, ... cigarettes a day, the following strength of tobacco... (from ultra-light to ultra-strong)
Hay et al. (2007)	USA	Quantitative study	188 patients diagnosed with either head and neck or lung cancer within the prior six months, at least 18 years of age, had evidence of tobacco use within 6 months prior to cancer diagnosis	Lung cancer (LC) Head and neck (HNC)	Smoking	ARKP: HNC patients: if you were to continue smoking, what do you think your chances are of developing another HNC / LC / other form of cancer? LC patients: if you were to continue smoking, what do you think your chances are of developing another LC / other form of cancer? What do you think your chances are of developing the following ... (a) another HNC (b) LC (c) any other form of cancer? implied: under the current smoking behavior From 1 = not likely to 5 = extremely likely
Ho et al. (2014)	Taiwan	Quantitative study	2742 adults in Taiwan who live within and beyond 30 km from a nuclear power plant	Cancer Death	Nuclear power	ARKP < 30 km: how many people do you think have cancer for each 1,000 residents living within 30 km of a nuclear power plant? ARKP > 30 km: how many people do you think have cancer for each 1,000 residents beyond 30 km of a nuclear power plant? Perceived relative risk (PRR) = ARKP < 30 km – ARKP > 30 km
Khwaja et al. (2009)	USA	Quantitative study	663 adults aged between 50 and 70 years-old	Smoking-related cancers	Smoking	Other's ARKP: Out of 100, how many will get lung cancer? ARKP: what is the chance you will get lung cancer? What is the percentage chance you will experience (physical condition alteration) within the next 6 years?
Kiviniemi and Ellis (2014)	USA	Quantitative study	National representative sample 1476	Skin cancer (SC)	Sun exposure	ARKP: how likely do you think it is that you will develop SC in the future? 5-point scale from very low to very high CRKP: compared to the average person your age, would you say that you are more likely, less likely or about as likely to get SC?
Lin and Sloan (2015)	China	Quantitative study	5032 men who had smoked at least 10 years, had not move since 2003, and lived in a building with at least 15 units 2555 lived in buildings where a neighbor has been diagnosed of lung cancer and 2477 lived in buildings without such neighbor	Smoking-related diseases	Smoking	ARKP: strength of relationship between smoking and probability of getting specific diseases (lung cancer, lung diseases, heart disease, stroke) Definitely does not increase; probably does not increase; slightly increases; probably increases; and definitely increases

Lundborg and Andersson (2008)	Sweden	Quantitative study	19235 Swedish adolescents: 9963 Swedish adolescents aged between 12 and 18 year-olds + 9272 Swedish adolescents aged between 15 and 18 year-olds	Smoking-related cancers	Smoking	ARKP: in a group of 100 smokers, how many do you think will die from disease caused by their smoking? Answers divided by 100 = perceived probability of dying from smoking-related diseases
Lundborg and Lindgren (2004)	Sweden	Quantitative study	2618 teenagers aged between 12 and 18 years-old	Lung cancer (LC)	Smoking	ARKP: out of a 100 smokers, how many do you think will get lung cancer due to their smoking? Answers divided by 100 = perceived probability of getting LC
McCool et al. (2009)	New Zealand	Quantitative study	1283 workers from 9 outdoor occupational groups	Skin cancer (SC)	Sun exposure	NR: combination of variables perceived skin type, perceived resilience, concern, prioritization of sun protection, attitudes toward sun tanning, and workplace support.
McCoy et al. (1992)	USA	Quantitative study	680 participants Community sample: 560 adult current smokers, former smokers, and nonsmokers Clinic sample: 120 adults undergoing first clinic session for smoking cessation	Smoking-related diseases : coronary heart disease, emphysema, and lung cancer + other forms of cancer (generic illness not directly related to smoking)	Smoking	Community sample ARKP under behavioral statement: (assume that you are currently a smoker) / assume that you are not currently a smoker. (If you were to continue smoking), what do you think the chances are that you would develop [heart disease, emphysema, lung cancer, and other forms of cancer] Answers from 0 to 100%) Typical smoker's ARKP (average person who smokes) Clinic sample ARKP under behavioral statement: (assume that you are currently a smoker) / assume that you stopped smoking. (If you were to continue smoking) / if you were to stop smoking, what do you think the chances are that you would develop [heart disease, emphysema, lung cancer, and other forms of cancer] Responses from 0 to 100%) Typical smoker's ARKP
Ménard et al. (2014)	France	Quantitative study	Representative samples: 10759 2010: 6007 French adults aged from 18 to 75 2007: 4000 French adults aged from 15 to 85 2009: 752 French general practitioners	Cancer	Set of various hazards	NR
Peretti-Watel and Vergélys (2012)	France	Quantitative study	National representative sample 7007 participants = 3820 and 3727 French adults were interrogated respectively in 2005 and 2010, aged from 16 to 85 years	Cancer	Cell-phone antennas	4 potential environmental causes of cancer (living close to a cell-phone antenna, close to a nuclear plant, breathing polluted air, and eating food treated with chemical products): participants were asked to indicate if these situations are susceptible according to them to increase cancer occurrence. Answers: certainly not, probably not, probably, certainly
Peretti-Watel et al. (2007)	France	Quantitative study	Representative sample of the French population 3820 participants in 2005 + 979 where current smokers	Smoking-related cancers	Smoking	CS: according to you, smoking how many cigarettes per day is a smoker at risk of cancer because of smoking? N For a given response N: and according to you, after how many years is someone who smokes N cigarettes per day at high risk of cancer? CS and NS perception of smoking as a cancer risk factor Answers: certainly not, probably not, probably, certainly
Peretti-Watel et al. (2014)	France	Quantitative study	838 reported current smoking from sample of 3727 participants in 2010 aged between 18 and 85 year-old	Smoking-related cancers	Smoking	Current smokers: according to you, how many cigarettes per day is a smoker at risk of cancer because of smoking? Answer = N For a given response N: and according to you, after how many years is someone who smokes N cigarettes per day at high risk of cancer? CS perception of smoking as a cancer risk factor Answers: certainly not, probably not, probably, certainly
Persoskie et al. (2014)	China	Quantitative study	2517 Chinese people from 2 cities: Beijing and Hefei including 555 current smokers	Cancer	Smoking	ARKP: participants judged the likelihood of getting cancer in their lifetime. From extremely unlikely to extremely likely CRKP: participants rated their likelihood of getting cancer compared to other similarly aged people. From extremely unlikely to extremely likely
Rice et al. (2015)	USA	Quantitative study	405 adults aged 18 years or older, self-identified as Black or African American	Cancer	Set of various hazards	ARKP: how likely do you think you are to get cancer in your lifetime? 5-point Likert scale from very unlikely to very likely Perceived environmental health risks: do you think the environment plays a major role, minor role, or no role at all in causing cancers?
Sastre et al. (1999)	France	Quantitative study	155 French adults aged from 15 to 79 years-old	Lung cancer (LC)	Smoking	Fictitious person (FP) ARKP: 25 scenarios describing smoking habits of a fictitious person: in your opinion, what level of risk of developing smoker's cancer is (s)he taking? 120-mm scale from no risk to very high risk
Trumbo et al. (2007)	USA	Quantitative study	1111 individuals from 30 cluster areas with hazard of concern	Cancer	Set of various hazards	Set of statements = "I am exposed to cancer risk by living in this area.", "I have little or no control over any cancer risk that could be caused by living in this area.", "The topic of the cancer rate in this area is something I am worried about.", "I am concerned that living in this area poses a cancer risk that extends to future generations", "Cancer risk possibly posed by living in this area is increasing" 5-point agree/disagree scale
Trumbo et al. (2008)	USA	Quantitative study	1111 individuals from 30 cluster areas with hazard of concern	Cancer	Set of various hazards	Set of statements = "I am exposed to cancer risk by living in this area.", "I have little or no control over any cancer risk that could be caused by living in this area.", "The topic of the cancer rate in this area is something I am worried about.", "I am concerned that living in this area poses a cancer risk that extends to future generations", "Cancer risk possibly posed by living in this area is increasing" 5-point agree/disagree scale
Vaughan (1993)	USA	Quantitative study	282 immigrant farm workers: Mexican men aged from 16 to 702 years-old	Cancer	Pesticides	How often in the past month have you had thoughts or fears about the health effects of pesticides? 4-point scale from never to constantly

						Open-ended question asked participants to name any health problems that they believed could be caused by pesticides Perceived likelihood that farm workers would experience health problems in the future that were due to pesticide exposure. 4-point scale from not chance to definitely likely Perceived likelihood that respondent, himself, would experience health problems in the future that were due to pesticide exposure. 4-point scale from not chance to definitely likely
Viscusi (2015)	USA	Quantitative study	1041 US adults aged at least over 18	Smoking-related diseases	Smoking conventional cigarettes (conv-cig) and e-cigarettes (e-cig)	Assume that a typical smoker smokes a pack a day or 20 cigarettes. ARKP LC mortality: out of 100 smokers, how many of them do you think will die of lung cancer because they smoke? ARKP total mortality: and out of every 100 cigarette smokers, how many of them do you think will die from lung cancer, heart disease, throat cancer or any other illness because they smoke? Comparison conventional and e-cigarettes RKP: how would you compare the risks of smoking a typical e-cigarette to smoking a conventional cigarette assuming that the person smokes just as often?
Wandersman and Hallman (1993)	USA	Literature review	Articles	Cancer	Set of various hazards	NR
Weinstein et al. (2005)	USA	Quantitative study	National representative sample 6369 1245 current smokers. Oversampling of African Americans and Hispanics	Lung cancer (LC) Cancer	Smoking	Participant's ARKP of cancer: chances of developing cancer before any smoking questions. Responses from very low to very high Average smoker' ARKP of LC: how likely do you think it is that the average (male/female) cigarette smoker (that you) will develop lung cancer in the future? Response options: very low, somewhat low, moderate, somewhat high, or very high Average's smoker CRKP: would you say the average smoker has (you have) about the same lung cancer risk as a non-smoker, a little higher lung cancer risk than a non-smoker, twice the non-smoker's risk, five times the nonsmoker's risk, or 10 or more times the non-smoker's risk?'
Cancer						
Absetz et al. (2000)	Finland	Quantitative study	1157 women	Breast cancer (BC)		ARKP of BC: personal risk of developing BC someday Possible answers: non-existent risk, low, moderate, quit high, very high risk, cannot tell Other's ARKP of BC: risk of developing BC someday for an average Finnish woman of the same age. Possible answers: non-existent risk, low, moderate, quit high, very high risk, cannot tell
Adams et al. (2013)	Australia	Quantitative study	National representative sample 2824	Cancer		Lifestyle behaviors: how much of a health risk they perceived (smoking, alcohol, diet, weight, exercise) to be in developing cancer for all Australians? Possible answers: not important, slightly/ moderately important, very/ extremely important, do not know/cannot answer ARKK: what do you think the percentage chance is of developing cancer in your lifetime? From 0% no chance to 100% will definitely
Beck et al. (2009)	France	Quantitative study	National representative sample 4046	Cancer		NR
Bowen et al. (2004)	USA	Quantitative study	1366 women aged 18-74 years-old, not diagnosed with breast cancer	Breast cancer (BC)		ARKP of BC: what do you think your chances of getting BC are on a scale of 0 (0 = no chance) to 100 (100= definitely)? What do you think the chances are that you will have BC someday? From 0 to 100%
Buster et al. (2012)	USA	Quantitative study	National representative sample : 1246	Skin cancer (SC)		ARKP: likelihood of future SC. From very low to very high CRKP: likelihood of SC compared to the average person of same age. From more likely to less likely
Buxton et al. (2003)	Canada	Quantitative study	761 rural and urban women with no personal history of breast cancer 3 age groups: 20-39 yrs, 40-59 yrs, 60-79 yrs	Breast cancer (BC)		APRK: To rate their perceived likelihood of developing BC sometime in their lifetime from 0 (definitely not get it) to 100 (definitely will get it) Average woman (AW) ARKP: how likely it was that the average woman would develop BC in her lifetime? From 0 to 1000
Fagerlin et al. (2007)	USA	Quantitative study	249 adult female visitors to a hospital cafeteria	Breast cancer (BC)		If your risk of developing BC was 6%, how likely would you be to take the pill, which would decrease your RK of BC to 3%? We told you that the cancer decreasing pill would lower your risk from 6% to 3%. Does this seem like a significant decrease to you? When choosing whether or not to take the cancer decrease pill, how helpful was it to know the average women's 5-year risk of BC? 5-point Likert scale
Fehniger et al. (2014)	USA	Quantitative study	1261 women aged between 40 and 74 year-olds with no personal history of breast cancer	Breast cancer (BC)		CRKP of BC: chance of getting BC higher, same, or lower than other women their age
Garcia et al. (2005)	Spain	Quantitative study	1438 subjects who answered a first study in 1994, aged more than 15 years old, 668 men and 770 women	Cancer		Do you consider avoiding/limiting … can prevent cancer? 9 major recognized or potential risk factors for cancer (smoking, sun exposure, electromagnetic fields, genetically modified food, alcohol drinking, food coloring and other additives, overweight, excessive calorie intake, pesticide-treated fruit and vegetables, exposure to UV)
Haber et al. (2012)	USA	Quantitative study	6706 representative sample of US women aged between the ages of 46 and 74 years with no personal history of breast cancer	Breast cancer (BC)		CRKP of BC: compared to the average women your age, would you say that you are more likely to get BC, less likely, or about as likely?

Hamilton and Lobel (2012)	USA	Quantitative study	623 with 454 young women (18-25) and 169 middle-aged women (40-64)	Cardiovascular diseases (CVD) Breast cancer (BC) Lung cancer (LC)		Personal RKP of disease risk: chance of developing (CVD/BC/LC) during her lifetime. 5-point scale from no chance to very high chance Average woman (AW) RKP of disease risk: the AW's chance of developing (CVD/BC/LC) during her lifetime. 5-point scale from no chance to very high chance Perceived prevalence and mortality: how many women out of 100 would develop / would die from (CVD/BC/LC) during their lifetime
Han et al. (2009) _1	USA	Qualitative study	48 adults aged 50 to 74 years in 8 focus groups	Colon cancer (CC)		Meaning of risk and cancer risks New risk prediction model write down how they would explain this estimate Interpretation of three risk expressions with varying representations of uncertainty
Han et al. (2009) _2	USA	Qualitative study	48 adults aged 50 to 74 years in 8 focus groups	Colon cancer (CC)		Meaning of risk and cancer risks New risk prediction model write down how they would explain this estimate Interpretation of three risk expressions with varying representations of uncertainty
Honda and Neugut (2004)	USA	Quantitative study	National representative sample 30223	Cancer		ARKP of C: would you say your risk of getting cancer in the future is low, medium, high?
Jones et al. (2011)	Australia	Quantitative study	5008 women aged between 30 and 69 years-old Wave 2003: 2995 women Wave 2007: 3005 women	Breast cancer (BC)		Population ARKP of BC: how many women do you think will get BC in their lifetime? Possible answers: 1 in 5, 1 in 8, 1 in 14, or 1 in 20 Comparative RKP of BC: compared to other women your gage, what do you think the chances are that you might get BC at some point in the future? Possible answers: a lot higher, a little higher, about the same, a little lower, a lot lower Perceived BC RK factors: what do you think are the two biggest risk factors for developing BC?
Katapodi et al. (2005)	USA	Qualitative study	11 women with experiences with abnormal breast symptoms aged between 28 and 63 year-olds	Breast cancer (BC)		ARKP of BC: what do you think is your risk for getting BC?
Kelly et al. (2012)	USA	Quantitative study	571 Appalachian women aged 18 years-old or older with no invasive cervical cancer or hysterectomy	Cervical cancer (CVC)		Comparative RKP of CVC: perceived risk of cervical cancer compared with other women their age in the general population. Possible answers: much lower, lower, same, higher, much higher
Klein et al. (2014)	USA	Quantitative study	National representative sample 3376	Cancer Heart diseases		NR
Kye et al. (2015)	South Korea	Quantitative study	National representative sample 1009	Cancer		ARKP of cancer: do you think that you have a chance of developing cancer? Possible answers: yes or no Cancer risk factors: what do you think is the cause of cancer risk, if you have a chance of developing cancer? Three possible answers in seven predefined categories: smoking, alcohol consumption, unhealthy diet, physical inactivity, stress, heredity, and environmental pollution.
Lee (2010)	USA	Qualitative study	48 adults aged 50 to 74 years in 8 focus groups	Colon cancer (CC)		Meaning of risk and cancer risks New risk prediction model write down how they would explain this estimate Interpretation of three risk expressions with varying representations of uncertainty
Lemal and van den Bulck (2009)	Belgium	Quantitative study	500 women from the Health and Media Interview survey	Breast cancer (BC)		Personal ARKP of BC: how likely do you think you are to get BC in your lifetime? 7-point scale from certain not to happen to certain to happen
Lipworth et al. (2010)	Australia	Literature review	87 articles	Cancer		NR
Matthew et al. (2011)	Canada	Qualitative study	15 men with no personal history of prostate cancer, with at least one first-degree relative diagnosed with prostate cancer	Prostate cancer (PC)		Participants' conceptualization of their risk of developing PC and factors they take into account when considering their risk
McClish et al. (2014)	USA	Quantitative study	183 participants: 70 First degree relatives (FDRs) of colorectal cancer patients + 113 healthy participants from 3 medical practices aged 18-72 years old (GP sample)	Colorectal cancer (CRC)		ARKP of Cancer: on a scale from 1 to 5, where 1 would mean that you are not at all at risk and 5 would mean that you are very much at risk, how much are you at risk for cancer?
Montgomery et al. (2003)	USA	Quantitative study	522 adults aged 18 or older at the entrance of a medical center cafeteria, 62% women	Breast cancer (BC) Prostate cancer (PC) Colon cancer (CC) Heart diseases (HD) Diabetes (DB)		ARKP of each disease: how likely they thought they were to develop (BC/PC/CC/HD/DB) in their lifetimes. Scale of 0% (not at all likely) to 100% (extremely likely)
Moser et al. (2007)	USA	Quantitative study	National representative sample 6149	Breast cancer (BC) Prostate cancer (PC) Colorectal cancer (CRC)		ARKP of each disease: how likely do you think it is that you will develop (BC: women / PC: men / CC: both) in the future? Would you say your chance of getting (BC: women / PC: men / CC: both) is? Possible answers: from very low to very high.
Moser et al. (2014)	USA	Quantitative study	Nationally representative sample 6827	Cancer		When I think of cancer, I automatically think of death. Agree or disagree
Park et al. (2009)	Korea	Quantitative study	1,000 women aged more than 40 year-olds with no diagnostic history of breast cancer	Breast cancer (BC)		CRKP of BC: compared to other women your age, how likely are you to get breast cancer in your lifetime? From very much lower to very much higher
Peipins et al. (2015)	USA	Quantitative study	2,011 women in the Henry Ford Health system in Detroit, aged 30 at least, not diagnosed with ovarian cancer, not having had both of their ovaries removed	Ovarian cancer (OC)		Comparative PRK of OC: whether their 10-year and lifetime risks of developing OC are much higher, higher, about the same, lower, or much lower than risk in most women their age
Peretti-Watel et al. (2016)	France	Quantitative study	Nationally representative sample 3359	Cancer		Population ARKP: To report whether they thought this factor could increase a person's risk of developing a cancer. Possible answers: certainly not, probably not, probably, certainly, don't know/no response

						14 items: behavioral factors (tobacco smoking, alcohol consumption, sun exposure without protection, lack of physical activity, having tanning lamp sessions, cannabis smoking); environmental factors (exposure to air pollution, chemicals in food, living near a nuclear power plant, living near a mobile phone relay station); psychological factors (stress, painful experiences, difficulties in expressing feelings and emotions, bitterness due to personal or professional disappointment)
Rhee et al. (2008)	USA	Quantitative study	183 adults non-melanoma skin cancer patients aged from 21 to 85 years-old, 93 women and 90 men	Skin cancer (SC)		CRKP of 2nd basal or squamous SC: likelihood of developing another basal or squamous SC within the next 10 years compared to someone same age, gender, race. CRKP of melanoma SC: likelihood of developing melanoma SC compared to someone the same age, gender, race. CRKP of non-SC: likelihood of developing non-SC compared to someone the same age, gender, race.
Robb et al. (2004)	UK	Quantitative study	11524 Men and women aged 55 to 64 years old with no screening for CRC in the past	Colorectal cancer (CRC)		CRKP of CRC: compared with other men and women of your age, do you think your chances of getting bowel cancer are: lower; about the same; higher?
Robb et al. (2007)	UK	Mixed design: quantitative study + qualitative study	648 adults aged 45 to 67 years old 20 adults aged from 45 to 67 but 2 excluded: 12 women, 6 men	Colorectal cancer (CRC)		CRKP of CRC: compared to others of the same sex and age, my chances of getting bowel cancer are: much below, below average, average, above average, much above average, have had bowel cancer Followed by why have you rated your chance of getting cancer in this way?
Rowe et al. (2005)	USA	Quantitative study	66 women employed of medical center without personal history of cancer or abnormal screening test	Breast cancer (BC)		ARKP of BC: on a scale from 0% (not at all likely) to 100% (extremely likely), how likely do you think it is that you will develop BC in your lifetime? ARKP of being free from BC: on a scale from 0% (not certain at all) to 100% (completely certain), how certain you are that you remain free of BC for the rest of your life? CRKP of BC: compared to other women your age with a similar history of cancer, how likely do you think it is that you will develop BC in your lifetime? Much higher, little higher, same, little less, much less
Shiloh et al. (2009)	Israël	Quantitative study	249 adults at increasing risk of cancer 66 from environmental cause, 65 from behavioral cause, 33 for genetic cause + 1 control group with 85 individuals at average-risk for cancer	Cancer		Combination of three measures Numerical ARKP of C: perceived chances to develop cancer at some time in the future Percentage Verbal ARKP of C: perceived chances to develop the disease. 7-point scale from no chance to very high Verbal CRKP of C: perceived chance to develop the disease compared to same sex and age-matched individuals. 7-point scale from much less to much more Are you at increasing risk for cancer?
Shiloh et al. (2013)	Israël	Quantitative study	293 adults aged between 25 and 40 years-old	Type 2 diabetes (DB) Osteoroposis (OS) Hypertension (HT) Coronary heart disease (HD) Hypercholesterolemia (HC) Skin cancer (SC) Lung cancer (LC) Colorectal cancer (CRC)		ARKP of each disease: on a scale from 1 to 7, where 1 = certain not to happen and 7 = certain to happen, what do you think is your chance of getting the following condition in your lifetime? DB/ OS/ HT/ HD/ HC/ SC/ LC/ CRC
Silk et al. (2006)	USA	Qualitative study	10 focus groups with 91 participants = Adolescents aged from 9 to 15 years-old and their mothers (or not) aged from 21 to 55 years-old	Breast cancer (BC)		NR
Spector et al. (2009)	USA	Qualitative study	20 whites and 12 blacks adults women with at least one sister diagnosed with breast cancer	Breast cancer (BC)		ARKP of BC: do you consider yourself to be at risk for BC?
Wang et al. (2009)	USA	Quantitative study	National representative sample 2362	Heart diseases (HD) Diabetes (DB) Stroke (SK) Breast cancer (BC) Ovarian cancer (OC) Colon cancer (CC)		CRKP of each disease: compared to most people your age and sex, what would you say your chances are for developing HD/ DB/ SK/ BC/ OC/ CC? From much lower than average to much higher than average
Waters et al. (2011)	USA	Quantitative study	14426 women aged 18 and older who reported never being diagnosed with any cancer	Breast cancer (BC)		CRKP of BC: compared to the average woman your age, would you say that you are more likely to get BC, less likely or about as likely? Objective RK of BC computed with Gail model Accurate RKP if objective relative risk of BC matched CRKP
Environmental factors						
Beck et al. (2013)	France	Quantitative study	National representative sample 3359	Health risks	Radon	Departments concerned with risk radon: (1) radon as a health risk (2) radon exposure in homes as a risk factor for lung cancer
Bord and O'Connor (1997)	USA	Quantitative study	2 independent national surveys of 500 adult subjects each	Health risks	Hazardous waste sites Global warming	NR

Brenot et al. (1998)	France	Quantitative study	National representative sample 1022	Risks	Set of various hazards	Personal risk: do you think that the existence of X endangers you or your relatives? 5-point scale from no, not at all to yes absolutely Residual risk: existing safety measures are never totally effective. For X, do you consider that the remaining risks are almost non-existent, low, moderate, high or very high? Demand for safety measures: measures to prevent risks and increase safety are expensive. In your opinion, is it urgent to strengthen prevention and safety measures for X? 5-point scale from not at all urgent to extremely urgent
Carlton and Jacobson (2013)	USA	Quantitative study	558 undergraduate students at the University of Florida aged between 18 and 22 years old	Risks	Set of various hazards related to climate change	RKP: rate level of concern about 17 coastal environmental risks
Claeson et al. (2013)	Sweden	Quantitative study	722 persones aged 18-75 years	Health risks	Air pollution	Are you worried about your own or your family's/household's health due to odor pollution from the following conditions due to the following facilities or activities? If yes, are you worried that you or your family/household will be at increased risk for the following conditions due to the following facilities or activities?
Denny-Bas et al. (2014)	France	Quantitative study	290 volunteers aged between 18 and 75 years, living in the Lorraine region	Risks	Cell phone use and antennas Active and passive smoking	NR 11psychometric properties of risk
Flynn et al. (1994)	USA	Quantitative study	1275 white and 214 nonwhite English-spoken individuals	Health risks	Set of various hazards	Rate public health risks associated with each of 25 hazards: set of technologies, lifestyle risks, and environmental condition. Possible answers: almost no health risk, slight health risk, moderate health risk, and high health risk
Gerking and Khaddaria (2012)	USA	Quantitative study	2002 individuals aged between 14 and 22 years	Health risks	Smoking	Perceived risk of health damage from smoking: in your opinion, would your smoking everyday be very risky for your health, somewhat risky, a little risky, or not at all risky for your health? Now I would like you to imagine 100 cigarette smokers, both men and women, who smoked cigarettes for their entire adult lives. How many of these 100 people do you think will die from LC?
Greene et al. (2014)	UK	Literature review	17 articles	Health risks	Set of various hazards	NR
Haluza and Cervinka (2013)	Austria	Quantitative study	563 Austrian adults spending leisure time outdoors, 65.4% women, aged between 18 and 83 years-old	Health risks	Sun exposure	Combination of three items: participants' perceived or subjective perception of dangers of sun exposure regarding skin cancer, skin ageing, and overall risk of tanning. 5-point-Likert scale from no risk to very high risk
Harrison et al. (2004)	Italy + USA	Quantitative study	968 participants: 459 consumers from Northern Italy + 509 adults living in areas of Denver, Chicago, Atlanta, Los Angeles, New Orleans, New York and Houston	Risks	Genetically modified food	Risk perception index ranges from 0 to 100 => Combined score of -10 and +10 GM foods are reasonably safe for human consumption. 10-point scale from +5 strong disagreement to -5 strong agreement GM crops may have adverse effects on wildlife and the environment. 10-point scale from +5 strong agreement to -5 strong disagreement There is no need to be concerned about the safety of GM foods because government agencies would not let these products be sold if they are no safe. 10-point scale from +5 strong agreement to -5 strong disagreement
Johnson et al. (2002)	USA	Quantitative study	223 with 74 high school students and 149 college students	Lung cancer Sexually transmitted diseases	Smoking Unprotected sexual relations	How likely are you to contract a sexually transmitted disease? / What are your chances of getting LC some day? From absolutely no chance to absolutely will happen Compared to other people your age and sex, how likely are you to contract a sexually transmitted disease? From much below average to much above average Compared to … , what are your chances of getting LC some day? From much below average to much above average How risky is it to have sex without a condom? / How risky is it for you to smoke cigarettes? Not at all risky and extremely risk
Kim et al. (2015)	Korea	Quantitative study	1096 men and women aged more than 20 years old, living in Seoul and in 6 other metropolitan cities	Risk	Light pollution: light trespass, over-illumination, glare, and light clutter Mobile phone radiation Noise pollution Asbestos Medical accident Chemical accident Atmospheric pollution Climate change	RKP : I think that the environmental risk factors including light pollution are dangerous Light pollution: light trespass, over-illumination, glare, and light clutter) 7-point Likert scale from completely untrue to completely true
Marshall (2004)	USA	Quantitative study	774 adults aged more than 18 years old with low-moderate income	Health risks	Plant pollution	11 variables measure the perception of environmental risks: "for each item I read tell me whether you think it is not much of a problem, somewhat of a problem or a serious problem." Environmental risks: water pollution, noise, disposal of hazardous waste, air pollution, toxic chemical leaks, odors, flames from a refinery smoke stack, plumes of smoke, pollution of land from improper waste disposal, industry too close to people's homes, and illness caused by industries
Marcon et al. (2015)	Italy	Quantitative study	3697 parents of children aged from 3 to 14 years old	Health risks	Electromagnetic fields City traffic Lack of public parks and gardens Air pollution Indoor cigarette smoke	How much do you think that the following aspects can be a risk for the health of the population? For 7 environmental issues. Possible answers: a little, quite a lot, a lot, not at all, I don't know

					Chemical products in food Excess fluorine in the water	
Nishikawa et al. (2016)	Japan	Quantitative study	1459 participants 2010 n=822: Kashiwazaki (n=434), Nishiyama (n=203), and Kariwa (n=185) 2011 n=637: Kashiwazaki (n=304), Nishiyama (n=165), and Kariwa (n=168)	Risks and benefits	Nuclear accidents	Which is greater, the positives or negatives of having a nuclear power generation plant? Possible answers: negative, not obvious, positive Subjective prob. Of earthquake: how often do you think a major earthquake will force you to evacuate or stay in a shelter over the next 30 years? Possible answers: never, almost never, once or twice, thrice or more Subjective prob. Of man-made: how often do you think human causes will force you to evacuate or stay in a shelter over the next 30 years? Possible answers: never, almost never, once or twice, thrice or more
Orita et al. (2015)	Japan	Quantitative study	285 residents in Kawauchi in Fukushima prefecture located less than 30 km from Fukushima Daiichi nuclear power plant (FNPP) aged 18 years or older	Health risks	Nuclear radiation	To evaluate risk perception of the health effects of radiation such as health effects of radiation in children and on offspring Whether residents thought that Acute Radiation Symptom might occur in residents due to the FNPP accident
Poortinga et al. (2008)	UK	Quantitative study	1528 individuals living in areas exposed environmental health risks Exposure to radon gas: areas determined with high and very high exposure through radon atlas of England and Wales Exposure to overhead powerlines: living within 50 m of a 400-KV OP = 1 km wide buffer	Health risks	Indoor radon gas (IRG) Overhead power lines (OPL)	Perception of health risks: NR How concerned respondents are about radon / overheard power lines?7-point scale from no concern to extreme concern On the whole, how acceptable or unacceptable are the risks of [radon/powerlines] to you? On the whole, how acceptable or unacceptable are the risks of [radon/powerlines] to you?7-point scale from very unacceptable to very acceptable
Rafique et al. (2008)	Pakistan	Quantitative study	5325 individuals aged more than 18 years-old leaving in the state of Azad Kashmir	Health risks	Radon	Have you ever heard about radioactivity or radon? Yes/No Is radon a health hazard? Yes/No What type of health threat is imposed by radon? Lung cancer, blood cancer, thyroid cancer, brain tumor
Rios-Gonzàles et al. (2013)	Mexico	Mixed design: Qualitative study + Quantitative study	222 participants Qualitative study: 27 interviews and field observations conducted with large-scale farmers (n=8), small-holders (n=4), and farm-workers (n=4), health professionals (n=4), scientists (n=3), and extensionists (n=4) Quantitative study:195 participants including smallholders (n=99) and extentionists (n=96)	Risks	Pesticides	Health professionals: principal health risks in the area Farmers/Farm workers, extensionists, scientists, and health professionals about their views on pesticide risks, for example, if they think that pesticides are harmful or not to environmental and human health
Saba and Messina (2003)	Italy	Quantitative study	947 consumer panel provided by Italian market research company, 51.5% were women	Health risks	Pesticides residues on food	4 perceived risks statements: risks associated with pesticides are still underrated / pesticides are a big danger to human beings / fruits and vegetables produced without pesticides are healthier / pesticides advance nature's ruinous exploitation 4 perceived benefits statements: benefits associated with pesticides must not be underrated / food would be more expensive without pesticides / a thorough consideration indicated that a general ban on pesticides would be irresponsible / without the use of pesticides more human beings would suffer from hunger 5-point scale from strongly disagree to strongly agree
Savoy et al. (2014)	USA	Quantitative study	2274 adults aged more than 25 years old, self-identified African American, White or Latino, self-identified current daily or nondaily smokers	Health risks	Smoking	3 questions averaged in one single risk perception variable: if you continue to smoke, how likely do you think it is that you will develop lung cancer / other lung diseases such as emphysema / heart disease? Possible answers: no chance, very unlikely, unlikely, moderate chance, likely, very likely, certain to happen
Sessa et al. (2010)	Italy	Quantitative study	1181 parents of students	Health risks	Solid waste management (SWM)	Perceived health risk related to waste management: perceived risk of contracting infectious diseases due to improper SWM, beliefs that improper SWM is linked to allergies, perception of risk of falling ill by eating products grown near the landfill, perceived risk of developing cancer due to SW burning
Shepherd et al. (2012)	Australia	Quantitative study	1261 adult residents in Queensland	Human reproduction	Pesticides, household chemicals and paints, radiation, cosmetic and hair colors, animal-borne diseases, lead, stress, carrying and lifting, water pollution, air pollution	Whether they considered a list of potential environmental hazards to be very harmful, harmful, neutral, slightly harmful, or not harmful at all to reproduction
Siegrist et al. (2005)	Switzerland	Quantitative study	1015 adults aged from 18 to 74 year-olds, 75% from German and 25% from French speaking part of Switzerland	Risks and benefits	Electromagnetic fields : Base stations (BS) Mobile phones (MP)	Perceived risk: I will mention different sources of electro-magnetic radiation. Indicate, using a number between 1 and 5, how risky you perceive the radiation emitted by these technologies to be, for Swiss society as a whole? Perceived benefit: In general, how beneficial do you consider each of the following technologies to be, for Swiss society as a whole?
Smith and Johnson (1988)	USA	Quantitative study	230 sample of households from an epidemiological study + control group	Health risks	Radon	APRK: how serious (risk of death) a respondent considered his health risk from radon. Scale from 0 to 10 ARKP: how serious they thought the risk from radon was before and after they received the test results. Scale from 0 to 10

Stewart et al. (2013)	USA	Quantitative study	402 daily smokers, aged 18 to 70 years-old	Health risks	Smoking	Absolute RKP: (1) if you don't quit smoking for good (2) if you quit smoking for good - what are your chances of ever developing a smoking-related health problem? 7-point scale from extremely unlikely to extremely likely + Scale from 00% to 100% Comparative RKP: compared to other smokers, what are your chances of ever developing a smoking-related health problem (3) if you continue smoking? (4) if you quit smoking for good? 7-point scale from extremely unlikely to extremely likely
Wilson et al. (2004)	Australia	Quantitative study	242 Autralian adults	Risks and benefits	Genetically modified food	Perception of dangers associated with these crops Perception of opportunities associated with these crops Risk judgment measured with 15 items
Screening						
Atkinson et al. (2015)	USA	Literature review	58 articles	Colorectal cancer (CRC)	.	CRC RKP measures: 21 studies used two or more items to measure risk perception =>21 social comparative, 21 verbal absolute, 4 numeric absolute, 12 combinations of measures.
Katapodi et al. (2004)	USA	Literature review	42 articles	Breast cancer (BC)	.	NR Numerical scale often leads to overestimation and systematic errors. Likert scales often lead to optimistic bias and especially for BC RKP.
Walker et al. (2013)	Canada	Literature review	20 articles	Breast cancer	.	NR
Risk communication						
Edwards et al. (2013)	UK	Literature review	41 articles	Personalized risk communication	.	NR
Fitzpatrick et al. (2010)	Canada	Literature review	24 articles	Communication about environmental health	.	NR
Vernon (1999)	USA	Literature review	27 articles	Risk communication for cancer		NR

3.2 Individuals' perceptions of their cancers' risks stemming from environmental factors

3.2.1 Perceptions of cancers' risks stemming from various set of hazards

Wandersman and Hallman supported already in 1993 that individuals were concerned about health risks stemming from environmental factors such as hazardous chemical waste sites. According to Ménard and colleagues, individuals nowadays are more sensitive about associations between cancers' occurrence and environmental factors (32).

More generally, across several studies, respondents perceived high health threats associated with environmental factors (20,22,32–40). Environmental factors reported the most in association with health risks and/or cancers' risks were pollution of air, water and soils (20,22,32–34,36,38,39,41), pesticides and chemical products in food (20,22,36,38,40,42), waste management from chemical and/or nuclear industries (33,36,39,42), asbestos (32,37), passive or secondhand smoking (35,38) and sun exposure (32,36). In the study conducted by Flynn and colleagues, hi-volt powerlines and indoor radon exposure were very low in respondents' ranking of risks (36).

Influence of lifestyle was also perceived associated with health risks and/or cancers' risks. A wide range of studies found smoking (20,21,36,41,43–45), stress and psychological factors (20–22,36,43), unhealthy diet (21,22,41), alcohol consumption (41,43,44), lack of exercise (22,41,43) and overweight (46) perceived as cancer risk factors. However, in some studies, respondents perceived low risk associated with alcohol consumption and smoking (33). Results were also mitigated when answers from adolescents and middle-age women were compared especially regarding the link between lifestyle factors and breast cancer risk (17). Use of mobile phones was found associated with polarized risk perceptions (32).

Cancer family history was perceived as breast and colorectal cancer risk factors (17,20,22,45,47) and ageing as a colorectal cancer risk factor (22).

3.2.2 Individuals' perceptions of cancers' risks stemming from smoking

Half of studies (n=15) dealing with perceptions of cancers' risks stemming from environmental factors analyzed perceptions of cancers' in general, lung cancers' risks and/or smoking-related diseases' risks or other chronic diseases stemming from smoking.

Respondents associated high perceived health risks (35) and perceived greater likelihood of developing lung cancer associated with smoking compared to not smoking (48,49). Gerking and Khaddaria found young adults and teenagers to perceive that 60% of smokers on average

would die from lung cancer (50), an overestimation compared to objective epidemiological data (51). Two additional studies found that most young adults and teenagers perceive their risk of developing smoking-related cancers to be higher than the estimated epidemiological risk (52,53). In addition, respondents perceived a stronger relationship between smoking and lung cancer than with any other diseases such as heart diseases, stroke, or respiratory diseases (54).

Studies reported respondents, not currently smokers (never or former smokers), to perceive their risk of developing lung cancer in the future to be low (55,56) or lower than other individuals of the same age and gender (55,56).

Results among current smokers were less consistent. Current smokers were found in some studies to perceive their risk of cancer or lung cancer high (57,58) or higher than others (55). These studies supported the assumption that smokers acknowledge their higher risks of cancers compared to non-smokers. This assumption was also supported by two studies conducted among adults current smokers who displayed high risk perceptions of smoking-related health diseases or problems (46,59) and one study conducted among young adults and teenagers (60). In addition, Ford and colleagues found half of current smokers cancer survivors to perceive their risk of having heart problems higher than others (57). On the other hand, other studies found current smokers to display an optimistic bias, i.e. they perceive their own risk of developing lung cancer to be low (54) or lower than others (56,61–63). A fact also supported by Stewart and colleagues who found current smokers to perceive their risk of smoking-related health problems lower than other smokers (46). A significant number of current smokers was also found to perceive their own daily consumption of cigarettes and/or duration of smoking to be lower than the level necessary to be at risk of cancer (58,64). This optimistic bias was less found across a sample of individuals aged between 50 and 70 years-old (65). According to the authors, people in this age group were on average not overly optimistic because of the awareness about risk factors coming with ageing. More generally, current smokers were found to display lower perceptions of cancers' risks in general than former and never smokers (66).

Regardless their smoking status, individuals appeared to agree on the existence of a specific risk group of typical smokers (48,61).

3.2.3 Individuals' perceptions of cancers' risks stemming from pesticides and genetically modified food

Among the studies dealing with perceptions of cancers' risks stemming from environmental factors, two analyzed perceptions of cancers' risks in general stemming from pesticides (21,67)

among professional of the agricultural sector. Around half of immigrant farm workers perceive cancer as the result of unavoidable exposure to pesticides (67). Around the same proportion of current pesticide applicators and supervisors or managers perceived chemical exposures to be moderate contributors to cancer incidence while one fourth of them perceived this link as significant (21).

Two additional studies investigated perceptions of risks stemming from pesticides. Among the Italian sample of respondents, the extent to which individuals perceived risks associated with pesticides appeared linked with the extent to which they perceived associated benefits (68). Farm workers appeared to associated pesticides with cancer according to the products' labels which actually report the acute toxicity levels (23). In addition, most of the agricultural workers interrogated in this survey showed cognitive dissonance regarding risks associated with pesticides: they combined risk awareness and risk disregarding in their practices (23). Occupational categories relied on different concepts when constructing their risk perceptions although risk perceptions appeared similar: agricultural workers seemed to rely on direct experiences of handling pesticides and office workers seemed to rely on formal education (23).

Two additional studies investigated perceptions of risks stemming from genetically modified food (GMF). Most of Australian respondents were found to be balanced (n=81) regarding dangers and opportunities associated with GMF. Among those with polarized views, more respondents associated GMF with more dangers than opportunities (n=70) than the opposite (n=33). Higher concerns regarding health and environmental risks were found to be the most important factors affecting consumer acceptance of genetically modified food (70).

3.2.4 Individuals' perceptions of cancers' risks stemming from solar radiation

Perceptions of skin cancers' risks were analyzed in three surveys. However, in any of these three studies, individuals were asked about their perceived risk to develop skin cancer stemming from sun exposure. The majority of Swedish respondents perceived their risk of developing skin cancer to be neither high nor low or the same than for other people. In addition, a larger proportion of Swedish respondents perceived their skin cancer's risks to be high or higher than for others rather than low or lower than for others (71). A different pattern was observable among US respondents: around half of US respondents perceive their skin cancer's risks to be low or lower than for other people. Then, a larger proportion of US respondents perceived their skin cancer's risks to be neither high nor low or the same than for other people rather than high or higher than for others (74). In a study conducted among outdoor workers, risk perceptions of skin cancer was not directly asked to respondents. Risk perceptions measures in this article

encompassed perceived skin type, perceived resilience to sunburn, concern, priorization of sun protection, workplace support and perceived knowledge about a range of skin cancer risk factors (73).

An additional study analyzed sum-scores of risk perception of dangers (skin cancer, skin ageing and overall tanning's risk) related to sun exposure (75). However, data regarding the sum-scores of risk perceptions were not reported.

3.2.5 Individuals' perceptions of health risks stemming from indoor radon exposure

None of the included studies investigated perceptions of cancers' risks stemming from indoor radon exposure but four studies analyzed perceptions of health' risks. These studies showed that awareness of indoor radon exposure of individuals living in at-risk areas was low: 25% and 17% of samples of French and Pakistani respondents have heard about indoor radon exposure (76,77). The association with lung cancer's occurrence appeared especially unknown among the sample of Pakistani individuals as 5% knew that radon was associated with lung cancer's occurrence (77). This result was also found among UK with around half of a sample of UK respondents who did not know if "breathing in radon gas can cause lung cancer". Those who answered, on average, moderately agree with this statement. UK respondents moderately agree also that their "health is at risk if" they "live with radon gas for a long time" (78). Awareness of association between indoor radon exposure and lung cancer's risks was higher among French respondents: 61% declared that radon exposure increased lung cancer's risks. However, only few of them felt personally concerned about this issue (76).

Smith and Johnson showed a decrease in perceived health risks associated with indoor radon exposure before and after the test of radon concentration in their house. On average, respondents' perceived risks was 0.33 before and 0.27 after the test (79).

3.2.6 Individuals' perceptions of cancers' risks stemming from nuclear-related factors

Only one study analyzed perceptions of cancers' risks in general stemming from living near a nuclear power plant among a sample of Taiwanese adults (80). Nuclear-related factors such as nuclear accidents, radioactive nuclear waste disposal and potential health effects were associated with high level of concern. Respondents living beyond 30 km of a nuclear power plant perceived higher risk of cancer for people living within 30 km of a nuclear power plant. More generally, respondents perceived higher death's risks related to nuclear-related factors than smoking, motorcycling, or air travel (80).

Two additional studies, conducted among the Japanese population, analyzed perceptions of nuclear-related risks. Risk perceptions of radiation health effects were more polarized among individuals living in the village of Kawauchi, located within 30 km of the Fukushima-Daiichi nuclear power plant, after the accident (81). Around half of the respondents had anxieties about radiation's health effects on children and offspring and were reluctant to eat rice or vegetables produced in the village (81). Higher perceptions of nuclear-related risks and lower perceptions of benefits was also found, after the Fukushima-Daiichi nuclear plant accident, among a sample of individuals living near the Kashiwazari-Karima nuclear power plant (82). According to the authors, this change in the discount rate between perceived costs and benefits was higher than the change in individuals' subjective expectations of a nuclear accident (82).

3.2.7 Individuals' perceptions of cancers' risks stemming from electromagnetic fields

Only one study analyzed perceptions of cancers' risks stemming from living close to a cell-phone antenna (83). This study found that cell-phone antennas were perceived at least probably carcinogenic by half and then six over ten respondents respectively in the 2005 and 2010 Cancer French KABP surveys, showing an increase of twelve percent points between the two periods. According to the authors, a mechanism of social amplification of risk (84) was supported by these data as risk perceptions associated with cell-phone antennas increased similarly across all age categories (83).

Perceptions of health risks stemming from exposure to electromagnetic fields were analyzed in three additional surveys: one was focused on cell-phone use and antennas (35), mobile phones and base stations (85) and overhead powerlines (86). These studies showed that exposure to base stations or cell-phone antennas was perceived with higher health risks than use of mobile phones (35,85). Consistently, UK individuals living a 1km wide buffer tended to agree that "the closer that people live to powerlines, the greater the risk to their health" (78,86). However, inconsistently, UK individuals living a 1km wide buffer tended to disagree that their health was at risk from overhead powerlines when they are at home. Around one fifth of the sample gave a DK answer (78). Furthermore, mobiles phones were associated with the highest ratings of benefits (35). In addition, mobile phones and base stations received the lowest trust ratings of management authorities (35,85). When respondents were asked to associated words with base stations, they associated more negative than neutral or positive words (85). According to Denny-Bas and colleagues, hazard's source appeared more important than the nature of exposure (35).

3.2.8 Individuals' perceptions of health risks stemming from air pollution and global warming

One study analyzed perceptions of health risks stemming from global warming among samples of US adults (87). This study showed that, on average, individuals moderately agreed that global warming increases risk of heat stroke, diseases such as malaria, heart attack and stroke and birth defects and miscarriages (87).

One study analyzed perceptions of health risks stemming from air pollution among a sample of Swedish respondents (88). This study found that, on average, four over ten respondents perceived an increasing risk for them or their family of annoyance, asthma or other airway disease, or cancer due to odor emissions from biofuel facility, road traffic, wood burning or rubber industry (88).

3.2.9 Individuals' perceptions of health risks stemming from waste management

Two studies analyzed perceptions of health risks stemming from waste management, one was focused on hazardous chemical waste sites among samples of US adults (87) and the other one focused on solid waste management sites among a sample of Italian adults (89). The first study showed that, on average, individuals moderately perceived an increasing risk for them or their family of developing cancer or other health problems stemming from hazardous chemical waste sites. However, they agreed a bit more on an increasing risk for them or their family of experiencing pollution of the local drinking water or breathing air (87). Majority of respondents in the second study perceived improper solid waste management to increase risk of developing allergies, cancers and infectious diseases (89).

3.2.10 Additional data on individuals' perceptions of cancers' risks

Studies conducted among national representative samples showed negative perceptions associated with cancers (44,90), also perceived as the most serious among severe diseases (32,91). On the other hand, the majority of these US samples perceived themselves as having a low likelihood of developing breast, prostate, or colorectal cancer (92).

However, when asked about their risk of developing cancers among other serious diseases, respondents displayed sometimes higher risk perceptions for breast, ovarian, or colon cancer than heart diseases, stroke and diabetes (93) while sometimes higher risk perceptions for heart diseases, high blood pressure, high cholesterol and type 2 diabetes (91). According to Shiloh

and colleagues, respondents in their study displayed a general optimistic bias regarding their risk of developing serious diseases (they perceived themselves less at risk than others) (91).

A fact supported among studies conducted on breast, colorectal and ovarian cancers. Women tended to perceive their own risk of developing breast cancer to be low or moderate while they tended to perceive their peer's risk of developing breast cancer to be moderate or high (11,18,45,47,94–98). The same observation was made among a sample of women regarding their perceived risk of developing ovarian cancer (99) and among two samples of adults regarding their perceived risk of developing colorectal cancer (22,100).

Results from studies comparing objective estimation of breast cancer risk computed with instruments such as Gail model and women's breast cancer risk perception were mitigated: some studies found a tendency among women to overestimate their own risk (30,94) and the risk of another woman same age (94), one study found a tendency among women to underestimate breast cancer risk (98), while another one found accurate perceptions among women at average risk of breast cancer but a tendency towards underestimation among women at high risk (101).

According to Hamilton and Lobel, disease risk perception is a multidimensionality concept: they found women in their study to base their risk perception of severe diseases on their global disease risk perception whilst endorsing different risk perception of cardiovascular diseases, breast cancer and lung cancer based on diseases-related beliefs and misconceptions (102).

Han and colleagues pointed out through their qualitative study that individuals tended to associate their risk of cancer with concrete risk factors allowing them to be reassured about disease's controllability (15). In addition, they elicited a two-step process in individual estimation of risk. According to the authors, individuals construct first an objective probability made from an interpretation of numerical and objective data based on epidemiological studies. Then, they construct a subjective probability reflecting whether the individual himself would be in the sick population or not. This assumption supports the empirical finding that individuals often estimate their risk with a probability close to 50%: being in the group who will be sick or not (15,16).

Beck and colleagues warned in their article about the perceived proliferation of cancer risk factors. Individuals could be indeed lead to put some risks in perspective with others creating thus their own risk's ranking. They could also attribute less risk to adopted behaviors and more risk to other not-adopted behaviors (44).

3.3 Relationships between individuals' perceptions of cancers' risks stemming from environmental factors and adoption of health-related behaviors

Relationships between individuals' risk perceptions and adoption of health-related behaviors were analyzed in forty-two studies.

Health-related behaviors perceived as preventive towards cancers' risks across the selected studies were eating healthy diet with significant fruit and vegetable intakes (17–19,22,45,66), having a regular physical activity (17–19,22,45), avoiding exposure to chemicals in food 22,66, genetically modified food (22,66), smoking (22,66), electromagnetic fields (66), stress (18) and sun (66). Following screening recommendations was also pointed out (17).

Health-related behaviors perceived as risk-taking towards cancers' risks across the selected studies were excessive alcohol consumption, (19,22,41,45), smoking (19,41,42,45), unhealthy diet (22,41,45), low exercise (22,41,45), exposure to environmental pollution (41,42), stress (19,41), drug use (19), overweight (45), and urban living (19).

Several relationships between individuals' perceptions of cancers' risks stemming from environmental factors were found across our range of selected studies.

Individuals perceiving their cancers' risks stemming from sun exposure or smoking as high were found to adopt preventive health-related behaviors regarding these risks (56,72,73). This relationship was also supported among individuals perceiving their health risks stemming from environmental factors such as air pollution, chemical products in food as well as exposure to electromagnetic fields, nuclear radiation and pesticides as high (23,38,81,85). More generally, individuals perceiving their cancers' risks as high were found to adopt preventive health-related behaviors regarding these risks (20,92,103). Consistently, individuals perceiving their cancers' risks stemming from pesticides' exposure (67) or their general cancers' risks (97) as low were found to not adopt preventive health-related behaviors regarding these risks. Furthermore, individuals perceiving their cancers' risks stemming from genetically modified food, smoking or sun exposure as high were found to adopt less risk-taking health-related behaviors regarding these risks (35,48,52–54,60,70,71,104). The same relationship was found regarding health risks stemming from use of cell phones, genetically modified food, smoking and unprotected sexual relations: individuals perceiving their health risks stemming from these factors as high were found to adopt less risk-taking health-related behaviors regarding these risks (35,59,60,70).

Individuals adopting risk-taking health-related behaviors were however found to perceive their cancers' risks stemming from smoking as high (61) as well as their general cancers' risks (19,44,45,99,100,105). Reciprocally, individuals adopting several preventive health-related

behaviors were found to perceive their cancers' risks stemming from smoking, radon or various set of hazards (39,79,104) or their general cancers' risks as low (22).

No significant association was also found across a number of studies between adoption of health-related behaviors and individuals' perceptions of cancers' risks stemming from smoking (65) and general cancers' risks (47,94,106–108).

Interestingly, Weinstein and colleagues found higher smoking cessation planning among individuals displaying high absolute and comparative risk perception of cancer stemming from smoking but overall personal cancer risk perception was not significant (56).

Focus on screening behaviors

A weak but positive association between breast cancer risk perceptions and adherence to mammography was found by Katapodi and colleagues (11) and Walker and colleagues (30). In the last study, however, no significant relationship was found between breast cancer risk perceptions and adherence to clinical- or self-examination.

A small, significant, positive relationship moderated by the quality of studies was found between colorectal cancer risk perception and screening behavior: low quality study group reported higher size effects than high quality study group (31).

Some warnings were made by these different authors in their literature reviews. The first one concerns the difficulty in determining whether individual cancer risk perceptions are the cause or the consequence of individual cancer screening behaviors (27). A point particularly important as personal experience with mammography, and especially negative ones, could be an important determinant of adherence to mammography (11). The second point concerns the fact that most studies examined ever-use screening and not guideline-adherent screen use. Therefore, a woman who declared a one-time screening was in the same category than a woman who follows screening guidelines (30).

3.4 Determinants of individuals' perceptions of cancers' risks stemming from environmental factors

3.4.1 Level of knowledge

Individuals' level of information was found associated with one's risk perception. Individuals were indeed found to use pre-existing knowledge and information to update their risk assessment (18,25,79) and to evaluate their own level of risk using information coming from

others as an indicator (103,107). For instance, high knowledge of cervical cancer was associated with high risk perception of developing cervical cancer (99). Increase in knowledge related to environmental factors was also found associated with higher awareness (86) and risk perception (37). In the study conducted by Peretti-Watel and colleagues, smokers were found to acknowledge their higher cancers' risks stemming from smoking. The authors explained this finding by individuals' knowledge because a significant part of current smokers declared themselves to be well informed about smoking health consequences (58). Viscusi found respondents to have assessed risks associated with e-cigarettes by using their risk assessment of conventional ones as main information (51). Nonetheless, this relationship was not consistent across all studies. Having knowledge about breast cancer risk factors was indeed found unlinked with breast cancer risk perception (47). The same fact was supported regarding knowledge on genetically modified food (70).

In addition, information spreading was found associated with increasing worry and anxiety without necessarily accurate updating of risk perception (19,66,89,96). A negative relationship was also found between satisfaction about information and risk perception (109). Information needs indeed varied among individuals: individuals feeling vulnerable to (35) or perceiving high uncertainty associated with (87) risk factors were found to have high information needs.

3.4.2 Focus on risk communication

Risk communication interventions to modify individual's cancer risk perceptions appeared effective in changing cancer risk perceptions in the assumption direction as well as impacting cancer screening behaviors (27).

Individuals averse to ambiguity in risk communication tended to display higher level of worry, higher perceived risk and be more pessimistically focused than individual tolerant to ambiguity whom reciprocally tended to display lower level of worry, lower perceived risk, and higher perception that they can do something to alter their risk (14).

The most effective risk communication strategy to reach a large audience regarding environmental health risk was found to be the establishment of a multi-facetted delivery method incorporating the needs of the targeted audience. In addition multi-media approaches appeared to be more effective to communicate information to people. One-time communications were effective in the sense that it increased the risk knowledge but it decreased across time. Thus, people should receive regular information about the meaning of warnings in order to recall their purpose and what to do. The authors also showed that responses to risk communication were

impacted by personal risk perception, previous personal experience with risk, sources of information and trust in those sources (people pay more attention to information delivered by credible sources), and preferences for information (28).

Personalized risk estimates incorporated within communication interventions for screening programs enhance informed choices as personalized risk communication increased individual level of knowledge. Individuals' risk perceptions were more accurate after the intervention. However, no specific and significant results emerged with anxiety. Evidence for increasing uptake of screening tests was weak and no contrasted statement could be made about the increase of informed choices (29). This finding is consistent with and supports the importance of risk issues' framing: risk information displayed as estimates at the aggregate level reflecting general health information might not be judged relevant by individuals (67).

3.4.3 Beliefs related to cancers and environmental factors

Individuals' beliefs were found to influence individuals' risk perceptions. For instance, positive beliefs towards pesticides in food were associated with less perceived risks and more perceived benefits (68). Feeling that chance or fate could influence prostate cancer occurrence was also found to decrease individual's prostate cancer risk perception (19). Pro-environmental attitudes were found as well to be positively associated with greater physical environmental and biological risk perception (34). Finally, according to Rice and colleagues, cancer-related beliefs endorsed by respondents were associated with their perceptions and responses to risks (39).

Several studies pointed out the strong role of smoking-related beliefs among adults who are current smokers who hold beliefs minimizing smoking risks and helping them to justify their smoking-behavior such as ''exercise can undo most of the effects of smoking'', ''there's no risk of getting cancer if someone only smokes a few years'' (56) or "smoking is no more dangerous than breathing polluted air in urban areas" and "some people can smoke their whole life and never get sick" (64). This mechanism was also supported among young adults and teenagers (60). More generally, optimistic bias regarding absolute risk of lung cancer was also found associated with beliefs related to curability of lung cancer and survival after diagnosis (56). Reciprocally, young people believing that "it is difficult to giving up smoking" and that "health consequences related to smoking can occur quickly" displayed high cancer risk perceptions and were less likely to smoke or start smoking (50).

3.4.4 Perceived voluntariness of exposure

Perceived voluntariness of exposure was found as a concept correlated with individual risk perceptions: individuals display lower (higher) risk perceptions for a risk perceived as voluntarily (involuntarily) vs. involuntarily (voluntarily) endorsed (35,66). Feeling of vulnerability was found positively correlated with perceiving risk as imposed (83).

For instance, a small portion of adolescents' smokers appeared to have a great awareness of the increasing risk of smoking-related lung cancers but they decided anyway to smoke (53). This result about smoking was supported by other studies such as current smokers were more likely to perceive themselves at risk for cancers and lung cancers than individuals who do not smoke (55,60,65). This fraction of the population seemed to choose voluntarily to be exposed to this specific risk.

3.4.5 Perceived control

Perceived control was found associated with individual risk perceptions: individuals display lower (higher) risk perception for a risk perceived as controllable (uncontrollable) vs. uncontrollable (controllable) (16,19–22,33,35,67,71,93,110).

According to Han and colleagues, being able to identify specific risk factors with cancer seemed to reassure individuals on the role they can play on their health (15). Indeed, if a risk factor is clearly identified it becomes possible to endorse practices in order to control it.

Besides, individuals who perceive the occurrence of cancer as controllable also tend to endorse healthier behaviors than people with low perception of control (18,20,22,110). More generally, Wang and colleagues supported this finding among six chronic diseases: perception of control was negatively associated with risk perceptions (93). Reciprocally, adopting preventive health-related behaviors created a sense of control over cancer occurrence (19,110).

3.4.6 Personal history of cancer

Personal history of cancer was found positively associated with individuals' general perceptions of cancers' risks or cancers' risks stemming from environmental factors (25,39,79,109,111) but negatively associated with cancer-related anxiety (109). In addition, experience of benign diseases or symptoms was found positively associated with individuals' risk perceptions of breast cancer (97), colorectal cancer (100) and prostate cancer (19). Individuals with personal

cancer history were also found to have a strong motivation to stay informed on potential environmental risk of cancer (111).

However, personal history of cancer was not found associated with individuals' perceptions of cancers' risks (107) or cancer as a death sentence (90). A study conducted among heavy smokers cancer survivors found them to perceive their own risk of serious health problem greater than others but to not perceive themselves at greater risk than others for a second cancer or recurrence (57).

3.4.7 Cancer history among family, friends, colleagues, acquaintances

Cancer family history was found positively associated with individuals' perceptions of general cancers' risks (39,41,44) as well as individuals' perceptions of breast (11,16,18,20,25,30,45,47,94,95,97,105,110,112), colorectal (22,100,108,112), lung (55), prostate (112) and ovarian (113) cancers' risks. This finding was also consistent across other serious diseases such as heart disease and diabetes (112). No impact of cancer family history was found regarding individuals' perceptions of skin cancers' risks (72,114).

Individuals' experience with cancer appeared not limited to family history. Knowing a friend or a non-blood relative affected with cancer was also found positively associated with individuals' perceptions of cancers' risks (18,54,109,112). Several authors supported the assumption that the more experience an individual has with cancer through his own history and the one of his family, friends, and colleagues, the higher his perceptions of his own risk to develop cancer (16,20,105,113).

Studies with more detailed analyses on cancer history among others pointed out two elements determining the strength of this experience: the distance with the affected person – geographical, emotional, or temporal – and the nature of the experience – positive, neutral, negative, or traumatic – (18,19,22). Indeed, affected relative's treatment, experience and outcome were showed to influence individual prostate cancer risk perception. Matthew and colleagues found in their study that a successful experience with prostate cancer (the person was cured) decreased respondents' perceptions of their own cancers' risks whereas traumatic experience (the person was deceased) increased respondents' perceptions of their own cancers' risks (19).

3.4.8 Emotions

From a general perspective, Lipworth and colleagues underlined that individuals' emotional state, such as degree of anxiety felt towards cancers, may affect the construction of their general cancers' risks perceptions (25). Lee pointed out, based to his qualitative corpus, the strong implication of emotions in individuals' perceptions of colorectal cancers' risks (16). Katapodi and colleagues draw the same conclusion based on their literature review: intensity of emotional responses was found positively correlated with women perceptions of their breast cancers' risks (11).

Worry was found positively associated with individuals' perceptions of their general cancers' risks (39) as well as their perceptions of cervical (99), ovarian (113), skin (72) and colorectal (22,100) cancers' risks. Worry was also found positively associated with individuals' perceptions of health risks stemming from smoking (35). A finding also supported for across a wide range of chronic diseases (91). Interestingly, two studies showed complementary and exclusivity in individuals' worry regarding diseases. Wang and colleagues thus found their respondents to display lower worry for diseases they did not perceived their risks to be high (93). Shiloh and colleagues found their respondents to display worry for all diseases embedded in the same category of diseases (91). For instance, individuals worried about developing diabetes were found to be worried about developing other metabolic diseases. Finally, being objectively at risk was found positively associated with worry (63).

Anxiety was found positively associated with individuals' perceptions of their general cancers' risks (109,111) as well as their perceptions of cervical cancers' risks (99) and perceptions of health effects stemming from radiation (81).

Concerns about nuclear-related health effects were found positively associated perceptions of general cancers' risks (80) and health risks (81) stemming from nuclear-related factors. Concern about long term effects of pesticides' exposure was as well found positively associated with perceptions of general cancers' risks (67). Concern about breast cancer was found to vary according to women's adequacy of actual and perceived risk to develop breast cancer. Increasing concern about breast cancer was thus found among women who were objectively at high risk of breast cancer and who perceived their risk their risk as high, while decreasing concern was observed among women at average risk who perceived themselves as such (101).

3.4.9 Proximity to environmental factors and trust in management authorities

Actual or perceived proximity with environmental factors was found positively associated with perceptions of cancers' risks or other negative health consequences five studies (79,83,86,88,115). Nevertheless, this relationship was not found regarding climate change (34) and sun exposure (71). Ho and colleagues found a higher proportion of individuals living close to a planned nuclear power plant who perceived high cancers' risks for people living close to a nuclear power plant than individuals actually live next to one 80. In this context, perceived exposure to environmental factor was associated with higher perceptions of cancers' risks than actual exposure.

Familiarity with environmental risks was also found negatively associated with risk perception such as more familiarity with environmental factors was associated with lower health risk perception (35,37,83,85).

Trust in management or regulatory authorities was found negatively associated with perceived risk but positively associated with perceived benefits regarding environmental factors such as cell phone-related factors (85), pesticides residues on food (68) and more generally across set of hazards (36). Individuals were found to display high risk perceptions regarding environmental factors when then do not know who or what to trust for instance regarding genetically modified food, electromagnetic fields, and food additives (66).

3.4.10 Socio-demographic characteristics

3.4.10.1 Gender

The impact of gender was clearly contrasted and supported through the studies. Women displayed higher perceptions of cancers' risks stemming from nuclear-related factors, smoking, sun exposure and various set of environmental hazards (39,51–53,57,71–73,80,109,111). They also perceived their general cancers' risks higher than men did (41,66,91–93,100,105). Perceived health risks associated with climate change, indoor radon exposure, industrial plant pollution, global warming, overhead powerlines waste management and set of various hazards were higher among women than men (33,34,36,40,86,87,89,115).

Men perceived the risk of colon cancer as higher than any other chronic diseases (91,93) while women appeared more focused on breast and ovarian cancers (93) as well as osteoporosis (91). Moser and colleagues found men to perceive their risk of prostate cancer higher than women perceived their risk of breast cancer (92).

3.4.10.2 Age

The relationship between age and risk perception was not clearly contrasted among studies. Some studies found being younger to be associated with higher perceptions of cancers' risks (11,41,45,94,97,100,102,113,116) and higher perceptions of risks stemming from smoking and other environmental factors (49,52,53,60,64,80,89) than being older. However, other studies found being younger associated with lower perceptions of cancers' risks (39,105) and lower perceptions of risks stemming from environmental factors (40) than being older. Finally, this relationship appeared unclear in some studies (73,83) or not existent in others (36,79,107,110).

According to some authors, age was also associated with accuracy of individuals' risk perceptions. For instance, for Buster and colleagues, older adults displayed more inaccurate skin cancer risk perceptions than young adults (116). A result also found by Fehniger and colleagues when women were at high risk of breast cancer but the contrary was actually found when women were at average risk (101). Findings from Khawaja and colleagues supported this last assumption: respondents aged between 50 and 70 year-old were more realistic in their health risk perceptions than younger individuals (65).

3.4.10.3 Education, income, and socioeconomic situation

The relationship between education, income and socioeconomic situation was not clearly contrasted among studies. Individuals with higher socioeconomic situations, higher level of education and income, were found to display lower risk perceptions than individuals with low socioeconomic situation (33,36,43,66). Peretti-Watel and colleagues also found individuals declaring current financial difficulties in the household to perceive more cancers' risks stemming from environmental and psychosocial factors than individuals with higher socioeconomic status (42). However, when education and income were studied separately the findings were less contrasted, especially regarding the level of education. A negative association was found in some studies between level of education and individuals perceptions of cancers' risks meaning that lower level of education was associated with higher risk perceptions (107. Consistently, higher level of education was found associated with lower risk perceptions stemming from environmental factors (80,86,89), lower associations between cancer and death (90 and better accuracy in individuals' perceptions of risks (11,116). However, a positive association was found between level of education and individuals perceptions of cancers' risks meaning that higher level of education was associated with higher risk

perceptions (45,116) and more unrealistic optimism regarding breast cancer occurrence (98). Finally, some studies found no association between level of education and individuals perceptions of cancers' risks (110).

Regarding level of income, a negative association was found with individuals perceptions of cancers' risks meaning that lower level of income was associated with higher individuals' perceptions of cancers' risks (41,45,52,105,116). Only one study found a positive association meaning that higher level of income was associated with higher individuals' perceptions of cancers' risks stemming from smoking (62). Two studies found no associations (11,110).

3.4.10.4 Marital status

Only two studies analyzed the impact of the marital status on individuals' risk perception. One of these studies showed that married women perceived their risk of breast cancer lower than non-married women (110) while the other one showed that being married was associated with higher perceptions of cancers' risks stemming from nuclear-related factors than being not married (80).

4 Discussion

Several key points can be wrapped up from our literature review. First of all, 47 over 101 papers included in this literature review were published after 2011. Whereas the number of papers published in cancer area was already high, the number of papers published on environmental factors increased. This highlights the increased interest on environmental factors as a research subject.

Second, a rather important part of studies focused on cancer were devoted to breast cancer and smoking-related diseases (28/69=40%). Other types of cancers were underrepresented: studies focused on colon or bowel or colorectal cancers, skin cancer, cervical or ovarian cancers, lung cancer (not related to smoking), and prostate cancer represented only 22% of the cancer-focused included studies (16/69). The same conclusion can be drawn on studies focused on environmental factors among whom smoking is the most studies environmental factor (20/55=36%). Other environmental factors are underrepresented: food-related factors counted for 11%, nuclear-related factors for 9%, sun exposure for 7%, indoor radon gas exposure for 7%, cell phone-related factors for 4%, industrial pollution for 2% and air pollution for 2% among studies focused one environmental factors.

Third, whatever the cancer studied, the existence of an optimistic bias among respondents was underlined among a wide range of studies, and especially in studies focused on smoking. The concept of optimistic bias was not so explored among studies focused on other factors than smoking. However, studies focused on food-, nuclear-, radon-, and cell phone-related hazards explored the association between perceived risks and benefits, concepts not so much explored in studies focused on smoking. In addition, even when risk perceptions were analyzed in context of risks stemming from environmental factors, individuals' perceptions of risks were often assessed regarding cancers' risks in general rather than cancers' risks stemming from a specific environmental factor.

Fourth, relationships between individuals' risk perceptions and adoption of health-related behaviors were analyzed in forty-two studies. Findings from these studies tended to support that risk perceptions act as a trigger to adopt health-related behaviors since high risk perceptions were associated with adoption of preventive health-related behaviors in ten studies and with non-adoption of risk-taking health-related behaviors in thirteen studies. In addition, in two studies, low risk perceptions were associated with non-adoption of preventive health-related behaviors. On the contrary, eleven studies supported that risk perceptions as individuals' assessments of their risk considering their lifestyle since seven of them found high risk perceptions associated with non-adoption of risk-taking health-related behaviors and four found low risk perceptions associated with adoption of preventive health-related behaviors. Six studies found no association between individuals' risk perceptions and adoption of health-related behaviors.

Finally, gathering studies addressing individuals' perceptions of cancers' risks in general and risks stemming from environmental factors allowed us to identify specific determinants of these perceptions such as family history, perceived voluntariness of exposure, which might be important to consider when analyzing individuals' perceptions of their cancers' risks stemming from environmental factors.

Population's risk perception is often misjudged to be irrational and a wrong understanding of objective risk probabilities (24,26). Nonetheless, all the data gathered through this literature review underlined how much they are indeed individuals constructions based on cognitive and affective determinants. Thus, when risk managers tried to quantify risks in order to rationalize the debate, numbers appeared to not bring so much help to handle public skepticism especially if the population has a lack of trust in official risk statements (24,26). Individuals' acceptability

of risk was indeed assumed to be influenced by hazards' characteristics and risks' perceptions 24 and a community's response is different than the sum of individuals' responses (26).

4.1 Individuals' optimistic risk perceptions and low rely on objective risk assessment

Cancers appeared associated with negative words and feelings across several years and countries (15,25,44,90,96,117). It appeared also to be perceived as the most severe disease across a range of serious chronic diseases such as heart diseases, stroke, diabetes, etc. (91,93,107). Clark and Lavielle also found their subjects to be more concerned about and perceived more likely to develop cancer than osteoporosis whereas half of them suffered from the disease (118).

Cancer risk perceptions among men and women appeared to vary across cancer locations (92) such as women (men) perceived higher risk for cancers related to their female (male) sexual organs for instance breast, cervical, or ovarian cancers (prostate or testicular cancers) than other cancer locations.

Environmental factors appeared as a real public subject of interest especially when associated with health risks and cancer. However, studies conducted among environmental factors often did not assess individuals' risk perception of cancer related to environmental factors as such, limiting the data analysis on this subject.

4.1.1 Observation of a general optimistic bias

A striking fact from this literature review is that whatever the cancers' risks considered, general or specific, the concept of optimistic bias – individuals perceive their risk low or lower that other people (119) – was widely supported across studies and especially regarding smoking-related diseases and breast cancer (11,18,45,47,56,58,61,64,66,71,91,94–98,100). Individuals displayed also optimistic bias regarding their risk of heart attack (120,121) and more generally regarding involvement in risk behaviors (122,123). Several authors presented optimistic bias as an individual defensive process (61,91). In fact, optimistic bias was found to impact positively other dimensions such as displaying a lower level of worry, a higher perceived control and, a higher belief in the effectiveness of preventive precautions (67,124).

According Katapodi and colleagues, women inaccurate breast cancer risk perceptions found in studies could be partly explained by a selection bias: women recruited within communities

tended to display an optimistic bias whereas women recruited through a relative currently treated for breast cancer or from a health care setting tended to overestimate their risk (11).

Radcliffe and Klein proposed to identify three categories of optimistic individuals (121). Dispositional optimists are individuals with knowledge about the disease and thus are aware about their risk-reducing behavioral profile, are aware about their actual lower level of risk than others, and are less worried than others. Comparative optimists have less knowledge about the disease than dispositional optimists and are more likely to acknowledge that their behavioral profile can increase their risk, even if they adopted preventive behaviors. Unrealistic optimists have low knowledge about the disease and its risk factors but yet believe they are at lower risk because of their behavioral profile and are less worried than others about their risk whereas their behavioral profile put them at high risk for the disease (121). Risk communication and information spreading could fail to reach this last category of individuals who tend to construct personal reinterpretation of information in order to decrease the threat they are exposed to, and thus to rely on a form of risk denial (117,121,125).

4.1.2 Discrepancies between objective and subjective risk perception

Studies comparing individual risk perception with objective risk assessments mostly found discrepancies between these two computations (94,97,98,101,120,121). Vernon concluded from her literature review that individual risk perceptions are modestly associated with objective risk measures 27 giving a start for an explanation. To go further, according to Han and colleagues, individuals have difficulties to perceive cancer risk estimates as objective and numerical indicators because cancer is associated with strong negative emotions. Thus, individuals confronted to potential outcomes with strong affective meaning tend to display probability insensitivity (15). This probability insensitivity has as a consequence that professional debates about statistics in risk communication attempts are of little interest for lay people and do not help at all the public to understand environmental hazards (126). In line with these assumptions, several authors supported that lay individuals' risk perceptions are higher than experts' risk estimations because they have different risk perceptions and needs such as lay individuals are more focused on severity of damage than on probability of occurrence as experts (126,127). Thus, individuals' risk perceptions should not be taken at face value (117) but as specific individual constructions, keeping in mind that most people do not want to think of themselves as being at risk for cancer (117).

People's numeracy (ability to reason and to apply numerical concepts) was found as having an important underlying role in the construction of individual risk perceptions of cancers (117).

Indeed, studies they gathered supported that people have difficulty using and responding to numerical information but also have trouble working with frequencies, proportions, and probabilities. For instance, individuals often estimate a probability differently than its equivalent frequency information because they have trouble to interpret proportions. In addition, people seem to overestimate the occurrence of co-occur events because of their misunderstanding of conditional probability. Thus, they fail to perceive increasing cancer risk due to accumulation over time or multiple exposures (117).

4.2 Individuals' risk perceptions and health-related behaviors: endogenous relationship

As stated in the beginning of this discussion, high risk perceptions were associated with adoption of preventive health-related behaviors in ten studies whilst low risk perceptions were associated with non-adoption of preventive health-related behaviors in two studies. In addition, in four studies, adoption of preventive health-related behaviors were associated with low risk perceptions. Higher risk judgments regarding Lyme disease and flu appeared also to have encouraged people to engage in protective behavior, vaccination (10,12). Consistently with other studies, our literature review showed the role played by individuals' health risk perception as a motivator to endorse preventive health-related behaviors. More precisely, according to Leventhal and colleagues, perceived risk is a motivator of behaviors to prevent, detect, and manage cancer (128). These results have to be taken with caution as desirability and recall biases can impact individuals' reporting of their adopted health-related behaviors. According to Robb and colleagues, individuals tended to perceive themselves with having healthier lifestyle behaviors than they really were (22).

On the other hand, high risk perceptions were found associated with non-adoption of risk-taking health-related behaviors in seven studies whilst non-adoption of risk-taking health-related behaviors were found associated with low risk perceptions in thirteen studies. This finding was also supported outside the health context. More precisely, individuals who overestimated the probability of being arrested for impaired driving committed less violations against the Highway Safety Code than individuals who underestimated this probability, who however, tended to commit more violations (129). In addition, individuals displaying high risk perceptions of car crash adopted less risky-driving behaviors than those displaying low risk perceptions (130). Larsman and colleagues concluded too on the evidence of a negative relationship implying that adolescents' higher risk perceptions were associated with lower involvement in long-term consequences' risk behavior (123). Interestingly, and as it was reported in one study, they concluded also on the existence of a positive relationship implying

that adolescents' higher risk perceptions were associated with higher involvement in risk behavior (123). According to some authors, individuals' adoption of risk-taking behaviors could be the result of an individual's trade-off between perceived risks and benefits as individuals endorsing risk-taking activities declared to perceive higher benefits than risks associated with the activity (60,68,89). Besides, adoption of several risk-taking behaviors at the individual suggested that individuals tend to accumulate risk-taking behaviors (21,53).

A non-negligible proportion of studies (six) reported no relationship between individuals' risk perceptions and adoption of health-related behavior(s). This finding was also supported across the literature. Avis and colleagues found no association between increase in heart attack risk perception and greater endorsement of preventive behaviors (120) and Larsman and colleagues reported that one third of studies included in their literature found no association or relation between risk perception and risk behavior (123).

Gathering all this literature, the "behavior motivation hypothesis" appeared more supported than the "accuracy hypothesis" (10). In other words, individuals' perceptions of cancers' risks appeared as a motivator to adopt preventive, but also to not adopt risk-taking, health-related behaviors. This assumption has, however, to be considered with caution because risk perceptions and behaviors appeared with an endogenous relationship but few studies, like Lin and Sloan (2015), actually took into account that they may impact each other in their analyses. As underlined by Weinstein and Nicolich, "researchers interested in determining whether risk perceptions are accurate look for a negative correlation between perceived risk and precautions. […] researchers who want to determine whether risk perceptions cause changes in behavior, in contrast, look for a positive correlation between perceived risk and precautions. […] something is wrong when the same correlations are being used to answer two quite different questions" (131). Thereby, conclusions regarding these relationships are de facto limited. In addition, these relationships appeared though still understudied in the context of cancers' risks stemming from environmental factors calling thus for further analyses.

4.3 Determinants of individuals' risk perceptions

4.3.1 The limit of knowledge level: essential but not enough weight to influence alone individuals' risk perceptions

According to the "deficit-model", individuals' inaccurate risk perceptions are associated with a lack of information and knowledge (127). Thus, giving more information to individuals make them adjust in an accurate direction their risk perceptions (127). Individual's level of knowledge

about cancer and its risk factors was indeed showed to be an important determinant of cancer risk perceptions as individuals use information to construct their perception of their own risk of cancer (25,79,99,103,107), whether this information concerns themselves through personalized risk communication (27,29,123) or other people. Individuals appeared indeed to use comparative risk information as an indicator to evaluate their own level of risk (103,107). Increasing individual's level of knowledge related to cancer or environmental factors was found to positively impact the adoption of preventive behaviors preventive health-related behaviors (25,67,75,76,117,124).

However, increasing individuals' level of knowledge regarding cancer was also found to increase individuals' worry, anxiety, and cancer risk perceptions rather than going towards more accurate perceptions (66,96,117). According to Leventhal and colleagues, risk perception indicators are inflating when healthy participants receive risk information and thus are encouraged to think about their own disease family history and environmental exposures (128). At the population level, higher degree of information on environmental factors can even result in more bipolar and ambivalent public risk perception in the sense that some people become more in favor to and other people more against the factor considered (127).

Besides, some studies reported no association between individual's level of knowledge and risk perception of cancer (47,70) but also heart attack (120), driving risks (130), or environmental problems (132). Larsman and colleagues arrived at the same mixed conclusion regarding the impact of knowledge on risk perception in their literature review: over seven studies analyzing this relationship, one found a negative relationship (higher knowledge associated with lower risk perception), one a positive relationship (higher knowledge associated with higher relative but not absolute risk perception), and four found no association (123).

Based on the findings from their literature review, Ndugwa Kabwama & Berg-Beckhoff proposed to look at the relationship between HIV/AIDS-related knowledge and risk perception as a continuum. More precisely, in the first step, knowledge and risk perception are low because "people cannot perceive a risk they are not aware about". In the second step, knowledge increases but this knowledge is insufficient for individuals to have accurate risk perception. In the third step, knowledge increases until a point where individuals have some knowledge about how to deal with risk and prevention. They can adopt preventive behaviors. In the fourth step, beyond this point of level of knowledge, fear or dread in a risk is decreasing, controllability or ability to mitigate the risk is increasing because individuals are taking preventive action. Thus risk perceptions are decreasing (125).

Information sources appeared also as a determinant to consider as it was found to have an impact on the way individuals took into account the information (19,42,52,58,67,79). The main sources of people's information seemed to be the mainstream media such as television, prevention campaigns, and health care providers (44,66,96). According the model of risk amplification (84), when communication starts on something, for instance cancers and associated risk factors (proven or not), it tends to go through a more or less important number of communication channels among society. Thus, some things tend to become highly publicized and related-risk to be amplified, especially as mainstream media tend to cover in a disproportionate way rare or dramatic risks and events (66,84). Thereby, people's risk estimation could be pull towards inaccurate ones. At the end, some risks and lifestyle behaviors could end relativized against others, for instance aging which appeared clearly underestimated or even not cited as a cancer risk factor despite its importance (105).

Thereby, the way to promote messages appeared essential in order to avoid negative attitudes toward cancer (43) or environmental factors (126) but also to promote preventive behaviors 117. Some studies found indeed preventive messages described as ambiguous and confusing especially because of an impression of being surrounded by too much information (44,107). The challenge of prevention public policies was underlined to be the maximization of individual's perceived personal relevance of the risk issue within a large communication campaign (124).

4.3.2 The importance of beliefs related to cancers and related-risk factors, of perceived control and perceived voluntariness of risks' exposure

Beliefs on cancer and cancer risk factors were found to have a role to fulfill in construction of individual risk perceptions of cancer (19,34,80). The assumption can be made that the more negative beliefs an individual associates with cancer, the higher his risk perception of cancer.

Perceived control of cancer was especially found as an important belief having a negative relationship with cancer risk perception. This negative relationship was supported across other contexts (123,133–135). For instance, people endorsing high personal sense of control over life displayed lower risk perceptions related to the economic crisis (133).

Voluntariness of exposure to risk factors was also found to be negatively correlated with risk perception such as a risk would be more tolerated if the individual perceives he has choose to be exposed to a specific risk (135–140).

In addition, beliefs were found to influence the adoption of preventive health-related behaviors (11,20,22,110) but also to justify the adoption of risk-taking health-related behaviors and especially smoking (50,56,60,64).

4.3.3 The weight of individual experience with cancers and environmental factors

Whether experience with cancer was direct (personal history of cancer) or indirect (cancer experience among family, friends, or colleagues), it was found to increase individual's risk perception compared to individuals without cancer experience across most of the included studies. This finding was supported across other health contexts such as heart attack (120) or osteoporosis (118). Only two studies found no impact of cancer indirect experience on cancer risk perception (72,114) and both studies were interestingly related to skin cancer, a cancer for which family history is less publicized as a cancer risk factor compared to breast or colorectal cancer.

Results were more mixed in the literature review conducted by Larsman and colleagues who found that personal, friend, or family history of disease was associated with higher risk perceptions in four studies while three found no relationship and four found mixed results (123). According to McDowell and colleagues, men with cancer family history judge likelihood of developing prostate cancer to be lower for each year they remain undiagnosed (141).

Individual experience with environmental was found positively associated with individual's risk perception such as actual or perceived exposure to environmental factor was found associated with higher risk perception of cancers or health risks supporting a positive "context-effect" (79,80,83,86,88,109,115). Previous experience with environmental risk factors was also indeed found to play a role in individual reaction to risk communication 28. However, at the same time, the more experience an individual has with an environmental factor, the more it becomes familiar, the less is the related-perceived risk (35,37,83,85,127). As these results are not always supported (34,71,109), it can be assumed that these relationships between risk perception and perceived/actual exposure or familiarity may depend on the environmental factor considered. Indeed, each environmental factor has his own characteristics perceived differently by individuals (135,138).

4.3.4 "Risk as feeling" and "risk as analysis": the emotional side of individual's risk perceptions

Negative emotions such as worry and anxiety were found to be positively associated with risk perception such as worried individuals displayed higher risk perception than unworried ones. This finding was also found in other contexts. For instance, negative emotions related to the financial crisis such as sadness, anger, and stress were found positively associated with one's perceived risks regarding job, savings, and retirement (133). Leiter brought out the same conclusion: negative feelings towards avalanche was positively associated with avalanche perceived risk (134). More generally, negative attitudes toward the future were found associated with higher personal risk perception (133,134).

These findings support the assumption that perceived risk is a combination of a cognitive and an affective component which can be described as an affectively charged evaluation of risk (113). Slovic and colleagues labeled these two sides of risk perception "risk-as-feeling", for the affective part, and "risk-as-analysis" for the cognitive part (142) incorporating both an individual's experience and cognitive understanding (113). More concretely, affective risk perception would correspond to "I feel at risk" and cognitive risk perception to "I am at risk" (117). Janssen and colleagues tested the relevance to distinguish cognitive and affective components in the measure of cancer risk perception as their impact on behavioral intentions (143). Their results showed a stronger correlation between affective likelihood and worry than cognitive measure of risk perception. Affective measure of risk perception was also positively correlated with all variables related to behavioral intentions – smoking, fruit consumption, sun protection, and sunbed use – whereas the cognitive likelihood as only associated with behavioral intention of sun protection. The authors concluded that cancer-related behaviors were more associated with the affective measure of risk than with the cognitive one. A conclusion supported by other authors (117,133). According to Slovic and colleagues, "risk-as-feeling" information processing is quicker, easier and more efficient than "risk-as-analysis" (142). Despite the relevance of this distinction underlined in a non-negligible number of studies, this brings new difficulties in assessment and prediction of individuals risk perceptions in the sense that a volatile component is included. Indeed, people were found to have trouble to adequately report their current affective states and thus they might have trouble to predict their future ones or ones related to hypothetical situations (117).

4.3.5 The multiple intervention of heuristics on individual's risk perceptions

As it is noteworthy through this literature review, there is a lot of information and a lot of concepts influencing individual risk perceptions of cancers, of environmental factors, and cancers stemming from environmental factors. As individuals have limited time and cognitive faculties, they rely on "heuristics" in order to save time and cognitive faculties (117,144). However, as they are logical shortcuts 18, heuristics can be as the origin of judgments' errors and biases (117). Kahneman and Tversky emphasized two heuristics which appeared particularly relevant to the cancer context: availability and representativeness (144).

The availability heuristic describes the individuals' tendency to judge the likelihood or frequency of an event by the ease with which its instances come to mind (144). Individual experience with cancers was proposed to influence cancer risk perception through the same mechanism, meaning that individual rely on their experience with the disease to construct their risk perception (16,112. Thereby, high negative individual experience with the disease, personal or familial, was found associated with higher individual's disease risk perception (18,141,145). In addition, this assumption is consistent with the increasing influence on risk perception of increasing individual experience found in some studies (16,20,105,113). McDowell and colleagues interestingly showed that the number of discussions about prostate cancer had also, as the number of acquaintances diagnosed with prostate cancer, a positive influence on individual perceived risk of prostate cancer (141).

The representativeness heuristic describes the individuals' tendency to judge the likelihood or frequency of an event by the extent to which it resemble the typical case. This heuristic appeared relevant as we found across the studies conducted on smoking, people tended to agree on the existence of a typical smoker at risk for smoking-related diseases (48,61). Individuals were found to use this stereotypical representation to evaluate their own risk of cancer (56,61,73). Consistently, perceived similarity with the typical man who gets prostate cancer appeared as an important factor associated with greater prostate cancer risk perceptions, especially among first-degree relatives (141) and endorsing higher HIV-stereotypes was found associated with lower HIV risk perceptions (123). Relying on representativeness heuristic can partly explained why comparative risk information help individuals to rate their own disease risk and to take decisions (103).

4.3.6 Variation in individuals' risk perceptions by socio-demographic variables

The finding that women tend to perceive risk generally higher than men do was supported across other studies whatever the context: car crash risks (130), economic crisis (133) or long-term health consequences (123).

Contrarily to the findings of several studies that young people displayed lower risk perception than older people (39,40,105,122,129), the majority of the included studies found that young people displayed higher risk perception than older people (41,45,52,60,80,89,94,97,100,102,113,116). Studies in other contexts found consistent findings (134. Across a non-negligible number of studies, the relationship between risk perception and age was unclear (73,83,123) or non-existent (36,79,107,110). Interestingly, younger respondents displayed higher risk perceptions of smoking-related diseases than older respondents (49,52,53,64). This finding could reflect the impact of national campaigns against smoking on the young generations conducted in Western countries in the last decade. Cohn and colleagues conducted a study among adolescents and their parents. They found that parents rated health-threatening activities such as drinking alcohol, getting drunk, using diet pills, driving after drinking, drag racing, smoking pot, smoking cigarettes, and not wearing seat belts more harmful for their teenagers than the teenagers did for themselves. However, teenagers' unrealistic optimism scores decreased as involvement in health-threatening activities increased. Thus, teenagers did not regard their behavior as extremely risky or unsafe, but when involved in health-threatening activity, they acknowledged to some degree their increased vulnerability to harm (122).

Findings regarding the impact of education and income were contrasted. The same observation was made in another literature review (123). A positive relationship between risk perception and level of education was also found in the context of heart attack risks (120) while a negative relationship was found in the economic crisis context (133). Interestingly, more educated individuals who smoked perceived their risk of heart attack to be greater than others (120).

4.4 Limitations

Some limitations can be pointed out in the literature review. First of all, the selection of keywords may have missed some publications. Reference lists from selected articles were reviewed in order to limit this drawback. Secondly, some articles could not be included to this literature review due to publication access. Working papers were searched in order to limit this

point. Finally, not all results from all articles were included in this literature review because some were out the scope of this literature review.

5 Conclusion

Individuals perceptions of cancers' risks stemming from environmental factors appeared as dynamic processes shaped by individuals' level of knowledge, beliefs endorsed regarding cancers and cancers' causes, perceived control over cancer's occurrence and environmental factors' exposure, perceived voluntariness of exposure to environmental factors, experience with cancer (whether personal or among relatives and friends), worry about cancer, concern about environmental factors and sociodemographic characteristics. It also appeared more as a motivator to adopt preventive health-related behaviors but potential endogeneity of risk perception questioned this finding. In addition, individuals' perceptions of cancers' risks stemming from environmental factors appeared not widely studied as such because assessment often refers to cancers' risks in general, limiting de facto conclusions regarding their relationship with adoption of health-related behaviors.

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Conflict of interest

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2 Appendix 2: Additional information on the quantitative study

2.1 Characteristic of individuals who stopped the questionnaire

Table 17 presents the comparison of sociodemographic variables between representative sample and individuals who stopped the questionnaire

We found significant differences on gender, age, regional distribution, socio-professional category, professional situation and marital status.

Compared to those who completed the questionnaire, individuals who stopped were significantly more likely:

- To be a woman
- Aged between 18 and 49 years-old
- To live in Paris or in its surroundings, and in Mediterranean region
- To be an executive, intermediate profession, office worker, or unemployed
- To be full- or part- time employed, housewife/husband, or student
- To have children

Thus, it seems to appear, based on the comparison of sociodemographic variables, that individuals who dropped our questionnaire may have dropped it because of a lack of time. These comparisons are however to take with caution as very few data was available for drops regarding net annual household income and level of education. Two variables important to compare socio-economic situations.

Table 17 Comparison between sociodemographic characteristics of respondents who completed and stopped the questionnaire

Sociodemographic variables	**Respondents**		**Drops**		
	N	%	N	%	*p-value*
Gender	**1500**	**100**	**1933**	**72**	*0.000*
Man	735	49	596	31	
Woman	765	51	1337	69	
Age	**1500**	**100**	**1932**	**72**	*0.000*
18-29	329	22	481	25	
30-39	282	19	427	22	
40-49	301	20	535	28	
50-59	286	19	256	13	
60-75	302	20	233	12	
Regional distribution	**1500**	**100**	**1899**	**70**	*0.000*
Agglomeration of Paris	286	19	481	25	
Parisian Basin West/East	254	17	377	20	
North	90	6	97	5	
West	135	9	130	7	
East	195	13	182	10	
South-East	165	11	157	8	
South-West	180	12	86	5	
Mediterranean Region	195	13	389	20	
Socio-professional category	**1500**	**100**	**1857**	**69**	*0.000*
Farmer	16	1	12	1	
Independent profession	60	4	47	3	
Executive	163	11	281	15	
Intermediate profession	245	16	317	17	
Office worker	279	19	589	32	
Skilled/unskilled worker	182	12	104	6	
Retired	356	24	213	11	
Unemployed	199	13	294	16	
Professional situation	**1500**	**100**	**1883**	**70**	*0.000*
Full-time employed	658	44	976	52	
Part-time employed	119	8	204	11	
Independent workers	62	4	68	4	
Jobless	182	12	177	9	
Housewife/husband	49	3	112	6	
Retired	356	24	213	11	
Student	73	5	133	7	
Marital status	**1500**	**100**	**84**	**3**	*0.004*
Single	449	30	22	26	
Living in a couple	205	14	11	13	
Married	714	48	38	45	
Divorced / Widowed	132	9	13	15	
Having children	**1500**	**100**	**1894**	**70**	*0.077*
Yes	825	55	1099	58	
No	675	45	795	42	
Number of children	**825**	**55**	**1095**	**100**	*0.793*
1	264	32	336	17	
2	346	42	488	25	
3	149	18	198	10	
4 and more	66	8	73	4	
Net annual household income	**1500**	**100**	**84**	**3**	*0.412*
0-6,000€	64	4	6	7	
6,001€-9,000€	30	2	4	5	
9,001€-12,000€	56	4	3	4	
12,001€-15,000€	85	6	4	5	
15,001€-18,000€	78	5	4	5	
18,001€-21,000€	101	7	6	7	
21,001€-24,000€	108	7	9	11	
24,001€-30,000€	169	11	10	12	
30,001€-36,000€	173	12	8	10	

36,001€-48,000€	205	14	8	10	
48,001€-60,000€	126	8	1	1	
60,001€-120,000€	51	3	4	5	
120,001€ and more	3	0	0	0	
I prefer to not answer	251	17	17	20	
Level of education	**1500**	**100**	**84**	**3**	*0.633*
High school degree not completed	98	7	8	10	
Professional degree	333	22	19	23	
High school degree completed	337	22	19	23	
1st college degree or eq. (HSD + 2 years)	346	23	21	25	
2nd college degree or eq. (HSD + 3/4 years)	232	15	13	15	
3rd college degree or eq. (HSD + 5 years and more)	154	10	4	5	
Self-rated health	**1500**	**100**	**84**	**3**	*0.379*
Poor/very poor	197	13	5	6	
Fair	612	41	38	45	
Very good/good	691	46	41	49	

2.2 Knowledge related to environmental factors and their link with cancers

We mentioned in the method section in Chapter 3 that respondents were asked to answer with *"true"* or *"false"* to 20 statements about environmental factors and their link with cancers. Then, these answers were evaluated to be *"right"* or *"wrong"* according to the actual scientific knowledge (see Table 18 for the details).

Two types of information sources were chosen to construct our questions. The first information source was the IARC Monographs identifying environmental factors that can increase the risk of human cancer. The second information source was websites designed to wide audience: the INCa website (French National Cancer Institute) and the website of the Department Cancer and Environment. The rational to include these websites was that individuals searching for information may probably look for accessible information with limited specialized language in their mother tongue rather than specialized information with complex features.

Table 18 Knowledge's assessment: questions and justifications

French version	English translation	Right/Wrong	Justification	References
L'amiante présente un risque pour la santé lorsqu'il y a dispersion dans l'air de fibres d'amiante.	Asbestos is associated with a health risk when there is dispersion of asbestos' fibers in the air.	Right	Inhalation and ingestion are the primary routes of exposure to asbestos. The degree of penetration in the lungs is determined by the fibre diameter, with thin fibres having the greatest potential for deep lung deposition.	IARC, monograph 100C 2012
L'exposition domestique au radon est cancérogène.	Domestic exposure to radon is carcinogenic.	Right	The concentrations of radon and its short-lived decay products in confined air spaces, particularly in underground work areas and in buildings may be a significant source of exposure to ionizing radiation. Radon and its decay products are carcinogenic ta humans (Group 1).	IARC, monograph 43 1988 IRSN[11]
La pollution de l'air n'a pas d'influence sur le risque de développer un cancer.	Air pollution does not have an influence on individual's risk of cancer.	Wrong	Outdoor air pollution is carcinogenic to humans (Group 1). Sufficient evidence in humans supports the carcinogenicity of outdoor air pollution. Outdoor air pollution causes cancer of the lung. A positive association has been also observed between exposure to outdoor air pollution and cancer of the urinary bladder.	IARC, monograph 109 2016
Les pesticides sont des substances utilisées pour prévenir, contrôler ou éliminer des organismes jugés nuisibles.	Pesticides are substances used to prevent, control, or eliminate organisms judged as harmful.	Right	Definition on Cancer and Environment website.	Website Cancer-Environment[12]
La majorité des cancers du poumon est attribuable au tabagisme.	The majority of lung cancers is attributable to smoking.	Right	Active smoking is responsible of 80% of lung cancers. In addition, currently, 92% of lung cancers' deaths among men and 71% among women are attributable to smoking. Tobacco smoking is carcinogenic to humans (Group 1).	INCA[13] IARC, monograph 100E 2012
Les fibres alimentaires présentes par exemple dans les céréales complètes et les légumes secs ont un rôle protecteur contre le développement de certains cancers.	Dietary fibres found for example in wholegrain cereals and dried vegetables have a protective role against the development of some cancers.	Right	Diet is part of behaviors on which we can act to increase cancers' prevention. Some nutriments or foods are recognized for their protective role towards some cancers like dietary fibres in wholegrain cereals, fruits, vegetables, dried vegetables. L'alimentation fait partie des comportements sur lesquels on peut agir pour accroître la prévention des cancers. Elle agit comme un facteur de protection: nutriments ou aliments reconnus pour leur rôle protecteur contre certains cancers, comme les fibres alimentaires présentes dans les céréales complètes, les fruits, les légumes, les légumes secs.	INCA[14] European Code against Cancer
En termes d'intensité, l'utilisation des téléphones portables représente le mode d'exposition principale des citoyens aux radiofréquences.	In terms of intensity, the use of mobiles phones is the main mode of exposure to radiofrequencies of the general population.	Right	The dominant sources of human exposure to radiofrequences radiation are near-field sources for workers and transmitters operating on or in close vicinity to the body suc as hand-held decives for the general population.	IARC, monograph 102 2013

[11] http://www.irsn.fr/FR/connaissances/Environnement/expertises-radioactivite-naturelle/radon/Pages/1-que-faut-il-savoir-sur-le-radon.aspx?dId=9aef83d8-dab7-4201-beed-16551b10812c&dwId=2c2a9274-9106-41cf-b110-445981d4784e

[12] http://www.cancer-environnement.fr/326-Pesticides.ce.aspx

[13] http://www.e-cancer.fr/Patients-et-proches/Les-cancers/Cancer-du-poumon/Facteurs-de-risque/Tabac

[14] http://www.e-cancer.fr/Comprendre-prevenir-depister/Reduire-les-risques-de-cancer/Alimentation

			The AFSSET underline that in termes of intensity, the use of mobile phones representes the main mode of exposure to radiofrequencies of cthe general population. L'AFSSET souligne qu'en termes d'intensité, l'utilisation des téléphones portables représente le mode d'exposition principal des citoyens aux radiofréquences. En comparaison, l'exposition induite par les stations de base ou antennes relais est bien plus faible.	Nguyen-Thanh and Richard 2009
La consommation d'alcool augmente le risque de cancer colorectal.	Alcohol consumption increases the risk of colorectal cancer.	Right	Sufficient evidence in humans supports the carcinogenicity of consumption. Alcohol consumption causes cancers of the oral cavity, pharynx, larynx, oesophagus, colorectum, liver and female breast. A positive association has also been observed between alcohol consumption and cancer of the pancreas. Alcohol consumption is carcinogenic to humans (Group 1).	IARC, monograph 100E 2012
Les traitements hormonaux substitutifs de la ménopause (THS) augmentent le risque de développer certains cancers.	Hormonal replacement treatments of menopause (HRT) increase the risk of developing some cancers.	Right	Sufficient evidence in humans supports the carcinogenicity of combined estrogen– progestogen menopausal therapy. Combined estrogen–progestogen menopausal therapy causes cancer of the breast. Combined estrogen–progestogen menopausal therapy is carcinogenic to humans (Group 1). Important note: these substances were considered by a previous Working Group (IARC, 1999), under the title 'Post-menopausal hormonal therapy. Evidence from the Women's Health Initiative, which showed a clearly harmful effect of the use of estrogen–progestogen combinations, has modified the 'medicalization' of the menopause; as a result, use of the term 'replacement' has diminished. Patterns of exposure are also changing rapidly as the use of hormonal therapy declines, the indications are restricted and the duration of the therapy is reduced.	IARC, monograph 91 2007
Le radon est un gaz d'origine naturelle provenant du sol.	Radon is a natural gas coming from soils.	Right	Radon is a natural radioactive gas. It stems from the radioactive decay chain of uranium and the radium in the earth's crust. Radon is ubiquitous and comes primarily from granitic and volcanic subsoils.	IARC, monograph 43 1988 IRSN[15]
Boire beaucoup de café est un facteur de risque de cancer.	Drinking a lot of coffee is a cancer risk factor.	Wrong	There is evidence suggesting lack of carcinogenicity in humans of coffee drinking for cancers of the pancreas, liver, female breast, uterine endometrium, and prostate. Inverse associations with coffee drinking have been observed with cancers of the liver and uterine endometrium.	IARC, monograph 116 (in preparation)[16]
L'amiante est une fibre minérale naturelle présente dans de nombreux produits industriels ou domestiques.	Asbestos is a natural and mineral fiber used in a large number of domestic and industrial products.	Right	Asbestos is a generic commercial designation for a group of naturally occuring mineral silicate fibres of the serpentine and amphibole series.	IARC, monograph 100C 2012

[15] http://www.irsn.fr/FR/connaissances/Environnement/expertises-radioactivite-naturelle/radon/Pages/1-que-faut-il-savoir-sur-le-radon.aspx?dId=9aef83d8-dab7-4201-beed-16551b10812c&dwId=2c2a9274-9106-41cf-b110-445981d4784e

[16] http://monographs.iarc.fr/ENG/Classification/latest_classif.php

Seul le mésothéliome (cancer de la plèvre) est attribuable à l'exposition à l'amiante.	Only the mesothelioma (pleura cancer) is attributable to asbestos exposure.	Wrong	Sufficient evidence in humans supports the carcinogenicity of all forms of asbestos. Asbestos causes mesothelioma and cancer of the lung, larynx, and ovary. All forms of asbestos (chrysotile, crocidolite, amosite, tremolite, actinolite and anthophyllite) are carcinogenics to humans (Group 1).	IARC, monograph 100C 2012
Dans votre département, le radon peut présenter un risque pour la santé.	In your department, radon can present a health risk.	It depends	Right if the respondent declared to live in one of these 31 departments: 14 / 22, 29,56 / 79 / 65, 09 / 88, 52, 70, 25 90 / 73, 05 / 2B, 2A / 58, 71, 03, 42, 69, 36, 23, 63, 43, 07, 87, 19, 15, 12, 48 Wrong if the respondent declared to live in none of these 31 departments.	IRSN[17] See Figure 2 for the associated map
Il est conseillé d'éviter de téléphoner en vous déplaçant par exemple en train.	It is recommended to avoid making phone calls while moving, for example, when travelling by train.	Right	The health ministry recommends some simples rules. Here are the principal messages […] Avoid to make phone calls while moving, for example, when travelling by train: the mobile phone is successively in relation with several base stations and is emitting with maximum power. Le ministère chargé de la Santé recommande ainsi quelques règles simples à appliquer. En voici les principaux messages: […] Evitez de téléphoner en vous déplaçant, par exemple dans un train : le téléphone entre successivement en relation avec plusieurs stations de base, et émet alors à sa puissance maximale	Nguyen-Thanh and Richard 2009
Le vieillissement est un facteur démontré de risque de cancer.	Aging is a demonstrated risk factor of cancer.	Right	Ageing is a fundamental factor for the development of cancer. The overall risk accumulation is combined with the tendency for cellular repair mechanisms to be less effective as a person grows older.	IARC 2017
La consommation quotidienne de produits laitiers est un facteur protecteur contre le développement du cancer colorectal.	Daily consumption of dairy products is a protective factor against the development of colorectal cancer.	Right	Daily consumption of dairy products is a protective factor against the development of colorectal cancer.	INCA[18]
Le radon est une substance chimique utilisée dans les peintures, les vernis pour les meubles, les revêtements de sols.	Radon is a chemical substance used in paints, varnishes for furniture, and soils coating.	Wrong	Radon is a natural radioactive gas. It stems from the radioactive decay chain of uranium and the radium in the earth's crust.	IARC, monograph 43 1988 IRSN[19]
Des chocs émotionnels forts sont à l'origine de l'apparition de certains cancers.	Strong emotional shocks are the origin of some cancers' development.	Wrong	There is no scientific support nowadays for a link between stress and cancer. It has never been proven that a psychological shock linked to life events could induce cancer. A lot of scientific studies have explored this assumption but they cannot conclude that life events, personality features or depression play a role in cancers' occurrence. A ce jour, il n'y a pas de preuve scientifique d'un lien de cause à effet entre stress et cancer. Il n'a jamais été démontré qu'un choc psychologique lié à un évènement de vie stressant pouvait provoquer un cancer. De nombreuses	INCa [20] Cited as a support: Schraub et al 2008

[17] http://www.irsn.fr/FR/connaissances/Environnement/expertises-radioactivite-naturelle/radon/Pages/1-que-faut-il-savoir-sur-le-radon.aspx?dId=9aef83d8-dab7-4201-beed-16551b10812c&dwId=2c2a9274-9106-41cf-b110-445981d4784e

[18] http://www.e-cancer.fr/Comprendre-prevenir-depister/Reduire-les-risques-de-cancer/Alimentation

[19] http://www.irsn.fr/FR/connaissances/Environnement/expertises-radioactivite-naturelle/radon/Pages/1-que-faut-il-savoir-sur-le-radon.aspx?dId=9aef83d8-dab7-4201-beed-16551b10812c&dwId=2c2a9274-9106-41cf-b110-445981d4784e

[20] http://www.e-cancer.fr/Comprendre-prevenir-depister/Regarder-les-cancers-autrement/Idees-recues

			études scientifiques ont exploré cette hypothèse mais elles n'ont pas permis de conclure à un rôle direct de facteurs psychologiques dans l'apparition de cancer.	
Les pesticides de manière générale sont reconnus comme agents cancérogènes.	Pesticides are generally speaking recognized as carcinogenic agents.	Wrong	There is nowadays around 300 active phytosanitary substances, a hundred of active biocide substances and tens of antiparasites. IARC has evaluated and classified around sixty pesticides: arsenic is carcinogenic to humans (Group 1), occupational application of non-arsenic insecticides, captafol and ethylene dibromide are probably carcinogenic to humans (Group 2A) and 19 molecules are possibly carcinogenic to humans (Group 2B). Il y a aujourd'hui environ 300 substances actives phytosanitares, une centaine de substances actives biocides et quelques dizaines d'antiparasites. Le CIRC a évalué et classé une soixantaine de pesticides : l'arsenic est classé cancérogène certain pour l'Homme (groupe 1) ; l'application d'insecticides non arsenicaux en milieu professionnel, le captafol et le dibromure d'éthylène sont classés comme cancérogènes probables (groupe 2A) et dix-neuf molécules classées comme cancérogènes possibles (groupe 2B).	Website Cancer-Environment[21]

[21] http://www.cancer-environnement.fr/326-Pesticides.ce.aspx

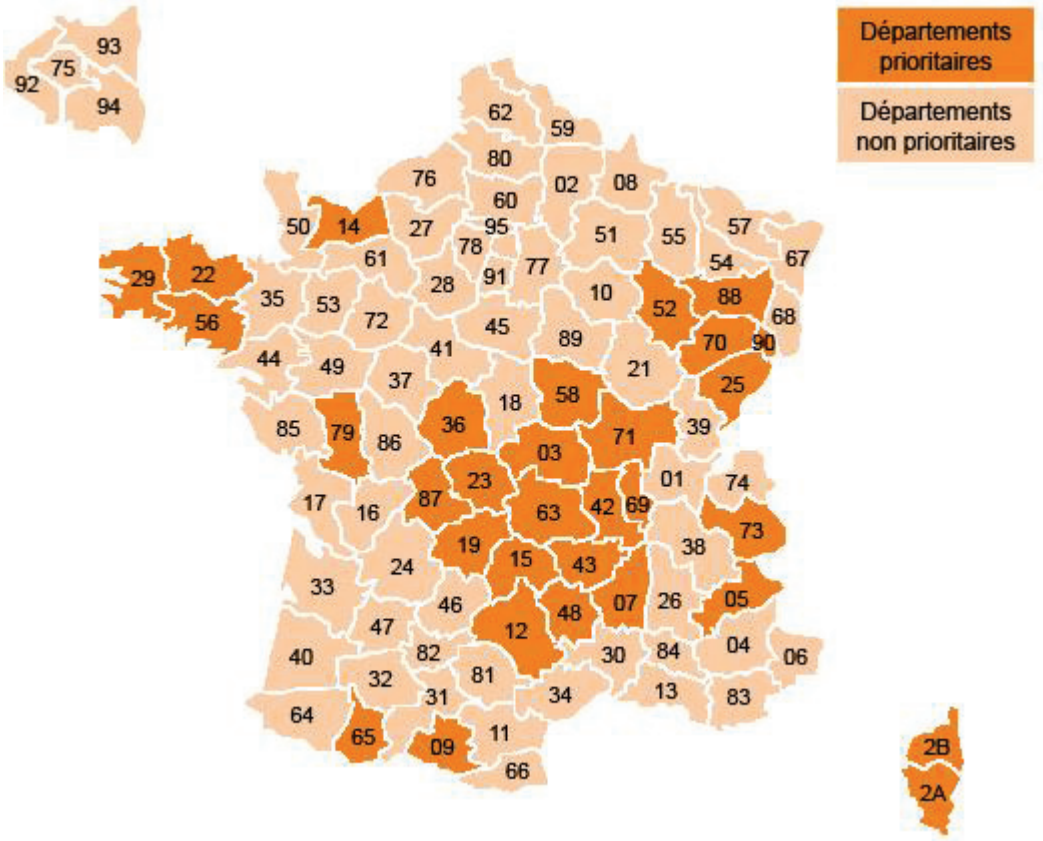

Figure 2 Map of France with the classification of departments according to their level of radon concentration in soils. Source :IRSN, http://www.developpement-durable.gouv.fr/-Radon,889-.html

A right answer gave +1 and a wrong answer 0. A simple additive score was then calculated for each participant to construct an indicator of cancer-related knowledge with raw scores ranging from 0 to 20. Answers from participants are displayed in Table 19.

Table 19 Respondent's knowledge about environmental factors and their link with cancers, ranked by decreasing proportion of true answers

	True		False		Right		Wrong	
	N	%	N	%	N	%	N	%
Asbestos is associated with a health risk when there is dispersion of asbestos' fibers in the air.	1395	94	83	6	1395	94	83	6
Domestic exposure to radon is carcinogenic.	1244	84	234	16	1244	84	234	16
Air pollution does not have an influence on individual's risk of cancer.	261	18	1217	82	1217	82	261	18
Pesticides are substances used to prevent, control, or eliminate organisms judged as harmful.	1194	81	284	19	1194	81	284	19
The majority of lung cancer is attributable to smoking.	1163	79	315	21	1163	79	315	21
Dietary fibers found for example in complete cereals and dry vegetables have a protective role against the development of some cancers.	1172	79	306	21	1172	79	306	21
In terms of intensity, the use of mobiles phones is the main mode of exposure to radiofrequencies of citizens.	1134	77	344	23	1134	77	344	23
Alcohol consumption increases the risk of colorectal cancer.	1102	75	376	25	1102	75	376	25
Hormonal replacement treatments of menopause (HRT) increase the risk of developing some cancers.	1099	74	379	26	1099	74	379	26
Radon is a natural gas coming from soils.	1079	73	399	27	1079	73	399	27
Drinking a lot of coffee is a cancer risk factor.	424	29	1054	71	1054	71	424	29
Asbestos is a natural and mineral fiber used in a large number of domestic and industrial products.	956	65	522	35	956	65	522	35
Only the mesothelium (pleura cancer) is attributable to asbestos exposure.	609	41	869	59	869	59	609	41
In your department, radon can present a health risk.	603	41	875	59	863	58	615	42
It is advising to avoid talking on the phone while moving such as in train.	699	47	779	53	699	47	779	53
Aging is a demonstrated risk factor of cancer.	646	44	832	56	646	44	832	56
Daily consumption of dairy products is a protective factor against the development of colorectal cancer.	605	41	873	59	605	41	873	59
Radon is a chemical substance used in paints, varnishes for furniture, and soils coating.	884	60	594	40	594	40	884	60
Strong emotional shocks are the origin of some cancers' development.	1119	76	359	24	359	24	1119	76
Pesticides are generally speaking recognized as carcinogenic agents.	1380	93	98	7	98	7	1380	93

2.3 Scores' construction

This section presents the construction of our scores. First, we describe the construction of our scores of time preference, impulsivity and risk preferences used in analyses in Chapter 3. Then we describe the construction of our scores of endorsement of beliefs related to cancers and cancers' causes used in analyses in Chapter 4.

2.3.1 Time preferences

Participants' answers to the question related to time preferences are displayed in Table 20.

2.3.1.1 Coding

Based on the work conducted by Luc Arrondel and André Masson in the PATER survey (Arrondel et al. 2002; Arrondel and Masson 2014) as well as by Corinne Thanina Zerrar in her thesis (Zerrar 2016), respondents' answers were coded as presented in the Table 20.

Future-oriented answers were coded with -1 while present-oriented answers were coded with +1 and answers neither future- nor present- oriented were coded with 0 as neutral answers.

Table 20 Respondents' answers coded in being future-oriented, being neutral, and being present-oriented

	Coding	**N**	**%**
It is important to encourage children to be farsighted and to give them the taste of savings.			
Absolutely	-1	471	32
Somewhat	0	860	58
Not really / Not at all	1	147	10
Retirement is something that has to be prepared long in advance.			
Absolutely / Somewhat	-1	1163	79
Not really	0	263	18
Not at all	1	52	3
Worth, to earn few years of life, to deprive oneself of what we called the pleasures of existence.			
Absolutely	-1	223	15
Somewhat / Not really	0	1125	76
Not at all	1	130	9
Buying travels' ticket by train or plane (excluding regular trips) far in advance.			
Absolutely	-1	196	13
Somewhat / Not really	0	956	65
Not at all	1	326	22
Do not approve children who give more importance to their leisure, passions, or friends than to their studies.			
Absolutely	-1	234	16
Somewhat / Not really	0	1164	79
Not at all	1	80	5
Being preoccupied by the fact of finishing one life in a retirement home.			
Absolutely / Somewhat	0	726	49
Not really / Not at all	1	752	51
Waiting for sales to buy the things one really wants rather than buying them at the moment.			
Absolutely	-1	335	23
Somewhat / Not really	0	997	67
Not at all	1	146	10

Always plan holidays long in advance.			
Absolutely	-1	206	14
Somewhat / Not really	0	1040	70
Not at all	1	232	16
Doing mandatory boring things right away to get rid of it.			
Absolutely	-1	331	22
Somewhat / Not really	0	1021	69
Not at all	1	126	9
Having children is a lifetime engagement.			
Absolutely / Somewhat	0	1392	94
Not really / Not at all	1	86	6
It is necessary to provide against one disappearance in a couple where most of the income comes from one person.			
Absolutely / Somewhat	0	1215	82
Not really / Not at all	1	263	18
Waiting the last moment to buy Christmas gifts.			
Mot at all / Not really	-1	753	51
Absolutely / Somewhat	1	725	49
Already had difficulties making ends meet because of a consumer debt.			
Mot at all / Not really	0	1132	77
Absolutely / Somewhat	1	346	23
Marriage is for the best and the worst.			
Absolutely / Somewhat	0	1116	76
Not at all / Not really	1	362	24
Unexpected workload at the time of holidays: holidays versus supplementary days-off to negotiate.			
Absolutely / Somewhat 1 to 3 AND 4 to 6 CP sup. days-off	-1	843	57
Other situations	0	399	27
Not at all / Not really 1 to 3 AND 4 to CP sup. days-off	1	236	16
Being someone making plans in professional and family life.			
Absolutely / Somewhat at 1 AND 5 AND 10 years	-1	225	15
Other situations	0	742	50
Not at all / Not really at 1 AND 5 AND 10 years	1	511	35
Lottery price of $5.000 won. The payment has to be done at an ulterior date.			
Absolutely / Somewhat Waiting AND Not at all / Not really -1500€ vs now AND -1000€ vs 1 year AND -500€ vs 2 year	-1	1003	68
Other situations	0	464	31
Not at all / Not really Waiting AND Absolutely / Somewhat -1500€ vs now AND -1000€ vs 1 year AND -500€ vs 2 years	1	11	1
Monitoring what one is eating, without doing a strict diet, and monitoring weight.			
Often Weight AND Diet	-1	368	25
Other situations	0	1042	70
Never Weight AND Diet	1	68	5
System that allows stopping working at 55 year olds with a full retirement pension until 65 years old is reached, then minimum pension.			
Not at all interesting / Hardly interesting	-1	1056	71
Somewhat interesting	0	285	19
Very interesting	1	137	9

2.3.1.2 Cronbach's alpha and item-rest correlation

A Cronbach alpha was computed on the following 19 variables related to time preferences.

	Variables
It is important to encourage children to be farsighted and to give them the taste of savings.	rev_pt_enf_epg
Retirement is something that has to be prepared long in advance.	rev_pt_ret_av
Worth, to earn few years of life, to deprive oneself of what we called the pleasures of existence.	rev_pt_priv_yrs
Buying travels' ticket by train or plane (excluding regular trips) far in advance.	rev_pt_bilts_av

Do not approve children who give more importance to their leisure, passions, or friends than to their studies.	rev_pt_enf_etd
Being preoccupied by the fact of finishing one life in a retirement home.	rev_pt_fvie_msret
Waiting for sales to buy the things one really wants rather than buying them at the moment.	rev_pt_wait_soldes
Always plan holidays long in advance.	rev_pt_vac_av
Doing mandatory boring things right away to get rid of it.	rev_pt_obg_now
Having children is a lifetime engagement.	rev_pt_enf_eng
It is necessary to provide against one disappearance in a couple where most of the income comes from one person.	rev_pt_prev_disp
Waiting the last moment to buy Christmas gifts.	rev_pt_ach_av
Already had difficulties making ends meet because of a consumer debt.	rev_pt_diff_bug
Marriage is for the best and the worst.	rev_pt_mar_lt
Unexpected workload at the time of holidays: holidays versus supplementary days-off to negotiate.	rev_pt_holnow_vs_holny
Being someone making plans in professional and family life.	rev_pt_lt_proj
Lottery price of $5.000 won. The payment has to be done at an ulterior date.	rev_pt_lot_euro_tps
Monitoring what one is eating, without doing a strict diet, and monitoring weight.	rev_pt_maintien
System that allows stopping working at 55 year olds with a full retirement pension until 65 years old is reached, then minimum pension.	rev_pt_ret_prec

```
Test scale = mean(unstandardized items)
                                                        average
                              item-test     item-rest     interitem
Item          |  Obs  Sign   correlation   correlation   covariance      alpha
--------------+-------------------------------------------------------------
rev_pt_en~pg | 1478    +       0.5007        0.3634        .0207003      0.5580
rev_pt_ret~v | 1478    +       0.4296        0.3092        .0220796      0.5698
rev_pt_pri~s | 1478    +       0.3985        0.2810        .0225358      0.5742
rev_pt_bil~v | 1478    +       0.4683        0.3318        .0212559      0.5639
rev_pt_enf~d | 1478    +       0.3973        0.2889        .0226781      0.5744
rev_pt_fvi~t | 1478    +       0.2959        0.1671        .0237371      0.5885
rev_pt_wai~s | 1478    +       0.3635        0.2243        .0228027      0.5807
rev_pt_vac~v | 1478    +       0.5224        0.4040         .020713      0.5548
rev_pt_obg~w | 1478    +       0.4533        0.3275        .0216529      0.5662
rev_pt_en~ng | 1478    +       0.2813        0.2220        .0244636      0.5877
rev_pt_pre~p | 1478    +       0.4160        0.3259        .0227862      0.5731
rev_pt_ach~v | 1478    +       0.3596        0.0976        .0234789      0.6215
rev_pt_dif~g | 1478    +       0.2034        0.0914        .0247829      0.5966
rev_pt_mar~t | 1478    +       0.2351        0.1223         .024455      0.5934
rev_pt_hol~y | 1478    +       0.3193        0.1240        .0235469      0.6008
rev_pt_lt_~j | 1478    +       0.4391        0.2752        .0214532      0.5717
rev_pt_lot~s | 1478    -       0.1443        0.0143        .0255437      0.6070
rev_pt_mai~n | 1478    +       0.3451        0.2184        .0231296      0.5819
rev_pt_ret~c | 1478    +       0.1999        0.0266        .0252987      0.6128
--------------+-------------------------------------------------------------
Test scale   |                                             .0230049      0.5965
-------------------------------------------------------------------------------
```

Variables rev_pt_lot_euro_tps and rev_pt_ret_prec had item-rest correlations lower than 0.05 and overall Cronbach Alpha was almost good. They were thus excluded one after another, beginning with the lowest-item-rest-correlation variable. A Cronbach alpha was re-computed each time on the remaining variables.

In fine, all item-rest correlations were over 0.05 when the 17 following variables were included and the associated overall Cronbach Alpha was improved.

	Variables
It is important to encourage children to be farsighted and to give them the taste of savings.	rev_pt_enf_epg
Retirement is something that has to be prepared long in advance.	rev_pt_ret_av
Worth, to earn few years of life, to deprive oneself of what we called the pleasures of existence.	rev_pt_priv_yrs
Buying travels' ticket by train or plane (excluding regular trips) far in advance.	rev_pt_bilts_av
Do not approve children who give more importance to their leisure, passions, or friends than to their studies.	rev_pt_enf_etd
Being preoccupied by the fact of finishing one life in a retirement home.	rev_pt_fvie_msret
Waiting for sales to buy the things one really wants rather than buying them at the moment.	rev_pt_wait_soldes
Always plan holidays long in advance.	rev_pt_vac_av
Doing mandatory boring things right away to get rid of it.	rev_pt_obg_now
Having children is a lifetime engagement.	rev_pt_enf_eng
It is necessary to provide against one disappearance in a couple where most of the income comes from one person.	rev_pt_prev_disp
Waiting the last moment to buy Christmas gifts.	rev_pt_ach_av
Already had difficulties making ends meet because of a consumer debt.	rev_pt_diff_bug
Marriage is for the best and the worst.	rev_pt_mar_lt
Unexpected workload at the time of holidays: holidays versus supplementary days-off to negotiate.	rev_pt_holnow_vs_holny
Being someone making plans in professional and family life.	rev_pt_lt_proj
Monitoring what one is eating, without doing a strict diet, and monitoring weight.	rev_pt_maintien

```
Test scale = mean(unstandardized items)
                                                        average
                             item-test     item-rest     interitem
Item          |  Obs  Sign   correlation   correlation   covariance      alpha
--------------+-------------------------------------------------------------
rev_pt_en~pg | 1478    +       0.5257        0.3875       .0255446      0.5860
rev_pt_ret~v | 1478    +       0.4424        0.3195       .0274831      0.5994
rev_pt_pri~s | 1478    +       0.4051        0.2844       .0281421      0.6045
rev_pt_bil~v | 1478    +       0.4797        0.3400       .0264819      0.5942
rev_pt_enf~d | 1478    +       0.3934        0.2812       .0284591      0.6058
rev_pt_fvi~t | 1478    +       0.3032        0.1707       .0296188      0.6186
rev_pt_wai~s | 1478    +       0.3692        0.2259       .0284922      0.6115
rev_pt_vac~v | 1478    +       0.5486        0.4300       .0255705      0.5824
rev_pt_obg~w | 1478    +       0.4755        0.3482       .0267994      0.5945
rev_pt_en~ng | 1478    +       0.2861        0.2251       .0305445      0.6170
rev_pt_pre~p | 1478    +       0.4200        0.3273       .0284806      0.6032
rev_pt_ach~v | 1478    +       0.3679        0.0981       .0293433      0.6566
rev_pt_dif~g | 1478    +       0.2044        0.0889        .030992      0.6268
rev_pt_mar~t | 1478    +       0.2435        0.1275       .0304905      0.6229
rev_pt_hol~y | 1478    +       0.3231        0.1217       .0294842      0.6336
rev_pt_lt_~j | 1478    +       0.4461        0.2775       .0268141      0.6036
rev_pt_mai~n | 1478    +       0.3510        0.2206       .0288891      0.6123
--------------+-------------------------------------------------------------
Test scale   |                                            .0283312      0.6248
-------------------------------------------------------------------------------
```

2.3.1.3 Score

Based on the analyses conducted in section 2.3.1.2, a score was constructed to take into account the time preferences of respondents. This score was calculated for each individuals and ranged from -12 to 17. Distribution of respondents' scores of time preference is displayed in Figure 3.

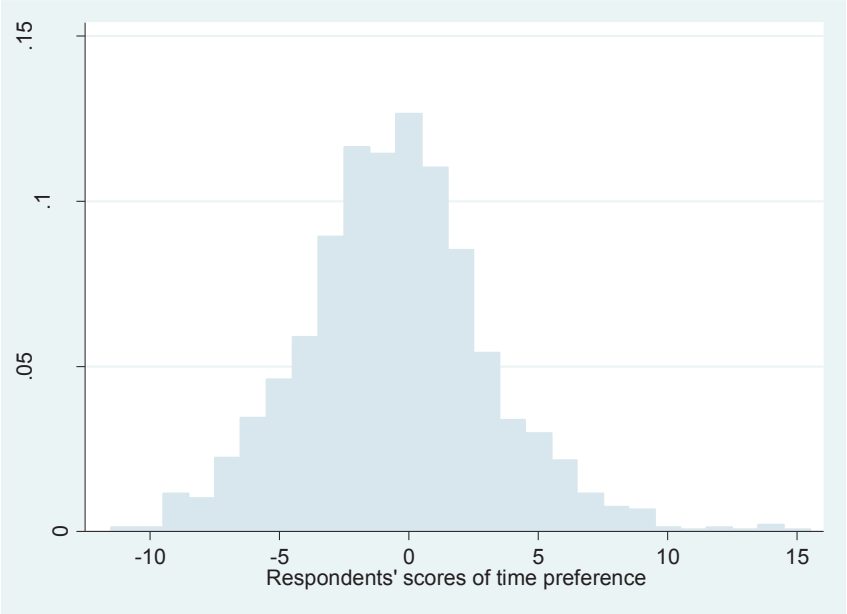

Figure 3 Distributional graph of respondents' scores of time preference

2.3.2 Impulsivity

Participants' answers to the question related to impulsivity are displayed in Table 21.

2.3.2.1 Coding

Coding patterns and cross-checking were the same as those described in the time preferences' section. Respondents' answers were coded as presented in the Table 21.

Thoughtfulness-oriented answers were coded with -1 while impulsivity-oriented answers were coded with +1 and answers neither thoughtfulness- nor impulsivity- oriented were coded with 0 as neutral answers.

Table 21 Respondents' answers coded in being thoughtful, being neutral, and being impulsive

	Coding	**N**	**%**
Always taking the highway to gain time.			
Not at all	-1	321	22
Not really / Somewhat	0	986	67
Absolutely	1	171	11

Do not finish a book when the first pages didn't catch one attention.			
Not at all	-1	277	19
Not really / Somewhat	0	904	61
Absolutely	1	297	20
Becoming impatient when facing a waiting line.			
Not at all / Not really	-1	600	41
Somewhat / Absolutely	1	878	59
Buying right away something that one will be happy to buy.			
Not at all	-1	123	8
Not really / Somewhat	0	1224	83
Absolutely	1	131	9
Already had difficulties making ends meet because of a consumer debt.			
Not at all / Not really	-1	1132	77
Somewhat / Absolutely	1	346	23
Going quickly to see a doctor when one doesn't feel good.			
Not at all	-1	486	33
Not really / Somewhat	0	930	63
Absolutely	1	62	4
Already had stopped a diet because it didn't give enough fast results.			
Not at all	-1	643	43
Not really / Somewhat	0	66	46
Absolutely	1	159	11
Driving above speed limits.			
Not at all	-1	363	363
Not really / Somewhat	0	1011	1011
Absolutely	1	104	104
Passing traffic lights at the time limit.			
Not at all	-1	315	21
Not really / Somewhat	0	1083	73
Absolutely	1	80	5
Waiting for sales to buy the things one really wants rather than buying them at the moment.			
Absolutely	-1	335	23
Somewhat / Not really	0	997	67
Not at all	1	146	10

2.3.2.2 Cronbach's alpha and item-rest correlation

A Cronbach alpha was computed on the 10 variables related to impulsivity.

	Variables
Always taking the highway to gain time.	it_aut_tps
Do not finish a book when the first pages didn't catch one attention.	it_lvr_stp
Becoming impatient when facing a waiting line.	it_imp_att
Buying right away something that one will be happy to buy.	it_sch_pls
Already had difficulties making ends meet because of a consumer debt.	it_dif_edt
Going quickly to see a doctor when one doesn't feel good.	it_mal_mdc
Already had stopped a diet because it didn't give enough fast results.	it_reg_stp
Driving above speed limits.	it_speed
Passing traffic lights at the time limit.	it_orange
Waiting for sales to buy the things one really wants rather than buying them at the moment.	it_wait_soldes

```
Test scale = mean(unstandardized items)
                                                        average
                              item-test     item-rest       interitem
Item          |  Obs  Sign    correlation   correlation     covariance       alpha
--------------+-------------------------------------------------------------------
it_aut_tps    | 1478    +       0.4429        0.2419        .0266844       0.3775
it_lvr_stp    | 1478    +       0.3654        0.1328        .0302294       0.4139
```

```
it_imp_att   | 1478    +       0.5627        0.2165        .0228624      0.3851
it_sch_pls   | 1478    +       0.3739        0.2246        .0294444      0.3926
it_dif_edt   | 1478    +       0.4444        0.1298         .028677      0.4243
it_mal_mdc   | 1478    +       0.3274        0.1259        .0311855      0.4152
it_reg_stp   | 1478    +       0.4629        0.2285         .025944      0.3780
it_wait_so~s | 1478    +       0.1871       -0.0281        .0369278      0.4618
it_speed     | 1478    +       0.4393        0.2511        .0268655      0.3767
it_orange    | 1478    +       0.4181        0.2435        .0277487      0.3820
-------------+-----------------------------------------------------------------
Test scale   |                                             .0286569      0.4273
-------------------------------------------------------------------------------
```

The variable it_wait_soldes had an item-rest correlation lower than 0.05 and the overall Cronbach Alpha was not satisfying. This variable was excluded and Cronbach's alpha was re-computed.

In fine, all item-rest correlations were over 0.05 when the 9 following variables were included. However, even if the overall Cronbach Alpha was slightly improved, it is still lower than 0.6.

	Variables
Always taking the highway to gain time.	it_aut_tps
Do not finish a book when the first pages didn't catch one attention.	it_lvr_stp
Becoming impatient when facing a waiting line.	it_imp_att
Buying right away something that one will be happy to buy.	it_sch_pls
Already had difficulties making ends meet because of a consumer debt.	it_dif_edt
Going quickly to see a doctor when one doesn't feel good.	it_mal_mdc
Already had stopped a diet because it didn't give enough fast results.	it_reg_stp
Driving above speed limits.	it_speed
Passing traffic lights at the time limit.	it_orange

```
Test scale = mean(unstandardized items)

                                                    average
                          item-test     item-rest    interitem
Item          |  Obs  Sign  correlation  correlation  covariance      alpha
--------------+-----------------------------------------------------------
it_aut_tps    | 1478    +       0.4517        0.2481        .0356786      0.4157
it_lvr_stp    | 1478    +       0.3895        0.1551        .0392871      0.4466
it_imp_att    | 1478    +       0.5806        0.2324        .0301052      0.4245
it_sch_pls    | 1478    +       0.3683        0.2157        .0397398      0.4332
it_dif_edt    | 1478    +       0.4539        0.1346          .03816      0.4663
it_mal_mdc    | 1478    +       0.3372        0.1328        .0413197      0.4526
it_reg_stp    | 1478    +       0.4823        0.2466         .034105      0.4124
it_speed      | 1478    +       0.4361        0.2438        .0364933      0.4188
it_orange     | 1478    +       0.4173        0.2393        .0374612      0.4226
--------------+-----------------------------------------------------------
Test scale    |                                           .0369278      0.4618
-------------------------------------------------------------------------------
```

2.3.2.3 Score

Based on the analyses conducted in section 2.3.2.2, a score was constructed to take into account the impulsivity of respondents. This score was calculated for each individual and ranged from -9 to 9. Distribution of respondents' scores of impulsivity is displayed in Figure 4.

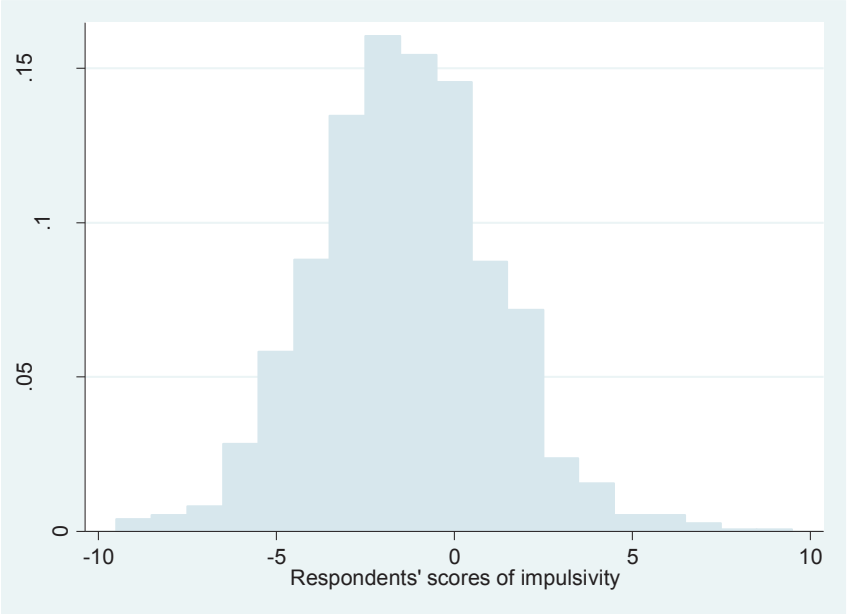

Figure 4 Distributional graph respondents' scores of impulsivity

2.3.3 Risk preferences

Participants' answers to the question related to risk preferences are displayed in Table 22.

2.3.3.1 Coding

Coding patterns and cross-checking were the same as those described in the time preferences' section. Respondents' answers were coded as presented in the Table 22.

Risk-averse-oriented answers were coded with -1 while risk-prone-oriented answers were coded with +1 and answers neither risk-averse- nor risk-prone- oriented were coded with 0 as neutral answers.

Table 22 Respondents' answers coded in being risk-averse, being neutral, and being risk-prone

	Coding	N	%
Situation 1 : Contract A : guarantee same wage over occupational life vs Contract B : 50% wage doubled, 50% reduction of 1/3 S2 if choice A : Contract A vs Contract C : 50% wage doubled, 50%reduction of 20%			

S2 if choice B : Contract B vs Contract D : 50% wage doubled, 50% reduction of 1/2			
Least risky : Contract A AND Contract A	-1	928	63
Other situations (A AND C or B AND A)	0	426	29
Most risky : Contract B AND Contract D	1	124	8
Doing or having done risky sports			
Never	-1	1080	73
Rarely / Sometimes	0	354	24
Often	1	44	3
Already have had the feeling that one had been reckless in professional life.			
Never	-1	588	40
Rarely / Sometimes	0	819	55
Often	1	71	5
Already have had the feeling that one had been reckless when doing sports.			
Never	-1	826	56
Rarely / Sometimes	0	612	41
Often	1	40	3
Monitoring what one is eating, without doing a strict diet, and monitoring weight.			
Often Weight AND Diet	-1	368	25
Other situations	0	1042	70
Never Weight AND Diet	1	68	5
Going to the casino to gamble and / or gambling on sports betting or horse racing.			
Never	-1	1072	73
Rarely / Sometimes	0	370	25
Often	1	36	2
Parking one car outside permitted areas.			
Never	-1	906	61
Rarely / Sometimes	0	550	37
Often	1	22	2
Parking one car without putting money in the parking meter.			
Never	-1	771	52
Rarely / Sometimes	0	648	44
Often	1	59	4
Driving above speed limits.			
Never	-1	363	25
Rarely / Sometimes	0	1011	68
Often	1	104	7
Taking public transports without a valid ticket.			
Never	-1	1238	84
Rarely / Sometimes	0	224	15
Often	1	16	1
Not wearing seatbelt.			
Never	-1	1269	86
Rarely	0	91	6
Sometimes / Often	1	118	8
Passing traffic lights at the time limit.			
Never	-1	315	21
Rarely / Sometimes	0	1083	73
Often	1	80	5
Going sometimes to the movie theater or to see a performance at random with the risk to be deceived.			
Never	-1	568	38
Rarely / Sometimes	0	867	59
Often	1	43	3
Arriving far in advance the departure day of a trip by plane or by train.			
Often	-1	724	49
Sometimes / Rarely	0	642	43
Never	1	112	8
Encouraging children to take risks in their life.			
Not at all	-1	170	12
Somewhat / Not really	0	1262	85
Absolutely	1	46	3
Taste of adventure is an important value to transmit to children.			

Not at all	-1	119	8
Not really / Somewhat	0	1243	84
Absolutely	1	116	8
Marriage is a security			
Absolutely	-1	151	10
Somewhat / Not really	0	966	65
Not at all	1	361	25
Investing most of one savings on risky investments which can earn one back a lot of money.			
Not at all	-1	903	61
Not really / Somewhat	0	546	37
Absolutely	1	29	2
Taking the most covering insurance regarding goods.			
Absolutely	-1	218	15
Somewhat / Not really	0	1170	79
Not at all	1	90	6
Taking the most covering insurance regarding people.			
Absolutely	-1	205	14
Somewhat / Not really	0	1183	80
Not at all	1	90	6
Being home owner is the insurance to always have a roof above the head.			
Absolutely	-1	482	33
Somewhat / Not really	0	871	59
Not at all	1	125	8
Marriage is for the best and the worst.			
Absolutely	-1	507	34
Somewhat / Not really	0	826	56
Not at all	1	145	10
Going for vaccination even when the vaccine is not compulsory.			
Absolutely	-1	124	8
Somewhat / Not really	0	766	52
Not at all	1	588	40
Always thinking about vaccine reminders.			
Absolutely	-1	329	22
Somewhat / Not really	0	905	61
Not at all	1	244	17
Searching for new destinations when travelling.			
Not at all	-1	213	14
Not really / Somewhat	0	1025	69
Absolutely	1	240	16
Searching mainly newness, responsibility, and innovation in job.			
Not at all	-1	199	16
SNot really / Somewhat	0	1143	77
Absolutely	1	136	9
Necessary that partners shared similar taste for a couple to last.			
Absolutely	-1	306	21
Somewhat / Not really	0	1096	74
Not at all	1		5
Always taking precautions against rain when going out under an uncertain weather.			
Absolutely	-1	328	22
Somewhat / Not really	0	1063	72
Not at all	1	87	6
One relative is thinking about leaving his actual stable job for a risky carrier but which can be brilliant. Encouraging him/her without any doubts in this path.			
Not at all	-1	112	8
Not really / Somewhat	0	1242	84
Absolutely	1	124	8
One has won a prize of $100.000. The bank suggests to invest on a risky investment: 1 chance over 2 to double this amount, 1 chance over 2 to lose it.			
Nothing	-1	794	54
Less than 1/3	0	523	35
More than 1/3	1	161	11

System that allows stopping working at 55 year olds with a full retirement pension until 65 years old is reached, then minimum pension.			
Not at all interesting / Hardly interesting	-1	1056	71
Somewhat interesting	0	285	19
Very interesting	1	137	9
Worth, to earn few years of life, to deprive oneself of what we called the pleasures of existence.			
Absolutely	-1	223	15
Somewhat / Not really	0	1125	76
Not at all	1	130	9
It is necessary to provide against one disappearance in a couple where most of the income comes from one person.			
Absolutely / Somewhat	0	1215	82
Not really / Not at all	1	263	18
Going quickly to see a doctor when one doesn't feel good.			
Absolutely	-1	62	4
Somewhat / Not really / Not at all	0	1416	96

2.3.3.2 Cronbach's alpha and item-rest correlation

A Cronbach alpha was computed on the 34 variables related to risk preferences.

	Variables
Choosing the riskiest contract	ar_lot_wage
Doing or having done risky sports	ar_sport
Already have had the feeling that one had been reckless in professional life.	ar_rk_pro
Already have had the feeling that one had been reckless when doing sports.	ar_rk_sport
Monitoring what one is eating, without doing a strict diet, and monitoring weight.	ar_maintien
Going to the casino to gamble and / or gambling on sports betting or horse racing.	ar_bet
Parking one car outside permitted areas.	ar_park
Parking one car without putting money in the parking meter.	ar_pay_park
Driving above speed limits.	ar_speed
Taking public transports without a valid ticket.	ar_transp
Not wearing seatbelt.	ar_seatbelt
Passing traffic lights at the time limit.	ar_orange
Going sometimes to the movie theater or to see a performance at random with the risk to be deceived.	ar_spectacle
Arriving far in advance the departure day of a trip by plane or by train.	ar_av_transp
Encouraging children to take risks in their life.	ar_enf_rk
Taste of adventure is an important value to transmit to children.	ar_enf_aventure
Marriage is a security	ar_mar_secur
Investing most of one savings on risky investments which can earn one back a lot of money.	ar_saves_plcmt
Taking the most covering insurance regarding goods.	ar_ass_biens
Taking the most covering insurance regarding people.	ar_ass_pers
Being home owner is the insurance to always have a roof above the head.	ar_proprio
Marriage is for the best and the worst.	ar_mar
Going for vaccination even when the vaccine is not compulsory.	ar_vaccin
Always thinking about vaccine reminders.	ar_rappel_vac
Searching for new destinations when travelling.	ar_voyage
Searching mainly newness, responsibility, and innovation in job.	ar_metier
Necessary that partners shared similar taste for a couple to last.	ar_couple
Always taking precautions against rain when going out under an uncertain weather.	ar_meteo
One relative is thinking about leaving his actual stable job for a risky carrier but which can be brilliant. Encouraging him/her without any doubts in this path.	ar_emploi_rk
One has won a prize of $100.000. The bank suggests to invest on a risky investment: 1 chance over 2 to double this amount, 1 chance over 2 to lose it.	ar_plcmt_rk
System that allows stopping working at 55 year olds with a full retirement pension until 65 years old is reached, then minimum pension.	ar_ret_prec

Worth, to earn few years of life, to deprive oneself of what we called the pleasures of existence.	ar_priv_yrs
It is necessary to provide against one disappearance in a couple where most of the income comes from one person.	ar_prev_disp
Going quickly to see a doctor when one doesn't feel good.	ar_mal_mdc

```
Test scale = mean(unstandardized items)
                                                        average
                              item-test     item-rest    interitem
Item          |  Obs  Sign   correlation   correlation  covariance      alpha
--------------+-------------------------------------------------------------
ar_lot_wage   | 1478    +       0.2858        0.1769      .0204424      0.7277
ar_sport      | 1478    +       0.3622        0.2790      .0201256      0.7209
ar_rk_pro     | 1478    +       0.3807        0.2903      .0199206      0.7199
ar_rk_sport   | 1478    +       0.4172        0.3324      .0197402      0.7175
ar_maintien   | 1478    -       0.2720        0.1871       .020644      0.7260
ar_park       | 1478    +       0.3825        0.3004      .0200104      0.7197
ar_pay_park   | 1478    +       0.3378        0.2439      .0201756      0.7228
ar_speed      | 1478    +       0.3083        0.2197      .0204067      0.7243
ar_bet        | 1478    +       0.2928        0.2080      .0205256      0.7249
ar_transp     | 1478    +       0.3104        0.2437      .0205941      0.7234
ar_seatbelt   | 1478    +       0.2555        0.1574      .0206826      0.7282
ar_orange     | 1478    +       0.3272        0.2467      .0203645      0.7228
ar_spectacle  | 1478    +       0.2987        0.2094      .0204591      0.7249
ar_av_transp  | 1478    -       0.2508        0.1434      .0206904      0.7298
ar_enf_rk     | 1478    +       0.3757        0.3172      .0203936      0.7207
ar_enf_ave~e  | 1478    +       0.4451        0.3861      .0200293      0.7172
ar_mar_secur  | 1478    -       0.3426        0.2495        .02015      0.7225
ar_saves_p~t  | 1478    +       0.4021        0.3196      .0198765      0.7184
ar_ass_biens  | 1478    -       0.3861        0.3159      .0201563      0.7196
ar_ass_pers   | 1478    -       0.3774        0.3081      .0202178      0.7201
ar_proprio    | 1478    -       0.3247        0.2267      .0202314      0.7240
ar_mar        | 1478    -       0.2655        0.1605      .0205961      0.7285
ar_vaccin     | 1478    -       0.3523        0.2516      .0200169      0.7224
ar_rappel_~c  | 1478    -       0.3380        0.2362      .0201113      0.7235
ar_voyage     | 1478    +       0.4777        0.3972      .0193735      0.7134
ar_metier     | 1478    +       0.4482        0.3777      .0197769      0.7160
ar_couple     | 1478    -       0.3304        0.2514      .0203609      0.7226
ar_meteo      | 1478    -       0.2768        0.1920      .0206178      0.7257
ar_emploi_rk  | 1478    +       0.2669        0.1998      .0207928      0.7254
ar_plcmt_rk   | 1478    +       0.3354        0.2231      .0200592      0.7248
ar_ret_prec   | 1478    +       0.1370        0.0230      .0214791      0.7383
ar_priv_yrs   | 1478    -       0.2100        0.1265      .0209876      0.7291
ar_prev_disp  | 1478    -       0.2070        0.1413      .0210631      0.7278
ar_mal_mdc    | 1478    -       0.1727        0.1381      .0213416      0.7282
--------------+-------------------------------------------------------------
Test scale    |                                           .0203651      0.7296
------------------------------------------------------------------------------
```

The variable ar_ret_prec had an item-rest correlation lower than 0.05. The overall Cronbach Alpha was good even if 14 variables had a negative contribution to the scale. The variable ar_ret_prec was excluded and Cronbach's alpha was re-computed.

```
Test scale = mean(unstandardized items)
                                                        average
                              item-test     item-rest    interitem
Item          |  Obs  Sign   correlation   correlation  covariance      alpha
--------------+-------------------------------------------------------------
ar_lot_wage   | 1478    +       0.2871        0.1773      .0216018      0.7371
ar_sport      | 1478    +       0.3610        0.2769       .021282      0.7303
```

```
ar_rk_pro    | 1478    +       0.3799        0.2886        .0210647      0.7294
ar_rk_sport  | 1478    +       0.4217        0.3363         .020841      0.7266
ar_maintien  | 1478    -       0.2778        0.1923        .0217884      0.7349
ar_park      | 1478    +       0.3899        0.3074        .0211095      0.7286
ar_pay_park  | 1478    +       0.3409        0.2462        .0213085      0.7320
ar_speed     | 1478    +       0.3185        0.2296         .021509      0.7329
ar_bet       | 1478    +       0.2923        0.2066        .0216997      0.7342
ar_transp    | 1478    +       0.3061        0.2386        .0217867      0.7328
ar_seatbelt  | 1478    +       0.2491        0.1497        .0219056      0.7379
ar_orange    | 1478    +       0.3322        0.2512        .0214981      0.7318
ar_spectacle | 1478    +       0.3034        0.2134        .0215985      0.7339
ar_av_transp | 1478    -       0.2605        0.1524        .0218037      0.7385
ar_enf_rk    | 1478    +       0.3779        0.3190        .0215456      0.7298
ar_enf_ave~e | 1478    +       0.4437        0.3841        .0211772      0.7265
ar_mar_secur | 1478    -       0.3413        0.2472        .0213102      0.7320
ar_saves_p~t | 1478    +       0.3996        0.3161        .0210274      0.7280
ar_ass_biens | 1478    -       0.3898        0.3191        .0212871      0.7287
ar_ass_pers  | 1478    -       0.3832        0.3136        .0213415      0.7290
ar_proprio   | 1478    -       0.3313        0.2328         .021343      0.7329
ar_mar       | 1478    -       0.2668        0.1608        .0217642      0.7378
ar_vaccin    | 1478    -       0.3623        0.2613        .0210921      0.7312
ar_rappel_~c | 1478    -       0.3438        0.2415        .0212205      0.7325
ar_voyage    | 1478    +       0.4761        0.3947        .0204922      0.7231
ar_metier    | 1478    +       0.4468        0.3755        .0209135      0.7255
ar_couple    | 1478    -       0.3240        0.2440        .0215573      0.7322
ar_meteo     | 1478    -       0.2772        0.1917         .021791      0.7350
ar_emploi_rk | 1478    +       0.2623        0.1945        .0219972      0.7347
ar_plcmt_rk  | 1478    +       0.3385        0.2253        .0211848      0.7341
ar_priv_yrs  | 1478    -       0.2135        0.1293        .0221642      0.7381
ar_prev_disp | 1478    -       0.2129        0.1467        .0222358      0.7366
ar_mal_mdc   | 1478    -       0.1661        0.1312        .0225679      0.7372
-------------+-----------------------------------------------------------------
Test scale   |                                                .0214791      0.7383
-------------------------------------------------------------------------------
```

All variable had item-rest correlations > 0.05. We still observed that 13 variables had a negative contribution to the scale. Thus, these variables were excluded one by one and Cronbach alphas re-computed each time.

In fine, all item-rest correlations were over 0.05 when the 19 following variables were included. The overall Cronbach Alpha is still good and was even slightly improved.

	Variables
Choosing the riskiest contract	ar_lot_wage
Doing or having done risky sports	ar_sport
Already have had the feeling that one had been reckless in professional life.	ar_rk_pro
Already have had the feeling that one had been reckless when doing sports.	ar_rk_sport
Going to the casino to gamble and / or gambling on sports betting or horse racing.	ar_bet
Parking one car outside permitted areas.	ar_park
Parking one car without putting money in the parking meter.	ar_pay_park
Driving above speed limits.	ar_speed
Taking public transports without a valid ticket.	ar_transp
Not wearing seatbelt.	ar_seatbelt
Passing traffic lights at the time limit.	ar_orange
Going sometimes to the movie theater or to see a performance at random with the risk to be deceived.	ar_spectacle
Encouraging children to take risks in their life.	ar_enf_rk
Taste of adventure is an important value to transmit to children.	ar_enf_aventure

Investing most of one savings on risky investments which can earn one back a lot of money.	ar_saves_plcmt
Searching for new destinations when travelling.	ar_voyage
Searching mainly newness, responsibility, and innovation in job.	ar_metier
One relative is thinking about leaving his actual stable job for a risky carrier but which can be brilliant. Encouraging him/her without any doubts in this path.	ar_emploi_rk
One has won a prize of $100.000. The bank suggests to invest on a risky investment: 1 chance over 2 to double this amount, 1 chance over 2 to lose it.	ar_plcmt_rk

```
Test scale = mean(unstandardized items)
                                                        average
                              item-test     item-rest    interitem
Item          |  Obs  Sign   correlation   correlation   covariance      alpha
--------------+-------------------------------------------------------------
ar_lot_wage   | 1478    +       0.4024        0.2628       .0367263      0.7447
ar_sport      | 1478    +       0.4706        0.3663       .0361903      0.7347
ar_rk_pro     | 1478    +       0.4689        0.3536       .0359241      0.7355
ar_rk_sport   | 1478    +       0.5038        0.3965       .0354966      0.7319
ar_bet        | 1478    +       0.3697        0.2589       .0376683      0.7431
ar_spectacle  | 1478    +       0.3991        0.2843       .0371416      0.7413
ar_enf_rk     | 1478    +       0.3945        0.3159       .0380117      0.7398
ar_enf_ave~e  | 1478    +       0.4295        0.3476       .0374777      0.7375
ar_saves_p~t  | 1478    +       0.4386        0.3287       .0365886      0.7377
ar_voyage     | 1478    +       0.4409        0.3260       .0364381      0.7379
ar_metier     | 1478    +       0.4520        0.3556       .0367218      0.7359
ar_emploi_rk  | 1478    +       0.3383        0.2504       .0384764      0.7434
ar_plcmt_rk   | 1478    +       0.4239        0.2783       .0362386      0.7440
ar_park       | 1478    +       0.5303        0.4326         .03533      0.7293
ar_pay_park   | 1478    +       0.5103        0.3988       .0352411      0.7315
ar_speed      | 1478    +       0.4250        0.3129       .0367681      0.7390
ar_transp     | 1478    +       0.4400        0.3573       .0373121      0.7368
ar_seatbelt   | 1478    +       0.2842        0.1652       .0388527      0.7505
ar_orange     | 1478    +       0.4214        0.3184       .0370277      0.7386
--------------+-------------------------------------------------------------
Test scale    |                                            .0368227      0.7489
------------------------------------------------------------------------------
```

The 14 variables excluded at the first step appeared to be correlated together (none of them changed sign during the step-by-step-exclusion-procedure). Thus, we computed a Cronbach alpha between these variables. Interestingly, a good alpha was obtained and none of these variables had an item-rest correlation lower than 0.05.

	Variables
Monitoring what one is eating, without doing a strict diet, and monitoring weight.	ar_maintien
Arriving far in advance the departure day of a trip by plane or by train.	ar_av_transp
Marriage is a security	ar_mar_secur
Taking the most covering insurance regarding goods.	ar_ass_biens
Taking the most covering insurance regarding people.	ar_ass_pers
Being home owner is the insurance to always have a roof above the head.	ar_proprio
Marriage is for the best and the worst.	ar_mar
Going for vaccination even when the vaccine is not compulsory.	ar_vaccin
Always thinking about vaccine reminders.	ar_rappel_vac
Necessary that partners shared similar taste for a couple to last.	ar_couple
Always taking precautions against rain when going out under an uncertain weather.	ar_meteo
Worth, to earn few years of life, to deprive oneself of what we called the pleasures of existence.	ar_priv_yrs
It is necessary to provide against one disappearance in a couple where most of the income comes from one person.	ar_prev_disp
Going quickly to see a doctor when one doesn't feel good.	ar_mal_mdc

```
Test scale = mean(unstandardized items)

                                                    average
                          item-test     item-rest    interitem
Item          |  Obs  Sign  correlation  correlation  covariance      alpha
--------------+-------------------------------------------------------------
ar_maintien   | 1478    +      0.3836       0.2405      .0388766      0.6849
ar_av_transp  | 1478    +      0.4512       0.2780      .0369181      0.6821
ar_mar_secur  | 1478    +      0.4325       0.2741      .0375607      0.6815
ar_ass_biens  | 1478    +      0.5521       0.4451      .0359343      0.6611
ar_ass_pers   | 1478    +      0.5661       0.4632      .0357749      0.6594
ar_proprio    | 1478    +      0.4945       0.3380      .0359533      0.6723
ar_mar        | 1478    +      0.4709       0.3037      .0364406      0.6778
ar_vaccin     | 1478    +      0.4609       0.2918      .0366923      0.6797
ar_rappel_~c  | 1478    +      0.5524       0.3982       .034322      0.6628
ar_couple     | 1478    +      0.4341       0.3020      .0379222      0.6772
ar_meteo      | 1478    +      0.5317       0.4064      .0357588      0.6637
ar_priv_yrs   | 1478    +      0.3613       0.2221      .0393908      0.6869
ar_prev_disp  | 1478    +      0.3268       0.2162      .0403465      0.6867
ar_mal_mdc    | 1478    +      0.2187       0.1589       .042374      0.6918
--------------+-------------------------------------------------------------
Test scale    |                                        .0374475      0.6926
------------------------------------------------------------------------------
```

These analyses lead to several observations. First of all, both Cronbach alphas were above 0.6 showing a very acceptable consistency between the variables included. Besides, all variables included in the first group appeared related to decisions taken in context of risk-taking behaviors such as sport, occupation, money, car-infractions while the second group of variables appeared to decisions taken in context of protective behaviors such as insurance, marriage, health, etc.

2.3.3.3 Score

On the strength of the analyses and findings in section 2.3.3.2, two score were constructed to take into account respondents' attitude towards risk in context of risk-taking and protective behaviors. These two scores were calculated for each individuals. Raw scores ranged from -19 to 19 for risk preference regarding decisions in context of risk-taking behaviors and from -13 to 13 for risk preference regarding decisions in context of protective behaviors. Distributions of respondents' scores of risk preferences in context of risk-taking and protective behaviors are displayed in Figure 5.

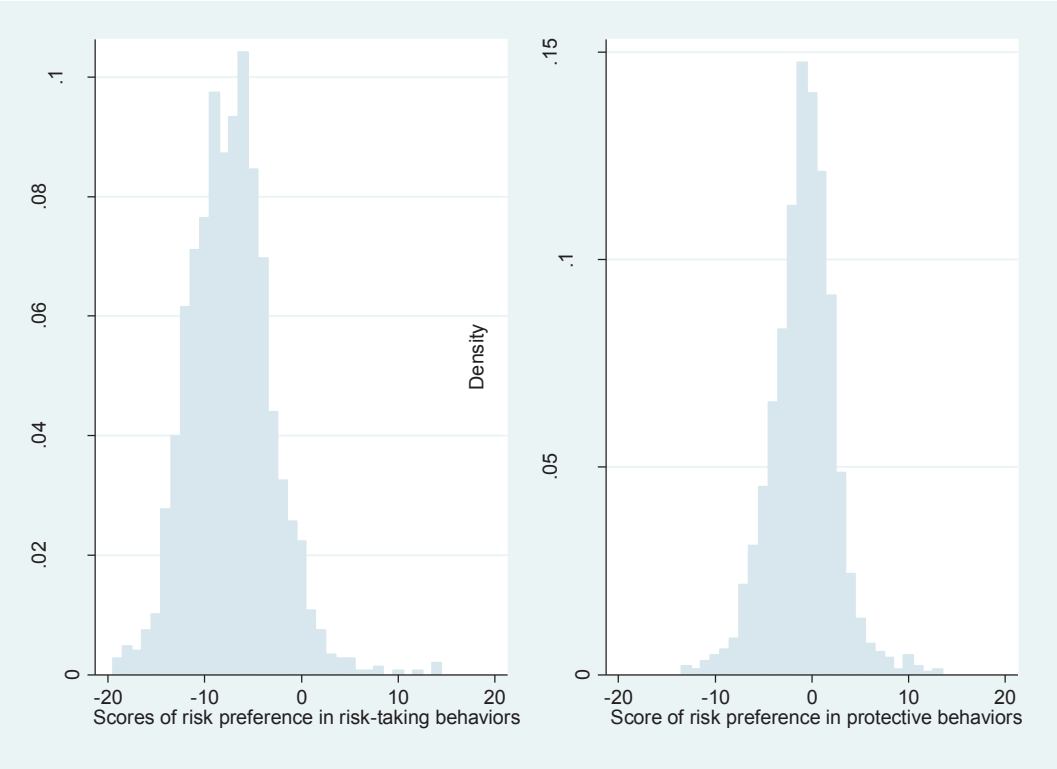

Figure 5 Distributional graphs of respondents' scores of risk preferences in context of risk-taking and protective behaviors

2.3.4 Beliefs related to cancers

Participants' endorsement of beliefs related to cancers are reported in Table 23.

Table 23 Beliefs related to cancers endorsed by respondents, ranked by decreasing proportion of "Absolutely"

	Not at all		Not really		Somewhat		Absolutely	
	N	%	N	%	N	%	N	%
Cancer can affect everyone, from all ages.	14	1	63	4	450	31	951	64
Cancer is a disease with multiple causes in interaction with each other.	23	2	97	6	768	52	590	40
Cancer is a very negative term, associated with death and suffering.	36	2	129	9	778	53	535	36
Cancer is a disease which can nowadays be cured.	36	2	352	24	816	55	274	19
It is possible to prevent cancer occurrence by our daily behaviors.	51	3	423	29	831	56	173	12
Nothing can be done to avoid a cancer.	219	15	672	45	438	30	149	10
It is possible to have a similar life before and after a cancer.	135	9	669	45	534	36	140	10
Having a cancer is often hereditary.	144	10	590	40	667	45	77	5
Cancer is a chronic disease among others.	482	32	646	44	289	20	61	4
Cancer is a disease affecting only elderly.	1008	68	371	25	84	6	15	1

2.3.4.1 Cronbach's alpha and item-rest correlation

A Cronbach alpha was computed on the 10 variables related to cancers' beliefs.

	Variables
Cancer can affect everyone, from all ages.	rev_c81scale
Cancer is a disease with multiple causes in interaction with each other.	c82scale
It is possible to prevent cancer occurrence by our daily behaviors.	c83scale
Having a cancer is often hereditary.	c84scale
Cancer is a disease affecting only elderly.	c85scale
Nothing can be done to avoid a cancer.	rev_c86scale
Cancer is a chronic disease among others.	c87scale
Cancer is a very negative term, associated with death and suffering.	rev_c88scale
It is possible to have a similar life before and after a cancer.	c89scale
Cancer is a disease which can nowadays be cured.	c810scale

```
Test scale = mean(unstandardized items)
                                                        average
                              item-test     item-rest     interitem
Item          |  Obs  Sign   correlation   correlation   covariance      alpha
--------------+-----------------------------------------------------------------
rev_c81scale | 1478    +       0.2801        0.0685       .0397326      0.4136
c82scale     | 1478    +       0.2048       -0.0235       .0442519      0.4449
c83scale     | 1478    +       0.4798        0.2634       .0295952      0.3448
c84scale     | 1478    +       0.2795        0.0253       .0415835      0.4345
c85scale     | 1478    +       0.4230        0.2167       .0326101      0.3648
rev_c86scale | 1478    +       0.4323        0.1517        .033535      0.3883
c87scale     | 1478    +       0.4693        0.2038       .0307801      0.3646
rev_c88scale | 1478    +       0.3042        0.0642       .0395555      0.4184
c89scale     | 1478    +       0.5435        0.3079       .0257914      0.3193
c810scale    | 1478    +       0.5284        0.3151       .0268059      0.3228
--------------+-----------------------------------------------------------------
Test scale   |                                            .0344241      0.4096
-------------------------------------------------------------------------------
```

C82scale and C84scale had item-rest correlations inferior to 0.05 and the overall Cronbach Alpha was not satisfying. They were thus excluded one after another, beginning with the lowest-item-rest-correlation variable. A Cronbach alpha was re-computed each time on the remaining variables.

In fine, all item-rest correlations were over 0.05 when the 8 following variables were included.

	Variables
Cancer can affect everyone, from all ages.	rev_c81scale
It is possible to prevent cancer occurrence by our daily behaviors.	c83scale
Cancer is a disease affecting only elderly.	c85scale
Nothing can be done to avoid a cancer.	rev_c86scale
Cancer is a chronic disease among others.	c87scale
Cancer is a very negative term, associated with death and suffering.	rev_c88scale
It is possible to have a similar life before and after a cancer.	c89scale
Cancer is a disease which can nowadays be cured.	c810scale

```
Test scale = mean(unstandardized items)
                                                        average
                          item-test     item-rest       interitem
Item          |  Obs  Sign  correlation  correlation     covariance      alpha
--------------+-------------------------------------------------------------
rev_c81scale | 1478    +       0.3610        0.1425        .0648022      0.4768
c83scale     | 1478    +       0.4739        0.2420        .0557313      0.4420
c85scale     | 1478    +       0.4367        0.2189        .0587455      0.4514
rev_c86scale | 1478    +       0.4825        0.1920        .0566331      0.4644
c87scale     | 1478    +       0.4621        0.1775        .0584172      0.4699
rev_c88scale | 1478    +       0.4031        0.1575        .0622736      0.4736
c89scale     | 1478    +       0.5600        0.3122        .0476933      0.4096
c810scale    | 1478    +       0.5389        0.3133        .0497691      0.4132
-------------+-------------------------------------------------------------
Test scale   |                                             .0567582      0.4842
-------------------------------------------------------------------------------
```

2.3.4.2 Multiple Correspondence Analysis

A multiple correspondence analysis (MCA) was then conducted on these 8 variables to see if some consistent pattern of respondents' answers can be identified.

Respondents' position on axis 1 accounted for 53% of the inertia. The mean inertia was 0.031 and variables with modality(s) contribution on axis 1 higher than the mean inertia were the following ones.

	Variables
It is possible to prevent cancer occurrence by our daily behaviors.	c83scale
Cancer is a disease affecting only elderly.	c85scale
Cancer is a chronic disease among others.	c87scale
It is possible to have a similar life before and after a cancer.	c89scale
Cancer is a disease which can nowadays be cured.	c810scale

A second MCA was conducted on these 5 variables which seemed to contribute significantly to axis 1. Respondents' position on axis 1 accounted for 54% of the inertia. The mean inertia was 0.05. The modality 4 ("Absolutely") appeared to significantly contribute on axis 1 only for all 5 variables (variable's inertia > mean inertia). Besides all absolutely-modalities are positively correlated and none of them contributed on axis 2.

2.3.4.3 Score

Based on the analyses conducted in section 2.3.4.2, a score was constructed to take into account the total endorsement (answer "absolutely") of the beliefs selected in the first step.

Thus, variables were created to account for asbolute endorsement to each of these five beliefs. The Cronbach alpha between these variables was acceptable. Besides, all item-rest correlations were higher than 0.05.

```
Test scale = mean(unstandardized items)

                                                        average
                          item-test     item-rest       interitem
Item          |  Obs  Sign  correlation  correlation     covariance       alpha
--------------+-----------------------------------------------------------------
c83absl       | 1478    +       0.6113        0.2674        .014008      0.4929
c85absl       | 1478    +       0.4381        0.3317       .0193366      0.5055
c87absl       | 1478    +       0.4999        0.2851       .0166588      0.4843
c89absl       | 1478    +       0.6678        0.3855       .0112079      0.4088
c810absl      | 1478    +       0.7342        0.3584       .0098058      0.4400
--------------+-----------------------------------------------------------------
Test scale    |                                             .0142034      0.5268
-------------------------------------------------------------------------------
```

A simple additive score was then computed. Its distribution is displayed in Table 24.

Table 24 Score of absolute endorsement of cancers-related beliefs

	N	%
0	1026	69
1	311	21
2	96	6
3	29	2
4	7	1
5	9	1
Total	1478	100
Dispersion's indicators		
Min – Max	0 – 5	
Mean (sd) - Variance	0.45 (0.82) – 0.67	

2.3.5 Beliefs related to cancers' causes

Participants' endorsement of beliefs related to cancers are reported in Table 25.

Table 25 Beliefs related to cancers' causes endorsed by respondents, ranked by decreasing proportion of "Absolutely"

	Not at all		Not really		Some-what		Absolu-tely		I don't know	
	N	%	N	%	N	%	N	%	N	%
Drinking sodas and eating hamburgers is as bad for the health as drinking alcohol.	34	2	202	14	543	37	574	39	125	8
Living in the periphery of large cities near a highway increases significantly the risk of cancer.	25	2	161	11	697	47	331	22	264	18
Eating 5 fruits and vegetables per day has a significant protective effect on the risk of cancer.	70	4	322	22	632	43	265	18	189	13
Taking the pill for many years increases significantly the risk of some cancers.	49	3	210	15	493	33	232	16	494	33

Keeping a healthy weight using diet is more important than being physically active.	92	6	532	36	450	30	215	15	189	13
Breathing the air in cities is worse for health than smoking cigarettes daily.	107	7	458	31	398	27	198	13	317	22
Drinking alcohol, even moderately, increases significantly the risk of developing cancer.	81	6	464	31	527	36	194	13	212	14
If sunburns in childhood are well cared for, they have no consequence in adulthood.	234	16	471	32	356	24	152	10	265	18
Using mobile phones for long conversations without hand-free kit does not present any risks for health.	230	16	584	40	268	18	94	6	302	20
Eating industrial-cooked dishes is as good for the health as eating self-cooked dishes.	631	43	507	34	152	10	81	6	107	7

2.3.5.1 Cronbach's alpha and item-rest correlation

A Cronbach alpha was computed on the 10 variables related to cancers' causes-related beliefs without the "I don't know" modality. This modality was found indeed to bring a lot of noise in the analysis. It was thus decided to analyze this modality distinctly.

	Variables
Breathing the air in cities is worse for health than smoking cigarettes daily.	c91scale_99
Keeping a healthy weight using diet is more important than being physically active.	c92scale_99
If sunburns in childhood are well cared for, they have no consequence in adulthood.	c93scale_99
Drinking alcohol, even moderately, increases significantly the risk of developing cancer.	c94scale_99
Eating 5 fruits and vegetables per day has a significant protective effect on the risk of cancer.	c95scale_99
Living in the periphery of large cities near a highway increases significantly the risk of cancer.	c96scale_99
Drinking sodas and eating hamburgers is as bad for the health as drinking alcohol.	c97scale_99
Eating industrial-cooked dishes is as good for the health as eating self-cooked dishes.	c98scale_99
Using mobile phones for long conversations without hand-free kit does not present any risks for health.	c99scale_99
Taking the pill for many years increases significantly the risk of some cancers.	c910scale_99

```
Test scale = mean(unstandardized items)
                                                        average
                          item-test     item-rest       interitem
Item          |  Obs  Sign   correlation   correlation     covariance       alpha
--------------+-------------------------------------------------------------------
c91scale_99   | 1161    +       0.5335        0.3226        .0840445       0.5600
c92scale_99   | 1289    +       0.5309        0.3109        .0846451       0.5599
c93scale_99   | 1213    +       0.4896        0.2475         .088197       0.5782
c94scale_99   | 1266    +       0.5047        0.2921        .0883513       0.5693
c95scale_99   | 1289    +       0.4351        0.2099         .094198       0.5868
c96scale_99   | 1214    +       0.4440        0.2608        .0918681       0.5724
c97scale_99   | 1353    +       0.3940        0.1652        .0977781       0.5959
c98scale_99   | 1371    +       0.4816        0.2473        .0898796       0.5789
c99scale_99   | 1176    +       0.4743        0.2589        .0899462       0.5765
c910scale_99  |  984    +       0.4451        0.2427        .0907731       0.5767
--------------+-------------------------------------------------------------------
Test scale    |                                           .0899533       0.6012
-------------------------------------------------------------------------------
```

All item-rest correlations were over 0.05 and the overall Cronbach Alpha was satisfying. All variables were kept for further analyses.

2.3.5.2 Multiple Correspondence Analysis

A multiple correspondence analysis (MCA) was then conducted on these 10 variables to see if some consistent pattern of respondents' answers can be identified.

Respondents' position on axis 1 accounted for 51% of the inertia. The mean inertia was 0.025 and variables with modality(s) contribution on axis 1 higher than the mean inertia were the following ones.

	Variables
Breathing the air in cities is worse for health than smoking cigarettes daily.	c91scale_99
Keeping a healthy weight using diet is more important than being physically active.	c92scale_99
Drinking alcohol, even moderately, increases significantly the risk of developing cancer.	c94scale_99
Eating 5 fruits and vegetables per day has a significant protective effect on the risk of cancer.	c95scale_99
Living in the periphery of large cities near a highway increases significantly the risk of cancer.	c96scale_99
Drinking sodas and eating hamburgers is as bad for the health as drinking alcohol.	c97scale_99
Eating industrial-cooked dishes is as good for the health as eating self-cooked dishes.	c98scale_99
Taking the pill for many years increases significantly the risk of some cancers.	c910scale_99

A second MCA was conducted on these 8 variables which seemed to contribute significantly to axis 1.

Respondents' position on axis 1 accounted for 49% of the inertia. The mean inertia was 0.031. The modality 4 (« Absolutely ») appeared to significantly contribute on axis 1 for all 8 variables (variable's inertia > mean inertia) and modality 3 ("Somewhat") significantly contributed on axis 1 for C96scale and C97scale but negatively. Besides all absolutely-modalities are positively correlated and none of them contributed on axis 2.

2.3.5.3 Score on modalities 1 to 4

Based on the analyses conducted in section 2.3.5.2, a score was constructed to take into account the total endorsement (answer "absolutely") of the following beliefs.

	Variables
Breathing the air in cities is worse for health than smoking cigarettes daily.	c91scale_99
Keeping a healthy weight using diet is more important than being physically active.	c92scale_99
Drinking alcohol, even moderately, increases significantly the risk of developing cancer.	c94scale_99
Eating 5 fruits and vegetables per day has a significant protective effect on the risk of cancer.	c95scale_99
Living in the periphery of large cities near a highway increases significantly the risk of cancer.	c96scale_99
Drinking sodas and eating hamburgers is as bad for the health as drinking alcohol.	c97scale_99
Eating industrial-cooked dishes is as good for the health as eating self-cooked dishes.	c98scale_99
Taking the pill for many years increases significantly the risk of some cancers.	c910scale_99

Thus, variables were created to account for asbolute endorsement to each of eight beliefs. The Cronbach alpha between these variables was good. Besides, all item-rest correlations were higher than 0.05.

```
Test scale = mean(unstandardized items)
                                                        average
                          item-test     item-rest       interitem
Item          |  Obs  Sign  correlation  correlation     covariance      alpha
--------------+-------------------------------------------------------------
c91absl       | 1478    +       0.4986        0.3079        .0248604      0.6013
c92absl       | 1478    +       0.5296        0.3372        .0239993      0.5935
c94absl       | 1478    +       0.5372        0.3556        .0239063      0.5893
c95absl       | 1478    +       0.5006        0.2826        .0246913      0.6087
c96absl       | 1478    +       0.6214        0.4122        .0209745      0.5695
c97absl       | 1478    +       0.5932        0.3297        .0217749      0.6013
c98absl       | 1478    +       0.3930        0.2597        .0277827      0.6152
c910absl      | 1478    +       0.5335        0.3348        .0238348      0.5939
--------------+-------------------------------------------------------------
Test scale    |                                             .023978      0.6288
------------------------------------------------------------------------------
```

Then a simple additive score was computed. Its dispersion is displayed in Table 26.

Table 26 Score of absolute endorsement of cancers' causes-related beliefs

	N	%
0	556	37
1	340	23
2	266	18
3	172	12
4	72	5
5	41	3
6	16	1
7	7	0.5
8	8	0.5
Total	1478	100
Dispersion's indicators		
Min – Max	0 – 8	
Mean (sd) - Variance	1.41 (1.56) – 2.44	

2.3.5.4 Score on modality 99: I don't know

As stated above, DK answers appeared to introduce a lot of noise in the preliminary analyses. Thus, it was decided to create a distinct score for answering "I don't know" to beliefs' questions related to cancers' causes.

Variables accounting for don't known answers were created for each of the beliefs. Then, a Cronbach alpha was computed on the 10 variables related to DK cancers' beliefs.

	Variables
Breathing the air in cities is worse for health than smoking cigarettes daily.	c91_DK
Keeping a healthy weight using diet is more important than being physically active.	c92_DK
If sunburns in childhood are well cared for, they have no consequence in adulthood.	c93_DK
Drinking alcohol, even moderately, increases significantly the risk of developing cancer.	c94_DK

Eating 5 fruits and vegetables per day has a significant protective effect on the risk of cancer.	c95_DK
Living in the periphery of large cities near a highway increases significantly the risk of cancer.	c96_DK
Drinking sodas and eating hamburgers is as bad for the health as drinking alcohol.	c97_DK
Eating industrial-cooked dishes is as good for the health as eating self-cooked dishes.	c98_DK
Using mobile phones for long conversations without hand-free kit does not present any risks for health.	c99_DK
Taking the pill for many years increases significantly the risk of some cancers.	c910_DK

```
Test scale = mean(unstandardized items)
                                                        average
                          item-test     item-rest       interitem
Item          |  Obs  Sign  correlation  correlation     covariance      alpha
--------------+-------------------------------------------------------------
c91_DK        | 1478    +       0.6448        0.5216         .043385      0.8184
c92_DK        | 1478    +       0.6238        0.5228        .0454243      0.8180
c93_DK        | 1478    +       0.6333        0.5170        .0441897      0.8185
c94_DK        | 1478    +       0.6700        0.5725        .0440345      0.8132
c95_DK        | 1478    +       0.6168        0.5145        .0455747      0.8188
c96_DK        | 1478    +       0.6561        0.5449        .0436385      0.8156
c97_DK        | 1478    +       0.6400        0.5603        .0464192      0.8168
c98_DK        | 1478    +       0.6364        0.5622        .0469799      0.8176
c99_DK        | 1478    +       0.6564        0.5384        .0432209      0.8164
c910_DK       | 1478    +       0.6286        0.4792        .0428388      0.8261
--------------+-------------------------------------------------------------
Test scale    |                                             .0445706      0.8331
------------------------------------------------------------------------------
```

All item-rest correlations > 0.05 and the overall Cronbach Alpha was very good.

We thus calculated a simple additive score to take into account to answer "I don't know" to cancers' causes related beliefs. Its dispersion is displayed in Table 27.

Table 27 Score of DK answers to cancers' causes-related beliefs

	N	%
0	648	44
1	292	20
2	160	11
3	145	10
4	77	5
5	53	3
6	28	2
7	15	1
8	12	1
9	5	0
10	43	3
Total	1478	100
Dispersion's indicators		
Min – Max	0 – 10	
Mean (sd) - Variance	1.67 (2.31) – 5.35	

2.4 Summary of scores' implementation

The Table 28 below presents a summary of our scores' implementation. Overall, the scores have good to very good thresholds of Cronbach Alpha. The only exception is the score of absolute endorsement of cancers-related beliefs for which the Cronbach Alpha is only acceptable but not poor enough to be not used.

Table 28 Summary of scores' implementation

	Number of items at start	Number of items selected	Cronbach alpha
Time preference	19	17	0.6248
Impulsivity	10	9	0.4618
Risk preference Context of risk-taking behaviors Context of protective behaviors	34	 19 14	 0.7489 0.6926
Endorsement of cancers-related beliefs	10	5	0.5268
Endorsement of cancers' causes-related beliefs Modalities 1-4 DK	10	 8 10	 0.6288 0.8331