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Efficiency and regulation in the health sector : insights from developed and developing countries

Pauline Kergall

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THÈSE POUR OBTENIR LE GRADE DE DOCTEUR DE L'UNIVERSITÉ DE MONTPELLIER

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**Efficienc e et régulation en santé : une double approche
pays en développement - pays développés**

Présentée par Pauline KERGALL

Le 17 novembre 2023

**Sous la direction de Edmond BARANES
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**UNIVERSITÉ
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*L'université n'entend donner aucune approbation ni improbation
aux opinions émises dans la thèse : ces opinions doivent être
considérées comme propres à leur auteur.*

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Guide de lecture

Les chapitres de cette thèse sont issus d'articles de recherche empiriques qui peuvent être lus indépendamment les uns des autres. Les trois chapitres de cette thèse ont été rédigés en anglais, cependant, un court résumé en français est proposé à chaque début de chapitre.

Valorisation de la thèse

Le chapitre 1 a été présenté en communication orale en ligne le 20 novembre 2020 lors du webinaire « Hospinnomics & Montpellier Recherche Économie : Atelier technique médicament ». Il a été publié dans la revue *Value in Health* en septembre 2021 sous le titre « Coverage and Pricing Recommendations of the French National Health Authority for Innovative Drugs: A Retrospective Analysis From 2014 to 2020 » (<https://doi.org/10.1016/j.jval.2021.06.013>).

Le chapitre 2 a été présenté en communication orale lors des conférences suivantes : European Health Economics Association (EuHEA) conference 2022 (5-8 juillet 2022), 71^{ème} congrès de l'Association Française de Sciences Economiques (AFSE) (14-16 juin 2023). Il sera également présenté lors des 45^{ème} Journées des Economistes de la santé Français (JESF) en décembre 2023. Une version courte du chapitre 2 est actuellement soumise à la revue *BMJ Global Health*.

Le chapitre 3 a été présenté en communication orale lors des conférences et séminaires suivants : séminaire doctorants du Centre d'Economie de l'Environnement - *Montpellier* (CEE-M) (25 octobre 2022), 44^{ème} Journées des Economistes de la santé Français (JESF) (7-9 décembre 2022), Center for Health Economics of University College London (UCL) Brown bag seminar (1^{er} février 2023). Il a également été présenté sous forme de poster lors de la conférence European Health Economics Association (EuHEA) PhD 2022 (29-31 août 2022). Ce chapitre est en cours de révision dans la revue *Economie et Statistique*.

En dehors des chapitres présentés dans la thèse, la réalisation de ce doctorat a conduit à la production de travaux sur la COVID-19 qui ont fait l'objet des publications suivantes :

Guillon, M. & Kergall, P. (2020). Attitudes and opinions on quarantine and support for a contact-tracing application in France during the Covid-19 outbreak. Public Health. <https://doi.org/10.1016/j.puhe.2020.08.026>

Guillon, M., & Kergall, P. (2021). Factors associated with COVID-19 vaccination intentions and attitudes in France. Public health. <https://doi.org/10.1016/j.puhe.2021.07.035>

Kergall, P., & Guillon, M. (2022). Lockdown support, trust and COVID-19 conspiracy beliefs: Insights from the second national lockdown in France. Health Policy. <https://doi.org/10.1016/j.healthpol.2022.09.004>

(Article présenté le 18 février 2021 dans le cadre du EuHEA Seminar Series 2021 et lors des 5^{ème} journées doctorales du Laboratoire Interdisciplinaire de Recherche Appliquée en Économie-Gestion et Santé (LIRAES) le 25 mars 2021)

Baranes, E., Guillon, M., & Kergall, P. (2022). Méinformation et comportements en santé dans le contexte de la pandémie de Covid-19. Annales des Mines-Responsabilité et environnement. <https://doi.org/10.3917/re1.108.0036>

(Article présenté le 18 novembre 2022 lors de la table ronde « premiers enseignements de la crise sanitaire » organisée par la rédaction des Annales des Mines)

Résumé de la thèse

La santé constitue un droit humain fondamental et occupe une place centrale dans les problématiques de développement. Elle est également au cœur des Objectifs de Développement Durable (ODD). Afin de pouvoir répondre aux besoins de santé de la population et de participer à l'atteinte des ODD, des systèmes de santé performants sont nécessaires. L'efficacité et la régulation des systèmes de santé sont donc essentielles afin d'obtenir les meilleurs résultats au regard des ressources investies. Cependant, mesurer la performance des systèmes de santé n'est pas aisé et différentes méthodes coexistent. Par ailleurs, les enjeux sanitaires auxquels les pays font face varient selon les contextes géographiques et économiques. Cette thèse a pour objectif d'apporter des éléments de réflexion sur le sujet de l'efficacité des systèmes de santé en investiguant différents leviers d'amélioration.

Dans un contexte d'augmentation des dépenses de santé, l'évaluation des technologies de santé est cruciale pour garantir une utilisation optimale des ressources. Le premier chapitre utilise les avis produits depuis l'introduction de l'évaluation médico-économique en France pour créer une base de données unique dans l'objectif de révéler *ex post* les critères d'accès au marché utilisés par le régulateur. Dans un premier temps, l'analyse se concentre sur l'étude des critères associés au Service Médical Rendu (SMR), qui définit le taux de remboursement des médicaments en France, et sur les critères associés à l'Amélioration du Service Médical Rendu (ASMR), qui sert de base pour la négociation de prix. Parmi les critères officiellement énoncés, tous ne semblent pas en réalité pris en compte dans l'attribution du SMR et de l'ASMR. Dans un second temps, les Ratios Différentiels Coûts-Résultats (RDCR) présentés par les industriels sont étudiés. Il apparaît notamment que ces ratios sont plus faibles pour les médicaments visant une large population cible et plus élevés pour les médicaments avec une indication pédiatrique ou qui n'ont pas d'alternative thérapeutique.

Dans les pays à revenu faible, les soins de santé primaires sont particulièrement importants. Le deuxième chapitre propose une analyse d'efficacité technique des hôpitaux de district au Burkina Faso. L'efficacité des hôpitaux de district est évaluée à l'aide de la méthode non paramétrique d'analyse par enveloppement de données (DEA) avec bootstrap. L'analyse de la production de soins comparativement aux ressources mobilisées fait ressortir des scores

d'efficacité relativement faibles, indiquant qu'il existe une marge de manœuvre importante pour accroître la production de soins sans coûts additionnels. Par ailleurs, l'étude des facteurs associés au niveau d'efficacité montre l'influence sur les performances des hôpitaux de district de la taille de la population desservie, de son niveau d'éducation, de son état de santé ainsi que de la densité de structures de santé de premier niveau dans la zone de desserte.

Dans une vision large de l'efficacité des systèmes de santé, il est possible d'intégrer l'analyse de toutes les politiques permettant d'améliorer le niveau de santé des populations. Le troisième chapitre s'intéresse à la manière dont l'accès à l'information sur internet est susceptible d'influencer les comportements de santé préventifs. En effet, différentes études ont établi un lien entre l'accès à l'information en santé et les comportements en santé. Plus précisément, le but de ce chapitre est de déterminer si l'accès à internet affecte le recours aux consultations prénatales, l'utilisation de moustiquaires ainsi que la vaccination infantile au Sénégal. À l'aide de la méthode des doubles différences, nos résultats montrent que l'accès à internet augmente l'utilisation de moustiquaires pour les enfants de moins de cinq ans mais qu'il a un effet non déterminé ou nul sur les consultations prénatales et les vaccinations infantiles.

Mots-clés : systèmes de santé ; pays en développement ; régulation ; efficacité ; prix des médicaments ; France

Thesis summary

Health is a fundamental human right and is central to development challenges. Health is also at the heart of the Sustainable Development Goals (SDGs). In order to meet the health needs of the population and to participate in the achievement of the SDGs, efficient health systems are necessary. Therefore, the efficiency and regulation of health systems are essential to achieve better health results given the resources used. However, measuring health performance is not always easy, and there are many ways to do so. Moreover, the health challenges that countries are facing differ according to geographic and socio-economic contexts. This thesis seeks to provide insights into the topic of efficiency of health systems by investigating various ways to improve it.

In the context of increasing healthcare expenditures, health technology assessment has become crucial to optimize resources' utilization in high-income countries. The first chapter exploits the introduction of medico-economic evaluation of innovative drugs in France since 2014 to create a unique database with the objective of revealing *ex post* the market access criteria used by the regulator. Firstly, the analysis focuses on the criteria associated with the clinical value (SMR - Service Médical Rendu), which determines the reimbursement rate of drugs in France, and on the criteria associated with the improvement of the clinical added value (ASMR - Amélioration du Service Médical Rendu), which constitutes a basis for price negotiation. Among official criteria, not all seem to be actually considered in the evaluation of these two criteria. Secondly, the Incremental Cost-Utility Ratios (ICURs) calculated by pharmaceutical firms are studied. These ratios appear to be lower for drugs with a large target population and higher for drugs with a pediatric indication or with no therapeutic alternative.

Health challenges differ from one country to another, and primary health care is of crucial importance in low-income countries. The second chapter of this thesis provides an analysis of the technical efficiency of advanced medical centers (AMC), which correspond to district hospitals, in Burkina Faso. The efficiency of AMCs is assessed using a bootstrapped non-parametric data envelopment analysis (DEA) method. Efficiency scores calculated for AMCs are relatively low, indicating the potential for increased healthcare production without additional costs. Moreover, the size, education level, and health status of the covered

population and the density of the healthcare supply in the district appeared as the main driving factors of AMCs' efficiency.

In a broader vision, all policies that enable the improvement of the population's health might be considered when assessing health systems' efficiency. The third part of this thesis chapter focuses on how access to information on the internet can influence preventive healthcare behaviors. Indeed, various studies have established a link between the provision of health information and health behaviors. More precisely, this study aims at investigating whether internet access impacts the use of antenatal visits, the use of mosquito nets, and children's vaccinations in Senegal. Using a double-difference methodology, our results show that internet access increases the use of bed nets for children under five but has undetermined or no effect on children's vaccinations and antenatal visits.

Keywords: health systems; low- and middle-income countries; regulation; efficiency; pharmaceutical prices; France

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Chapitre 0 : Introduction Générale

« Bonne année, bonne santé », « Santé ! ». Ces expressions utilisées pour exprimer ses vœux à la nouvelle année ou lorsque des personnes trinquent à table illustrent bien le fait que la santé est au cœur des préoccupations de nos sociétés. La santé constitue même un droit humain fondamental d'après la constitution de l'Organisation mondiale de la Santé (OMS) (WHO, 1946). De plus, la santé occupe une place centrale dans les problématiques de développement. L'OMS lie ainsi la santé et le développement avec les termes suivants *« une meilleure santé est essentielle au bonheur et au bien-être. Une meilleure santé contribue également de manière importante au progrès économique, puisque les populations en bonne santé vivent plus longtemps, sont plus productives et épargnent plus »* (David, 2011). Cette vision de la santé comme contribuant au développement économique est appuyée par la théorie du capital humain (Schultz, 1961 ; Mushkin, 1962 ; Becker, 1964).

La santé est également au cœur des objectifs de développement durable (ODD), qui font suite aux objectifs du millénaire pour le développement (OMD), définis dans le cadre de l'Agenda 2030 de l'Organisation des Nations unies (ONU). Cet agenda regroupe 17 objectifs cibles à atteindre à l'horizon 2030 afin d'éradiquer la pauvreté sous toutes ses formes et de protéger la planète pour garantir la prospérité de tous. Le secteur de la santé est particulièrement concerné par l'ODD 3 qui se concentre sur l'accès à la santé et a pour but de *« donner aux individus les moyens de vivre une vie saine et promouvoir le bien-être à tous les âges »*. Cependant, la santé représente également un aspect fondamental pour d'autres objectifs (ODD 1 *« éradication de la pauvreté »* ; ODD 2 *« lutte contre la faim »* ; ODD 10 *« réduction des inégalités »*), ces derniers étant interconnectés.

Afin de pouvoir répondre aux besoins de santé de la population et participer à l'atteinte des ODD, des systèmes de santé performants apparaissent nécessaires. L'efficacité et la régulation des systèmes de santé sont donc essentielles afin d'obtenir de meilleurs résultats en matière de santé, pour les individus et les populations, et pour garantir l'accès à des services de santé abordables et de qualité. En effet, la façon dont les systèmes de

santé sont organisés, financés et gérés peut avoir un impact significatif sur l'efficacité et l'efficience des soins de santé. C'est pourquoi, comprendre les facteurs qui influencent l'efficience et la réglementation des systèmes de santé est important pour améliorer les résultats tout en contenant les dépenses de santé. Différents moyens sont possibles pour améliorer l'efficience des systèmes de santé partout dans le monde. Cette thèse apporte des éléments de réflexion sur le sujet en investiguant diverses façons d'améliorer l'efficience des systèmes de santé dans des contextes géographiques et économiques variés.

L'objectif de ce chapitre introductif est, dans un premier temps, de définir les systèmes de santé et leurs objectifs. Dans un second temps, l'inclusion de la couverture sanitaire universelle (CSU) dans le cadre des ODD est discutée. Dans un troisième temps, la problématique de l'efficience est abordée. Les différences entre les pays à revenu élevé et les pays à revenu faible sont discutées dans un quatrième temps. Pour finir, les différents chapitres de la thèse sont introduits.

1. Définition, objectifs et mesure des résultats des systèmes de santé

Avant de parler d'efficience ou de régulation, il convient de définir les systèmes de santé, leurs périmètres ainsi que leurs objectifs. Le système de santé permet d'organiser la rencontre entre la demande et l'offre de soins. Cependant, et contrairement à ce qu'il est possible de penser au premier abord, définir un système de santé n'est pas aisé et sa définition a évolué au cours du temps. L'OMS, dans son rapport 2008 sur la santé dans le monde, définit un système de santé comme étant « *toutes les organisations, personnes et actions dont l'intention première est de promouvoir, restaurer ou maintenir la santé* » (WHO, 2008). Mais il est possible d'avoir une définition plus étroite du système de santé où l'on considère uniquement les activités visant principalement les soins de santé personnels, et où les politiques de prévention et promotion de la santé sont exclues. À l'inverse, il est possible d'avoir une définition plus large qui englobe toutes les activités ayant une répercussion sur la santé, par exemple les campagnes de scolarisation des filles, la promotion d'une agriculture saine, etc. (Raimondeau, 2018).

La structure d'un système de financement des soins de santé se compose de deux types d'entités : les régimes de financement (tels que le service national de santé, l'assurance maladie sociale, l'assurance volontaire, etc.) et les unités institutionnelles (les agents de financement, tels que les unités gouvernementales, un organisme de sécurité sociale, des compagnies d'assurance privées, etc.) qui opèrent en pratique les régimes de financement (OECD et al., 2017). Les régimes de financement des soins sont les dispositifs par lesquels les services de santé sont payés et obtenus par la population. Le système de financement d'un pays se compose d'un ensemble de régimes de financement. Parmi les régimes de financement on distingue quatre grandes catégories définies par l'OCDE, l'OMS et la Commission européenne : les régimes publics et les régimes contributifs obligatoires ; les régimes de paiement volontaire ; les paiements directs des ménages ; les régimes de financement du reste du monde (non-résidents) (OECD et al., 2017). Malgré ces différences, l'objectif sous-jacent de tout type de systèmes de santé est d'améliorer l'état de santé de la population.

Pour autant, pendant longtemps il n'y a pas eu de consensus sur les objectifs des systèmes de santé dont la vision a beaucoup évolué au cours du temps. La déclaration d'Alma-Ata, en 1978, considérait que le principal objectif d'un système de santé est l'amélioration de l'état de santé de la population. Cette même déclaration mettait en avant l'importance des soins de santé primaires comme vecteur de la couverture de santé universelle : cela correspond à l'idée de la « santé pour tous » avec pour objectif l'an 2000. Dans les années 1980, la place centrale des soins de santé primaires comme vecteur d'accomplissement des objectifs d'amélioration de la santé a été remise en cause. L'initiative de Bamako, en 1987, promouvait une participation financière active des communautés pour l'approvisionnement en médicaments et produits essentiels. En effet, la vision décrite dans la déclaration d'Alma-Ata a été questionnée pour son manque d'attention à la demande de soins et sa focalisation sur une certaine perception des besoins (WHO, 2000).

Aujourd'hui, on considère généralement que les systèmes de santé doivent répondre à trois objectifs fondamentaux :

- Améliorer la santé de la population servie ;
- Répondre aux attentes de la population ;
- Assurer une protection financière contre les coûts de la mauvaise santé.

En effet, en plus de l'objectif premier consistant à l'amélioration de la santé de la population, les systèmes de santé doivent veiller à ce que chacun soit traité avec dignité. Ainsi, il est essentiel que les systèmes de santé répondent aux attentes de la population en matière de délais de soins, de confidentialité, etc. De plus, en raison de l'imprévisibilité des dépenses de santé et de leurs coûts pouvant être « catastrophiques »¹, la protection financière apparaît comme essentielle.

La mesure des résultats en santé est cruciale afin d'estimer si le système de santé répond correctement aux objectifs fixés. Cependant, il n'existe pas d'accord sur la « bonne façon » de mesurer les résultats en santé. Certains indicateurs tels que l'espérance de vie, le taux de mortalité, le taux de morbidité ou encore des indicateurs de couverture des soins (par exemple, taux de vaccination) sont parfois considérés. Cependant, un indicateur unique ne permet pas de prendre en considération la pluralité des objectifs susmentionnés. Les notions d'équité, d'accès aux soins ou encore de qualité de soins sont également mises de côté par l'utilisation de tels indicateurs.

La question de la mesure des résultats en santé se pose aussi dans le domaine de l'assurance et plus largement lorsque l'on s'intéresse à l'évaluation économique en santé. Contrairement à un bien classique échangé sur un marché, il est très difficile d'estimer une valeur pour la vie. La valeur de la vie statistique (VVS) est ainsi souvent utilisée dans le domaine assurantiel ou pour valoriser économiquement des politiques de transport, sanitaires, environnementales, etc. La mesure des résultats en santé est également cruciale lorsque l'on veut comparer différentes politiques de santé ou technologies de santé, et notamment des médicaments. En effet, pour pouvoir comparer l'efficacité de politiques ou produits de santé, il est important de disposer d'une métrique commune des résultats en santé. Dans ce contexte l'indicateur de l'espérance de vie ajustée de la qualité de vie, le QALY (Quality-Adjusted Life Years), est le plus utilisé. Cet indicateur permet de synthétiser au sein d'une seule mesure l'espérance de vie, mesurée en années de vie, et la qualité de cette survie. Le QALY n'est pas le seul indicateur, et souffre bien évidemment de limites, les principales critiques étant d'ordre éthique. Parmi les autres

¹ Les dépenses de santé dites « catastrophiques » correspondent à un paiement supérieur à un certain pourcentage (10 % ou 25 %) du revenu disponible, selon la définition utilisée par l'OMS. L'OCDE quant à elle considère que les dépenses de santé catastrophiques correspondent à un paiement supérieur à 40 % du revenu disponible après déduction des besoins élémentaires.

indicateurs couramment utilisés pour mesurer l'état de santé, mais à un niveau populationnel plutôt qu'individuel, on peut citer le DALY (Disability-Adjusted Life Years) élaboré au début des années 1990 en vue de quantifier le fardeau que font peser les maladies et facteurs de risque sur la population d'un pays.

2. La santé et la CSU au cœur des ODD

Les objectifs de développement durable (ODD), regroupent 17 objectifs cibles à atteindre à l'horizon 2030. Ils constituent un plan à suivre pour un avenir plus durable en répondant aux défis mondiaux actuels tels que la pauvreté, les inégalités, le climat, la dégradation de l'environnement, la prospérité, la paix et la justice. L'ODD 3 se concentre sur l'accès à la santé et a pour objectif de « donner aux individus les moyens de vivre une vie saine et promouvoir le bien-être à tous les âges ». Chaque cible est décomposée en sous-objectifs, eux-mêmes évalués par un ou plusieurs indicateurs. Ainsi, l'atteinte de chacune des cibles peut être vue comme un objectif à atteindre pour les systèmes de santé. La réalisation simultanée de tous les sous-objectifs de l'ODD 3 permet donc de prendre en considération les différentes dimensions des objectifs des systèmes de santé.

Parmi l'ODD 3, on peut mentionner les sous-objectifs 3.1 et 3.2 qui visent à réduire le taux mondial de mortalité maternelle sous le seuil de 70 pour 100 000 naissances vivantes et à diminuer la mortalité infanto-juvénile à 25 pour 1 000 naissances vivantes au plus d'ici à 2030. Le sous-objectif 3.3 vise quant à lui à mettre fin à l'épidémie de SIDA (Syndrome d'Immunodéficience Acquise), à la tuberculose, au paludisme et aux maladies tropicales négligées et à combattre l'hépatite, les maladies transmises par l'eau et autres maladies transmissibles. Malgré de très nombreux progrès dans ces domaines depuis le début de XXI^{ème} siècle ; avec notamment une forte diminution de la mortalité maternelle (baisse de 34 % entre 2000 et 2020), des décès évités grâce à la vaccination (23,2 millions de décès évités grâce à la vaccination contre la rougeole entre 2000 et 2018) et un meilleur accès à la thérapie antirétrovirale (28,7 millions de personnes avaient accès à la thérapie antirétrovirale en 2021) ; le sous-objectif 3.3 n'a pas été atteint et la crise sanitaire de la Covid-19 a fragilisé les progrès obtenus ces dernières années. En 2020, le taux de mortalité maternelle était de 223 pour 100 000 à l'échelle mondiale, 430 pour les pays à revenu faible contre 12 pour les pays à revenu élevé. Le taux mondial de mortalité infanto-

juvénile était lui de 38,1 pour 1 000 en 2021, et 67,4 pour les pays à revenu faible d'après les données de la Banque Mondiale. Enfin, pour la première fois depuis de nombreuses années, les décès liés au paludisme ou à la tuberculose ont augmenté en 2020.

Le sous-objectif 3.8 des ODD est particulièrement important au regard de l'efficacité des systèmes de santé. En effet, il vise à « *faire en sorte que chacun bénéficie d'une couverture sanitaire universelle, comprenant une protection contre les risques financiers et donnant accès à des services de santé essentiels de qualité et à des médicaments et vaccins essentiels sûrs, efficaces, de qualité et d'un coût abordable* ». La mise en place de la couverture sanitaire universelle (CSU) fait également partie des objectifs de la conférence d'Astana qui, en 2018 soit quarante ans après celle Alma-Ata, a remis les soins de santé primaires en avant pour l'atteinte des objectifs de santé mondiale via la mise en place d'une couverture sanitaire universelle.

Deux indicateurs pour mesurer la CSU sont définis dans les ODD : l'indice de couverture des services en vue de la couverture sanitaire universelle (indicateur 3.8.1) et l'indice de dépenses de santé catastrophiques (indicateur 3.8.2) (UHC2030, 2018). La CSU représente la volonté de permettre à chacun de bénéficier de services de santé de bonne qualité, au moment et à l'endroit où il en a besoin, sans avoir à subir de difficultés financières. On distingue trois dimensions de la couverture sanitaire universelle : la couverture de la population (qui reçoit les services, en lien avec les questions d'équité) ; la couverture des services (quels services de santé sont disponibles) ; et la protection financière (la garantie que les services de santé n'entraînent pas de difficultés financières).

L'indice de couverture est défini comme « *la couverture moyenne des services essentiels telle que déterminée par les interventions de référence concernant notamment la santé procréative, ainsi que la santé de la mère, du nouveau-né et de l'enfant ; les maladies infectieuses ; les maladies non transmissibles ; la capacité des services et l'accès pour l'ensemble de la population, dont la plus défavorisée* ». Les services de santé essentiels sont des services que tous les pays ; indépendamment de leur profil démographique, épidémiologique ou économique ; sont censés fournir d'après l'OMS. Cet indice de couverture est construit à l'aide de quatorze indicateurs de référence répartis en quatre catégories : santé reproductive, maternelle, néonatale et infantile ; maladies infectieuses ; maladies non transmissibles ; capacité et accès aux services.

La Figure 0-1 décrit la répartition des pays selon le score de couverture au cours du temps. On observe une nette amélioration depuis l’an 2000, où seuls 27 % des pays avaient un score supérieur ou égal à 60 contre 66 % en 2019. Cependant, ces progrès apparaissent insuffisants pour permettre d’atteindre l’objectif minimal de 80 % de pays avec un score supérieur à 60 d’ici à 2030. De plus, une dégradation de la CSU durant la pandémie de COVID-19 a été observée. (WHO & IBRD, 2021).

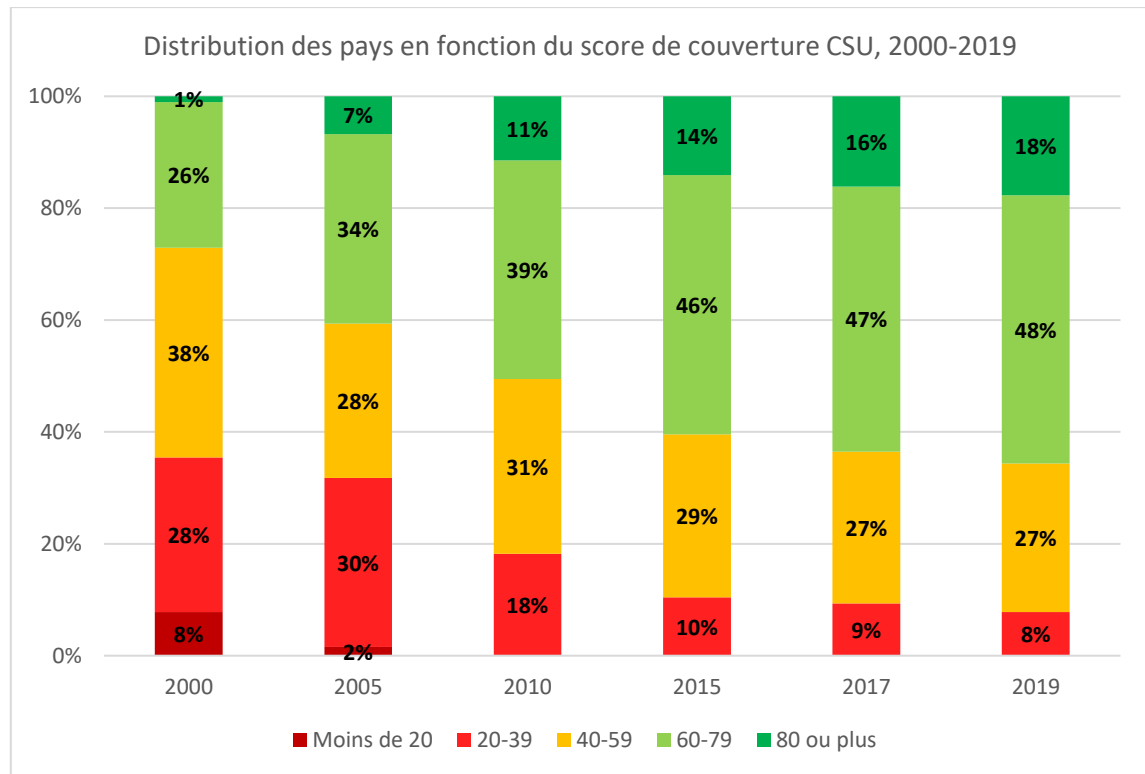


Figure 0-1: Évolution de la couverture de service entre 2000 et 2019

Source : Banque Mondiale

L’indice de dépenses de santé catastrophiques mesure les dépenses directes en santé excédant 10 % ou 25 % du montant total de la consommation ou du revenu du ménage. Le but de cet indicateur est d’estimer la proportion de ménages pour qui les dépenses en santé constituent un « fardeau » économique.

La Figure 0-2 représente pour chaque année disponible, le nombre de personnes et le pourcentage de la population faisant face à des dépenses de santé supérieures à 10 % ou 25 % de leur revenu. Depuis les années 2000, le nombre de personnes affectées par des dépenses catastrophiques en santé n’a cessé de croître. La population mondiale pour laquelle les dépenses de santé directes dépassent 10 % du budget du ménage est passé

de 571 millions en 2000 à près d'un milliard en 2017. Si l'on considère les dépenses de santé dites appauvrissantes² en sus des dépenses catastrophiques, le nombre de personnes concernées se situe alors entre 1,4 et 1,9 milliard pour l'année 2017 (WHO & IBRD, 2021). Lorsque cette augmentation est mise en perspective avec l'augmentation de la population au cours de la même période, et que l'on regarde le pourcentage de la population touchée par de telles dépenses, l'évolution est moins marquée mais toujours présente. En effet, en 2017, 13,2 % de la population mondiale connaissait des dépenses de santé catastrophiques contre seulement 9,4 % en 2000.

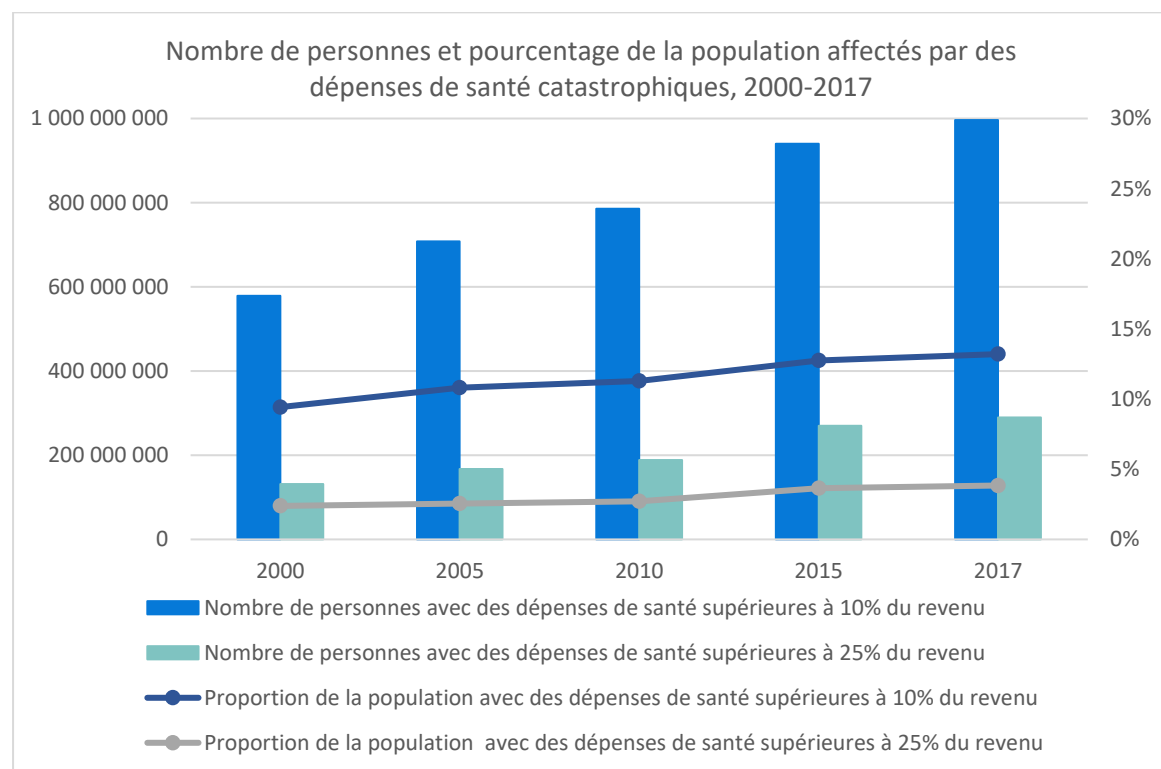


Figure 0-2: Évolution de la protection financière entre 2000 et 2017

Source : Banque Mondiale

Les indicateurs de la CSU ne suffisent pas à eux seuls à évaluer la performance des systèmes de santé, même s'ils permettent une première approche. Il est essentiel de prendre en considération d'autres aspects lors de l'évaluation des systèmes de santé.

² Les dépenses de santé sont dites « appauvrissantes » lorsque la consommation d'un ménage, dépenses de santé directes comprises, est supérieure au seuil de pauvreté mais qu'à l'exclusion de celles-ci elle est inférieure au seuil de pauvreté.

3. Mesure de la performance et mise en avant de la problématique de l'efficacité

Mesurer la performance d'un système de santé, d'une politique, ou d'une intervention, afin de juger de son efficacité et de permettre la prise de décision est un processus compliqué. À l'heure actuelle, il n'existe pas de consensus international sur la meilleure façon de mesurer la performance des systèmes de santé. Plusieurs indicateurs coexistent, sans qu'aucun ne fasse l'unanimité, bien que celui de l'OMS soit souvent vu comme étant une bonne référence (Schütte et al., 2018). En effet, dans son rapport « Pour un système de santé plus performant », publié en 2000, l'OMS a développé un indicateur pour évaluer les systèmes de santé de 191 états membres (WHO, 2000). La réalisation des objectifs des systèmes de santé a été évaluée sur la base de cinq indicateurs : le niveau de santé générale, la distribution de l'état de santé dans la population, le degré général de réactivité du système, la distribution de la réactivité et la répartition de la contribution financière. L'indicateur ainsi obtenu constitue une mesure absolue des résultats, sans comparaison avec ce qu'il aurait été possible de faire. Cet indicateur est ensuite mis en perspective avec les ressources mobilisées pour atteindre un tel résultat, ce qui permet de mesurer la performance des différents systèmes de santé. Les résultats de cette étude plaçaient la France au premier rang global et la Sierra Leone au dernier rang. Le Japon qui était classé premier en matière de résultats de santé, était rétrogradé à la quatrième place une fois les ressources prises en compte.

Cet indicateur n'est pas le seul utilisé et la récente pandémie de la Covid-19, qui a fait peser une forte tension sur les systèmes de santé partout dans le monde et a mis en avant la difficulté de ces derniers à affronter des crises d'une telle ampleur, a mis sur le devant de la scène le « Global Health Security (GHS) Index ». Cet indicateur développé par la « Nuclear Threat Initiative » et le « Johns Hopkins Center for Health Security with Economist Impact » vise à mesurer pour chaque pays le niveau des capacités en matière de santé publique afin de mieux préparer de futures crises en donnant des outils d'amélioration aux décideurs publics. L'évaluation de cet indicateur se fait à travers six catégories : la prévention (prévention de l'émergence ou de la diffusion d'agents pathogènes), la détection (détection et signalement précoces des épidémies susceptibles

de poser un problème au niveau international), la capacité de réponse (réponse rapide et atténuation de la propagation d'une épidémie), la capacité du système de santé (système de santé suffisant pour traiter les malades et protéger les travailleurs du secteur de la santé), les normes (engagement à améliorer les capacités nationales, à financer des plans pour combler les lacunes et à adhérer aux normes mondiales), et la prise en compte des risques (contexte de risque et vulnérabilité des pays aux menaces biologiques). Les États-Unis sont en tête de ce classement avec un score de 75,9 sur 100, tandis que la Somalie occupe la 195^{ème} place avec un score de 16. La France quant à elle se classe en 14^{ème} position avec un score de 61,9. Elle apparaît bien classée en matière de capacité du système de santé (4^{ème} place), mais beaucoup moins en matière de capacité de réponse (37^{ème} place).

Jusqu'au milieu des années 1970, en raison de la forte croissance économique, l'augmentation des dépenses de santé n'est pas perçue comme particulièrement problématique et la question de l'efficacité n'est pas encore présente dans le débat public (Palier, 2010). La question de l'efficacité, qui mesure le niveau de performance des résultats obtenus aux moyens déployés pour les obtenir, a néanmoins pris de l'importance depuis la fin du XX^{ème} siècle et début du XXI^{ème} siècle, tant au niveau académique qu'institutionnel comme en témoignent les travaux de la Banque Mondiale (1996), Hollingsworth (2008), ou Giuffrida & Grabelle (2001). En effet, le rapport de l'OCDE « Vers des systèmes de santé plus performants », publié en 2004, posait également les questions suivantes : « *Améliorer la performance des systèmes de santé nécessite de s'attaquer à des questions difficiles. Comment faire en sorte que les dépenses de santé soient supportables aujourd'hui comme demain ? Que faire pour améliorer la qualité et la sécurité des soins et faire en sorte que les systèmes de santé répondent aux besoins des patients et des autres acteurs ? Comment assurer un accès équitable et en temps voulu aux soins nécessaires ? Enfin, la question peut-être la plus difficile de toutes : que faire pour optimiser l'utilisation des ressources ?* », témoignant ainsi de l'importance nouvelle de la question de l'efficacité en santé (OCDE, 2004).

Cette émergence de la problématique de l'efficacité peut être mise en perspective avec l'augmentation exponentielle des dépenses de santé au même moment, en lien notamment avec des changements de pratiques (Dormont, 2006 ; Tenant, 2014), et avec

l'apparition de coûteux médicaments innovants qui ont mis en avant l'importance de la maîtrise des dépenses au travers de l'évaluation des technologies de santé (ETS) et ont porté l'intérêt croissant pour le calcul économique dans la décision d'allocation des ressources en santé. En effet, entre 1970 et 2020, les dépenses de santé des pays de l'OCDE sont passées de 177 \$ à 5 409 \$ par habitant (parité de pouvoir d'achat - PPA, prix courants). Il y a donc un besoin de rationalisation de la dépense collective : il s'agit de garantir qu'il est fait le meilleur usage possible des ressources (HAS, 2014).

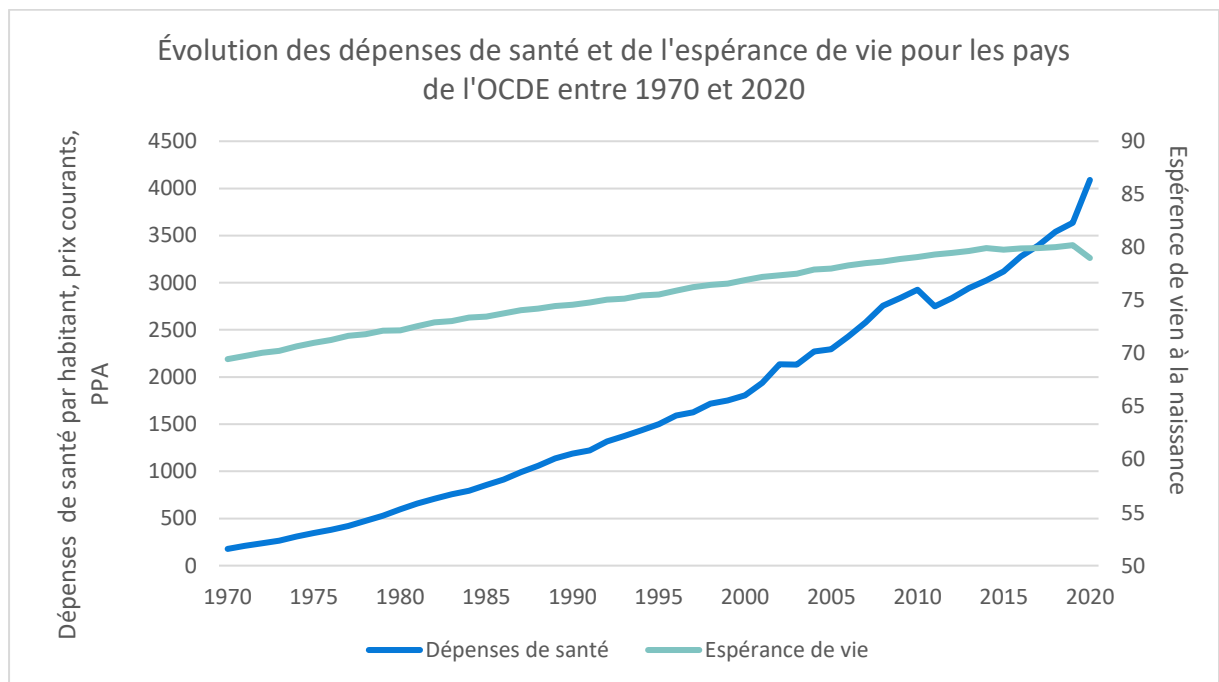


Figure 0-3: Évolution des dépenses de santé et de l'espérance de vies des pays de l'OCDE

Source : OCDE

Dans le même temps, l'espérance de vie a certes augmenté, mais de façon beaucoup moins prononcée. Toujours pour les pays de l'OCDE, elle est passée de 69,5 ans en 1970 à 79 ans en 2020. La même tendance est constatée au niveau mondial, avec des valeurs toutefois inférieures.

Lorsque l'on s'intéresse à la relation entre dépenses de santé et espérance de vie, on remarque une corrélation positive comme illustrée sur la Figure 0-4 pour l'année 2019. Cependant, de fortes dépenses de santé ne sont pas nécessairement synonymes d'espérance de vie plus élevée, la différence tenant en partie dans l'hétérogénéité de l'efficacité des dépenses de santé entre pays. Ainsi, en 2019 aux Etats-Unis les dépenses de santé s'élèvent à 10 921 \$ (PPA, prix courants) par habitant pour une espérance de vie

de 79 ans alors que cette même espérance de vie est atteinte en Thaïlande pour des dépenses de 731 \$ par habitant. Par ailleurs, l'espérance de vie la plus élevée (84 ans) est observé en Suisse, au Japon et en Espagne alors que les dépenses respectives de ces pays sont 8 532 \$, 4 587 \$ et 3 998 \$.

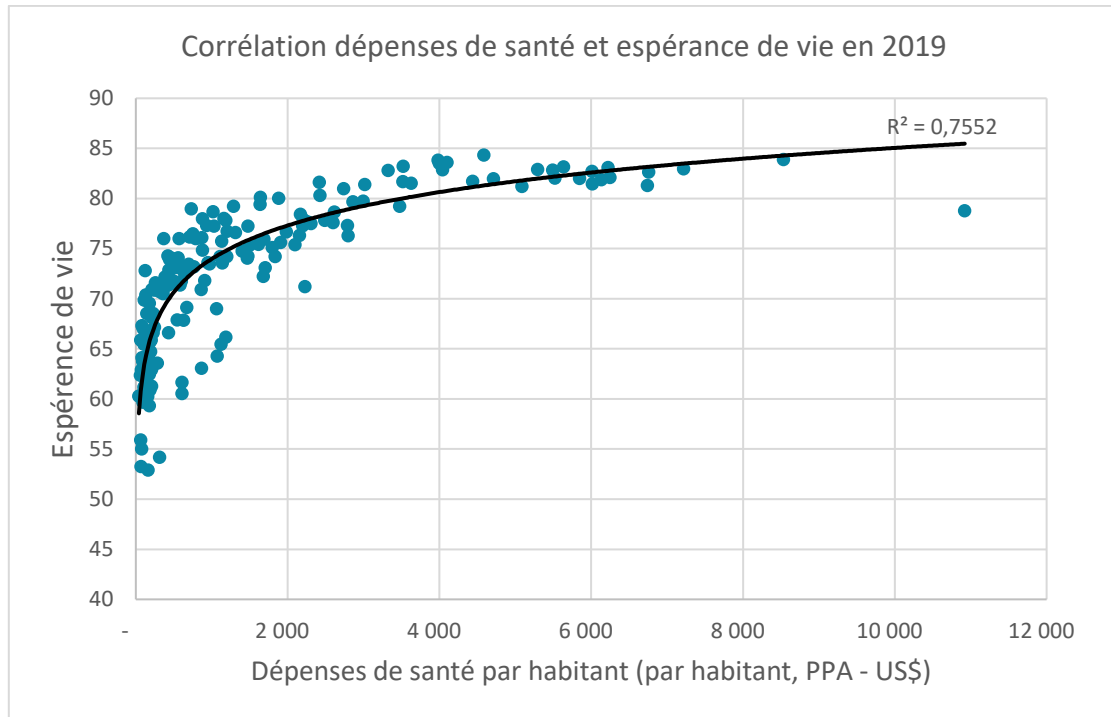


Figure 0-4: Corrélation dépenses de santé et espérance de vie

Source : Banque Mondiale

L'efficacité des systèmes de santé peut être mesurée selon deux approches aux logiques différentes : une vision de maximisation des outputs ou une vision de minimisation des inputs. Dans le cadre d'une maximisation des outputs l'efficacité reflète la capacité d'un système de santé à obtenir le niveau maximal d'état de santé de la population à partir d'un ensemble donné de ressources. Dans le cadre d'une minimisation des inputs l'efficacité reflète la capacité d'un système de santé à minimiser l'utilisation des ressources pour atteindre un niveau d'état de santé de la population donné. Ces deux visions dépendent des objectifs et contraintes qui pèsent sur les systèmes de santé des différents pays. Par exemple, un pays ayant un système de santé très performant en matière de résultats, mais au prix d'une dépense de santé très importante, va favoriser une orientation inputs afin de dégager des ressources pour d'autres domaines de l'intervention publique. À l'inverse, un pays qui dispose de peu de moyens à allouer à son système de santé, et avec des résultats faibles, favorisera une orientation outputs pour

améliorer l'état de santé de la population sans augmentation des ressources qui sont contraintes. Il est important de noter que l'efficacité peut être allocative ou technique. L'efficacité technique prend en considération la « production » en santé uniquement tandis que l'efficacité allocative introduit les prix et ressources financières. Peu importe la vision ou le type d'efficacité étudié, plusieurs méthodes de mesure existent et sont présentées en détail dans le chapitre 2 de cette thèse.

Pour améliorer l'efficacité des systèmes de santé, il est important d'identifier les sources d'inefficacité afin de lutter contre celles-ci. Dans son rapport consacré à l'amélioration de l'efficacité des systèmes de santé en vue de réaliser la CSU, l'OMS a identifié en 2010 dix sources principales d'inefficacité des systèmes de santé, dont trois sont liées à l'utilisation des médicaments (Chisholm & Evans, 2010) :

1. L'utilisation de personnel de santé inapproprié ou coûteux ;
2. La sous-utilisation des médicaments génériques et les prix excessifs des médicaments ;
3. L'utilisation inappropriée et inefficace des médicaments ;
4. L'utilisation de médicaments de faible qualité et de contrefaçon ;
5. L'utilisation excessive d'équipements et de technologies de santé ;
6. Les erreurs médicales et la qualité sous-optimale des soins ;
7. La taille inappropriée des hôpitaux ;
8. Les admissions et durées d'hospitalisation inappropriées ;
9. Les pertes du système de santé (gaspillage, corruption, fraude) ;
10. La mauvaise priorisation des prestations et programmes (utilisation d'interventions peu coût-efficaces).

Les chapitre 1 et 2 de cette thèse explorent certaines des sources d'inefficacités mentionnées par Chisholm et Evans (2010). En effet, le chapitre 1 s'intéresse aux sources d'inefficacité liées aux médicaments et notamment à la question de leur coût. Le chapitre 2, quant à lui, se concentre sur l'allocation du personnel ainsi que sur la question de la taille optimale des structures de santé.

Cependant, la question de l'efficacité en santé ne se résume pas à l'analyse des ressources et résultats du système de santé. Dans une vision plus large, il est possible

d'inclure toutes les politiques permettant d'améliorer le niveau de santé des populations à la mesure de l'efficacité. Les politiques, visant d'autres champs que celui de la santé, comme des campagnes en faveur de l'éducation ou visant à améliorer la sécurité routière, peuvent par exemple également avoir un impact positif sur l'efficacité en santé via des effets d'entraînements ou de contagions (spillover effects). Une meilleure littératie en santé permise par une meilleure éducation au sein de la population peut par ailleurs favoriser des comportements de santé plus sains au sein de la population, (Berkmann et al., 2011 ; Nutbeam, 2000 ; Wagner et al., 2014), participant ainsi à l'amélioration de son état de santé à ressources données pour le secteur de la santé. Le chapitre 3 explore cette vision plus large de l'efficacité en étudiant le lien entre l'accès à l'information sanitaire et les comportements de prévention.

4. Différence entre les pays à revenu élevé et les pays à revenu faible

La thématique de l'efficacité et de la régulation en santé est importante quel que soit le contexte. Cependant, les enjeux et priorités peuvent varier selon le type de pays. En effet, les problématiques rencontrées par les pays à revenu élevé, intermédiaire et faible ne sont pas les mêmes. L'avancement des pays dans leur transition épidémiologique influence notamment largement les objectifs recherchés. La transition épidémiologique, telle que définie par Abdel Omran en 1971, correspond au recul des maladies infectieuses qui mène vers une charge de morbidité et mortalité liée aux maladies chroniques et dégénératives (Omran, 1971). Trois stades sont ainsi définis : « l'âge de la peste et de la famine », « l'âge du recul des pandémies » et « l'âge des malades de la dégénérescence et des maladies de société ». On comprend aisément qu'un pays touché par une forte prévalence du VIH ou de la tuberculose ne rencontre pas les mêmes problématiques de financement et d'organisation des soins qu'un pays où les cancers et maladies artérielles sont les principales causes de mortalité.

De manière générale, dans les pays à revenu élevé, les soins de base (ou soins de santé primaires) sont largement accessibles. La charge de morbidité a évolué de maladies transmissibles vers des maladies non transmissibles, telles que l'hypertension, le diabète, les maladies cardio-vasculaires ou les cancers, en lien notamment avec le vieillissement

de la population. Dans ce contexte, les principales préoccupations de ces pays sont la maîtrise des dépenses de santé ainsi que la réduction des inégalités sociales de santé. Ces pays sont confrontés à de nouvelles contraintes : files d'attente croissantes, augmentation des coûts et patients vieillissants et polyopathologiques notamment. Il apparaît alors nécessaire de mettre en place une démarche systémique pour renforcer les services de soins de santé, mais aussi pour prévenir les maladies et promouvoir des modes de vie sains tout en prenant en compte les impératifs financiers.

Au contraire, dans les pays à revenu faible, et particulièrement dans les pays les moins avancés (PMA), les soins de santé primaires ne sont pas toujours accessibles et la santé préventive joue un rôle crucial pour réduire la charge des maladies dans laquelle les maladies transmissibles sont majoritaires. Les pays à revenu intermédiaire cumulent quant à eux un double fardeau car ils doivent faire face à la montée des maladies non transmissibles tout en faisant face à un poids important de maladies transmissibles. La Figure 0-5, représentant la structure de la charge de la maladie en 2019 selon le type de pays (catégorisation de la Banque Mondiale), illustre bien ces différences.

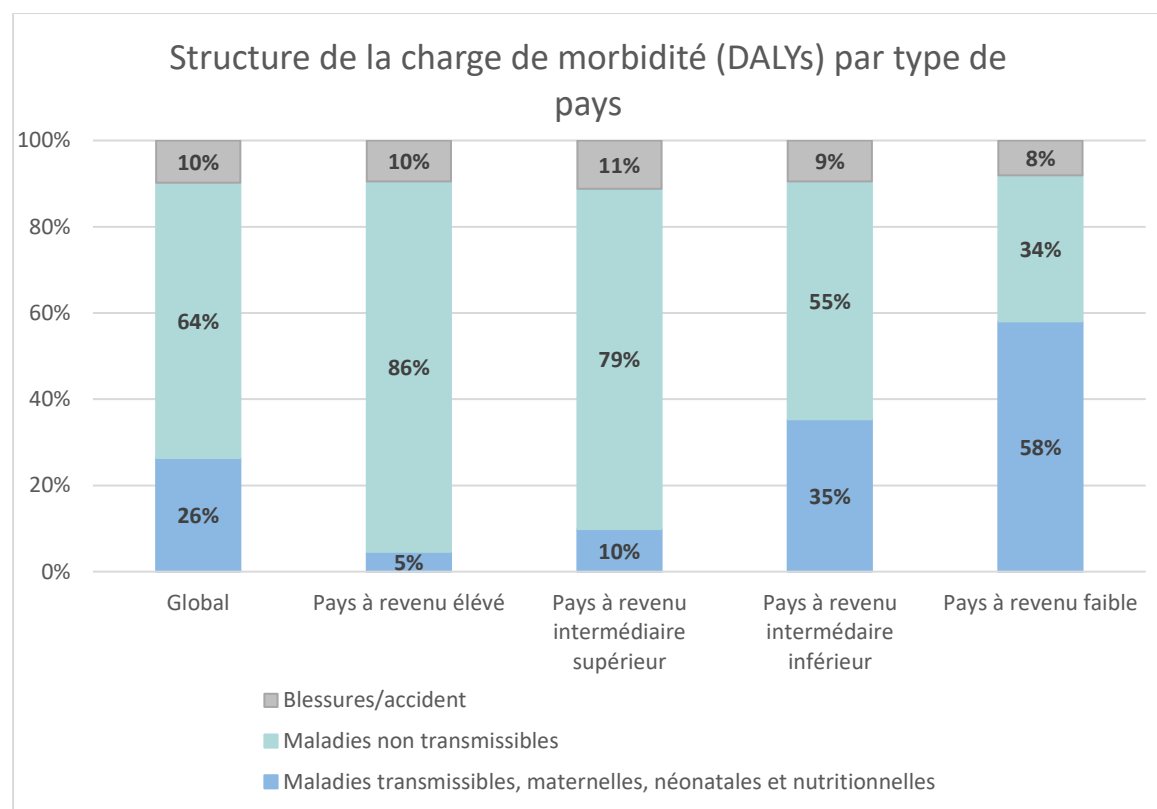


Figure 0-5: Structure de la charge de morbidité

Source : Global Burden of Disease

Ces différentes problématiques rencontrées selon les pays font écho à la pertinence et à la disponibilité des indicateurs de résultats du système de santé. Un indicateur pertinent pour un pays ne l'est pas forcément pour l'autre, et à ce sujet l'OMS observe des différences de disponibilité des indicateurs selon les pays (WHO & IBRD, 2021). Par exemple, dans les pays à revenu élevé, il est plus difficile de trouver des informations sur la santé reproductive, maternelle, néonatale, infantile alors que dans les pays à revenu faible il n'existe pas toujours d'informations sur le poids des maladies non transmissibles.

Les problèmes auxquels font face les différents pays ne sont pas les mêmes, et les ressources disponibles, tant humaines que financières, varient également fortement selon les pays. En effet, la concentration moyenne de médecins dans les PMA (3 pour 10 000 habitants) correspond à un dixième de celle enregistrée dans les pays développés (31 pour 10 000 habitants) (CNUCED, 2020). Par ailleurs, les pays à revenu élevé concentraient 80 % des dépenses de santé mondiale en 2020 (WHO, 2022) alors qu'ils ne représentaient que 16 % de la population mondiale. Les dépenses de santé par habitant étaient ainsi de 6 240 \$ par habitant (PPA, prix courants) dans les pays à revenu élevé contre seulement 106 \$ dans les pays à revenu faible en 2019.

Au-delà de l'hétérogénéité des ressources financières et humaines en santé, des différences dans la « technologie de production » en santé existent entre ces groupes de pays. Si l'on s'intéresse à l'évaluation des technologies en santé, les enjeux diffèrent selon le type de pays. Ainsi, le remboursement des médicaments et des technologies innovantes sont des préoccupations majeures pour les pays à revenu élevé alors que l'enjeu majeur dans les pays à revenu faible concerne la provision d'un paquet minimum de soins au plus grand nombre d'habitants (WHO, 2021). Toutefois, malgré ces différences, l'ETS reste un outil essentiel pour la prise de décision en matière d'allocation des ressources en santé dans les deux contextes, tout en contribuant à l'établissement d'une couverture sanitaire universelle dans les pays à revenu faible et à des systèmes de soins de santé plus durables dans les pays à revenu élevé.

Les différences entre les pays à revenu faible et élevé sont nombreuses, et les écarts déjà existants risquent de s'accroître dans les prochaines années. En effet, en plus de potentielles pandémies futures qui pourraient à nouveau entraîner une forte pression sur les systèmes de santé, le réchauffement climatique actuel va avoir un impact fort et direct

sur la santé humaine (Patz et al., 2005 ; Rocque et al., 2021). Les pays les plus impactés par les changements climatiques à venir sont également ceux dont les systèmes de santé sont aujourd'hui les plus fragiles. Les pays à revenu faible et intermédiaire situés en zone tropicale risquent par exemple de voir les maladies infectieuses monter en flèche en lien avec le réchauffement climatique (Lee et al., 2023). L'OMS estime que le changement climatique sera responsable de 250 000 décès additionnels par an entre 2030 et 2050 ; parmi ces décès 38 000 seront dus à l'exposition des personnes âgées à la chaleur, 48 000 de la diarrhée, 60 000 du paludisme et 95 000 de la malnutrition infantile (WHO, 2018).

5. Présentation des chapitres de la thèse

Les trois chapitres principaux de la thèse, rédigés sous forme d'articles scientifiques en anglais, s'insèrent dans les problématiques précédemment développées. Ces chapitres traitent ainsi de l'efficacité et de la régulation dans le domaine de la santé au sens large et examinent des cas particuliers dans des contextes variés. Le premier chapitre s'intéresse à la question de la maîtrise des dépenses grâce à l'évaluation des technologies de santé dans un pays à revenu élevé, la France. Le deuxième chapitre se concentre sur l'optimisation des ressources allouées aux structures de santé dans un pays à revenu faible, le Burkina Faso. Le troisième chapitre, quant à lui, considère une vision plus large de l'efficacité en santé et se concentre sur le volet de la santé préventive dans un pays à revenu intermédiaire, le Sénégal.

Le premier chapitre concerne les critères d'évaluation des technologies de santé en France en s'intéressant au cas des médicaments innovants. Comme mentionné précédemment, l'ETS joue un rôle crucial dans la plupart des pays développés, dont la France, car les dépenses pharmaceutiques ont très fortement augmenté au cours des dernières décennies entraînant des pressions financières majeures sur les systèmes de santé. Il est donc important de réguler les dépenses dans ce domaine afin d'assurer à la population les meilleurs soins dans un contexte de ressources financières contraintes. L'émergence de nouvelles thérapies, notamment contre le cancer au cours des dernières années, a conduit à des progrès thérapeutiques majeurs en contrepartie de coûts très élevés. En France, l'évaluation médico-économique des médicaments innovants a été mise en place en 2014. Ce premier chapitre exploite l'introduction de cette nouvelle

pratique en créant une base de données unique sur les médicaments innovants ayant fait l'objet d'une mise sur le marché ou extension d'indication entre 2014 et 2020. Dans un premier temps, le système de remboursement des médicaments en France est décrit. L'analyse se concentre ensuite sur les critères pris en compte dans l'établissement du Service Médical Rendu (SMR), qui conditionne le taux de remboursement en France, et de l'Amélioration du Service Médical Rendu (ASMR), qui sert de base pour la négociation de prix. Parmi les critères officiellement établis, tous ne semblent pas en réalité contribuer à l'établissement de l'appréciation de ces deux critères d'évaluation. Le ratio efficacité-effets indésirables ainsi que le type de médicaments (préventif, curatif ou symptomatique) apparaissent notamment comme les principaux déterminants du SMR. Dans un second temps, les Ratios Différentiels Coûts-Résultats (RDCR) calculés par les industriels dans le cadre des avis d'efficience sont étudiés. Il apparaît que ce ratio a tendance à être plus faible pour les médicaments visant une large population cible, et plus élevé pour les médicaments avec une indication pédiatrique ou n'ayant pas d'alternative thérapeutique.

Le deuxième chapitre est une analyse d'efficience technique des hôpitaux de district au Burkina Faso. Le Burkina Faso fait partie des Pays les Moins Avancés. Comme dans la plupart des PMA, le système de santé de ce pays souffre d'un manque de personnel de santé qualifié et les infrastructures et le matériel médical y sont également insuffisants. Au Burkina Faso, la densité de médecins pour 1 000 habitants est seulement de 0,1 alors que le seuil recommandé par l'OMS est d'au moins 2,3 médecins pour 1 000 habitants. Pour comparaison, en France, où le manque de médecins et les déserts médicaux sont l'objet de débats, la densité médecins pour 1 000 habitants est de 3,18. L'article de recherche présenté dans ce chapitre est issu d'une étude financée par l'Agence Française de Développement et réalisée dans le cadre d'un programme de recherches appliquées FERDI-Agence Française de Développement sur les effets de la Covid-19 en Afrique subsaharienne. L'efficience des hôpitaux de district est évaluée à l'aide de la méthode non paramétrique d'analyse par enveloppement de données (DEA) avec bootstrap. Les ressources considérées sont le nombre de docteurs, d'infirmiers, de personnel médical autre, de personnel non médical ainsi que le nombre de lits. La production de soins est mesurée par le nombre de consultations externes, d'hospitalisations et de chirurgies ainsi

que par le nombre de jours d'hospitalisation. Comparativement à la littérature, les scores obtenus sont relativement faibles, indiquant une possibilité d'augmentation significative de la production de soins des hôpitaux de district sans coûts additionnels. Par ailleurs, l'étude des facteurs associés au niveau d'efficacité a montré l'influence importante de la taille de la population desservie, de son niveau d'éducation et de son état de santé, sur l'efficacité des hôpitaux de district ainsi que le rôle majeur de la densité de structures de santé de premier niveau.

Les soins de santé préventifs, comparativement aux soins curatifs, sont très coût-efficaces et sont donc essentiels dans un objectif d'efficacité des systèmes de santé. Ils sont d'autant plus importants dans les pays à revenu faible qui sous-investissent très largement dans ce domaine dans un contexte global de ressources contraintes pour les systèmes de santé. Ainsi, le troisième chapitre se concentre sur le recours aux soins préventifs et traite de l'impact de l'arrivée de l'internet à haut débit en 2010 sur les comportements de santé préventive au Sénégal. Différentes études ont établi un lien entre la provision d'information en santé et les comportements en santé, et internet constitue une source d'information très importante dans nos sociétés actuelles. Plus précisément, le but de cette étude est de tester si l'accès simplifié à internet à partir de 2010 a influencé le recours aux consultations prénatales, à l'utilisation de moustiquaires pour les enfants et à la vaccination infantile. L'accès à internet est souvent vu comme un catalyseur des capacités productives dans l'agriculture ou l'industrie (UNCTAD, 2020) mais est plus rarement mis en lien avec la santé, et notamment la santé préventive. Au Sénégal, la connexion des câbles sous-marins de fibre optique en 2010 a permis de donner accès à l'internet haut débit aux habitants proches du réseau central terrestre. À l'aide d'une méthodologie de double différences, l'évolution des trois indicateurs de santé préventive susmentionnés est étudiée avant et après l'arrivée de l'internet haut débit au Sénégal. Nos résultats montrent que l'accès à internet augmente l'utilisation de moustiquaires pour les enfants de moins de cinq ans, ainsi que le recours aux soins prénataux dans certains cas. Le résultat obtenu sur l'utilisation de moustiquaires est d'autant plus important qu'il concerne tout particulièrement les individus les plus pauvres et les moins éduqués. En revanche, l'impact de l'accès à internet sur les consultations prénatales reste

indéterminé et aucun impact sur les vaccinations infantiles n'est mis en évidence par notre étude.

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Chapitre 1 : Coverage and Pricing Recommendations of the French National Health Authority for Innovative Drugs: A Retrospective Analysis From 2014 to 2020

Abstract

Objectives: This study provides a retrospective analysis of the recommendations of the French National Health Authority on the reimbursement and pricing of innovative drugs.

Methods: The analysis includes drugs subjected to both economic and clinical evaluations in France from 2014 to 2020. Ordered logistic and quantile regressions are used to estimate the factors associated with the clinical value (SMR), the clinical added value (ASMR), and the incremental cost-utility ratio (ICUR) of innovative drugs. All variables used in the regression analyses are extracted from the Clinical and Economic Opinions for the 146 observations.

Results: Regression analyses indicate that 2 of the 5 official criteria, the efficacy-adverse events balance of the drug and its function, are significantly associated with the SMR rating. The ASMR is positively associated with the disease severity, the quality-adjusted life-year (QALY) gain provided by the drug, and the validation of the ICUR in the Economic Opinion. At the first quartile of the ICUR distribution (approximately €50 000/QALY), higher ICUR levels are observed for drugs with a smaller target population and for drugs claimed as more innovative. Higher ICUR levels are also observed for pediatric drugs and for drugs with no therapeutic alternative at the third quartile of the distribution (approximately €240 000/QALY).

Conclusions: Not all official criteria of the SMR are associated with actual ratings obtained. Regarding the ASMR, the results support the idea of a convergence between the 2 independent clinical and economic appraisal processes. Finally, the factors influencing the ICUR level vary across the distribution of the ICUR.

Keywords: clinical added value; clinical benefit; drug pricing; economic evaluation; France; health technology assessment; incremental cost-utility ratio; reimbursement.

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Résumé en français :

Ce premier chapitre propose une analyse rétrospective des recommandations de la Haute Autorité de Santé (HAS) qui conditionnent le remboursement et la tarification des médicaments innovants. L'évaluation des technologies de santé joue un rôle crucial dans la plupart des pays développés, dont la France, car les dépenses pharmaceutiques ont très fortement augmenté au cours des dernières décennies entraînant des pressions financières majeures sur les systèmes de santé. En effet, l'émergence de nouvelles thérapies, notamment récemment contre certains cancers, a conduit à des progrès thérapeutiques majeurs en contrepartie de coûts très élevés. En France, l'évaluation médico-économique des médicaments innovants a été mise en place en 2014. Ce chapitre exploite l'introduction de cette nouvelle pratique en créant une base de données unique sur 146 médicaments innovants ayant fait l'objet d'une mise sur le marché ou d'une extension d'indication entre 2014 et 2020. Toutes les variables utilisées dans les analyses de régression sont extraites des avis cliniques et économiques.

L'analyse se concentre dans un premier temps sur les critères pris en compte dans l'établissement du Service Médical Rendu (SMR), qui conditionne le taux de remboursement en France, et de l'Amélioration du Service Médical Rendu (ASMR), qui sert de base pour la négociation de prix. Les résultats des régressions logistiques montrent que parmi les critères officiellement établis, tous ne semblent pas en réalité contribuer à l'établissement de ces deux critères d'évaluation. En effet, seul deux des cinq critères officiels, le ratio efficacité-effets indésirables et le type de médicaments (préventif, curatif ou symptomatique), sont significativement associés à l'évaluation du SMR. Les critères de sévérité et d'impact sur la santé publique n'influencent pas le niveau de SMR obtenu dans notre échantillon. Les analyses de régression indiquent que l'ASMR est positivement associé à la sévérité de la maladie, au gain en année de vie ajustée sur la qualité (QALY) apporté par le médicament, et à la validation du Ratio Différentiel Coûts-Résultats (RDCR) dans l'avis économique. Les résultats montrent également qu'aucune pénalité sur l'ASMR attribué n'est observée pour les médicaments anticancéreux n'utilisant pas la survie globale comme critère principal pour mesurer l'efficacité clinique, bien qu'il soit prouvé que le fait de s'appuyer sur des substituts (e.g., survie sans progression ou sans récurrence) augmente l'incertitude autour de la taille de l'effet en termes de résultats finaux pertinents pour les patients.

Dans un second temps, l'analyse se concentre sur les RDCR calculés par les industriels dans le cadre des avis d'efficacité. Pour cela, des régressions quantiles sont utilisées pour permettre d'étudier si les facteurs associés aux RDCR revendiqués par les entreprises diffèrent le long de la distribution des RDCR. Au bas de la distribution des RDCR (environ 50 000 €/QALY), des niveaux de RDCR plus élevés sont observés pour les médicaments destinés à une population cible plus restreinte et pour les médicaments considérés comme plus innovants. L'anticipation des accords prix/volume, parfois mis en œuvre par le Comité économique des produits de santé (CEPS) dans les négociations de prix avec les entreprises pharmaceutiques, pourrait être un élément d'explication de cette association négative. Au sommet de la distribution des RDCR (environ 240 000 €/QALY), des niveaux de RDCR plus élevés sont observés pour les médicaments pédiatriques et pour les médicaments sans alternative thérapeutique. Ces résultats semblent indiquer que les firmes pharmaceutiques anticipent le soutien collectif des décideurs et du public sur ces critères de priorisation.

1. Introduction

Health technology assessment (HTA) is used to inform decision-making on health technologies' reimbursement and pricing in most developed countries and as such critically contributes to the access of patients to safe and effective innovative drugs while maintaining the financial sustainability of socialized health systems. In the context of limited health budgets, decisions based on HTA imply trade-offs between competing objectives and criteria, and related key issues are what attributes should count in the new medicines funding decisions when they are expected to be socially acceptable and legitimate. Thus, HTA is crucial in the pursuit of health systems efficiency.

At the European Union level, although market authorizations are centrally issued by the European Medicines Agency, HTA remains the prerogative of decentralized national HTA bodies. Inside the EU, the nature of the organizations, objectives, or criteria of HTA varies quite a lot (Beletsi et al., 2018). The philosophy of HTA or the extent of influencing decision-making is country-specific. Indeed, the UK HTA process differs widely from the German one - even before Brexit. The former is based on a baseline threshold of acceptable price ratio of £20 000-30 000/QALY (a "severity" modifier has been added since 2022) while the latter based its assessment on the additional therapeutic benefit largely and does not calculate any incremental cost-utility ratio. Those differences have contributed to delays and inequalities in the availability of innovative health technologies for patients (European Commission, 2018). However, a process of harmonization with the European Network for Health Technology has emerged recently with joint clinical assessment.

In France, the HTA process for innovative drugs includes both clinical and economic evidence assessments conducted independently and simultaneously by 2 commissions of the French National Health Authority (HAS), the Transparency Commission (CT), and the Economic and Public Health Evaluation Commission (CEESP), respectively. Figure 1-1 illustrates the HTA process in France for innovative drugs.

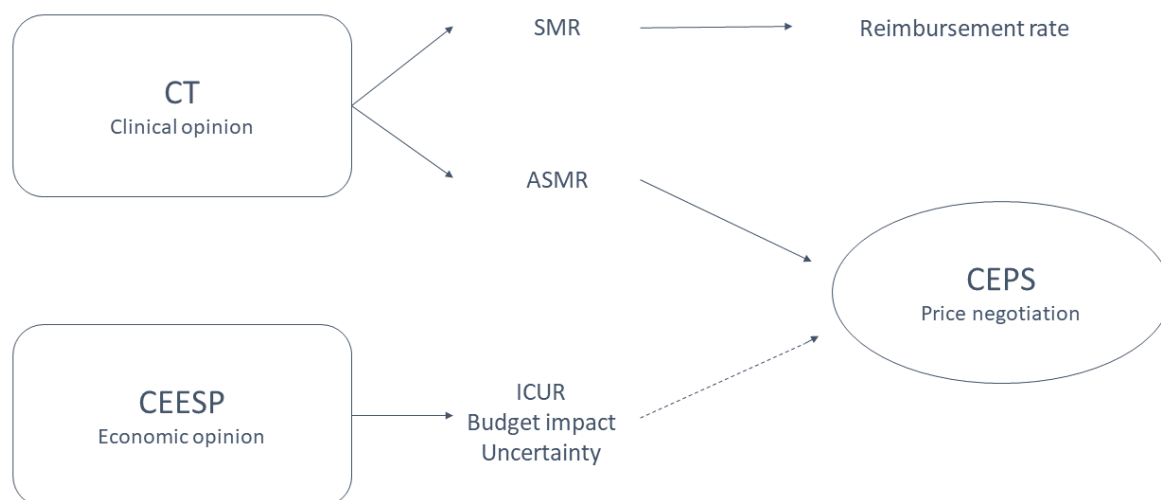


Figure 1-1: HTA process in France for innovative drugs

The assessment of the clinical value of new drugs relies on 2 main composite indicators, namely, the clinical value (SMR - Service Service Médical Rendu) and the clinical added value (ASMR - Amélioration du Service Médical Rendu). The SMR rates the drug's clinical benefit on a 4-level scale from "insufficient" to "important" and drives the reimbursement rate granted by the national health insurance. If the rating of the SMR is "insufficient" the drug is not reimbursed, then as the rating improves reimbursement rate goes up to 15%, 30%, and 65% respectively (in some specific cases, it can go up to 100%). The determination of the SMR is based on 5 official criteria: (1) the severity of the disease, (2) the efficacy-adverse events balance of the drug, (3) the drug function, (4) its place in the therapeutic strategy, and (5) its public health impact (R163-1 French social security code).

The ASMR rates the clinical added value of the drug on a 5-level scale from "no therapeutic progress" to "major therapeutic progress" and conditions the price level that the manufacturer can claim in its negotiation with the Committee of Health Product (CEPS). If the added value is as least important the price is negotiated based on the European price, otherwise, the negotiation margin is higher and the price also depends on the planned volumes of sales and the size of the target population. Indeed, a European price guarantee exists for innovative drugs, ensuring a price equal to the minimum of those in the UK, Germany, Italy, and Spain (ref³). On the opposite, if a drug has no added value, the price has to be inferior to its

³ Ministère des solidarités et de la santé. (2015). Accord cadre du 31/12/2015 entre le Comité économique des produits de santé et les entreprises du médicament (Leem).

competitor. For the ASMR, even though official criteria are not clearly established by regulations as for the SMR, the CT doctrine recently clarified the dimensions considered in the rating process, that is, the treatment effect size, the quality of the evidence and of the demonstration, and the medical need and severity of the disease (HAS, 2018). The Clinical Opinion issued by the CT decides on the SMR and ASMR obtained by new drugs.

An economic evaluation was first introduced in 2013 in the French HTA process and only concerns a subset of all drugs seeking reimbursement by the national health insurance – i.e. those called innovative drugs in this article. Indeed, the submission of cost-effectiveness evidence is mandatory only for drugs claimed as innovative by their manufacturer at the time of the application for reimbursement, that is, drugs with a claimed ASMR from “moderate” to “major” before the evaluation of the ASMR by the CT (HAS, 2013; R161-71-3 French social security code). In addition, a criterion based on “significant impact of healthcare spending” – defined by annual sales revenue above twenty million euros during the second full year of marketing across all indications - is necessary to be subject to economic evaluation. Thus, drugs targeting a very small target population are often not compelled to economic evaluation even if the added value is important. The CEESP reviews the reliability and consistency of the economic evidence provided by the pharmaceutical firm. The Economic Opinion concludes on the validity of the quality-adjusted life-year (QALY) gain and of the incremental cost-utility ratio (ICUR) level reported by the pharmaceutical firm and characterizes the uncertainty around this claimed ICUR [6]. This information is used together with the ASMR to define the framework for price negotiation with the CEPS. Nevertheless, in the absence of an official “acceptable threshold” for ICURs in France, Economic Opinions are not binding for coverage and pricing decisions except in cases where the CEESP invalidates the reported ICUR and concludes that the efficiency of the drug is not demonstrated. In the latter case, the European price guarantee no longer holds. In addition, a budget impact is also sometimes performed. Indeed, among drugs subject to economic evaluation, only those for which the estimated sales revenue of the manufacturer in the 2nd year of commercialization are above fifty million euro have the obligation to provide a budget impact analysis to the CEESP, for the other, it is suggested but not required. If the pharmaceutical company does not claim an ASMR “moderate”, “important” or “major”, economic evaluation is not conducted and only the clinical evaluation by the CT is performed.

This article aims to study the French upgraded HTA process after the introduction of economic evaluation in 2013. Given that economic evaluation is mandatory only for drugs claimed as innovative by their manufacturers, the analysis is conducted on this subset of innovative drugs with 2 main objectives. The first objective is to investigate the factors associated with the SMR and the ASMR obtained by innovative drugs in France. Previous academic and institutional studies have highlighted several limitations of the SMR and ASMR rating processes linked to a lack of clarity, a low discriminating power, and an overlap of the criteria used in the assessment (Le Pen et al., 2003; Polton, 2015). Within this first objective, we then more specifically aim to study the extent to which the official criteria and dimensions on which the SMR and ASMR must be based actually explain the SMR and ASMR obtained by innovative drugs after the CT evaluation. The second objective of the article is to document the ICURs of innovative drugs which entered the French drug market between 2014 and 2020, as few studies have analyzed the influence of the economic evaluation on HTA outcomes in France given its recent introduction in the assessment process. Filling this gap is of particular interest because there is limited information on the ICURs commonly accepted in France. More specifically, this study provides results on the characteristics of the drugs—in terms of disease severity, size of the target population, and therapeutic innovation—that are associated with the ICURs claimed by pharmaceutical firms.

Within a growing literature on the revealed preferences of decision-makers for HTA criteria (Clement et al., 2009; Deticek, 2018; Ghijben et al., 2018; Skedgel et al., 2018), our study is the first to provide a retrospective analysis of the recommendations made by the French HTA body, including clinical and economic evidence assessments. By documenting the clinical criteria actually considered in the reimbursement and pricing of innovative drugs in France, our study also provides information that will be useful for the forthcoming harmonization process of drugs' clinical evaluations among European Union member states.

2. Data and methods

The analysis includes all drugs that applied for reimbursement between 2014 and 2020, with claimed ASMR from 'major' to 'moderate', apart from the six direct-acting antivirals (DAAs) against hepatitis C. The latter are excluded due to too many ICURs being presented for the different fibrosis statuses or genotypes (105 ICURs in 6 Economic Opinions on the 6 DAAs) which would lead to an over-representation of these drugs in the database and could bias the regression results. The specific case of DAAs should then be treated separately as was already done in a qualitative way for France in a previous study (Clément & Raimond, 2019). The drugs included are subjected to both clinical and economic evaluations by the CT and the CEESP as part of the regulatory HTA procedure. A total of 91 Economic Opinions, and their associated Clinical Opinions, are considered. Table 1-5 in Appendix 1 provides the list of all the Clinical and Economic Opinions studied, that are publicly available on the HAS website.

As some drugs applied for market authorizations for different indications during the study period, the 91 available Economic Opinions concern 68 different drugs. In the Economic Opinions, cost-effectiveness can be assessed for several sub-populations, leading to the calculation of several ICURs. These ICURs represent separate observations in the database. Then, the total number of observations in the database amounts to 146.

All variables used in the regression analyses are extracted from the Clinical and Economic Opinions. Table 1-6 in Appendix 2 provides a full description of the extracted data, their source and coding. The following development presents and justifies the independent variables used in the regression analyses.

For the regression analysis on the obtained SMR, the independent variables correspond to the five official SMR criteria. Based on the categories reported in the Clinical Opinions, the severity of the disease is dichotomized as 'life-threatening' or not. For the efficacy-adverse events balance of the drug, the seven categories reported in the Clinical Opinions are merged in three main categories: 'Not or poorly established, insufficient or low', 'Intermediate' and 'Important'. Given that few drugs have at least some public health impact (reported as 'likely', 'small' or 'moderate' in the Clinical Opinions), the public health impact is binary coded as 'yes' or 'no'. The coding of the drug function is based on the categories reported in the Clinical Opinions, i.e.,

‘Curative’, ‘Preventive’ and ‘Symptomatic’. The place of the drug in the therapeutic strategy is evaluated in our analysis by the existence of therapeutic alternatives which is reported as ‘yes’ or ‘no’ in the Clinical Opinions.

The latest activity report of the CT, in accordance with its doctrine, presents the three dimensions considered in the determination of the ASMR (HAS, 2020): the quality of the evidence and of the demonstration, the treatment effect size, and the medical need. The objective of the regression analysis on the ASMR is to find out whether these dimensions are significantly associated with the ASMR obtained by innovative drugs. All the variables chosen to embody these dimensions are extracted from the Clinical and Economic Opinions.

As the efficacy of almost all drugs is evaluated using comparative double blinded phase 3 RCTs, the quality of evidence and of the demonstration is operationalized through two variables: the primary endpoint reported in the efficacy study and the validation of the firm’s reported ICUR by the CEESP in the Economic Opinion. The primary endpoint is clearly mentioned as an indicator of the demonstration’s quality in the CT doctrine. The classification of the primary endpoints reported in the Clinical Opinions is made with a focus on the therapeutic area of oncology, given the high prevalence of cancer drugs in our sample (68 out of 146 observations) and the debate over the use of surrogate endpoints in cancer drugs’ clinical efficacy studies (Ciani et al., 2017; EUnetHTA, 2015; Haslam et al, 2019; Kemp & Prasad, 2017; Savina et al., 2018). The first two categories of the ‘primary endpoint’ variable allow to differentiate between final patient relevant and surrogate endpoints for cancer drugs while the third category gathers endpoints of drugs non-related to this therapeutic area. The three categories retained for the ‘primary endpoint’ variable are then: 1) overall survival in cancer drugs; 2) surrogate endpoints in cancer drugs; and 3) other primary endpoints. The Economic Opinion also documents the quality of the evidence and of the demonstration to the extent that the ICUR claimed by the firm may be invalidated if there is a major caveat regarding an aspect of the methodology used. Therefore, the ICUR validation by the CEESP is used as a proxy for the quality of the demonstration in the regression analysis of the ASMR. The second dimension, the treatment effect size, is defined in the CT doctrine as the magnitude of the effect of the drug relative to its comparator. The QALY gain reported in the Economic Opinion is used as a proxy for the treatment effect size in the regression analysis on the ASMR. Finally, the medical need is

operationalized in the ASMR regression through two variables: the severity of the disease and the existence of therapeutic alternatives.

For the regression analysis on the claimed ICUR, the independent variables include drugs and diseases' characteristics commonly used in the literature to explain HTA agencies' coverage and reimbursement decisions (Gandjour et al., 2020; Harris et al., 2016; Lancsar et al., 2020; Lopez-Bastida et al., 2019; Pauwels et al., 2015; Skedgel et al., 2015; Svensson et al., 2015): the function of the drug, the existence of therapeutic alternatives, the severity of disease, the pediatric use of the drug, and the size of the target population. To test whether reported ICURs are higher for drugs claimed as more innovative by pharmaceutical firms, the claimed ASMR is also used as an independent variable in this regression.

Table 1-7 in Appendix 2 provides full details regarding the matching between the official SMR criteria, the CT doctrine's ASMR dimensions and the variables used in the regression analyses.

The factors associated with the obtained SMR and ASMR are studied using ordered logit regressions which are appropriate for ordinate categorical variables with more than two categories. Given the wide variance in ICURs, quantile regressions are used to study the factors associated with the claimed ICURs. Quantile regressions, contrary to OLS regressions, allow to discriminate between the characteristics associated with the ICUR level along the ICUR distribution (first quartile, the median and third quartile in our analysis) and thus to lift the assumption that the regression coefficients are constant across the sample. Quantile regressions are especially useful in understanding outcomes that have non-linear relations with predictor variables or that are non-normally distributed, as it is the case for the ICURs in our sample. For all regression analyses, multicollinearity issues were investigated and acceptable VIF were found (<1.50). All regression analyses are performed using Stata 15®.

3. Results

3.1. Descriptive statistics

Table 1-1 provides the key summary statistics for the dependent and independent variables.

Variable name	Description	Modality	Mean	Frequency (%)	[CI 95%] ^a
Obtained SMR	Clinical benefit	Insufficient		14 (9.6%)	[5.74; 15.60]
		Mild		1 (0.7%)	[0.09; 5.77]
		Moderate		18 (12.3%)	[7.88; 18.78]
		Important		113 (77.4%)	[69.84; 83.51]
Obtained ASMR	Clinical added value (N= 132) ^b	No clinical improvement		30 (22.7%)	[16.32; 30.73]
		Minor		53 (40.2%)	[32.07; 48.80]
		Moderate		41 (31.1%)	[23.70; 39.53]
		Important		8 (6.1%)	[3.04; 11.72]
Claimed ASMR	Clinical added value claimed by the pharmaceutical company	Moderate		86 (58.9%)	[50.69; 66.65]
		Important		60 (41.1%)	[33.35; 49.31]
Claimed ICUR	ICUR level reported by the pharmaceutical firm (N= 123) ^b		287,821		[179,614; 396,028]
ICUR validation	ICUR validation by the economic committee (N=145) ^b	No		80 (55.2%)	[46.94; 63.13]
		Yes		65 (44.8%)	[36.87; 53.06]
Severity	Severity of the treated disease	Not life threatening		39 (26.7%)	[20.12; 34.53]
		Life threatening		107 (73.3%)	[65.47; 79.88]
Efficacy – adverse events	Efficacy-adverse events balance	Not or poorly established, Insufficient or Low		15 (10.3%)	[6.26; 16.40]
		Intermediate		24 (16.4%)	[11.23; 23.42]
		Important		107 (73.3%)	[65.47; 79.88]
Drug function	Function of the drug	Curative		87 (59.6%)	[51.38; 67.30]
		Preventive		32 (21.9%)	[15.90; 29.42]
		Symptomatic		27 (18.5%)	[12.96; 25.69]
Public health impact	Public health impact	No		111 (76.0%)	[68.37; 82.31]
		Yes		35 (24.0%)	[17.69; 31.63]
Alternatives	Existence of therapeutic alternatives	No		30 (20.5%)	[14.71; 27.94]
		Yes		116 (79.5%)	[72.06; 85.29]
Pediatric	Drug is used on under 18 years old patients	No		120 (82.2%)	[75.06; 87.62]
		Yes		26 (17.8%)	[12.38; 24.94]
Target population	Target population in thousands (N= 138) ^b	Mean (SD)	47.83		[20.01; 75.66]
Primary endpoint		Overall survival for cancer drugs		25 (17.1%)	[11.80; 24.18]

	Primary endpoint used in the clinical efficacy study	Surrogate endpoints for cancer drugs ^c Primary endpoints for non-cancer drugs ^d		43 (29.5%) 78 (53.4%)	[22.58; 37.41] [45.25; 61.42]
QALY gains	QALY gains reported by the pharmaceutical firm (N= 114) ^b	Mean (SD)	1.40		[0.8089;1.9994]

^a CI=confidence interval. For categorical variables the confidence interval corresponds to the proportions in percentages.

^b N=146 except when otherwise indicated. The ASMR is missing for 14 observations for which an insufficient SMR was given by the CT. The target population is only available in 138 Clinical Opinions. ICUR levels, ICUR validation and QALY gains are not publicly available in all the Economic Opinions.

^c progression-free survival (PFS), disease-free survival (DFS), metastasis-free survival (MFS), overall response rate (ORR) and percentage of patients with overall remission.

^d includes, for example, the variation in the walking perimeter on the 6-minute walk test; the variation in the number of migraine days per month; overall response rate (ORR); number of hereditary angioedema crisis confirmed by the investigators in monthly rates; variation of the Multi-Luminance Mobility Test score...

Table 1-1: Descriptive statistics

The obtained SMR is 'important' for 77.4% of the sample. Although 41.1% of the observations originally claimed an 'important' ASMR, only 5.5% obtained this level. The obtained ASMR is 'no therapeutic progress' and 'minor' for 20.5% and 36.3% of the observations, respectively. Almost three-quarter of the observations are drugs targeting life-threatening diseases. According to the classification of the CT, 24% of the observations correspond to drugs with a public health impact. Drugs with therapeutic alternatives constitute 79.5% of the observations and only 17.8% of the observations are drugs with a pediatric indication. The target population ranges from 30 to 1,011,505 patients with a mean of 47,830 patients. For the 68 cancer drugs, the primary endpoint is overall survival in 25 cases only, while a surrogate endpoint is used in 43 cases.

Claimed ICURs range from 622€/QALY to 4,345,650€/QALY with a mean of 287,821€/QALY. Regarding the distribution of the ICURs, the first quartile is at 51,447€/QALY, the median is at 112,328€/QALY and the third quartile is at 239,145€/QALY. Less than half (44.5%) of the ICURs claimed by the pharmaceutical firms were validated by the CEESP. The median ICUR is significantly higher for drugs targeting rare diseases compared to other therapeutic areas ($Z = -6.160$, $p < .001$), for drugs without alternative ($Z = 1.719$, $p = 0.0856$) and for drugs targeting life-threatening diseases ($Z = -3.463$, $p = 0.0005$). The mean ICUR is also significantly higher for drugs with a pediatric indication ($t = -4.3836$, $p < 0.0001$). On the contrary, no significant

differences are found in median ($Z = -0.390$, $p = 0.6969$) or mean ($t = 0.5225$, $p = 0.6023$) ICURs for drugs whose ICURs were validated or not.

3.2. Regression analyses on the obtained SMR and ASMR and on the claimed ICUR

Table 1-2 presents the regression analysis results for the obtained SMR.

		Obtained SMR
		Odd ratio (90% confidence interval)
Severity (ref: not life threatening)	Life threatening	0.9119 (0.2858, 2.9097)
Efficacy – adverse events balance (ref: not established, insufficient or low)	Intermediate	51.6011** (3.9748, 669.8938)
	Important	8330.595*** (130.9538, 529948.8)
Drug function (ref: curative)	Preventive	0.0469*** (0.0087, 0.2519)
	Symptomatic	0.0464*** (0.0133, 0.1623)
Public health impact (ref: no)	Yes	3.0718 (0.9984, 9.4511)
Alternatives (ref: no)	Yes	1.0069 (0.3036, 3.3396)
Observations		146
Pseudo R2		0.67

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1-2: Results of regression analysis for the factors associated with the obtained SMR

The severity of the disease is not significantly associated with the SMR. Drugs whose efficacy-adverse events balance is classified as ‘intermediate’ or ‘important’ tend to obtain higher SMR. On the contrary, drugs used for preventive or symptomatic purposes tend to obtain a lower SMR compared to curative drugs. Neither the public health impact nor the availability of alternatives is significantly associated with the obtained SMR. Table 1-8 in Appendix 3 provides supplementary analyses on the relative contribution of each criterion to the SMR classification. These analyses show that two criteria – the efficacy-adverse events balance and the drug function – have a strong discriminatory power whereas the three other criteria do not contribute to the SMR classification.

Table 1-3 presents the regression analysis results for the factors associated with the obtained ASMR.

		Obtained ASMR
		Odd ratio (90% confidence interval)
Primary endpoint (ref: overall survival for cancer drugs)	Surrogate endpoints for cancer drugs	1.9582 (0.7175, 5.3444)
	Primary endpoints for non-cancer drugs	0.4535 (0.1140, 1.8034)
Alternatives (ref: no)	Yes	1.0575 (0.3192, 3.5039)
Severity (ref: not life threatening)	Life threatening	11.1442*** (3.0124, 41.2271)
QALY gains		1.6257*** (1.2697, 2.0815)
ICUR validation (ref: no)	Yes	2.5793** (1.2170, 5.4667)
Observations		104 ^a
Pseudo R2		0.25

* p<0.10, ** p<0.05, *** p<0.01

^a the number of observations is 104 due to missing values for the QALY gains and the ASMR rating

Table 1-3: Results of regression analysis for the factors associated with the obtained ASMR

The QALY gain of the drug is positively associated with its ASMR. On the contrary, the existence of therapeutic alternatives is not significantly associated with the ASMR. Drugs targeting life-threatening diseases tend to obtain a higher ASMR. The type of primary efficacy endpoint used is not associated with the ASMR. Lastly, results show a positive and significant association between the validation of the ICUR by the CEESP and the ASMR.

Table 1-4 presents the regression analysis results for the claimed ICUR. ICURs at the median and at the third quartile of the ICUR distribution are significantly lower, by 108,821€/QALY and 429,189€/QALY respectively, for drugs with therapeutic alternatives compared to drugs without alternative. At the third quartile of the ICUR distribution, the ICUR is significantly higher for drugs with a pediatric indication. Moreover, the size of the target population is negatively and significantly associated with the value of the ICUR at the first quartile of the ICUR distribution only. More specifically, a 1,000 increase in the size of the target population is associated with a 94.83€/QALY decrease in the value of the ICUR at the first quartile. The claimed ASMR is positively associated with the value of the ICUR at the first quartile of the ICUR distribution. At this point of the distribution, a €37,409 increase in the value of the ICUR is observed when

moving from a 'moderate' to an 'important' claimed ASMR. The value of the ICUR at the median of the distribution is significantly higher (by 85,293€/QALY) for drugs targeting life-threatening diseases.

		Claimed ICUR		
		First quartile	Median	Third quartile
Alternatives (ref: no)	Yes	-14,069.4 (-0.78)	-108,821.1** (-2.46)	-429,189.5* (-1.85)
Pediatric (ref: no)	Yes	-1329.1 (-0.07)	47,878.7 (0.96)	1,361,801.2*** (5.24)
Target population (thousands)		-94.83** (-2.17)	-96.88 (-0.90)	-235.4 (-0.42)
Claimed ASMR (ref: moderate)	Important	37,409.6** (2.60)	-6,192.4 (-0.17)	-74,478.5 (-0.40)
Severity (ref: not life threatening)	Life threatening	18,828.1 (1.11)	85,239.2** (2.04)	194,986.2 (0.89)
Constant		54,767.6*** (2.80)	150,141.3*** (3.12)	500,872.5** (1.99)
Observations		115 ^a	115 ^a	115 ^a
Pseudo R2		0.06	0.04	0.14

t-statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01

^a the number of observations is 115 due to missing values for the ICUR level and the size of the target population

Table 1-4: Results of quantile regression analyses for the factors associated with claimed ICUR

4. Discussion

This retrospective analysis of the 2014-2020 HAS recommendations on innovative drugs provides three main results that are worth discussing in terms of the French HTA decision making process.

First, the study contributes to the analysis of the consistency and the transparency of the SMR and ASMR which are the two main composite indicators used in the clinical assessment. The issue at stake is the extent to which the SMR and ASMR obtained by innovative drugs actually reflect the official criteria included in these indicators.

Regarding the SMR, significant associations are found between the SMR obtained and only two of its official criteria, the efficacy-adverse events balance of the drug and the drug function.

Moreover, the results underline the contrasting discriminatory power of the SMR criteria: the efficacy-adverse events balance has by far the highest explanatory power, whereas the severity and the public health impact criteria have none. These results are in line with the conclusions of the Polton's report (2014) which shows, based on all drugs assessed by the CT in 2014, that the SMR rating is mainly driven by the efficacy-adverse events criterion. Moreover, unlike Le Pen C, Priol G, Lilliu H. (2003) who found that disease severity was an important criterion in the determination of the SMR in the early 2000's, Polton, D (2014) found that this criterion was playing a secondary role in 2014. Our results seem to confirm the conclusion of the Polton's report as we also find that the disease severity criterion provides no contribution to the SMR obtained by innovative drugs in recent years. However, beyond differences in results, a common point between our study and those previously conducted by Le Pen C, Priol G, Lilliu H. (2003) and Polton, D (2014) is that the public health impact criterion always contributes little to the SMR rating obtained by new drugs.

Provided that they are confirmed by analyses conducted on a larger sample of drugs recently evaluated by the CT, our results on the SMR drivers seem to indicate the need for a reevaluation of the criteria considered to evaluate the clinical benefit of new drugs in France. Indeed, the discrepancies found between guidelines and practices impair the transparency and the predictability of the French HTA procedure whereas the enforcement of official criteria are key to legitimate a prioritizing procedure (Daniels & Sabin, 1997).

The case of the public health impact criterion, which was found to have a low discriminating power in all studies conducted on reimbursement decisions of new drugs in France, calls for a specific comment on the consistency of the SMR rating. The public health impact criterion is based on elements that are potentially redundant with the other official criteria of the SMR. Indeed, its classification is officially based on the prevalence of the disease, the severity of the disease, and the existence of a relevant comparator. However, these last two factors are already directly considered as full-fledged criteria in the SMR rating process. It follows that a coherent treatment of the public health impact in the French HTA process would certainly lead to removing this criterion from the SMR and treating it as a separate criterion in the clinical evaluation.

As far as the disease severity criterion is concerned, our results echo the lack of transparency regarding the relative weight of this criterion in drug reimbursement decisions reported in the

literature even in countries where it explicitly plays a role in reimbursement assessments (Franken et al., 2015). Indeed, despite the official inclusion of disease severity as a criterion in the SMR rating in France, our results show that this criterion had no discriminating power in reimbursement decisions of innovative drugs in recent years. On the contrary, the disease severity criterion is significantly associated with the obtained ASMR. Thus, the disease severity appears as a main driving factor of the ASMR classification for innovative drugs in France, in line with HTA in other European (Franken et al., 2013; Svensson et al., 2015) and non-European countries (Harris et al., 2016; Harris et al., 2008). The change in the pharmaceutical environment, with the entry of a much higher number of new drugs on the French market as compared to the early 2000's, could explain that the weights of the SMR criteria have evolved over time, Polton's report argues. Nevertheless, beyond weighting considerations within the SMR indicator, our results also question the articulation and the complementarity between the SMR and the ASMR, especially regarding the disease severity criterion. Further empirical work is needed to document this important issue for the HTA process in France as the latter would certainly gain in consistency by explicitly fixing whether the disease severity criterion intervenes at the level of admission to reimbursement or at the level of price negotiation.

Regarding the ASMR, the results also show that no ASMR penalty is observed for cancer drugs using surrogates, instead of overall survival, as primary endpoints to measure clinical efficacy although relying on surrogates is known to increase the uncertainty around the effect size in terms of final outcomes relevant to patients (Ciani & al., 2017; Kemp & Prasad, 2017). In the perspective of a European harmonization of clinical assessments, the debate on the use of surrogates will have to be settled and it is interesting to know, beyond the positions, the practices of each country to converge to a common evaluation framework.

Second, the paper documents how Economic Opinions, which were introduced into the French HTA process in 2013, are articulated with Clinical Opinions. Clinical and economic evaluations are indeed conducted independently in the assessment process of the HAS and the question arises as to whether they converge (Akehurst et al., 2017). The results support the idea of a convergence in two ways. First, as previously documented for cancer drugs (Drummond et al., 2014), the results show a consistency between the ordinal rating of the ASMR in the Clinical Opinions and the QALY gains in the Economic Opinions: the higher the QALY gain, the higher the ASMR obtained. Second, this dual assessment of the added value of innovative drugs does

not lead to contradictory results since a positive association is found between the validation of the ICUR in the Economic Opinion and the ASMR obtained in the Clinical Opinion.

Third, the study contributes to fill the information gap on the ICURs of innovative drugs in France. The analysis provides a benchmark for acceptable levels of ICUR in the French setting but also shows how pharmaceutical firms are adapting to the regulations. Within all the innovative drugs entering the French drug market between 2014 and 2020, about a quarter of claimed ICURs are below the hypothetical threshold of 50,000€/QALY (Cartier-Bechu et al., 2014) and two thirds (79/123) are below the estimate for the value of statistical QALY (147,093€) recently calculated using the official French value of statistical life (Téhard et al., 2020).

Finally, the quantile regression analysis allows to investigate how the factors associated with the ICURs claimed by the firms differ along the ICUR distribution: moving from the bottom to the top quartile, individual characteristic considerations related to the disease or to the population substitute themselves to health population level considerations. At the bottom of the ICUR distribution, on the one hand, the innovation premium associated with moving from a 'moderate' to an 'important' claimed ASMR appears significant. A negative association between the size of the target population and the ICUR level is also found. The anticipation of price/volume agreements, sometimes implemented by the CEPS in the price negotiations with pharmaceutical firms, could be an element of explanation for this negative association (CEPS, 2020). At the top of the ICUR distribution, on the other hand, the drug value claimed by pharmaceutical firms embraces considerations which go beyond the level of innovation and includes specific characteristics related to the target population and the medical need. A higher collective investment is indeed asked by pharmaceutical firms in France for pediatric drugs and for drugs without alternative as shown by the positive associations we find between these drug characteristics and the value of the ICUR at the top of the ICUR distribution. For the former, the results are consistent with observed derogatory financing schemes and ICUR thresholds used for pediatric drugs in some countries. In the UK, NICE for example considers pediatric drugs as a special circumstance when making judgments about cost-effectiveness (Rawlins et al., 2010). Moreover, there is also empirical evidence that the general population gives more weight and expresses a higher willingness to pay for QALY gains among children (Lancsar et al., 2020; Skedgel et al., 2015). A qualitative study on the reimbursement criteria carried out in four

European countries, including France, showed that decision makers themselves tend to be more lenient on reimbursement decisions when the drugs target children or younger people (Franken et al., 2015). As they tend to claim higher ICURs for pediatric drugs, our results seem to indicate that pharmaceutical firms anticipate the collective support from the decision makers and the public on this prioritization criteria. Regarding drugs with no therapeutic alternative, empirical studies have also shown that the public (Green & Gerard, 2009; Lopez-Bastida et al., 2019; Sussex et al., 2013) and decision makers (Pauwels et al. 2015) give priority for the funding of treatment without alternative.

Two limitations of the study should be acknowledged. First, the interpretation of the results and the insights they provide on the French HTA procedure are conditioned by the sample used, which only includes drugs with claimed ASMR from ‘major’ to ‘moderate’ for which economic evaluation is mandatory. Second, it should be emphasized that ICURs used in the regression analyses are those claimed by pharmaceutical firms at the time they apply for reimbursement and then integrate the price of drugs before the negotiation with the CEPS. Studying the factors associated with the actual social willingness to pay for health gains in France would require recalculating the ICURs provided by the firms using negotiated prices, which unlike facial prices are not public, or to work with a different metric such as the cost per patient as was recently done in a study on the German HTA process (Gandjour et al., 2020). Despite this limit, the analysis of the ICURs associated with the drugs recently accepted for reimbursement in France provides useful quantitative benchmarks to inform priority setting.

5. Conclusion

Based on a retrospective analysis of the HAS recommendations for innovative drugs from 2014 to 2020, this study identifies the criteria that are actually considered in the clinical assessment of drugs entering the French market. Discrepancies are found between guidelines and practices which impair the transparency and the predictability of the French HTA procedure. Our results also point to the consistency between the economic and clinical assessments of the added value of innovative drugs. The analysis provides a benchmark for acceptable levels of ICUR in the French setting.

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Appendix

Appendix 1: List of Economic and Clinical Opinions studied

Name of the Drug	Date Economic Opinion	Link Economic Opinion	Date Clinical Opinion	Link Clinical Opinion	Indication of the marketing authorization as reported in the Clinical Opinion (<i>in French</i>)
Adempas	10/14/2014	https://www.has-sante.fr/upload/docs/application/pdf/2015-02/adempas_14102014_avis_efficience.pdf	07/23/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13594_ADEMPAS_PIC_INS_avis2_CT13594.pdf	Traitement de l'hypertension pulmonaire thromboembolique chronique en classe fonctionnelle OMS II ou III, inopérable ou persistante/récurrente après traitement chirurgical
Aimovig	02/12/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-05/aimovig_12022019_avis_efficience_2019-05-10_13-50-54_656.pdf	02/27/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17223_AIMOVIG_PIC_INS_Avis3_CT17223.pdf	Prophylaxie de la migraine chez l'adulte ayant au moins 4 jours de migraine par mois.
Alecensa	07/10/2018	https://www.has-sante.fr/upload/docs/application/pdf/2019-03/alecensa_11102018_avis_efficience.pdf	05/30/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16771_ALECENSA_1ere%20Ligne_Avis%20CT_16771.pdf	En monothérapie dans le traitement de 1e ligne des adultes atteints d'un cancer bronchique non à petites cellules (CBNPC) métastatique avancé avec un réarrangement ALK
Avastin	10/11/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-03/avastin_11102016_avis_efficience.pdf	07/06/2016	https://www.has-sante.fr/upload/docs/application/pdf/2016-12/avastin_col_uterus_pic_ei_avispostaud_ct1_5038.pdf	Chez les adultes atteintes d'un carcinome du col de l'utérus persistant, en rechute ou métastatique, en association au paclitaxel et au cisplatine (ou en association au paclitaxel et au topotécan chez celles ne pouvant pas recevoir de traitement à base de sels de platine).
Botox	11/25/2014	https://www.has-sante.fr/upload/docs/application/pdf/2016-09/botox_25112014_avis_efficience.pdf	11/19/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13729_BOTOX_PIC_CT13729_Avis%202.pdf	Chez l'adulte dans le traitement de l'hyperactivité vésicale idiopathique associée à des symptômes incluant trois épisodes d'incontinence urinaire avec urgenturie pendant 3 jours, un nombre de mictions ≥ 8 par jour et ne répondant pas de manière adéquate aux anticholinergiques (après 3 mois de traitement) ou intolérants au traitement anticholinergique et à une kinésithérapie bien conduite
Cabometyx	07/11/2017	https://www.has-sante.fr/upload/docs/application/pdf/2019-05/cabometyx_11072017_avis_efficience.pdf	01/11/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15738_CABOMETYX_PIC_INS_AvisPostObs_CT1_5738.pdf	Traitement des adultes atteints d'un carcinome rénal avancé après une thérapie ciblée des récepteurs du facteur de croissance de l'endothélium vasculaire (VEGF)
Cosentyx	09/15/2015	https://www.has-sante.fr/upload/docs/application/pdf/2017-03/cosentyx_-_avis_defficience_m.pdf	10/05/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14295_COSENTYX_PIC_INS_Avis3_CT14295.pdf	Traitement du psoriasis en plaques modéré à sévère chez l'adulte qui nécessite un traitement systémique
Cotellic	06/14/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/cotellic_14062016_avis_efficience.pdf	03/16/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14929_COTELLIC_PIC_INS_Avis2_CT14929.pdf	En association au vemurafenib, dans le traitement des adultes atteints d'un mélanome non résecable ou métastatique porteur d'une mutation BRAF V600

Darzalex	12/12/2017	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/darzalex_12122017_avis_efficience.pdf	02/21/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16172_DARZALEX_en_association_PIC_INS_Avis3_CT16172.pdf	En association au lénalidomide et à la dexaméthasone, ou au bortézomib et à la dexaméthasone pour le traitement des adultes atteints d'un myélome multiple ayant reçu au moins un traitement antérieur
Defitelio	02/18/2014	https://www.has-sante.fr/upload/docs/application/pdf/2016-02/defitelio_18022014_avis_efficience.pdf	07/09/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13383_DEFITELIO_PIC_INS_Avis3_CT13383.pdf	Traitement de la maladie veino-occlusive (MVO) hépatique sévère, également appelée syndrome obstructif sinusoidal (SOS) survenant après transplantation de cellules souches hématopoïétiques (TCSH)
Dupixent	05/22/2018	https://www.has-sante.fr/upload/docs/application/pdf/2020-02/dupixent_22052018_avis_efficience_2020-02-12_11-37-56_458.pdf	07/11/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16605_DUPIXENT_PIC_INS_avis3_CT16605.pdf	Traitement de la dermatite atopique (DA) modérée à sévère de l'adulte qui nécessite un traitement systémique
Entresto	04/12/2016	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/entresto_12042016_avis_efficience.pdf	05/11/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14835_ENTRESTO_PIC_INS_Avis3_CT14835.pdf	Chez les patients adultes dans le traitement de l'insuffisance cardiaque chronique symptomatique à fraction d'éjection réduite
Entyvio	11/25/2014	https://www.has-sante.fr/upload/docs/application/pdf/2016-09/entyvio_25112014_avis_efficience.pdf	01/07/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13736_ENTYVIO_PIC_INS_Avis3_CT13736.pdf	Traitement de la rectocolite hémorragique (RCH) et de la maladie de Crohn (MC) active modérée à sévère chez les patients adultes présentant une réponse insuffisante ou une perte de réponse ou une intolérance à un traitement conventionnel ou par anti TNF
Erleada	09/17/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-12/erleada_17092019_avis_efficience.pdf	06/12/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17640_ERLEADA_PIC_INS_Avis2_CT17640.pdf	Traitement des adultes atteints d'un cancer de la prostate résistant à la castration non métastatique avec un risque élevé de développer une maladie métastatique (défini par un temps de doublement de PSA \leq 10 mois)
Esbriet	02/03/2015	https://www.has-sante.fr/upload/docs/application/pdf/2017-03/esbriet_20150203_avis_efficience.pdf	02/18/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13850_ESBRIET_PIC_REEV_Avis3_CT13850.pdf	Traitement de la fibrose pulmonaire idiopathique légère à modérée
Fluenz tetra	06/09/2015	https://www.has-sante.fr/upload/docs/application/pdf/2017-03/fluenz_tetra_20150609_avis_efficience.pdf	04/19/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13920_FLUENZ_TETRA_PIC_INS_Avis3_CT13920.pdf	Prévention de la grippe chez les enfants et les adolescents âgés de 24 mois à moins de 18 ans
Gardasil 9	09/12/2017	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/gardasil9_12092017_avis_efficience.pdf	09/13/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15867_GARDASIL_9_PIC_INS_Avis3_CT15867.pdf	Immunisation active contre les maladies liées à certains papillomavirus humains (HPV) : verrues génitales et lésions précancéreuses et cancéreuses du col de l'utérus, de la vulve, du vagin et de l'anus
Gazyvaro	05/16/2017	https://www.has-sante.fr/upload/docs/application/pdf/2019-04/gazyvaro_lf_16052017_avis_efficience.pdf	03/08/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15477_GAZYVARO_PIC_EI_AvisPostAud_CT15477.pdf	Chez les patients ayant un lymphome folliculaire (LF), en cas de non-réponse ou de progression, pendant ou dans les 6 mois suivant un traitement incluant du rituximab

Gazyvaro	02/13/2018	https://www.has-sante.fr/upload/docs/application/pdf/2019-04/gazyvaro_03022015_avis_efficiency.pdf	02/18/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13872_GAZYVARO_PIC_INS_Avis2_CT13872.pdf	En association au chlorambucil pour le traitement des patients adultes atteints de leucémie lymphoïde chronique (LLC) non précédemment traités et présentant des comorbidités les rendant inéligibles à un traitement à base de fludarabine à pleine dose
Genvoya	04/12/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/genvoya_12042016_avis_efficiency.pdf	03/02/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14810_GENVOYA_PIC_INS_Avis2_CT14810.pdf	Traitement de l'infection par le virus de l'immunodéficience humaine de type 1 (VIH-1) chez les adultes et des adolescents (âgés de 12 ans et plus, pesant au moins 35 kg) infectés par le VIH-1 dépourvu de toute mutation connue pour être associée à une résistance à la classe des inhibiteurs de l'intégrase, à l'emtricitabine ou au ténofovir
Halaven	07/22/2015	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/halaven_21072015_avis_efficiency.pdf	09/23/2015	https://www.has-sante.fr/upload/docs/evamed/CT-14274_HALAVEN_PIC_EI_REEV_Avis3_CT14274_&14276.pdf	Traitement du cancer du sein localement avancé ou métastatique, chez les patients dont la maladie a progressé après au moins un protocole de chimiothérapie pour le traitement du stade avancé. Le traitement antérieur, en situation adjuvante ou métastatique, doit avoir comporté une anthracycline et un taxane, sauf chez les patients ne pouvant pas recevoir ces traitements.
Halaven	03/14/2017	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/halaven_14032017_avis_efficiency.pdf	05/03/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15616_HALAVEN_PIC_EI_Avis3_CT15616.pdf	Traitement des patients ayant un liposarcome non résecable ayant reçu un protocole de chimiothérapie antérieur comportant une anthracycline (sauf chez les patients ne pouvant pas recevoir ce traitement) pour le traitement d'une maladie avancée ou métastatique
Hemlibra	10/09/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-12/hemlibra_13122018_avis_efficiency.pdf	07/11/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16921_HEMLIBRA_PIC_Ins_Avis2_CT16921.pdf	En prophylaxie pour prévenir les épisodes hémorragiques chez les patients atteints d'hémophilie A ayant développé un inhibiteur anti-facteur VIII
Ibrance	07/11/2017	https://www.has-sante.fr/upload/docs/application/pdf/2018-05/ibrance_11072017_avis_efficiency.pdf	05/03/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15873_IBRANCE_PIC_INS_Avis3_CT15873.pdf	Traitement du cancer du sein localement avancé ou métastatique, RH+ et HER2 négatif : - en association avec un inhibiteur de l'aromatase ; - en association avec le fulvestrant chez les femmes ayant été traitées antérieurement par hormonothérapie.
Ilaris	12/12/2017	https://www.has-sante.fr/upload/docs/application/pdf/2020-02/ilaris_12122017_avis_efficiency_2020-02-24_12-38-1_104.pdf	11/09/2017	https://www.has-sante.fr/upload/docs/evamed/CT-16220_ILARIS_PIC_EI_Avis3_CT16220.pdf	Traitement de trois formes de fièvres récurrentes héréditaires chez les adultes, adolescents et enfants de 2 ans et plus : - le syndrome périodique associé au récepteur du TNF (TRAPS), - le syndrome de l'hyperimmunoglobulinémie D (HIDS)/ le

					déficit en mévalonate kinase (MKD) et, - la fièvre méditerranéenne familiale (FMF)
Imbruvica	04/07/2015	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/imbruvica_dans_la_lcm_07042015_avis_d_efficiency.pdf	06/17/2015	https://www.has-sante.fr/upload/docs/evamed/CT-14012_IMBRUVICA_PIC_INS_Avis3_CT14012.pdf	Traitement des adultes atteints d'un lymphome à cellules du manteau (LCM) en rechute ou réfractaire
Imbruvica	06/14/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/imbruvica_dans_la_llc_07042015_avis_defefficiency.pdf	06/17/2015	https://www.has-sante.fr/upload/docs/evamed/CT-14012_IMBRUVICA_PIC_INS_Avis3_CT14012.pdf	Traitement des adultes atteints d'une leucémie lymphoïde chronique (LLC) ayant reçu au moins un traitement antérieur, ou en première ligne en cas de délétion 17p ou de mutation TP53 chez les patients pour lesquels une immunochimiothérapie est inadaptée
Imfinzi	05/14/2019	https://www.has-sante.fr/jcms/p_3102739/fr/imfinzi-14052019-avis-efficience	02/06/2019	https://www.has-sante.fr/jcms/c_2908477/fr/imfinzi-06022019-avis-ct17432	Avec une restriction d'utilisation selon l'expression PD-L1 (≥ 1% des cellules tumorales) dans le traitement des adultes atteints d'un CBNPC localement avancé, non opérable, et dont la maladie n'a pas progressé après une chimioradiothérapie à base de platine
Jakavi	10/15/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-12/jakavi_15102019_avis_efficiency.pdf	07/06/2016	https://www.has-sante.fr/jcms/c_2727637/fr/jakavi-06072016-avis-ct14600	En monothérapie dans le traitement de la splénomégalie ou des symptômes liés à la myélofibrose primitive ou secondaire à une polyglobulie de Vaquez ou une thrombocytémie essentielle
Jardiance	09/13/2016	https://www.has-sante.fr/jcms/c_2967246/fr/jardiance-13092016-avis-efficience	10/19/2016	https://www.has-sante.fr/jcms/c_2722413/fr/jardiance-19102016-avis-ct15171	Traitement du diabète de type 2 en monothérapie et en association à d'autres médicaments hypoglycémisants, y compris l'insuline, lorsque ces derniers, combinés à un régime alimentaire et à l'exercice physique, ne permettent pas d'obtenir un contrôle glycémique adéquat
Kadcyla	03/11/2014	https://www.has-sante.fr/upload/docs/application/pdf/2014-12/kadcyla_11032014_avis_efficiency.pdf	03/19/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13453_KADCYLA_PIC_INS_Avis2_CT13453.pdf	En monothérapie, chez les adultes atteints d'un cancer du sein HER 2 positif métastatique ou localement avancé non résecable, ayant reçu au préalable du trastuzumab et un taxane, séparément ou en association. Les patients doivent avoir reçu un traitement antérieur pour la maladie localement avancée ou métastatique ou avoir présenté une progression de la maladie pendant un traitement adjuvant ou dans les six mois suivant sa fin

Keytruda	01/17/2017	https://www.has-sante.fr/upload/docs/application/pdf/2018-11/keytruda_cbnpc_ltt2_17012017_avis_efficience.pdf	05/03/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15634_KEYTRUDA_PIC_EI_poumon_Avis3_modifiele03052017_CT15634.pdf	Traitement des adultes atteints d'un cancer bronchique non à petites cellules (CBNPC) localement avancé ou métastatique dont les tumeurs expriment PD-L1 et ayant reçu au moins une chimiothérapie antérieure. Les patients présentant des mutations tumorales d'egfr ou d'alk doivent également avoir reçu un traitement autorisé pour ces mutations avant de recevoir KEYTRUDA
Keytruda	05/16/2017	https://www.has-sante.fr/upload/docs/application/pdf/2018-11/keytruda_cbnpc_ltt1_16052017_avis_efficience.pdf	05/17/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15941_KEYTRUDA_PIC_EI_poumon_1ere_ligne_Avis2_CT15941.pdf	Traitement de 1e ligne des adultes atteints d'un cancer bronchique non à petites cellules (CBNPC) métastatique dont les tumeurs expriment PDL1 au seuil $\geq 50\%$, sans mutation tumorale d'egfr ou d'alk
Keytruda	07/10/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-10/keytruda_10072018_avis_efficience.pdf	02/21/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16530_KEYTRUDA_carcinome_urothelial_PIC_EI_Avis3_CT16530.pdf	Traitement des adultes ayant un cancer urothélial localement avancé ou métastatique ayant reçu une chimiothérapie antérieure à base de sels de platine
Keytruda	02/12/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/keytruda_12022019_avis_efficience.pdf	02/20/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17280_KEYTRUDA_PIC_EI_poumon_avec_pemetrexed_Avis3_CT17280.pdf	En association à une chimiothérapie pemetrexed et sel de platine, dans le traitement de 1ère ligne des adultes atteints de CBNPC métastatique non-épidermoïde dont les tumeurs ne présentent pas de mutations d'egfr ou d'alk
Keytruda	02/12/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/keytruda_12022019_avis_efficience.pdf	02/20/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17280_KEYTRUDA_PIC_EI_poumon_avec_pemetrexed_Avis3_CT17280.pdf	En association à une chimiothérapie pemetrexed et sel de platine, dans le traitement de 1ère ligne des adultes atteints de CBNPC métastatique non-épidermoïde dont les tumeurs ne présentent pas de mutations d'egfr ou d'alk
Keytruda	07/16/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17558_KEYTRUDA_m%C3%A9lanoAdjuv_PIC_EI_Avis2_CT17558.pdf	06/26/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17558_KEYTRUDA_m%C3%A9lanoAdjuv_PIC_EI_Avis2_CT17558.pdf	Traitement adjuvant des adultes atteints d'un mélanome de stade III avec atteinte ganglionnaire, ayant eu une résection complète
Keytruda	10/15/2019	https://www.has-sante.fr/upload/docs/application/pdf/2020-02/keytruda_15102019_avis_efficience_2020-02-28_13-58-43_28.pdf	10/09/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17673_KEYTRUDA_CBNPC_%C3%A9pidermo%C3%AFde_PIC_EI_Avis3_CT17673.pdf	En association au carboplatine et au paclitaxel ou au nab-paclitaxel dans le traitement de 1ère ligne des patients adultes atteints de cancer bronchique non à petites cellules (CBNPC) métastatique épidermoïde
Kisqali	05/22/2018	https://www.has-sante.fr/upload/docs/application/pdf/2020-02/kisqali_22052018_avis_efficience.pdf	01/31/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16471_KISQALI_PIC_INS_Avis2_CT16471.pdf	En association à un inhibiteur de l'aromatase dans le traitement initial à base d'hormonothérapie chez les femmes ménopausées ayant un cancer du sein avancé, avec récepteurs hormonaux positifs (RH+) et récepteurs du facteur de croissance épidermique humain 2 négatifs (HER2 -)
Kymriah	01/15/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-12/kymriah_ldgcb_pic_ins_avis3_ct17238.pdf	12/12/2018	https://www.has-sante.fr/upload/docs/application/pdf/2019-12/kymriah_ldgcb_pic_ins_avis3_ct17238.pdf	Traitement de 3 ^e ligne ou plus du lymphome diffus à grandes cellules B (LDGCB) réfractaire ou en rechute

		03/kymriah_lal_15012019_avis_efficiency.pdf			
Kymriah	01/15/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-03/kymriah_lal_15012019_avis_efficiency.pdf	12/12/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-12/kymriah_lal_pic_ins_avis3_ct17202.pdf	Traitement des enfants et jeunes adultes jusqu'à 25 ans atteints de LAL à cellules B réfractaire, en rechute après greffe ou après la deuxième rechute ou plus
Kyprolis	05/10/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/kyprolis_10052016_avis_efficiency.pdf	05/25/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14858_KYPROLIS_PIC_INS_AvisPostAud_CT14858.pdf	En association au lénalidomide et à la dexaméthasone dans le traitement du myélome multiple chez les adultes ayant reçu au moins un traitement antérieur
Lemtrada	09/15/2015	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/lemtrada_15092015_avis_efficiency.pdf	01/06/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14394_LEMTRADA_PIC_INS_Avis3_CT14394.pdf	Chez les adultes ayant une forme active de sclérose en plaques rémittente (SEP-RR), définie par les paramètres cliniques ou IRM des patients inclus dans les études de phase III, patients naïfs de traitement de fond ou pré-traités ayant eu au moins une poussée au cours de l'année précédant l'inclusion ou au moins deux dans les deux ans précédant l'inclusion
Lutathera	05/22/2018	https://www.has-sante.fr/upload/docs/application/pdf/2020-02/lutathera_22052018_avis_efficiency_2020-02-12_11-34-19_105.pdf	07/11/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16606_LUTATHERA_PIC_INS_Avis3_CT16606.pdf	Traitement des tumeurs neuroendocrines gastroentéropancréatiques (TNE-GEP) inopérables ou métastatiques, progressives, bien différenciées (G1 et G2) et exprimant des récepteurs de la somatostatine chez les adultes
Luxturna	05/14/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-09/luxturna_14052019_avis_efficiency.pdf	04/03/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17535_LUXTURNA_PIC_INS_Avis2_CT17535.pdf	Traitement des adultes et des enfants présentant une perte visuelle due à une dystrophie rétinienne héréditaire résultant de mutations bi-alléliques confirmées du gène RPE65 et possédant suffisamment de cellules rétinienne viables
Mekinist	03/22/2016	https://www.has-sante.fr/upload/docs/application/pdf/2017-01/mekinist_avis_efficiency.pdf	01/20/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14705_MEKINIST_PIC_INS_Avis3_CT14705.pdf	En association au dabrafenib, dans le traitement des adultes atteints d'un mélanome non résecable ou métastatique porteur d'une mutation BRAF V600
Ocaliva	09/12/2017	https://www.has-sante.fr/upload/docs/application/pdf/2018-12/ocaliva_12092017_avis_efficiency.pdf	06/07/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15943_OCALIVA_PIC_INS_Avis3_CT15943.pdf	Traitement de la cholangite biliaire primitive en association avec l'acide ursodésoxycholique (AUDC) chez les adultes insuffisamment répondeurs à l'audc, ou en monothérapie chez les adultes qui ne tolèrent pas l'audc
Ocrevus	10/09/2018	https://www.has-sante.fr/upload/docs/application/pdf/2019-01/ocrevus_sep_r_20122018_avis_efficiency.pdf	05/30/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16878_OCREVUS_PICINS_SEP-R_avis2_CT16878_def.pdf	Traitement des patients adultes atteints de formes actives de sclérose en plaques récurrente (SEP-R) définies par des paramètres cliniques ou d'imagerie
Ocrevus	10/09/2018	https://www.has-sante.fr/upload/docs/application/pdf/2019-01/ocrevus_sep_pp_20122018_avis_efficiency.pdf	07/11/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-07/ocrevus_pic_ins_avis3_ct16833.pdf	Traitement de la SEP-PP à un stade précoce en termes de durée de la maladie et de niveau du handicap associé à des

					données d'imagerie caractéristiques d'une activité inflammatoire
Octaplaslg	11/08/2016	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/octaplaslg_08112016_avis_efficience.pdf	07/20/2016	https://www.has-sante.fr/upload/docs/evamed/CT-15085_OCTAPLASLG_PIC_INS_Avis2_CT15085.pdf	<ul style="list-style-type: none"> - Déficiences complexes en facteurs de coagulation, tels que les coagulopathies dues à une insuffisance hépatique sévère ou à une transfusion massive. - Thérapie de substitution en cas de déficiences en facteurs de coagulation, lorsqu'un concentré de facteur de coagulation spécifique (cf. Facteurs V ou XI) n'est pas disponible, ou dans les situations d'urgence lorsqu'un diagnostic de laboratoire précis n'est pas possible. - Antagonisation rapide des effets des anticoagulants oraux (coumarine ou indanedione) lorsqu'un concentré de complexe prothrombinique n'est pas disponible ou lorsque l'administration de vitamine K est insuffisante en raison d'une altération de la fonction hépatique ou lors de situations d'urgence. - Hémorragies potentiellement dangereuses pendant un traitement fibrinolytique utilisant par ex. Des activateurs tissulaires du plasminogène chez des patients qui ne répondent pas aux mesures conventionnelles. - Procédures d'échange plasmatique thérapeutique, incluant celles pour purpura thrombocytopenique thrombotique (PTT)
Onpattro	06/11/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/onpattro_11062019_avis_efficience.pdf	03/20/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17388_ONPATTRO_PIC_INS_Avis3_CT17388.pdf	Traitement de l'amylose héréditaire à transthyréline (amylose hattr), chez les adultes atteints de polyneuropathie de stade 1 ou de stade 2
Opdivo	12/08/2015	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/opdivo_08122015_avis_efficience.pdf	02/03/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14655_OPDIVO_PIC_INS_Avis3_CT14655.pdf	Traitement des adultes atteints d'un cancer bronchique non-à-petites cellules (CBNPC) de type épidermoïde localement avancé ou métastatique après une chimiothérapie antérieure
Opdivo	10/11/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-06/opdivo_11102016_avis_efficience.pdf	01/11/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15261_OPDIVO_non_epidermoide_PIC_INS_Avis3_CT15261.pdf	Traitement des patients adultes atteints d'un cancer bronchique non à petites cellules de type non épidermoïde localement avancé ou métastatique après une chimiothérapie antérieure
Opdivo	11/08/2016	https://www.has-sante.fr/upload/docs/application/pdf/2017-03/dir1/opdivo_rein_avis_deficience_m.pdf	10/05/2016	https://www.has-sante.fr/upload/docs/evamed/CT-	Traitement des adultes atteints d'un carcinome à cellules rénales avancé après un traitement antérieur

				15277 OPDIVO cancer rein PIC INS Avis2 CT 15277.pdf	
Opdivo	07/11/2017	https://www.has-sante.fr/upload/docs/application/pdf/2020-01/opdivo_20171107_avis_efficience.pdf	01/31/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16242 OPDIVO ORL PIC EI %20Avis3 CT16242_2.pdf	Traitement des adultes atteints d'un cancer des voies aérodigestives supérieures au stade avancé, en progression pendant ou après une chimiothérapie à base de sels de platine
Opdivo	04/16/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/opdivo_16042019_avis_efficience_2019-07-29_15-55-38_800.pdf	12/05/2018	https://www.has-sante.fr/upload/docs/evamed/CT-17226 OPDIVO melanome adjuvant PIC EI Avis2 CT17226.pdf	Traitement adjuvant des adultes atteints d'un mélanome avec atteinte des ganglions lymphatiques ou une maladie métastatique, et ayant subi une résection complète
Opdivo	10/15/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-12/opdivo_15102019_avis_efficience.pdf	07/10/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17628 OPDIVO YERVOY PIC EI CCR Avis2 CT17633&CT17628.pdf	En association dans le traitement de 1ère ligne des adultes atteints d'un carcinome à cellules rénales avancé de pronostic intermédiaire/défavorable
Opsumit	06/24/2014	https://www.has-sante.fr/upload/docs/application/pdf/2017-05/dir9/opsumit_24062014_avis-efficience.pdf	09/17/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13528 OPSUMIT%20ins PIC avis%20%203 CT%2013479.pdf	En monothérapie ou en association, pour le traitement au long cours des patients adultes atteints d'hypertension artérielle pulmonaire (HTAP) en classe fonctionnelle OMS II ou III. Son efficacité a été démontrée chez des patients atteints d'htap idiopathique et héritable, associée aux connectivites et associée à des cardiopathies congénitales simples corrigées
Orkambi	05/10/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-02/orkambi_10052016_avis_efficience.pdf	06/22/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14927 ORKAMBI PIC INS Avis3 CT14927.pdf	Traitement de la mucoviscidose chez les patients âgés de 12 ans et plus homozygotes pour la mutation f508del du gène CFTR
Pradaxa	03/13/2018	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/pradaxa_13032018_avis_efficience.pdf	01/24/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-02/pradaxa_avis_ct15697.pdf	Prévention de l'accident vasculaire cérébral (AVC) et de l'embolie systémique (ES) chez les patients adultes atteints de fibrillation atriale non valvulaire (FANV) et présentant un ou plusieurs facteurs de risque tels qu'antécédent d'AVC ou d'accident ischémique transitoire (AIT), âge ≥ 75 ans, insuffisance cardiaque (classe NYHA ≥ 2), diabète, hypertension artérielle
Praluent	04/12/2016	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/praluent_12042016_avis_efficience.pdf	04/20/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14777 PRALUENT PIC INS Avis3 CT14777.pdf	Hypercholestérolémies primaires (hétérozygotes familiales et non familiales) ou les dyslipidémies mixtes
Repatha	12/08/2015	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/repatha_08122015_avis_efficience.pdf	12/16/2015	https://www.has-sante.fr/upload/docs/evamed/CT-14598 REPATHA PIC INS Avis3 CT14598.pdf	Hypercholestérolémies primaires (hétérozygotes familiales et non familiales) ou les dyslipidémies mixtes et les hypercholestérolémies familiales homozygotes en association aux statines (excepté en cas d'intolérance ou de contre-indication aux statines)

Rotarix	04/22/2014	https://www.has-sante.fr/upload/docs/application/pdf/2015-05/rotarix - avis_masque.pdf	04/01/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13564 ROTARIX PIC INS Avis3 CT13564.pdf	Prévention des gastro-entérites aiguës dues à une infection à rotavirus (GEA-RV) chez les nourrissons
Rotateq	09/16/2014	https://www.has-sante.fr/upload/docs/application/pdf/2015-05/rotateq - avis_masque.pdf	04/01/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13560 ROTATEQ PIC INS Avis3 CT13560.pdf	Prévention des gastro-entérites aiguës dues à une infection à rotavirus (GEA-RV) chez les nourrissons
Rydapt	04/10/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-10/rydapt-msa_10042018_avis_efficience.pdf	06/27/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16648 RYDAPT mastocytose INS Avis3 %20CT16648.pdf	Traitement des adultes présentant une mastocytose systémique agressive (MSA), une mastocytose systémique associée à une autre hémopathie maligne (MS-AHM), ou une leucémie à mastocytes (LM), en monothérapie
Rydapt	05/22/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-10/rydapt-lam_22052018_avis_efficience.pdf	06/13/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16582 RYDAPT LAM PIC INS Avis3%20 CT16582.pdf	Traitement des adultes présentant une leucémie aiguë myéloïde (LAM) nouvellement diagnostiquée avec mutation du gène FLT3, en association avec une chimiothérapie standard d'induction associant daunorubicine et cytarabine et une chimiothérapie de consolidation avec cytarabine à haute dose, suivie pour les patients en rémission complète, d'un traitement d'entretien par RYDAPT en monothérapie
Spinraza	12/12/2017	https://www.has-sante.fr/upload/docs/application/pdf/2018-03/spinraza_12122017_avis_efficience.pdf	01/31/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16362 SPINRAZA PIC INS Avis3 CT16362.pdf	Traitement étiologique de l'amyotrophie spinale 5q
Strensiq	05/10/2016	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/strensiq_10052016_avis_efficience.pdf	03/16/2016	https://www.has-sante.fr/upload/docs/evamed/CT-14864 STRENSIQ PIC INS Avis3 CT14864.pdf	Traitement enzymatique substitutif au long cours chez les patients atteints d'hypophosphatasie (HPP) dont les premiers signes sont apparus avant l'âge de 18 ans pour traiter les manifestations osseuses de la maladie
Tafinlar-Mekinist	05/14/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/tafinlar_mekinist_14052019_avis_efficience.pdf	02/06/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17406 MEKINIST TAFINLAR MelanomeAdjuv PIC EI Avis2 CT17406.pdf	En association dans le traitement adjuvant des adultes atteints d'un mélanome de stade III porteur d'une mutation BRAF V600, après résection complète
Tagrisso	09/12/2017	https://www.has-sante.fr/upload/docs/application/pdf/2019-03/tagrisso_12092017_avis_efficience.pdf	09/13/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15996 TAGRISSO PIC REEV Avis3 CT15996.pdf	Traitement des patients adultes atteints d'un cancer bronchique non à petites cellules (CBNPC) localement avancé ou métastatique, avec mutation T790M d'egfr
Takhzyro	10/15/2019	https://www.has-sante.fr/icms/p_3146283/fr/takhzyro-15102019-avis-efficience	06/05/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17546 TAKHZYRO PIC INS Avis3 CT17546.pdf	Prévention des crises récurrentes d'angio-oedème héréditaire (AOH) chez les patients âgés de 12 ans et plus
Tecentriq	10/09/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-12/tecentriq_13122018_avis_efficience.pdf	05/30/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16457 TECENTRIQ CBNPC PIC INS Avis2 CT16457.pdf	Traitement des patients adultes atteints d'un CBNPC localement avancé ou métastatique après une chimiothérapie antérieure, les patients avec mutations activatrices de l'egfr devant également avoir reçu une thérapie ciblée

Tecentriq	07/16/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-10/tecentriq_16072019_avis_definitif.pdf	10/09/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17655_TECENTRIQ_PIC_EI_Avis3_CT17655.pdf	En association au bevacizumab, paclitaxel et carboplatine, en 1ère ligne de traitement des adultes atteints de cancer bronchique non à petites cellules (CBNPC) non épidermoïde métastatique. Chez les patients avec EGFR muté ou réarrangement du gène ALK, TECENTRIQ, en association au bevacizumab et à la chimiothérapie concernée est indiqué seulement après échec des thérapies ciblées appropriées
Tecfidera	06/24/2014	https://www.has-sante.fr/upload/docs/application/pdf/2016-03/tecfidera_24062014_avis_efficiency.pdf	05/07/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13005_TECFIDERA_PIC_INS_Avis3_CT13005.pdf	Traitement des adultes atteints de formes rémittentes récurrentes de sclérose en plaques (SEP-RR)
Tegsedi	05/14/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/tegsedi_14052019_avis_efficiency.pdf	04/17/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-04/tegsedi_pic_ins_avis3_ct17282.pdf	Traitement de la polyneuropathie de stade 1 ou 2 chez les adultes atteints d'amylose à transthyrétine héréditaire (amylose hatrr)
Tivicay	05/27/2014	https://www.has-sante.fr/upload/docs/application/pdf/2014-12/tivicay_27052014_avis_efficiency.pdf	05/28/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13530_TIVICAY_PIC_Avis2_CT13530.pdf	En association avec d'autres médicaments antirétroviraux, dans le traitement de l'infection par le VIH, chez les adultes et adolescents à partir de 12 ans
Vectibix	05/27/2014	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/vectibix_27052014_avis_efficiency.pdf	09/03/2014	https://www.has-sante.fr/upload/docs/application/pdf/2014-09/vectibix_mci_avispostaudition_ct13386.pdf	Cancer colorectal métastatique sans mutation des gènes RAS (K-RAS et N-RAS), en 1 ère ligne en association avec un protocole FOLFOX ou 2ème ligne en association avec un protocole FOLFIRI pour les patients qui ont reçu en 1 ère ligne un protocole à base de fluoropyrimidine (excluant l'irinotécan) ou en monothérapie après échec des protocoles de chimiothérapie à base de fluoropyrimidine, oxaliplatine et irinotécan
Venclyxto	06/13/2017	https://www.has-sante.fr/upload/docs/application/pdf/2017-12/venclyxto_20170613_avis_efficiency.pdf	07/05/2017	https://www.has-sante.fr/upload/docs/evamed/CT-15932_VENCLYXTO_PIC_INS_avispostAUD_CT15932_.pdf	Traitement de la leucémie lymphoïde chronique (LLC) : - en présence de délétion 17p ou de mutation TP53 chez les adultes inéligibles ou en échec à un inhibiteur du récepteur antigénique des cellules B. - en l'absence de délétion 17p ou de mutation TP53 chez les adultes en échec à la fois à une chimio-immunothérapie et à un inhibiteur du récepteur antigénique des cellules B
Venclyxto	05/14/2019	https://www.has-sante.fr/upload/docs/application/pdf/2020-02/venclyxto_14052019_avis_efficiency.pdf	09/04/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17610_VENCLYXTO_PIC_EI_Avis2_CT17610.pdf	En association au rituximab pour le traitement des adultes atteints d'une leucémie lymphoïde chronique (LLC) ayant reçu au moins un traitement antérieur
Victoza	02/12/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-05/victoza_15012019_avis_efficiency.pdf	12/05/2018	https://www.has-sante.fr/upload/docs/evamed/CT-17253_VICTOZA_PIC_REEV_Avis2_CT17253.pdf	- En bithérapie ou trithérapie avec la metformine et/ou un sulfamidelorsque les patients sous ADO(s) sont insuffisamment contrôlés lorsque l'imc≥30 kg/m ² ou la prise de poids est une situation préoccupante ; - En trithérapie avec la metformine et l'insulinelorsque les

					patients sous insuline basale cor-rectement titrée sont insuffisamment contrôlés lorsque l'imc≥30 kg/m ² ou la prise de poids sous insuline ou le risque hypoglycémique sont une situation préoccupante
Xofigo	03/11/2014	https://www.has-sante.fr/upload/docs/application/pdf/2017-01/dir1/xofigo - avis defficiency masque.pdf	04/02/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13429 XOFIGO%20Ins Avis%202 CT13429.pdf	Traitement du cancer de la prostate résistant à la castration, avec métastases osseuses symptomatiques et sans métastases viscérales connues
Xolair	11/25/2014	https://www.has-sante.fr/upload/docs/application/pdf/2015-11/xolair_25112014_avis_efficiency.pdf	04/15/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13773 XOLAIR PIC EI Avis2 CT13773.pdf	Traitement de l'urticaire chronique spontanée (UCS) chez les patients à partir de 12 ans, ayant une réponse insuffisante aux traitements antihistaminiques anti-H1
Xtandi	06/09/2015	https://www.has-sante.fr/upload/docs/application/pdf/2016-06/xtandi - avis defficiency m.pdf	03/04/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13973 XTANDI PIC EI Avis2 CT13973.pdf	Cancer métastatique de la prostate résistant à la castration chez les patients asymptomatiques ou peu symptomatiques (score de la douleur la plus intense ressentie dans les 24 dernières heures ≤ 3 sur une échelle de 0 à 10), après échec d'un traitement par suppression androgénique et pour lesquels la chimiothérapie n'est pas encore cliniquement indiquée
Xtandi	03/19/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-07/xtandi_19032019_avis_efficiency.pdf	11/20/2013	https://www.has-sante.fr/upload/docs/evamed/CT-13108 XTANDI PIC INS Avis2 CT13108.pdf	Cancer métastatique de la prostate résistant à la castration ayant progressé pendant ou après une chimiothérapie à base de docétaxel
Xtandi	07/16/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-10/xtandi_16072019_avis_efficiency.pdf	06/12/2019	https://www.has-sante.fr/upload/docs/evamed/CT-17551 XTANDI PIC EI Avis2 CT17551.pdf	Traitement du cancer de la prostate résistant à la castration (CPRC) non métastatique à haut risque chez les adultes
Yescarta	01/15/2019	https://www.has-sante.fr/upload/docs/application/pdf/2019-04/yescarta_20190225_avis_efficiency.pdf	12/05/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-12/yescarta_pic_ins_avis3_ct17214.pdf	Traitement de 3e ligne ou plus du lymphome diffus à grandes cellules B (LDGCB) ou du lymphome médiastinal primitif à grandes cellules B (LMPGCB) réfractaire ou en rechute
Zejula	07/10/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-10/zejula_12102018_avis_efficiency.pdf	06/13/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16722 ZEJULA PIC %20Ins Avis%202 CT16722_2.pdf	Traitement d'entretien de patientes atteintes d'un cancer épithélial séreux de haut grade de l'ovaire, des trompes de Fallope ou péritonéal primitif, sensible au platine et récidivant, qui sont en réponse (réponse complète ou partielle) à une chimiothérapie à base de platine
Zostavax	04/15/2014	https://www.has-sante.fr/upload/docs/application/pdf/2015-11/zostavax_avis_defficiency_m.pdf	10/15/2014	https://www.has-sante.fr/upload/docs/evamed/CT-13478 ZOSTAVAX PIC Ins Avis3 CT13478.pdf	Prévention du zona et des douleurs post-zostériennes chez les adultes de 50 ans et plus

Zydelig	04/07/2015	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/zydelig_07042015_avis_efficience.pdf	06/17/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13930_ZYDELIG_PIC_INS_Avis3_CT13930.pdf	- en association au rituximab dans le traitement des adultes atteints d'une leucémie lymphoïde chronique (LLC) ayant reçu au moins un traitement antérieur ou en première ligne en cas de délétion 17p ou de mutation TP53, chez les patients pour lesquels une immuno-chimiothérapie n'est pas appropriée. - en monothérapie dans le traitement des adultes atteints de lymphome folliculaire (LF) réfractaire à deux lignes de traitement antérieures
Zydelig	05/16/2017	https://www.has-sante.fr/upload/docs/application/pdf/2018-01/zydelig_16052017_avis_efficience.pdf	06/17/2015	https://www.has-sante.fr/upload/docs/evamed/CT-13930_ZYDELIG_PIC_INS_Avis3_CT13930.pdf	En association au rituximab pour le traitement de patients adultes atteints de leucémie lymphoïde chronique (LLC) ayant reçu au moins un traitement antérieur
Zytiga	07/10/2018	https://www.has-sante.fr/upload/docs/application/pdf/2018-11/zytiga_10072018_avis_efficience.pdf	05/16/2018	https://www.has-sante.fr/upload/docs/evamed/CT-16729_ZYTIGA_PIC_EI_avis2_CT16729.pdf	En association à la prednisone ou à la prednisolone, dans le traitement du cancer métastatique de la prostate hormono-sensible à haut risque nouvellement diagnostiquer, chez les adultes, en association à un traitement par suppression androgénique (ADT)

Table 1-5: List of Economic and Clinical Opinions used to construct the database

Appendix 2: Description of extracted variables

Data extraction was performed by all authors on a sample of ten Economic and Clinical Opinions to identify a potential lack of coding consistency. Data extraction for the remaining Opinions was performed independently by all authors.

Table 2 provides the definitions and coding of the variables used in regression analyses while Table B2 describes the matching between the official SMR/ASMR criteria the corresponding variables used in regressions analyses

Variable name	Definition	Source	Modalities reported in the source	Modalities used in regression analyses	Coding in regression analyses
SMR obtained	Rating of the clinical value of the drug by the CT	Clinical Opinion	Insufficient Mild Moderate Important	Insufficient Mild Moderate Important	1 2 3 4
ASMR obtained	Rating of the clinical added value of the drug by the CT	Clinical Opinion	No clinical improvement Minor Moderate Important	No clinical improvement Minor Moderate Important	1 2 3 4
Claimed ASMR	Clinical added value claimed by the pharmaceutical firm in its application for the CT	Clinical Opinion	Moderate Important	Moderate Important	0 1
ICUR	ICUR provided by the pharmaceutical firm in its economic evaluation submitted to the CEESP	Economic Opinion			Number
ICUR validation	ICUR validation by the CEESP	Economic Opinion	No Yes	No Yes	0 1
Severity	Severity of the treated disease	Clinical Opinion	Impact on quality of life Disabling Potentially serious complications Vital prognosis is engaged	Not life threatening: impact on quality of life, disabling, potentially serious complications Life threatening: vital prognosis is engaged	0 1
Efficacy-adverse events	Efficacy-adverse events profile categorization by the CT	Clinical Opinion	Not or poorly established Insufficient Low Medium Modest Moderate Important	Not or poorly established, insufficient or low Intermediate: medium, modest, moderate Important	1 2 3

Drug function	Therapeutic function of the drug	Clinical Opinion	Curative Preventive Symptomatic	Curative Preventive Symptomatic	1 2 3
Public health impact	Public health impact categorization by the CT	Clinical Opinion	No Likely Small Moderate	No Yes: likely, small, moderate	0 1
Alternatives	Existence of therapeutic alternatives	Clinical Opinion	No Yes	No Yes	0 1
Pediatric	Drug is used on patients under 18 years old	Clinical Opinion	No Yes	No Yes	0 1
Target population	Size of the target population	Clinical Opinion			Number in thousands
Primary endpoint	Primary endpoint used in the clinical efficacy study	Clinical Opinion	Overall survival	Overall survival for cancer drugs	1
			Progression-free survival	Surrogate endpoints for cancer drugs: progression-free survival (PFS), disease-free survival (DFS), metastasis-free survival (MFS), overall response rate (ORR) and percentage of patients with overall remission	2
			Disease-free survival		
			Metastasis-free survival	Primary endpoints for non-cancer drugs	3
			Overall response rate		
			Percentage of patients with overall remission		
			Variation of the walking perimeter in the 6-minute walk test		
			Variation of the number of migraine days per month		
			Number of hereditary angioedema crisis confirmed by the investigators in monthly rates		
			Variation of the Multi-Luminance Mobility Test score		
				
QALY gain	QALY gains associated with the ICUR calculated by the pharmaceutical firm	Economic Opinion			Number

Table 1-6: Definition and coding of variables

Variable of Interest	Criteria in CT doctrine	Variable name	Definition of variables used	Source
Obtained SMR	Severity of the disease	Severity	Severity of the treated disease	Clinical Opinion
	Efficacy-adverse events balance of the drug	Efficacy- adverse events balance	Efficacy-adverse events profile categorization by the CT	Clinical Opinion
	Drug function (preventive, curative, symptomatic)	Drug function	Therapeutic function of the drug	Clinical Opinion
	Place in the therapeutic strategy	Alternatives	Existence of therapeutic alternatives	Clinical Opinion
	Public health impact	Public health impact	Public health impact categorization by the CT	Clinical Opinion
Obtained ASMR	Quality of the evidence and of the demonstration	Primary efficacy endpoint	Type of main criteria used in the clinical study measuring efficacy	Clinical Opinion
		ICUR validation	ICUR validation by the CEESP	Economic Opinion
	Treatment effect size relative to the best available alternative	QALY gain	QALY gains associated with the ICUR reported by the pharmaceutical firm	Economic Opinion
	Medical need	Alternatives Severity	Existence of therapeutic alternatives Severity of the treated disease	Clinical Opinion Clinical Opinion

Table 1-7: Matching between the official SMR and ASMR criteria and the variables used in regressions analyses

Appendix 3: Complementary analysis on the SMR

Table 1-8 provides a complementary analysis on the SMR by evaluating the relative contribution of each criterion to the SMR classification. To do so, we investigate how the model fit is affected when each SMR criterion is one by one withdrawn from the regression. We use two measures of model fit, the Akaike Information Criteria (AIC statistic) and the Bayesian Information Criteria (BIC statistic), which are widely used for model selection. A lower AIC or BIC statistic indicates a better model fit. However, as both statistics (and especially the AIC statistics) include a penalty for the number of estimated parameters to discourage overfitting, the addition of an explanatory variable which weakly contributes to the goodness of fit of the model might increase the AIC or BIC.

		Obtained SMR Odd ratio (90% confidence interval)					
		Model 1 (all variables)	Model 2 (without severity)	Model 3 (without efficacy- adverse events balance)	Model 4 (without drug function)	Model 5 (without public health impact)	Model 6 (without alternatives)
Severity (ref: not life threatening)	Life threatening	0.9119 (0.2858, 2.9097)		0.2345** (0.0837, 0.6569)	4.7489** (1.4196, 15.8865)	1.1534 (0.3677, 3.6176)	0.9145 (0.4127, 2.0262)
Efficacy – adverse events balance (ref: not established, insufficient or low)	Intermediate	51.6011** (3.9748, 669.8938)	52.1882*** (4.280491, 636.284)		39.3383*** (3.9788, 388.9335)	52.9861** (4.0131, 699.5959)	51.5723** (3.8325, 693.9847)
	Important	8330.595*** (130.9538, 529948.8)	8723.426*** (164.071, 463812.3)		12980.34*** (228.1485, 738506.9)	12164.24*** (226.556, 653122.1)	8361.23*** (154.8861, 451365)
Drug function (ref: curative)	Preventive	0.0469*** (0.0087, 0.2519)	0.0503*** (0.0105, 0.2401)	0.0046*** (0.0011, 0.0195)		0.0593*** (0.0112, 0.3141)	0.0471*** (0.0118, 0.1874)
	Symptomatic	0.0464*** (0.0133, 0.1623)	0.0486*** (0.0130, 0.1812)	0.0471*** (0.0135, 0.1649)		0.0563*** (0.0166, 0.1903)	0.0465*** (0.0137, 0.1576)
Public health impact (ref: no)	Yes	3.0718 (0.9984, 9.4511)	2.9017 (0.9691, 8.6887)	59.0566*** (8.6569, 402.8765)	0.7088 (0.135558, 3.7065)		3.0614* (1.1161, 8.3971)
Alternatives (ref: no)	Yes	1.0069 (0.3036, 3.3396)	0.9757 (0.3990, 2.3863)	4.7487** (1.7202, 13.1089)	0.5278 (0.2148, 1.2971)	0.8654 (0.2756, 2.7178)	
Observations		146	146	146	146	146	146
Pseudo R2		0.67	0.67	0.39	0.63	0.67	0.67
Akaike Information Criteria (AIC statistic)		88.04927	86.05864	144.4	94.2881	86.52333	86.04933
Bayesian Information Criteria (BIC statistic)		117.8853	112.9111	168.2688	118.157	113.3758	112.9018
Log likelihood							

* p<0.10, ** p<0.05, *** p<0.01

Table 1-8: Complementarity analysis on the discriminatory power of each of the SMR criteria

Model 1 corresponds to the full analysis including all SMR criteria presented in Table 2. Withdrawing the disease severity, public health impact or alternatives variables does not lower the quality of the model fit which indicates that these criteria have no discriminatory power in the SMR classification. On the contrary, withdrawing the efficacy-adverse events balance or the drug function criteria significantly lower the quality of the model fit indicating that these two criteria provide a significant contribution to the determination of the SMR. It can be noted that among these two criteria, the relative contribution of the adverse-events balance to the SMR classification is higher compared to that of the drug function.

Chapitre 2 : Efficiency analysis of Advanced Medical Centers in Burkina Faso

Abstract

Burkina Faso ranks among the least developed countries according to the World Bank and faces many challenges in the health domain with no real opportunity for an increase in public health expenditures in the short or medium term. As in all low-income countries, health spending efficiency is of crucial importance to cover most of the existing health needs in Burkina Faso. The analysis of this paper focuses on the first level of the Burkinabe health system, and more precisely on Advanced Medical Centers (AMCs) which correspond to district hospitals and provide primary care to the population. Our first objective is to assess the efficiency level of the 45 AMCs running in the country between 2017 and 2020. In a second step, determinants of AMC's efficiency levels are explored. We found a mean efficiency score of 0.51 over the study period, indicating that AMCs could have almost doubled their healthcare production without additional resources. The size, education level, and health status of the covered population and the density of the healthcare supply in the district appeared as the driving factors of AMCs' efficiency. Our results indicate that resources could be reallocated across AMCs to increase the overall efficiency of the health system.

Keywords: efficiency; healthcare; hospitals; Burkina Faso

This study was financed by the French Development Agency and conducted as part of a FERDI-French Development Agency applied research program on the effects of Covid-19 in Sub-Saharan Africa. A preliminary version of the study was presented at an internal seminar in April 2022 at the Burkina Faso Ministry of Health, attended by directors of central services, regional health directors, and directors of AMCs. The authors thank the participants for their comments and suggestions, but remain solely responsible for the analyses and conclusions presented in this article.

Résumé en français :

Ce deuxième chapitre est une analyse d'efficacité technique des Centres Médicaux Avancés (CMA), qui correspondent aux hôpitaux de district, au Burkina Faso sur la période 2017-2020. Le Burkina Faso est classé parmi les pays les moins avancés par la Banque mondiale et fait face à de nombreux défis dans le domaine de la santé, sans réelle possibilité d'augmentation des dépenses de santé publiques à court ou moyen terme. Comme dans tous les pays à faible revenu, l'efficacité des dépenses de santé est donc d'une importance cruciale pour la couverture des besoins de santé existants au Burkina Faso. Les CMA ont été sélectionnées en raison de leur fonction centrale dans le système de santé burkinabé et du rôle fondamental qu'ils jouent dans la réalisation des Objectifs de Développement Durable en matière de santé. Trois sources principales de données sont utilisées pour ce chapitre : des données provenant du système d'information sanitaire (SIS) et des annuaires statistiques publiés ; des données existantes mais non publiées qui étaient disponibles sur autorisation du Ministère de la Santé ; et des données spécifiques collectées par le biais d'un questionnaire envoyé à toutes les CMA.

Le premier objectif est d'évaluer le niveau d'efficacité des 45 CMA en activité dans le pays entre 2017 et 2020. L'efficacité des hôpitaux de district est évaluée à l'aide de la méthode non paramétrique d'analyse par enveloppement de données (DEA) avec bootstrap. Les ressources considérées sont le nombre de docteurs, d'infirmiers, de personnel médical autre, de personnel non médical ainsi que le nombre de lits. La production de soins est mesurée par le nombre de consultations, d'hospitalisations et de chirurgies ainsi que par le nombre de jours d'hospitalisation. Nous trouvons un score d'efficacité moyen de 0,51 sur la période, ce qui indique que les CMA auraient pu presque doubler leur production de soins de santé sans ressources supplémentaires. Comparativement à la littérature portant sur des structures de santé ou des contextes similaires, les scores obtenus sont relativement faibles.

Dans un second temps, les déterminants du niveau d'efficacité des CMA sont explorés à l'aide d'une méthodologie en double bootstrap. Les CMA situés dans des districts plus peuplés, faisant face à une population plus éduquée et en moins bonne santé ont tendance à être plus efficaces, tandis que ceux situés dans des districts avec une plus grande densité de structures de santé de niveau inférieur ont tendance à être moins efficaces. Ainsi, afin d'augmenter l'efficacité globale du système de santé, une réallocation des ressources pourrait être opérée

vers les districts fortement peuplés et où les besoins en santé de la population sont plus importants. Cependant, il peut être tout à fait justifié de maintenir le fonctionnement d'un nombre réduit de CMA inefficients afin de maintenir la continuité des soins telle que définie dans leurs missions.

Par ailleurs, la réalisation de l'étude a mis en évidence d'importants problèmes concernant la qualité des données collectées au niveau des structures de santé au Burkina Faso, soulignant la nécessité pour les autorités sanitaires burkinabé de mieux contrôler leur système d'information sanitaire en intégrant, entre autres actions possibles, des vérifications systématiques des données d'activité rapportées par les structures de santé. En effet, afin de pouvoir réaliser des études de bonne qualité desquelles découlent des décisions de politiques publiques pertinentes, la qualité de l'information et sa disponibilité sont particulièrement importantes.

1. Introduction

1.1. Context

Burkina Faso, like most sub-Saharan African countries, faces complex health challenges, with considerable unmet health needs and a long way to go to achieve universal health coverage (UHC) despite important progresses over the last decades. The population of Burkina Faso is rather young with two third of the population currently under 25 years old, life expectancy is only 62 years, maternal mortality and morbidity indicators are worrying. Indeed, the maternal mortality ratio (MMR) is 320 per 100,000 births while the average for low- and middle-income countries (LMICs) is 231, while the sustainable development goal (SDG) number 3 includes an ambitious target of “reducing the global MMR to less than 70 per 100 000 births, with no country having a maternal mortality rate of more than twice the global average” by 2030. Under-5 mortality rate is 85 per 1,000 births, far above the average of 40 in LMICs. In addition, Burkina Faso ranks 182 out of 189 countries for the Human Development Index.

From an economic point of view, Burkina Faso belongs to the least developed countries according to the World Bank definition. Resources are very limited and the economy is still mainly based on agriculture, with more than 70% of the population living in rural areas. Macroeconomic constraints are significant despite the rebound in growth observed in 2021 and 2022, which is important but considered fragile (IMF, 2022). The overall fiscal deficit including grants which averaged 3.3% of GDP over the 2011-19 period, rose to 10.4% in 2022 and is estimated at 7.8% for 2023. Over the same period, public debt rose from 30.3% of GDP to 54.3% in 2022 and is expected to reach 60% in 2024 (IMF, 2023), limiting the room for maneuver in deficit financing.

Despite huge health needs and chronic underfunding of the healthcare system, it is very difficult to envisage a substantial and sustainable increase in public financing for health in the short and medium term in Burkina Faso, especially as healthcare is - and will always be - in competition with other sectors. In addition to these challenges, national security concerns were brought forward in recent years due to the presence of terrorist groups in the Northern part of the country leading to the closing of healthcare facilities for prolonged periods. Moreover, the country is now facing political instability, making it more difficult to have

medium term policy planning. In view of these severe constraints, the need to make the best use of the resources currently allocated to the health system is critical, and improving efficiency is becoming of paramount importance for the health policy in Burkina Faso. In a generic sense, efficiency reflects the relationship between the resources used (inputs) and the results obtained (outputs), whatever they may be. Improving efficiency means obtaining the same results with fewer resources or obtaining more results with the same amount of resources. In both cases, achieving efficiency gains is *de facto* equivalent to an increase in available resources for the health system.

The efficiency of healthcare structures has already been studied in various sub-Saharan countries. District hospitals' efficiency was for example investigated in Ghana (Jehu-Appiah et al., 2014), Ivory Coast (Tiehi, 2020), Kenya and Eritrea (Kirigia et al., 2002; Kirigia & Asbu, 2013), Botswana (Tlotlego et al., 2010) or Zimbabwe (Guillon et al., 2022a). However, to the best of our knowledge, no recent study has explored the efficiency of healthcare structures in Burkina Faso. The only study available for Burkina Faso, published in 2011, focused on primary care facilities in the district of Nouna exclusively (Marschall & Flessa, 2011).

The objective of this study is to assess the efficiency of Advanced Medical Centers (AMCs) on the whole territory of Burkina Faso and to identify the factors that spur, or on the contrary, limit the efficiency of these health structures. The AMCs were selected because of their pivotal function in the Burkinabe healthcare system and the fundamental role they play in progressing toward the health SDGs.

In Burkina Faso, the public healthcare system is organized following a common three-level healthcare pyramid described in Figure 2-1. The first level of care includes two layers: the first layer, which is composed of medical centers (MCs), health and social promotion centers (HSPCs), and isolated dispensaries and maternity wards; and the second layer, which is constituted of medical centers with a surgical branch (called Advanced Medical Centers or AMCs which correspond to district hospitals). AMCs are the reference structures for the first-layer health facilities of the first-level of care. The second and third levels of care are

constituted of regional hospitals and university hospitals, respectively, which provide specialized care.

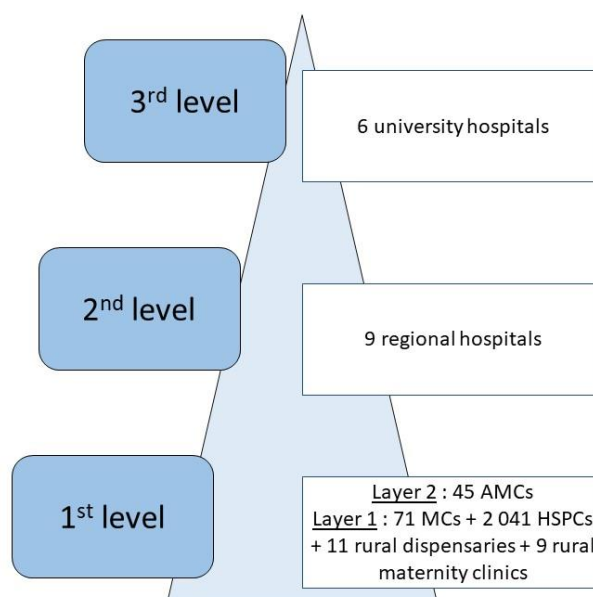


Figure 2-1: Description of the Burkinabe healthcare system

The first layer of the first level of care, i.e. the HSPCs and the MCs, constitutes the entry point to the health system. They provide a minimum package of activities (MPA) composed of curative, preventive, rehabilitative, and promotional care. This package of care includes the diagnosis and treatment of common conditions, prenatal and postnatal consultations, and monitoring of children, deliveries, vaccinations, and family planning. The role of the HSPCs and MCs also includes referring patients to the AMC. The HSPCs are not staffed by doctors, but only by nurses, midwives, and itinerant health workers. The second layer of the first level of care, the AMCs, complements the first layer by providing a complementary package of activities (CPA). The missions of AMCs include taking charge of cases referred by the first-layer health facilities and of medical, surgical, and gyneco-obstetrical emergencies but also comprise hospitalizations, laboratory and medical imaging activities, counter-referrals, referrals to the regional or university hospitals, and the collection, processing, and analysis of health information.

In the first step of this study, bias-corrected efficiency scores of AMCs (Simar & Wilson, 1998, 2000, 2002) are calculated over the 2017-2020 period using data extracted from the national health information system. Studying the efficiency of AMCs - which provide care for the most common infectious, chronic, maternal and infantile diseases at the first level of the healthcare

system - is of crucial importance to better understand the weaknesses and strengths of the Burkinabe health system and to improve the healthcare supply for the population. In the second step, we use a double bootstrap procedure (Simar & Wilson, 2007) to estimate the factors associated with AMCs' efficiency. This analysis is crucial to draw policy implications on how to reallocate resources within the healthcare system in order to boost its overall efficiency. We distinguish between two main categories of factors that might influence the efficiency of AMCs: on the one hand, internal factors, which are characteristics specific to AMCs that they (or health authorities) can modify, and on the other hand, external factors, known as environmental factors, which do not depend directly on AMCs such as characteristics of the population they serve or the geographical environment in which they operate.

The study is organized as follows: section 2 details the methods and data used to estimate both the efficiency scores and the factors associated with those scores, section 3 presents the results while section 4 discusses the main findings.

2. Data and method

2.1. Efficiency analysis

2.1.1. Method

The efficiency of health facilities can be assessed using two orientations, an input orientation and an output orientation. In an input orientation, technical efficiency reflects the capacity of a health facility to minimize the use of inputs to achieve a given level of healthcare production. In this orientation, technical efficiency thus makes it possible to identify the healthcare facilities that use the fewest resources for the same level of care production (in quantity and quality). In an output orientation, technical efficiency reflects the capacity of a healthcare facility to obtain a maximum level of care production (of a given quality) from a given set of inputs. In this orientation, technical efficiency thus makes it possible to identify the healthcare facilities that produce the most care of a given quality for a given level of resources. An output orientation was chosen to measure the efficiency of AMCs because of the existence of unmet

health needs in Burkina Faso and the absence of a possible increase in health expenditure in the near future due to the severe economic constraints on health financing.

Measuring technical efficiency is a two-step process. The first step consists in estimating a production frontier (efficiency frontier) representing the maximum amount of output (health care production) achievable for different levels of input use (resources used by the selected health facilities, i.e. the AMCs). The second step involves calculating the efficiency score for each AMC. This score is determined by measuring how far the AMC is from the production frontier, i.e. the difference between the actual healthcare production of an AMC and the maximum production achievable if it were perfectly efficient (i.e. located at the efficiency frontier). Efficiency can be measured with two different methodologies: a parametric one using the Stochastic Frontier Analysis (Aigner et al., 1977) and a non-parametric one, which includes several methods such as the Data Envelopment Analysis - DEA - (Farrel, 1957; Charnes et al., 1978) or the Free Disposal Hull (FDH) (Deprins et al., 1984). In the parametric methodology, a hypothesis on the form of production function is made. In the non-parametric approach, no such hypothesis is made and the efficiency frontier is formed by the most performing units of the sample. In that case, only relative efficiency scores are obtained since all decision-making units are compared to the best performers in the sample.

Since there is a high degree of uncertainty about the production process of healthcare facilities, especially about the substitutability/complementarity relationships between capital and labor or between the different types of human resources, we used a nonparametric approach to measure the efficiency of AMCs. In addition, the non-parametric approach, unlike the parametric one, allows for the use of multiple inputs and outputs, which is essential to best represent the diversity of missions provided and resources used by AMCs. Within the non-parametric approach, the most common methods are Data Envelopment Analysis (DEA) (Farrell, 1957; Charnes et al., 1978) and Free Disposal Hull (FDH) (Deprins et al., 1984). Among nonparametric technics, we choose DEA which is by far the most common method for assessing efficiency of healthcare facilities in sub-Saharan Africa (Babalola & Moodley, 2020) or more globally (Hafidz, 2018; Mbau et al., 2023).

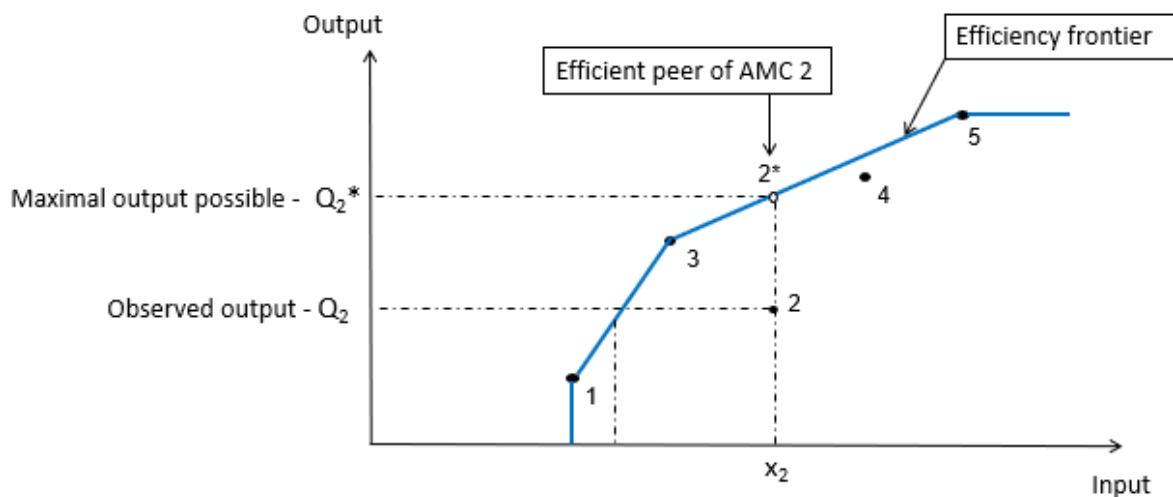


Figure 2-3: DEA analysis with output orientation

Figure 2-2 illustrates the DEA analysis in the case where only one input and one output are used. An efficiency frontier is estimated using the most efficient AMCs of the dataset (1,3, and 5). For other AMCs, the distance between the observed output and the maximal output possible on the efficacy frontier is calculated to obtain the efficiency score. For example, if AMC 2 were perfectly efficient, it would be located on the frontier on 2* and produce Q_2^* instead of its actual production level Q_2 . DEA efficiency scores lie between 0 and 1, with 1 representing perfect efficiency.

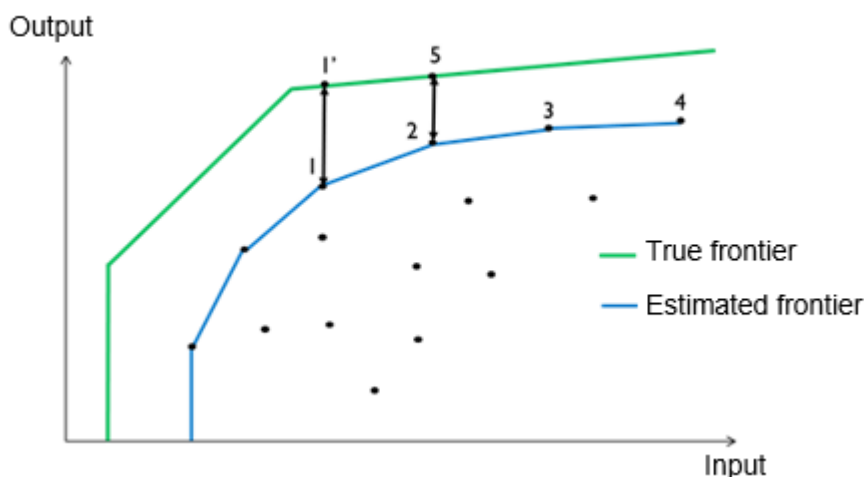


Figure 2-2: DEA with bootstrap

Statistical inference for DEA estimates can be obtained by using bootstrapping that allows for the estimation of the sampling bias and the confidence interval of the original estimate, and to produce bias-corrected efficiency scores (Simar & Wilson, 2008). Figure 2-3 represents the consequences of sampling bias in the measurement of efficiency scores when using the

original DEA deterministic approach. If AMCs 1, 2, 3, and 4 are part of the sample of data collected, the estimated efficiency frontier will correspond to the blue frontier within which these 4 AMCs are considered perfectly efficient (with a score of 1). However, it is possible that the sample does not include some AMCs, such as AMC 5. In this case, AMC 2 will appear artificially efficient in the DEA estimation, whereas, in reality, AMC 5 produces more using the same level of resources. It is also possible that some of the AMCs in the sample were observed in unfavorable periods (for example, years in which extreme weather conditions restricted access to health facilities), leading them to produce a smaller quantity of care than usual with the same resources. In Figure 2-3, this case is illustrated for AMC 1, which usually produces the level of care found in 1' with the same resources. As in the previous situation, because AMC 1 is observed only in one unfavorable "state of the nature", it artificially appears efficient in the estimation whereas, in usual years this AMC produces more care with the same level of inputs. Classical DEA estimations then tend to overestimate technical efficiency scores due to sampling bias.

Efficiency can be measured using constant or variable returns to scale. The assumption of constant returns to scale is appropriate only if all healthcare structures operate at an optimal size. If this is not the case, measures of efficiency will include both economies of scale and pure technical efficiency, whereas we wish to measure only the latter. Healthcare structures are often subject to multiple factors (health policy choices, public regulations, imperfect competition in the healthcare market, etc.) that may lead them to produce at an over- or sub-optimal scale. The presence of economies (or diseconomies) of scale is therefore very common in the health sector, and AMCs are no exception. We, therefore, consider varying returns to scale for the calculation of efficiency scores. After testing for the appropriate bootstrap procedure to apply, we estimate bias-adjusted efficiency scores for AMCs using homogeneous bootstrap with 1000 replications. Estimations were conducted using Stata®, version 17.

2.1.2. Input and output data

To measure the efficiency of AMCs, the main resources available to them should be considered as inputs and the activities that reflect their main functions should be included as outputs. However, the greater the number of inputs and outputs, the greater the number of observations needed to calculate the scores. It is therefore recommended to select only a limited number of input and output variables and to retain only variables that are most relevant to representing the resources used by AMCs and their main activities.

According to Babalola and Moodley (2020), the inputs most often used in the literature to measure the efficiency of health facilities in sub-Saharan countries include staff resources (medical and non-medical), financial resources (operating expenses, drug expenditures), data on the size of facilities (number of beds), and functional equipment when the information is available. The most frequently used outputs are variables related to outpatient consultations, hospitalizations (number of hospitalizations or inpatient days), maternal and child health (prenatal consultations, deliveries, postnatal consultations, child vaccinations), and surgeries or health education, depending on the level of the facilities considered and the context in which they operate.

In this study, five input variables were selected: the number of doctors, nurses, other medical staff, non-medical staff, and beds. The number of doctors includes doctors from all specialties in activity in the AMC. The number of nurses covers both registered nurses and state-certified nurses. Other medical staff includes pharmacists, midwives, certified birth attendants, auxiliary birth attendants, laboratory/biology technicians, manipulators in radiology, and pharmacy technicians. The number of non-medical staff is the addition of sanitary technicians, ward boys/girls, hospital executive assistants, hospital and health service managers, and hospital and health service administrators. Lastly, the number of beds corresponds to the total of beds available in all wards, including maternity and post-delivery services.

Four main output variables were selected: the number of inpatients, surgeries, outpatients, and the number of inpatient days. The number of inpatients days and outpatients was available in total and disaggregated by age categories (<5 years; 5-14 years; > 15 years). The number of surgeries included both planned and emergency surgeries. For all outputs, means

per trimester, rather than annual values, were calculated to allow the inclusion of hospitals with missing values.

Three main sources of data were used: 1) data from the health information system (HIS) and from published statistical yearbooks; 2) existing but unpublished data that were available upon authorization; 3) and specific data collected through a questionnaire sent to all AMCs. Based on the literature, a poll of candidate variables was created before reaching final selection after discussions with local health authorities. Data were collected for all public AMCs in the country.

The choice of input and output variables was constrained by the availability of data and by quality issues. For example, it was not possible to include data on medical imagery or biology acts as outputs because they were not recorded by all the AMCs. In addition, year 2019 was marked by various large-scale events in the country. First, a major strike of healthcare workers prevented the recording and correct reporting of input and output data. Second, insecurity-related problems (terrorism and intercommunity conflicts) have led to the closure or reduced operation of some AMCs during repeated prolonged periods. The Sahel, North Central, and Eastern regions have been particularly affected by the latter issue (UNOCHA, 2021). As a result, year 2019 had to be excluded from the analysis. The study period, therefore, includes years 2017, 2018, and 2020.

2.1.3. Efficiency models

Since the DEA method is sensitive to the number of input and output variables selected, and to ensure the robustness of the results, six efficiency models were estimated (Table 2-1). The main model includes the number of doctors, nurses, and beds as inputs and the number of inpatients, outpatients, and surgeries as outputs.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Inputs						
Doctors	X	X	X	X	X	X
Nurses	X	X	X	X	X	X
Other medical staff		X	X			
Non-medical staff			X			
Beds	X	X	X	X	X	X
Outputs						
Inpatients	X	X	X			X
Inpatients < 5 years					X	
Inpatients 5-14 years					X	
Inpatients >15 years					X	
Inpatients days				X		
Surgeries	X	X	X	X	X	X
Outpatients	X	X	X	X	X	
Outpatients <5 years						X
Outpatients 5-14 years						X
Outpatients >5 years						X

Table 2-1: Inputs and outputs used for efficiency score calculation

Compared to the main model (model 1), input changes have been made in models 2 and 3. Non-medical staff is included, as well as medical staff other than doctors and nurses. Alternative outputs to Model 1 are introduced in Models 4 to 6. In Model 4, the number of hospitalizations has been replaced by the number of inpatient days. In Model 5, the number of hospitalizations was disaggregated by the age groups. Finally, in Model 6, the number of outpatient visits was disaggregated by age groups.

2.2. Factors associated with efficiency

2.2.1. Method

We use the two-step procedure proposed by Simar and Wilson (2007) to estimate the factors influencing AMCs' efficiency. This procedure relies on a double bootstrap and provides a valid inference for the regression of efficiency scores on a set of explanatory variables in the second step. The use of two-stage models, where efficiency scores are first calculated and then regressed on a set of explanatory variables, to study the factors associated with efficiency has been challenged in the literature (Simar and Wilson, 2007). The controversy lies in the nature of the efficiency scores used as the dependent variable in the second stage and the methodological issues that arise from this. If the efficiency scores estimated in the first stage are considered to be descriptive and perfect measures of the relative technical efficiency of

the sampled decision units, these scores can be treated as a standard dependent variable, and classical regression analyses performed in the second stage are considered to provide a valid inference (McDonald, 2009; Ramalho et al., 2010). On the contrary, if efficiency scores estimated in the first stage are considered imperfect estimates of true efficiency scores (Simar and Wilson, 2007; Simar and Wilson, 2013), especially because of sampling bias, or because there is statistical noise in the measurement of inputs and outputs, the classical inference approaches used in the second-stage regression analysis cannot be validly applied. This argument is reinforced by the fact that efficiency scores estimated by non-parametric approaches are dependent on each other. The efficiency estimates are therefore considered by some authors as serially correlated, calling for the use of robust regression methods, such as the one proposed by Simar and Wilson (2007). In this procedure, unbiased DEA scores are first computed by subtracting from the initial estimates of the scores the sampling bias computed through a first bootstrap. The unbiased scores are then regressed on a set of explanatory variables using a bootstrapped truncated regression that produces unbiased estimators and confidence intervals.

2.2.2. Explanatory variables data

As mentioned previously, two categories of factors influencing the efficiency of AMCs can be identified; internal and environmental factors. Internal factors are characteristics specific to AMCs that they (or health authorities) can modify, while environmental factors do not depend directly on AMCs such as the geographical environment in which they operate. The choice of explanatory variables used to estimate the factors influencing AMCs' efficiency was limited by the availability of data. For example, it was not possible to include the age of the hospital or patient satisfaction. Furthermore, the relatively small number of observations (45 AMCs over three years) restricted the number of explanatory variables that can be used in the regression analyses. Given these constraints, the selection was made based on discussions with local health authorities and after carefully reviewing previous efficiency studies on similar health structures to retain only explanatory variables that are most influential within the Burkinabe context. We describe below the retained internal and environmental variables and our hypotheses regarding their effect on AMCs' efficiency level.

*Internal factors.**Percentage of doctors among medical staff and percentage of medical staff among total staff.*

The available data made it possible to select these two internal factors which are likely to affect the efficiency of AMCs and are frequently used in the literature. The channels through which they potentially affect efficiency differ, but since these two indicators are highly correlated, they have been introduced alternately into the regression analyses.

Doctors are able to treat a broader spectrum of diseases than nurses, which might increase, all else being equal, the activity and efficiency of AMCs with a higher ratio of doctors to nurses. AMCs with a better endowment of doctors may also benefit from a reputation effect that spurs their activity and efficiency. However, and in opposition to the two aforementioned effects, the presence of a higher share of doctors could lead to a reduction in the number of revisits and re-hospitalizations through a "quality of care" effect, and thus to a reduction in the level of activity and efficiency of the AMCs with proportionally more doctors. It may also be the case that a proportionally high share of doctors, whose salaries are much higher than that of other medical staff, reduces AMCs' efficiency by decreasing task shifting or by limiting AMCs' financial capacity to hire other productive medical staff.

AMCs with more medical staff (relative to total staff) can produce more and better healthcare services, and are thus likely to be more efficient. In addition, they may benefit from a reputation effect, being more attractive to patients.

Environmental factors.

Population size. Population size and dependency ratio are among the most commonly used environmental variables in studies assessing the efficiency of health facilities in LMICs. AMCs located in more populous districts, and those situated in districts with a comparatively high percentage of youth under the age of 14 and adults over the age of 65, are expected to face greater demand, all else being equal, leading to higher efficiency. However, no recent population data were available for individuals over 65 years of age at the health district level in Burkina Faso, so only the young dependency ratio could be calculated. However, this young dependency ratio is not widely used in the literature and given its strong correlation with the poverty rate, the choice was made to include only the size of the population as an explanatory variable.

Urbanization rate. AMCs located in urban areas, where the population is denser, may face a higher healthcare demand that fosters their activity level and efficiency. In addition, the distance to healthcare facilities is reduced in urban area allowing easier access. Nevertheless, because of the strong correlation between the urbanization rate and the education variables (described below), the former was only included in the robustness analysis.

Density of lower-level healthcare supply. The density of the healthcare supply from lower-level health facilities in the coverage area of AMCs can influence their efficiency. To capture this effect, we used the number of public and private health facilities below the AMC level (first layer of the first level of care) per 10,000 inhabitants in the district. Alternative measures of the density of lower-level healthcare supply used were the number of nurses per 10,000 inhabitants in the district (excluding AMC nurses), and the presence of at least one MC in the district. Access to basic primary care is facilitated in health districts with a higher density of nurses or a denser supply from first-level (first layer) healthcare facilities. In all cases, this may result in a decrease in the activity of the AMCs, and then of their efficiency for a given level of resources. Indeed, better access to primary preventive and curative care allows to avoid deterioration in health status and thus consumption of more specialized care in AMCs. Moreover, denser lower-layer health facilities in the district might reduce bypassing of the referral system and self-referral of patients to AMCs.

Several characteristics of the population are likely to influence the efficiency level of AMCs.

Education level of the population. The literacy rate, which constitutes a good proxy for the population's education level, was only available at the regional level. Moreover, this variable was strongly correlated with the poverty rate. Thus, we considered other proxies for the population's education level, namely the lower secondary education completion rate, the higher secondary education completion rate, and the enrolment rate for secondary education. We selected the lower secondary education completion rate in the main model (model 1) because this indicator demonstrated the highest correlation with the literacy rate. The higher secondary education completion rate and the enrolment rate for secondary education were used as alternative measures in robustness analyses⁴. The effect of education on AMCs' efficiency can work in two opposite directions. A higher level of education encourages greater

⁴ The lower secondary education completion rate was also the indicator with the highest geographic heterogeneity (mean = 32%, SD = 16).

use of care in the event of illness (Bonfrer et al., 2014; Simona et al., 2022). Thus, AMCs located in districts with a more educated population might face a greater healthcare demand that could boost their activity and efficiency. However, a higher level of education is also generally associated with a better lifestyle, i.e., less risky behaviors and more preventive behaviors (Cutler & Lleras-Muney, 2010), which reduces the prevalence of communicable and non-communicable diseases. AMCs located in districts with a more educated population could then face a comparatively lower demand for healthcare services, thereby reducing their activity and efficiency.

Poverty rate. The impact of the poverty rate on health structures' efficiency is frequently studied in the literature (Mbau et al., 2023; Binyaruka et al., 2020; Yang et al., 2021). However, the direction of the effect is *a priori* indeterminate. A first assumption would be that poverty has a negative effect on efficiency. Poor people are more likely to forego care in the face of high out-of-pocket payments, transportation costs, and opportunity costs. This might then reduce the healthcare demand faced by AMCs located in poor districts and their efficiency. On the contrary, a high poverty rate may counterintuitively favor efficiency, all other things being equal, because poor populations are generally in poorer health. Poorer populations may indeed seek care later for financial, accessibility, and other reasons, which could lead to more serious pathologies requiring care provided by the AMCs rather than care provided in HSPCs. In that situation, AMCs located in poor districts could experience greater activity favoring their efficiency. Poverty rates were only available at the regional level, and for year 2018, so that we applied the regional poverty rate for all AMCs located within the same region.

Health status of the population. The malaria incidence rate was the only health indicator available for all districts. Only severe cases of malaria - about 4% of all cases - fall under the mission of AMCs, mild cases being the competence of HSPCs. The direct effect of malaria incidence on the activity and efficiency of AMCs is therefore quite marginal. However, the malaria incidence rate was introduced into the analysis as a proxy for the health status of the district population, which appeared to be a realistic hypothesis after discussions with the Burkinabe Ministry of Health. A comparatively high incidence rate would then indicate a lower health status of the district population that could translate into a higher healthcare demand and efficiency for AMCs.

Insecurity. The existence of violent events and of a strong insecurity climate within a district, often reinforced in Burkina Faso by the deterioration of social cohesion (UNICEF, 2021; Pflaum, 2021; Feindouno and Wagner, 2020), can reduce travel opportunities and restrict access to care. The number of people who do not seek care will be higher in districts where security is higher, reducing the activity and efficiency of AMCs located in those districts. Moreover, AMCs facing high insecurity, particularly in the Sahel (UNOCHA, 2021), may have to operate on a smaller scale or even close temporarily which *de facto* reduces their activity. In some places, however, the closure of HSPCs facing insecurity issues may encourage the population to self-refer to the AMC. After discussions with the Ministry of Health, the variable chosen to measure insecurity was the number of violent events recorded by the ACLED (The Armed Conflicts Location & Event Data Project) platform⁵.

For ease of readability, Table 2-2 summarizes the different assumptions about the effect of the variables selected as potential drivers of AMCs' efficiency.

⁵ Because ACLED data were available at the province level (sub-division of the regions) and not at the health district level, when a province was composed of several health districts, the number of violent events was distributed equally among each district in the province.

	Variable	Effect on efficiency	Hypotheses
Internal variables	Share of doctors in medical staff	+/-	+ Doctors are able to treat a broader spectrum of diseases, which increases the activity and efficiency of AMCs with proportionally more doctors. Due to a reputation effect, AMCs with more doctors are likely more attractive to patients. - A greater number of doctors could lead to a decrease in the number of revisits and re-hospitalizations through a "quality of care" effect, and therefore lead to a decrease in the level of activity and efficiency of AMCs. A high proportion of doctors could be a sign of low task-shifting reducing AMCs' efficiency.
	Share of medical staff in total staff	+	AMCs that are staffed with proportionally more medical personnel may produce more care and are likely to be more efficient. They may also face higher demand due to a reputation effect.
Environmental variables	Population size	+	AMCs located in more populated districts might face a greater demand.
	Urbanization rate	+	AMCs located in urban districts might face a greater demand.
	Lower secondary education completion rate	+/-	+ Higher levels of education are associated with greater use of care in the case of illness. Thus, AMCs located in districts with a more educated population may face a greater healthcare demand which stimulates their activity and efficiency. - A higher level of education in the population is associated with less risky behaviors and more preventive behaviors. AMCs located in districts with a more educated population could therefore face a lower healthcare demand that would reduce their activity and efficiency.
	Higher secondary education completion rate		
	Enrolment rate for secondary education		
	Poverty rate	+/-	+ Poor populations are in poorer health and in more need of care. They seek care later, which leads to a worsening of their pathologies, which are more likely to be treated at the AMC level. - Poor populations are more likely to forego care because of comparatively high medical, travel and opportunity costs. This could reduce the demand for care directed to the AMCs located in poor districts.
	Malaria incidence	+	Indicator retained as a proxy of the health status of the population. The higher the incidence rate, the lower the health status of the population and the higher the healthcare demand might be.
	Insecurity	-	Higher levels of health care renunciation in insecure districts (travel limitations) and part-time closure of AMCs in those districts could lead to a reduction in AMCs' activity and efficiency.
Number of healthcare centers below AMC in the district for 10,000 inhabitants	-	Access to basic care is easier in districts where the supply of primary care through first-layer first-level health facilities is denser. This could result in a decrease in the activity of the AMCs through less self-referral and reduced disease complications.	
Presence of a medical center in the district			
Number of nurses for 10,000 inhabitants			

Table 2-2: Hypotheses on the effect of variables influencing efficiency

The matrix correlation of all candidates' variables is displayed in Appendix 1.

2.2.3. Regression specifications

Eight regression models combining the variables identified as potential efficiency determinants were estimated (Table 2-3). All regressions were run using inputs and outputs described in Model 1 (see Section 2.1.3. Efficiency models).

	Regression specifications							
	1	2	3	4	5	6	7	8
Population size (ten thousand)	X	X	X	X	X	X	X	X
Urbanization rate				X				
Lower secondary education completion rate	X				X	X	X	X
Higher secondary education completion rate		X						
Enrolment rate for secondary education			X					
Poverty rate								X
Malaria incidence for 1,000 inhabitants	X	X	X	X	X	X	X	X
Insecurity								X
Number of healthcare centers below ACM in the district for 10,000 inhabitants	X	X	X	X			X	X
Number of nurses for 10,000 inhabitants					X			
Medical center in the district						X		
Share of doctors in medical staff	X	X	X	X	X	X		X
Share of medical staff in total staff							X	
Years	X	X	X	X	X	X	X	X

Table 2-3: Regressions models of factors influencing efficiency

Regression 1 included the following variables: population size, lower secondary education completion rate, malaria incidence, number of health facilities below the AMC level per 10,000 inhabitants, share of doctors in AMC’s medical staff, and a categorical variable for the year. In regressions 2 and 3, the higher secondary education completion rate (regression 2) and the secondary education enrollment rate (regression 3) were used as alternative measures of educational attainment. In regression 4, the urbanization rate was introduced in replacement of educational attainment (the two measures being highly correlated, see Appendix 1). In regressions 5 and 6 the measure of healthcare supply density was changed for the number of nurses per 10,000 inhabitants (regression 5) and for the existence of a MC in the district (regression 6). In regression 7, the share of doctors in AMCs’ medical staff was replaced by the

share of medical staff in AMCs' total staff. Regression 8 added the poverty rate and the number of violent events to regression 1.

3. Results

3.1. Descriptive statistics

Descriptive statistics for inputs and outputs of the 129 observations for which an efficiency score was calculated are displayed in Table 2-4. On average, 9.12 doctors and 54.40 nurses operated in each AMC. The mean number of beds available was 70.87. Per trimester, the average number of inpatients in each AMC was 985 while the average number of outpatient visits was 4 068. The mean number of surgeries per trimester was 123.

	Mean	Standard deviation	Coefficient of variation
Inputs (N=129)			
Doctors	9.12	7.80	0.86
Nurses	54.40	43.82	0.81
Other medical staff	29.55	26.37	0.89
Non-medical staff	13.78	5.11	0.37
Beds	70.87	23.37	0.33
Outputs (N=129)			
Inpatients	984.69	419.38	0.43
Inpatients < 5 years	360.97	185.31	0.51
Inpatients 5-14 years	93.03	50.02	0.54
Inpatients >15 years	530.69	298.40	0.56
Inpatients days	2 392.12	1 238.69	0
Surgeries	123.38	91.05	0.74
Outpatients	4 068.38	3 684.01	0.91
Outpatients <5 years	1 450.13	1 736.08	1.20
Outpatients 5-14 years	430.90	500.34	1.16
Outpatients >15 years	2 187.36	1 710.31	0.78

Table 2-4: Descriptive statistics for inputs and outputs

Table 2-5 presents the descriptive statistics of the explanatory variables for the 123 observations used in regression 1. The mean district population size was 308,000 inhabitants. About a third (32.39%) of districts' children completed lower secondary education. The mean incidence rate of malaria for 1 000 inhabitants was 578.64 in the districts studied. The average number of healthcare centers of the first layer of the first level for 10 000 inhabitants was

1.29. On average, doctors represented 6.71% of AMCs' medical staff and medical staff accounted for 88.41% of AMCs' total staff.

	Mean	Standard deviation	Coefficient of variation
<i>Explanatory variables (N=123)</i>			
Population size	308 038.8	(151 671.5)	0.49
Urbanization rate	19.16	(19.88)	1.04
Lower secondary education completion rate	32.39	(16.37)	0.51
Higher secondary education completion rate	17.00	(8.93)	0.53
Enrolment rate for secondary education	25.40	10.60	0.42
Poverty rate	44.67	15.61	0.35
Malaria incidence for 1,000 inhabitants	578.64	170.75	0.30
Insecurity	6.55	31.06	4.74
Number of healthcare centers below AMC in the district for 10,000 inhabitants	1.29	0.35	0.27
Number of nurses for 10,000 inhabitants	3.11	1.01	0.33
Medical center in the district	0.53	0.50	0.95
Share of doctors in medical staff	7.70	3.32	0.43
Share of medical staff in total staff	88.41	5.10	0.06

Table 2-5: Descriptive statistics for factors associated with efficiency

3.2. Efficiency scores

The scores of the six models were highly correlated (Table 2-6). Indeed, all rank-correlation were significant at 1% level and comprised between 0.81 (between models 3 and 5) and 0.99 (between models 2 and 3). This high correlation between our six models indicates a good robustness of the efficiency scores calculated. The scores presented in the following sections are those of Model 1 but bias-adjusted scores for all six models are available in Appendix 2.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Model 1	1.00					
Model 2	0.96	1.00				
Model 3	0.94	0.99	1.00			
Model 4	0.87	0.86	0.86	1.00		
Model 5	0.87	0.82	0.81	0.84	1.00	
Model 6	0.93	0.88	0.88	0.89	0.94	1.00

Table 2-6: Rank correlation between models

AMCs' bias-adjusted efficiency scores ranged from 0.19 to 0.85 over the study period (2017-2020), with an overall average of 0.51. This means that, on average, AMCs could have almost doubled their healthcare (+96% with stable resources). Figure 2-4 presents the detailed distribution of efficiency scores in our sample.

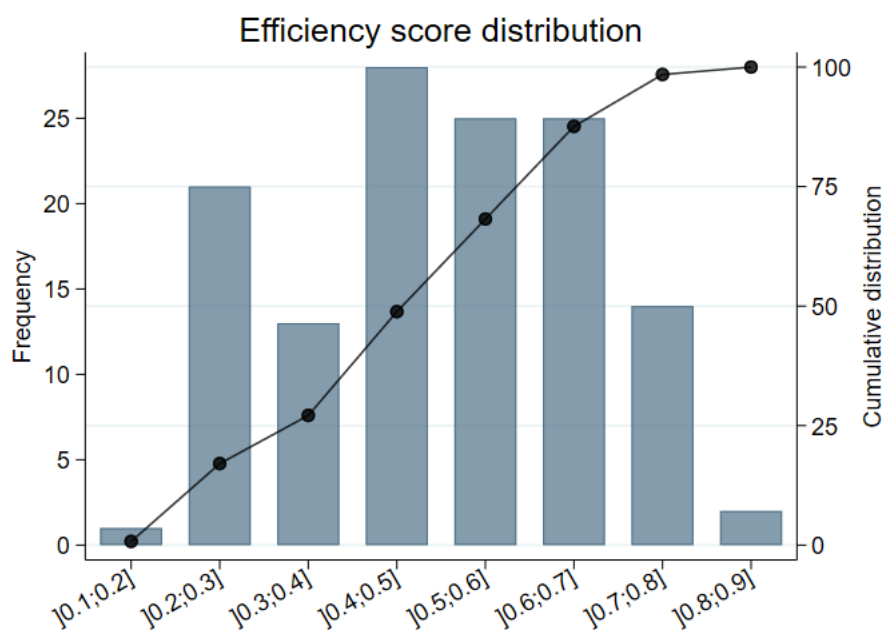


Figure 2-4: Efficiency score distribution

Table 2-7 details, by regions, the mean bias-adjusted score, the media, standard deviation as well as minimum and maximum scores for model 1. Heterogeneity was high across regions, with the lowest mean in the Sahel region (0.34) and the highest in the Haut Bassins region (0.65).

Region	Mean	Median	Standard deviation	Minimum	Maximum
Boucle du Mouhoun	0.45	0.45	0.14	0.21	0.68
Cascades	0.58	0.62	0.08	0.49	0.63
Centre	0.63	0.62	0.10	0.48	0.79
Centre Est	0.54	0.54	0.13	0.31	0.85
Centre Nord	0.47	0.50	0.14	0.28	0.69
Centre Ouest	0.47	0.50	0.13	0.20	0.60
Centre Sud	0.38	0.33	0.13	0.21	0.57
Est	0.52	0.45	0.15	0.30	0.71
Hauts Bassins	0.65	0.66	0.12	0.40	0.78
Nord	0.46	0.42	0.16	0.25	0.74
Plateau Central	0.52	0.61	0.19	0.25	0.74
Sahel	0.34	0.24	0.19	0.19	0.67
Sud Ouest	0.61	0.57	0.14	0.43	0.84

Table 2-7 : Efficiency results for model 1 by region

Table 2-8 below summarizes the descriptive statistics of the efficiency scores for the three years studied. The mean efficiency scores were 0.52, 0.53, and 0.47 respectively in 2017, 2018, and 2020. The decreasing trend observed between 2018 and 2020 was significant ($t=0.9189$ et $p=0.0582$). Both the minimum score (0.19) and the maximum (0.85) scores were observed for the year 2018. The maximum score reached in 2020, 0.74, was smaller than the maximum for the previous periods, 0.84 and 0.85 for 2017 and 2018, respectively. Details of yearly scores for each AMC are displayed in Appendix 3. However, for confidentiality reasons, the names of the hospitals were not reported. Due to both the methodology used, and to missing data, score calculation was not possible for the whole period studied for some AMCs.

Year	N	Mean	Median	Standard deviation	Minimum	Maximum
2017	39	0.52	0.52	0.17	0.22	0.84
2018	45	0.53	0.56	0.16	0.19	0.85
2020	45	0.47	0.49	0.16	0.20	0.74

Table 2-8: Descriptive statistics of efficiency scores by year

3.3. Factors associated with efficiency

The results of the double bootstrap truncated regressions analyzing the factors associated with AMCs' efficiency levels are presented in Table 2-9.

	Specification							
	1	2	3	4	5	6	7	8
Population size (ten thousand)	0.0023* (0.0009)	0.0026* (0.0009)	0.0030** (0.0009)	0.0018 [†] (0.0010)	0.0038*** (0.0011)	0.0035* (0.0014)	0.0019* (0.0009)	0.0019* (0.0010)
Urbanization rate				0.0028*** (0.0007)				
Lower secondary education completion rate	0.0048*** (0.0009)				0.0027** (0.0009)	0.0026** (0.0009)	0.0052*** (0.0009)	0.0037** (0.0011)
Higher secondary education completion rate		0.0060*** (0.0016)						
Enrolment rate for secondary education			0.0075*** (0.0015)					
Poverty rate								-0.0013 (0.0010)
Malaria incidence for 1,000 inhabitants	0.0006*** (0.0001)	0.0005*** (0.0001)	0.0005*** (0.0001)	0.0006*** (0.0001)	0.0005*** (0.0001)	0.0005*** (0.0001)	0.0006*** (0.0001)	0.0006*** (0.0001)
Insecurity								-0.0006 (0.0006)
Number of healthcare centers <AMC in the district for 10,000 inhabitants	-0.1975*** (0.0445)	-0.1321** (0.0409)	-0.1930*** (0.0424)	-0.1067* (0.0369)			-0.1897*** (0.0420)	-0.1948*** (0.0436)
Number of nurses for 10,000 inhabitants					-0.0016 (0.0152)			
Medical center in the district						0.0037 (0.0135)		
% of doctors among medical staff in AMC	-0.0094* (0.0038)	-0.0093* (0.0038)	-0.0104** (0.0040)	-0.0100** (0.0038)	-0.0109* (0.0042)	-0.0103* (0.0043)		-0.0096* (0.0040)
% of medical staff among total staff in AMC							-0.0013 (0.0010)	
Year 2018 (Ref: 2017)	0.0522 [†] (0.0304)	0.0460 (0.0302)	0.0397 (0.0296)	0.0314 (0.0295)	0.0337 (0.0316)	0.0402 (0.0316)	0.0345 (0.0296)	0.0550 [†] (0.0299)
Year 2020 (Ref: 2017)	0.0290 (0.0317)	0.0156 (0.0309)	-0.0023 (0.0306)	0.0167 (0.0301)	0.0009 (0.0321)	-0.0045 (0.0328)	0.0055 (0.0297)	0.0327 (0.0313)
Constant	0.2045* (0.0828)	0.2000* (0.0842)	0.2251** (0.0818)	0.2376** (0.0870)	0.0723 (0.0908)	0.0589 (0.0890)	0.0693 (0.2241)	0.3369** (0.1207)
Observations	123	120	122	121	122	123	122	122

[†] p<0.1, * p<0.05, ** p<0.01, *** p<0.001; standard errors in parentheses

Table 2-9: Results of factors associated with efficiency levels

Population size was positively associated with AMCs' efficiency in all specifications. When introduced in specification 4, the urbanization rate was also positively associated with the efficiency of AMCs. These results imply that AMCs located in districts with a large and urban population tended to be more efficient over the study period. Regardless of the measure used, education was always positively associated with efficiency of AMCs (specification 1 to 3). In all regressions, a positive association was found between malaria incidence and AMCs' efficiency. On the contrary, the poverty rate and insecurity level were negatively but insignificantly associated with AMCs' efficiency. The density of healthcare facilities of the first layer of the first level in the district was negatively associated with AMCs' efficiency levels in all specifications. However, the density of nurses per 10 000 inhabitants in the district (specification 5) and the presence of at least one MC in the district (specification 6) did not reach significance. Having a medical staff largely composed of doctors seemed to decrease efficiency of AMCs while the share of medical staff in total staff did not seem to have an influence.

4. Discussion

The efficiency scores of AMCs obtained in our analysis, 0.51 on average, appear relatively low compared to the scores obtained in efficiency studies of health facilities conducted in similar countries using the DEA method. For example, in Ghana, a neighboring country of Burkina Faso, a study conducted at the district hospital level found an average efficiency of 0.61 and efficiency scores ranging from 0.37 to 1 (Jehu-Appiah et al., 2014). In Kenya and Eritrea, mean efficiency scores of 0.96 and 0.97 were found for district and secondary-level community hospitals, respectively (Kirigia et al., 2002; Kirigia & Asbu, 2013). In Botswana, a country with a higher GDP per capita than Burkina Faso, a mean efficiency score of 0.70 was found for primary and district hospitals (Tlotlego et al. 2010). However, the lower scores obtained in our study are partly due to the use of a bootstrap methodology, which corrects the problem of overestimation of simple DEA scores due to sampling bias. A study assessing the efficiency of district hospitals in Zimbabwe using a double bootstrap method found a mean efficiency score of 0.70 with a range of 0.37 to 0.99 (Guillon et al., 2022a). Still using a bootstrap procedure, mean efficiency of district hospitals in Ivory Coast in 2012 and 2013 was found to be 0.62 and 0.56 respectively with extrema of 0.14 and 0.86 (Tiehi, 2020). In a different context, but using

a similar methodology, a mean efficiency score of 0.55 was obtained for county-level maternal and child health hospitals in China (Zhang et al., 2020). Nevertheless, the overall low level of efficiency among AMCs found in our study indicates that there is a large room for maneuver to increase care provided to the population without a foreseen increase in AMCs' resources.

Regarding the factors associated with AMCs' efficiency levels, most of our results are in line with previous literature. Indeed, similar to our study, the size of the catchment population was found to be positively associated with the efficiency of public district hospitals in Bangladesh (Ahmed et al., 2019), public health centers in Ethiopia (Bobo et al., 2018), community health centers in Indonesia (Miharti et al., 2021), public hospitals in Iran (Mohamadi et al., 2021), and maternal and child health services in Ethiopia (Yitbarek et al. 2019a; Yitbarek et al., 2019b). Moreover, as in our study (specification 4), Achoki et al. (2017) highlighted that healthcare structures located in urbanized districts were more efficient in Zambia. The positive association we find between population size/urbanization rate and AMCs' efficiency might be linked to the fact that AMCs located in more populous and denser districts face a greater healthcare demand, all else being equal, leading to higher efficiency.

The positive association between educational attainment and AMCs' efficiency obtained in our analysis is also in line with previous results in the literature. In a macroeconomic analysis including 172 countries, Jordi et al. (2020) found that more years of schooling within a country was associated with greater technical efficiency in converting health spending to UHC goals. In a study investigating the efficiency of maternal and child health services in Zambia, a higher proportion of educated women in the district was found to be positively associated with efficiency (Achoki et al., 2017). The positive association between the population education level, measured here by proxies of children school attendance, and AMCs' efficiency is likely related to differences in care-seeking behaviors based on patients' education level (Cutler & Lleras-Muney, 2010). A higher level of education is associated with greater use of care in the event of illness, which leads AMCs located in districts where the level of education is higher to face greater demand for care, increasing in turn their activity and efficiency.

The positive effect of malaria incidence on AMCs' efficiency also seems to be consistent with previous literature. The health status of the population can be measured using several proxies depending on the main challenges faced by a country and the epidemiological profile of the population. In Ivory Coast, HIV-tuberculosis co-infection prevalence among the population

was found to be positively associated with district hospitals' efficiency (Tiehi, 2020). In Kenya, higher HIV prevalence was positively associated with the efficiency of health systems at county level (Barasa et al. 2021). A population with a higher malaria incidence or HIV burden presents a lower health status and exhibits higher healthcare needs, resulting in higher healthcare demand and efficiency for health structures.

We found that the density of lower layer healthcare supply in the covered area was negatively associated with AMCs' efficiency. This indicates that AMCs located in districts where the supply of the first layer of the first level of care is denser tend to be less efficient. This could mean that the first layer of care formed by the HSPCs and MCs drains a substantial part of the demand regarding the basic health needs of the population in Burkina Faso, in line with their role in the healthcare pyramid, thus limiting direct access and unjustified referrals to AMCs which reduces their activity and efficiency. This result is consistent with a previous study conducted in Palestine which found that the efficiency of public hospitals was negatively correlated with the number of primary care centers available per 10,000 inhabitants in the governorate (Sultan and Crispim, 2018). In contrast, a Chinese study found a positive association between the number of village health posts per 10,000 households and the efficiency of municipal hospitals (Audibert et al., 2013).

Despite a negative coefficient, and contrary to the results of many studies previously conducted, we did not find a significant negative association between poverty and AMCs' efficiency. This result is surprising since the literature on LMICs already extensively documented the negative impact of poverty on the efficiency of health facilities. For example, the poverty level was found to be negatively associated with the efficiency of multilevel health facilities in Tanzania (Binyaruka et al., 2020) and with the efficiency of community health centers in remote areas of Indonesia (Miharti et al., 2021). Other studies found a positive association between income level in the catchment area and the efficiency of public hospitals in Tunisia (Chaabouni and Abednnadher, 2012) or the efficiency of county public hospitals in China (Yang et al., 2021). The lack of significance of the poverty rate in our study might be explained by the fact that poverty was only measured at a regional level, and not a district level, and was constant over the period studied. Thus, our indicator lacked precision and could not fully capture the heterogeneity of poverty levels across districts and its impact on AMCs' efficiency. Another surprising result is the lack of significant association between insecurity

and AMCs' efficiency. One explanation could be that AMCS located in district where insecurity is high are also the ones with a high malaria incidence and a low education rate.

Regarding internal factors, the negative association we found between the share of doctors in medical staff and AMCs' efficiency differs from the main results of the literature. Indeed, Guillon et al. (2022b) found a positive association between the share of doctors in medical staff and the efficiency of first-level rural health centers in Mongolia while Jing et al. (2020) reported a positive association between the ratio of doctors to nurses and the efficiency of public and private hospitals in China. In Ghana, a positive association was also found between the proportion of qualified staff in total staff and hospitals' efficiency (Ayiko et al., 2020). Finally, Zhang et al. (2020) found a positive correlation between the share of medical staff in total staff and the efficiency of first-level maternal and child health centers in China. However, one study conducted in Iran highlighted conclusions in line with our results. Kakemam and Dargahi (2019) found a positive correlation between the ratio of nurses per doctor and the efficiency of public hospitals in Iran, meaning that the lower the share of doctors was, the higher the efficiency of hospitals was. The negative association we found between the share of doctors in medical staff and AMCs' efficiency could be explained by a "quality effect" if care provided by doctors is more effective than that provided by other health staff and leads to a reduction in the number of revisits and re-hospitalizations. It is also possible that a high share of doctors reduces AMCs' efficiency by decreasing task shifting or by limiting AMCs' financial capacity to hire other productive medical staff given high salaries of doctors.

Our study bears some limitations. First, we cannot measure quality of care in AMCs given the lack of routine data collection on this aspect. This might be problematic for the measurement and comparison of AMCs' efficiency if quality of care is heterogeneous across studied health facilities, especially in LMICs. The systemic review of Hafidz et al. (2020) highlighted the poor availability of quality of care measures as the most common limitation among studies assessing the efficiency of healthcare facilities in sub-Saharan Africa. Second, data on various inputs and outputs and explanatory factors could not be integrated into the analysis due to a lack of data or low quality of collected data. This is, for example, the case for inputs and outputs related to medical imagery or biology acts or for precise measures (i.e., at the district level) on population's poverty or education level.

To conclude, despite these limitations, three main implications for Burkina Faso's health policy emerge from the study's findings.

First, improving the efficiency of AMCs is a high-level priority in health policy. With large heterogeneity across the sampled health facilities, we find that, on average, AMCs could have almost doubled their healthcare production with no additional resources over the study period. This result is grounds for making the improvement of AMCs' efficiency a top priority in healthcare policy, whose financing is drastically insufficient in relation to needs and is strongly constrained by the macroeconomic and fiscal situation in Burkina Faso. *Second, reconsidering the distribution of health personnel among AMCs.* Ours results indicate that resources reallocation could be operated to more populous districts and districts with low density of healthcare supply and poor population health, where healthcare needs are higher, to increase the overall efficiency of the Burkinabe health system. That said, it should be noted that it may be entirely justified to have a reduced number of very inefficient AMCs if it is not possible to go below a certain level of resources in order to maintain the continuity of care as defined in their missions. This could be a form of subsidy grounded on an equity criterion, mainly for low-efficiency AMCs that operate in particularly high-needs areas. Additional investigations supported by a solid knowledge of local specificities are required in all cases. *Third, tackling the issue of effective and robust verification of AMCs resource and activity data.* The realization of the study highlighted several issues regarding the quality of data collected at the health facility level in Burkina Faso, including data published in statistical yearbooks. This stresses the need for Burkinabe health authorities to better monitor their health information system by, amongst other possible actions, integrating systematic verifications of activity data reported by health facilities. The official procedures state that this should be done at the regional level before the data are entered into the information system, but it is only poorly performed as the study has shown. This problem distorts reality and hinders relevant decision making. However, this issue is not specific to the Burkinabe context, and health data quality was previously identified as a challenge in various LMICs (Lee et al., 2021; Lemma et al., 2020; Gimbel et al., 2017).

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Appendix

Appendix 1: Correlation Matrix

	Population size	Young dependency ratio	Urbanization rate	Number of healthcare centers <ACM in the district	Number of nurses for 10,000 inhabitants	Medical center in the district	Share of doctors in medical staff	Share of medical staff in total staff	Lower secondary education completion rate	Higher secondary education completion rate	Enrolment rate for secondary education	Literacy rate	Malaria incidence	Poverty rate	Insecurity
Population size	1.0000														
Young dependency ratio	-0.4017*	1.0000													
Urbanization rate	0.4523*	-0.6364*	1.0000												
Number of healthcare centers <ACM in the district for 10,000 inhabitants	-0.1468	-0.3402*	0.0463	1.0000											
Number of nurses for 10,000 inhabitants	-0.4698*	-0.1232	-0.0538	0.5343*	1.0000										
Medical center in the district	0.3902*	-0.1489	0.2678*	0.1037	-0.0831	1.0000									
Share of doctors in medical staff	-0.0119	0.1435	-0.2666*	-0.1484	0.0857	0.0158	1.0000								
Share of medical staff in total staff	0.3279*	-0.2621*	0.4386*	0.0760	-0.1524	0.2529*	-0.6274*	1.0000							
Lower secondary education completion rate	0.2743*	-0.5559*	0.6827*	0.4569*	0.0812	0.2351*	-0.3346*	0.3935*	1.0000						
Higher secondary education completion rate	0.2283*	-0.4448*	0.6473*	0.4256*	0.0868	0.2338*	-0.3563*	0.4383*	0.9636*	1.0000					
Enrolment rate for secondary education	0.1212	-0.4876*	0.4919*	0.5844*	0.1593	0.1266	-0.3461*	0.3414*	0.9423*	0.9111*	1.0000				
Literacy rate	0.5167*	-0.7260*	0.7597*	0.2252*	-0.0325	0.2477*	-0.1061	0.2718*	0.7067*	0.6109*	0.5815*	1.0000			
Malaria incidence	-0.3613*	0.1697*	-0.1764*	0.2045*	0.3272*	-0.1041	-0.0227	-0.1119	-0.0707	-0.0558	0.0934	-0.2006*	1.0000		
Poverty rate	-0.3169*	0.6552*	-0.4735*	-0.3253*	-0.2556*	-0.2841*	-0.0186	-0.0827	-0.4777*	-0.3427*	-0.4059*	-0.6825*	0.0582	1.0000	
Insecurity	0.1148	-0.0015	-0.0705	-0.2074*	-0.0426	0.1394	0.1722*	-0.0065	-0.3097*	-0.3072*	-0.3681*	-0.1821*	-0.2768*	0.0114	1.0000

Table 2-10: Correlation matrix

Appendix 2: Bias-adjusted scores for all six models

CMA	Year	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
AMC 1	2018	0.48	0.46		0.70	0.56	0.54
AMC 1	2020	0.34	0.33	0.32	0.30	0.50	0.35
AMC 2	2017	0.73	0.66	0.64	0.74	0.76	0.75
AMC 2	2018	0.47	0.56	0.55	0.57	0.53	0.54
AMC 2	2020	0.46	0.52	0.52	0.51	0.55	0.49
AMC 3	2017	0.44	0.45		0.44	0.57	0.48
AMC 3	2018	0.58	0.58		0.54	0.78	0.62
AMC 3	2020	0.49	0.48		0.36	0.83	0.55
AMC 4	2017	0.43	0.41	0.40	0.50	0.38	0.4
AMC 4	2018	0.42	0.43	0.44	0.57	0.42	0.42
AMC 4	2020	0.45	0.43	0.42	0.47	0.45	0.44
AMC 5	2017	0.46	0.54	0.53	0.47	0.36	0.39
AMC 5	2018	0.53	0.65	0.65	0.85	0.45	0.43
AMC 5	2020	0.65	0.66	0.72	0.58	0.58	0.58
AMC 6	2017	0.28	0.36	0.36	0.30	0.33	0.28
AMC 6	2018	0.33	0.40	0.40	0.53	0.57	0.34
AMC 6	2020	0.56	0.55	0.55	0.39	0.68	0.57
AMC 7	2017	0.48	0.56	0.56	0.49	0.53	0.50
AMC 7	2018	0.61	0.68	0.72	0.63	0.64	0.63
AMC 7	2020	0.62	0.71	0.73	0.64	0.65	0.64
AMC 8	2017	0.73	0.72	0.71	0.71	0.69	0.70
AMC 8	2018	0.72	0.71	0.7	0.77	0.76	0.75
AMC 8	2020	0.63	0.63	0.62	0.66	0.62	0.70
AMC 9	2017	0.43	0.43	0.42	0.34	0.43	0.40
AMC 9	2018	0.40	0.41	0.40	0.33	0.42	0.37
AMC 9	2020	0.56	0.54	0.54	0.41	0.7	0.59
AMC 10	2018	0.57	0.61	0.60	0.85	0.64	0.64
AMC 10	2020	0.53	0.59	0.59	0.69	0.53	0.55
AMC 11	2017	0.71	0.67	0.73	0.68	0.73	0.73
AMC 11	2018	0.68	0.64	0.68	0.71	0.73	0.7
AMC 11	2020	0.30	0.28	0.28	0.38	0.26	0.25
AMC 12	2017	0.84	0.78	0.78	0.86	0.86	0.86
AMC 12	2018	0.74	0.86	0.85	0.72	0.72	0.71
AMC 12	2020	0.56	0.62	0.68	0.47	0.47	0.47
AMC 13	2017	0.23	0.32	0.32	0.16	0.23	0.23
AMC 13	2018	0.19	0.30	0.30	0.13	0.17	0.14
AMC 13	2020	0.25	0.35	0.35	0.12	0.20	0.16
AMC 14	2017	0.76	0.74	0.73	0.76	0.75	0.74
AMC 14	2018	0.77	0.75	0.74	0.8	0.79	0.76
AMC 14	2020	0.74	0.72	0.71	0.84	0.71	0.77
AMC 15	2017	0.41	0.43		0.38	0.52	0.47
AMC 15	2018	0.38	0.37	0.37	0.38	0.52	0.44
AMC 15	2020	0.47	0.44	0.44	0.51	0.64	0.57
AMC 16	2017	0.22	0.29		0.18	0.23	0.24
AMC 16	2018	0.23	0.23	0.27	0.25	0.21	0.22
AMC 16	2020	0.29	0.27	0.29	0.4	0.28	0.26
AMC 17	2017	0.38	0.35	0.33	0.42	0.42	0.38
AMC 17	2018	0.48	0.46	0.43	0.39	0.63	0.48
AMC 17	2020	0.27	0.31	0.31	0.25	0.39	0.28
AMC 18	2017	0.78	0.76	0.72	0.77	0.85	0.81
AMC 18	2018	0.70	0.69	0.67	0.72	0.77	0.75
AMC 18	2020	0.65	0.64	0.63	0.55	0.68	0.68
AMC 19	2018	0.45	0.46	0.61	0.52	0.52	0.45
AMC 19	2020	0.50	0.48	0.50	0.46	0.49	0.46
AMC 20	2017	0.52	0.54		0.60	0.52	0.54
AMC 20	2018	0.54	0.50	0.53	0.39	0.69	0.51
AMC 20	2020	0.69	0.64		0.71	0.63	0.58
AMC 21	2017	0.62	0.62	0.57	0.38	0.38	0.39
AMC 21	2018	0.61	0.62	0.58	0.34	0.33	0.36
AMC 21	2020	0.59	0.59	0.57	0.35	0.35	0.33
AMC 22	2017	0.78	0.72	0.70	0.72	0.78	0.77
AMC 22	2018	0.85	0.71	0.70	0.70	0.83	0.87
AMC 22	2020	0.53	0.65	0.65	0.49	0.49	0.53

AMC 23	2017	0.54	0.57	0.53	0.51	0.55	0.57
AMC 23	2018	0.53	0.56	0.53	0.44	0.54	0.55
AMC 23	2020	0.43	0.45	0.44	0.41	0.49	0.44
AMC 24	2017	0.56	0.57	0.58	0.58	0.59	0.6
AMC 24	2018	0.57	0.56	0.55	0.53	0.66	0.55
AMC 24	2020	0.21	0.28	0.28	0.26	0.25	0.22
AMC 25	2017	0.60	0.58	0.60	0.68	0.46	0.48
AMC 25	2018	0.68	0.67	0.68	0.61	0.51	0.51
AMC 25	2020	0.52	0.51	0.52	0.53	0.47	0.47
AMC 26	2017	0.55	0.54	0.53	0.58	0.65	0.62
AMC 26	2018	0.66	0.64	0.63	0.67	0.71	0.72
AMC 26	2020	0.60	0.59	0.59	0.7	0.69	0.68
AMC 27	2017	0.47	0.43	0.43	0.51	0.54	0.5
AMC 27	2018	0.56	0.51		0.41	0.58	0.59
AMC 27	2020	0.47	0.45	0.50	0.42	0.50	0.50
AMC 28	2017	0.41			0.47	0.53	0.45
AMC 28	2018	0.70	0.62	0.61	0.52	0.62	0.71
AMC 28	2020	0.62			0.62	0.65	0.67
AMC 29	2017	0.69	0.67	0.67	0.64	0.64	0.73
AMC 29	2018	0.79	0.77	0.77	0.73	0.74	0.74
AMC 29	2020	0.48	0.48	0.48	0.42	0.37	0.4
AMC 30	2017	0.29	0.27	0.26	0.28	0.30	0.30
AMC 30	2018	0.39	0.36	0.37	0.38	0.39	0.38
AMC 30	2020	0.33	0.35	0.34	0.38	0.36	0.33
AMC 31	2017	0.61	0.58		0.76	0.72	0.69
AMC 31	2018	0.59	0.56		0.64	0.64	0.61
AMC 31	2020	0.54	0.47	0.47	0.56	0.65	0.47
AMC 32	2018	0.61	0.60	0.59	0.48	0.49	0.74
AMC 32	2020	0.20	0.24	0.23	0.23	0.23	0.22
AMC 33	2017	0.28	0.27	0.27	0.33	0.28	0.25
AMC 33	2018	0.33	0.32	0.32	0.29	0.29	0.29
AMC 33	2020	0.24	0.24	0.24	0.27	0.26	0.26
AMC 34	2018	0.49	0.53	0.51	0.42	0.50	0.52
AMC 34	2020	0.50	0.56	0.57	0.46	0.52	0.52
AMC 35	2018	0.64	0.62		0.68	0.66	0.68
AMC 35	2020	0.67	0.59	0.58	0.76	0.65	0.71
AMC 36	2017	0.44	0.40	0.40	0.35	0.58	0.47
AMC 36	2018	0.44	0.51	0.50	0.29	0.61	0.46
AMC 36	2020	0.37	0.40	0.40	0.30	0.48	0.38
AMC 37	2017	0.62	0.61	0.60	0.77	0.75	0.76
AMC 37	2018	0.63	0.61	0.61	0.78	0.74	0.76
AMC 37	2020	0.49	0.48	0.47	0.46	0.53	0.52
AMC 38	2017	0.58	0.65	0.64	0.55	0.63	0.62
AMC 38	2018	0.45	0.60	0.58	0.47	0.51	0.41
AMC 38	2020	0.45	0.47	0.46	0.51	0.55	0.48
AMC 39	2017	0.41	0.36	0.34	0.29	0.40	0.41
AMC 39	2018	0.34	0.32	0.33	0.28	0.32	0.35
AMC 39	2020	0.25	0.26	0.26	0.27	0.3	0.26
AMC 40	2017	0.35	0.35	0.35	0.36	0.41	0.37
AMC 40	2018	0.29	0.29	0.30	0.27	0.35	0.29
AMC 40	2020	0.21	0.22	0.22	0.27	0.24	0.22
AMC 41	2017	0.30	0.35	0.35	0.34	0.31	0.30
AMC 41	2018	0.30	0.34	0.34	0.32	0.31	0.30
AMC 41	2020	0.37	0.34	0.34	0.35	0.43	0.37
AMC 42	2017	0.64	0.61	0.60	0.71	0.69	0.72
AMC 42	2018	0.70	0.65	0.64	0.71	0.70	0.71
AMC 42	2020	0.74	0.70	0.69	0.65	0.64	0.64
AMC 43	2017	0.57	0.55	0.54	0.64	0.67	0.63
AMC 43	2018	0.58	0.52	0.51	0.61	0.74	0.59
AMC 43	2020	0.31	0.28	0.28	0.31	0.37	0.32
AMC 44	2017	0.29	0.37	0.37	0.29	0.27	0.25
AMC 44	2018	0.29	0.40	0.40	0.31	0.23	0.25
AMC 44	2020	0.25	0.37	0.37	0.32	0.34	0.26
AMC 45	2017	0.66	0.72	0.76	0.62	0.70	0.63
AMC 45	2018	0.71	0.78	0.80	0.67	0.76	0.69
AMC 45	2020	0.74	0.88	0.88	0.73	0.83	0.74

Table 2-11: Bias-adjusted scores for all six models

Appendix 3: Bootstrapped efficiency results for model 1

DMU	Year	Score	Bias	Bias-adjusted score	Lower bound	Upper bound
AMC 1	2018	0,76	0,27	0,48	0,15	0,52
AMC 1	2020	0,46	0,12	0,34	0,20	0,37
AMC 2	2017	1,00	0,27	0,73	0,36	0,83
AMC 2	2018	0,61	0,14	0,47	0,31	0,53
AMC 2	2020	0,63	0,17	0,46	0,29	0,49
AMC 3	2017	0,70	0,26	0,44	0,13	0,49
AMC 3	2018	0,93	0,35	0,58	0,15	0,67
AMC 3	2020	0,73	0,24	0,49	0,20	0,57
AMC 4	2017	0,53	0,10	0,43	0,34	0,47
AMC 4	2018	0,52	0,10	0,42	0,35	0,45
AMC 4	2020	0,56	0,10	0,45	0,37	0,49
AMC 5	2017	0,52	0,06	0,46	0,42	0,49
AMC 5	2018	0,61	0,08	0,53	0,47	0,56
AMC 5	2020	0,69	0,05	0,65	0,60	0,68
AMC 6	2017	0,33	0,05	0,28	0,24	0,30
AMC 6	2018	0,40	0,06	0,33	0,29	0,35
AMC 6	2020	0,62	0,06	0,56	0,50	0,60
AMC 7	2017	0,54	0,06	0,48	0,43	0,51
AMC 7	2018	0,68	0,07	0,61	0,55	0,65
AMC 7	2020	0,69	0,07	0,62	0,56	0,66
AMC 8	2017	0,88	0,15	0,73	0,55	0,81
AMC 8	2018	0,89	0,17	0,72	0,54	0,79
AMC 8	2020	0,77	0,14	0,63	0,50	0,69
AMC 9	2017	0,61	0,18	0,43	0,19	0,48
AMC 9	2018	0,50	0,10	0,40	0,28	0,43
AMC 9	2020	0,67	0,11	0,56	0,44	0,61
AMC 10	2018	0,78	0,20	0,57	0,36	0,63
AMC 10	2020	0,67	0,13	0,53	0,44	0,58
AMC 11	2017	0,90	0,20	0,71	0,52	0,77
AMC 11	2018	0,88	0,20	0,68	0,46	0,77
AMC 11	2020	0,37	0,07	0,30	0,23	0,33
AMC 12	2017	0,97	0,13	0,84	0,73	0,90
AMC 12	2018	0,84	0,09	0,74	0,66	0,79
AMC 12	2020	0,61	0,05	0,56	0,52	0,59
AMC 13	2017	0,28	0,05	0,23	0,20	0,25
AMC 13	2018	0,24	0,04	0,19	0,16	0,22
AMC 13	2020	0,29	0,04	0,25	0,21	0,27
AMC 14	2017	1,00	0,24	0,76	0,57	0,79
AMC 14	2018	1,00	0,23	0,77	0,60	0,82
AMC 14	2020	1,00	0,26	0,74	0,56	0,77
AMC 15	2017	0,66	0,26	0,41	0,10	0,40
AMC 15	2018	0,55	0,17	0,38	0,18	0,44
AMC 15	2020	0,70	0,23	0,47	0,17	0,52
AMC 16	2017	0,32	0,10	0,22	0,11	0,24
AMC 16	2018	0,30	0,07	0,23	0,16	0,26
AMC 16	2020	0,36	0,07	0,29	0,21	0,32
AMC 17	2017	0,48	0,10	0,38	0,30	0,42
AMC 17	2018	0,57	0,09	0,48	0,41	0,51
AMC 17	2020	0,32	0,04	0,27	0,25	0,29
AMC 18	2017	1,00	0,22	0,78	0,56	0,86
AMC 18	2018	0,88	0,18	0,70	0,48	0,77
AMC 18	2020	0,77	0,12	0,65	0,56	0,69
AMC 19	2018	0,65	0,19	0,45	0,21	0,50
AMC 19	2020	0,66	0,15	0,50	0,30	0,55
AMC 20	2017	0,66	0,14	0,52	0,40	0,56
AMC 20	2018	0,69	0,15	0,54	0,38	0,60
AMC 20	2020	0,84	0,15	0,69	0,53	0,77
AMC 21	2017	0,69	0,07	0,62	0,52	0,67
AMC 21	2018	0,68	0,07	0,61	0,51	0,67
AMC 21	2020	0,65	0,07	0,59	0,49	0,63
AMC 22	2017	0,94	0,16	0,78	0,64	0,85
AMC 22	2018	1,00	0,15	0,85	0,72	0,92

AMC 22	2020	0,64	0,11	0,53	0,45	0,57
AMC 23	2017	0,64	0,10	0,54	0,47	0,58
AMC 23	2018	0,63	0,09	0,53	0,46	0,57
AMC 23	2020	0,49	0,06	0,43	0,39	0,46
AMC 24	2017	0,75	0,19	0,56	0,35	0,62
AMC 24	2018	0,73	0,16	0,57	0,42	0,62
AMC 24	2020	0,27	0,05	0,21	0,18	0,22
AMC 25	2017	0,73	0,13	0,60	0,48	0,67
AMC 25	2018	0,83	0,15	0,68	0,54	0,76
AMC 25	2020	0,65	0,12	0,52	0,42	0,57
AMC 26	2017	0,80	0,25	0,55	0,25	0,62
AMC 26	2018	0,96	0,29	0,66	0,30	0,73
AMC 26	2020	1,00	0,40	0,60	0,16	0,59
AMC 27	2017	0,65	0,18	0,47	0,26	0,53
AMC 27	2018	0,74	0,18	0,56	0,35	0,63
AMC 27	2020	0,62	0,16	0,47	0,30	0,51
AMC 28	2017	0,65	0,25	0,41	0,12	0,42
AMC 28	2018	1,00	0,30	0,70	0,29	0,81
AMC 28	2020	1,00	0,38	0,62	0,20	0,65
AMC 29	2017	0,83	0,14	0,69	0,59	0,72
AMC 29	2018	1,00	0,21	0,79	0,65	0,83
AMC 29	2020	0,59	0,10	0,48	0,41	0,51
AMC 30	2017	0,39	0,10	0,29	0,17	0,33
AMC 30	2018	0,52	0,13	0,39	0,21	0,43
AMC 30	2020	0,41	0,08	0,33	0,25	0,36
AMC 31	2017	1,00	0,39	0,61	0,15	0,54
AMC 31	2018	1,00	0,41	0,59	0,14	0,52
AMC 31	2020	0,67	0,12	0,54	0,43	0,60
AMC 32	2018	1,00	0,39	0,61	0,13	0,65
AMC 32	2020	0,30	0,10	0,20	0,09	0,23
AMC 33	2017	0,43	0,15	0,28	0,10	0,31
AMC 33	2018	0,50	0,17	0,33	0,11	0,36
AMC 33	2020	0,35	0,10	0,24	0,10	0,27
AMC 34	2018	0,72	0,23	0,49	0,20	0,54
AMC 34	2020	0,71	0,21	0,50	0,23	0,54
AMC 35	2018	0,98	0,35	0,64	0,19	0,71
AMC 35	2020	1,00	0,33	0,67	0,35	0,70
AMC 36	2017	0,52	0,07	0,44	0,38	0,48
AMC 36	2018	0,51	0,07	0,44	0,37	0,49
AMC 36	2020	0,43	0,06	0,37	0,32	0,40
AMC 37	2017	1,00	0,38	0,62	0,19	0,66
AMC 37	2018	1,00	0,37	0,63	0,21	0,61
AMC 37	2020	0,69	0,20	0,49	0,23	0,56
AMC 38	2017	0,73	0,14	0,58	0,47	0,62
AMC 38	2018	0,55	0,10	0,45	0,38	0,48
AMC 38	2020	0,56	0,11	0,45	0,37	0,49
AMC 39	2017	0,46	0,05	0,41	0,35	0,44
AMC 39	2018	0,44	0,11	0,34	0,22	0,36
AMC 39	2020	0,34	0,09	0,25	0,15	0,27
AMC 40	2017	0,45	0,10	0,35	0,26	0,38
AMC 40	2018	0,36	0,07	0,29	0,22	0,31
AMC 40	2020	0,28	0,06	0,21	0,15	0,23
AMC 41	2017	0,37	0,08	0,30	0,24	0,31
AMC 41	2018	0,37	0,07	0,30	0,24	0,32
AMC 41	2020	0,47	0,10	0,37	0,28	0,41
AMC 42	2017	1,00	0,36	0,64	0,24	0,62
AMC 42	2018	1,00	0,30	0,70	0,43	0,72
AMC 42	2020	0,97	0,23	0,74	0,55	0,82
AMC 43	2017	0,70	0,13	0,57	0,42	0,63
AMC 43	2018	0,68	0,10	0,58	0,47	0,65
AMC 43	2020	0,36	0,05	0,31	0,26	0,34
AMC 44	2017	0,34	0,06	0,29	0,24	0,32
AMC 44	2018	0,36	0,06	0,29	0,25	0,32
AMC 44	2020	0,31	0,06	0,25	0,21	0,28
AMC 45	2017	0,74	0,08	0,66	0,60	0,70
AMC 45	2018	0,80	0,09	0,71	0,64	0,76
AMC 45	2020	0,83	0,09	0,74	0,66	0,79

Table 2-12: Bootstrapped efficiency results for model 1

Chapitre 3 : Impact of broadband internet on preventive healthcare behaviors in Senegal

Abstract

In sub-Saharan African (SSA) countries the main channels of morbidity and mortality are preventable and treatable diseases. Yet, SSA countries invest little in preventive healthcare. Available literature has shown that providing health information can have an impact on health behaviors. In SSA, most of the internet traffic (fixed and mobile) goes through backbone networks. The arrival of optic fiber submarine cables in 2010 brought broadband connectivity to Senegal, allowing access to healthcare information online. Using the Demographic and Health Surveys (DHS) datasets combined with the Afterfibre database, and a Difference-in-Difference methodology, this study aims to assess the impact of the arrival of broadband internet on preventive health behaviors in Senegal. Broadband access is found to be positively associated with the use of bednet, mixed results are found regarding the use of antenatal care, while no impact on child immunization is found. If the positive impacts of internet access are confirmed, the expansion of broadband internet could have important positive spillover effects to improve health through increased access to information.

Keywords: preventive healthcare; broadband Internet; Senegal; difference-in-difference

Résumé en français :

Ce troisième chapitre s'intéresse à l'effet de l'accès à internet sur les comportements de santé préventifs au Sénégal en se concentrant sur le recours aux soins prénataux, l'utilisation de moustiquaires et la vaccination infantile. Les soins de santé préventifs, comparativement aux soins curatifs, sont très coût-efficaces et sont donc essentiels dans un objectif d'efficience des systèmes de santé. Dans les pays d'Afrique subsaharienne (ASS), les principales causes de morbidité et de mortalité sont les maladies évitables et traitables. Pourtant, ces pays investissent peu dans les soins de santé préventifs. L'objectif de ce chapitre est d'évaluer l'effet de l'arrivée de l'internet à haut débit en 2010 sur le recours aux soins préventifs à l'aide de la méthodologie des doubles différences. En effet, internet constitue un moyen efficace de transmission des données et des connaissances qui peut fournir des informations sur la santé mais aussi constituer un nouveau mode de connexion à l'environnement médical. En ASS, la majeure partie du trafic internet (fixe et mobile) passe par des réseaux centraux terrestres. Au Sénégal, la connexion des câbles sous-marins de fibre optique en 2010 a permis de donner accès à l'internet haut débit aux habitants proches du réseau central terrestre. Les analyses sont effectuées à l'aide des données des Enquêtes Démographiques et de Santé (EDS) combinées avec la base de données Afterfibre.

Les analyses montrent que l'utilisation de moustiquaires a significativement augmenté dans les zones connectées suite à l'arrivée de l'internet à haut débit en 2010. Ce résultat est d'autant plus intéressant que les analyses complémentaires effectuées montrent que l'ampleur de cet effet est plus importante pour les populations pauvres et avec un faible niveau d'éducation. Du point de vue des politiques publiques, l'effet positif de l'accès à internet sur l'utilisation de moustiquaires semble indiquer que des campagnes de communication utilisant internet pourraient constituer un outil efficace dans la lutte contre le paludisme au Sénégal. Cela est particulièrement pertinent dans le contexte sénégalais dans la mesure où les campagnes de communication font partie des interventions les plus coût-efficaces dans le domaine de la santé.

Les résultats de l'analyse mettent également en avant des effets mitigés ou non significatifs de l'arrivée de l'internet à haut débit sur le recours aux soins prénataux et à la vaccination infantile. Ces résultats peuvent s'expliquer de différentes façons. Premièrement, il est possible que les individus utilisent internet plutôt à des fins de divertissement qu'à des fins

d'information. Les comportements de recherche d'informations en santé en ligne peuvent mettre du temps à se développer après l'arrivée d'internet et les autorités publiques pourraient avoir besoin de lancer des plateformes officielles et des campagnes de promotion de la santé en ligne afin de fournir des informations fiables sur la santé et de renforcer les capacités de la population en matière de littératie numérique en santé. De plus, la réalisation des vaccinations infantiles nécessite non seulement d'avoir accès à l'information sur la nécessité de la vaccination, mais requiert également la disponibilité desdits vaccins ainsi que la possibilité logistique et financière de pouvoir se rendre dans un centre de santé. Ainsi, d'autres barrières à la vaccination peuvent subsister malgré un accès à l'information amélioré. Il est également important de garder à l'esprit que l'accès à internet peut également accroître l'exposition à la désinformation en matière de santé, en particulier au sein d'une population ayant une faible culture du numérique en santé.

1. Introduction

Preventive healthcare is of the utmost importance for developing countries. Since the Alma-Ata Declaration in 1978, primary health care, in which preventive healthcare plays an important role, has been considered a necessary step towards achieving universal health coverage (UHC) and the Sustainable Development Goals (SDGs). Nonetheless, households in Low and Middle-Income Countries (LMICs) invest little in preventive care but rather face high levels of curative health expenditures (Dupas, 2011a). This low level of investment is even more problematic for LMICs given the multiple health challenges they face. Indeed, disease burden affects people at a younger age than in developed countries and the main channels of morbidity and mortality are infectious and parasitic diseases. The great majority of diseases encountered in those countries (e.g., malaria, respiratory infections, diarrhea, AIDS) can be prevented or treated, highlighting the crucial role of primary and preventive care. In sub-Saharan Africa, communicable, maternal, neonatal, and nutritional diseases accounted for two third of mortality in 2010, according to the Institute for Health Metrics and Evaluation (IHME).

Low-level of investments in preventive healthcare is sometimes linked to individuals' present bias (Kremer & Glennerster, 2011). In the absence of budget constraints, under-optimal adoption of high-return health products or behaviors can also be explained by a lack of information on the health costs or benefits of different products or behaviors (Dupas & Miguel, 2017). Literature available in developing countries has shown that providing health information can have an important impact on health behaviors such as a change in sexual behaviors in response to information on the risk of contracting HIV (Dupas, 2011b) or improvements in good hygiene practices after promotion campaigns for handwashing to reduce diarrhea (Cairncross et al., 2005; Luby et al., 2004). Another example is the change in household behaviors toward water storage to limit dengue contamination after repeated exposure to information in Peru (Dammert et al., 2014). However, the impact of information provision on health behaviors is not always so clear. Indeed, other studies have found little effect of information on health behaviors. For example, Meredith et al. (2013) found that health information did not impact healthcare demand for preventive healthcare products (rubber shoes for children as prevention against hookworm infection in Kenya, hand soap as

prevention against diarrhea or multivitamin supplement as prevention against nutritional deficiencies in Guatemala, Uganda, and India). These results are consistent with the study of lajya et al. (2013) highlighting that blood donations were not impacted by information on their importance in Argentina.

Internet is an established effective way of data and knowledge transmission that can provide health information as well as constitute a new mode of connection to the healthcare environment (Lewis & Behana, 2001). Information and communication technologies can help improve access for geographically isolated communities, provide support for healthcare workers or even inform the population regarding outbreaks of a disease (Majeed & Khan, 2018). In America, Rains (2008) highlighted that broadband users were more likely than those with dial-up access⁶ to internet to perform health-related communication and information-seeking behaviors online. As submarine cables giving access to broadband connectivity are fairly recent in sub-Saharan Africa, very few studies regarding the impact of high-speed internet on health outcomes have been conducted in this region. Most of the available studies on LMICs focus on cell phone access only and do not address the specific effect of broadband internet, such as Gonzalez & Maffioli (2020) who studied the impact of mobile phone access on the spread of Ebola during the 2014 epidemic in Liberia. Their results pointed to a reduction in the likelihood of Ebola cases in villages with access to mobile phone coverage.

Outside of the health area, the literature on the various impacts of high-speed internet in LMICs is growing. Bahia et al., (2020) found that mobile broadband internet boosted household consumption and contributed to a reduction in moderate and extreme poverty in Nigeria. In Senegal, a World Bank report on the impact of digital technologies on household welfare (Rodriguez-Castelan et al., 2021) confirmed this result. Hjort & Poulsen (2019) also found that broadband internet enabled more rapid job creation and economic activity in 12 sub-Saharan countries. Farrell (2015) and Campante et al. (2018) investigated the relationship between internet and political participation finding a negative impact on election turnout.

Within the health domain, studies on the effect of internet connectivity on health mainly focused on developed countries. Amaral-Garcia et al. (2022) studied the effect of internet

⁶ Dial-up internet users must establish a connection each time they desire to use the Internet and are subject to substantially longer wait-time for Web pages to properly load and files to be transmitted than broadband users.

diffusion on childbirth procedures in England. Evidence of the growing importance of the internet as a source of health-related information was provided by the authors and reflected by the C-section 'gap' between high-income and low-income mothers that closed after the diffusion of broadband internet. Studies also investigated how 5G internet could improve medical practices with the help of virtual reality of artificial intelligence (Latif et al., 2017; Dananjayan, 2021). However, as for the relationship between information and health behaviors, a positive relationship between internet use and health outcome is not systematic. Indeed, in a survey of the literature investigating internet use and well-being mixed results were found (Castellacci & Tveito, 2018). These discrepancies might be explained by the health indicators used and specific behaviors associated with them, but also due to differences in individuals' use of internet. Nonetheless, most of those studies conducted in developed countries focused on concerns that are not yet the ones that matter to developing countries. Indeed, these studies did not focus on primary care, including preventive healthcare, which is of the utmost importance in LMICs. Moreover, the development of broadband internet and the utilization of the internet differ between developed and developing countries (improvement of internet speed was more gradual over time in developed countries), thus calling for specific analyses regarding the impact of broadband internet on health behaviors in LMICs.

In LMICs, a notable exception in the lack of literature is a study by the World Bank assessing the effect of mobile phone access (2G, 3G, and 4G) on health outcomes in 25 African countries (Mensah et al., 2022). This study found that a 10% increase in mobile phone coverage was associated with a 0.45% reduction in infant mortality. We aim to extend the analysis offered in this paper by broadening the scope of health preventive behaviors studied. Moreover, the study of the World Bank included the effect of 2G coverage, which corresponds only to voice calls and text messaging, that largely drove the main results obtained, while we aim to study the impact of broadband internet which is supported by 3G and 4G coverage only. Finally, our study also differs from that of the World Bank by the econometric techniques used to identify the effect of broadband internet on preventive healthcare behaviors.

Other studies have recently emerged such as Byaro et al. (2023) who studied the impact of internet use on infant mortality, under-five mortality, and life expectancy in 48 sub-Saharan countries. They found that internet use has a positive effect on health outcomes. A recent

Demographic and Health Surveys (DHS) analytical study investigated, at macro-level, the relationship between three types of access to or use of digital resources (ownership of a mobile phone, use of a mobile phone for financial transactions, and frequent use of the internet) and several health outcomes, namely correct knowledge of the fertility cycle, current use of modern contraception, use of a condom at last sexual intercourse, use of antenatal care, iron supplementation during pregnancy, medical treatment of child illness, and health-seeking for experience with physical or sexual violence (Edmeades et al., 2022). Their results suggested that the strength of the relationship between digital resources access and use varies depending on the health outcome examined and between men and women, even though digital resources access and use were generally associated with better health outcomes.

The objective of this study is to assess the impact of the arrival of broadband internet on preventive health behaviors in Senegal. Since access to the internet might allow individuals to gather information regarding good health practices, but also to benefit from information on the behaviors of others (via access to social networks for example), we formulate the hypothesis that the availability of broadband internet (both fixed and mobile) has positive effects on the use of preventive health care in connected areas, and more specifically on the use of antenatal care, bednet and child immunization.

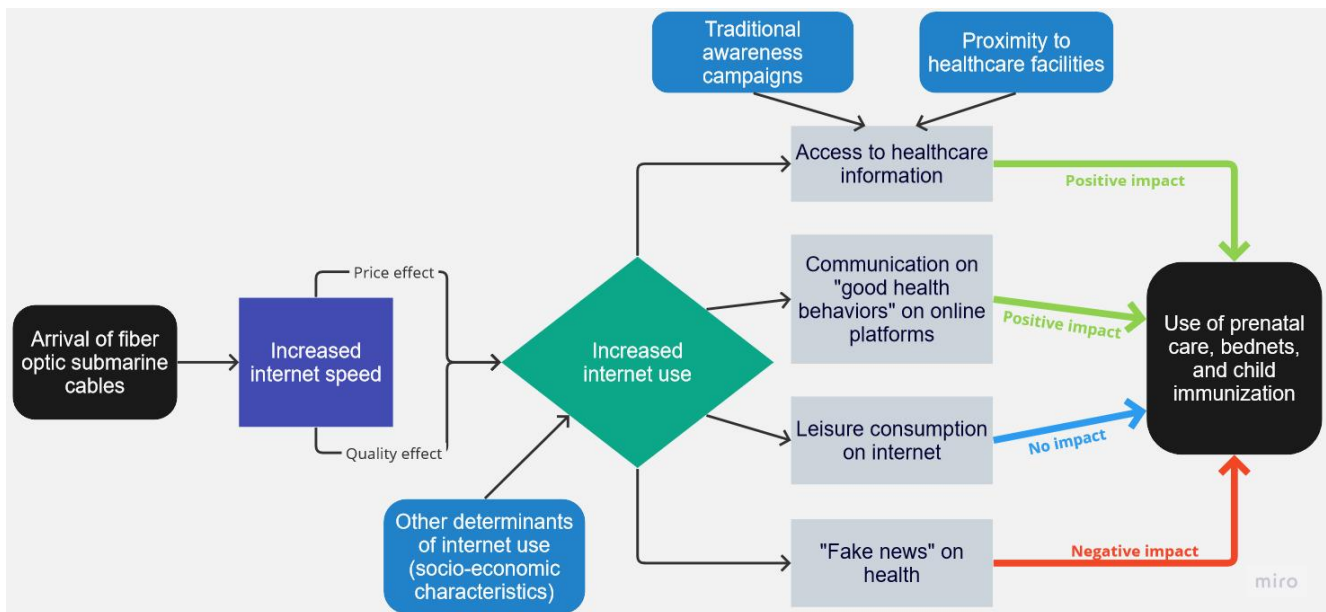


Figure 3-1: Diagram summarizing the study hypotheses and illustrating the potential transmission channels between the arrival of the submarine cables and preventive healthcare.

Note: This diagram summarizes the hypotheses used in the study. The black boxes represent the main variables analyzed, namely the impact of the arrival of fiber optic submarine cables on preventive healthcare use. The other boxes represent the potential effects and mechanisms underlying the main link studied. To signify the hypothetical relationships between these variables, arrows connect each box, indicating the assumed direction of the link between two variables. Furthermore, to capture the potential range of outcomes, we have color-coded the arrows. A green, red and blue arrow represents a positive, negative, and null impact, respectively.

Figure 3-1 summarizes the framework and hypotheses of the study. The arrival of fiber optic submarine cables increased internet speed (Akamai 2012; Hjort & Poulsen, 2019). This increased speed of the internet led to an increase in internet utilization. Access to internet does not guarantee internet use as many socio-economic characteristics matter for internet adoption. However, it has been shown that the arrival of broadband internet led to an increase in internet use in SSA, thanks to both a price reduction and quality improvement effect (Cariolle, 2021; Hjort & Poulsen, 2019). This increase in internet use can have consequences on healthcare utilization and healthcare behaviors through many channels. The main channel we are interested in this study is the impact on access to information. Thanks to internet use, people can easily access health information leading to a positive effect on preventive healthcare behaviors (Dupas, 2011b; Cairncross et al., 2005). Another channel through which the use of preventive healthcare behaviors can increase with internet use is the communication on “good health behaviors” on online platforms such as social media (Willis,

2016). In addition, increased internet use can translate into an increase in leisure consumption online (Bryce, 2001; Falck et al., 2014), without influencing healthcare behaviors. Some studies have shown that intensive internet use can lead to depression, anxiety, and poor sleep quality, but most of the studies on the subject focus on teenagers in developed countries (Morrison & Gore, 2010; Weinstein & Lejoyeux, 2010). Additionally, the increased use of internet can also lead to an increased exposition to fake news (Del Vicario et al., 2016), which in turn can modify healthcare behaviors and reduce some preventive healthcare use such as vaccinations (Wilson & Wiysonge, 2020). Internet use can also affect other aspects of health not studied here, for example, the use of social networks allows communication with distant relatives and friends which can lead to a positive effect on mental health, or internet use can increase healthy behaviors such as engaging in physical activity (Li et al, 2020). Nevertheless, as those pathways are out of the scope of our study, they do not appear in Figure 1. It is also important to keep in mind that access to healthcare information does not occur exclusively thanks to the internet, but that traditional awareness campaigns or proximity to healthcare facilities are also important transmission vectors of health-related information. Indeed, the transmission of preventive health information can occur thanks to community health workers or peers. In addition, the channels presented in Figure might not be effective right after individuals gain access to the internet, as a “learning phase” might be necessary to identify appropriate health information online.

Access to information (thanks to internet or via other means) does not solve all the issues of financial or spatial barriers to healthcare access and healthcare utilization. Indeed, for healthcare services to be used, they must be accessible both economically and geographically. The Senegalese health system is organized following the standard 3-level pyramid. Achieving universal health coverage is a strategic priority for the country. However, improvements on the subject are still needed despite progress made over the last decades. Communicable, maternal, neonatal, and nutritional diseases were responsible for 87% of deaths in children under-5 in 2010, according to the IHME. Insurance coverage was quite low (Daff et al., 2020) but healthcare services, especially for women and children such as vaccination included in the Extended Program on Immunization (EPI), were provided free of charge.

The paper is organized as follows. Section 2 provides information on internet infrastructure in Senegal, the data and methodology used. Section 3 presents the results which are further discussed in section 4.

2. Material and methods

2.1. Background on internet infrastructure

In sub-Saharan Africa, most of the internet traffic (fixed and mobile) goes through backbone networks. The backbone network, also called the core network, is partly the legacy of the fixed telephone network and the first mobile telephone antennas and provides low internet connectivity. As shown in Figure 2, in Senegal, the backbone network (represented by the black line) mostly follows the borders of the country, both in rural and urban areas, leaving the central and south-eastern parts of the country uncovered. Each observation in our database is associated with GPS coordinates represented by colored dots (the color depending on the distance to the network), allowing to see differences in the density of the population. Fiber-optic submarine cables can carry a huge amount of data from one remote location to another (e.g., from Europe to Southern Africa). The arrival of optic-fiber submarine cables in 2010 brought international broadband connectivity to Senegal which highly increased the availability of high-speed internet in areas near the already existing backbone networks.

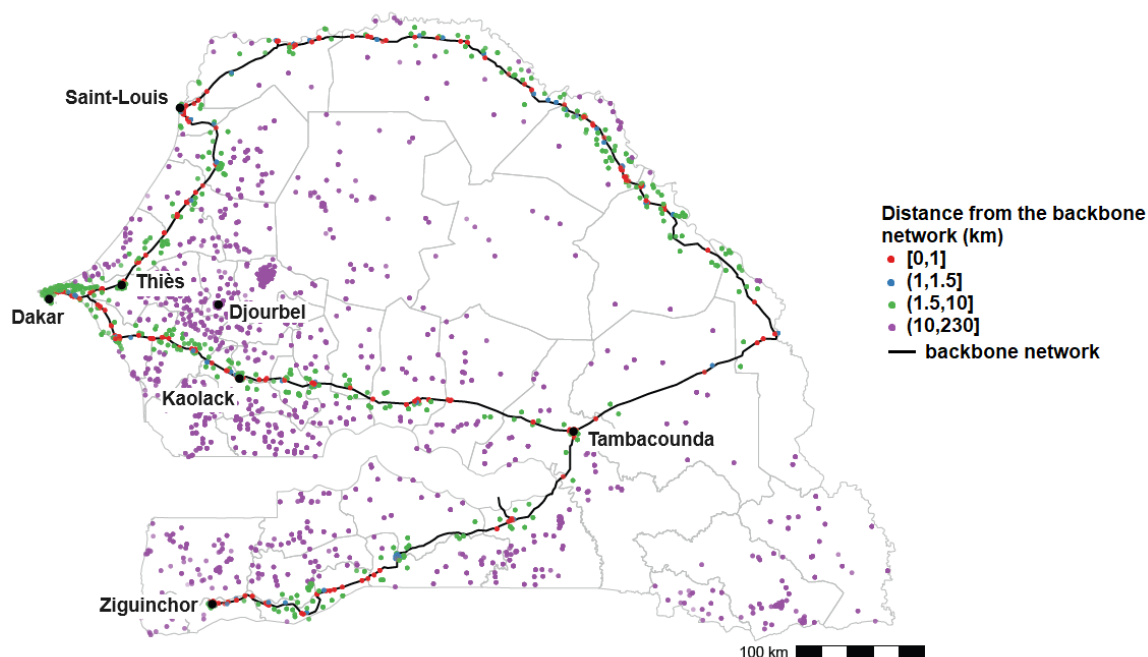


Figure 3-2: Backbone Network in Senegal

Note: This map provides a comprehensive overview of Senegal, displaying geolocated observations (the points) from the DHS databases. The black lines represent the projection of pre-existing backbone cables, which were in place prior to the introduction of submarine cables. The color of the points on the map indicates the distance of each observation from the backbone infrastructure.

It is globally recognized that a radius between 1000m and 1500m from the backbone is the maximum acceptable distance to benefit from broadband. Indeed, the quality of bandwidth, and thus access to the internet, decreases very quickly as the distance to the main network increases in the absence secondary network or antenna as it is the case in Senegal⁷.

As our study focuses on internet access rather than internet use, it is crucial to establish a relationship between the two. This has been done by Hjort and Poulsen (2019) who highlighted a clear link between submarine cable arrival and internet speed and use in SSA. Indeed, based on the Akamai's data⁸, they found that cable arrival increased measured speed by around 35 to 38 percent in connected locations compared to unconnected locations (these coefficients being likely underestimated). Regarding internet use, and based on data provided

⁷ For fixed network (copper network) the attenuation decreases very quickly 1.5 km after the splitter, depending on the technology (ADSL, VDSL, ADSL2...). For mobile network (cell phone antennas), the signal quality decreases rapidly after 1km distance.

⁸ Akamai Technologies, Inc. is a content delivery network which owns servers around the world. Akamai's data provides average internet speeds recorded for different users (residential, educational, government and business) in a given area for each quarter, excluding mobile network connections.

by the Afrobarometer, the authors found that daily and weekly internet use among connected individuals increased by 12 and 14 percent respectively after the arrival of submarine cables arrival compared to unconnected individuals.

2.2. Data

Data on health behaviors were extracted from the Demographic and Health Surveys datasets which are nationally representative population-based surveys with large sample sizes. Our database included Standard DHS from the years 1997, and 2005 as well as Continuous DHS from 2012, 2014, and 2016 with geolocation of participating households for all surveys. In addition to the DHS datasets, the Malaria Indicators Survey (MIS) of 2008 was included in our database for regressions regarding the use of bednet.

Insights on DHS datasets

The Demographic and Health Surveys (DHS) program is responsible for collecting nationally representative data on health and population in developing countries (over 90 countries since 1984). The project is funded by the United States Agency for International Development (USAID) with contributions from other donors such as UNICEF, UNFPA, WHO, and UNAIDS. Several data collections are available among which we can find:

- *The Demographic and Health Surveys (DHS). Those surveys are nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition. The samples are stratified, weighted, and representative at national, regional, and residence levels (urban-rural). We used women's questionnaire targeting women age 15-49. We used Standard DHS for the years 1997 as well as 2005 and Continuous DHS for the years 2012, 2014 and 2016. Standard DHS surveys are typically conducted every few years, with a gap of several years between each survey round whereas continuous DHS surveys are conducted continuously throughout the year, enabling more frequent data collection. Croft et al. (2018) provide more details about DHS surveys.*
- *The Malaria Indicators Surveys (MIS) are surveys nationally representative focusing on malaria. The methodology is similar to standard or continuous DHS. We also used the women's questionnaire. More details about MIS 2008 can be found in Ndiaye and Ayad (2009).*
- *The Service Provision Assessment (SPA) Surveys are surveys of a national sample of formal health facilities. We used SPA Senegal 2012, the sample of surveyed facilities includes 35 hospitals, 64 health centers, 265 health posts, and 74 health huts. More details can be found in the final reports (ANSD & ICF International, 2012).*

All of those databases are available upon request on <https://dhsprogram.com/>, journal articles based on those databases are also available on the website.

We considered three preventive health indicators: use of antenatal care, use of bednet for children, and child immunization.

- *Use of antenatal care* was measured as a dummy variable equal to 1 if the mother had at least 4 antenatal care visits during her last pregnancy. The threshold of 4 visits was used as the World Health Organization (WHO) considered a minimum of 4 visits to have complete antenatal care before 2016 – since then this number has been increased to 8 visits. Indeed, in 2002 the WHO recommended a focused or goal-orientated approach to antenatal care (ANC) to improve the quality of care and increase ANC coverage, particularly in LMICs. The focused ANC (FANC) model, also known as the basic ANC model, includes four ANC visits occurring between 8 and 12 weeks of gestation, between 24 and 26 weeks, at 32 weeks, and between 36 and 38 weeks.
- *Use of bednet* was measured as a dummy variable equal to 1 if some or all children under the age of 5 in the household slept under a bed net the previous night.
- *Child immunization* was measured as a dummy variable equal to 1 if children from 1 to 5 years old received all vaccination from the Extended Program on Immunization. This EPI includes 4 vaccines: BCG vaccine, DPT/pentavalent vaccine, OPV vaccine, and measles vaccine, and should be completed by the time the children are 9 months old. The BCG vaccine (named after its inventors Calmette and Guérin) targets tuberculosis and is injected at birth. The DPT vaccine targets diphtheria, pertussis, and tetanus. After 2005, the DPT vaccine has been replaced by the Pentavalent vaccine which additionally targets hepatitis B and Haemophilus influenzae type b (Hib) disease. Both vaccines are injected at 6, 10, and 14 weeks. The OPV vaccine targets polio and is also injected at 6, 10, and 14 weeks. The measles vaccine is injected at 9 months. For vaccination requiring three doses, we considered receiving the third dose of vaccine as full vaccination.

These outcomes were chosen according to the availability of data and to account for the main health issues in Senegal. Indeed, maternal care, malaria prevention, and child immunization are well-known preventive healthcare behaviors and are of paramount importance within the Senegalese epidemiological context. In 2010, neonatal disorders, diarrheal diseases, lower respiratory infection, and malaria were indeed the four main causes of death for children under-5 according to the IHME. For this specific year, maternal disorder alone caused 1705

deaths, while tuberculosis caused 3700 deaths. Malaria and measles were responsible for 14.5% and 3.8% of under-5 deaths respectively.

Control variables corresponded to socio-economic and demographic variables and included localization of residence (urban or rural), wealth index factor (a composite measure of a household's cumulative living standard), mother's age, highest educational level (no education, primary, secondary, or higher), marital status (married or living together vs single, divorced, or widowed), employment status (working or unemployed) and children birth order⁹. These variables were collected from the DHS datasets and MIS datasets. Children's birth order was preferred over the total number of children to account for shifts in parental knowledge and behaviors as they gain more experience with children. DHS program proposes the construction of a wealth income indicator (Rutsetin & Johnson, 2004) instead of household income which is extremely difficult to measure accurately. DHS surveys collect a number of variables, usually for purposes other than ascertaining economic status which are thought to be correlated with a household's economic status. Almost all household assets and utility services available, such as type of flooring, water supply, type of vehicle, ownership of agricultural land, etc..., are included in the construction of the wealth index factor. In addition, an indicator of healthcare centers' density at the regional level was included. This measure was constant throughout the whole study period and was obtained from the Service Provision Assessments (SPA) dataset of 2012. This database contains a representative sample of health facilities (health huts, health centers, hospitals, and health posts) in Senegal, and their GPS coordinates. To construct an indicator of health facility density, we aggregated the number of health facilities per region and divided the resulting value by the surface area in each region. However, only fixed health facilities were included in the indicator; itinerant healthcare services were not included, which may lead to an under-representation of healthcare services in rural areas.

Depending on outcome variables, the availability of data was different. Thus, for each outcome, different datasets were used. Table 1 displays which waves of DHS or MIS were used depending on the outcome considered. More recent surveys were also available, but we choose not to include them due to the recent development of new internet infrastructures in

⁹ Expect in regressions including MIS 2008 database in which employment and marital status of the mother were not available.

Senegal which increases the risk of individuals considered as controls being in reality treated (i.e. having access to the internet).

	Before optic-fiber cable arrival			After optic-fiber cable arrival		
	DHS 1997	DHS 2005	MIS 2008	DHS 2012	DHS 2014	DHS 2016
Use of antenatal care	X N=7146	X N=6604			X N=4375	X N=4470
Use of bednet		X N=10 202	X N=15 217	X N=6771	X N=6629	
Child immunization		X N=7243		X N=5154	X N=5154	

Table 3-1: DHS wave used by outcome

Note: This table indicates the surveys used depending on the outcome considered (one line per outcome). The number of observations in each survey is also included.

Access to broadband internet (our treatment variable) was measured by the distance from the backbone network, only backbone cables that have been installed prior to the arrival of broadband were considered. Data on the localization of the backbone network and on the date of the cables' installation was obtained thanks to the Afterfibre database (www.afterfibre.nsrc.org). The date of arrival of the submarine cable, and thus connection, was obtained from www.infrapedia.com.

It is important to note that GPS localization in DHS is not exact. Indeed, to protect the confidentiality of respondents the geo-located data are displaced up to 2km in urban areas and up to 5km in rural areas (and even can go up to 10km every 100th point). The displacement is a random direction/random distance process, and the new location is checked to make sure it falls within the designated administrative boundaries, i.e., within the same district in Senegal. Several analyses have been made on the impact of displacement. For example, for the 2010 wave in Senegal (not used in this study as it was the year of optic-fiber cable arrival) the average displacement was 0.92 km in urban areas and 2.36 km in rural areas (Burgert et al., 2013). Despite the inexact localization of our individuals, a household actually living within a 1-kilometer distance from the backbone network has a higher chance to be relocated in the 1-kilometer area around the network than a household located 1.5 kilometers away or more from the backbone network. Then, inexact localization in DHS data does not prevent the creation of the control and treatment groups but only implies interpreting our results as 'intention to treat' estimators.

To ensure the robustness of our analyses, we incorporated additional data sources. Population density information was obtained from the WorldPop hub (<https://hub.worldpop.org/>), which provides highly precise spatial demographic data for countries worldwide. We utilized gridded population counts data with a resolution of 30 arc seconds, available since 2000¹⁰. This data source enabled us to assess population density at a fine-grained level. For information on the localization of healthcare centers, we referred to the dataset available at https://data.humdata.org/dataset/hotosm_sen_health_facilities. This dataset, derived from OpenStreetMap data, not only provides the location of healthcare facilities but also includes some of their characteristics. To enrich our analysis, we computed the distance between each cluster of surveyed individuals and the nearest healthcare facility. By incorporating these additional datasets, we aimed to capture the influence of healthcare accessibility on our research outcomes, thus enhancing the robustness of our findings. However, this database is not exhaustive and includes currently existing healthcare structures today, while structures might have been created during or after the arrival of broadband internet.

2.3. Data analysis

Two different empirical strategies, both based on the Difference-in-Differences (DiD) methodology, were used to estimate the impact of broadband internet on the three outcomes considered. DiD relies on several assumptions, the main one being the parallel trend assumption. Indeed, to ensure internal validity, DiD assumes that in the absence of treatment, the difference between the 'treatment' and 'control' groups would be constant over time. DiD also requires the intervention to be unrelated to the outcome at baseline, and the composition of the two groups to be stable over time, in the case of repeated cross-sectional design as it is the case here.

The first methodology follows the work of Hjort & Poulsen (2019), who assessed the impact of the arrival of high-speed internet on employment in Africa, and used a DiD methodology with fixed effects to estimate the causal impact of the arrival of broadband internet on preventive health behaviors in Senegal. Fixed effects based on localization (10*10kms cell-

¹⁰ Open data available at this address <https://hub.worldpop.org/geodata/listing?id=29> accessed June 2023

level characteristics) were included in regression analysis along the aforementioned control variables. The databases used for this methodology were the ones presented in table 1.

The model estimated with this first methodology is specified by equation (1):

$$Y_{ijt} = \alpha + \beta * SubCables_t * Connected_i + \delta_j * Connected_i + X_{it} + \gamma_t + \epsilon_{ijt} \quad (1)$$

Where Y_{ijt} is one of the three health outcomes (use of antenatal care, use of bednet, child immunization) for an individual i in cell j and at time period t . $SubCables_t$ is a dummy variable indicating whether the submarine cable was available in the country at time t . $Connected_i$ corresponds to the treatment variable, based on the distance to the backbone cables. The coefficient on the interaction between the arrival of submarine cables and individuals' distance from the network β is our coefficient of interest as it measures the impact of internet access on health behaviors. The δ_j coefficient (10*10kms cell-level fixed effects) captures time-invariant differences in health outcomes between treatment and control groups. X_{it} is a vector of control variables for an individual i at time t and γ_t corresponds to time fixed effects.

Figure 3-3 provides a zoom of Figure 3-2 of the coast of Senegal around the city of Thiès, to better illustrate individuals included in our analyses. People living between 0 and 1000m of the backbone network were considered connected, as illustrated by the red dots, and thus constitute the treatment group, whereas people living between 1500m and 10km were considered unconnected (green dots) and constitute the control group. As a result, people living between 1000m and 1500m (blue dots) from the backbone network were excluded. We also excluded individuals living further than 10km (purple dots) as we considered those individuals to be too different from a socio-economic point of view from those living in connected areas, and we want to avoid including less comparable individuals. We chose this double cut-off of 1000m and 1500m given the fact that there is no clear consensus on the distance until which the quality of the bandwidth is acceptable. The most conservative definition for the treated group (1000m) and the least conservative definition for the control group (1500m), based on internet speed attenuation (see Section 2.1), was used to limit the risk of an individual being wrongly attributed to a group. This distinction between connected and unconnected areas slightly differed from the one used by Hjort & Poulsen (2019) who

defined 500m as the maximal distance acceptable. However, no clear justification for that very restrictive threshold was given in their paper.

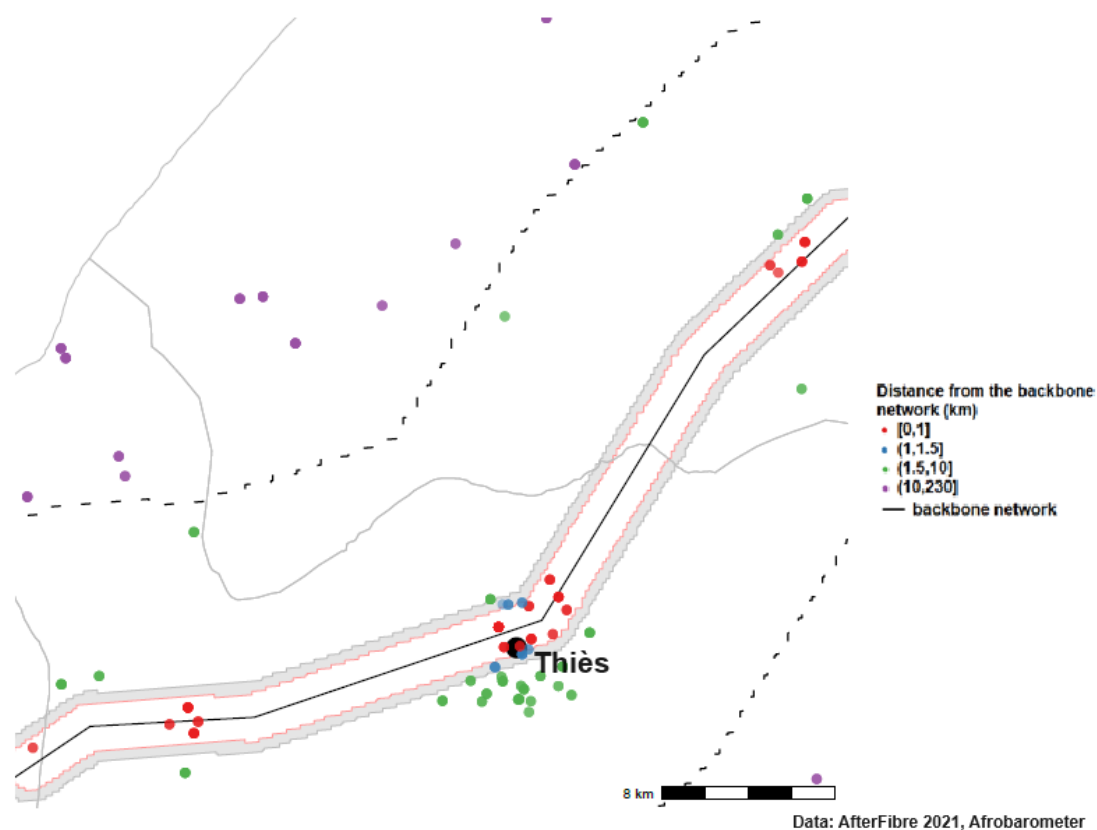


Figure 3-3: Connected vs unconnected

Note: This map zooms in on a specific area near Thiès, Senegal, representing the connectivity status of respondents based on their proximity to a central backbone (represented by a black line). Buffers demarcate integration into treatment or control groups, excluding individuals outside these zones. Additionally, those between 1km and 1.5km from the backbone are excluded. Colors indicate distance from the backbone.

As DHS surveys are not panel data but repeated cross-sectional surveys, the second methodology used in this study was DiD with coarsened exact matching. Exact matching provides perfect balance but produces few matches with continuous variables. Coarsened exact matching temporally coarsens continuous variables into strata to operate the matching. The `-cem-` Stata® command (Blackwell et al., 2009) was used to perform this matching. The variables used for matching at baseline were the localization of residence, household wealth index factor, age, highest educational level, working and marital status of the mother, and child birth order. For categorical variables (localization of residence, highest educational level,

working status, and marital status), exact matching was used while for continuous variables, bins were created. The age of the mother was divided into four strata, each covering 8 years (15-23; 24-32; 33-40; 41-49). The household wealth index factor was divided into five strata by quintile while child birth order was divided into 4 strata based on the distribution (1st kid; 2nd or 3rd; 4th or 5th; 6th or above). For the use of antenatal care, out of the 965 strata created, 532 were matched representing 11 847 observations out of 12 693 (93%). For the use of bednet out of the 364 strata created, 277 were matched representing 15 514 observations out of 15 750 (98%). Finally, for child vaccination, out of the 844 strata created, 469 were matched representing 8 897 observations out of 9 625 (92%). Once the weights were obtained from the matching, ordinary least squares regression was used.

In robustness analyses, urban and rural areas were analyzed separately. Then, the cut-offs for treated and controls were modified to limit the bias linked to the displacement of GPS localizations. In the second robustness analysis, we modified the control group to include people living between 3km and 10km from the backbone network in urban areas and people living between 6km and 10km from the backbone network in rural areas. In a third robustness analysis, the cut-off of 500m used by Hjort & Poulsen (2019) for the treated group was considered. Finally, alternative coding of the health outcomes was used. Regarding antenatal care, different cut-offs were considered (8 visits as recommended since 2016 or 3 visits as recommended before 2002). Regarding the use of bednet, we considered a dummy variable equal to 1 only if all under-5 children slept under a bednet during the previous night and we restricted to household with bednets. Regarding vaccination, analyses were disaggregated by vaccines. In addition, robustness analysis performed heterogeneity analyses by wealth quintile and educational level. As the methodology with cells fixed effects relies on the hypothesis of no migration over time some robustness analyses with a measure of population density were performed. Lastly, since our proxy for healthcare offer (density of healthcare structures) extracted from the SPA database is not perfect, the main regressions were conducted with an alternative measure, the distance to the closest healthcare facility.

Geographical data were dealt with using R while regression analyses were run using Stata® version 17. With both methodologies, the same datasets were used.

3. Results

Table 3-2 displays the descriptive statistics before and after treatment. As the years considered varied from one outcome to another given data availability, the table is split into panel A for the use of antenatal care, panel B for the use of bednet, and panel C for child immunization. At baseline there was a higher utilization of antenatal care from respondents living connected in areas, this difference was still significant after treatment following progress in both treatment and control groups. In detail, before treatment, only 29% of respondents were using antenatal care in the control group, whereas this percentage was up to 35% in the treated group. After treatment, the use of antenatal care was around 52% and 58% in the control and treatment groups, respectively. The use of bednet was significantly higher for the treated group both before (45% vs. 41%) and after treatment (73% vs. 57%). This difference between the two groups increased over time. Child immunization was equal to 59% at baseline for the two groups. After treatment, the mean vaccination score was 73% and 72% for unconnected and connected respondents, respectively. In all cases (panels A, B, and C) respondents living in connected areas were on average more urban, wealthier, and more educated than unconnected respondents, both before and after treatment.

Variables	Before [†]			After [°]		
	Control (1.5-10km)	Treated (0-1km)	Difference	Control (1.5-10km)	Treated (0-1km)	Difference
Panel A: Use of antenatal care						
Outcome	0.30 (0.46)	0.35 (0.48)	-0.05 ***	0.52 (0.50)	0.58 (0.49)	-0.06 ***
Controls						
Urban	0.45 (0.50)	0.65 (0.48)	-0.20 ***	0.38 (0.48)	0.75 (0.43)	-0.36 ***
Age	29.77 (7.20)	29.58 (7.35)	0.18	29.83 (7.29)	30.05 (7.10)	-0.26
Wealth index	0.21 (1.15)	0.33 (0.93)	0.12 ***	0.39 (10.17)	5.10 (8.49)	-4.89 ***
No education	0.69 (0.46)	0.61 (0.49)	0.07 ***	0.64 (0.48)	0.49 (0.50)	0.14 ***
Primary	0.21 (0.41)	0.29 (0.45)	-0.08 ***	0.22 (0.42)	0.30 (0.46)	-0.07 ***
Secondary or higher	0.10 (0.30)	0.10 (0.29)	-0.00	0.13 (0.34)	0.20 (0.40)	-0.07 ***
Married or living together	0.92 (0.27)	0.92 (0.27)	0.00	0.94 (0.24)	0.88 (0.33)	0.06 ***
Currently working	0.48 (0.50)	0.48 (0.50)	0.00	0.41 (0.49)	0.43 (0.50)	-0.02
Child birth order	4.05 (2.67)	3.93 (2.66)	0.12 *	3.68 (2.40)	3.43 (2.27)	0.21 ***
N	4010	2003		2347	986	
Panel B: Use of bednet						
Outcome	0.41 (0.49)	0.45 (0.50)	-0.05 ***	0.57 (0.50)	0.73 (0.44)	-0.17 ***
Controls						
Urban	0.38 (0.49)	0.59 (0.49)	-0.21 ***	0.39 (0.49)	0.76 (0.43)	-0.36 ***
Age	29.27 (7.02)	28.85 (7.02)	0.42 ***	29.67 (6.87)	29.79 (6.87)	-0.12
Wealth index	0.70 (8.10)	1.88 (5.97)	-1.19 ***	0.92 (9.78)	3.71 (8.68)	-2.80 ***
No education	0.71 (0.45)	0.62 (0.49)	0.09 ***	0.65 (0.48)	0.51 (0.50)	0.14 ***
Primary	0.22 (0.41)	0.28 (0.45)	-0.06 ***	0.24 (0.43)	0.32 (0.47)	-0.08 ***
Secondary or higher	0.07 (0.26)	0.09 (0.29)	-0.02 ***	0.11 (0.31)	0.17 (0.37)	-0.06 ***
Child birth order	3.75 (2.52)	3.51 (2.40)	0.24 ***	3.53 (2.35)	3.43 (2.36)	0.10
N	7328	3333		3350	1477	

Panel C: Child Immunization						
Outcome	0.59	0.59	0.00	0.73	0.72	0.01
	(0.49)	(0.49)		(0.44)	(0.45)	
Controls						
Urban	0.43 (0.49)	0.67 (0.47)	-0.25 ***	0.40 (0.49)	0.76 (0.43)	-0.36 ***
Age	29.68 (6.84)	29.53 (6.90)	0.16	30.11 (6.89)	30.35 (6.76)	-0.24
Wealth index	0.05 (1.06)	0.33 (0.87)	-0.28 ***	1.00 (9.73)	3.88 (8.70)	-2.88 ***
No education	0.72 (0.45)	0.60 (0.49)	0.12 ***	0.66 (0.48)	0.52 (0.50)	0.14 ***
Primary	0.21 (0.41)	0.30 (0.46)	-0.09 ***	0.24 (0.43)	0.33 (0.47)	-0.08 ***
Secondary or higher	0.07 (0.26)	0.10 (0.30)	-0.03 ***	0.11 (0.30)	0.16 (0.37)	-0.06 ***
Married or living together	0.94 (0.23)	0.95 (0.22)	-0.01	0.94 (0.23)	0.88 (0.32)	0.06 ***
Currently working	0.33 (0.47)	0.42 (0.49)	-0.09 ***	0.42 (0.49)	0.51 (0.50)	-0.09 ***
Child birth order	3.67 (2.52)	3.55 (2.42)	0.12	3.50 (2.35)	3.46 (2.38)	0.04
N	2077	1255		2603	1153	

† for Panel A: 1997 & 2005; for Panel B: 2005 & 2008; for Panel C: 2005

‡ for Panel A: 2014 & 2016; for Panel B and C: 2012 & 2014

Means with standard errors in parentheses

*** p<0.01; **p<0.05; *p<0.1

Table 3-2: Descriptive Statistics

Note: the first 3 columns “Before” refer to the period before arrival of broadband connection in Senegal while the last 3 columns “After” refer to the period of the arrival of broadband connection. The treatment group is composed of all individuals located between 0 and 1000 meters from the closest backbone. The control group is made up of individual who are located between 1500 meters and 10 kms from the backbone.

In addition, the variable “density of healthcare structures”, used as a proxy of the healthcare supply at the regional level in 2012, varied from 0.09 to 5.57 per 100 000 km² with an average of 1.45. As part of the robustness analyses, the distance from the closest healthcare facility was used. The distance varied from 0.1 km to 4.5 km with an average of 6.4km. We looked at the distance for connected and unconnected respondents separately. For connected respondents, the average distance was 4.8 km whereas for unconnected respondents the average distance was 7.1 km, this difference being significant (t=22, p<0.01).

Before conducting the regression analyses, the parallel trend assumption (i.e., the stability in the difference in the outcome variable between the ‘treatment’ and ‘control’ group over time in the absence of treatment) was checked as illustrated by Figure 3-4. For the use of antenatal

care and bednet, the years displayed in Figure 3-4 were the ones used for regression analyses. For child immunization, the 1992 wave (the most recent wave available before 2005) was added to the graphical representation but was not used in regression analysis as it was judged too old. Graphically, the parallel trend assumption seems to hold for all three outcomes. Indeed, before the arrival of submarine optic-fiber cables in 2010, represented by the vertical red line, outcome variables appeared to evolve in parallel. In addition, placebo tests with an earlier treatment date were performed for all the three outcomes. Placebo tests consist of running the regression with a fake treatment date prior to actual treatment, necessitating at least two periods before the treatment. No impact was found for our three outcomes confirming our visual impression that before actual treatment our two groups had similar evolution. Results of these tests are available in Appendix 1.

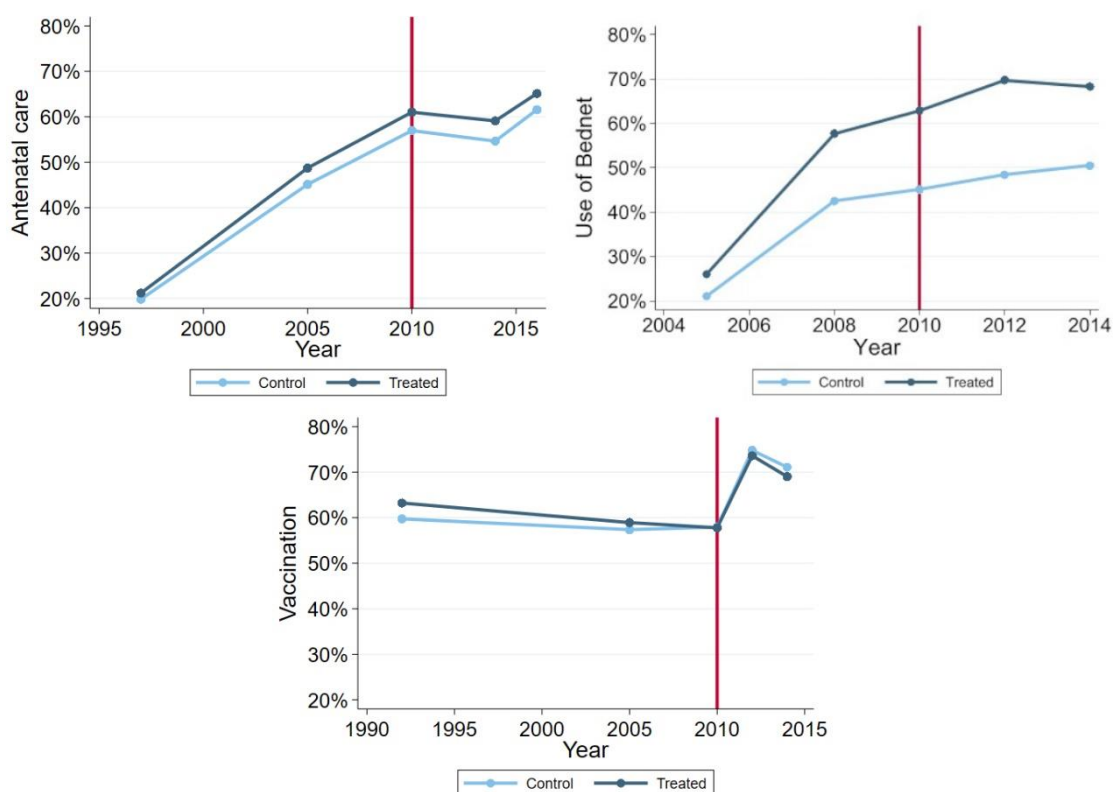


Figure 3-4: Parallel trend assumption

Note: In this figure, each point represents the share of individual having used antenatal care, bednet, and child immunization for the specified group and for each available wave. The treatment group consists of individuals located within 1000 meters of the nearest backbone. The control group consists of those located between 1500 meters and 10kms.

The results of the regression analyses are presented in Table 3-3. Mixed results were found regarding the utilization of antenatal care. While the first methodology using fixed effects highlighted a positive and significant association between broadband internet access and the use of antenatal care, the second methodology pointed to no impact. Regarding the utilization of bednet, our results pointed out a positive effect of the arrival of broadband internet with both methodologies. As could be expected from the descriptive statistics, broadband internet access did not seem to impact child immunization. Results of regression analyses including all control variables are available in Appendix 2.

Outcome	Fixed Effects	Matching	Impact of broadband
Use of antenatal care	0.057* (p=0.058) N=9346	-0.030 (p=0.240) N=8703	Positive / Not significant
Use of bednet	0.143* (p=0.056) N=15488	0.078*** (p<0.001) N=15254	Positive
Child immunization	-0.060 (p=0.460) N=7088	-0.007 (p= 0.822) N=6551	Not significant

*** p<0.01; **p<0.05; *p<0.1

Table 3-3: Results of regressions analyses

*Note: The "Fixed Effects" column displays the reported estimates of the β coefficient on the $Subcables_t * Connected_i$ variable in model (1). Time Fixed Effects correspond to years, while Location Fixed Effects represent grid-cells of 0.1*0.1 decimal degrees, approximately equivalent to 10*10 km. Individuals within a 1km proximity to the backbone network are classified as connected, while those located between 1.5km and 10km from the backbone are considered controls. Robust standard errors are clustered at the level of Location Fixed Effects. The regressions include control variables such as urban or rural classification, age, wealth index, education level, marital status and employment status of the mother, and child birth order. The "Matching" column presents the estimation results of the Difference-in-Differences (DiD) analysis with coarsened exact matching, based on the localization of residence, household wealth index factor, age, highest educational level, working status and marital status of the mother, and child birth order variables. Each row reports the results for a distinct outcome variable.*

Several robustness analyses were conducted to confirm the main findings. First, the main analysis was performed for urban and rural areas separately. Results are displayed in Table 3-4. Our main finding regarding the positive impact of internet access on the use of bednet was confirmed. Use of antenatal care also seemed to increase for connected respondents in

urban areas, but not in rural areas. On the contrary, internet access was found to decrease child vaccination in rural areas.

	Urban areas		Rural areas	
Outcome	Fixed Effects	Matching	Fixed Effects	Matching
Use of antenatal care	0.087*** (p=0.009) N=4769	-0.016 (p=0.632) N=4506	0.062 (p=0.536) N=4577	-0.047 (p=0.259) N=4197
Use of bednet	0.118 (p=0.149) N=7200	0.095*** (p<0.001) N=7130	0.279*** (p<0.001) N=8288	0.057* (p=0.078) N=8124
Child immunization	-0.057 (p=0.574) N=3637	-0.001 (p=0.973) N=3441	-0.338*** (p=0.001) N=3451	-0.018 (p=0.686) N=3110

*** p<0.01; **p<0.05; *p<0.1

Table 3-4: Results of robustness analyses for urban and rural areas

Note: The same models (Fixed Effects and Matching) are estimated by subgroups of individuals (urban areas vs rural areas).

Secondly, the cut-offs used to classify connected and unconnected respondents were modified as explained in the material and methods section. Results are displayed in Table 3-5. The positive association between internet access and the use of bednet was confirmed in the first two specifications. A positive impact of internet access on antenatal care utilization was found when the distance to the backbone used to identify connected respondent is reduced, supporting the mixed results found in the main specification. However, given the displacement of the data and the lack of support for the 500m limit from a technical point of view, results with this cut-off should be treated with caution. Lastly, child immunization did not seem to be impacted by internet access in robustness checks.

Outcome	Control group > 3km (urban area) or > 6km (rural area) from backbone		Analysis of urban areas only and control group > 3km from backbone		Treatment group <500m and control group > 500m from backbone		Treatment group <500m and control group > 3km (urban area) or >6km (rural area) from backbone	
	Fixed Effects	Matching	Fixed Effects	Matching	Fixed Effects	Matching	Fixed Effects	Matching
Use of antenatal care	0.073 (p=0.145) N=5926	-0.009 (p=0.789) N=5609	0.086 (p=0.150) N=3360	0.020 (p=0.645) N=3201	0.091*** (p=0.002) N=10375	0.049* (p=0.094) N=8703	0.112** (p=0.040) N=4657	0.053 (p=0.163) N=4394
Use of bednet	0.172** (p=0.015) N=9464	0.077*** (p= 0.001) N=9343	0.161** (p=0.042) N=4936	0.073** (p=0.022) N=4790	0.068 (p=0.581) N=17491	0.016 (p=0.493) N=14905	0.141 (p=0.272) N=7205	0.023 (p= 0.433) N=6979
Child immunization	-0.035 (p=0.712) N=4642	0.008 (p= 0.844) N=4360	-0.050 (p=0.666) N=2679	-0.001 (p= 0.978) N=2545	-0.069 (p=0.205) N=7901	-0.052 (p=0.118) N=6551	-0.008 (p=0.926) N=3429	-0.033 (p= 0.444) N=3218

*** p<0.01; **p<0.05; *p<0.1

Table 3-5: Results of robustness analyses with different cut-offs for treated and control group

Note: The same models (Fixed Effects and Matching) are estimated by varying the connection radius and the distances to determine the control group.

Alternative coding of the outcomes was also tested with Table 3-6 displaying the results. Once again, the main findings were confirmed. Mixed results were found regarding the use of antenatal care while a positive effect of broadband internet on bednet use was evidenced and no effect on child immunization was found.

Outcome	Fixed Effects	Matching
Use of antenatal care	0.057* (p=0.058) N=9346	-0.030 (p=0.240) N=8703
	-0.019 (p=0.680) N=9346	-0.017 (p=0.403) N=8703
	0.010 (p=0.196) N=9346	0.012** (p=0.049) N=8703
Use of bednet	0.143* (p=0.056) N=15488	0.078*** (p<0.001) N=15254
	0.121* (p=0.062) N=15488	0.071*** (p=0.001) N=14905
	0.123* (p=0.070) N=15152	0.080*** (p<0.001) N=14558

Child immunization	<i>Complete EPI</i>	-0.060 (p=0.460) N=7088	-0.007 (p= 0.822) N=6551
	BCG vaccination	-0.039 (p=0.214) N=9071	-0.014 (p=0.305) N=8399
	DPT/Pentavalent vaccination	-0.030 (p=0.455) N=9052	-0.005 (p=0.812) N=8381
	OPV vaccination	-0.017 (p=0.781) N=9055	0.005 (p=0.827) N=8384
	Measles vaccination	0.003 (p=0.964) N=9017	0.007 (p=0.785) N=8346

*** p<0.01; **p<0.05; *p<0.1

Table 3-6: Results of robustness analyses with different outcomes

Note: The same models (Fixed Effects and Matching) are estimated by changing the outcomes used. Original outcomes are in italics.

In addition, as our outcomes, and especially child vaccination, could have been affected by disinformation spread on the internet some heterogeneity analyses were conducted. As income or education levels were found to be linked with the probability to holds such beliefs (Douglas et al., 2019), analyses based on the quintile of wealth and educational level were performed to identify a potential differentiated effect of internet access. Results are available in Appendix 3. The main findings were confirmed, no matter the level of wealth or education internet access did not impact children's vaccination except for those with a secondary or higher education level for which a positive impact was found. The use of bednet increased for respondents with lower levels of wealth (poorest, poorer, intermediate) or education (no education, primary) and the effect on the use of antenatal care remained uncertain.

Robustness analyses conducted with the variation of population density over time showed no major migration of individuals from unconnected areas to connected areas. More details are available in Appendix 4.

Lastly, as controlling for healthcare supply is important but our indicator of healthcare centers' density has some limits (available only at the regional level and constant throughout the period studied) supplementary analyses were conducted using the distance to the closest healthcare facility. However, this alternative measure also bears some limits as we do not have

information on the date of creation of the healthcare facilities, thus this variable is constant throughout the period studied. Using this alternative variable, our results still hold, and no difference is observed as shown in Appendix 5.

4. Discussion

According to our initial hypothesis, the arrival of broadband internet, and thus of increased information flows, combined with exposure to a variety of information sources was expected to increase knowledge in the healthcare domain translating into higher preventive healthcare demand. However, we found mixed results regarding the impact of broadband internet on various preventive health behaviors. Confirming our initial hypothesis, access to the internet was associated with an increase of bednet utilization for under 5 children. Heterogeneity analyses highlighted this positive impact for respondents with lower levels of wealth or education. Results regarding the impact of internet access on the utilization of antenatal care remained unclear, since there seemed to be a positive impact in some of our specifications, especially in urban areas, but not in others. Finally, no significant result was found in regression analyses regarding child vaccination, meaning that internet access did not seem to influence child immunization.

The positive association between internet access and some preventive health indicators (use of bednet in particular) is a positive finding for public authorities. Indeed, once broadband internet access is established, communication campaigns, which are among the most cost-effective interventions in the health domain, can easily be set up. As a result, the health of the population could be improved at low costs. Such campaigns have proven to be effective (Wakefield et al., 2010). Still, an important challenge remains for public authorities in order to make sure that information of quality is easily accessible on official websites and in all the languages needed.

The mixed or non-significant results for some of the outcomes studied (use of antenatal care and child immunization) seem in line with recent literature on the subject (Edmeades et al., 2022). It could be explained by the fact that people may use the internet rather for entertainment purposes than for informative purposes (Falck et al., 2014). Indeed, online care-seeking behaviors might be uncommon at first and public authorities may need to launch

official platforms and online health promotion campaigns to provide trusted health information and build e-health literacy capacity among the population. Moreover, as evidenced by the literature presented in the introduction section, information provision can have a heterogeneous effect on different types of behaviors. Thus, it is also possible that access to broadband does not impact all preventive health behaviors, and therefore more research is needed to understand why internet access has a heterogeneous impact on various health behaviors. One explanation could be linked to the results of Jalan and Somanathan (2008) who found that giving specific information on contamination of water sources (i.e., telling each household the actual level of fecal contamination) led to deeper changes in healthcare behaviors (i.e., purifying their water) compared to the households that were only informed about the general importance of treating water. Our mixed results might then be explained by the lack of specific and targeted information online. In addition, it is also possible that the length of exposure to information matters regarding its effect on healthcare behaviors. Indeed, in the studies of Cairncross et al. (2005) and Luby et al. (2004) educational interventions were conducted over months and a positive effect was found whereas in the studies reviewed by Meredith et al. (2013) one-time-only visit did not have any effect. Although in our case the potential length of exposition to information is important, but we do not know how frequently respondents looked for information and a one-time visit to a webpage might not be enough to modify behaviors.

It is also important to keep in mind that access to internet can also increase exposition to health misinformation. As the recent COVID-19 pandemic has illustrated, such misinformation can have dramatic consequences on health behaviors (Baranes et al., 2022). In our case, the use of antenatal care and bednet are less likely to be sensitive to disinformation while vaccination is very often affected by fake news that fuel vaccine hesitancy which remains an important issue in Africa (Cooper et al., 2018). This could explain the negative association found between internet access and child immunization in rural areas, combined with difficulties in healthcare access. Indeed, if someone fears vaccination, they will make less effort to go to healthcare centers. However, the heterogeneity analyses conducted highlighted no clear differentiated effect for the poorest or less educated respondents, which are more susceptible to adhere to by conspiracy beliefs (Douglas et al., 2019), pointing to the relatively low influence of such phenomenon in our study. More globally, the quality of the

information found on the internet is a real concern. Eysenbach et al. (2002) conducted a systematic review of studies assessing the quality of health information online and found that 70% of included studies presented significant quality issues. More recently, while analyzing prostate cancer information online, Moola et al. (2020) highlighted that the majority of websites are unreliable as a source of information by themselves for patients. Even though those studies looked at information available online worldwide, and mostly consulted by people living in developed countries, there is no reason to think that the quality of information online is not a matter in SSA also.

Some limitations of this study can be underlined. First, we only measured internet access and not internet use. As some households located in the treatment area are not internet users for financial or other reasons, our analysis tends to underestimate the effect of information provided through internet on health behaviors. However, even if we could not measure actual internet use, according to the International Telecommunication Union, the percentage of individuals using internet was multiplied by more than three between 2009 and 2016 (from 7.5% to 25.6%) in Senegal¹¹. Second, while our outcome variables were more likely to be influenced by mothers, we did not know among households with internet connection which members can decide to buy internet access or use it. Third, we do not have information on possible obstacles to healthcare centers' access, thus mothers might have been informed about the four antenatal care visits recommended thanks to the internet but unable to consult. This could explain why we found a positive effect of internet access in urban areas but not in rural areas where geographical constraints to access are higher. Additionally, traditional awareness campaigns were likely conducted during the period studied allowing respondents from unconnected areas to have access to information they would not have had otherwise, leading to an underestimation of the effect of internet access on health behaviors. Internet access could also possibly affect the healthcare supply and introduce some bias in our results. Indeed, doctors and others skilled workforce might also benefit from easier access to information to improve their medical practice. However, as our outcome variables fall under primary care and only require basic medical knowledge, it is unlikely that such issues affected our results. Indeed, medical workers should already know the importance of antenatal consultations, child vaccination, and bednet utilization without internet. Moreover,

¹¹ <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx> accessed June 2023

vaccination or prenatal monitoring require in person-consultation and cannot be done via tele-consultation since physical acts are needed. However, internet access can influence the management of vaccine stocks and allow easier access to bednet purchase. Moreover, as mentioned in the data section, GPS localization is not exact in DHS data. As a result, some individuals might have been wrongly assigned to treatment and control groups, especially in rural areas where displacements for anonymity reasons can be made further away. However, to tackle this issue, we conducted different robustness analyses using different backbone distance cut-offs for treatment and control groups and a sub-analysis on urban areas only. All these robustness analyses confirmed the results of the main analysis then pointing to no or a low bias introduced by this issue. At last, we did not consider the migration of individuals over time, as DHS data does not allow it. This could be a problem with the first methodology if some respondents, with specific characteristics, decided to move from unconnected to connected areas because of internet access. However, our robustness analyses using change in population density seem to rule out a major impact of this issue. Moreover, the matching performed in the second methodology allowed us to make sure that differences in observable characteristics among respondents remained constant, therefore limiting this issue. Lastly, as there may be an omitted variable, the causal impact of our results must be used with caution while discussing the results.

In the future, investigations on other sub-Saharan countries could be conducted to confirm our results and to test whether geographical disparities exist. Indeed, the timing of connection to sub-marine cables differed from one country to another in sub-Saharan Africa. The first African submarine internet cables arrived in 2009 and covered the east coast of Africa, while the western part of Africa was connected in 2010-2011 and the southeast part of Africa in 2012. These differences in the timing of optic-fiber submarine cable connection between African countries could be exploited to produce more robust results and to assess whether internet access had a differentiated effect on health behaviors depending on countries. The first studies on the topic seem to point out that relationship between digital resource use and health outcomes are linked to the country's context (Edmeades, 2022), reinforcing the need for further studies to better understand those mechanisms.

If the positive impact of internet access on some health outcomes, such as bednet use, are further confirmed, expansion of broadband internet could have important positive spillover

effects to improve health through increased access to information. Prevention and promotion health campaigns would have to integrate online campaigns as complementary to in-person actions to improve their efficacy and efficiency. On the other hand, equal access to the internet across a territory, especially between rural and urban areas, would be extremely important not to exacerbate already existing geographical health inequalities.

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Appendix

Appendix 1: Results of placebo tests

	Use of antenatal care	Use of bednet	Child immunization
Treatment	0.027 (p=0.46)	0.127 (p=0.11)	-0.032 (p=0.84)
Urban	0.044 (p=0.32)	-0.103* (p=0.05)	0.185** (p=0.02)
Age	0.004*** (p=0.01)	0.003** (p=0.03)	0.006*** (p=0.00)
Wealth index	0.077*** (p=0.00)	-0.001 (p=0.913)	
Education level	0.019* (p=0.07)	0.007 (p=0.64)	0.105*** (p=0.00)
Married or living together	-0.079*** (p=0.00)		-0.079** (p=0.04)
Currently working	-0.030* (p=0.06)		-0.021 (p=0.18)
Kid birth order	-0.023*** (p=0.00)	-0.008** (p=0.04)	-0.021*** (p=0.00)
Density of healthcare center			-.016*** (p=0.00)
Constant	0.164* (p=0.05)	0.322*** (p=0.00)	0.539*** (p=0.00)
2005	0.267*** (p=0.00)		-0.057 (p=0.70)
2008		0.206*** (p=0.00)	
N	9346	10661	4770

*** p<0.01; **p<0.05; *p<0.1

Table 3-7: Results of placebo tests with the first methodology

Placebo tests with an earlier treatment date were performed for all three outcomes with the first methodology. Placebo tests consist of running the regression with a fake treatment date prior to actual treatment (between 1997 and 2005 for antenatal care, between 2005 and 2008 for use of bednet, and between 1992 and 2005 for child immunization). The wave 1992 DHS wave for Senegal was added in order to perform the placebo test for child immunization as at least two periods before treatment are needed. No impact was found for our three outcomes confirming (first line, confirming that before actual treatment our two groups had similar evolutions).

Appendix 2: Full results or regressions analyses

	Use of antenatal care	Use of bednet	Child immunization
Treatment	0.058* (p=0.06)	0.143* (p=0.06)	-0.060 (p=0.46)
Urban	0.022 (p=0.59)	-0.116* (p=0.07)	0.069 (p=0.16)
Age	0.006*** (p=0.00)	0.003** (p=0.02)	0.006*** (p=0.00)
Wealth index	0.012*** (p=0.00)	-0.002 (p=0.21)	0.001 (p=0.82)
Education level	0.043*** (p=0.00)	0.024 (p=0.11)	0.059*** (p=0.00)
Married or living together	-0.089*** (p=0.00)		-0.115** (p=0.02)
Currently working	-0.023 (p=0.14)		-0.010 (p=0.59)
Child birth order	-0.029*** (p=0.00)	-0.007** (p=0.01)	-0.022*** (p=0.00)
Density of healthcare center	-0.026*** (p=0.00)	-0.410** (p=0.03)	-1.181*** (p=0.00)
2005	0.273*** (p=0.00)		
2008		0.267*** (p=0.00)	
2012		0.265*** (p=0.00)	0.136** (p=0.04)
2014	0.210*** (p=0.00)	0.323*** (p=0.00)	0.086* (p=0.06)
2016	0.313*** (p=0.00)		
Constant	0.287*** (p=0.00)	1.589*** (p=0.01)	4.110*** (p=0.00)
N	9346	15488	7088

*** p<0.01; **p<0.05; *p<0.1

Table 3-8: Full results of regressions analyses with the first methodology

	Use of antenatal care	Use of bednet	Child immunization
Treatment	-0.030 (0.240)	0.078*** (0.000)	-0.007 (0.822)
Connected	0.035** (0.017)	-0.044*** (0.000)	-0.013 (0.582)
Submarine	0.176*** (0.000)	0.181*** (0.000)	0.125*** (0.000)
Urban	-0.042*** (0.003)	-0.023** (0.035)	0.044*** (0.009)
Age	0.008*** (0.000)	0.001 (0.382)	0.008*** (0.000)
Wealth index	0.011*** (0.000)	0.002*** (0.009)	0.001 (0.581)
Education level	0.053*** (0.000)	0.019*** (0.009)	0.084*** (0.000)
Married or living together	-0.136*** (0.000)		-0.109*** (0.003)
Currently working	-0.042*** (0.001)		-0.014 (0.350)
Child birth order	-0.031*** (0.000)	-0.000 (0.982)	-0.022*** (0.000)
Density of healthcare center	-0.002 (0.295)	-0.040*** (0.000)	-0.009*** (0.003)
Constant	0.406*** (0.000)	0.517*** (0.000)	0.485*** (0.000)
N	8703	15254	6551

*** p<0.01; **p<0.05; *p<0.1

Table 3-9: Full results of regressions analyses with the second methodology

Appendix 3: Results of heterogeneity analyses

	Poorest		Poorer		Intermediate		Richer		Richest	
Outcome	Fixed Effects	Matching	Fixed Effects	Matching	Fixed Effects	Matching	Fixed Effects	Matching	Fixed Effects	Matching
Use of antenatal care	-0.452** (p=0.001) N=1661	-0.181** (p=0.014) N=1473	0.066 (p=0.585) N=1819	-0.047 (p=0.495) N=1696	-0.002 (p=0.981) N=2214	-0.049 (p=0.309) N=2112	0.154*** (p<0.001) N=2025	0.074 (p=0.141) N=1901	0.056 (p=0.208) N=1627	-0.068 (p=0.232) N=1532
Use of bednet	0.449* (p=0.052) N=2826	0.055 (p=0.391) N=2697	0.205* (p=0.076) N=3595	0.164*** (p=0.001) N=3465	0.116 (p=0.259) N=3819	0.087* (p=0.014) N=3715	0.099 (0.340) N=3015	-0.001 (p=0.986) N=2910	0.132 (p=0.225) N=2233	0.071 (p=0.130) N=2118
Child immunization	0.268 (p=0.625) N=1110	0.092 (p=0.388) N=966	-0.039 (p=0.734) N=1434	-0.122 (p=0.113) N=1636	-0.037 (p=0.685) N=1904	0.018 (p=0.730) N=1798	-0.261 (p=0.122) N=1483	-0.006 (p=0.915) N=1397	0.014 (p=0.933) N=1157	0.021 (p=0.735) N=1068

*** p<0.01; **p<0.05; *p<0.1

Table 3-10: Heterogeneity analyses on wealth quintile

	No education		Primary		Secondary or higher	
Outcome	Fixed Effects	Matching	Fixed Effects	Matching	Fixed Effects	Matching
Use of antenatal care	-0.038 (p=0.532) N=5979	-0.009 (p=0.792) N=5723	0.171*** (p=0.001) N=2263	-0.021 (p=0.666) N=2038	0.057 (p=0.485) N=1104	-0.143** (p=0.035) N=942
Use of bednet	0.122 (p=0.176) N=10210	0.050* (p=0.057) N=10063	0.189** (p=0.047) N=3836	0.111*** (p=0.002) N=3584	0.105 (p=0.266) N=1442	0.088 (p=0.120) N=1258
Child immunization	-0.088 (p=0.379) N=4539	-0.011 (p=0.773) N=4324	-0.133 (p=0.305) N=1827	-0.027 (p=0.603) N=1626	-0.007 (p=0.957) N=722	0.129* (p=0.099) N=601

*** p<0.01; **p<0.05; *p<0.1

Table 3-11: Heterogeneity analyses on the educational level

Appendix 4: Results of robustness analyses on the population density

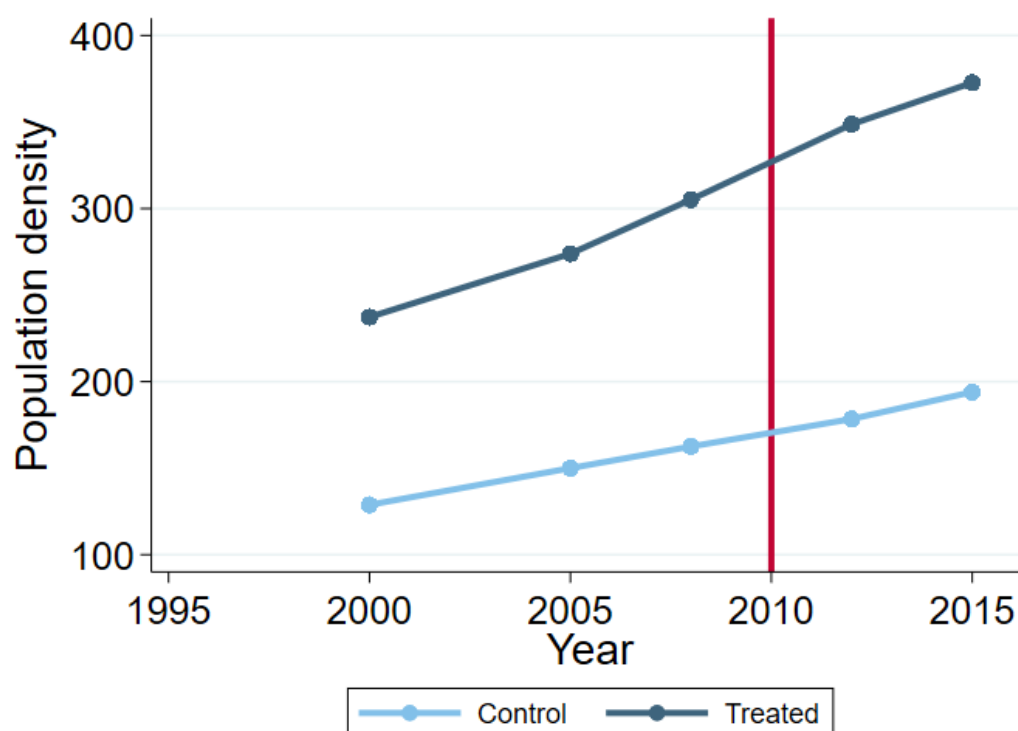


Figure 3-5: Evolution of the density of population in Senegal between 2000 and 2015

From additional data, we checked if the population density evolved due to internet access. Figure 5 shows that in both connected areas (treated group) and unconnected areas (control group), population density increased over the period. However, the increase in density is higher in connected areas than in unconnected areas ($t=3.67$, $p<0.01$). Yet, those results are still reassuring, the growth rate of population density was already higher in connected areas before treatment. The arrival of broadband internet does not seem to have had a huge impact on migrations from unconnected to connected places.

Appendix 5: Results of robustness analyses with alternative proxy of healthcare supply

Outcome	Fixed Effects	Matching
Use of antenatal care	0.057* (p=0.064) N=9346	-0.029 (p=0.268) N=8703
Use of bednet	0.133* (p=0.070) N=15488	0.095*** (p<0.001) N=15254
Child immunization	-0.074 (p=0.356) N=7088	0.001 (p= 0.998) N=6551

*** p<0.01; **p<0.05; *p<0.1

Table 3-12: Results of regressions analyses with distance to the closest healthcare facility instead of density of healthcare center

Chapitre 4 : Conclusion

La question de la mesure de l'efficacité en santé est complexe. Selon le contexte, les enjeux sanitaires et les priorités diffèrent. Pour autant, afin de pouvoir répondre aux besoins de santé de la population et de participer à l'atteinte des ODD, des systèmes de santé performants apparaissent nécessaires. Cette thèse est une contribution à l'analyse des facteurs qui influencent l'efficacité des systèmes de santé et permet d'apporter des éléments de réflexion sur différents leviers d'action possibles. Elle met notamment en exergue les questions de mesure de la performance en santé, les différences existantes selon les pays et la variété des possibilités pour les décideurs publics. Nous revenons, dans cette partie conclusive sur les principaux résultats et contributions des trois articles qui la composent ainsi que sur les discussions soulevées et les futures pistes de recherche.

Principaux résultats et contributions

Le premier chapitre de cette thèse, qui correspond à une analyse rétrospective des recommandations de la HAS sur les médicaments innovants, conclut à plusieurs résultats pertinents dans une perspective d'efficacité. Dans une première partie, l'enjeu était de savoir dans quelle mesure le Service Médical Rendu (SMR - qui détermine le taux de remboursement) et l'Amélioration du Service Médical Rendu (ASMR - qui est utilisé dans la négociation de prix) obtenus par les médicaments innovants reflètent les critères officiellement inclus dans ces indicateurs. Nos résultats, en accord avec ceux du rapport Polton (2014), montrent le pouvoir discriminant contrasté des critères du SMR : le ratio efficacité-effets indésirables a, de loin, le pouvoir explicatif le plus élevé, alors que les critères de sévérité et d'impact sur la santé publique en sont dépourvus. Sous réserve de confirmation sur un échantillon plus large de médicaments à mesure que de nouvelles évaluations sont menées, ces résultats sur les déterminants du SMR semblent indiquer la nécessité d'une réévaluation des critères considérés pour évaluer le bénéfice clinique des nouveaux médicaments en France. En effet, les divergences constatées entre les lignes directrices et les pratiques nuisent à la transparence et à la prévisibilité de la procédure française d'évaluation des technologies de santé, alors que l'application des critères officiels est essentielle pour légitimer une procédure

de hiérarchisation (Daniels & Sabin, 1997). Concernant l'ASMR, les résultats montrent également qu'aucune pénalité n'est observée pour les médicaments anticancéreux n'utilisant pas la survie globale comme critère principal pour mesurer l'efficacité clinique, bien qu'il soit connu que le fait de s'appuyer sur des substituts (e.g., survie sans progression ou sans récurrence) augmente l'incertitude autour de la taille de l'effet en termes de résultats finaux pertinents pour les patients (Ciani et al., 2017 ; Kemp et Prasad, 2017). Dans la perspective d'une harmonisation européenne des évaluations cliniques, le débat sur l'utilisation des substituts devra être tranché et il est intéressant de connaître, au-delà des positions, les pratiques de chaque pays pour converger vers un cadre d'évaluation commun. Dans une deuxième partie, l'étude contribue à combler le manque d'information sur les RDCR des médicaments innovants en France. L'analyse fournit une référence pour les niveaux acceptables de RDCR dans le contexte français, mais montre également comment les entreprises pharmaceutiques s'adaptent à la réglementation. Pour les médicaments innovants entrés sur le marché français entre 2014 et 2020, environ un quart des RDCR déclarés étaient inférieurs au seuil hypothétique de 50 000 €/QALY (Cartier-Bechu et al., 2014) et près de deux tiers (79/123) étaient inférieurs à l'estimation de la valeur du QALY statistique (147 093 €) récemment calculée à partir de la valeur officielle française de la vie statistique (Téhard et al., 2020). L'analyse par régression quantile permet d'étudier comment les facteurs associés aux RDCR revendiqués par les entreprises diffèrent le long de la distribution des RDCR. En passant du quartile inférieur au quartile supérieur, les considérations de caractéristiques individuelles liées à la maladie ou à la population cible se substituent aux considérations de santé au niveau de la population. Au bas de la distribution des RDCR, une association négative entre la taille de la population cible et le niveau des RDCR est constatée. L'anticipation des accords prix/volume, parfois mis en œuvre par le CEPS dans les négociations de prix avec les entreprises pharmaceutiques, pourrait être un élément d'explication de cette association négative (CEPS, 2020). En revanche, au sommet de la distribution des RDCR, nous trouvons des associations positives entre la valeur du RDCR et une indication pédiatrique ou l'absence d'alternative thérapeutique. Ces résultats semblent indiquer que les firmes pharmaceutiques anticipent le soutien collectif des décideurs et du public sur ces critères de priorisation.

Le deuxième chapitre de cette thèse est une étude d'efficience technique des Centres Médicaux Avancés (CMA), qui correspondent aux hôpitaux de district, au Burkina Faso sur la

période 2017-2020. La question de l'efficacité des dépenses de santé est cruciale pour le pays dans la mesure où les financements publics en santé sont drastiquement insuffisants par rapport aux besoins de la population et fortement contraints par la situation macroéconomique et budgétaire. Les CMA ont été sélectionnées en raison de leur fonction centrale dans le système de santé burkinabé et du rôle fondamental qu'ils jouent dans la réalisation des ODD en matière de santé. La réalisation de l'étude a permis de mettre en avant trois principales implications de politiques publiques afin d'améliorer l'efficacité du système de santé burkinabé. En premier lieu, les autorités publiques devraient faire de l'amélioration de l'efficacité des CMA une priorité de haut niveau dans la politique de santé. En effet, il existe une marge d'amélioration considérable pour que les CMA produisent plus de soins sans augmenter les ressources déployées. Avec une grande hétérogénéité entre établissements, les CMA auraient pu en moyenne presque doubler leur production de soins sans ressources supplémentaires au cours de la période étudiée. Deuxièmement, les autorités publiques devraient reconsidérer la répartition du personnel de santé et des ressources entre les CMA. Les CMA situés dans des districts plus peuplés et faisant face à une population plus éduquée et en moins bonne santé ont tendance à être plus efficaces, tandis que ceux situés dans des districts avec une plus grande densité de structures de santé de niveau inférieur ont tendance à être moins efficaces. Ainsi, afin d'augmenter l'efficacité globale du système de santé, une réallocation des ressources pourrait être opérée vers les districts fortement peuplés et où les besoins en santé de la population sont plus importants. Cependant, il peut être tout à fait justifié de maintenir le fonctionnement à l'identique d'un nombre réduit de CMA très inefficaces s'il n'est pas possible de descendre en dessous d'un certain niveau de ressources afin de maintenir la continuité des soins telle que définie dans leurs missions. Il pourrait s'agir d'une forme de subvention fondée sur un critère d'équité, principalement pour les CMA peu efficaces qui opèrent dans des zones où les besoins sont particulièrement importants. Dans tous les cas, des études de cas complémentaires s'appuyant sur une solide connaissance des spécificités locales sont nécessaires avant de procéder à toute réallocation des ressources. Troisièmement, la réalisation de l'étude a mis en évidence d'importants problèmes concernant la qualité des données collectées au niveau des structures de santé au Burkina Faso, soulignant la nécessité pour les autorités sanitaires burkinabé de mieux contrôler leur système d'information sanitaire en intégrant, entre autres actions possibles, des vérifications systématiques des données d'activité rapportées par les structures de santé. En effet, afin de

pouvoir réaliser des études de bonne qualité desquelles découlent des décisions de politiques publiques pertinentes, la qualité de l'information et sa disponibilité sont particulièrement importantes. Ce problème n'est cependant pas spécifique au contexte burkinabé, et la qualité des données de santé a déjà été identifiée comme un défi dans divers pays à revenu faible ou intermédiaire (Lee et al., 2021 ; Lemma et al., 2020 ; Gimbel et al., 2017).

Enfin, le dernier chapitre de cette thèse s'intéresse à l'effet de l'accès à internet sur les comportements de santé préventifs au Sénégal en se concentrant sur le recours aux soins prénataux, l'utilisation de moustiquaires et la vaccination infantile. Comparativement aux soins curatifs, les soins de santé préventifs sont particulièrement coût-efficaces et donc essentiels dans un objectif d'efficience des systèmes de santé. La place des soins de santé préventifs est d'autant plus importante dans les pays à revenu faible, qui sous-investissent très largement dans ce domaine, dans un contexte global de ressources contraintes pour les systèmes de santé. Ce chapitre a pour objectif d'évaluer l'effet de l'arrivée de l'internet à haut débit en 2010 sur le recours aux soins préventif à l'aide d'une méthodologie de doubles différences. En effet, internet est un moyen efficace de transmission de données et de connaissances qui peut fournir des informations sur la santé mais aussi constituer un nouveau mode de connexion à l'environnement médical. Les résultats obtenus montrent que l'utilisation de moustiquaires a significativement augmenté suite à l'arrivée de l'internet à haut débit en 2010. Ce résultat est d'autant plus intéressant que les analyses complémentaires effectuées montrent que l'ampleur de cet effet est plus importante pour les populations pauvres et avec un faible niveau d'éducation. Du point de vue des politiques publiques, l'effet positif de l'accès à internet sur l'utilisation de moustiquaires semble indiquer que des campagnes de communication utilisant ce medium pourraient constituer un outil efficace dans la lutte contre le paludisme au Sénégal. Cet outil est particulièrement intéressant dans la mesure où les campagnes de communication font partie des interventions les plus coût-efficaces dans le domaine de la santé (Wakefield et al., 2010), la santé de la population pouvant ainsi être améliorée à peu de frais. Toutefois, les pouvoirs publics doivent encore relever un défi de taille, celui de veiller à ce que des informations en santé de qualité soient facilement accessibles sur internet via les sites officiels. Les résultats de l'analyse mettent également en avant des effets mitigés ou non significatifs de l'arrivée de l'internet à haut débit sur le recours aux soins prénataux et à la vaccination des enfants qui peuvent s'expliquer de

différentes façons. Premièrement, il est possible que les individus utilisent internet plutôt à des fins de divertissement qu'à des fins d'information (Falck et al., 2014). En effet, les comportements de recherche d'informations en santé en ligne peuvent mettre du temps à se développer après l'arrivée d'internet et les autorités publiques pourraient avoir besoin de lancer des plateformes officielles et des campagnes de promotion de la santé en ligne afin de fournir des informations fiables sur la santé et de renforcer les capacités de la population en matière de santé en ligne. Deuxièmement, la réalisation des vaccinations infantiles nécessite non seulement d'avoir accès à l'information sur la nécessité de la vaccination mais requiert également la disponibilité desdits vaccins ainsi que la possibilité logistique et financière de pouvoir se rendre dans un centre de santé. Ainsi, d'autres barrières à la vaccination peuvent subsister malgré un accès à l'information amélioré. La question des barrières à l'accès aux soins est également présente pour les consultations prénatales alors qu'elle apparaît moins pertinente pour l'utilisation de moustiquaires, ce qui pourrait expliquer les résultats obtenus dans ce dernier chapitre. Il est également important de garder à l'esprit que l'accès à internet peut également accroître l'exposition à la désinformation en matière de santé, en particulier au sein d'une population ayant une faible littératie numérique et en santé. Comme l'a montré la récente pandémie de Covid-19, les informations erronées circulant sur internet peuvent avoir des conséquences dramatiques sur les comportements en matière de santé (Baranes et al., 2022). Si d'autres études menées dans différents pays et sur des périodes plus récentes confirment l'effet positif de l'accès à internet sur certains comportements de santé tels que l'utilisation de moustiquaires, l'expansion de l'internet à haut débit pourrait jouer un rôle crucial pour l'amélioration de l'état de santé des populations des pays à revenu faible en permettant meilleur accès à l'information. Une attention particulière doit cependant être portée à l'égalité d'accès à l'internet sur l'ensemble d'un territoire, en particulier entre les zones rurales et urbaines, afin de ne pas exacerber les inégalités géographiques déjà existantes en matière de santé.

Discussions et futures recherches

Les travaux effectués dans le cadre de cette thèse soulèvent d'autres questions qu'il pourrait être intéressant d'approfondir dans le futur. Les résultats obtenus dans le premier chapitre appellent à se questionner plus largement sur les critères utilisés dans l'évaluation des

technologies de santé en France, au-delà du cas spécifique des médicaments innovants qui, à l'heure actuelle, sont les seuls à faire l'objet d'un avis d'efficience. Cette étude met également en avant la problématique de l'harmonisation européenne des procédures d'évaluation des médicaments afin d'augmenter la comparabilité entre les pays, de mutualiser les ressources et d'améliorer la transparence et la cohérence des évaluations. Il serait également intéressant que de futures études se concentrent sur les mécanismes de régulation des prix des médicaments, en mettant l'accent sur les interactions entre les autorités de régulation, les entreprises pharmaceutiques et les organismes payeurs afin de contribuer à l'amélioration de l'efficience des systèmes de santé. Les travaux du premier chapitre pourraient également être prolongés par des études visant à évaluer si les critères révélés dans ce chapitre correspondent à ceux ayant la plus grande acceptabilité en population générale. En effet, comprendre les attentes et les préférences des patients et du grand public vis-à-vis des critères d'évaluation des technologies de santé est crucial pour participer à la construction de décisions de politique publique éclairées et légitimes. Ce premier chapitre porte sur la France uniquement alors que l'évaluation des technologies de santé est également essentielle dans les pays à revenu faible pour la prise de décision en matière d'allocation des ressources en santé. Il est essentiel de poursuivre les recherches dans ces contextes pour trouver des solutions innovantes et adaptées, en tenant compte des contraintes économiques et des priorités spécifiques de ces pays.

La notion de la qualité des soins n'est pas directement abordée dans les chapitres deux et trois, notamment par manque de données. Pour autant, la question de la qualité des soins est essentielle à l'évaluation de la performance d'un système de santé. En effet, la comparaison de l'activité entre différentes structures de santé n'est valable qu'à qualité égale des soins. Plusieurs façons d'envisager et de mesurer la qualité des soins sont possibles et différentes approches coexistent. Il est d'abord possible de construire un indicateur de qualité des soins via des mesures de satisfaction des patients. Cette approche permet de mieux cerner les attentes de la population et d'affiner les politiques publiques à mettre en place. On peut également envisager des indicateurs de qualité plus factuels visant à mesurer si les soins ou examens réalisés sont pertinents et efficaces, en reportant par exemple l'exactitude des diagnostics, le pourcentage de guérison ou le taux de réadmission. Il faut cependant noter que ces indicateurs pris un à un ne fournissent qu'un aperçu partiel de la qualité des soins,

l'évaluation de leur qualité nécessitant souvent la combinaison de plusieurs indicateurs. La qualité de soins ou d'un système de santé est également indissociable de la notion de sécurité, dont l'objectif est la réduction du risque de préjudice évitable subi par les patients. Selon une étude récente (Kruk et al., 2018), le nombre de décès lié à la qualité des soins est plus important que le nombre de décès lié au manque de soins dans les pays à revenu faible et intermédiaire, illustrant ainsi la nécessité d'une meilleure prise en compte de cette problématique. Dans cette perspective, l'atteinte de la CSU est conditionnée à la qualité de soins (WHO, World Bank, and OECD, 2018). Les futures recherches portant sur l'efficacité des systèmes de santé dans les pays à revenu faible et intermédiaire devraient davantage explorer la dimension de la qualité des soins. Pour cela, un travail sur la disponibilité des données semble essentiel. Cela pourrait impliquer la collecte d'indicateurs spécifiques de qualité des soins (e.g., mesures de satisfaction des patients, mesures d'efficacité des soins) dans les structures de santé, ainsi qu'un travail de comparaison et d'agrégation de ces indicateurs. Il serait également intéressant de mener des travaux comparatifs visant à évaluer les politiques et pratiques en matière de qualité des soins à l'échelle internationale, en mettant l'accent sur les pratiques qui pourraient être adoptées pour améliorer la qualité des soins dans tous les contextes.

Si l'efficacité est souvent présentée comme un objectif à atteindre, il est important de noter que l'inefficacité peut parfois être justifiée et volontaire, notamment pour assurer l'équité dans l'accès aux soins. L'équité, selon l'OMS, implique « *l'absence de différences systémiques et potentiellement remédiables, dans un ou plusieurs aspects de la santé parmi la population qui sont définis socialement, économiquement, démographiquement ou géographiquement* » (WHO, 2010). On peut distinguer deux types d'équité : l'équité horizontale et l'équité verticale. L'équité horizontale implique que les individus reçoivent des soins équivalents pour des besoins équivalents alors que l'équité verticale suppose que les individus ayant des besoins plus importants reçoivent plus de soins. Les notions d'équité et d'efficacité sont souvent perçues comme antinomiques bien qu'elles ne s'opposent pas intrinsèquement. En effet, une allocation inefficace peut être équitable et une allocation efficace peut être inéquitable. Il est également possible qu'une allocation devienne plus efficace sans accroître l'iniquité ou qu'une allocation évolue vers plus d'équité sans réduire l'efficacité (Culyer, 2015). Il est donc essentiel de trouver un équilibre entre efficacité et équité dans la prise de

décisions en matière de santé. Il peut être nécessaire d'être flexible sur les approches à adopter, en tenant compte des spécificités de chaque situation. L'évaluation régulière des politiques de santé, la participation des parties prenantes et la transparence des processus de décision sont, dans ce cadre, importantes pour promouvoir des systèmes de santé plus équitables et efficaces.

Dans un avenir proche, le réchauffement climatique va créer de nouvelles pressions sur les systèmes de santé, en particulier dans les pays où ces systèmes sont déjà fragiles. L'OMS dans son rapport faisant suite à la COP24 qualifiait le changement climatique de « plus grand défi en matière de santé » du XXI^{ème} siècle (WHO, 2018). Le changement climatique est notamment responsable de l'augmentation d'événements climatiques extrêmes, tels que les vagues de chaleur, les inondations ou tempêtes, qui ont des répercussions directes sur la santé en augmentant notamment la transmission des maladies à transmission vectorielle, les troubles respiratoires dus à la pollution de l'air et les maladies d'origine alimentaire (telle que la salmonellose). Face à ces défis, les pays vont devoir renforcer la résilience de leurs systèmes de santé pour faire face aux impacts du changement climatique. La résilience implique la capacité à s'adapter aux nouvelles contraintes et à répondre efficacement aux défis émergents, tout en maintenant la prestation des services de santé essentiels. Cependant, cette tâche est d'autant plus difficile dans un contexte de ressources financières limitées, car la construction de systèmes de santé résilients nécessite des investissements importants. Une coopération internationale et une solidarité mondiale sont donc nécessaires pour soutenir les pays les plus vulnérables dans cette construction. Les transferts de connaissances, le partage d'expériences et l'assistance financière constituent donc des éléments clés pour renforcer la résilience des systèmes de santé face au changement climatique.

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