Universidad de Oviedo

ENSAYOS EN ECONOMIA DE LA SALUD Y JUEGO PROBLEMATICO

Andrey Shmarev Shmarev

PROGRAMA DE DOCTORADO EN ECONOMÍA:

INSTRUMENTOS DEL ANÁLISIS ECONÓMICO

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Introducción

Como señalan, entre otros, Downward and Rasciute (2020), la salud puede considerarse como un activo. La inversión en salud favorece el crecimiento económico, pues implica un aumento del capital humano que repercute positivamente en la productividad del trabajo y favorece la eliminación de la pobreza y la exclusión.

Sin embargo, el gasto en salud como porcentaje del PIB en 2017 solo alcanzó un 8.8% frente al 9.8% de media de la UE (OECD, 2021).[1] Además, las medidas de austeridad implementadas durante la Gran Recesión, y destinadas a reducir los déficits públicos tanto a nivel nacional como regional, afectaron gravemente al sector de la salud. Según datos del Ministerio de Sanidad (2021), la financiación pública en sanidad presentó una tendencia a la baja desde 2009. Así, por ejemplo, en términos de porcentaje del PIB, el gasto público en sanidad descendió de forma sostenida desde el 7% en 2009 al 6,5 % en 2014. Medido en términos *per cápita*, el gasto cayó alrededor de un 12% en ese período. Aunque estos indicadores muestran una mejoría a partir de 2014, el Sistema Nacional de Salud, tanto en atención primaria como especializada, sigue aquejado de importantes problemas que se han visto agravados por la crisis sanitaria del COVID-19. Específicamente, los problemas más graves a los que se enfrenta el Sistema Nacional de Salud son las crecientes listas de espera y una posible pérdida de calidad en la atención médica a medida que los recursos se vuelven más escasos.

A pesar de estas cifras, y según datos de la Comisión Europea, España lideró en 2016 el ranking relativo a la esperanza de vida al nacer (83.5 años) entre los países de la Unión Europea (OECD/EU, 2018). Entonces, ¿qué determina la salud de los individuos? Además de factores genéticos, los condicionantes socioeconómicos son determinantes importantes de los resultados de salud, aún en contextos en los que los servicios sanitarios son universales. Así, aunque en España el sistema sanitario y otros factores relacionados con el cuidado de la salud garantizan unos elevados estándares de salud y, por ello, una elevada esperanza de vida, también existe un porcentaje significativo de la población que vive en situación de precariedad y, por lo tanto, que afronta un mayor riesgo de salud. Por

[1] Es preciso señalar que el gasto en salud ha mejorado en los últimos años (así, en 2019 este gasto fue del 9.1 en España versus el 8.8 para la media de la OECD). No obstante, se reportan datos anteriores por ser más coherentes con los estudios presentados en la Tesis.

ello, el objetivo de esta Tesis es estudiar los determinantes que inciden en la salud, analizando además de factores individuales (edad, educación, situación familiar o comportamientos más o menos saludables), factores socioeconómicos (renta o situación social y laboral). El análisis de este conjunto de factores permitirá ofrecer propuestas sobre la mejor forma de actuar, mediante políticas públicas, con el fin de actuar sobre los factores con consecuencias más graves sobre la salud.

Con este fin, el primer capítulo de la Tesis propone modelizar una función de producción de salud que distinga entre el stock inicial y la inversión en ciertos determinantes de salud, con el objeto de analizar por separado el efecto de las potenciales políticas públicas encaminadas a mejorar los niveles observados en estos determinantes.

Asimismo, la literatura ha puesto especial atención en recalcar la importancia de los desórdenes mentales en la salud pública ya que forman una parte substancial del porcentaje de enfermedades a nivel mundial (Prince et, al 2007). La falta de salud mental es un estado de discapacidad o morbilidad debido a desórdenes mentales o abuso de sustancias. Las causas de los desórdenes mentales son muy complejas y varían dependiendo de su particularidad y del individuo. Estas incluyen elementos que van desde características intrínsecas del individuo (predisposición genética) hasta factores ambientales. Las ediciones más recientes del Manual de Diagnóstico de Enfermedades Mentales (DSM) han considerado las adicciones como desórdenes mentales, incluyendo los desórdenes del juego, juego por Internet y la adicción a Internet. Entre ellos, destacamos la ludopatía (*problem gambling*) al estar asociada con un número importante de efectos adversos de salud (Abbot, 2020). El juego repercute negativamente sobre la salud ya que reduce el bienestar mental de los individuos. Para el individuo, los problemas ocasionados por el juego no están limitados a problemas monetarios (préstamos, pérdida de bienes, bancarrota y falta de vivienda) sino que incluyen, además, estrés psicológico, problemas cardíacos, presión sanguínea, desórdenes del sistema digestivo, etc. Por otro lado, los individuos que participan en actividades de juego suelen también participar en otras conductas poco saludables como una vida sedentaria, consumo de alcohol y tabaco. Por este motivo, el segundo capítulo de la Tesis estudia los factores que intervienen en la recuperación de los individuos con problemas de ludopatía, analizando las condiciones socioeconómicas y comportamientos ligados a las recaídas.

Por otro lado, el acceso a más oportunidades de jugar está muy presente en la adicción al juego. Aquellos barrios con una mayor oferta de juego suelen reportar un mayor nivel de participación en el juego o mayor nivel de recaídas. Así, por ejemplo, Welte et al., (2006) encuentran que la proximidad a la oferta de juego está fuertemente correlacionada con problemas de ludopatía en los individuos. Por ello, en el tercer capítulo de la tesis se analiza si existe un *cluster* de juego en áreas de mayor privación socioeconómica (los individuos en áreas más desfavorecidas tienen mayor tendencia a jugar) y, si las aglomeraciones de *clusters* están asociadas a una mayor incidencia de problemas de salud relacionados con el juego.

La Tesis está estructurada en tres capítulos cuyo contenido se resume someramente a continuación:

Capítulo 1: *Distinguiendo entre el efecto inicial y la inversión en determinantes de salud*

El primer capítulo propone un modelo de producción de la salud que distingue entre el stock inicial de ciertos determinantes de salud y la inversión en ellos. Todo ello, con vistas a proveer de información a los agentes sanitarios en cuanto a los efectos de políticas orientadas a mejorar la salud de los ciudadanos. La aportación de este capítulo es el desarrollo de un modelo teórico y empírico que distinga los efectos sobre la salud de cambios en el stock inicial de ciertos determinantes, de los cambios en la inversión de dichos determinantes. Para su desarrollo se ha utilizado un modelo de frontera estocástica. Se presenta un ejemplo empírico usando datos de los años 2002 y 2008. Los resultados apoyan la decisión de analizar separadamente los efectos de los valores iniciales de los determinantes de salud de manera separada a aquellos derivados de la inversión en el periodo. Más concretamente, los resultados indican que, para variables asociadas a aspectos ligados a comportamientos individuales (por ejemplo, ser o no bebedor), el efecto de una inversión destinada a mejorarlos es significativamente mayor que una variación de los valores iniciales. Sin embargo, en lo relativo a variables relacionadas con factores socioeconómicos tales como la clase social o la situación laboral, se observa que los efectos de una inversión en estos determinantes provocan un efecto menor que cambios en el stock inicial, debido a que estos determinantes tienen un efecto sobre la salud a más largo plazo.

Capítulo 2: *Evaluación de la efectividad del tratamiento del Juego Problemático a través de un modelo mixto multinivel*

En el segundo capítulo se presenta un modelo empírico para evaluar la efectividad del tratamiento en la rehabilitación de jugadores con ludopatía. Los datos, cedidos por las asociaciones españolas dedicadas a problemas de juego, son a nivel de individuos y de centros de tratamiento. Para el análisis empírico, se usa una regresión logística multinivel que permite controlar por la heterogeneidad inobservable de las distintas asociaciones. Los resultados parecen indicar que aquellos aspectos como la edad, historial familiar, estado conyugal, situación laboral o aspectos relativos al comportamiento del individuo (abandonos previos, recaídas durante el tratamiento o consumo de otras sustancias) son relevantes a la hora de evaluar la efectividad de los tratamientos para desórdenes ligados al juego. Este análisis de los predictores de la efectividad del tratamiento puede servir como guía para rediseñar y adaptar los tratamientos dependiendo de las características de las personas y evaluar los programas ofrecidos por los centros de rehabilitación.

Capítulo 3: *Un análisis de econometría espacial para el posicionamiento de los centros de juego en zonas urbanas: un caso de estudio para la ciudad de Madrid*

El objetivo del tercer capítulo de la Tesis es analizar la localización de los centros de juego en las zonas urbanas y examinar los posibles enlaces potenciales entre las características socioeconómicas y demográficas y la oferta de juego, teniendo en cuenta la dependencia de las zonas vecinas. Este análisis puede ser de interés porque las características de los barrios pueden afectar a la decisión de los operadores de juego de establecerse o no en una determinada zona. Utilizando datos de barrios de Madrid para el año 2017 se han considerado 3 aproximaciones de econometría espacial: un modelo espacial autorregresivo (SAR), un modelo de error espacial (SEM) y un modelo de retardo espacial de X (SLX). Los resultados indican una fuerte correlación entre las características de los barrios y el posicionamiento de los establecimientos de juego, encontrándose un patrón de distribución entre las zonas urbanas menos aventajadas. Este resultado puede ser relevante tanto para las decisiones llevadas a cabo por los operadores de juego, como para las autoridades locales que deban controlar y regular su oferta.

Introduction

As explained by, among others, Downward and Rasciute (2020), health can be considered as an asset. Investing in health fosters economic growth as it is implied that a consequence of better health there's an increase in human capital which in turn translated into work productivity and helps with the reduction of poverty and disparities.

Nonetheless, health expenditure as a percentage of the GDP in 2017 only reached 8.8% compared to the 9.8% of the EU average (OECD, 2021)[2]. The austerity measures implemented during the Great Recession focused on reducing public deficit, both on a country as well as a regional level. This gravely affected the healthcare sector which, according to the data from the Ministry of Health (2021) show a downwards trend since 2009. If we put it in terms of percentage of the GDP, public health expenditure decreased on a yearly basis from a 7% in 2019 to a 6.5% in 2014. Measured *per cápita*, public expenditure fell 12% in the period. Although these indicators show improvements starting 2014, the National Health System (both in primary care as well as specialized) is still severally afflicted by problems such as increasing waiting lists and a loss in the quality of the medical attention. The resources available to the NHS are continuously dwindling and the situation has worsened after the COVID-19 health crisis.

Despite this situation and, according to the data of the European Commission, Spain at the top of the 2016 ranking for health expectancy (83.5 years) between the European Union countries (OECD/EU, 2018). With this in mind we have to ask the question, "What determines individual's health?" Genetics aside, the socioeconomic factors are important determinants of health even within the context of universal health services. While Spain has a high standard of healthcare and therefore a high life expectancy there exists a significant percentage of the population that lives with risks to their health. This is why, the objective of this PhD will be the study of the determinants of health, analysing individual factors (age, education, family situation and labour situation). The analysis of these factors will deliver improvements in health policy to act upon those determinants with bigger impacts on population health.

[2]It is necessary to indicate that the health expenditure has improved over the past few years (in 2019 the expenditure was 9.1 in Spain versus 8.8 OECD average). Nonetheless, we report previous years' data to be coherent with the studies presented in this PhD.

The first chapter of this PhD will propose a model that expresses health through a production function. This model will distinguish between the initial stock and the investment in different health determinants and the goal will be a separate analysis of the effect of potential public policies.

Likewise, special attention has been given by the literature towards mental illnesses in public policy as they form a substantial percentage of all diseases on a global scale (Prince et al, 2007). The debilitation of an individual's mental health is a status caused by mental disorders o substance abuse. The root cause of these mental disorders is complex and vary from one individual to another. These include elements that range from intrinsic to the individual (genetic disposition) to environmental. The most recent editions of the DSM have considered addictions as mental disorders, including gambling disorders, Internet gambling and Internet addiction.

Among all mental disorders, we focus on problem gambling given it's associated with a large number of health risks (Abbot, 2020). The negative impacts of gambling on health can be seen as a decrease of the mental wellbeing of the individuals. Compulsive gambling is not only responsible for monetary risks (loans, bankruptcy, homelessness) but also include psychological stress, cardiac risks, blood pressure, digestive system disorders, etc. On the other hand, individual which participate in gambling activities also take part in other unhealthy behaviours such as a sedentary lifestyle, alcohol and tobacco consumption. This is the reason why the second chapter of this PhD will study the factors that intervene in the recovery of individuals with gambling problems. The analysis will focus on the socioeconomic factors of the participants and behaviours that are tied to relapses.

Aside from socioeconomic factors, access to gambling opportunities is ever present in gambling addiction. Those neighbourhoods with higher gambling supply report higher participation in gambling activities or higher relapse rates. As described by Welte et al., (2006) higher proximity to gambling supply is strongly correlated with gambling disorders. This is the reason why the focus of the Third chapter of this PhD will analyse whether areas with higher socioeconomic have gambling clusters (individuals that live in less affluent areas have a higher tendency to gamble and higher concentration of gambling supply is associated with higher gambling related health problems).

This PhD is structured in three chapters summarized as follows:

Chapter 1: *Making a distinction between the effect of initial stock and investment in health determinants*

The first chapter propose a health production model that distinguishes between the initial stock of health determinants and the subsequent investment in them, with a view to providing information to policy-makers regarding the effects of determinant-aimed policies. In this sense, the main contributions of the chapter stem from the development of a theoretical and empirical model that distinguishes between the effect of the initial stock and that of investment in health determinants. To achieve this, a stochastic frontier model was used to estimate the health production function. An empirical example is presented using data for the years 2002 and 2008. The results support the decision to analyse the effects of the initial values attributable to health determinants separately from those arising following investment in the period. Concretely the results seem to indicate that, for variables labelled with the behavioural aspects of health (such as being or not a regular drinker), the effect over time of a change in investment in health is significantly greater than that resulting from a variation in initial values. In contrast, for socioeconomic variables such as the social class or employment status for which effects on health tend to be more long-term in nature, the opposite occurs, with variation over time having a lower effect on health than the initial stock.

Chapter 2: *A multilevel mixed effects model to evaluate effectiveness of treatment for problem gambling*

The second chapter presents an empirical model for evaluating the effectiveness of treatment for problem gambling using a sample of problem gamblers treated by a set of Spanish associations dedicated to gambling addiction issues. Data consists of multiple levels of nested groups (individuals and problem gambling recovery centres). A multi-level, mixed-effects logistic regression is used which permits controlling for unobserved heterogeneity across different problem gambling associations. The results seem to indicate that individual aspects such as age, family history, marital status or work situation, but also behavioural factors (previous dropouts, relapses during treatment, or consumption of other substances) are found to affect the effectiveness of treatment for gambling disorders. The analysis of the predictors for treatment efficacy may help treatment techniques to be adapted depending on the characteristics of individual patients and to evaluate programmes designed by treatment centres.

Chapter 3: *A spatial econometric analysis of gambling outlets location in urban areas: A case study of Madrid*

Finally, the Third chapter aims to map the location of gambling outlets in urban areas and to examine potential links between neighbourhoods socioeconomic and demographic characteristics and gambling supply, taking into account spatial dependencies of neighbouring areas. This correlation is of interest because neighbourhood characteristics may attract sellers, and because the presence of gambling sellers may cause changes in neighbourhood demographics. Using detailed official data from the city of Madrid for the year 2017, three spatial econometric approaches are considered: spatial autoregressive (SAR) model, spatial error model (SEM) and spatial lag of X (explicative variables) model (SLX). Empirical analysis finds a strong correlation between neighbourhood's characteristics and co-location of gambling outlets, highlighting a specific geographic patterning of distribution within more disadvantaged urban areas. This may have interesting implications for gambling stakeholders and for local governments when it comes to the introduction and/or increase of gambling availability.

Chapter 1. Making distinction between the effect of the initial stock and the investment in health determinants

1.1 Background: the health production function

Aside from the unique factors associated with individuals on an epigenetical basis, other social factors exist which determine how those social groups belonging to a class with greater access to resources (material and information) usually obtain better health results than those belonging to a less privileged social class (Lantz et al, (2007), Lanz et al. (2010), Marmot (1978), Moss and Krieger (1995), Rose (2001), Wilkinson (2003)). The initial hypothesis (i.e. a direct relationship between access to resources and health), assumes that the health differences attributed to avoidable diseases are directly related to differences in: education levels (Woolf (2007), Terza (2008)); professions (Case y Deaton (2005)); and material deprivation and unemployment (Benach et al. (2001), Urbanos-Garrido and Lopez-Valcarcel (2015) and (2013)). This is due to a common behavioural pattern associated with Socioeconomic Status (SES), as it is referred to in the literature. Besides the individual's lifetime gains, SES includes, all those determinants influencing their health. An individual with a higher SES not only has a better access to healthcare but will also enjoy an advantage in terms of information and education. As such, it is expected that they will maintain a healthier lifestyle, avoiding risk behaviours (better disease-prevention knowledge, more access to physicians/specialists and treatments); additionally it follows that they may allocate a higher value to their personal health in preference to other goods (e.g., they may check themselves for illnesses instead of waiting for the symptoms to manifest themselves) and logically, their environment and living conditions will contribute towards their health, albeit indirectly (e.g. living in a less polluted area, living in an area with a lower crime index). Therefore, as stated by Galama and Kipperluis (2010), SES influences present and future (health gains Case and Deaton, (2005)).

The first study that analysed the marginal effects of SES on health is found in Marmot et al. (1978) who, adjusting for the effects of profession, education levels and age, observed that individuals associated with characteristics suggesting a lower social status presented a higher risk of suffering from heart diseases (this experiment was later repeated by Galama and Kipperluis in (2019) under the framework of Grossman's model for health capital (1972) and (2000)). Phelan et al. (2004), following the same principles, in their study they prove that an individual's social and economic characteristics (income, occupation and education levels) explained differences in mortality rates for avoidable diseases; although proved less relevant in the case of unavoidable/late-detected and genetic diseases.

Link and Phelan (1995) and Link et al. (2010) analyse how socioeconomic factors alter the incidence risks of contracting a disease as an individual benefiting from a privileged status usually has a better access to resources for the treatment of diseases as well as more information on risk behaviours. The circumstances that contribute towards the development of a disease can be separated into two groups: on the one hand, those intrinsic to individuals (genetic) that cannot be acted upon; and on the other hand, those caused by socioeconomic factors that pre-emptively increase the chances of incidence in groups or populations.

The conclusion reached from the foregoing frame of reference is that differences in education levels, professions and material deprivation[3] generate differences in health among individuals and, therefore, populations. However, this is not the case for each particular disease, but only for avoidable afflictions, avoidable diseases in their initial stages or diseases caused by unhealthy behaviour.

Moreover, as pointed out by DaVanzo and Gertler (1990), individual decisions can be influenced by public policy actions: modifying access, availability or public education on health programs. In other words, policy makers can alter behaviours through programs that promote healthier life styles as well as developing an investment plan that enhances a population's well-being and utility (improvement in health services, water treatment, etc.). In this sense, with a view to understanding health as a social outcome, the economic approach developed by the aforementioned literature assumes that local, regional or central governments act as the health-producing entities via the use of an instrument denominated healthcare services.

[3] Area-wide material deprivation can be defined as the relative lack of goods, resources or services that are widely available to the society it belongs to (Benachet al. [10]).

The main objective of this study is to propose a health production function by which to analyse the relationship between health and its determinants. Unlike the traditional health production functions outlined already which, in general terms, describes a static relationship, a more flexible approach is adopted. The present proposal aims at providing policy makers with information as to the potential effects on population health of those investments aimed at improving health determinants.

The chapter is structured as follows: the second section analyses the theoretical framework used to explain the differences in population health. The third section explains the proposed empirical model based on the estimation of a stochastic health production function frontier. The fourth section presents the data and defines the variables used for the population model. The fifth section sets forth the estimations and results. The final section is dedicated to overall conclusions and further discussion of the model.

1.2 Theoretical model

The theoretical model borrows in part the concept of health capital originally proposed by Grossman (1972) and (2000). This model assumes that individuals inherit a diminishing stock of health (Elrich and Chuma (1990)) and when that stock reaches below a certain threshold, it signifies their death. The concept of health capital was formulated initially on an individual level and it is possible, under certain restrictions, to apply it to groups of individuals. For such a restructuring, it is assumed that population health is the product of aggregating a set of individual health results.

A model is proposed that seeks to analyse to what extent, actions taken on the social determinants of health, can affect population-wide health outcomes. This paradigm has been promoted by the World Health Organization as a method of reducing the level of health inequalities between countries (Solar and Irwin (2007)). The reasoning underpinning this idea is the expected higher level of effectiveness of population-wide policies. Acting on health determinants from the perspective of reducing socioeconomic inequalities or reducing risk behaviours is seen as a simpler solution for reducing the risk of disease for the general population. This assumption (e.g. Auster (1969), or Link and Phelan (1995)), establishes that the individual's health is conditioned by certain determinants that are partially outside of their control but can be modified by a social planner. Therefore, it is proposed the modelling of a health production function for the population as a whole within the framework of the papers of Auster (1969), Fayisa and Gutema (2005), Griffiths et al. (2010), Bayati et al. (2013), Puig-Junoy (1998) or Nasab et al. (2013).

Elaborating on the theoretical model, I start with a policymaker that seeks to maximize a population's aggregated stock of health. Hence, the maximization model can be formalized using the following specification:

$$\max H_t \tag{1}$$

$$s.t. \quad H_t = F(Xt) \tag{2}$$

The equations (1)-(2) specify a maximization model for a population-wide stock of health (H) at the moment t, as a function of a series of health determinants (X). These determinants encompass all the spheres of action surrounding a population that can have an impact on them. Said determinants are usually divided into 4 major groups (Booske et al.):

- *Socioeconomic*: Socioeconomic health determinants are seen as a series of social conditions surrounding the individuals working and living environments, that, although partially under their control have a tendency to reflect more closely global societal trends and as such, can and do ultimately impact on their health. The elements focused upon by these policies are those susceptible to effective interventions (for example, income or employ).

- *Environmental:* These include factors belonging to the natural environment, such as water and air quality that are considered as key determinants to a population's health.

- *Behavioural*: These include all those individual actions that have a repercussion on health. The main relevant indicators of health behaviours are closely linked to risk factors (binge drinking, unhealthy dieting, lack of exercise…etc.).

- *Healthcare*: A general improvement in health care services could have a direct effect on health results. Additionally, the constant innovation in medical processes undeniably improves health results (Lantz P., Lichestein R., Pollack H.(2007)).

The initial hypothesis within Eq. (2) states that the output of health is functionally dependent on its determinants at the initial moment t. However, the stock of health can improve through investments in health determinants (e.g. more exercise, healthier foods, more medical centres or more staffed ones, etc.) or can deteriorate through unhealthy behaviours. As stated by DaVanzo and Gertler (1990) the inputs chosen are investments that produce increments to overall health. Inputs are not instantaneously transformed into health because the process takes time. Therefore, today's health status could be influenced by these investments which over time will transform future health status.

For this reason, besides analysing the population's initial level of health determinants, in this Chapter I attempt to study how investments in health and social policies can modify health results by measuring the effect of their actions. In other words, how policymakers may influence a population`s health through investments in socioeconomic policies aimed at improving health determinants and/or proposing a complimentary set of measures for healthcare. To achieve this, Eq. (2) has been modified separating the determinants of health into two components: the initial stock of health determinants and the investment in them during the time period. This way, population health for the period t, will depend on the health determinants at the beginning of the period (X_{t-1}); the investment in determinants during the period (ΔX) and the depreciation of health during said period (δ). Finally, it is assumed that both the initial level and the investment will each have a different impact on the future stock of health. This assumption will be tested later. The final form of the production function will be:

$$H_t = F(X_{t-1}, \Delta X, \delta) \tag{3}$$

Eq. (3) specifies the difference of the impacts: it distinguishes between the effects on the initial stock of health determinants compared with those effects arising as a result of investment over a period of time. This investment may be attributable to individual decisions or alternatively it could be the effect resulting from social and/or health policies. Within this chapter it is proposed to analyse both effects separately.

1.3 Empirical Model

In this section, an empirical model is built to estimate the functional relationship between health, its determinants and health depreciation. To do this, a frontier model is assumed where the observed level of health cannot exceed a maximum possible value (given a vector of determinants). The potential health status constitutes the upper frontier of the observations, and is explained by a set of health determinants. Given these variables, potential heath will be determined by the maximum health level observed. Some municipalities will achieve their potential health status (as measured by the maximum health level observed), whilst others will operate below their frontier. In this framework, the distance to the frontier would indicate the difficulties that some regions have in obtaining their maximum potential health level, once taken into account individuals' or groups' characteristics.

Moreover, if the difference between potential and observed health exists and it is not taken into account in the estimation, results will be biased (Lovell (2003)). Because of this, the information obtained from the frontier estimators is more accurate than one that is derived from research based on average health production functions given that the former includes the possibility of not achieving the objective of maximizing health assumed in the Eq. (1).

This gap between observed and potential health has been widely used in the literature by several authors. The first attempt at applying the frontier methodology to estimate a health frontier was made by Evans, Tandon et al. (2001). The frontier analysis proposed by these authors uses aggregated population data and a sample of 191 countries with data provided by the World Health Organization (WHO) for the period between 1963 and 1997. Greene (2004) and Greene (2005), using the same data set, estimates a health frontier using a panel data structure to correct the problems caused by unobserved heterogeneity. Other examples of health frontiers estimated with aggregated data are: Kathuria and Sankar (2005); Hernandez de Cos and Moral-Benito (2011); Danquah et al.(2014); Novignon et al. (2014), Ogloblin (2011) or Hadad et al. (2013).

Frontiers can be specified either as deterministic or stochastic. In the case of deterministic frontiers, the error component is entirely attributable to the distance between the potential and the observed health. In contrast, stochastic frontiers, apart from the term that captures the distance to the frontier, include a random error component, allowing the incorporation of the effects of statistical noise common to economic data. For this reason, a stochastic frontier specification was chosen (for details see for example Kumbhakar and Lovell (2000)).

Moreover, and in contrast to the previous studies, the production function frontier is designed according to the model outlined in the previous section, summarised in Eq. (3). Thus, by using an inequality in order to permit the differentiation of observed health and optimum health status; assuming a Cobb-Douglas functional form and employing parameter vector b, the Eq. (3) is rewritten in the following manner:

$$H_{ct} \leq Af(X_{ct-1}, \beta_x) \exp(\beta_\Delta \Delta X_C - \beta_\delta \delta) \quad (4)$$

Where A is a constant, t is time and c is region or council.

In Eq. (4) Hct is the observed health status and $Af(X_{ct-1}, \beta_x) \exp(\beta_\Delta \Delta X_C - \beta_\delta \delta)$ is the deterministic production function that represents the *optimal or maximum* health level. By formally expressing inequality inside the model, observations are allowed to deviate from their optimal values. In order to contrast the model, the inequality above is transformed into an equality:

$$H_{ct} = Af(X_{ct-1}, \beta_x) \exp(\beta_\Delta \Delta X_C - \beta_\delta \delta) \exp(v_c) \quad (5)$$

Where the term v_c is a random disturbance term included to capture the effects of statistical noise and u_c allows the observed health of any region to fall short of the maximum possible health level which is determined not by the deterministic production frontier $Af(X_{ct-1}, \beta_x)\exp(\beta_\Delta \Delta X_C - \beta_\delta \delta)$ but by the stochastic production frontier $Af(X_{ct-1}, \beta_x) \exp(\beta_\Delta \Delta X_C - \beta_\delta \delta) \exp(v_c)$.

In this way, as Lovell (1995) points out, good or bad fortune (captured by v_c) is not confused with good or bad performance (captured by u_c).

By rearranging Eq. (5) we obtain:

$$Af(X_{ct-1}, \beta_x) \exp(\beta_\Delta \Delta X_C - \beta_\delta \delta) \exp(v_c) / H_{ct} = \exp(-u_c) = \text{HDI} \quad (6)$$

Where exp($-u_c$) indicates the difference between the optimal and the observed health status (in council c in period t). This difference will be defined as the Health Differential Index (HDI) where $0 \leq HDI \leq 1$ given that $u_c \leq 0$.[4]

Taking logarithms of Eq. (5) we have:

$$\ln H_{ct} = \alpha + \ln f(X_{ct-1}, \beta_x) + \beta_{\Delta}\Delta X_C - \beta_{\delta}\delta + v_c + u_c \qquad (7)$$

Where α=lnA.

The final interpretation of this model will be that a municipality's health in period t is a function of its health status in the previous period and the gross investment minus depreciation.

1.4 Data

To estimate the theoretical model presented by Eq. (7) the analysis is restricted to a small area, concretely Asturias, which is a region in northern Spain, in order to control as much as possible for health determinant characteristics, as well as other demographic or regional characteristics that influence the health status of the population.[5] The data have been obtained from "La Encuesta de Salud de Asturias" (Asturian Health Survey, hereinafter referred to as AHS), which is a multi-output questionnaire targeted at randomly selected participants all of whom are 18 years or more and have been residents in the Principality of Asturias for the twelve months prior to the survey. Great care is taken in the survey to ensure that a fair representation of the population's diversity is taken into account and that all territories have a representative number of participants. Granted the nature of the data, the difficulties associated with the drafting and execution of a population-wide survey as well as the compilation of data, this survey is not performed on a periodic basis. Asturias includes 9 health areas but given that data is

[4] In microeconomic production theory behaviour, this difference is known as technical inefficiency.
[5] As pointed out by Lee (2011), using a sample at municipal level (where similar populations are being compared) can help avoid unobservable heterogeneity problems presented in studies that employ country data with too many differences between them.

available at a more disaggregated level, specifically at municipal level, we have taken advantage of this fact for our estimates. In this context, the data used in this study refer to the 78 municipalities of the Principality of Asturias as observed in the years 2002 and 2008. For the estimation of equation (7) both health data as well as the data for health determinants are required. In the text that follows, the variables selected for the study are explained.

1.4.1 Output: Health measure

There is no optimal measure of population health but a series of approximations have been proposed in the literature. One of these is the *mortality rate*. However, there exist a series of problems inherent to this form of measuring because it does not take into consideration factors regarding well-being and disability, which leads to a loss of information. Another indicator of health is given by the *years of life potentially lost* which is an estimate of the average years a person would have lived if he or she had not died prematurely. It is, therefore, a measure of premature mortality. As an alternative to death rates, it is a method that gives more weight to deaths that occur among younger people. This index has not been included because it excludes persons beyond the reference age of 75 and given the longevity which exists in the Principality of Asturias could influence our municipality results by losing persons in the form of observations. Another option could be the *rate of morbidity*, this being, the frequency that a disease appears within a population. But, like the previous index, this variable artificially removes segments of the population that would be relevant to the study, making it inappropriate for the case at hand.

Finally, *self-perceived health* has the advantages of a simple interpretation and can be used to draw comparisons between regions. The perception of persons with respect to their own health, although totally subjective and dependent on a variety of factors, is the result of the combined influence of health determinants. This measure provides an estimate of the quality of life in relation to the health or morbidity, of a population. Research exists which consistently confirms that self-perceived health is a good measure of health status (Moriarty et al. (2003), De Salvo et al. (2006) and Jylhä (2009)). For these reasons, the variable self-perceived health (HEALTH) is used as the dependent variable. It is accounted for as the percentage of the population surveyed whom, having been questioned as to their health status, reply that their present level of health is superior to/better than "bad" or "very bad".

1.4.2 Inputs: Health Determinants

Following the theoretical classification presented under Section 1.3, we now classify the variables to be used in the empirical analysis as health determinants by grouping them into 4 categories:

1.4.2.a Socioeconomic factors

Employment rate: Numerous studies have documented a positive association between employment and health (Moser et al. (1987); Mathers and Schofiels (1998) or Roelfs et al. (2011)), whilst others find an inverse relationship (Boone and van Ours (2006); Rhum (2000) or Stuckler et al. (2009)). Hence, this variable is included in order to contrast the relationship. Using the unemployment data available from the *Instituto Nacional de Estadistica* -INE (Spanish Institute of Statistics), the variable EMPLOY has been constructed as the percentage of adults employed in each municipality over the total active population (i.e., the persons who are unemployed but actively seeking employment and willing to work).

Social Class: The social class to which a person is assigned is a predictor of morbidity and mortality given that lower social classes tend to lead less healthy lifestyles and behaviours than superior social classes (see for example, Marmot (1978), Lantz et al. (2007), Lantz et al. (2010) Moss and Krieger (1995), Rose (2001), Case and Deaton (2005), Galama and Kipperluis (2019) among others). For the calculation of the social class, the AHS uses a classification that takes into account the individual's income, whether they find themselves in a situation of dependency or close to the poverty threshold and the current level of education to determine to which social class a person belongs. This classification ranges from I (the highest level) to V (the lowest class).[6] The constructed variable SOCIAL CLASS takes the percentage of the population surveyed in the municipality that belong to groups I to III over the whole of the population.

[6] With two sub-classes in class IV.

a) *Health Care factors*

Health Care Delays: This measures the responsiveness of the health system to the population's needs as well as being an indicator of organizational and logistic mismatches. The initial hypothesis is that a large waiting list for receiving surgical treatment may affect negatively the self-perceived health status of the population (Fogarty and Cronin (2007), Eilers (2004), Pizer and Prentize (2007)). The proxy for health care delays WAITING LIST takes the form of the number of days, on average that a patient has to wait in order to receive surgical treatment.

1.4.2.b Environmental factors

Water Quality: I tried to find an indicator of environmental quality for a resource as important as water consumption. Given the abundance of water in Asturias numerous supply systems exists particularly in rural areas where the diversity of water catchments and distribution channels are not always controlled in terms of health regulations which could affect the population´s health (WHO (1996), Hunter et al. (2010)). The variable WATER takes the percentage of the population that consume water controlled by the health authorities.

Seaside region: There exist studies which indicate a direct relationship between living close to the seaside and health given that this appears to reduce stress and serves to stimulate physical exercise (White et al. (2014)). In order to contrast this hypothesis, the dummy variable (COAST) is included which reflects whether or not the municipality is located in a coastal region.

Ageing: A variable for age has been included to contrast the hypothesis that age influences health negatively (Grossman (1972), Case and Deaton (2005), Galama and Kipperluis (2019)). The variable used (AGEING) reflects the percentage of individuals over 69 years old living in the municipality.

Population: this variable has been included with a view to observing whether municipalities with a higher population tend to present higher or lower self-perceived measures of health. Some authors attribute worse health outcomes to more inequalities between residents in cities (Freudenberg (2000)) while others assume worse health outcomes in rural environments due to worse health behaviours (Hartley (2004), Mainous and Kohrs (1995)). In contrast, Ebenhartd and Pamuk (2004) conclude that there are no consistent trends in mortality and morbidity when comparing rural to urban areas. In view of the foregoing, the variable POPULATION has been added, measured as the number of residents in each municipality for the year 2008, as a proxy of the size of the municipality.

1.4.2.c Lifestyle and behavioural factors

Activity and exercise (SPORT):

Exercise, be it in moments of leisure or work, is a healthy activity whilst sedentary practices contribute towards higher incidences of illness and risk factors (Barnes (2013); Booth et al. (2012)). For this reason, the variable SPORT is included and measures the percentage of persons from amongst the total surveyed who are not seated for the major part of the day i.e. they do not have a lifestyle which can be classified as sedentary.

Alcohol consumption (NON-DRINKING): The excessive consumption of alcohol during prolonged period of time can provoke dependence or addiction. In parallel, it generates serious physical and psychological consequences as well as important family, work-related and social problems, proving also to be one of the major causes of traffic accidents (see for example, Fayisa et al. (2005)). The variable NON-DRINKING provides information on the individuals' drinking habits. Specifically, the variable used takes into account the individuals that have a moderate consumption of alcohol per week. For this, the model adds the percentage of individuals who consume a moderate amount of alcohol compared with those exhibiting high-risk behaviour.[7]

On the other hand, the variables used to define health investments in each time period are the variation rates for the previously mentioned stock determinants (dEMPLOY, dSOCIALCLASS, dWAITING LIST, dSPORT, dNONDRINKER). All of these are parameters that policymakers can act upon, either directly or indirectly[8]. Finally, the variation rate for the index of seniors (dAGEING) is included as an indicator of health depreciation. This decision was done to control the effect of health depreciation caused naturally by the population´s ageing process during the time period being studied (Grossman (1972)).

[7]The consumption of alcohol is homogenized in SDU's (Standard Drink Units) which are equivalent to 10-12 grams of pure alcohol. According to AHS, high risk drinkers are those that consume amounts superior 9 SDUs for males and 7 SDUs for females

[8] The data for the variation rate of the Quality of Water variable could not be included because of a lack of observations for the 2 time periods.

Table 1 summarizes the aforementioned variables.

Table 1: Descriptive statistics

Variable	Mean	Std. Deviation	Unit of measure
HEALTH	78.58	8.20	%
EMPLOY	86.68	3.90	%
SOCIAL CLASS	54.33	13.64	%
SPORT	65.59	12.07	%
NONDRINKER	96.85	2.14	%
WAITING LIST	91.21	12.88	DAYS
AGEING	30.23	8.78	%
POPULATION	13847.92	40631.47	PEOPLE
COAST	24.35	43.20	%
WATER	74.69	17.93	%
dEMPLOY	6.55	4.39	Variation rate
dSOCIAL CLASS	11.37	54.15	Variation rate
dSPORT	9.86	28.22	Variation rate
dNONDRINKER	-2.83	4.23	Variation rate
dWAITING LIST	-37.85	4.23	Variation rate
dAGEING	11.35	12.05	Variation rate
SCHOOL	30.67	9.57	%

Finally, as already mentioned widely in the literature, it should be noted that health production functions may present problems of correlation between the independent variables (multicollinearity). As an example, education, which is a variable that has been used extensively as a determinant of health outcomes, clearly affects other socioeconomic determinants, such as, the chance of finding employment, income, lifestyle choices and risk behaviours. As pointed out by, amongst others, Galea and Ahern (2005); Moore, Daniel and Kestens (2007); or Urbanos and Lopez Varcarcel (2015), this may present a problem when including education as an independent variable with the rest. Hence, to avoid multicollinearity problems within the model, we have opted to include the aggregated variable SOCIAL CLASS that takes into account, besides education, other factors (such as income or the proximity to the poverty threshold) in order to determine to which social class an individual belongs. Nevertheless, given the relevance of the variable EDUCATION/SCHOOL in the context of health, as well as its close connection with other health determinants, said variable is used to analyze the health differences existing between the various municipalities, as explained below in the next section.

1.5 Estimation and Results

In accordance with Eq. (7) health is an endogenous variable that depends on variables such as medical care, environment and social variables or healthy habits. Moreover, health can be improved through investment in these variables. Also, the model takes into account the depreciation of health capital through the ageing process. The model can be expressed as follows:

$$
\begin{aligned}
\ln(HEALTH)\,ct \\
&= \beta_0 + \beta_1 lnEMPLOY_{ct-1} + \beta_2 lnSOCIALCLASS_{ct-1} + \beta_3 lnSPORT_{ct-1} \\
&+ \beta_4 lnNODRINKER_{ct-1} + \beta_5 LnWAITINGLIST_{ct-1} + \beta_6 lnAGING_{ct} \\
&+ \beta_7 lnPOPULATION_{ct} + \beta_8 COAST_c + \beta_9 lnWATER_{ct} + \beta_{10} dEMPLOY_c \quad (8) \\
&+ \beta_{11} dSOCIALCLASS_c + \beta_{12} dSPORT_c + \beta_{13} dNODRINKER_c \\
&+ \beta_{14} dWAITINGLIST_c + \beta_{15} dAGEING + u_c + v_c
\end{aligned}
$$

Where, as explained above, “c” is the council c=1,2,3..78 and “t” is time. Additionally, v_c is assumed to be independently and identically distributed as N $(0,\sigma_v^2)$ and u_c is independently half-normally $N(0,\sigma_u^2)$ distributed.

On the other hand, while heteroskedasticity in an OLS model does not pose too many problems, it is potentially more severe in the context of a stochastic frontier model given that it can cause biased estimations (Kumbhakar and Lovell, (2000)). Because of this, in the estimation heteroscedasticity is modelled in the u error term, i.e., it is assumed to have a non-negative half-normal distribution with a modal value of zero and a non-constant variance. This specification is achieved by modelling the variance of u as a linear function of a set of covariates z with δ representing a set of parameters to be estimated:

$$u \approx iid\ \mathrm{N}(0, \sigma_u^2), \sigma_u^2 = g(\theta z) \tag{9}$$

Where θ is a parameter vector to be estimated. In Eq. (9), a higher variance represents a larger distance to the frontier and vice versa (Caudill et al., (1995)).

When defining the variables to be included in vector z, it is important to mention that as explained previously in Section 1.4 with the express purpose of avoiding possible multicollinearity within the model, instead of a variable of education, the variable SOCIAL CLASS has been included (which encompasses, in addition to education, elements such as income, wealth and occupation). However, as pointed out by, amongst others, Woolf et al. (2007), Cohen and Syme (2013), Kindig et al. (2010), Freudenberg and Ruglis (2007), de Walque (2004) or Rettenmaier and Wang (2013), a higher education level usually signifies a greater knowledge on the individuals' part when making decisions aimed at improving their health and risk aversion behaviours which could have a significant effect on health. Because of this, and in order to analyse whether a variation in the population's educational level is pertinent for explaining the differences in health between municipalities, a conditional heteroskedastic half-normal model is used, where education is an explanatory variable in the variance function for the u term. That is to say, the variance of the u term is modelled as:

$$\sigma_{uc}^2 = \exp(\theta SCHOOL_c) \tag{10}$$

Where SCHOOL represents the percentage of the population with secondary or higher education. The modelling of Eq. (8)-(10) has been estimated by maximum likelihood. Tables 2 and 3 show the results of the estimation.[9] Table 2 shows the results of the stochastic health production frontier estimated (Eq. 8) and Table 3 presents the estimation results of Eq. (10) jointly estimated alongside Eq. (8).

[9] A Variation Inflation Rate Test (VIF) has been carried out on a previous OLS estimation of the Eq. (8). The average index is 3.06, which shows that multicollinearity does not present an important issue in the model.

With respect to the results obtained for the stochastic health frontier estimated (Table 2) and given that the dependent variable is defined in logarithms, the coefficients associated to the log variables are interpreted as elasticities. The coefficients associated with the rest of the variables, expressed as variation rates, are also interpreted in a similar fashion. i.e. the percentage change in self-perceived health as a response to a change in the investment rate of a determinant.

Table 2: Estimation Results

Health Production Function Frontier Estimated (Eq. 8)

HEALTH	Coef.	Z	P>|z|
Ln(EMPLOY)	0.2506	1.69	0.091*
Ln(SOCIALCLASS)	0.3118	2.34	0.019**
Ln (SPORT)	0.3081	2.88	0.004***
Ln(NONDRINKER)	0.4692	9.72	0.000***
Ln(WAITINGLIST)	-0.9189	-2.72	0.007***
Ln(AGEING)	-0.1955	-1.98	0.047**
Ln(POPULATION)	0.0187	2.08	0.038**
COAST	-0.1159	-0.19	0.848
Ln(WATER)	-0.00065	-0.46	0.643
dEMPLOY	1.9876	1.87	0.061*
dSOCIALCLASS	0.1258	2.55	0.011**
dSPORT	0.2445	1.75	0.080*
dNONDRINKER	4.4274	4.70	0.000***
dWAITINGLIST	-1.3457	-3.83	0.000***
dAGEING	0.0363	0.18	0.860
CONSTANT	4.7729	3.81	0.000***
Number of observations: 78			
Wald $\chi^2(15)$=429,75 Pr>χ^2=0.0000			

***significant at 10%   **significant at 5%   ***significant at 1%**

The Wald test (Table 2) is applied in order to ascertain whether joint significance exists for the combined set of variables included in the production function, thereby allowing us to strongly reject the hypothesis that the joint effect of said variables does not affect auto-perceived health.

Table 3: Estimation of the Variance of the Composite Error Term (Eq. 10)[10]

HEALTH	Coef.	Z	P>|z|
$\ln(\sigma_u^2)$			
SCHOOL	-0.25102	-2.14	0.032**
CONSTANT	0.3039	0.08	0.938

***significant at 10%   **significant at 5%   ***significant at 1%**

The results for the variables reflect the aggregated socio-economic factors from the different municipalities at the beginning of the time period (EMPLOY, SOCIAL CLASS), and both variables are observed as positive and statistically significant, which serves to corroborate the results obtained by the literature referred to in Section 1.4 above. Their coefficients indicate that, the population health determinants in the time frame t-1 have a positive and significant effect on health status at the end of the time lapsed. Specifically, a 1% improvement in regional employment and, on average, of the social class of its citizens in 2002 would imply an improvement in health in 2008 of 0.25% and 0.31%, respectively.

In a similar manner, substantiating the literature previously revised on the subject, the variables that refer to individual behaviours present a positive sign and have a significant impact on the output variable: an increase in the trend of health-positive behaviours, fitness and sport (SPORT), in 2002 and the prevalence of an initial moderate consumption of alcohol (NON DRINKING), would provide for health improvements of 0.31% and 0.47%, respectively. With respect to the variable WAITING LIST, that measures the excess of demand over the provision of health care services thus serving as a proxy for the initial state of the Health Care System, its coefficient is negative and statistically significant, which supports the initial hypothesis. Based on the foregoing result, it is deduced that an increase in the average waiting time in the time period t-1 would lead to a reduction of health in the year t by almost 0.92%. Regarding environmental variables, the size of the municipality, measured by its population in 2008, is positive and significant

[10] The relationship between the variance of the error term and other variables such as the population of the municipality has been tested but with no significant results.

which implies that municipalities with larger populations tend to present higher self-perceived health, specifically 0.02% better per 1% increase. On the other hand, living in a coastal region does not seem to influence individuals' perception of their health. The same happens with water quality, where no additional improvements seem to be observed from an increase in the number of homes supplied with certified clean water.[11]

As was to be expected, population ageing (lnAGEING), measured as the percentage of people over 69 living in each municipality, affects population health in a negative way. Within the estimation's framework, on average, increasing the number of senior citizens in the overall population by 1% approximately reduces the self-perceived health of that municipality by 0.2%.

On the other hand, and as explained previously, besides the effect of the initial provision of health (X_{t-1}) over self-perceived health status, the effect of investment in health determinants is analysed over the time frame (ΔX). As shown in Table 2, the investments made in the time frame aimed at improving the unemployment rate may indirectly improve self- perceived health. Specifically, an additional investment of 1% in the determinant EMPLOY is associated with a rise of 1.98% in self–perceived health. Similarly, an additional investment of 1% aimed at improving social class results in an increase of 0.12% in self–perceived health. This result is in line with the results obtained by Smith et al. (1998) and Currie and Goodman (2010) who present empirical work on the transmission of present-day levels of SES to future health. In their study, they state that a child's future health depends greatly on the parents' level of income, wealth and education. A lower social class in 6 years hence would severally cripple a child's development process.

It is also possible to observe that social policies aimed at increasing the population's awareness in terms of healthier habits could produce, where effective, an improvement in lifestyle, achieving a significant and positive effect on population health. Specifically, the investments made by the population in the 2002-2008 time period destined to increasing their participation in sports activities and the consumption of alcohol in moderation could have generated a 0.24 and 4.42% increase respectively, in the average number of people that admit to feeling better. Finally, and as expected, the estimated coefficient for the variable dWAITINGLIST (proxy variable for the regional health provision), indicates

[11] Other variables, such as air quality, have been checked but none were significant.

that, if over time the average time spent on a surgical waiting list had been longer, we would have observed a 1.34% deterioration in the population´s health. It follows therefore that improvements effected by policymakers to reduce the time spent on waiting lists would actually increase the well-being of the population. In summary, it is found that social and health policies conducted to encourage healthy behaviours could have a positive and significant impact on self-perceived health.

Nevertheless, based on the results obtained in Table 3, it is deduced that the presence of heteroskedasticity in the term u cannot be rejected. Specifically, from the estimated model, an inverse relationship that exists between the municipality's education rate and the stochastic error term u_c is observed (that reflects the difference between the highest potential rate of health to which a municipality can aspire –given its particular characteristics – and the observed one). As already mentioned previously, these results support the literature that maintains the importance of the effect of education on health results. In this context, the results sustain the idea that the development of education policies may contribute towards correcting the gap in observed health status between a municipality's population and its health frontier.

Moreover, and in order to contrast the validity of the model, the effects of the initial values of the health determinants (X_{t-1}) on observed health in the year t (H_t) are analysed separately from those arising from the investment (ΔX), by applying Wald tests. From the results presented in Table 4, it is deduced that there exist significant differences between the coefficients corresponding to the initial value and the investment for some of the health determinants. In fact, it has been contrasted that these differences are statistically significant for the determinants EMPLOY, SOCIALCLASS and NONDRINKER whilst they are not significant for the variables SPORT and WAITING LIST.

Analysing in more detail the differences between the statistically significant coefficients, the results seem to indicate that the effect of a change in the investment over time on behavioural variables, such as NONDRINKER, has a greater effect on health if we compare it to a variation of the initial values (given that the value of the coefficient is larger). These results seem reasonable because they appear to indicate that the effect of recent changes in this health determinant will have more impact on self-perceived health than that of a less recent variation in the initial values

Table 4: Significance tests

Null Hypothesis	Chi2	Prob>Chi2
Ln(EMPLOY)-dEMPLOY=0	3.49	0.0616*
Ln(SOCIALCLASS)-dSOCIALCLASS=0	3.42	0.0645*
Ln(SPORT)-dSPORT=0	0.36	0.5469
Ln(NODRINKER)-dNONDRINKER=0	17.29	0.0000***
Ln(WAITINGLIST)-dWAITINGLIST=0	2.36	0.1244
dEMPLOY=dSOCIALCLASS=dSPORT=dNONDRINKER=dWAITING=0	233.14	0.0000***

***significant at 10% **significant at 5% ***significant at 1%**

Analysing in more detail the differences between the statistically significant coefficients, the results seem to indicate that the effect of a change in the investment over time on behavioural variables, such as NONDRINKER, has a greater effect on health if we compare it to a variation of the initial values (given that the value of the coefficient is larger). These results seem reasonable because they appear to indicate that the effect of recent changes in this health determinant will have more impact on self-perceived health than that of a less recent variation in the initial values. On the contrary, socioeconomic variables such as SOCIAL CLASS or EMPLOY, where the effect over health seems to be more long-term, the effect of the investment during the time period is significantly lower than the effect of the initial provision. This significant difference between coefficients may prove to be a source of key information for the managers of social-health institutions, by which they can promote the implementation of socioeconomic and healthcare policies once enacted. Thus, if one of the objectives of the health researcher is the analysis of how improvements in education or in income affect health, or similarly, how unemployment influences the latter, it is necessary to take into account that the results seem to indicate that these effects are not immediate. In the absence of this knowledge, biased conclusions could be reached. In contrast, measures intended to modify unhealthy habits, can be evaluated on a shorter-term basis.

I also wish to test whether the investment in health determinants (ΔX), taken as a whole, is significant by testing whether the coefficients on ΔX are simultaneously zero. Applying Wald tests as in the previous case, I find that the significance level of the test is close to 0 (see Table 4), allowing me to strongly reject the hypothesis that the joint effect of investment in health determinants in the period studied has not affected self-perceived health status.

With the health frontier already estimated, it is possible to analyse in detail the difference between potential health status and observed status. As already explained, said differences can be analysed through the HDI (Health Differential Index) defined in Eq. (6), the value of which is located between 0 and 1. An index closer to 0 indicates that the municipality is located at considerable distance from its potential health maximum on the frontier. To the contrary, a value closer to one indicates that the municipality is located much closer to its optimal level of health. Table 5 shows the descriptive statistics for the estimated HDI. The average value is 0.96, which shows that on average, the regions are closer to their optimal level of health. Table 6 orders the different municipalities from the largest to the smallest in terms of their HDI rankings. As can be observed, no appreciable differences appear in the HDI indices, which is probably explained by our use of homogeneous samples with similar populations to avoid heterogeneity problems, once the principal health determinants are controlled for in our model. Those municipalities occupying the higher rankings are closer to their health frontiers, whilst the lowest rankings are municipalities with lower than expected self-perceived health, given their determinants and the investment in them for the period studied. Lastly, Figure 1 confirms the result observed previously, i.e. a population's education is significant when attempting to explain the results of health status, with regions possessing a higher education score having a higher probability of situating themselves closer to the health frontier.

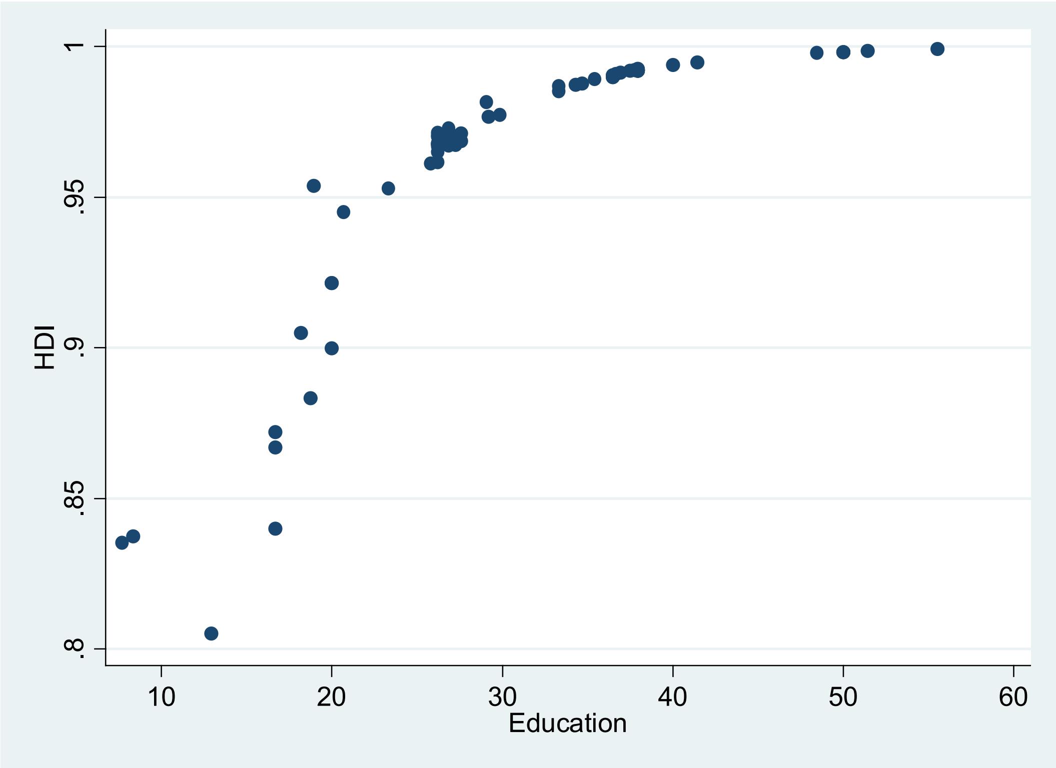
Table 5: HDI Estimated Indices

Variable	N	Mean	Standard Deviation	Min	Max
HDI	78	0.9650	0.04244	0.8050	0.99912

Table 6: Health Differential Index. Ranking by municipalities

Municipality	HDI	Position	Municipality	HDI	Position
Teverga	0.9991	1	Peñamellera Baja	0.9715	40
Vegadeo	0.9985	2	Villayón	0.9714	41
Gozón	0.9982	3	Riosa	0.9712	42
Ribera de Arriba	0.9982	4	Grandas de Salime	0.9709	43
Proaza	0.9982	5	Castropol	0.9706	44
Corvera de Asturias	0.9979	6	Onís	0.9705	45
Siero	0.9948	7	Santa Eulalia de Oscos	0.9702	46
Grado	0.9939	8	Villanueva de Oscos	0.9701	47
Nava	0.9926	9	Peñamellera Alta	0.9701	48
Noreña	0.9924	10	Coaña	0.9700	49
Cabranes	0.9922	11	Illano	0.9700	50
Sariego	0.9922	12	El Franco	0.9700	51
Yernes y Tameza	0.9921	13	San Martín de Oscos	0.9693	52
Avilés	0.9921	14	Aller	0.9686	53
Somiedo	0.9921	15	Ribadedeva	0.9680	54
Belmonte de Miranda	0.9921	16	Taramundi	0.9680	55
Bimenes	0.9921	17	Colunga	0.9677	56
Candamo	0.9921	18	Parres	0.9676	57
Morcín	0.9921	19	Amieva	0.9675	58
Las Regueras	0.9920	20	Cangas de Onis	0.9674	59
Quiros	0.9920	21	Pesoz	0.9671	60
Llanera	0.9920	22	Cabrales	0.9670	61
Santo Adriano	0.9920	23	Ponga	0.9651	62
Oviedo	0.9915	24	Caravia	0.9616	63
Ribadesella	0.9909	25	Mieres	0.9611	64
Illas	0.9906	26	Valdés	0.9539	65
Soto del Barco	0.9903	27	Piloña	0.9529	66
Pravia	0.9899	28	Villaviciosa	0.9451	67
Muros de nalón	0.9899	29	Laviana	0.9214	68
Gijón	0.9892	30	Cangas del Narcea	0.9214	69
Carreño	0.9877	31	San Tirso de Abres	0.9049	70
Navia	0.9873	32	Salas	0.8999	71
San Martín del rey Aurelio	0.9869	33	Llanes	0.8832	72
Sobrescobio	0.9851	34	Ibias	0.8719	73
Lena	0.9817	35	Allande	0.8668	74
Langreo	0.9773	36	Degaña	0.8398	75
Caso	0.9766	37	Castrillón	0.8373	76
Tapia de Casariego	0.9728	38	Cudillero	0.8353	77
Boal	0.9722	39	Tineo	0.8051	78

Figure 1: EDUCATION and HDI INDEX



1.6 Discussion and Conclusions

The need across Europe to justify resource allocation decisions based on expected results has given rise to the provision of empirical evidence to support the effectiveness of the measures implemented. In order to improve the chances of correct societal resource allocation decisions as well as maintain incentives for the continued development of social/public health measures, it is vital that modelling approaches are able to respond to the questions posed by health sector managers, questions such as the effectiveness of measures or the necessary time spans in order to achieve the expected goals.

In this Chapter some of these questions are addressed by asking whether at a given point in time, the initial stock of individual health determinants has a similar impact on health to more recent investments made in said determinants. With a view to contrasting the aforementioned hypothesis, a theoretical model where the coefficients of the initial stock of determinants is constructed and the investment in each one of them can differ.

An empirical example is presented by estimating a health production function using data from the municipalities of the Principality of Asturias for the years 2002 and 2008. In order to estimate this kind of function, a stochastic frontier model is used. In the literature, these models (using both parametric and non-parametric procedures) have been successfully applied to explain variations in health status. However, the literature provides with few examples where a distinction is made between the effect of the initial stock of health determinants and the investment in them over a time period, something that would be useful in providing information to policy-makers with respect to the expected results of specific policies on particular populations.

The results support the decision of analysing both effects separately. Our findings seem to indicate that changes in socioeconomic determinants (employ, social class) produce improvements in health status over a longer term compared with behavioural determinants such as alcohol consumption, which present results on a shorter-term basis. This conveys us to the idea that health-oriented policy makers face a trade-off between short term and long-term goals. The expected effect of healthcare policies that change initial health provision and are targeted at changing the behaviour of specific groups may have an impact in the short term whilst policies aimed at reducing structural unemployment or improving income, wealth and education show less immediate effects.

The results obtained by this study could serve as an aid to the managers of social-health institutions, when promoting the application of socioeconomic and healthcare policies as well as evaluating their effectiveness once in place. An awareness of the immediacy or not of the effectiveness of improvements in education, income or the impact of unemployment should necessarily be an objective of any health researcher if they are truly interested in arriving at unbiased and precise conclusions

Finally, the estimation of the health frontier permits an analysis of the distance to be covered by each region in order to obtain its maximum health potential via the HDI. The comparison of the different municipalities in the study reveals that, on average, the different populations share similar health status. Moreover, given that the model was estimated using the methodology proposed by Caudill et al. (1995), it is possible to explain the distance of each municipality from its health frontier. Specifically, the difference between potential health and the real health status reached by the municipalities is explained significantly by the education index for each municipality.

This result reinforces the hypothesis, already contrasted in previous studies, of the important role played by education when explaining the differences in health between populations. The level of studies achieved consolidates itself as an important predictor of morbidity and mortality for a population. Persons with inferior studies present less healthy lifestyles and health behaviours than individuals with more advanced studies. In addition, a higher level of education implies on average, greater income, while persons with less education run a higher probability of being adversely affected by variations in the labour market. Likewise, the level of knowledge with respect to health matters helps to explain individual behaviour and healthy lifestyles.

To conclude, several shortcomings of this model should be mentioned. Firstly, the variable health used is limited to the self-perceived health, which is a rough approximation to the true state of health of the population. Furthermore, whilst it is true that the availability of municipal data for the same province implies working with similar populations making comparisons easier due to a reduction in the problems related to heterogeneity and the omission of relevant variables, this also limits to a great extent the size of the sample. This in turn implies a problem with respect to the implementation of the model proposed. Concretely, given that we have a sample of only 78 observations, the functional form that was used is fairly inflexible, namely a Cobb-Douglas for the health function. The use of this form imposes, for example, the restriction that the marginal productivities of each health determinant are constant and do not depend on the amount of other health determinants. In any case, I trust that the model proposed in this study acts as an initial step towards research using larger databases which will permit the development and offer an extension of the work undertaken here, thereby advancing our knowledge with respect to investment in health determinants and how in reality they affect levels of health.

Chapter 2: A multilevel mixed effects model to evaluate effectiveness of treatment for problem gambling

2.1 Introduction

There are several arguments why gambling proves worthy of public health analysis. Gambling is a relevant worldwide market from which either local or national governments obtain resources from gambling participation. It is also a social phenomenon and a challenge for economic analysis (gambling consumption appears to contradict the premises of economic theory - risk aversion, maximization and rational conduct). Gambling research has fuelled the discussion about the correlated adverse effects this activity has across a wide spectrum of addictions (alcoholism, drug abuse) and the resulting adverse social consequences (suicide, crime and other mental concerns). Although no unified consensus exists on the measure of the social impacts of problem gambling (Morse and Goss, 2007), this has been depicted as a step towards bankruptcy, divorce and suicide (Wong et al., 2010; Gvion et al., 2015), and a cause for steady drain on household finances (Suurvali et al., 2012).

Gambling disorder has become the first recognized nonsubstance behavioural addiction with severe consequences for patients and their families. At present, problem gambling treatment is a challenging present-day topic and identifying individual difference variables that may influence treatment efficacy and effectiveness is an important goal of research on gambling disorders and other addictive behaviours. However, the literature studying the predictors for a successful treatment of problem gambling is still scarce (Battersby et al., 2010; Aragay et al., 2015). An empirical approach for evaluating the effectiveness of treatment for problem gambling is proposed. Concretely, the probability of an individual experiencing a new recurrence to gambling once recovered from problem gambling treatment is analysed.

A multilevel mixed-effects logistic regression offers an appropriate approach for the purpose of this study since it allows controlling for unobserved heterogeneity across different problem gambling associations (treatment centres) jointly with individual characteristics (personality or socioeconomic situation). The use of multilevel models has been established as method for allowing group level and individual level factors in modelling. The advantage of this method is the analysis of macro variables that would impact differently across populations and skewer the results if otherwise not separated. Diez-Roux (2000) addressed the advantages of using multilevel modelling for health policy purposes.

Multilevel modelling is not exclusively used to conceptualize spatial effects but all common, nested groups that could affect the outcomes. Specifically, it is aimed to estimate the probability of a recurrence to occur based on two different types of predictors. First, there are external factors unrelated with the individual such as the problem gambling centre where treatment was received (which may determine the success of treatment effect since differences may exist in the type or quality of treatment offered in the different rehabilitation centres, including the tools and skill patients are provided with) or the supply of gambling within the area of influence. Park et al. (2019) studied the effectiveness of intervention programs on problem gamblers to curb their behaviours; in their model, treatment received is used as a second level on patient outcomes. Kairouz et al. (2015) used multilevel modelling to estimate the gambling habits of 2,139 respondents; they segregated the individual cases of the respondents and the context of the consumption (the multilevel model grouped different respondents based on the context of the consumption). And, second, individual's socioeconomic indicators like education level, employment situation, civil and family status or age, and proxy variables which reflect behavioural factors, such as other addictive behaviours (alcohol, tobacco …), the number of different gambling products consumed, and/or other factors of the individual, and whether or not the individual has suffered dropouts or relapses in previous treatments.

The effectiveness of the treatment for problem gambling is therefore investigated using a sample of problem gamblers treated by a set of some Spanish associations dedicated to gambling addiction issues. The main objective of the current work is evaluating treatment success by estimating the probability of a recurrence to occur. For such aim a multilevel mixed-effects logistic regression is proposed. First, the variables definition and sample selection are discussed. Subsequently, present the empirical model is presented and the results are reported. Finally, this Chapter is closed by clarifying its contributions which are expected to give guidance for problem gambling preventive measures conductive to avoiding post treatment recurrence.

2.2 Methodology

2.2.1 Data and collection method

The data used in this Chapter consists of a sample of problem gamblers treated by Spanish associations dedicated to gambling addiction issues in 12 different treatment centres. Information on individuals was collected in 2015 and it comes from the questionnaire given to all the new patients joining any association in the Federación Española de Jugadores de Azar Rehabilitados (FEJAR) (Spanish Federation for rehabilitated problem gamblers) at the beginning of their problem gambling treatment (with n=174). The data is therefore based on self-reported addiction i.e. individuals who admit face-to-face that they are problem gamblers and are in need of assistance. The consistency of the latter claims with reports validates the use of this data (Hodgins and Makarchuk, 2003). Some key statistics of the study participants are reported in Table 7, and the descriptive statistics of the data are presented in Tables 8.1 and 8.2.

The dependent variable is defined as the number of individuals who has answered positively to the question "Have you ever been treated for Gambling Addiction before?" As previously mentioned, the predictors of the effectiveness of treatment for problem gambling considered here are:

2.2.1.a Individual and socioeconomic factors:

Age: two age groups are considered, young and older individuals. The cut-off is set at the age of 37 (median age of the sample).

Family History: this variable is defined as the answer to the question: "Have you had relatives that have been afflicted or diagnosed with Problem Gambling behaviours?".

Labour, Marital Status, Education and Children are other categorical variables associated with individual socioeconomic factors as described in Tables 8.1 and 8.2.

2.2.1.b Behavioural factors.

Dropouts from the treatment: This variable is defined by the question: “Have you abandoned the treatment before?” Hence it collects information about the treatments individual may have had in the past. Predictors of treatment attrition, including dropouts, have been extensively discussed in the literature (Gonzalez et al., 2011; Suh et al., 2008).

Relapse: This variable is related to losses of control during the treatment phase. Note that this variable is different from the dependent variable since it does not involve transitioning from a healthy state to one where the individual can be considered an addict again. It is described by the number of individuals who have answered positively the question “Have you had relapses?” In the sample, 27 of the 44 individuals who suffered an FET experienced a relapse during the period of the treatment.

Addictive substances: This categorical variable is included to analyse the influence on the effectiveness of treatment controlling for the consumption of other additive substances - this refers to any use of substances, but not necessarily to meeting criteria for a substance use disorder.

Multi-gambling: To control for the impulsiveness of an individual to gamble, the number of gambling activities in which each person takes part is considered as a determinant.

Table 7. Key statistics of study participants (n=174)

Variable	Mean	Std. Deviation
37 years < Age < 65 years	0.534	0.500
Single	0.540	0.499
Any children	0.218	0.414
Higher education	0.207	0.406
Unemployed	0.218	0.414
Problem gambling antecedents in family	-0.140	0.089
1-3 different gambling activities	0.546	0.499
4-6 different gambling activities	0.385	0.488
>6 different gambling activities	0.069	0.254
No consumption of other substances (alcohol, tobacco…)	0.305	0.462

Table 8.1. Descriptive statistics of the variables

Variable	Definition	Num	%
Recurrence	Answer to the question:		
	Have you ever been in treatment before?		
	0 - NO	130	74,71
	1 - YES	44	25,29
Relapse	Answer to the question:		
	"Have you had relapses?"		
	0 - NO	139	79,89
	1 - YES	35	20,11
Dropouts	Answer to the question:		
	"Have you had interruptions in your treatment?"		
	0 - NO	154	88,51
	1 - YES	20	11,49
Addictive substances	Sum of all other substances that the individual has said "Yes" to consuming		
	0 - No addictive substances	53	30,46
	1 - Addictive substances	121	69.54
Family history	Answer to the question:		
	"Do you have family members with gambling adiction?"		
	0 - NO	128	73,56
	1 - YES	46	26,44
Marital status	Answer to the question:		
	"What is your marital status?"		
	0 – To be married/in union	70	40.23
	1 – Others (Single, divorced, widow…)	104	59.77
Children	Answer to the question:		
	"What is your live-in situation"		
	0 - Without children (single, married, divorced)	136	78,16
	1 - With children (married, divorced)	38	21,84

Table 8.2. Descriptive statistics of the variables

Variable	Definition	Num	%
Age	The individual is above the median age (37)		
	0 - Above 37	81	46,55
	1 - Below 37	93	53,45
Education	Highest level of education		
	0 - Trade school or lower	138	79,31
	1 - University or higher	36	20,69
Labour	Answer to the question: *"What is your professional situation"*		
	0 - Unemployed	38	21.84
	1 – Worker or Student	122	70.11
	2 - Retired or pensioner	14	8.05
Multi-gambling	Individual plays more than one game		
	0 - NO	95	54.6
	1 -YES	79	45.4

2.3 Empirical model

The empirical model is developed based on a standard latent variable model, where Y_i is an unobservable indicator variable that determines whether individual i experiences a recurrence. In Equation (11), α_0 is the intercept; x_i is a vector of variables including characteristics of individual i that affect the probability of experiencing a recurrence and ui is an unobservable random variable.

$$Y_{ij} = \alpha_0 + \beta x_{ij} + u_{ij} \tag{11}$$

The linear probability model states that the probability of Yi = 1 (Pi) is given by a function of the vector xi, and can be interpreted as the expected value of the variable Yi

$$E(Y / x_i) = 1 \cdot P[Y_i = 1 / x_i] + 0 \cdot P[Y_i = 0 / x_i] = P[Y_i = 1 / x_i] = P_i \tag{12}$$

where the frequency Pi observed in the sample can be proxied by Pi with a sampling error u_i:

$$p_i = P_i + u_i = x_i^{'}\beta + u_i \tag{13}$$

If instead of using a linear function of the variables xi, we use a monotonic increasing function of $x_i^{'}\beta$, this is $F(x_i^{'}\beta)$, where F is the logistic distribution function (logit model) we have:

$$F(z) = \frac{e^z}{1+e^z} \qquad -\infty < z < \infty \tag{14}$$

So

$$p_i = P_i + u_i = \frac{e^z}{1+e^z} + u_i \tag{15}$$

The non-linear model described above can be estimated via a maximum likelihood approach. However, the particular characteristics of each treatment centre (association) are going to be considered, such as types of therapies, particular environmental conditions... because these types of factors can have an effect on the probability of a recurrence happening. In order to include this effect, one possibility would be to incorporate a categorical variable (α_j) that identifies a particular centre j in the model:

$$Y_{ij} = \alpha_j + \beta x_{ij} + u_{ij} \tag{16}$$

Equation (16) requires a higher number of parameters to be estimated (as many as problem gambling recovery centres exist in the data), which reduces the model's degrees of freedom. In addition, if the number of individuals differs by centre, biased results could be obtained for those centres with small sample sizes (Gelman and Hill, 2007). However, if the "centre" effect is ignored, the variability between centres will be captured by the error term leading to biased results.

To deal with all these problems, a mixed-effects logistic model – that combines fixed and random effects - is proposed. This model takes into consideration that those individuals belonging to a group (a treatment centre in our case), share a diversity of group factors such that they must be taken into account when evaluating effectiveness of treatment; also the interactions between them can affect the outcome of the treatment. By using the mixed-effects logistic model, it is possible to analyse the effectiveness of problem gambling treatment taking into account the different treatment centre (group) characteristics.

In addition, given that individuals belonging to a group share similar characteristics, the assumption of independence between observations, on which traditional statistical techniques are based, is not fulfilled. For this reason, standard statistical models can lead to biased results (Heck and Thomas, 2009). In this sense, the multilevel model proposed here can solve this problem because it recognizes the nested structure of the data and allows obtaining unbiased estimates of the existing variations in the different levels of the hierarchy (West et al., 2011).

Specifically, we can define two levels, the individuals and the different groups (problem gambling treatment centres). The fixed effects in our model will be adjusted by parameters in the intercept, while the random effects are random variables that are not observed but for which a distribution can be estimated by the variance of a normal distribution (Bates et al. 2015). Specifically:

$$Y_{ij} = (\gamma_0 + x_i\beta) + (\mu_j + u_{ij}) \tag{17}$$

In the right hand part of the Equation (17) the fixed effects are in the first parenthesis and the random effects in the second one. γ_0 is the intercept and the parameters for each group (μ_j) are included in the model as random factors that follow a normal distribution $\alpha_j \approx N(0,\sigma^2)$.

Thus, Equation (17) represents a model similar to equation (16) but the number of parameters is considerably reduced. In addition, it takes into account an aggregated data structure at different levels (centres). That is, the model recognizes the nested (or hierarchical) structure of the sample since the different individuals are grouped in different treatment centres. Finally, this model makes it possible to extrapolate the results to all the problem gambling treatment centres in the population, even if they are not included in our sample.

2.4 Results

Estimates of Equation (17) are shown in Table 9.

In the top part of the Table 9 we report the results for fixed effects. Estimate coefficients indicate the direction of the change in probability (sign) but not the size of that change. Below the fixed effects results, Table 9 shows the estimated variance components. The random-effects equation is labelled Association, meaning that these are random effects occurring at the problem gambling treatment centre level. The estimate of the variance is 2.00 with a standard error of 1.31. At the end of Table 9, a likelihood-ratio test comparing the model to the ordinary logistic regression is provided and proves highly significant for this data set. The conclusion is that the fixed-effects model is preferred to the ordinary logistic regression. Next, the estimates are analysed according to the described classification of the covariates.

a) Individual and socioeconomic factors

With respect to age as a determinant factor for treatment effectiveness, there is no consensus in the literature given the lack of evidence to date (Melville et al., 2007 or Aragay et al., 2015). Here, Age refers to individuals who are less than 37 years old or who are unlikely to have a recurrence as compared with older individuals. The negative sign indicates that younger patients have on average a better chance of not experiencing a recurrence than older ones.

The negative coefficient of *Family History* indicates that family background decreases the chance of having gambling problems. This can be explained by the recognition of the problem, as well as by learning and previous knowledge that can help towards a more effective treatment.

The parameter associated with *Marital Status* indicates that not being married/in union has a positive impact on recurrence episodes. This result is consistent with Volberg (1994) or Aragay et al. (2015).

With respect to the *Labour* situation, individuals who are working or studying have less odds of experiencing a recurrence. Similarly, being retired decreases the chance of a recurrence as compared to a situation of *unemploymen*t. Situations of stress or depression related to being unemployed can be the cause of this result (Volberg et al., 2001 and Aragay et al., 2015).

The *Education* level and having *Children* do not seem to have a significant influence on treatment effectiveness in our sample.

Table 9. Mixed-effects model regression. Estimated Parameters

(Dependent variable is Recurrence episode coded as "0" or "1")

Covariate	Coefficient	St. Error	z	P > z
Age	-1.964	0.726	-2.710	0.007***
Family history	-1.014	0.579	-1.750	0.080*
Marital status	0.889	0.498	1.790	0.074*
Education	0.225	0.909	0.250	0.804
Labour				
Worker or student	-1.273	0.561	-2.270	0.023**
Retired	-3.364	1.615	-2.080	0.037**
Children	-0.032	0.468	-0.070	0.945
Dropouts	4.150	0.675	6.140	0.000***
Relapses	3.800	0.938	4.050	0.000***
Addictive substances	2.127	0.801	2.660	0.008***
Multi-addiction	-0.915	0.696	-1.310	0.189
constant	-1.970	1.361	-1.450	0.148

Association	Coefficient	St. Error
var(_cons)|	2.002.119	131.277

(Std. Err. adjusted for 12 clusters in asoc)

LR test vs logit model: Wald chi2(11)= 144455.92

Prob > chi2 = 0.0000

***significant at 10% **significant at 5% ***significant at 1%**

All these findings may be helpful for therapies efficacy in the treatment of problem gambling, since treatment is expected to provide an overall framework to facilitate lifestyle changes and restructure the environment to increase reinforcement from non-gambling behaviours.

b) Behavioural factors

Regarding Dropouts from the treatment, results significantly indicate that not having had dropouts during the previous treatment leads to a lower recurrence probability. On the other hand, having Relapses during the treatment is a significant determinant of the treatment effectiveness. Individuals, who admit never having lost control of their gambling impulses during treatment, show a much lower rate of recurrence than those who have had dropouts during the treatment.

In line with previous studies (Echeburúa et al., 2001; Battersby et al., 2010), results indicate that not being addicted to any other substance (alcohol, tobacco or others) while showing symptoms of problem gambling, seems to reduce the chance of recurrence as compared to those individuals who admit to being consumers of addictive substances.

Finally, for any given problem gambling treatment centre, the expected outcomes will be different.

In order to identify the magnitude of the different predictors of the probability of a recurrence occurring, we look at the marginal effect, which depends on all the parameters of the model and the functional form of F (.). Table 4 shows the marginal effects from the estimates of Equation 7. From the results it can be deduced that:

i) Individuals being younger than 37 have a 27.1% lower chance of having a recurrence.

ii) Individuals who have problem gambling family antecedents have a 14% lower chance of experiencing a recurrence.

iii) Regarding marital status, not being married increases the probability of suffering a recurrence in 11.9%.

iv) The employment situation is found to be statistically significant in explaining the probability of experiencing a recurrence. An individual who works or studies has a 20.2% lower chance of having a recurrence. This probability is reduced by 37.6% in the case of individuals being retired.

v) Quitting treatment (dropouts) in previous therapies increases the probability of recurrence by 57.2%.

vi) Having experienced relapses during treatment increases this probability by 52.4%.

vii) Being addicted to other substances increases the probability of recurrence by 24.9%.

Table 10 also displays the marginal effect of a variable for all the possible combinations of other variables. The chance of experiencing a recurrence for an individual who has had a relapse during treatment increases from 36.6% to 40.0% (in the case of withdrawing the treatment). On the other hand, the probability of having a recurrence for an individual who has had a relapse during treatment increases from 19.5% to 38.1% (in the case that they consume other addictive substances). That is, by joining those factors that explain behavioural factors of an individual, the probability of suffering a recurrence increases.

Table 10.1 Marginal effects (I)

	dy/dx	St. Error	z	P > z
Age	-0.271	0.099	-2.740	0.006***
Family history	-0.140	0.089	-1.580	0.115
Marital status	0.119	0.066	1.800	0.072*
Education	0.031	0.124	0.250	0.802
Labour				
Worker or student	-0.202	0.095	-2.130	0.034**
Retired	-0.376	0.148	-2.550	0.011**
Children	-0.004	0.064	-0.070	0.944
Dropouts	0.572	0.170	3.360	0.001***
Relapses	0.524	0.102	5.140	0.000***
Addictive substances	0.249	0.109	2.290	0.022**
Multi-addiction	-0.124	0.095	-1.310	0.190

***significant at 10%   **significant at 5%   ***significant at 1%**

Table 10.2 Marginal Effects (II)

	dy/dx	St. Error	z	P > z
Marginal effect of relapses for all possible combinations of dropouts and addictive substances				
Dropouts=0	0.366	0.053	6.880	0.000***
Dropouts=1	0.400	0.163	2.450	0.014**
Addictive Substances=0	0.195	0.068	2.840	0.004***
Addictive Substance=1	0.381	0.065	5.880	0.000***

***significant at 10%   **significant at 5%   ***significant at 1%**

2.5 Discussion and concluding remarks

The aim of this chapter is to evaluate the effectiveness of treatment for problem gambling in a sample of 174 Spanish adults. Specifically, the focus is on identifying individual different variables that predict recurrences. This may help treatment techniques to be adapted depending on the individual characteristics and predictors of likelihood of relapse of each patient (here problem gamblers seeking treatment). Accordingly, an empirical model is performed that relates these recurrences to individual socioeconomic characteristics and behavioural factors of the individual the assumption being that these factors may affect the success or failure of the treatment received.

To estimate the model, a multilevel mixed-effects logistic regression using STATA software is proposed. This specification allows controlling for the possible unobservable heterogeneity that may exist between the different problem gambling recovery centres which may have an impact on the final treatment outcome. The results confirm that such heterogeneity exists and, therefore, the mixed-effects logit regression model is used here in preference to a standard logit.

The findings here seem to indicate that individual characteristics such as age, family antecedents, marital status or work status may affect the chance of a recurrence occurring. The results also show that factors linked to the behaviour of the individual (previous dropouts, relapses during treatment, or consumption of other addictive substances) strongly affect that probability. Specifically, age > 37 years, no family history of gambling problems, being single/not partnered, unemployment, prior treatment dropout, prior relapses after treatment for problem gambling, and use of other drugs were significantly associated with treatment effectiveness in the sample. In fact, quitting treatment in previous therapies increases the probability of recurrence by 57.2% while having experienced relapses during treatment increases this probability by 52.4%. Moreover, consumption of other addictive substances increases the probability of recurrence by 24.9%. Furthermore, a combination of some of these factors significantly increases the chance of suffering a recurrence.

Since there is a substantial gap in the literature regarding problem gambling treatment effectiveness, our results are expected to contribute to the literature since identifying individual difference variables that may influence efficacy and effectiveness in the treatment of gambling disorder is an important goal of research on gambling disorders and other addictive behaviours.

Moreover, the analysis of these predictors provides useful information for somehow addressing this growing social and public health problem. Concretely, it would be relevant to know what works for treated problem gamblers and even which of them would likely benefit the most. Finally, from a general perspective, the results may shed some light on a current social concern, namely, problem gambling treatment, especially because of the emergence of online gambling (National Research Council, 1999 or more recently Effertz et al., 2018). This is important because worldwide there are calls greatly to increase provision of treatment services.

Chapter 3: A spatial econometric analysis of gambling outlets location in urban areas: A case study of Madrid

3.1 Introduction

Commercial gambling opportunities have greatly expanded throughout many jurisdictions worldwide in recent years. The impact of this phenomenon is varied across different countries but shows a decrease in overall gambling participation but increase in vulnerable population sectors (Abbott et al., 2014, Welte et al, 2015). Even though the "availability hypothesis" suggests that a positive correlation exists between gambling participation and expenditure and the number of opportunities to gamble (Orford, 2002, Storer et al 2009), participation in such activities may be conditioned not only by the availability and exposure of gambling, which are ultimately determined by many institutional factors, such as the main regulatory policies, but also by the willingness of individuals to gamble - in fact, if consumers prefer a corner solution (that is, they choose not to gamble), an expansion of gambling opportunities will have limited effect on consumer's behaviour (Kearney, 2005). While gambling operators and firms are basically interested in earning positive profits, local governments may be influenced by the characteristics of their own jurisdiction and those of neighbouring areas (Wenz, 2008). Where gambling is allowed, governments have traded its negative aspects for the potential benefits - tax revenues, jobs, and other economic development initiatives… -; as the driving for legalization and regulation (Nichols and Tosun, 2017).

The 2020 lockdowns changed he gambling framework and the attitudes towards gambling participation. Jenkinson et al report the positive benefits from the close of on-location venues to the household finances of the respondents but show an increase in online gambling. Early stages show that online gambling has become prevalent during the pandemic with a decrease in sports betting and a decrease in EGM and Casino activities (Hakansson, 2020). This result is consistent with consequent studies where the initial lockdowns were accompanied by a reduction of gambling frequency due to the lock of land-based gambling but an increase of online gambling (Hodgins and Stevens, 2021, Brodeur et al 2021) as well as an increase in the prevalence of problem gambling (Brodeur et al 2021).

Skidmore and Tosun (2008) found that the introduction of gambling products within a jurisdiction can have an impact on retail activity, suggesting that some economic benefits result from opening new gambling businesses. As for the negative side, expansion of gambling opportunities to an area could raise social concerns linked to a number of negative externalities, including regressivity of gambling taxation (Gandullia and Leporatti, 2018; Pérez and Humphreys, 2011), public health impacts (Wardle et al., 2014) and gambling-related harm beyond the loss of money (pathological gambling, social life and health issues, work performance, crime…) (Delfabbor and King, 2019; Grinols and Mustard, 2001). In addition, gambling could also be considered as immoral (Basham and White, 2002).

All these possible effects of exposure and accessibility to gambling opportunities exhibit a certain social and geographical patterning. In fact, previous research has explored the distribution of gambling outlets (Robitaille and Herjean, 2008; Wardle et al. 2014) and it has recognized the role environment plays in the relationship between access to gambling opportunities and individuals' behaviour (Korn and Shaffer 1999; Pearce et al. 2008). In general, analyses of spatial distribution of gambling show that people living in the most disadvantaged areas have greater access to gambling and are more affected by the harms of gambling (Papineau et al. 2020). The links between gambling availability and area characteristics, such as socioeconomic environment, have also been explored by Gilliland and Ross (2005). In addition, Beckert and Lutter (2009) explain that the lack of leisure opportunities for socially disadvantage people contributes to the expansion of gambling. Finally, it has been reported that an increased availability and accessibility of gambling outlets is related to an increase in related unhealthy behaviours and increased likelihood of problem gambling (Pearce et al., 2008; Rush et al., 2007; Young et al., 2012), with those living in areas of greater deprivation being more likely to experience harm (Orford et al. 2010).

As for measuring area-level socio-economic status most previous studies have considered information about the areas' degree of education, age structure of the population, income of households and unemployment rate (Raisamo et al., 2019). Along with sociodemographic variables, other studies, including Carrà et al. (2017), who analyses associations between gambling and baseline individual and area-level characteristics, and Marek et al. (2021), that examines how 'environmental goods' such as green spaces and ‘environmental bads’ such as alcohol outlets and gaming venues co-occur, used composite index at small level area to measure area-level deprivation. Even in that cases, variables such income, employment and education are considered as domains of relative deprivation (alongside other indicators such as health deprivation and disability, barriers to housing and services, crime and disorder, and living environment).

Cities are certainly a key factor in the location of gambling (Fiedor et al., 2017). Spatially, gambling is concentrated mainly in cities and large urban agglomerations (Klebanow and Gallaway, 2015), which contributes to create a specific retail environment and shaping the urban (Markham, 2015). Marshall (2009) highlighted the role of the local environment as a key determinant of the gambling intensity, while O’Flaherty and Sethi (2010) documented that street vice activities (including gambling) are largely limited to neighbourhoods that are centrally located and densely populated. Indeed, recent studies have put attention on gambling environments in cities when addressing social concerns with respect to gambling exposure. Papineu et al. (2020) characterize gambling environments in Quebec (Canada), Espadafor and Martínez (2021) estimate the effect of gambling opportunities on educational performance in Madrid (Spain), and Macdonald et al. (2018) examine the socio-spatial patterning of outlets such as alcohol, fast food, tobacco and gambling, within Glasgow City (Scotland).

In this chapter the focus is on the relationship of the gambling retail environment with urban area (neighbourhood) characteristics. This correlation is of interest because neighbourhood characteristics may attract sellers, and because the presence of gambling sellers may cause changes in neighbourhood demographics. This leads to the question why gambling opportunities concentrate in some neighbourhoods. Additionally, it is claimed that people in deprived areas are more likely to gamble and that gambling outlets clusters are associated with higher rates of problems among individuals from lower socio-economic groups (Livingstone 2001; Abbott et al. 2004; Wheeler et al. 2006). As in Grumstrup and Nichols (2021), it is argued that the concentration of gambling outlets can be mostly explained by income and other neighbourhood characteristics

In particular, the empirical exercise examines whether certain urban areas are subject to excess access to gambling retailers. Specifically, it aims to explain how the number of gambling outlets located in a certain neighbourhood correlates with income and other sociodemographic characteristics of that local area, as previously mentioned, but taking into account the supply of nearby areas. To ensure consistent and efficient estimates, the estimate model of gambling location tests and corrects for spatial effects. As discussed in Garrett and Marsh (2002), among others, spatial dependence results from a lack of independence among cross-sectional units caused, among others, by the presence of direct influence of neighbouring units.

The focus is on Madrid (Spain), where, as far as it is known, there has been no evaluation of the distribution of gambling opportunities and their spatial patterning. This is an interesting case of study since the Spanish gambling market has seen a dramatic increase in both economic figures and opportunities over the last decades. Until 1977, legal gambling was severely restricted and non-legal gambling mostly criminalized. Then, first licenses to privately operate casino gambling, bingo and slots machines were awarded and these types of establishments became more common in the main Spanish cities. In 2008, several bookmakers were awarded the first licenses to operate in Madrid, the first jurisdiction in Spain in allowing offline sports betting.

Following this practice, other Spanish regions also allowed bookmakers to operate, setting up a completely new gambling market and urban retail landscape. Indeed, the city of Madrid has experienced a significant increase in the supply of gambling opportunities in recent years reaching more than 800 gambling outlets at the end of 2017. As in Espadafor and Martínez (2021), the choice of Madrid as case study is then motivated by the intensive spread of new gambling outlets between 2015 and 2017. Was this increase in the access to gambling spatially uniform or was there a trend towards deprived neighbourhoods? Is there a spill over effect at the neighbourhood level or is the gambling supply dependent exclusively on the own determinants of the area? These are some of the questions this chapter endeavours to answer by trying add to the increasing social debate about the perceived clustering of gambling opportunities in areas of greatest socio-economic deprivation.

The next section describes the methods and provides some background on the spread of gambling opportunities in Madrid. Later, the results are discussed, followed by the discussion section which contains concluding remarks suggesting that gambling opportunities display similar spatial patterning across urban areas.

3.2 Data collection methodology

Using official municipal data from the city of Madrid for the year 2017 and various spatial regression techniques, the potential links between neighbourhoods' socioeconomic and demographic characteristics and gambling retail stores are examined.

3.2.1 Sample: A case study of Madrid

Madrid is the largest city of Spain. The city has a metropolitan area population exceeding 6.5 million. It includes 21 districts comprising 131 neighborhoods. The most populated neighborhood is *Aluche* (in *Latina* district) with almost 66,000 inhabitants in 2017, while the least populated area is located in *El Cañaveral* neighborhood (in *Vicálvaro* district) with just 945 inhabitants. The average population of the neighborhoods of the city of Madrid is 24,594 inhabitants (standard deviation is 13,624) while the average rate of migrant population (non-native) is 12.6 – with half of the neighborhoods accounting for almost 80% of it. The highest density of the population in the city of Madrid is in *Gaztambide* (in *Chamberí* district) with 448 inhabitants per hectare.

Also, in terms of income, neighborhoods are not uniform. The 10% of the neighborhoods accumulate 20% of the total city income.

3.2.2 Gambling outlets data collection

The City Council of Madrid (*Ayuntamiento de Madrid*) is the body responsible for the government and administration of the municipality. In 2008, Spain's first sports betting shops were allowed to open in Madrid. As an immediate outcome, some gambling firms planned to set up 70 sports betting shops across the Madrid area - the first jurisdiction in Spain in granting licenses. Within this context, the number of privately-operated licensed gambling outlets in the city of Madrid increased from 304 in 2013 to 509 in 2017. Also considering the number of lottery stores operated by either by SELAE (a state-owned company responsible for the operation of all types of lotteries) or ONCE (the national organization of Spanish blind people which is awarded a license to operate a charity lottery), total number of gambling outlets located in Madrid reached 812 in 2017. However, the gambling landscape in the city of Madrid does not draw an equally distributed map. The neighborhoods of *Vista Alegre* and *Embajadores* host more than 20 gambling outlets each, while there are 10 neighborhoods with none. Almost 50% of all gambling outlets are concentrated in 29 neighborhoods (out of 131) – each of them hosting at least 10 or more gambling outlets. There are 15 neighborhoods with just one gambling outlet.

Address data for gambling outlets as for 2017 were obtained from the Madrid City Council Open Data (i.e. the open data web site of the City Council of Madrid) according to the National Classification of Economic Activities (CNAE 2009) which listed all existing and operating businesses within the city of Madrid. Considering this administrative classification, the category that is of interest to this paper comprises "*all venues destined to satisfying the gambling needs of the public including casino gambling, bingo and gambling halls as well as horse betting and lotto*"– which includes, as previously mentioned, a total of 812 gambling outlets. The data held is deemed as comprehensive as information on the various premises is required to be held by Madrid City Council for inspection, planning and licensing purposes. As in Macdonald et al. (2018), the address for the outlets were linked to precise geo-coordinates via the Madrid City Council Open Data and then assigned to a specific neighborhood accordingly. So the dependent variable in the spatial model is the number of gambling outlets located in a certain neighborhood.

3.2.3 Measurements: Covariates and controls

Measures describing the neighborhood-level socio-economic characteristics were based on data from the Madrid City Council Open Data. The source is a database of open data containing information about the neighborhoods' population, population density - the number of people per hectare -, the rate of native Spanish population, age structure of the population - so the number of people aged 0 to 15 divided by the sum of people 16 to 65 and 65 and over – to proxy the socio-demographic structure of each neighborhood's population, the mean of household income in Euros as for 2016; and the unemployment rate. The data used was available at the neighborhood level. Madrid neighborhoods areas are obviously defined for a different purpose, and they are not coherent communities and vary in population and size. Notwithstanding, neighborhoods should reveal the socio-economic exposure to gambling outlets in daily life reasonably well. Table 11 shows the descriptive statistics for the considered covariates which encompass socioeconomic and demographic indicators for each of the neighborhoods of the city of Madrid

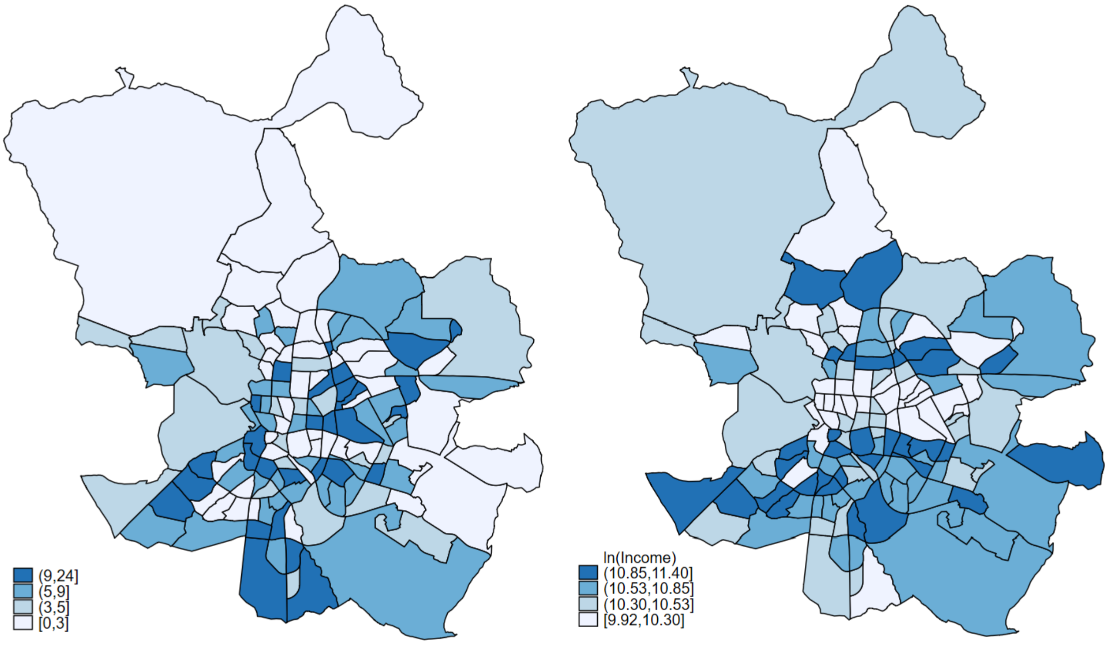
Table 11. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Gambling outlets (number)	6.27	5.06	0.00	24.00
Population (hab.)	24,594.08	13,571.91	945	65,961
Population density (hab./hectare)	181.02	119.75	0.20	448.00
Native Spanish population rate (%)	87.42	5.90	68.07	96.74
Youth population rate (%)	17.57	7.10	7.56	49.87
Income (euros)	41,746.00	16,599.00	19,674.00	89,015.00
Unemployment rate (%)	7.88	2.63	3.20	15.04

3.2.4 Data analysis

On the Figure 2 map, the distribution of gambling outlets and household income level across neighborhoods are shown, where darker colors indicate higher number of gambling outlets and larger level of income respectively; each category represents a quantile. A potential positive spatial autocorrelation in these data can be observed which can be described by the first law of geography which states that near things are stronger related than distant things (Tobler, 1970). First, a district with a high number of gambling outlets is surrounded by other districts with also a significant number of this type of venues. In order to determine whether there are significant spatial associations in the data, we use the widely used Moran's I test. This test is used to assess spatial dependence in the outcome from a model. Positive values for Moran's I indicate that similar units are near one another (that is, *positive* spatial autocorrelation) - see for example Elhorst (2014) for further details. To undertake a Moran's I test, it is first needed to specify how the units are related, that is, provide a W matrix. In this sense, a queen geographic contiguity (normalized by row) matrix is employed. Using this W, the spatial autocorrelation in the data is tested using Moran's I. Focusing first on the outcome, I find statistically significant spatial autocorrelation (chi2(1)=4.51; Prob.>chi2 =0.03), which confirms the preliminary insights from Figure 1 that gambling outlets are not entirely random across the city. This can be explained by a variety of spatial processes and mechanisms including neighborhoods' socioeconomic and demographic characteristics may cause gambling outlets to cluster, endogenous interaction effects (the number of gambling outlets in a neighborhood can affect another gambling business decisions).

Figure 2. Gambling outlets (left) and income (right)
(neighborhoods of the city of Madrid. 2017)



Source: Own elaboration from Madrid City Council Open Data.

In addition, due to the maturity of the Spanish gambling market in 2017, it could be assumed that rent-seeking agents have taken into consideration which location to occupy based on their decisions. That is to say independence of the variable Y between spatial units is not assumed. The operators would not establish new gambling outlets if the market is too crowded and would reasonably target spaces where the competition would be lower.

Second, a negative correlation can be primarily observed between household income and gambling outlets. However, by deeper analyzing this relationship, it is necessary to address a potential endogeneity problem, given that the relation between both variables could be bidirectional. This issue is tackled in the model considering values of the income variable lagged one period (so as predetermined).

3.3 Theoretical Models: Spatial econometric models

In order to model spatial autocorrelation in a way that other covariates are included in the analysis three econometric approaches are considered: spatial autoregressive (SAR) model, spatial error model (SEM) and spatial lag of X (explicative variables) model (SLX). Spatial econometric models allow to address heterogeneities across observations and assess spatial autocorrelation. In the spatial econometric framework, spatial dependence assumes that values observed for one area depend on the values of neighboring observations at nearby areas and vice versa (LeSage and Pace, 2009)

The standard approach with spatial econometric models would be to establish a benchmark model that needs to be expanded with spatial interaction effects (Hendry 1995). With this aim, we start with a non-spatial linear OLS regression:

$$Y = X\beta + \varepsilon \tag{18}$$

Where the dependent variable Y will be an N X 1 vector denoted as the number of gambling outlets in a spatial observation unit (here, a neighborhood); X will be the N x K matrix of exogenous explanatory variables; β the K x 1 vector of parameters to be estimated and ε the i.i.d disturbance term vector, $\varepsilon \approx iid\ N(0, \sigma^2)$.

As explained above, the proposed model accounts for the existence of unobservable heterogeneity within the distribution of the gambling outlets across the different neighborhoods within the city of Madrid. To account for this situation, a spatial econometric model that assumes an underlying spatial autoregressive process is proposed, either in the interactions of the dependent variable of the neighborhood j with the dependent variables of its neighbors (SAR model); the interactions of the error terms amongst themselves (SEM model); and including lagged independent variables from neighboring spatial units (SLX model). Certainly, it is also possible to define other spatial models, for example, controlling for both the interactions between the independent variables and the error terms at the same time (SAC model) – (see Elhorst (2014), among others, for further details on this).

Once the weights matrix W is defined, the specification of the model in Equation 18 is updated with an WY indicator:

$$Y = \rho WY + X\beta + \varepsilon \qquad (19)$$

Where the ρ (spatial autoregressive coefficient) accounts for the impact of the dependent variable of nearby neighborhoods. This is a first order autoregressive process in which ρ will range between -1 and 1 (Elhorst, 2014)

Equation 19 corresponds to the spatial autoregressive (SAR) model which assumes that the unobservable heterogeneity is captured solely by the dependent variable Y. The spatial autoregressive coefficient will indicate whether the presence of nearby gambling outlets will impact the decision of establishing a new venue while controlling for exogenous covariates X.

The second spatial econometric model considered in this paper is the spatial error model (SEM) which assumes that the error term ε from Equation 18 does not meet the i.i.d conditions. The assumptions on the structural instability of the model (inconsistent estimators based on underlying processes) are shifted from the dependent variable to an unexplained impact in the error term. In the end, the error terms across spatial units are correlated. This is modelled by explicitly describing ε as following a spatially autocorrelated process; the error term in the OLS model (Equation 18) is then re-written as:

$$\varepsilon = \lambda W_{\varepsilon} + v \qquad (20)$$

And so Equation 18:

$$Y = X\beta + \lambda W_{\varepsilon} + v \qquad (21)$$

where λ controls for heterogeneity in spatial autocorrelation (it will share the same properties as ρ with values ranging from -1 to +1 to indicate the strength of the correlation). The weight matrix W would still be catching the geographical information from the SAR model but applied to the residual part of the estimation (identified now as W_{ε}). In the end, not accounting for the spatial error will lead to biased estimations and inefficient OLS.

The last spatial econometric model specifications model examined here is the spatial lag of X model (SLX), that focuses on the spillover effects between exogenous variables. $X\beta$ will be accompanied by a control vector Nx1 $WX\theta$ where the distance matrix will update the Kx1 vector of exogenous variables X. The θ will be a fixed Kx1 vector of unknown parameters. Factoring in all these to the OLS model in Equation 18, it can be written as:

$$Y = X\beta + WX\theta + \varepsilon \qquad (22)$$

The model specification in Equation 22 will shift the weight of the spatial structure on the exogenous variables rather than the dependent variable Y or an unspecified process within the error term ε. It will account for the clustering effect within an area (a particular neighborhood and all the nearby ones). The number of gambling outlets in a neighborhood i would be dependent, not only on the socioeconomic and demographic conditions of the neighborhood, X, but also on the conditions of the surrounding area θ.

A further theoretical assumption in all cases is that the number of gambling outlets within the borders of a certain urban area (neighborhood) reflects economic equilibrium, which is a standard assumption in the industrial organizational literature that studies firms' entry into competitive and concentrated markets (Bresnahan and Reiss 1990, 1991).

3.4 Results

The previously described spatial econometric models are estimated by using maximum likelihood method in Stata 16 package. Variables not in percentages were transformed to their natural logarithms and an interaction term between income and unemployment is included (for ease of interpretation, both variables are mean-centered). So estimated coefficients can be interpreted as elasticities as the sample mean.

Table 12. Determinants of gambling outlets location
(neighborhoods of the city of Madrid. 2017)

	OLS(1)			SAR(2)			SEM(3)			SLX(4)		
	Coef.		**P>z**	**Coef.**		**P>z**	**Coef.**		**P>z**	**Coef.**		**P>z**
Income	-0.511	**	0.014	-0.560		0.069	-0.685	**	0.014	-0.690	**	0.016
Unemployment	-0.301		0.912	0.000		0.925	0.003		0.912	-0.010		0.745
Unempl.*Income	0.995		0.069	1.001		0.104	1.030	**	0.049	1.006		0.085
Population density	0.389	***	0.000	0.391	***	0.000	0.411	***	0.000	0.391	***	0.000
Native population	-0.034		0.060	-0.031		0.053	-0.032	**	0.050	-0.038	**	0.026
Youth population	-0.049	***	0.001	-0.047	***	0.000	-0.044	***	0.001	-0.043	***	0.001
Constant	8.837	***	0.000	8.750	***	0.001	10.209	***	0.000	3.078		0.458
ρ				0.163		0.114						
λ							0.332	***	0.006			
θ (Income)										0.748		0.086
Wald χ^2 test				2.500		0.114	7.670	***	0.006	2.940		0.086

Notes: 131 Observations. **p<0.05; ***p<0.01. OLS (non-Spatial model); SAR=Spatial Autoregressive Regression model; SEM=Spatial Error Model; SLX=Spatial Lag of X model. The variables are in natural logarithmic form (except those expressed in percentage terms). Income and Unemployment rate are mean-centered

Table 12 displays estimates from OLS (1), SAR (2), SEM (3), and SLX (4) – which includes the spatial lags of income. Results from a Wald test indicate that SEM model is preferred to others. The spatial parameter (λ) is positive and statistically significant (p-value 0.0056) confirming the result obtained from Moran's I test. This indicates that, first, OLS predictors are insufficient to purge the spatial dependence in the outcome and, therefore the results from OLS regression would be misleading. Second, there is a positive significant spatial autocorrelation in this model which could mean that the feedback of the existing gambling market may favor the appearance of more gambling outlets (Economopulous, 2015).

It should be noted that in SEM models there are not indirect effect, therefore, coefficients in Table 12 indicates total effects.

The results suggest that neighborhood household income have a negative, statistically significant effect on the number of gambling outlets located in such area. Concretely, a 1% increase in income is associated with a 0.68% decrease in the number of gambling outlets (at the sample data mean). This is in line with Welte et al. (2006) and Pearce et al. (2008), that confirm that the odds of gambling prevalence are higher when regions face lower income, and Dahan (2020), who suggests that the Israel National Lottery (Lotto) tend to set up significantly more sales points in disadvantaged neighborhoods, and it may suggest that the taxation of gambling outlets revenue is a regressive tax policy. Novak et al. (2006) reported a similar result for tobacco outlets. They found that retail tobacco outlets were disproportionately located in economic disadvantaged neighborhoods. In contrast, Espadafor and Martínez (2021), find no evidence of gambling outlets opening in already impoverished areas in the city of Madrid. However, it should be noted that they used no household income but rental price as an indicator of the area-level poverty. The negative sign of the estimated coefficient for income is consistent in all considered model specifications.

Evidence on the neighborhood unemployment is not statistically significant. This is consistent with some previous works, including Raisamo et al. (2019) that analyze location of electronic gambling machines (EGMs) in Finland providing evidence of insignificant effect of unemployment when combining all socio-economic indicators (income, unemployment, education) in the same model specification. However, the estimated effect of the interaction term between income and unemployment rate is positive and statistically significant (elasticity coefficient=1.03). This means that the negative effect of household income on the number of gambling outlets is smaller in absolute value for urban areas with higher levels of unemployment. That is to say, the negative effect of income on the gambling retail environment is less negative as unemployment rate increases. This could be explained by some income inequality within a neighborhood that may attract gambling outlets due to an increase in propensity to gambling by lower-income citizens.

As for neighborhoods demographic characteristics, the estimated effect of population density population on the gambling retail environment is positive and statistically significant. A 1% increase in the density of the population, increases 0.41% the number of gambling outlets. This is an interesting result as it seems to contradict previous findings. Raisamo et al. (2019) found that the population density had no significance correlation with EGMs density. Also Wardle et al. (2014) suggested that it does not appear to be the case that areas with high concentrations of EGMs were those with a high density of people and jobs.

Regarding neighborhoods population structure, it is found that the ratio of native Spanish population negatively impacts the establishment of gambling outlets. This provides evidence contrary to Wenz (2008), who found that large numbers of native Americans in the county predict native American casino openings, but it is in line with multiple studies that reported that ethnic minorities may be at higher risk of developing gambling problems (see Welte et al., 2004, among others). Even in the case of other products whose consumption is linked to gambling (e.g. tobacco and alcohol), retail outlets were found to be more prevalent in neighborhoods with high concentrations of foreign-born residents (see Novak et al. 2006 and Bostean et al. 2021, among others). A similar result is obtained for the percentage of youth population. Percentage under age 18 is negatively associated with gambling density. Bostean et al. (2021) show a similar result for retail tobacco outlet but the opposite effect in the case of alcohol density.

The results provide some evidence of co-location of gambling outlets within similar urban areas (neighborhoods). This confirms previous research showing co-location of individual types of outlets in similar geographical areas, including alcohol, fast food, tobacco, sub-prime financial services and even gambling outlet clusters (Pennay et al. 2021; Kim, 2018; Macdonald et al. 2018; Townshend, 2017).

3.5 Discussion and concluding remarks

Gambling regulations worldwide aimed at expanding gambling opportunities and availability seemed to gradually make people more prone to gamble. Previous research has found a significant relationship between exposure to gambling, which is strongly influenced by the corresponding regulatory environment, and severe social concerns, including, among others, risk of gambling-related harm and/or regressivity of gambling taxation. Examining the spatial availability of gambling may provide a better understanding of the role of the retail environment in such social/public issues. This chapter focuses on the factors influencing recent expansion of gambling opportunities – i.e. the number of gambling outlets - within urban areas – i.e. neighborhoods. A number of interesting patterns are observed.

Living in neighborhoods with low household income is linked to ease access to gambling opportunities. This is an interesting public finance finding, as may suggest that taxation of gambling business is a regressive tax policy (it should be acknowledged that, according to the nature of data and the study design, it cannot be certainly known that lower-citizens are those who exhibit a greater gambling prevalence). Also, resident population density positively impacts the establishment of gambling outlets, which interestingly seems to contradict previous findings. Finally, urban environments with older and/or non-native citizens host a higher number of gambling outlets. Overall, as shown by previous research on clusters of 'environmental bads' (alcohol, fast food, tobacco, gambling…), empirical spatial analysis demonstrates a strong correlation between neighborhood socio economic and demographic characteristics and access to gambling retailers highlighting a specific geographic patterning of distribution within more disadvantaged urban areas.

The results have interesting implications for gambling stakeholders and for local governments when it comes to the introduction and/or increase of gambling availability. While it is still too early to say if the attitudes of the pandemic will modify land-based gambling permanently In fact, this chapters' findings suggest that gambling opportunities display similar patterning and so the associated negative externalities may also have a spatial, geographical aspect, providing some support for policy measures to reduce concentration of gambling outlets in areas, such as low income neighborhoods – including restrictions on new outlets being opened or minimum distance requirements. All in all, understanding the distribution of gambling opportunities is an important public issue. In fact, public health concerns over gambling issues have been the strongest argument against the widespread expansion of gambling opportunities. This chapter provides support of the need to regulate existing supply within the scope of the current regulatory framework. The overprovision of gambling outlets is a relevant urban policy matter, and so the findings here may be helpful in planning regulations appropriate for the urban areas in greatest need.

3.6 Appendix

The first step in the construction of the spatial model is the definition of the relationship between the spatial units (neighborhoods). To do that, a spatial weights matrix W is constructed. The matrix W will be a N x N symmetric, non-negative matrix of q-nearest neighbor value, attributing a higher value to the proximity of the spatial units. The principal diagonal will be 0 since it will indicate the neighborhoods distance with itself – the neighborhood cannot be a neighbor of itself.

To create a Weights Matrix, what constitutes a neighbor must be explicitly defined. The condition to establish a relationship will be contiguity (sharing a border). The criteria under which the matrix W will establish a contiguity relationship can be rook or queen. Rook, more restrictive will only consider two spatial units to be neighbors if there is a common border between the two. Contiguity criterion queen for the weights matrix will be more inclusive, taking vertexes into account when establishing a connection. Because of this, in this chapter the queen assumption has been considered. The contiguity criterion gives a non-zero value to spatial units that are considered neighbors but it doesn't dismiss the relationship between non-neighboring spatial units.

For N spatial units, the weights matrix will be defined as:

$$W = \begin{pmatrix} W_{11} & W_{12} & \dots & W_{1n} \\ W_{21} & W_{22} & \dots & W_{n2} \\ \dots & \dots & \dots & \dots \\ W_{n1} & W_{n2} & \dots & W_{nn} \end{pmatrix} \tag{A.1}$$

Prior to the estimation of the model, the weights matrix W is row normalized (but not column normalized). The sum of the elements of each row will be 1.

For each W_{ij} with $i \neq j$:

$$W_{ij} = \frac{w_{ij}}{\sum_{j=1}^{N} w_{ij}} \tag{A.2}$$

The row and column implications of the weights matrix are as follows: the row elements of the weights matrix show the impacts on a spatial unit from the rest of each spatial unit; meanwhile the column elements of a weights matrix display the impact of a spatial unit on all others (the inverse effect). For this reason and as mentioned before, the specification of the principal diagonal of the weights matrix has to be 0 – a neighborhood cannot have an impact on itself since it would create a heteroscedasticity problem. For all N neighborhoods of the sample, W_{nn} will always be 0.

Concluding remarks

The main objective of this PhD has been the study of the social determinants that affect population health with the goal of helping the decision-making process in public policy. The basis of this study considers health as a multi-stage asset with multiple pathways towards its improvement.

Chapter 1 proposes a health model where population health is understood as the product of a production function which depends on different health determinants and their time over time investment. Self-rated health has been used as the measurement for population health. To estimate the production function, a stochastic frontier model was used. The results support the decision of separating the effects of the initial stock and the variations of health determinants since significant differences have been found.

This is why, given the significant effect of the variations, policies aimed at improving the socioeconomic situation of the population (i.e. active labour policies or preventing social exclusion) would imply an improvement of the self-rated health. The results also show the positive effect of potential policies aimed at raising awareness of healthier behaviours. Specifically, more active lifestyles, moderate alcohol consumption seem to drive an increase in the number of individuals which admit to feeling better. Finally, the results confirm that a reduction in the length of the patient waiting lists would lead to an improvement of population health. To summarize, Chapter 1 concludes that social, health and economic policy could have a direct impact over self-reported population health. It is also concluded that policies which affect socioeconomic determinants (for example, changes in the labour situation or the social class) have a long term impact, while modifications in behaviours (i.e. consuming alcohol) will be seen at a shorter term. Finally, the stochastic frontier analysis carried over helps corroborate the idea that the development of educational policies will help close the gap between the observed health status of a population and the potential health maximum.

The implication of this research can be useful in health management since they inform of the scope and temporal effect of the different policies. That is why policies dedicated to improving employment, education and healthier behaviours as well as strengthening the National Health Service have a significant influence over the population health and should therefore be considered as a whole when formulating an integrated health policy. It is relevant that this results be considered in a cost-benefit analysis on public intervention even if they are not directly tied to healthcare as they have a health aspect to them. Taking into account the results of Chapter 1, those policies which decrease social marginalization and a reduction of the unemployment will have a long term benefit in the individual's health.

Chapter 2 keeps investigating into the individual, social and environmental determinants of health, analysing the profiles of the problematic gambler and taking into account their socioeconomic characteristics and their behaviour. More specifically, this chapter seeks to evaluate the effectiveness of the gambling treatments by the different associations on a national level. This is executed by identifying the predictors of recurrences for recovering gamblers. On one hand, the results indicate that the probability that an individual loses control and needs to be treated again is heavily conditioned by individual factors. Age, lower social capital (no support networks, family or friends) and not completing previous treatments would be indicators of future recurrence. The conclusions also support the existing narrative regarding comorbidities: the consumption of other addictive substances such as alcohol and tobacco is a robust predictor of a recurrence. On the other hand, as it happened in Chapter 1, employment is a highly significant determinant. Unemployed individuals have a lower chance of successfully finishing a recovery program. Employment, aside from providing with material resources to the individuals also acts as a mitigation against recurrences. Being employed would be complimentary to therapy and improve the individual's mental health, a similar conclusion found in the first chapter: active labour policies aimed at decreasing unemployment rates will have a positive effect in population health.

To summarize, the results of the investigation gives us an interesting perspective when evaluating gambling treatment as it allows us to give an initial assessment of the individuals prior to them joining the rehabilitation program. Despite previous gambling being a strong indicator of the chances of success, the determinants related to the social, economic and labour situation of the individuals, their co-morbidities and their personal lives all can give additional information for the treatment. This way special attention could be anticipated or resources could be destined to other priorities.

Chapter 3 analyses the supply side of the gambling industry. Madrid has been selected as the case study because throughout the past decades the gambling marked has suffered a dramatic increase both in economic figures and gambling opportunities. This chapter seeks to understand, using a spatial perspective, the factors that have determined the recent expansion of the gambling outlets as well as their spatial distribution. The results of this investigation confirm that gambling venues tend to form clusters in the most deprived areas. Individuals living in these neighbourhoods will have a higher access to gambling houses or have a higher chance of relapse in case of problem gamblers. This is especially concerning if we consider that residents in these neighbourhoods cannot easily move to other areas with lower gambling opportunities.

These results have interesting implications for local authorities when it comes to determining if and in what measure a regulation is needed to be set in place. In a situation where no limitations are set up, gambling operators will have as objective those areas which fit the highest consumers of gambling products, resulting in higher gambling problems and a negative repercussion to population health. That is why an intervention in the gambling market, putting limitations on the number of operators can be considered an intervention in public health.

All of the above leads us back to the idea that inequality is the source of preventable health problems. That is why improvements in public health will be more efficient through a reduction of social inequalities. Social vulnerabilities which leads to an unequal social and economic structure causes important health inequalities because, as it has been described in this PhD, social determinants have a strong relationship with health outcomes even under the framework of universal healthcare such as the one in Spain. The analysis of these socioeconomic factors can shed more light when it comes to offering new proposals and better practices with the end goal of acting upon the most influential determinants for health in general and mental health in particular.

Conclusiones finales en español

El objetivo de esta Tesis ha sido el estudio de los determinantes sociales que afectan a la salud poblacional e individual con el objetivo de facilitar la toma de decisiones en política pública. La base del estudio ha sido considerar la salud como un activo donde convergen múltiples estados, con múltiples rutas para su mejora.

El Capítulo 1 propone un modelo de salud entendiendo ésta como el producto de una función de producción que depende de distintos determinantes de la salud y la inversión en los mismos durante un periodo de tiempo. La medida de salud considerada es la salud autopercibida, como predictor de la mortalidad y morbilidad. Para estimar la función de producción, se utiliza un modelo de frontera estocástica. Los resultados refuerzan la decisión de dividir ambos efectos, encontrando diferencias significativas entre el efecto del stock inicial y las variaciones en los determinantes de salud.

Así, dado el efecto significativo de dichas variaciones, las políticas dirigidas a mejorar la situación socioeconómica de la población (por ejemplo, políticas sociales orientadas a mejorar la situación laboral o el estatus social) implicarían una mejora en la salud autopercibida. Los resultados demuestran, además, el efecto positivo de las potenciales políticas sociales dirigidas a aumentar la concienciación de la población en cuanto a hábitos más saludables. En concreto, un incremento de las actividades deportivas y en el consumo moderado de alcohol parecen haber generado un incremento del promedio de personas que admiten sentirse mejor. Finalmente, los resultados confirman que una mejora en el Sistema Nacional de Salud, tendente a disminuir las listas de espera, conllevaría una mejora en la salud poblacional. En resumen, el Capítulo 1 concluye que políticas sociales, económicas y sanitarias podrían tener un impacto positivo y significativo en la salud autopercibida. Se concluye, también, que políticas que afectan a los determinantes socioeconómicos (por ejemplo, cambios en la situación laboral o la clase social) tienen impacto a largo plazo, mientras que modificaciones en los hábitos de los individuos (por ejemplo, ser o no bebedor) resultan en beneficios a más corto plazo. Finalmente, el análisis de frontera estocástica llevado a cabo para estimar la función de producción de salud permite corroborar la idea de que el desarrollo de políticas educativas puede contribuir a disminuir la brecha entre el estado de salud observado de una población y su frontera potencial (máxima) de salud.

Las implicaciones de este estudio pueden ser útiles en la gestión sanitaria, dado que informan del alcance y el efecto temporal de las distintas políticas. Así, políticas destinadas a mejorar el empleo, la educación, fomentar comportamientos saludables y reforzar el Sistema Nacional de salud influyen significativamente en la salud poblacional de los individuos y, por ello, se deberían tener en cuenta a la hora de formular una política de salud integrada. Es relevante, por tanto, que estos resultados se tengan en cuenta en los análisis coste-beneficio de la intervención pública en áreas, no directamente ligadas a la salud, pero con una dimensión sanitaria. Teniendo en cuenta los resultados del Capítulo 1, aquellas políticas que fomenten una reducción de la marginación social y disminución del desempleo estructural tendrán un beneficio a largo plazo en la salud de los individuos.

El Capítulo 2 sigue indagando en los determinantes individuales, sociales y medioambientales de la salud, analizando el perfil del jugador con problemas y teniendo en cuenta sus características socioeconómicas y su comportamiento. Más concretamente este capítulo busca evaluar la efectividad de los tratamientos de la ludopatía llevados a cabo por distintas asociaciones a nivel nacional, identificando las variables que predicen recaídas en los jugadores en tratamiento de rehabilitación. Por una parte, los resultados indican que la probabilidad de recaída está fuertemente condicionada por los factores individuales. La edad, un capital social reducido (sin redes de apoyo, familiares o amigos), y el no haber completado tratamientos previos serían indicadores de una recurrencia futura. Además, las conclusiones apoyan la narrativa existente acerca de las comorbilidades: el consumo de otras sustancias adictivas como el alcohol y el tabaco es un predictor robusto de la probabilidad de recaída. Por otra parte, al igual que ocurría en el Capítulo 1, la situación laboral es un determinante altamente significativo. Los individuos desempleados tienen una probabilidad menor de acabar con éxito un programa de rehabilitación. Así, el empleo, además de aportar una renta a los individuos, ejerce un papel protector frente a las recaídas. Estar empleado complementaría la terapia y mejoraría la salud mental de los individuos, con lo cual se obtiene una conclusión similar a la encontrada en el primer capítulo: políticas activas del mercado de trabajo tendentes a disminuir las tasas de desempleo tendrán un efecto positivo en la salud poblacional.

En resumen, el resultado de esta investigación nos da una perspectiva interesante a la hora de evaluar el tratamiento del juego y nos permite caracterizar *a priori* a los individuos antes de formar parte de un programa de rehabilitación. A pesar de que el historial de juego previo es un indicador fuerte de la probabilidad de éxito de los individuos, los determinantes relacionados con la situación económica y laboral de los individuos, las comorbilidades y la vida personal de los jugadores nos pueden proveer de información adicional para el tratamiento, anticipando si necesitan atención especial o si los recursos disponibles se pueden destinar a otras prioridades.

El Capítulo 3 se centra en analizar la oferta de la industria del juego. El caso de estudio ha sido Madrid donde el mercado del juego ha sufrido un incremento dramático, tanto en cifras económicas como en oportunidades a lo largo de las últimas décadas. Así, desde una perspectiva espacial, en este capítulo se busca entender los factores que han determinado la reciente expansión de locales de juego en zonas urbanas, así como su distribución espacial. Los resultados de la investigación confirman que las casas de apuestas tienden a formar *clusters* en los barrios más empobrecidos, de manera que aquellos individuos que vivan en estos barrios tendrán un mayor acceso a las casas de juego y, por tanto, mayor probabilidad de recaídas en caso de jugadores con problemas de ludopatía, en especial, si se tiene en cuenta la dificultad de los residentes de estos barrios a cambiar a otros con mayor renta y menos oportunidades de juego.

Estos resultados pueden tener implicaciones muy interesantes para las autoridades locales a la hora de determinar sí y en qué medida es necesaria una regulación al respecto. En otro caso, ante la falta de limitaciones, los operadores de juego tendrán como objetivo aquellas áreas que encajen con el perfil del consumidor más propenso al juego y, por tanto, a sufrir problemas de ludopatía, con la consiguiente repercusión negativa en la salud poblacional. Por ello, una intervención en el mercado del juego, limitando el número de operadores, podría considerarse, además, como una intervención en salud pública.

Todo lo anterior, nos lleva de vuelta a la idea de la desigualdad como motor de problemas de salud prevenibles. Así, las mejoras en salud pública serán más eficientes a través de la reducción de desigualdades sociales. La vulnerabilidad social a la que da lugar una desigual estructura social y económica provoca importantes desigualdades en salud puesto que, tal y como se ha puesto de relieve en esta Tesis, los condicionantes socioeconómicos guardan una fuerte relación con los resultados de salud aún en contextos, como en España, enmarcado en un Sistema Nacional de Salud, con servicios sanitarios universales. El análisis de este conjunto de factores socioeconómicos puede arrojar un poco más de luz a la hora de ofrecer propuestas sobre la mejor forma de actuar, mediante políticas públicas, con el fin de actuar sobre los determinantes que más influyen tanto en la salud general, como en la salud mental en particular.

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