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Geomarketing techniques to locate retail companies in regulated markets

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ABSTRACT

Our background is the investment when opening a retail business in a regulated market, such as the pharmaceutical sector in Spain, which involves many risks caused by external factors that hinder the choice of a new-business location process. To study this phenomenon, we optimized the choice of the location of a retail site in a regulated market via a methodology that entailed a combination of analytical methods of spatial geometry with geographic information systems (GIS) and the analytic hierarchy process (AHP) multicriteria decision method. The integration of both methods shows great efficiency in the measurement of spatial reality in detail and its influence on decision-making in retail businesses. The study, conducted in Seville (Spain), showed how legal restrictions for the location of a new pharmacy greatly hindered the possibility of success for new retail businesses. However, by implementing both methods, we discovered a series of suitable spaces, which were assigned a score based on several criteria. The combination of GIS methods and AHP multicriteria decision method can be used to reduce the risk of opening a new retail business in a regulated market with space restrictions.

1. Introduction

Geomarketing has significant potential for building marketing strategies with which to make business decisions based on spatial variables (Chaco-Yrigoyen, 2006; Church, 2002; Cliquet, 2013). This discipline is based on a set of techniques that analyze the social, economic and demographic reality from a geographical point of view through spatial market segmentation (Bloom, 2005; Cross et al., 2015; Tynan and Drayton, 1987), localization theory (Baviera-Puig et al., 2013; Garrocho-Rangel, 2003), and geographic information systems (GIS) (Fischer and Staufer-Steinnocher, 2001; Van Den Bossche et al., 2010).

By incorporating GIS tools, the capacity of geomarketing to process sales data associated with differential space has increased markedly (Crampton, 1995; Harris et al., 2005). In the wholesale, geomarketing and GIS techniques are still too “macro” and they fail to account for specific environmental factors of each store (Vyt, 2008). However, for retail businesses, environmental evaluation is necessary to determine the initial investment and future profits (Roig-Tierno et al., 2013).

The use of GIS techniques has been shown to be one of the most effective decision-making methods for territorial or spatial problems (Maguire et al., 2005; Xie and Yan, 2013). The ability to analyze social and economic data associated with entities that have topological, geometric, or geographical properties has made it possible to reduce uncertainty in decision-making in certain markets, such as retail (Benoit and Clarke, 1997; Okabe and Okunuki, 2001).

The spatial relationships of establishments in the same area can be classified into three types: competition, complementarity, or synergistic (Alcaide et al., 2012; Moreno-Jiménez, 2003). However, these three types of relationships are controlled and legislated in what are referred to as regulated markets (Phillips, 1975). The regulations established for such markets may limit the competitive capacity of a retailer in terms of price (Laffont and Tirole, 1994) and location (Zhu and Singh, 2009).

Although subject to internal factors, this competitiveness is mainly driven by factors outside the company (i.e., external factors) in regulated markets (Amit and Schoemaker, 1993; Porter, 1982). The primary factors include those aspects in which the entrepreneur has full capacity to operate, namely product range, costs, management, and, to some extent, prices. All these characteristics result in higher or lower attraction capacity (Campo et al., 2000; Grewal et al., 2009). However, in regulated markets, external factors, such as space restrictions or price fixing, exert a greater influence than internal factors (Chen et al., 2009).

The pharmaceutical market in Spain is a competitive market, and, simultaneously, it is a market that is regulated and financed by the public administration because it is considered a public service (Moreno-Torres et al., 2009). The opening of a new pharmacy, which requires public authorization that mandates a 250-m separation

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between each pharmacy to avoid direct competition, has been shown to reduce profits and undermine pharmaceutical assistance in some areas (Cabezas-López et al., 2010). This regulation also establishes cofinancing ranks for certain drugs depending on social and occupational characteristics of the population (Cabiedes-Miragaya, 2005).

Similar situations happen in countries such as Australia, where the pharmacy sector is highly regulated through legislation and agreements that determine the number of pharmacies that can operate, the distance between the nearest pharmacy, the conditions under which they operate, the ownership structure of the sector, and the prices they can charge (Australian Government Department of Health, 2015; Hattingh, 2011).

Therefore, the decision-making in this market is largely subject to the spatial dispersion and the sociodemographic characteristics of the environment.

The spatial dispersion is a critical factor in markets similar to Spanish pharmaceutical sector because this dispersion influences consumer behavior and profitability. Thus, the use of GIS tools has become a fundamental procedure when analyzing large amounts of data associated with a geographic area to determine the most appropriate spaces for opening a new retail business (Kosiak de Gesualdo et al., 2005; Longley and Mateos Rodríguez, 2005).

As a result of this market's characteristics, deeply influenced by spatial distribution and sociodemographic characteristics, it is essential to determine the most appropriate location decision-making model (Llamazares-Redondo and Berumen, 2011). Particularly for markets with strong competition, discrete multicriteria decision-making models are often used, for they facilitate several solutions depending on the available alternatives and criteria used (Ho et al., 2010). The main discrete multicriteria decision methods are linear weighting (scoring), multiattribute utility (MAUT), overrating relations, and the analytic hierarchy process (AHP), as demonstrated by Hurtado and Bruno (2005).

Since Saaty (1980) developed the AHP method in 1980, it has been widely used in the decision-making for complex problems, as shown by studies by Aragonés-Beltrán et al. (2014), Jalao et al. (2014), and Subramaniam et al. (2000). Its application is increasingly common in the decision-making of large companies (Kulak and Kahraman, 2005; Sari et al., 2008), in some industrial sectors (Abdelgawad and Fayek, 2010; Cebeci, 2009), and in spatial planning (Martínez-Harms and Gajardo, 2008). The AHP method allows for the structuring, measuring, and synthesizing of the reality perceived by the individual on a scale of reason, which reflects the relative priorities of the elements considered. Therefore, this method has made it possible in the decision-making process to structure a multi-criteria problem visually by building a hierarchy of attributes, which contains at least three levels: the overall objective of the problem, the different criteria in the environment, and alternatives (Berumen and Llamazares-Redondo, 2007).

The AHP method shows a number of advantages over other multicriteria decision methods, such as: the possibility of measuring quantitative and qualitative criteria using a common scale, checking the consistency of the results, and giving users some flexibility when making changes so that these changes do not affect the general structure of the objective (Kahraman et al., 2003).

In this study, we analyzed the current distribution of pharmacies in the city of Seville (Spain). In 2015, Seville had a population of about 700,000 inhabitants and had significant economic and social inequalities in terms of neighborhoods and districts. These characteristics have led to a saturation of pharmacies in the areas of greatest consumption and profitability, thereby hampering the success of new offices. Hence, the main objective of this study was to develop a methodology that identifies the most suitable areas for the opening of new pharmacies (retail) in regulated markets like Spain using GIS methods in combination with multicriteria decision method of AHP.

2. Method

To determine the best places to locate a new pharmacy, we used two methods: analytical GIS and AHP multicriteria decision method. For the former, we used the vector format, which defines geometric objects (points, lines, and polygons) by encoding a number of geographical coordinates. Specifically, the polygons are two-dimensional geometric elements that represent geographic features covering an area, such as plots or neighborhoods in a city. These polygons may contain attributes associated with the space they occupy, including total population, median household income, or population density (Aliaga, 2006). In this study, the attributes stored in the polygons associated with geographic areas were analyzed using the GIS methods referred to as buffering and overlay. The GIS software used was QGIS 2.10.

With the buffering method, an area of influence can be established by measuring the distance in a two-dimensional Cartesian plane, where the straight line or the Euclidean distances are calculated between two points on a flat surface. These areas are used to establish territorial boundaries or proximity calculations. The distance between points k and j is also the length of the straight segment between points k and j.

$$dk, j = \sqrt{(xk - xj)^2 + (yk - yj)^2}$$

Overlay analysis is used to combine the attributes or characteristics of several geometric objects (i.e., produce one). This method pinpoints specific areas that share a given set of attributes based on the specified criteria. The point-cutting operation between segments used in the overlap method allows for the extraction of a geometric object from a set of polygons that meets certain criteria. This operation is solved by the system formed by the equations of the line of both segments:

$$Ya = AXa + B$$

$$Yb = CXb + D$$

where

$$A = \frac{Y_a2 - Y_a1}{X_a2 - X_a1}$$

$$B = Ya1$$

$$C = \frac{Y_b2 - Y_b1}{X_b2 - X_b1}$$

$$D = Yb1$$

This system always produces a cutting point, except in cases in which segments are parallel. When segments are parallel, it is necessary to verify if the solution is part of both segments simultaneously and, therefore, its cutting point. That is, we must ensure that X is between Xa^1 and Xa^2 and between Xb^1 and $Xb^2$and that Y is between Yb^1 and Yb^2 and between Ya^1 and Ya^2.

The overlap method extracts attributes of a spatial geometric object based on certain criteria. Criteria selection in this study was done using the AHP multicriteria decision method proposed by Saaty (1980). This method constructs a hierarchical model with three levels: objectives, criteria (subcriteria), and alternatives. The objective is the aim to be achieved through the process, the criteria are the validation rules to achieve the objective, and the alternatives are the attributes to which the criteria are applied (Berumen and Llamazares-Redondo, 2007) (Fig. 1).

The AHP uses comparisons between pairs of attributes, building matrices based on expert assessment of each pair of variables

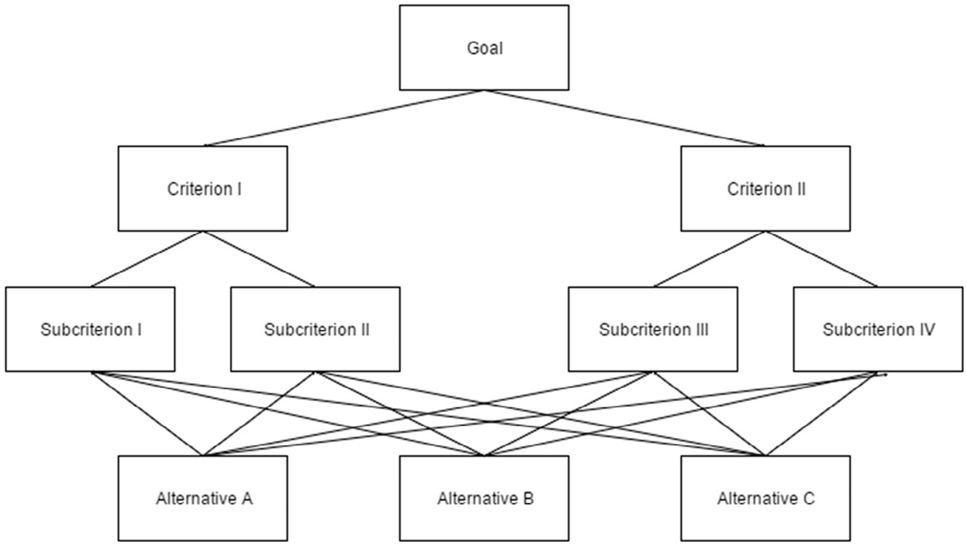

Fig. 1. AHP process.

and using matrix algebra to rank attributes (Osorio-Gómez and Orejuela-Cabrera, 2008). The AHP method initially breaks the decision problem into a hierarchy of interrelated attributes to further develop the pairwise comparison matrix (PCM) of alternatives for each criterion in the ranking of relative importance. This ranking was achieved using a 9-point scale, for which 9 (*the highest value*) indicates a higher degree of preference and one (*the lowest value*) indicates equal preference.

Once the PCM was built and tested to ensure a reliable consistency ratio (≤0.10), the normalized matrix was developed by dividing each number in each column of the PCM by the total sum of the column. The priority vector for each criterion was extracted from this matrix by calculating the average of each row of the normalized matrix. This average per row vector represents the priority of the alternative with respect to the criteria considered.

Finally, priority vectors of all criteria were summarized in a new matrix of priority alternatives, from which the global priority vector was obtained.

This modified AHP presented several advantages, such as the possibility of measuring qualitative and quantitative criteria with a common scale, verifying the consistency to make changes, and synthesizing the results to have an overview of the problems to be solved (Martínez-Rodríguez, 2007). However, this method often has problems of inconsistency related to large numbers of attributes. To avoid these problems, clustering using subcriteria inside a criterion is recommended.

In conjunction, these three methods allowed us to evaluate and rank the attributes that influence the success of a new pharmacy in a regulated market such as that of Spain, where legal restrictions for the location of new pharmacies undermine competitive capacity.

2.1. Data

The data used for this study came from different sources such as the catalogue of pharmacy addresses of the College of Pharmacists of Seville, the Database Population of Seville Government, and the Urban Audit database of EUROSTAT.

The sociodemographic data used in this study are linked to census districts, which are one of the smallest geographic units into which the area of a municipality can be divided. In cases where the databases did not contain information disaggregated by census district, superior geographic units (e.g., neighborhoods) were used.

2.2. Measures

A series of measures were extracted from the aforementioned databases. These measures had a direct impact on decision-making when locating new pharmacies in the regulated market.

2.2.1. Population density (population per km^2)

In a regulated market such as that of the case study, a major benefit is directly related to the capacity to bring together a larger population within the area of influence of the pharmacy (250 m). Therefore, census districts with a higher density are considered more profitable for this type of retail business.

2.2.2. Population >64 years old

In Spain, the retirement age is 64 years (extensible). At that age, a person who has contributed a minimum number of years becomes a pensioner and starts to benefit from a series of reductions in the final price of a medicinal drug. Specifically, this group must contribute less than the rest, only 10% of the price of the medicinal drug. This group accounts for the largest consumer group of drugs in Spain as demonstrated in the studies of Carrera-Lasfuentes et al. (2013) and Valderrama-Gama et al. (1998).

2.2.3. Median household income

Median household income (MHI) refers to the average income level earned by a given number of household members. This average income has a direct relationship with the purchasing capacity to buy medicinal drugs. However, in Spain, as medicinal drugs are cofinanced, people take on the final spending, such that, in 2014, the average spending on pharmaceutical products was only 76€ per inhabitant (INE, 2014). MHI data were extracted from the Urban Audit Project of EUROSTAT (2014), for which an MHI was obtained for a higher level district census called the subcity district.

2.3. Data analysis

In a regulated market, legal restrictions determine the criteria used. Specifically, with the AHP method, criteria and constraints that influence the success of a pharmacy in Spain were identified. To this end, we established two main criteria: areas of maximum profitability (MP) and neighborhood area. The former was divided into three subcriteria, which were population density, population

Table 1
GIS methods applied to obtain MP spaces.

Variables	Geometry	Criteria	Method
Pharmacies	Vector Point Feature	Area of Influence (250 m)	Buffering
Population Density	Vector Polygon Feature (Census Districts)	First Quartile (Q1) (>2,080 Pop. Per km^2)	Overlay
Population >64 years	Vector Polygon Feature (Census Districts)	First Quartile (Q1) (>279 people >64 years)	Overlay
Median Household Income (MHI)	Vector Polygon Feature	3 Levels – Low (<22.839€) – Middle (22.839€–29.267€) – High (>29.267€)	Overlay

>64 years old, and MHI. The latter was divided into three subcriteria, which were total population, population >64 years old, and MHI.

The MP criterion is the most valued by experts, for it corresponds to those spaces located outside the area of influence of the existing pharmacies (250 m) and containing a high density, large population >64 years old, and a high MHI. For its part, the criterion neighborhood area includes the characteristics of the census districts closer to the MP spaces (250 m). This criterion establishes a spatial relationship between the selected geometric objects (MP) and the nearest geometric objects.

To locate the MP spaces, first the buffering method was used to establish the area of influence of each of the existing pharmacies through a circumference with a radius of 250 m indicating restricted areas. Subsequently, using the overlay method, we obtained those areas that were not occupied by an area of influence of other pharmacies, had a high population density (Quartile 1), had a large population >64 years old (Quartile 1), and had a high MHI. In Table 1, we show the analytical process used with both GIS methods to obtain the MP spaces.

After obtaining the MP spaces, associated neighborhood areas were extracted for each. Using the buffering method, a circumference with a radius of 250 m was drawn. This circle includes the MP spaces and the nearest census districts. Finally, several spaces considered as alternatives were obtained. These alternatives were evaluated and ranked by AHP multicriteria decision method to achieve the objective of obtaining the most suitable areas for the opening of a new pharmacy (Fig. 2).

3. Results

Having described methods and spatial restrictions, criteria and subcriteria were evaluated using the 9-point scale used by Saaty (1980). Through the PCM, a group of experts from the pharmaceutical industry, public administration, and marketing companies was interviewed. To the extent possible, this group of experts was designed to be as heterogeneous to reduce failures of consistency in the responses.

Once the responses were obtained, a PCM was constructed. The responses with unreliable ratio of consistency (>0.10) were removed. Finally, vectors of each subcriterion were obtained with weight based on the answers from the experts. This final score can be seen in Table 2.

According to experts, the most influential subcriteria in the success of a pharmacy were population >64 years old of MP spaces criterion (0.462), the population density of MP spaces criterion (0.231) and the population >64 years old for neighborhood area criterion (0.152). These results allowed us to ensure that the experts' opinions regarding important factors for the success of a new pharmacy were taken into account. As mentioned, these factors were: MP spaces where there is a greater concentration of population >64 years old, high density, and neighborhood area with a high concentration of population >64 years old. Once the subcriteria scores were obtained with the AHP method, we analyzed the distribution of current pharmacies in Seville (Spain), the attributes of census districts of the MP spaces and neighborhood areas associated using GIS methods (buffering and overlay).

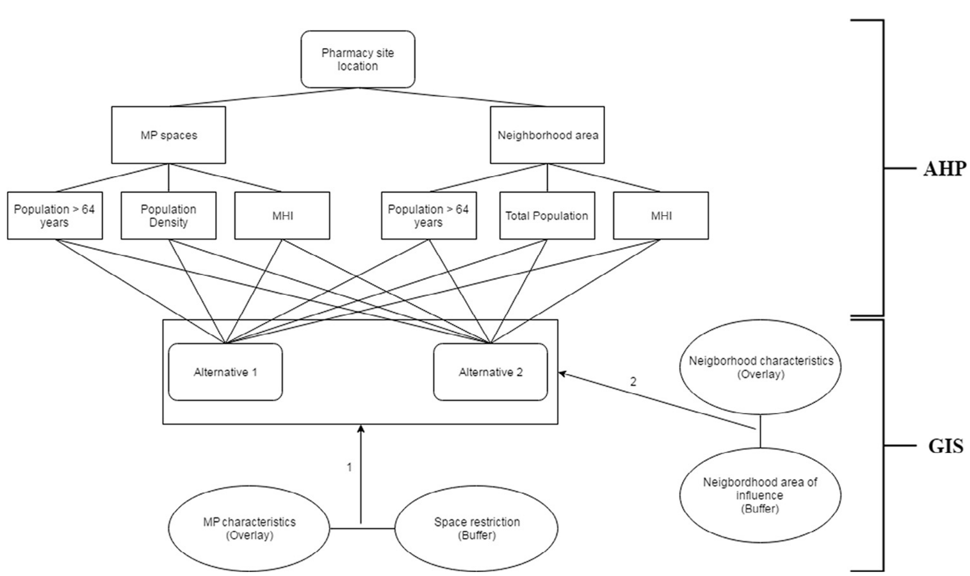

Fig. 2. Pharmacy site location decision process.

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Table 2
Ranking of the subcriteria that determine the success of a pharmacy.

Ranking	Criteria	Subcriteria	Score
1	MP spaces	Population > 64 years	0.462
4	MP spaces	Population Density	0.231
2	Neighborhood area	Population > 64 years	0.152
3	Neighborhood area	Total Population	0.076
5	MP spaces	MHI	0.057
6	Neighborhood area	MHI	0.022

Table 3
Characteristics of the alternatives locations.

Criteria	Subcriteria	Alternative 1	Alternative 2
MP spaces	Population Density (Pop. Per km^2)	2,757.89	2,550.0
	Population > 64 years	141	24
	MHI	29,655.29 €	42,691.70 €
Neighborhood areas	Total Population	3,466	1,331
	Population > 64 years	663	312
	MHI	29,655.29 €	42,691.70 €

In 2016, the city of Seville had a total of 410 pharmacies according to data provided by the College of Pharmacists of Seville. These pharmacies have an associated area of influence with a radius of 250 m, restricting the creation of new pharmacies. Therefore, the first step was to geolocate all pharmacies situated in the city's census districts and calculate each pharmacy's area of influence via the buffering method (Fig. 3).

A second step was to locate the MP spaces, which is high demand for experts. We did this by overlaying the attributes contained in each census district. First, we located those census districts with a high concentration of population >64 years old (Quartile 1) and a high population density (Quartile 1), selecting only districts that contain both attributes (Q1 Density + Q1 >64 years old) as seen in Fig. 4.

The census districts selected in the previous step were superimposed on MHI data to extract those census districts included within the subcity district with high MHI (Fig. 5). On these census districts (Q1 Density + Q1 >64 years old + High MHI), we superimposed the results obtained in Fig. 1 to apply the location restriction and to remove the census districts located within existing pharmacies' area of influence. With this operation, we obtained two MP spaces within four census districts (Fig. 6).

On these two MP spaces, we calculated the neighborhood area tracing a circumference with a radius of 250 m containing those MP spaces and the nearest census districts with the buffering method (Fig. 7). The two resultant spaces obtained via the use of both GIS methods became alternatives for the location of a new pharmacy because of their capacity to attract potential customers.

From these two alternatives, we obtained the characteristics of each MP space selected based on the proportional space they occupy of the total area of the census district. We also obtained the characteristics of census districts intersected by the neighborhood area (Table 3).

Once the characteristics of each alternative were determined, the AHP method was reapplied. At this step, the experts responded to a questionnaire, providing a unified response. This process gave the following ranking of the alternatives. The results obtained in Table 4 indicate that the best location in Seville for a new pharmacy was Alternative 1 with a score of 0.758, followed by Alternative 2 with a score of 0.242. These scores do not mean that Alternative 2 should be discarded, but rather that Alternative 1 is the best option.

In Fig. 8, we can see the score received by the criteria, subcriteria, and alternatives in the AHP process described before.

4. Discussion

To facilitate the choice of the most favorable locations for a retail business, the combination of GIS methods and multicriteria decision methods has proved effective in previous research (Arquero et al., 2009; Baviera-Puig et al., 2013). In this study, the main objective was the combined application of GIS methods and the multicriteria

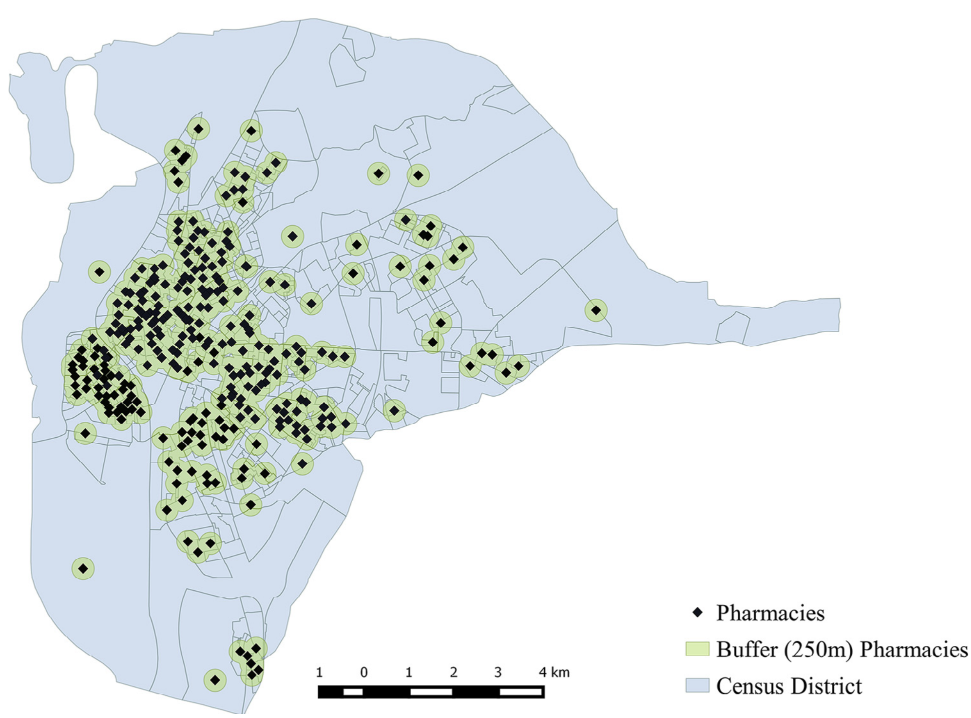

Fig. 3. Area of influence of existing pharmacies.

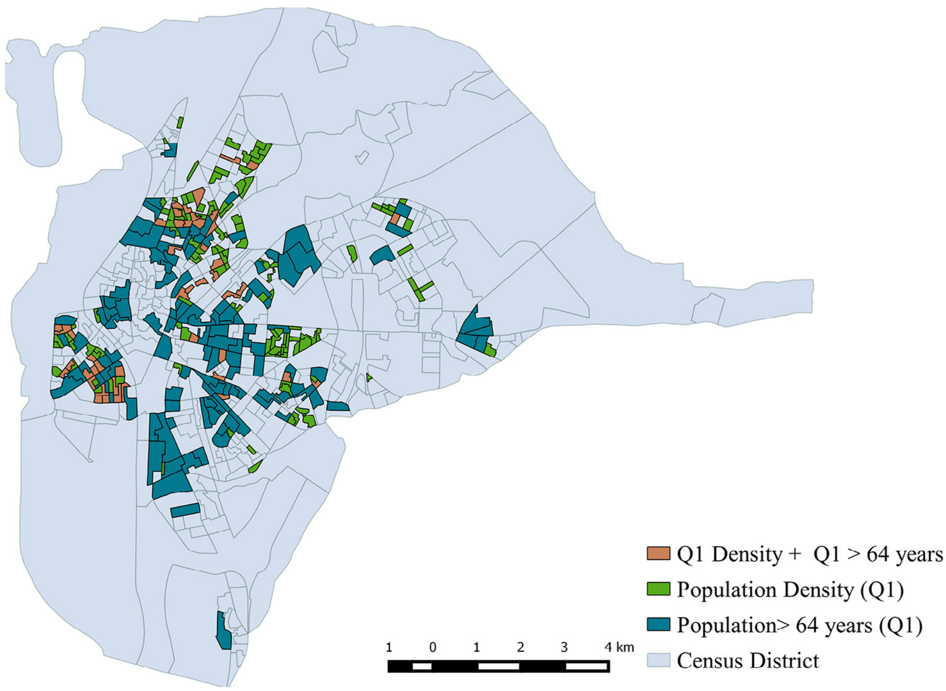

Fig. 4. Census Districts with Density (Q1) and Q1 >64 years.

Table 4
Ranking of the two alternatives.

Ranking	Alternatives	Score
1	Alternative 1	0.758
2	Alternative 2	0.242

decision AHP method in markets subject to laws, especially those regarding location and prices; to this end, we used the Spanish pharmaceutical market in Seville as our case study. In such markets, constraints may reduce the capacity of success in the final choice, so the joint use of the three methods was used to offer two alternatives depending on the criteria and subcriteria used.

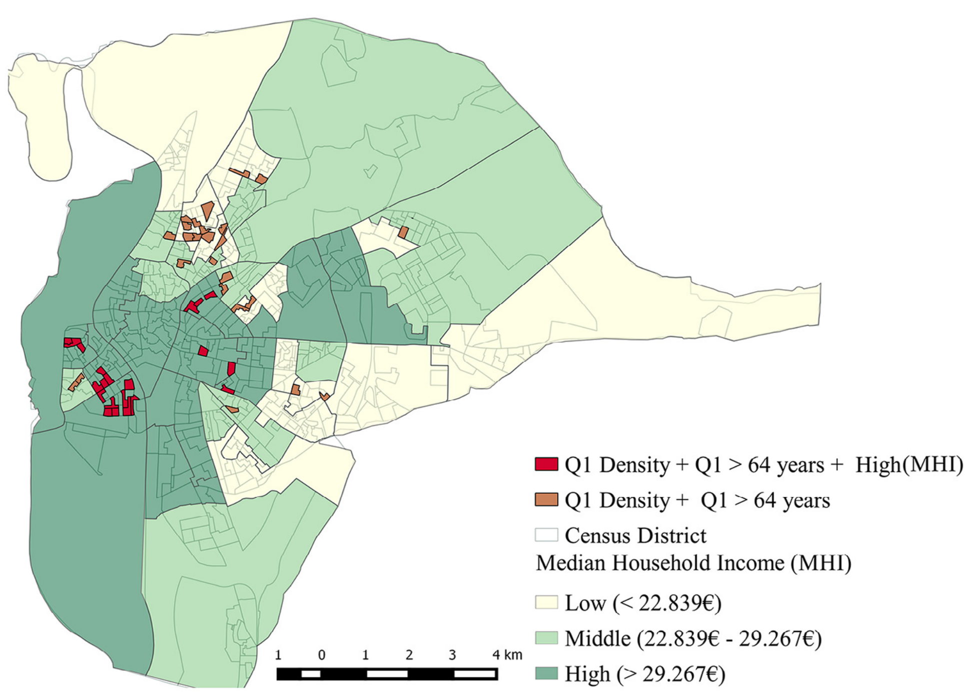

Fig. 5. Census District with Density (Q1), Q1 >64 years and High (MHI).

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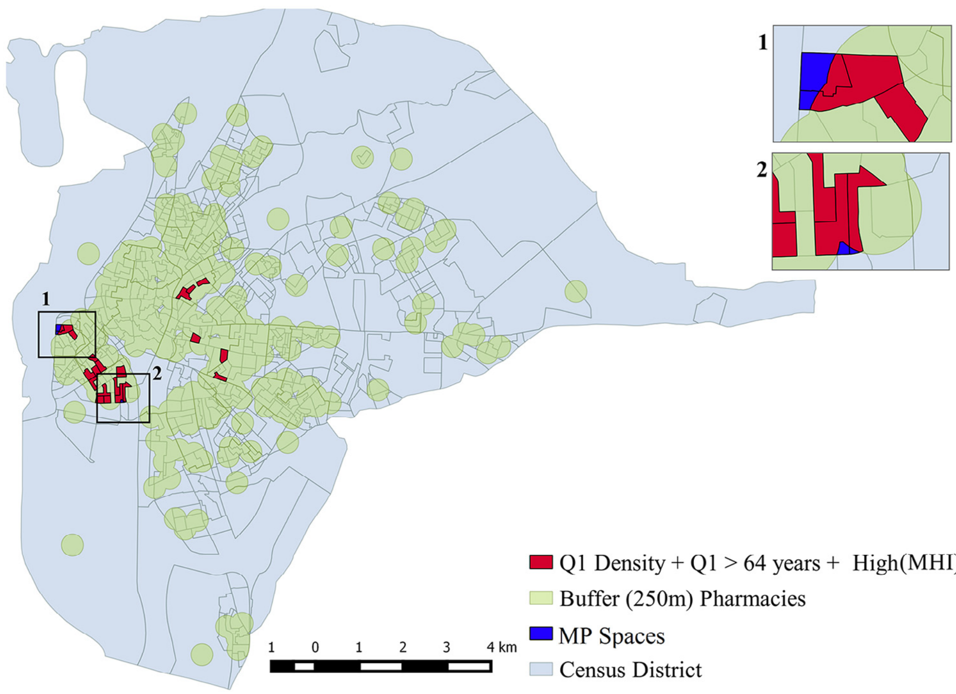

Fig. 6. MP spaces.

Evidence has shown that AHP is an excellent method for solving problems that entail a large number of criteria in the final decision (Chou et al., 2008; Ertuğrul and Karakaşoğlu, 2008; Kahraman et al., 2004). In this study, AHP was used to compare a certain number of criteria and subcriteria and subsequently determine the importance of each in terms of interaction. This method allowed us to standardize criteria and subcriteria and highlight those most important for our research. In particular, the main criterion was the MP spaces; and within them, the most relevant subcriterion was the population previously >64 years old. The MHI subcriterion for both criteria obtained lower scores because of existing pharmaceutical financing in Spain to prevent people with lower incomes from being able to access certain drugs.

The experts on the panel considered the inclusion of MP spaces within the area of influence essential to the success of a new pharmacy in Spain. However, spatial constraints hindered the location of the new pharmacy because of existing market saturation. Therefore, we used two GIS methods (buffering and overlay).

Fig. 7. MP spaces and neighborhood areas.

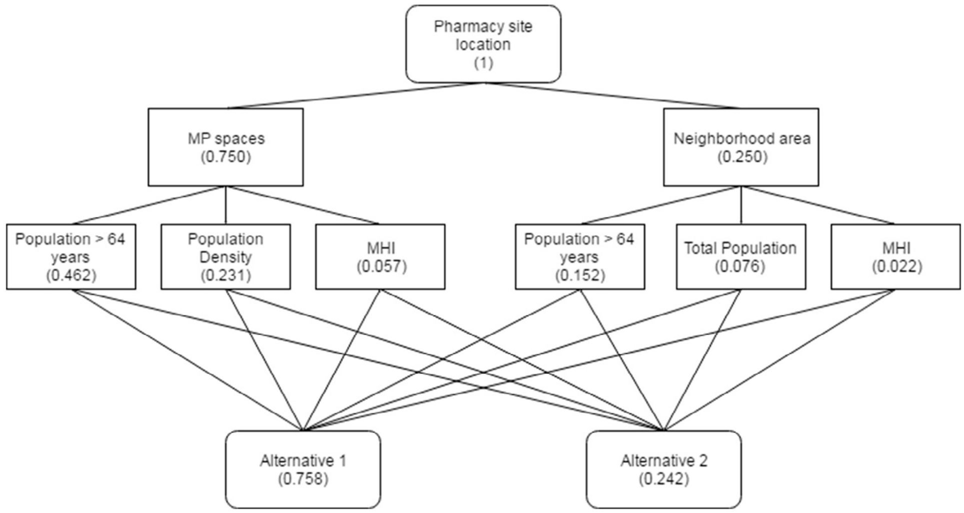

Fig. 8. Score in AHP process.

With the application of the overlap method, we selected census districts considered by experts to be MP spaces; with the buffering method, we delimited the restrictions or areas of influence of existing pharmacies. Once the MP spaces were selected, we obtained the characteristics of their neighborhood areas using the two GIS methods.

Finally, we obtained several locations considered alternatives for the location of a new pharmacy. These alternatives were classified in line with the points obtained for each criterion and subcriterion in the AHP method, with which a ranking of preference for the new pharmacy was developed.

The major limitation of this analysis was existing public data. The production of sociodemographic and socioeconomic information associated with a spatial geometry is costly for public institutions. In this study, we worked with data on a small territorial level (census district). However, it may be necessary to work with an even finer level to conduct a more detailed approach (e.g., housing blocks would enable a fine-grained analysis about spatial distribution).

5. Conclusion

The advantages of AHP over other multicriteria methods are its flexibility, intuitive appeal to the decision makers, and the ability to check inconsistencies. However, it has limitations for ranking catchment issues that have a spatial dimension. This limitation can be solved extensively using GIS techniques and spatial statistic.

In a regulated market, such as the pharmaceutical sector in Spain, the competitive capacity of a new office (retail) is greatly reduced. However, using the methodology described herein, we drew several advantageous alternatives for the location of a new pharmacy. Therefore, this methodology could be used in other countries with a similar pharmacy regulatory situation, such as Australia.

The combination of both methods in regulated markets and in retail business has not been fully implemented. Therefore, it is expected that future researchers apply other multicriteria decision methods (e.g., scoring and MAUT) in tandem with GIS methods to sectors where competition is not perfect and restrictions are essential criteria in decision-making.

Declaration of conflicting interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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