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Regulating the local availability of tobacco retailing in Madrid, Spain: a GIS study to evaluate compliance

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ABSTRACT

Background In Spain, tobacco sales are limited to tobacco-exclusive stores and associated vending machines. A minimum of 150 m between stores is required, unless they exceed a legal sales threshold. Minimum distances to schools are recommended but not defined. We evaluated compliance with these regulations in Madrid, Spain.

Methods Information about tobacco-exclusive stores and their sales volume was obtained in 2014. We used geographic information system to identify stores closer than 150 m between them and examine whether they exceeded the sales threshold. We estimated distances between stores and schools, considering different distance intervals (<150 m, 150–300 m and >300 m) and calculations (crow flies and street network). We assessed the association of area-level demographic and socioeconomic characteristics with the distribution of tobacco stores.

Results 5.3% (34/638) of tobacco stores were within 150 m of each other. Among those, 76% (26/34) did not meet the regulation sales threshold. These stores were in areas with lower proportion of young population (<15 years) and higher proportion of people with university-level education. 75% (476/638) of stores were situated closer than 300 m to schools. No differences were identified in sociodemographic and economic characteristics by the store distance to schools.

Conclusion Most tobacco stores are compliant with the regulations in Spain. However, these regulations are insufficient to reduce tobacco availability. More restrictive regulations are needed to limit the geographic distribution of tobacco retailers, and health criteria should also be considered in the current legislation. The evaluation of the Spanish regulatory model may provide useful insights for other jurisdictions looking to decrease the tobacco retail availability.

INTRODUCTION

In recent years, in a number of countries, there has been a rapid increase in the range of measures adopted to combat the global tobacco epidemic. MPOWER measures established by the WHO have been implemented across the world including smoke-free environments, advertising bans, health warnings or the increase of tobacco taxes.^{1 2} The availability of tobacco stores, however, remains ubiquitous in most countries. Regulating the supply and availability of tobacco products provides an important opportunity for achieving the tobacco endgame.^{3 4}

Growing international evidence shows that local density of tobacco retailers is associated with greater

risk of smoking⁵ and tobacco initiation⁶ and with lower cessation rates among adults^{7 8} and adolescents.^{9–11} A greater density of tobacco retailing minimises the time and resources needed to obtain cigarettes and contributes to tobacco normalisation.^{7–12} Emerging consensus indicates that tobacco stores tend to be disproportionately located in areas with high levels of social deprivation and/or greater proportion of vulnerable populations.^{13–17}

Tobacco retail reduction strategies vary considerably among countries. It is therefore important to evaluate the efficacy of existing policies that restrict the distribution of tobacco stores.^{3 4} The tobacco retail environment in Spain is distinctive since the sale of tobacco products is restricted to tobacco-exclusive stores (hereinafter, we refer to them as ‘tobacco stores’) and their associated vending machines.^{18 19} Vending machines are supplied by one of their three closest tobacco stores, and their location is permitted in bars, restaurants, pubs, discos, hotels, petrol stations and newspaper stands.^{20 21} The Tobacco Market Commission (TMC)²² is a governmental organisation tasked with monitoring the activity of tobacco stores and vending machines and their spatial distribution to ensure the ‘free competition’ of the tobacco retail environment in Spain.²³

Based on economic criteria, the TMC regulates the opening of new tobacco stores. A store is conceded through an auction procedure, in which it is awarded to the highest bid.²³ The location of the stores is predetermined by population service and business profitability criteria, based on the distances and the volume of sales of the neighbouring tobacco stores. Since 1999, the geographical concentration of stores is restricted by demanding a minimum distance of 150 m between premises. Exceptions can be made in areas with a high demand for tobacco, provided that the location of a new premise will not disrupt the activity of the existing stores. In any case, a new store cannot be located closer than 150 m to others if the aggregate tobacco sales volumes of the existing stores are lower than three times the average of the tobacco sales volume in the city in the previous year.^{20 21} In addition, the Spanish tobacco regulation also recommends that the TMC takes distance to schools as a guiding factor but does not provide clear enforcing guidelines, and no minimum distance has been specified between tobacco stores and schools.

The density of tobacco stores in Spain is lower compared with many other jurisdictions. For example, a recent study of 97 counties in the USA determined that the average density was 1.3 stores

per 1000 residents,²⁴ while in Madrid, this figure is 0.2 (vending machines not included). However, the smoking prevalence among adults (population older than 15 years) in Spain in 2015 was 29.1%, which is substantially higher than other countries (eg, 19.2% in the UK, 17.2% in the USA or 14.9% in Australia).²⁵

Given this regulatory context, we examine compliance with tobacco regulations in the city of Madrid, Spain. We applied a geographic information system (GIS)-based approach to: (1) analyse the proximity between tobacco stores and their associated sales volume, (2) assess distances from tobacco stores to schools and (3) evaluate how neighbourhood sociodemographic and economic characteristics are associated with the distance between tobacco stores and their proximity to schools.

METHODOLOGY

Study area

Our study area is the city of Madrid, Spain, with 3.2 million of inhabitants in 2017.²⁶ This study is part of the Heart Healthy Hoods project, which studies how social and physical characteristics of the urban environment, including the tobacco retailing, may affect residents' cardiovascular health (<https://hnhproject.eu>).^{27–29}

Databases

Tobacco stores

Information on the addresses and sales volume of all tobacco stores in the city ($n=639$) in 2014 was provided by the TMC. Data on the tobacco sales volume were reported by the tobacco wholesalers since they must declare their sales monthly to the TMC.^{20 21} These data were registered for four different types of products: cigarettes and cigars (units) and rolling and pipe tobacco (grams). The TMC did not provide data on the number and location of vending machines, and our analyses were restricted to tobacco stores. However, data on sales volume in each tobacco store also include the sales occurred in their associated vending machines.

Schools

Data on the addresses of all schools in Madrid were gathered and geocoded from the Open-data web service of the Madrid City Council for the year 2017.³⁰ Historical complete data for 2014 were not available for this database. We selected preschool, elementary, high schools and centres for children with disabilities to our analysis, regardless of their public or private funding.

Sociodemographic and economic data

Information about local population profiles including age and educational attainment was obtained at the census tract level ($n=2415$, with a mean population of 1311) from the 2014 Madrid Municipal Registry (<http://www-2.munimadrid.es/CSE6/jsps/menuBancoDatos.jsp>).³¹ Age was categorised in five groups: <15, 15–24, 25–44, 45–64 and >65 years old. Educational level was considered in three categories: low (elementary studies or below), medium (secondary or high school diploma) and high (university education or above). Data on education were registered for the population older than 25 years, and they were considered as an approximation of socio-economic status. Information about ethnicity was not included since in Spain, it is prohibited to collect, store or distribute data-related ethnicity.³²

Data about the location of recreational facilities were downloaded from the open-data web service of the Madrid City Council for 2014.³⁰ Recreational facilities were defined

as places for leisure activities. This information was used as a proxy for recreational land use, in order to evaluate how the distances between tobacco stores and their proximity to schools are associated with the density of recreational facilities. In our analyses, we considered hospitality venues (bars, restaurants, cafés, pubs and discos), tourist accommodation (hotels, hostels and guesthouses) and other recreational and cultural centres such as theatres, cinemas or museums.

Other spatial data

The street network for the whole study area updated to 2017 was downloaded from the Open Street Maps database.³³ Only the pedestrian road segments with public access were considered in our study. Information about the administrative boundaries and contextual data was downloaded from the Spanish National Mapping Agency.³⁴

Geographical analyses

Proximity analysis between tobacco stores

Of the 639 tobacco stores registered in the city, we excluded one from our analyses because sales volume data were not available, resulting in 638 stores with complete data (99.8%). We performed a proximity analysis between them using ArcGIS 10.1. software (ESRI, Redlands, California, USA). Since the Spanish legislation does not specify how the distance between tobacco stores should be measured, we decided to estimate distances through the pedestrian street network, which better represents population movement across space.⁸ However, an analysis using crow flies distances (straight line distances) was also performed for comparison.

Using GIS, we estimated the shortest paths between all stores in the city. We identified the routes shorter than 150 m and the stores involved in each route (figure 1A). Then, we checked whether the sum of the sales volume of the stores within the route exceeded the legal sales threshold. The total tobacco sales volume for each store was the sum of units of cigarettes and cigars and units of rolling tobacco and pipe. The legal sales threshold is three times the average of the whole tobacco sales in the city. Since the tobacco sales were provided in different units according to the type of product, we needed to standardise them. Based on previous literature, the sales volume of rolling and pipe tobacco were estimated in cigarettes. For this purpose, we defined a weight of 0.5 to approximate the amount of tobacco that each cigarette unit of rolling or pipe tobacco may include. Other weights, defined in 0.8 g and 1 g, were also tested to explore different results for robustness.³⁵

Proximity analyses from tobacco stores to schools

One thousand four hundred and seventy-nine schools were identified and geocoded within the study area. We used the pedestrian street network to estimate distances from all tobacco stores to their respective nearest schools using ArcGIS 10.1 software. Again, crow flies distances between tobacco stores and schools were also estimated for comparison. We assessed those distances by classifying all tobacco stores into different intervals: stores at less than 150 m of a school; between 150 and 300 m; or more than 300 m (figure 1B). These intervals were used in previous literature that studies the effect of the proximity of tobacco stores to school on smoking behaviours.³⁶

Characteristics of the population and recreational facilities around tobacco stores

We approximated the population served by each tobacco store using GIS and then computed the local sociodemographic characteristics. Specifically, we assigned each census tract to its closest tobacco store. We defined the closest tobacco store as that one whose location is closest to the centroid of each census tract. All stores were linked to at least one census tract (figure 1C).

We also assigned each recreational facility to their nearest tobacco store using GIS (figure 1D).

Statistical analyses

A descriptive analysis was conducted to calculate median and minimum distances between tobacco stores and between tobacco stores and schools. We estimated the percentage of stores that were closer than 150 m to another store and not exceeded the legal sales

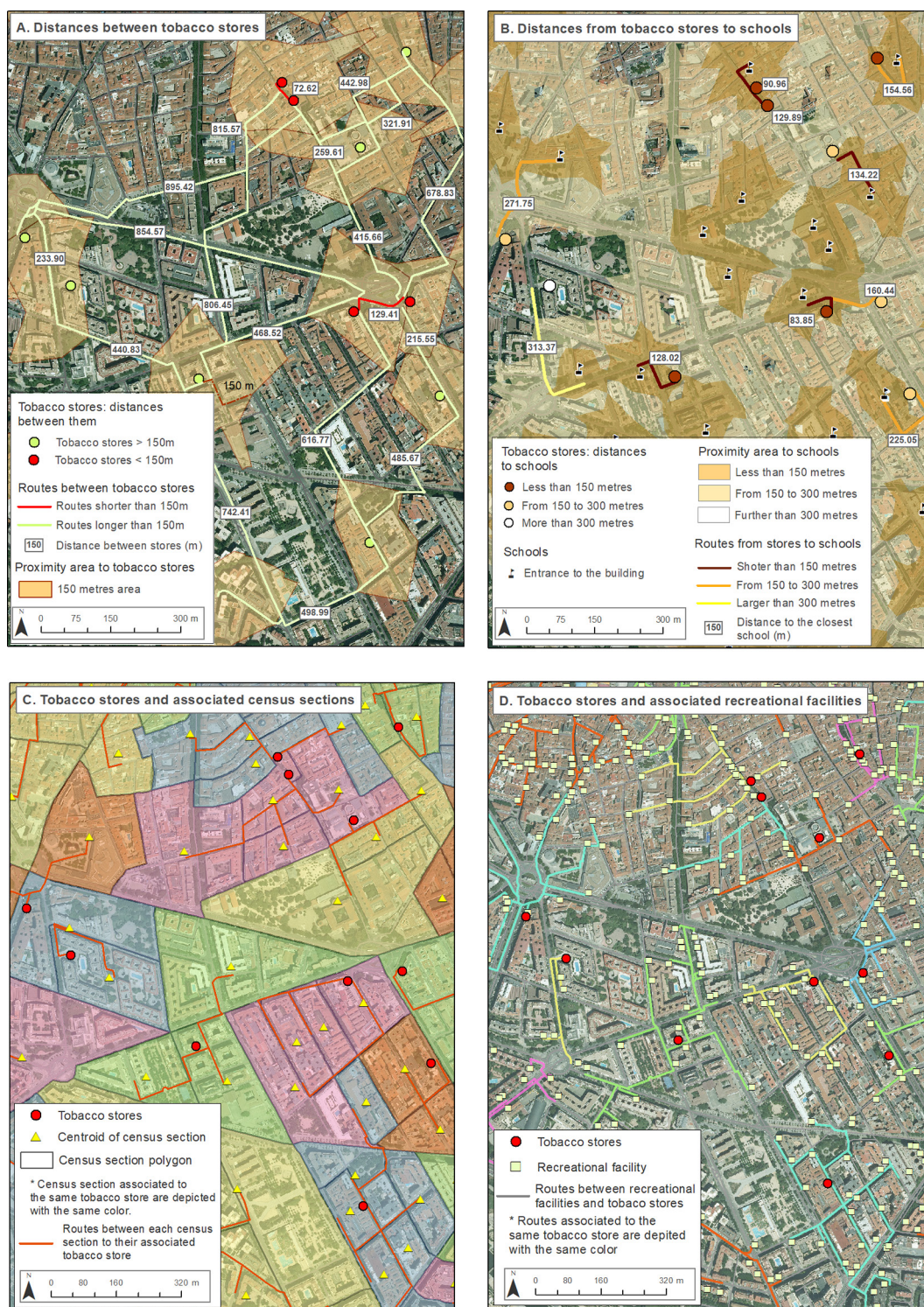


Figure 1 Illustration and summary of the geographical analyses relating tobacco stores, schools, population characteristics and recreational facilities in Madrid.

threshold, as well as the proportion of tobacco stores located in each of the intervals considered to analyse their proximity to schools.

We estimated the number of residents, and their related socio-demographic characteristics, associated to each tobacco store by aggregating the population of the census tracts that were linked to the same store through the geographical analysis. The proportion of people classified in each age group and educational level around each tobacco store were estimated. We also assessed the density of recreational facilities per 1000 inhabitants around each store by dividing the number of recreational facilities and the total

population associated to each store (expressed per 1000 residents) through the geographical analysis. We used Stata V.12.0. software to conduct a double-sided Kruskal-Wallis test with a significance level of 95% to assess disparities in the distribution of tobacco stores according to sociodemographic characteristics and density of recreational facilities.

RESULTS

Proximity between tobacco stores

The median street distance between the tobacco stores in Madrid was 283 m (SD=382m), while the minimum distance

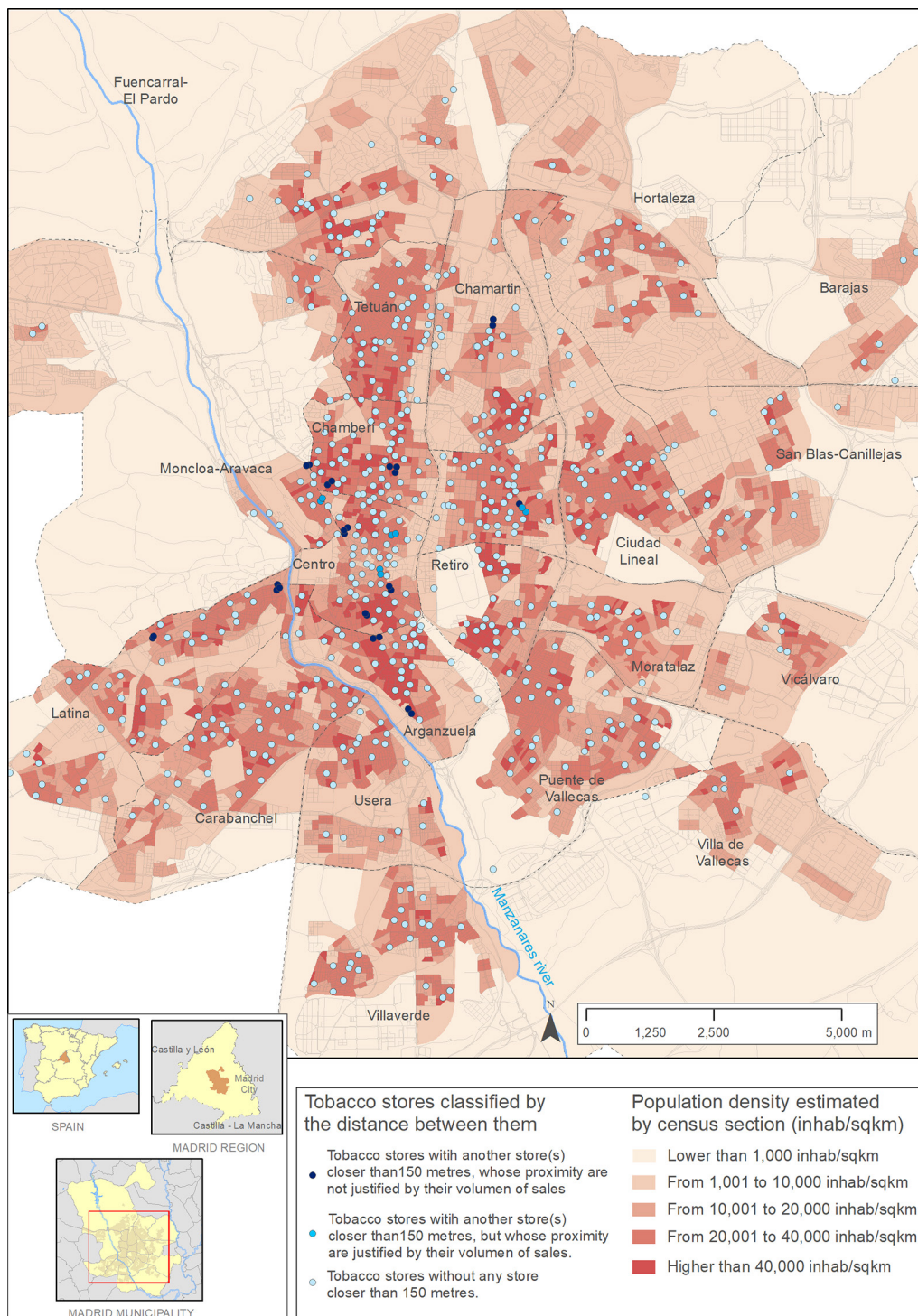


Figure 2 Tobacco stores by proximity between them and their volume of sales for the whole city of Madrid.

Table 1 Characteristics of the population and density of recreational facilities associated with tobacco stores according to tobacco retail regulation criteria

	Characteristics of the population associated with tobacco stores classified by proximity between them		
	Overprovisioned areas: tobacco stores closer than 150 m and not exceeding the legal sales threshold (n=26)	Non-overprovisioned areas: tobacco stores further than 150 m between them or closer than 150 m but exceeding the legal sales threshold (n=612)	P values*
Total population served (estimated residents), n (%)	67 036 (2.1)†	3 099 094 (97.9)†	<0.001
Age (years) (per cent of total residents for each group of stores)			
<15	11.1	13.7	<0.001
15–24	8.3	8.9	0.187
25–44	33.7	31.0	0.077
45–64	26.8	26.2	0.099
>65	20.1	20.2	0.401
Educational level (per cent of the residents older than 25 years for each group of stores)			
Less than elementary and elementary	35.9	43.3	0.038
Secondary	23.7	25.0	0.275
University	40.5	31.7	0.014
Median density of recreational facilities per store (number recreational facilities per 1000 inhabitants)	3.8 (0.3–58.7)	3.2 (0–79.4)	0.213

*Kruskal-Wallis test with a significance level of 95%.

†Percentages estimated respect the total population of Madrid: 3 166 130 inhabitants (data from 2014).

was 29 m. The total sales volume of tobacco products in Madrid in 2014 was 4211.3 million cigarettes (considering 0.5 grams as the weight to approximate the number of cigarettes of rolling and pipe tobacco). The mean sales volume was 6.6 million cigarettes per store, and the established legal sales threshold was 19.8 million cigarettes.

A total of 5.3% (34/638) establishments were less than 150 m from another tobacco store through the street network. A percentage of 76.5 of these stores (26/34) had sales volume lower than the legal sales threshold, which justify that proximity (figure 2). These figures were robust regardless the weights used to estimate the number of cigarettes of rolling and pipe tobacco. We considered these 26 stores were in overprovisioned areas, according to the Spanish legislation. Around 2% of the population of Madrid were living in that overprovisioned areas. We observed significant differences in the distribution of tobacco stores by sociodemographic characteristics (table 1). Within the overprovisioned areas, we found a lower percentage of population younger than 15 years old (11.1% vs 13.7%, $p < 0.001$), and a higher percentage of people with university studies (40.5% vs 31.7%, $p = 0.014$, respectively), compared with the rest of stores. Although the median density of recreational facilities around tobacco stores seemed higher among the overprovisioned areas, the statistical analysis showed no significant difference between both groups of tobacco stores (3.8 vs 3.3, $p = 0.213$).

The analyses using crow flies distances identified that 22.4% of tobacco stores (143/638) were located within a radius of 150 m to another store. A percentage of 76.2 of these stores (109/143) did not exceed the legal sales threshold. Around 10.4% of the total population of Madrid were living in these overprovisioned areas, and their sociodemographic characteristics were similar to the ones exposed in table 1.

Distance from tobacco stores to schools

The median street distance from tobacco stores to schools was 216 m (SD=647 m). The minimum distance identified was 19 m. Twenty-seven per cent of tobacco stores had at least one school closer than 150 m, 48% between 150 and 300 m and

25% further than 300 m through the street network (figure 3). Tobacco stores with at least one school closer than 150 m covered 28% of the total population in Madrid; stores that had at least one school between 150 and 300 m covered 47% of the population, and those with no school closer than 300 m covered 25% of the population ($p = 0.33$). Table 2 shows the sociodemographic characteristics of the population and the density of recreational facilities associated with tobacco stores according to their proximity to their closest school. We observed no significant differences in terms of age, educational level and density of recreational facilities by proximity to the closest school.

The analyses using crow flies distance showed that 48% of tobacco stores were located within a radius of 150 m to a school in Madrid. These stores covered 49.9% of the population. A percentage of 44.8 of tobacco stores were located between 150 m and 300 m and 7.2% were located further than 300 m. There were no significant differences between tobacco stores regarding sociodemographic characteristics of the population served by them.

DISCUSSION

This paper offers new insights into the tobacco retail regulation in Spain which restricts the sales of tobacco to tobacco-exclusive stores and their associated vending machines, demands minimum distances between retailers and recommends distances to schools. Our analyses showed how tobacco retail regulations in Madrid are reasonably well enforced in terms of minimum distances between tobacco stores when street distances are considered; as only 5.3% of tobacco stores were situated less than 150 m to another tobacco store. However, 76.5% of these tobacco stores were under the legal sales threshold and therefore were not compliant with the regulation. This level of compliance decreased when crow flies distances were considered, as opposed to using a street network distance. Non-compliant stores were more likely to be situated in areas with a lower proportion of population younger than 15 years and a higher proportion of people

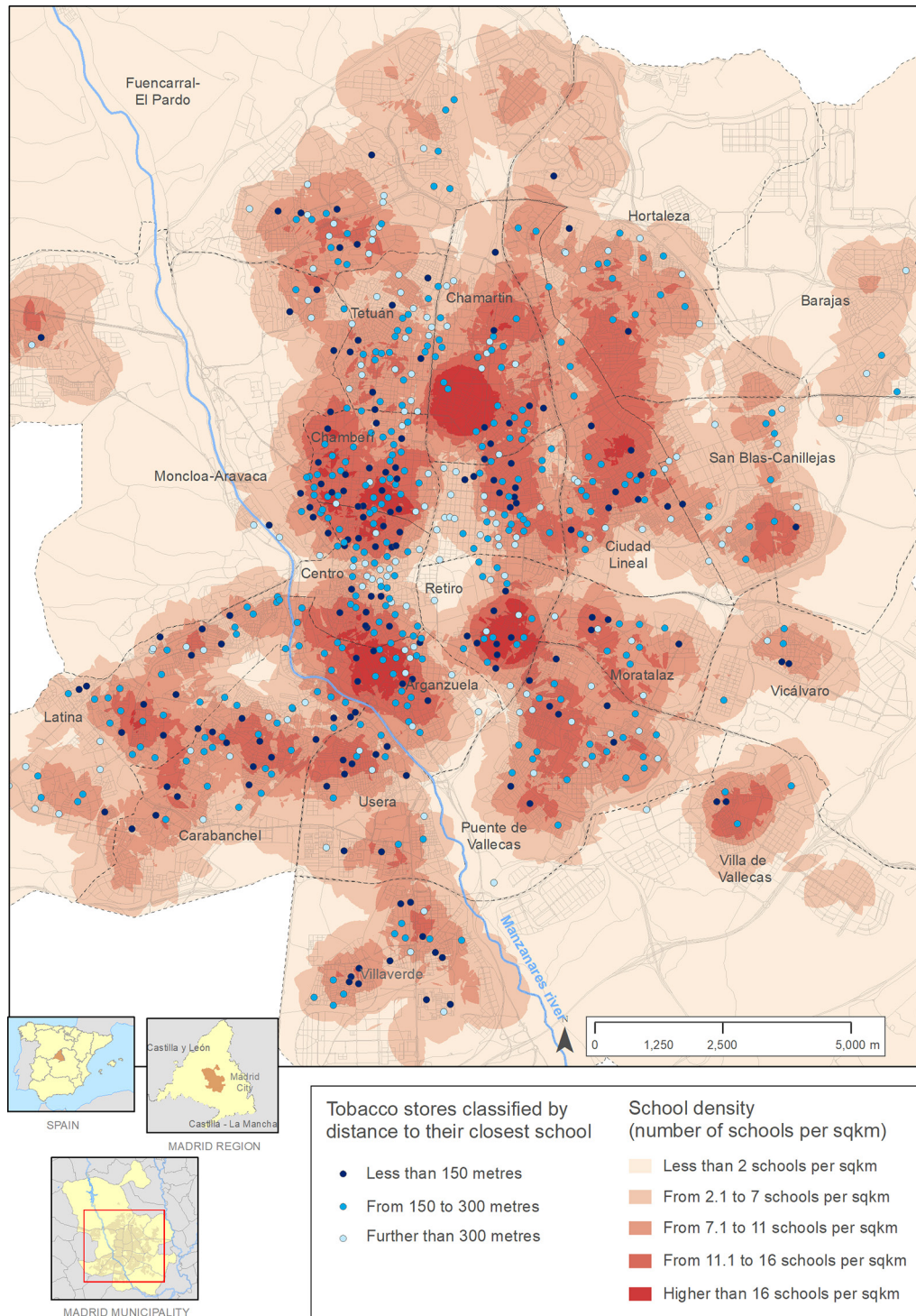


Figure 3 Tobacco stores as classified by of their distance to the closest school.

with university-level education. We suggest these areas likely contain more commercial and recreational activities and pedestrian traffic.

Our results also provide little evidence that distances to schools are a material consideration in the implementation of the regulation of tobacco store locations. Seventy-five per cent of tobacco stores in Madrid were situated closer than a street distance of 300 m to a given school. This proportion increased to 92.8% when distances were measured as the crow flies. Contrary to the results obtained in other studies, which associate the proximity between tobacco stores and schools

with social deprivation³⁷ and commercial and recreational land use,³⁸ in Madrid, we found that the distribution of the stores did not show disparities in terms of the total number of population served, age, educational level or density of recreational facilities when considering distances to schools.

The Spanish model may provide some keys for jurisdictions looking to reduce the availability of tobacco stores, especially, in places that do not restrict their distribution (eg, Scotland,³⁹ New Zealand⁴⁰ or most of the USA). Our results suggest that current regulations are reasonably well enforced, and the availability of tobacco stores in Madrid is lower than other places,

Table 2 Characteristics of the population and density of recreational facilities associated with tobacco stores according to their proximity to schools

	Characteristics of the population associated with tobacco stores classified by their distance to closest school			P values*
	Less than 150 m to a school (n=169 tobacco stores)	Closest school between 150 and 300 m (n=307 tobacco stores)	No school closer than 300 m (n=162 tobacco stores)	
Total population served (units, n (%))	891 584 (28.2)†	1 497 001 (47.3%)†	777 545 (24.5)†	0.326
Age (years) (per cent of total residents for each group of stores)				
<15	14.2	13.6	13.2	0.634
15–24	8.9	8.8	9.1	0.086
25–44	31.7	31.1	30.4	0.691
45–64	25.6	26.1	26.9	0.548
>65	19.6	20.4	20.4	0.510
Educational level (per cent of total residents older than 25 for each group of stores)				
Less than elementary and elementary	44.1	43.2	41.7	0.273
Secondary	24.5	25.3	24.8	0.379
University	31.4	31.5	33.5	0.420
Density of recreational venues (number recreational facilities per 1000 inhabitants)	3.0 (0.2–58.7)	3.3 (0–79.4)	3.4 (0–47.6)	0.439

*P values estimated through a Kruskal-Wallis test with a significance level of 95%.

†Percentages estimated respect the total population of Madrid: 3 166 130 inhabitants (data from 2014).

as we exposed in the introduction. However, our results also indicate the need to improve the effectiveness of the tobacco retail regulations and pose some potential recommendations that could be considered in other jurisdictions.

First, the tobacco retail regulation in Spain is driven only by business profitability criteria. Public health mandates could be incorporated into the regulatory model to better reduce the availability of tobacco products and achieve the public health goal of reducing tobacco use. Second, the mandated minimum distances between stores in Spain are relatively short. More restrictive minimum distances have been applied elsewhere to regulate the alcohol outlet distribution showing positive effects to reduce alcohol consumption⁴¹ (eg, the city of Edmonton demands minimum distances of 500 m between liquor stores).⁴² Moreover, more clarity should be achieved in specifying the methods to measure these distances (eg, street distances or crow flies distances), as our results show that compliance with the regulation varies widely depending on the measurement method. In this sense, the street network distances are more conservative and may bias the results towards high compliance. Policies based on crow flies distances may be more effective for tobacco retail reduction goals, as our results showed.

Third, some exceptions exist in the current regulation that allow for the location of new tobacco stores within 150 m to another store as long as they exceed a sales threshold in the previous year.^{20 21} These exceptions may be unwarranted and do not consider the market fluctuations of the tobacco products in the long term. This is especially important given that licences to open a tobacco retailer are valid for 25 years in Spain. We consider that these exceptions should be removed or, at least, a more comprehensive market research based on the sales volume registered during a broader period should be required. These licences should be also reviewed in shorter time periods (eg, annually instead of 25-year periods) to ensure their compliance with the law.

Fourth, tobacco vending machines are still permitted, and their location is not geographically restricted.¹⁹ These vending machines substantially increase the availability of tobacco products. Further tobacco regulations in Spain should consider

banning or restricting the tobacco vending machines, similarly to regulations in other countries, like France.⁴³

Fifth and last, the current regulatory framework does not explicitly mandate a minimum distance between tobacco stores and schools. Our analyses revealed that enforcing minimum street distances of 150 m to school would remove 27% of tobacco stores in Madrid (and up to 50% if distances were measured as the crow flies). Similar regulations have already been implemented in other places: India bans the tobacco sales within a buffer distance of 30 m to schools⁴⁴ and Santa Clara County, USA, established a minimum distance of 1000 feet (300 m).⁴⁵ Future policy interventions in Spain should consider explicitly limiting the number and location of tobacco stores near youth-serving facilities, including schools.

This study has some limitations. The data on the location of tobacco vending machines were not available, and thus could not be included in the analysis, leading to an underestimation of the real tobacco availability in Madrid. Future research should include vending machines in the analysis once these data are available. Moreover, data on tobacco stores were limited to 2014, with no data on the opening year of each store. We cannot rule out the possibility that stores that were not currently in compliance with the regulation were indeed compliant in previous years (at the time they got the licence to open). Last, we do not yet have data on smoking prevalence by neighbourhood in Madrid, so our results cannot yet inform the association between tobacco retail environment and smoking prevalence. However, this study is part of the 'Heart Healthy Hoods' project, which is currently collecting data on smoking behaviours among a cohort of adult in Madrid. Future studies will explore the association of tobacco retail environment in Madrid with tobacco consumption reported by its residents and their cardiovascular health.

This paper explores a unique regulatory framework that may provide new insights for tobacco retailing policies. Our findings underline some strengths and weaknesses of this legislation and emphasise the importance of considering public health criteria into tobacco availability regulations.

What this paper adds

What is already known on this subject

- Density and proximity to tobacco stores have been already associated with greater risk of smoking, favouring tobacco initiation and decreasing quitting success.
- Geographic information systems may constitute a valuable tool to understand the spatial distribution and the effect of tobacco stores on the smoking behaviours.

What important gaps in knowledge exist on this topic

- More research is needed to assess the effectiveness of the current policies to recommend new guidelines for restricting the number and location of tobacco retailers in the environment. This constitutes a critical step in the progress towards tobacco endgame.

What this paper adds

- This study provides the evaluation of a unique legislation framework regulating tobacco retail environment in Madrid, Spain.
- Our analysis identified some strengths and weaknesses within the tobacco retail regulation framework in Spain that may provide useful lessons for policymakers in other countries related to reduce the density of tobacco retailers and their related disparities.

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Contributors RV, XS and FE conceive the original idea. RV geocoded, prepared the databases and analysed the data with the advice of FE and XS. FE supervised both GIS analyses and cartographic outputs. XS designed and supervised tobacco epidemiological methods and quantitative analytical procedures. All authors contributed substantially to the interpretation of the data and manuscript review and approved its final version. XS and MF are the guarantors.

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