Physical and social environmental factors related to co-occurrence of unhealthy lifestyle behaviors

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Abstract

Previous work identifying determinants of co-occurrence of behavioral risk factors have focused on their association with individuals´ characteristics with scant attention paid to their relationship to contextual factors. Data came from 21,007 individuals ≥15 years of age who participated in the cross-sectional 2011-2012 Spanish National Health Survey. Two indicators were defined by tobacco consumption, alcohol intake, diet, physical activity, and body mass index. The first indicator, based on dichotomized measures, ranges from 0-5. The second one (unhealthy lifestyle index), ranges from 0-15, with 0 denoting the healthiest score. Among the determinants, we examined social support, five perceived characteristics of the neighborhood, and the socioeconomic deprivation index of the census tract of residence. Data were analyzed using multilevel linear and logistic regression models adjusted for the main sociodemographic characteristics. Using the dichotomized indicator, the probability of having 3-5 risk factors versus <3 factors was associated with low social support (Odds Ratio [OR] 1.50; 95% Confidence Interval [CI]: 1.25-1.80). Issues surrounding neighborhood cleanliness (OR=1.18; 95%CI: 1.04-1.33), air pollution (OR=1.38; 95%CI: 1.16-1.64), and street crime (OR=1.21; 95%CI: 1.03-1.42) were associated with determinants of co-occurrence. Risk factors co-occurrence increased as deprivation level increased: the OR for the highest deprivation quintile versus the lowest was 1.30 (95%CI: 1.14-1.48). Similar results were observed when using the unhealthy lifestyle index. Poorer physical and social environments are related to greater co-occurrence of risk factors for chronic diseases. Health promotion interventions targeting the prevention of risk factors should consider the contextual characteristics of the neighborhood environment.

Keywords: Health behaviors, co-occurrence, environment, multilevel analysis

Introduction

Unhealthy behaviors or lifestyles are the main modifiable risk factors for non-communicable diseases. Evidence shows that risk factors are responsible for the largest portion of disease burden worldwide. Their contribution, 340 deaths per 100,000 individuals in Western Europe in 2017, represents one third of total mortality (Institute for Health Metrics and Evaluation, 2017).

Although most work in the field examines lifestyles as unidimensional entities, several studies using different methodologies (McAloney et al., 2013) have established their multidimensionality (Birch et al., 2018; Li et al., 2012; Mawditt et al., 2016; Meader et al., 2016; Morris et al., 2016; Noble et al., 2015; Silva et al., 2013). This work corroborates that completely healthy behavioral patterns are uncommon and that, in fact, most individuals exhibit a combination of healthy and unhealthy behaviors. For instance, the relationship between tobacco and alcohol consumption is well known (Gulliver et al., 2006; Sobell et al., 1990), as well as that between smoking and unbalanced diet (Dallongeville et al., 1998), and low physical activity and poor dietary patterns(Gillman et al., 2001). Broader combinations where a greater frequency of clusters of 3 and 4 risk factors than expected have also been identified (Burke et al., 1997; Laaksonen et al., 2001; Schuit et al., 2002).

Clusters of risk factors are associated with a higher overall mortality risk (Colpani et al., 2018; Ding et al., 2015; Ford et al., 2012; Khaw et al., 2008; Krokstad et al., 2017; Li et al., 2018; Loef and Walach, 2012; Loprinzi, 2016) and with higher incidence and mortality due to cancer, coronary and cerebrovascular disease (Johansson and Sundquist, 1999; Luoto et al., 1998; Yusuf et al., 1998). Compared to those leading a thoroughly healthy life regarding the traditionally studied 5 risk factors (smoking, alcohol, diet, exercise, obesity), individuals reporting unhealthy choices in those 5 risk factors experienced a reduction in life expectancy at age 50 of 14 years in the case of men, and 12.2 years, in the case of women (Li et al., 2018).

Studies identifying co-occurrence of risk factors have focused mainly in the association between co-occurrence and individual characteristics (Meader et al., 2016). However, for the last three decades, the role played by the neighborhood of residence on the health status and its determinants has aroused great interest among certain researchers. These authors recognize that individuals´ health is not solely related to individual

characteristics but also to the context surrounding these individuals (Diez Roux, 2001; Macintyre et al., 2002; Oakes et al., 2015; Roux, 2008). A handful of studies have investigated the relationship between contextual characteristics and co-occurrence of risk factors, most focusing on the socioeconomic level of the area of residence (Boing et al., 2019; Feng and Astell-Burt, 2013; Halonen et al., 2012; Lakshman et al., 2011; Lawder et al., 2010).

The main aim of this study is to determine to which extent do census tracts, in general, and their social and physical characteristics, in particular, influence individual level co-occurrence of main behaviors or lifestyles considered risk factors of non-communicable diseases ("risk factors" from now on).

Methods

Study design and population

This is a cross-sectional study based on the 2011-2012 Spanish National Health Survey (ENSE for its Spanish acronym). Using a multi-stage sample design towns are selected within every Spanish province and stratified by size. Census tracts are selected within the chosen towns. Finally, all residences in these tracts are sampled and an adult ≥15 years of age residing in each household is selected for a face-to-face interview. Data collection took place between July 2011 and June 2012. Response rate among selected households was 71.1%. The original sample size was 21,007 individuals residing in 2,000 census tracts (Spanish Ministry of Health, Consumption, and Welfare and Spanish National Institute of Statistics, 2012).

Dependent variables

Tobacco consumption was measured based on the following question: Would you tell me if you currently smoke? Yes, I smoke daily; Yes, I smoke but not daily; I do not smoke now but I smoked in the past; I have never smoked. We identified current smokers (daily and occasional consumption) and ex-smokers as the risk group. The number of cigarettes of current smokers was classified in two categories: 1-14 and ≥15. Although there is no established recommended cut off number of cigarettes differentiating between low-moderate and heavy tobacco consumption, several studies use cut offs ranging from 10 to 20 cigarettes, so we consider it reasonable to establish a cut off point of 15 cigarettes between those two consumption categories.

Alcohol consumption: based on the frequency of regular consumption of any of 6 types of alcoholic drinks each day of the week we identified two average consumption levels. "Average low-risk consumption" was defined as the average consumption of >0 and ≤20 g/day for men and >0 and ≤10 g/day for women. Greater consumption levels were labeled "Average high-risk consumption." Complementing the average consumption, binge drinking was defined as the consumption of ≥6 alcoholic beverages for men and ≥5 for women, within a 4-6 hour window at least once in the previous month. Alcohol consumption cut off was consistent with the Spanish guidelines and recommendations.

Diet: This variable was based on a summary index of diet quality, an adaptation of the Mediterranean Diet Adherence Screener (MEDAS) index (Schröder et al., 2011). Total score varies between 0-10 according to the different points assigned to each item: fruit consumption: 1-2 pieces/day (1 point), ≥3/day (2 points); vegetables 1/day (1 point), >1/day (2 points); legumes ≥3/week (1 point); fish ≥3/week (1 point); meat <1/day (1 point); sweetened beverages <1/day (1 point); sweets <3/week (1 point); fast food (including snacks) <3/week (1 point).

Leisure-time sedentarism: It was based on the following question: Which of these statements best describes how often you engage in physical activity in your leisure time? I do not engage in physical activity. My leisure time is occupied almost completely by sedentary activities (e.g., reading, watching tv, going to the cinema); I occasionally engage in some physical or sports activity; I engage in physical activity several times a month; I do sports or physical training several times a week.

Body Mass Index (BMI). BMI was calculated based on self-reported weight and height.

Table 1 shows how the two indicators of co-occurrence of risk factors were typified: 1) Sum of dichotomized scores resulting in scores ranging between 0 (no risk behaviors) and 5 (all five risk behaviors); 2) Unhealthy lifestyle index: sum of scores from a quantitative scale, resulting in individual scores ranging between 0 and 15.

Independent variables

Contextual variables operationalized at the census tract level

Socioeconomic deprivation index. Contextual variable available from 2011 census on. This summary index was developed by the Spanish Epidemiological Society at the census tract level for the entire country. The index captures 6 socioeconomic indicators

expressed in percentages: population in manual professions, temporary workers, unemployment, insufficient education defined as primary studies or less among those of all ages and in young people (aged 16 to 29 years), and primary residences with no internet access (Duque et al., 2020). The index score is grouped by quintiles from lower to higher socioeconomic deprivation levels

Contextual variables operationalized at the individual level

Perceived social support. The ENSE used the Duke-UNC Functional Social Support Questionnaire to measure social support. We dichotomized it into low support (score <32 score) and normal-high support (score ≥32). The version in ENSE was validated for use in Spain (Bellón Saameño et al., 1996).

Perceived neighborhood social and physical environment. This variable was constructed based on the following variables in the ENSE questionnaire: Noise issues; cleanliness issues; air pollution issues; lack of green areas; and crime/safety issues. Responses were dichotomized as: None/Some vs. A lot.

Sociodemographic variables

The ENSE questionnaire collected the following individual level data for each participant: sex; age; educational attainment (primary school or less, first stage secondary school; second stage secondary school; university studies); household income adjusted by household size (tertiles); native or foreign-born; municipality of residence (rural <10,000 inhabitants, urban≥10,000 inhabitants).

Data analyses

For this study we selected 17,837 individuals with valid data for all the variables of interest. Two variables accounted for most of the missing data: BMI (n=1938, 9.2%) and social support (n=1010, 4.8%). Following a previously described methodology (Merlo et al., 2016) models were constructed in a stepwise fashion to better analyze the effects of the independent variables on the health risk factors. Model 1 included sociodemographic individual variables (Table 1S in the supplementary material); model 2 added perceived social support and neighborhood environment variables; model 3 built on model 2 and created a multilevel regression analysis by including the census tract as random effects; finally, model 4 further added the specific contextual variable (deprivation index). Dichotomized measures of the risk factors were analyzed using

logistic regression and the quantitative forms of the dependent variable (unhealthy lifestyle index) were analyzed using linear regression models.

We calculated the area under the curve (AUC) in the logistic regression models. The AUC provides information on the model´s ability to correctly classify individuals with or without co-occurrence of health risk factors.

We differentiated between specific and general contextual factors. To evaluate the former, we studied the odds ratios (OR) and β coefficients of the specific contextual variable. To evaluate general contextual effects we estimated: 1) the intraclass correlation coefficient (ICC) which represents the proportion of the total individual variance explained by the census tract of residence. To evaluate the size of the ICC, we used the classification proposed by Merlo and colleagues (Merlo et al., 2019) as a reference; 2) the change in AUC observed after adding the random effect of census tract to the model with all the individual level variables of interest; and 3) the Proportional Change of the Variance (PCV), i.e., the census tract variance explained after adjusting for the census tract deprivation index. The PCV complemented our evaluation of the contextual effects because it reveals to what extent the specific contextual variables mediate the overall contextual effect.

All analyses were performed using Stata v.15 (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

Results

Tables 2 and 3 describe the co-occurrence of behavioral risk factors by the sociodemographic characteristics of our sample, differentiating between our two measures: 1) the one based on binary scores which we dichotomized into <3 risk factors (low co-occurrence of risk factors) and 3-5 factors (high co-occurrence of risk factors); and 2) the one based on the unhealthy lifestyle index which ranges between 0 (completely healthy behaviors) and 15 (maximum unhealthy score). Overall, 43.3% (95% Confidence Interval [CI]: 42.4 - 44.1) of the participants reported 3-5 risk factors and the average score for the quantitative risk factor index was 6.1 (Standard Deviation [SD]: 2.5).

Table 4 shows the associations between contextual variables and reporting a cluster of 3-5 behavioral risk factors versus not (<3 factors). The fully adjusted model (Model 4), which includes all the individual sociodemographic variables, the perceived social and

physical characteristics of the neighborhood, and the contextual deprivation index, suggests that individuals with low social support had an Odds Ratio (OR) of 1.50 (95%CI: 1.25-1.80) of reporting a cluster of risk factors. Participants reporting cleanliness issues around their residence also had a higher likelihood of co-occurrence of risk factors (OR of 1.18; 95%CI: 1.04-1.33) similarly to those perceiving air pollution (OR: 1.38; 95%CI: 1.16-1.64) or street crime issues (OR: 1.21; 95%CI: 1.03-1.42). No association was observed between issues with noise or lack of green areas. When compared to the lowest socioeconomic deprivation quintile, as the level of deprivation increases, the degree of concurrent risk factors gradually increases. In fact, those in the 4^{th} and 5^{th} quintile (the highest deprivation) have statistically significant higher odds of co-occurrence of risk factors (OR: 1.17; 95%CI: 1.04-1.33 and OR: 1.30; 95%CI: 1.14-1.48, respectively).

Supporting these results, the relationships observed between contextual variables and the unhealthy lifestyle index mostly mirror those reported above. The only difference was that the association between perceived cleanliness issues and co-occurrence of risk factors, though in the expected direction, fails to reach statistical significance (Table 5).

Certain results are worth underlining. First, we observed an increase of 0.67 points (95%CI: 0.47-0.87) among those reporting low social support levels. Second, there was a gradual increase as the deprivation index increased. Those residing in census tracts with a deprivation index in the fourth and fifth quintiles (highest deprivation level) had scores 0.29 times larger (95%CI: 0.14-0.43) and 0.35 times larger (95%CI: 0.20-0.50) than those residing in the areas with the lowest deprivation levels.

Finally, table 6 shows the general contextual effects for both indicators. Adding the individual variables on perceived neighborhood issues and social support (model 2 of the binary co-occurrence indicator) to the model composed of sociodemographic variables does not yield changes in the ROC curve. The ICC for model 3, once we included the census tract as random effect, was 5.8% (95% CI: 4.6-7.2), increasing the ROC curve (AUC) from 64.1% in model 2 to 71.6% in model 3.

Regarding the PCV, the deprivation index (model 4) slightly modified the variance observed in model 3 (PCV= -3%). Concerning the unhealthy lifestyle index, the ICC was 7.0% in model 3 (95%CI: 6.0-8.2), also experiencing a small reduction in variance when the deprivation index was included (PCV= -3.3%). In sum, results were quite

similar when comparing the two indicators with the co-occurrence of 3-5 risk factors slightly underestimating the estimated general contextual effect on.

Discussion

Our main results show how several social and contextual characteristics are positively associated to co-occurrence of risk factor even after considering the main sociodemographic variables at the individual level.

More specifically, those reporting low social support, neighborhood issues with cleanliness, pollution, and street crime, and those residing in high deprivation areas are more likely to exhibit concurrent behavioral risk factors.

Our analyses also show that the contextual environment (at the census tract level) affects the individual level risk of engaging in various risk factors concurrently even after accounting for individual-level variables. This overall contextual effect is small in size given that, based on previously published criteria (Merlo et al., 2019), the census area of residence only accounts for 6 to 7% of the total individual variance. However, in the logistic regression model, the 7.5-unit increase in the AUC suggests that the contextual effect may be relevant. We also observed that the census level deprivation index only explains 3% of the census level variance. This is a much smaller effect than that the ICC of 13.8% reported by the only multilevel study describing the distribution of the variance explained (Boing et al., 2019). Our study may underestimate the overall contextual effect of the census area as well as the specific contextual effect of the census-level deprivation index. In fact, our analyses adjust for individual level variables which could be seen as actual contextual variables and as mediators of both the overall contextual effect and the specific one.

Most studies associating contextual factors with behavioral risk factors have focused on individual determinants such as physical activity (Kepper et al., 2019; Schüle and Bolte, 2015; Smith et al., 2017), diet (Black et al., 2014; Caspi et al., 2012), obesity (Black and Macinko, 2008), or alcohol and tobacco consumption (Karriker-Jaffe, 2011). Further, studies identifying causes of co-occurrence of risk factors have targeted, mainly, individual characteristics (Meader et al., 2016). Studies looking at the relationship between contextual characteristics and concurrent risk factors are not only scarce but tend to examine the association between the socioeconomic level of the area of

residence (Boing et al., 2019; Feng and Astell-Burt, 2013; Halonen et al., 2012; Lakshman et al., 2011; Lawder et al., 2010).

Social support, defined here as the degree to which someone´s social needs are met by their social relationships within the family, work, and friend environment, may be characterized based on structure (i.e., number of support networks or frequency of social interactions) and/or based on function (i.e., emotional and informational support) (Callaghan and Morrissey, 1993). The Duke-UNC scale used in this work measures the quality of the perceived functional social support (Bellón Saameño et al., 1996). Social support has been associated with many health status indicators. The underscored mechanisms underlying the association have been the regulation of beliefs, feelings, and behaviors related to health promotion (Callaghan and Morrissey, 1993; Wang et al., 2003). Although the specific mechanisms of action are not well-defined yet, social support is known for acting as a buffer in protecting individuals from the effects of negative social stress (Callaghan and Morrissey, 1993). This protective effect is not dependent on the number of social relationships as much as on the presence of a social network which, among other roles, has the ability to reduce feelings of loneliness and to offer support (Dean, 1986).

The presence of social network members leading healthy lifestyles increases the likelihood of any other member of being a non-smoker or engaging in healthy diet patterns (Heijmans et al., 2017). In addition, knowledge of the pathways through which social support influences health informs the design of interventions effective on changing behaviors and risk factors (Latkin and Knowlton, 2015).

As far as we know, this is the first study drawing association between the degree of social support and the co-occurrence of risk factors. Although previous works have reported on similar associations with many risk factors, they examined the risk factors independently, not in co-occurrence. Low social support has been associated to having an unbalanced diet (Carbonneau et al., 2019; Pieroth et al., 2017), low physical activity (Lindsay Smith et al., 2017), and obesity (Oliveira et al., 2013); whereas the association with alcohol or tobacco consumption is not as consistent (Carpiano, 2007; Nieminen et al., 2013; Poortinga, 2006). Still, emphasizing social support is a commonly used strategy in smoking and alcohol cessation programs (Brooks et al., 2017; Burns et al., 2014; Soulakova et al., 2018), as well as in weight reduction ones (Wang et al., 2014).

Factors traditionally considered as characteristics of our physical environment, such as noise (Münzel et al., 2018) and air pollution (An et al., 2018a, 2018b), as well as the ones recently deemed as such, for instance availability of neighboring green areas (WHO Regional Office for Europe, 2016), are considered important determinants of health. The quality of the physical environment also moderates the greater or lower probability of health-related factors such as alcohol and tobacco consumption (Ellaway and Macintyre, 2009; Jitnarin et al., 2015), physical activity (An et al., 2018b) and obesity (An et al., 2018a). However, as far as we are aware of, no study has described the association between physical environment characteristics and the co-occurrence of behavioral risk factors. Perception of the environment near where people live, together with objective measures, better capture the relationship of individuals with their physical environment (Hinckson et al., 2017; Jack and McCormack, 2014; McGinn et al., 2007). Thus the importance of accounting for perceptions to assess the quality of our physical surroundings. Several factors may explain this association but one in particular is worth underscoring: response to the greater amount of chronic stress caused by an unfavorable physical environment (Jitnarin et al., 2015; Kruize et al., 2014; Münzel et al., 2018).

The degree of neighborhood safety perceived has been associated with engagement in physical activity (Rees-Punia et al., 2018) and with tobacco consumption (Shareck and Ellaway, 2011), but not with co-occurrence of risk factors. Street crime and lack of safety embody important social characteristics of a neighborhood which may become chronic stressors and influence the residents´ unhealthy behaviors through negatively impacting stress and psychological well-being (Shareck and Ellaway, 2011).

Neighborhood low socioeconomic status has been associated to concurrent risk factors, although comparisons with other studies is difficult given methodological differences in the definition of co-occurrence and the measurement of contextual socioeconomic status. Three articles analyzed their data using multilevel models. In a Brazilian study, Boing and colleagues reported a statistically significant substantial increased risk (OR of 2.61) for co-occurrence of 3-4 modifiable risk factors (tobacco, high alcohol consumption, lack of physical activity, and unhealthy diet) for individuals residing in areas with lower educational achievement (Boing et al., 2019).

In Australia, Feng and Astell-Burt also reported an association between neighborhood socioeconomic status (as measured by the Index of Relative Socio-Economic

Advantage/Disadvantage) and unfavorable scores in the unhealthy lifestyle index (measuring the co-occurrence of the four modifiable risk factors: tobacco, alcohol, diet, and physical activity) (Feng and Astell-Burt, 2013). In Finland, Halonen and co-authors examined the relationship between the neighborhood socioeconomic disadvantage score and the summary co-occurrence of three risk factors (smoking, high alcohol consumption, and lack of physical activity). The OR for the quintile representing the lowest socioeconomic status versus the highest was 1.75 after adjusting for individual-level variables (Halonen et al., 2012). Another two studies assessed the association without multilevel modeling. In Scotland, Lawder and colleagues reported a 3-fold increased risk for having 4-5 risk factors among those residing in the neighborhoods with the highest deprivation index (vs lowest) (Lawder et al., 2010). Based on data from the East of England, Lakshman and colleagues concluded that the greater the neighborhood deprivation level the lower the score on a 4-behavior healthy lifestyle index even after adjusting for the individual´s occupational social class (Lakshman et al., 2011).

Previous studies have described several mechanisms through which neighborhoods with higher deprivation levels may influence behavioral risk factors. The more salient ones are lower participation in social structures, lower social cohesion and support, and greater exposure to social stressors. Low income neighborhoods experience multiple structural deficiencies: higher street crime and safety issues, greater discrimination, and worse services. This reality may increase the co-occurrence of unhealthy lifestyles (Halonen et al., 2012; Lawder et al., 2010).

Lower level of education or socioeconomic status and male gender, are the most consistent factors related to co-occurrence of unhealthy behaviors (Noble et al., 2015). Our study shows that neighborhood physical and environmental factors could increase the probability of co-occurrence of unhealthy behaviors which, in turn, would raise the risk of vulnerable populations. Therefore, policy makers designing and implementing multiple health behavior change interventions should consider the influence of neighborhood characteristics.

The results of our study should be interpreted keeping the following limitations in mind. First, the cross-sectional design of the study precludes us from establishing causal relations. Second, our risk factor measures are based on self-reported data but, although an underestimation of the prevalence of these factors can not be discounted, it is

unlikely for this bias to be differential across our variables of interest. Third, leisure time sedentarism was defined by a single question despite the fact that the ENSE includes the IPAQ short version questionnaire, a better measure of physical activity. Unfortunately, that questionnaire is only validated for those under 70 years of age. Comparing our results to measures of reference, we found that 89.7% and 91.5% of people under aged 70 classified in our study as sedentary, failed to meet the World Health Organization (WHO) and American Heart Association (AHA) physical activity recommendations based on IPAQ. Fourth, our assessments of both the neighborhood environment and the health outcome of interest are based on self-report data in an individual-level analysis. This approach increases the likelihood of same-source bias because the measurement error may be correlated in both measures (Diez Roux, 2007). Fifth, the use of the census tract as the contextual observational unit to define the area of residence or neighborhood is one of convenience given it is the unit used in the Spanish National Health Survey. This geographical unit may not actually capture the contextual factors affecting the probability of co-occurrence of risk factors at the individual level. Further, it is possible for other completely different social environments, such as individuals´ families or their social networks, to exert far more influence on behavior than the social and physical context in the census tract of residence. Nevertheless, census tracts are the geographical units of observation most often used when examining the effects of the social and physical environment on health outcomes (Arcaya et al., 2016). Finally, compared to other units of observation, census tract data show a strong association with the socioeconomic status of the area of residence (Merlo et al., 2012).

This study also has several strengths. First, the data come from a large population-based sample of all residents in Spain. Second, it is the first study examining the association between the physical and social environment of the area of residence and two indicators of co-occurrence of risk factors, while assessing both contextual and specific effects. Using two indicators was important due to the lack of consensus in the literature when it comes to selecting risk factors in the study of behavioral aggregations and in the methodological aspects when defining risk factors co-occurrence (Noble et al., 2015). Thus, the fact that we observed similar pattern of associations for two indicators with different methods of scoring risk factors co-occurrence suggests a degree of reliability of the results.

Conclusions

Several characteristics of the social and physical environment are associated with a higher probability of individuals engaging in aggregation of risk behaviors related to chronic diseases. Health promotion interventions targeting these risk factors, and especially their risk factor co-occurrence, should consider how to improve social and physical environments, both at the objective level as well as at the subjective level, i.e., the residents´ perception.

Funding

This work was supported by the Institute of Health Carlos III, Ministry of Science Innovation and Universities [grant number PI15CIII/00034 and FI17CIII/00003].

Conflict of interests

The authors declared no potential conflicts of interest.
This article presents independent research. The views expressed are those of the authors and not necessarily those of the Carlos III Institute of Health.

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Table 1. Definition of co-occurrence of behavioral risk factors.

Indicator	**Definition**	**Score**
Co-occurrence of behavioral risk factors (score 0-5)		
Tobacco*	Current or former tobacco consumption	1
Alcohol*	Average consumption >20 g/d (men) >10 g/d (women) and/or binge drinking in the previous month	1
Diet*	<7 points in the diet questionnaire	1
Leisure time sedentarism*	Almost or complete sendentary leisure time	1
Body Mass Index*	<18.5 or ≥25	1
Unhealthy lifestyle index (score 0-15)		
Tobacco	Non smoker	0
	Ex smoker	1
	Current smoker 1-14 cigarettes	2
	Current smoker ≥15 cigarettes	3
Alcohol	Non drinker	0
	Average consumption >0 and ≤20 g/d (men) >0 and ≤10 g/d (women)	1
	Average consumption >20 g/d (men) >10 g/d (women) or binge drinking	2
	Average consumption >20 g/d (men) >10 g/d (women) and binge drinking	3
Diet (diet questionnaire score)**	7-10 points	0
	6 points	1
	5 points	2
	0-4 points	3
Leisure time sedentarism	Physical activity or sports training several times a week	0
	Physical activity several times a month	1
	Occasional physical activity or sports training	2
	Almost or complete sendentary leisure time	3
Body Mass Index	18.5-24.9	0
	≥25-29.9	1
	<18.5	2
	≥30	3

* Score 0 otherwise**;** ** quartiles from the diet questionnaire score

Table 2. Co-occurrence of behavioral risk factors by sociodemographic variables. Population aged 15 and older, Spain 2011-2012.

		Co-occurrence of 3-5 risk factors		Unhealthy lifestyle index*	
	N	Yes	95%CI	Mean	SD
Total	17837	43.3	42.4 to 44.1	6.1	2.5
Sex					
Men	8475	51.9	50.8 to 53.1	6.7	2.6
Women	9362	35.5	34.4 to 36.5	5.6	2.3
Age					
15-24	1445	29.9	27.5 to 32.4	5.8	2.5
25-34	2514	42.9	40.9 to 44.8	6.4	2.6
35-44	3606	45.4	43.7 to 47.1	6.3	2.6
45-54	3206	50.8	49.0 to 52.6	6.5	2.6
55-64	2752	45.7	43.7 to 47.7	6.2	2.5
65-74	2219	39.0	36.9 to 41.2	5.7	2.3
≥75	2095	39.3	37.2 to 41.4	5.6	2.0
Educational Level					
Primary or less	4238	46.0	44.3 to 47.7	6.2	2.3
Secondary 1st stage	5840	46.8	45.4 to 48.2	6.4	2.6
Secondary 2nd stage	4913	42.8	41.4 to 44.2	6.1	2.5
University	2846	33.0	31.3 to 34.8	5.5	2.4
Household Income					
Low	4513	46.4	44.8 to 48.0	6.4	2.4
Medium	4716	42.8	41.3 to 44.4	6.1	2.5
High	4367	41.6	40.1 to 43.1	5.9	2.5
Not available	4241	42.2	40.6 to 43.8	6.0	2.5
Municipality of residence					
Urban	13794	42.6	41.7 to 43.6	6.1	2.5
Rural	4043	45.5	43.7 to 47.3	6.3	2.5
Country of birth					
Spain	16242	43.3	42.4 to 44.2	6.1	2.5
Other	1595	43.1	40.7 to 45.5	6.2	2.5

* Unhealthy lifestyle index (0 best score, 15 worst score)
SD: standard deviation

Table 3. Co-occurrence of behavioral risk factors by environmental variables. Population aged 15 and older, Spain 2011-2012.

		Co-occurrence of 3-5 risk factors		Unhealthy lifestyle index*	
	N	Yes	95%CI	Mean	SD
Social support					
Normal-high	17272	42.9	42.1 to 43.8	6.1	2.5
Low	565	54.2	49.8 to 58.5	6.9	2.4
Noise issues					
None-some	16051	43.1	42.2 to 44.0	6.1	2.5
A lot	1786	44.7	42.2 to 47.1	6.1	2.5
Cleanliness issues					
None-some	16385	42.9	42.0 to 43.7	6.1	2.5
A lot	1452	48.1	45.4 to 50.7	6.3	2.5
Air pollution issues					
None-some	17134	43.0	42.2 to 43.9	6.1	2.5
A lot	703	48.9	45.0 to 52.9	6.2	2.6
Lack of green areas					
None-some	16113	43.0	42.1 to 43.9	6.1	2.5
A lot	1724	45.8	43.4 to 48.2	6.3	2.5
Street crime issues					
None-some	17011	43.0	42.1 to 43.8	6.1	2.5
A lot	826	49.6	46.1 to 53.2	6.5	2.5
Deprivation index					
Q1 lower quintile	3673	37.9	36.1 to 39.7	5.8	2.4
Q2	3656	42.0	40.1 to 43.9	6.0	2.5
Q3	3540	43.4	41.5 to 45.3	6.2	2.5
Q4	3541	44.9	43.0 to 46.8	6.3	2.4
Q5 upper quintile	3427	48.7	46.8 to 50.6	6.4	2.5

* Unhealthy lifestyle index (0 best score, 15 worst score)
SD: standard deviation

Table 4. Associations between contextual variables and co-occurrence of behavioral risk factors*. Population aged 15 and older, Spain 2011-2012.

	Model 2		Model 3		Model 4	
	OR	95%CI	OR	95%CI	OR	95%CI
Specific Individual Environmental Perceived Average Effects						
Social support						
Normal-high	1 (ref)		1 (ref)		1 (ref)	
Low	1.48	1.24 to 1.76	1.51	1.26 to 1.81	1.50	1.25 to 1.80
Noise issues						
None-some	1 (ref)		1 (ref)		1 (ref)	
A lot	1.01	0.91 to 1.13	1.01	0.90 to 1.12	1.00	0.90 to 1.12
Cleanliness issues						
None-some	1 (ref)		1 (ref)		1 (ref)	
A lot	1.18	1.05 to 1.33	1.18	1.05 to 1.34	1.18	1.04 to 1.33
Air pollution issues						
None-some	1 (ref)		1 (ref)		1 (ref)	
A lot	1.33	1.13 to 1.57	1.34	1.13 to 1.60	1.38	1.16 to 1.64
Lack of green areas						
None-some	1 (ref)		1 (ref)		1 (ref)	
A lot	1.01	0.91 to 1.13	1.00	0.89 to 1.12	0.99	0.88 to 1.11
Street crime issues						
None-some	1 (ref)		1 (ref)		1 (ref)	
A lot	1.22	1.05 to 1.41	1.22	1.04 to 1.42	1.21	1.03 to 1.42
Specific Contextual Average Effects						
Deprivation index						
Q1 lower quintile					1 (ref)	
Q2					1.10	0.98 to 1.24
Q3					1.12	0.99 to 1.26
Q4					1.17	1.04 to 1.33
Q5 upper quintile					1.30	1.14 to 1.48

* Co-occurrence of 3-5 risk factors vs 0-2
Multilevel logistic regression models

Model 1: Sociodemographics (data not shown, see supplementary material)
Model 2: Sociodemographics + social support and perceived environment
Model 3: Sociodemographics + social support and perceived environment + random effects (census tracts)
Model 4: Sociodemographics + social support and perceived environment + deprivation index + random effects (census tracts)

Table 5. Associations between contextual variables and the unhealthy lifestyle index*. Population aged 15 and older, Spain 2011-2012.

	Model 2		Model 3		Model 4	
	β	95%CI	β	95%CI	β	95%CI
Specific Individual Environmental perceived Average Effects						
Social support						
Normal-high	(ref)		(ref)		(ref)	
Low	0.69	0.49 to 0.89	0.68	0.48 to 0.88	0.67	0.47 to 0.87
Noise issues						
None-some	(ref)		(ref)		(ref)	
A lot	-0.04	-0.16 to 0.08	-0.06	-0.18 to 0.06	-0.06	-0.18 to 0.06
Cleanliness issues						
None-some	(ref)		(ref)		(ref)	
A lot	0.12	-0.01 to 0.26	0.11	-0.02 to 0.25	0.11	-0.03 to 0.24
Air pollution issues						
None-some	(ref)		(ref)		(ref)	
A lot	0.23	0.04 to 0.42	0.21	0.01 to 0.40	0.25	0.05 to 0.44
Lack of green areas						
None-some	1 (ref)		1 (ref)		1 (ref)	
A lot	0.09	-0.03 to 0.22	0.09	-0.04 to 0.21	0.07	-0.06 to 0.19
Street crime issues						
None-some	(ref)		(ref)		(ref)	
A lot	0.24	0.07 to 0.41	0.22	0.05 to 0.39	0.22	0.04 to 0.39
Specific Contextual Average Effects						
Deprivation index						
Q1 lower quintile					(ref)	
Q2					0.11	-0.03 to 0.25
Q3					0.20	0.05 to 0.34
Q4					0.29	0.14 to 0.43
Q5 upper quintile					0.35	0.20 to 0.50

* Unhealthy lifestyle index (0 best score, 15 worst score)
Multilevel linear regression models

Model 1: Sociodemographics (data not shown, see supplementary material)
Model 2: Sociodemographics + social support and perceived environment
Model 3: Sociodemographics + social support and perceived environment + random effects (census tracts)
Model 4: Sociodemographics + social support and perceived environment + deprivation index + random effects (census tracts)

Table 6. General contextual effects of the multilevel logistic and linear regression

	ICC		Variance		PCV	AUC Roc		AUC Roc Change
	%	95%CI		95% CI	%	%	95% CI	%
Multilevel logistic regression (co-occurrence of risk factors)								
Model 1	-	-	-	-		64.0	63.2 to 64.8	-
Model 2	-	-	-	-		64.1	63.3 to 64.9	+0.1
Model 3	5.8	4.6 to 7.2	0.202	0.153 to 0.250	-	71.6	70.9 to 72.4	+7.5
Model 4	5.6	4.5 to 7.1	0.196	0.148 to 0.244	-3.0	71.6	70.9 to 72.4	0
Multilevel linear regression (unhealthy lifestyle index)								
Model 1	-	-	-	-	-	-	-	-
Model 2	-	-	-	-	-	-	-	-
Model 3	7.0	6.0 to 8.2	0.397	0.339 to 0.465	-	-	-	-
Model 4	6.9	5.9 to 8.0	0.384	0.328 to 0.453	-3.3	-	-	-

ICC: Intraclass correlation coefficient
PCV: Percent change of the variance of model 4 vs model 3
AUC Roc: Area under the curve
AUC Roc Change: Absolute change (%) of model 2 vs model 1; model 3 vs model 2; model 4 vs model 3

Model 1: Sociodemographic variables

Model 2: Sociodemographics + social support and perceived environment

Model 3: Sociodemographics + social support and perceived environment + random effects (census tracts)

Model 4: Sociodemographics + social support and perceived environment + deprivation index + random effects (census tracts)

Table 1S. Model 1. Associations between sociodemographic variables and co-occurrence of behavioral risk factors. Population aged 15 and older, Spain 2011-2012.

	Co-occurrence of 3-5 risk factors*		**Unhealthy lifestyle index****	
	OR	95%CI	β	95%CI
Sex				
Men	1 (ref)		(ref)	
Women	0.51	0.48 to 0.54	-0.98	-1.05 to -0.91
Age				
15-24	1 (ref)		(ref)	
25-34	2.08	1.81 to 2.40	0.79	0.63 to 0.94
35-44	2.25	1.97 to 2.57	0.67	0.52 to 0.81
45-54	2.73	2.39 to 3.13	0.88	0.73 to 1.03
55-64	2.05	1.78 to 2.36	0.39	0.23 to 0.54
65-74	1.46	1.26 to 1.70	-0.16	-0.32 to 0.00
≥75	1.42	1.22 to 1.66	-0.40	-0.57 to -0.23
Educational Level				
Primary or less	1 (ref)		(ref)	
Secondary 1st stage	0.87	0.80 to 0.95	-0.17	-0.27 to -0.06
Secondary 2nd stage	0.71	0.64 to 0.78	-0.51	-0.63 to -0.40
University	0.46	0.41 to 0.52	-1.07	-1.21 to -0.94
Household Income				
Low	1 (ref)		(ref)	
Medium	0.85	0.78 to 0.93	-0.25	-0.35 to -0.15
High	0.86	0.79 to 0.95	-0.39	-0.50 to -0.29
Not available	0.88	0.81 to 0.97	-0.35	-0.46 to -0.25
Municipality of residence				
Urban	1 (ref)		(ref)	
Rural	1.01	0.94 to 1.09	0.04	-0.05 to 0.12
Country of birth				
Spain	1 (ref)		(ref)	
Other	0.98	0.88 to 1.09	-0.06	-0.18 to 0.07

* Co-occurrence of 3-5 risk factors vs 0-1
** Unhealthy lifestyle index (0 best score, 15 worst score)