European Journal of Ageing (2020) 17:521–529
https://doi.org/10.1007/s10433-020-00560-z

ORIGINAL INVESTIGATION

Lifestyle factors and multimorbidity among older adults (ELSI-Brazil)

Marina Gabriela Nascimento de Almeida[1] · **Mary Anne Nascimento-Souza**[1] · **Maria Fernanda Lima-Costa**[1] · **Sérgio Viana Peixoto**[1,2]

Published online: 14 February 2020

Abstract
The objective of the study was to evaluate the association between unhealthy lifestyle factors (individual and combined) and multimorbidity stratified by sex, in a national sample representative of Brazilians aged 50 years or older. Data from the Brazilian Longitudinal Study of Aging (ELSI-Brazil) baseline, conducted in 2015–2016, were used. Multimorbidity was defined by the existence of two or more of the 19 chronic diseases. Four unhealthy lifestyle factors were considered: (1) at-risk alcohol consumption, (2) current or past smoking, (3) insufficient physical activity and (4) below-recommended consumption of fruits and vegetables. The association between unhealthy lifestyle factors, individual and combined, was assessed by logistic regression. Among the 7918 study participants, the prevalence of multimorbidity was 75.8% (95% CI 73.7–77.7) among women and 58.7% (95% CI 56.0–61.3) among men. Among women, none of the analyzed behaviors presented an independent and statistically significant association ($p < 0.05$) with multimorbidity. Among men, at-risk alcohol consumption was associated with lower odds of multimorbidity. On the other hand, current or past smoking and insufficient physical activity were associated with greater odds of this condition. In addition, the presence of three or four unhealthy lifestyle factors was associated with greater odds of multimorbidity among men. The results reinforce the need for interventions to promote healthy behaviors among older men with two or more chronic diseases. In addition, it is evident that the health services need to act in an attempt to modify unhealthy behaviors after medical diagnosis of chronic diseases to reduce the risk of future complications.

Keywords Ageing · Lifestyle · Risk factors · Chronic diseases · Multimorbidity

Introduction

Multimorbidity, defined as the simultaneous occurrence of two or more chronic diseases in the same individual (WHO 2016), is a health outcome with a high frequency in the world population and affects more than half the population of older adults (Fortin et al. 2012; Harrison et al. 2014). In Brazil, recent data from the Brazilian Longitudinal Study of Aging (ELSI-Brazil) showed that the prevalence of multimorbidity in the population aged 50 years or older was 67.8% (95% CI 65.6–69.9) (Nunes et al. 2018). Given this scenario, multimorbidity is an important public health problem due to its high prevalence, and its association with higher mortality risk, functional decline and low quality of life, in addition to the difficulty of adequate management by health services (Marengoni et al. 2011). Because of the cumulative effect of adverse factors throughout life, it is particularly important for older adults to adopt behaviors that minimize the risk of death and maximize their prospects for healthy aging (WHO 2002).

Thus, combating multimorbidity should not only consider the planning of effective interventions aimed at groups that already have multiple diseases, but also direct efforts for primary prevention. Public health programs that aim to prevent multimorbidity should consider health behaviors such as at-risk alcohol consumption, smoking, insufficient physical activity and low consumption of fruits and vegetables as important targets for prevention. Although the role of these behaviors has been extensively studied in relation to chronic

Responsible editor: Susanne Iwarsson

✉ Mary Anne Nascimento-Souza
maryannemoc@yahoo.com.br

[1] Instituto René Rachou, Fundação Oswaldo Cruz, Belo Horizonte, MG, Brazil

[2] Universidade Federal de Minas Gerais, Escola de Enfermagem, Belo Horizonte, MG, Brazil

disease prevention (Sasazuki et al. 2012; Kolb and Martin 2017), evidence of its association with multimorbidity in a population of older adults is inconsistent and controversial, especially when the analyses are stratified by sex (Fortin et al. 2014). In addition, little is known about the association between the concomitant presence of these behaviors in the same individual and multimorbidity (Fortin et al. 2014).

Studies on this topic were carried out in developed countries, and, to our knowledge, no study has evaluated this association in developing countries, such as Brazil. The rapid epidemiological and nutritional transition as well as the aging of the Brazilian population are challenging issues for developing countries, when compared to developed countries, due to existing socioeconomic differences (Prince et al. 2015; Bloom et al. 2015). In this context, in order to guarantee a better quality of life for older adults in Brazil, an effort is required for a comprehensive health assessment, which, in turn, demands an understanding of the occurrence and impact of multimorbidity, as well as its risk factors. The present study aimed to evaluate associations between unhealthy lifestyle factors (individual and combined) and multimorbidity among Brazilian men and women aged 50 years and older.

Methodology

Study sample

The present study used data from the Brazilian Longitudinal Study of Aging (ELSI-Brazil), a national household survey, whose baseline was conducted in the years 2015 and 2016. ELSI-Brazil aims to examine the social and biological determinants of aging and its consequences for the individual and society, and it was conducted by the *Fundação Oswaldo Cruz*—Minas Gerais. ELSI-Brazil was approved by the Research Ethics Committee of the *Fundação Oswaldo Cruz*, Minas Gerais (CAAE 34,649,814.3.0000.5091), and all interviewees signed the informed consent form to participate in the study. More details can be found on the research home page (http://elsi.cpqrr.fiocruz.br/) and in previous publication (Lima-Costa et al. 2018).

The ELSI-Brazil sampling plan was based on strata, considering the municipalities, census tracts and households. For smaller municipalities, the selection was made in three stages (municipality, census tract and household), and for larger municipalities, the selection was made in two stages (census tract and household). The sample size was estimated to 10,000 individuals (9412 participated) residing in 70 municipalities in different regions of the country. For the present study, participants who had complete information for all variables of interest were selected, resulting in a sample of 7918 older adults (84.12% of the participating older adults) with a mean age of 62.0 years (SD = 9.4).

Variables and collection procedures

The dependent variable of this study was multimorbidity, defined as the presence of two or more chronic diseases (WHO 2016). The conditions included were: cataract, glaucoma, diabetic retinopathy, macular degeneration, hypertension, diabetes, high cholesterol, heart problems (infarction, angina and heart failure), stroke, asthma, lung diseases (emphysema, chronic bronchitis or chronic obstructive pulmonary disease), arthritis or rheumatism, osteoporosis, spinal disorder, cancer, chronic renal failure, depression, Parkinson's and Alzheimer's disease (Nunes et al. 2018). The presence or absence of these diseases was assessed by answering the following question: "Has any doctor ever said that you have…," except for cataracts, glaucoma, diabetic retinopathy and macular degeneration, which were evaluated by an ophthalmologist.

The unhealthy lifestyle factors considered were: (1) at-risk alcohol consumption, (2) current or past smoking, (3) insufficient physical activity and (4) below-recommended consumption of fruits and vegetables. The variable at-risk alcohol consumption was constructed using the weekly consumption frequency and the amount of doses consumed using the cutoff points proposed by the National Institute on Alcohol Abuse and Alcoholism (NIAAA 2010). Ingestion of ≥ 7 doses/week for women and ≥ 14 doses/week for men was considered at-risk alcohol consumption. In addition, older adults who reported heavy drinking days (four or more doses/day for women and five or more doses/day for men in the last 30 days) were also considered as at-risk alcohol consumption. The current or past smoking variable was constructed from the individual's response to current or past use of any tobacco product, regardless of the amount consumed.

Insufficient physical activity was evaluated using the reduced version of the International Physical Activity Questionnaire, which was validated for Brazil (Matsudo et al. 2001). This instrument contained questions that evaluate the frequency (days per week) and duration (time per day) of the physical activities performed in the week before the interview, considering only those performed for at least 10 continuous minutes at a time, including: (1) walking (at home or at work; as transportation to go from one place to another; and for leisure, for pleasure or as exercise); (2) moderate activity (such as light cycling; swimming; dancing; light aerobics; amateur volleyball; lifting light weights; doing chores in the house, yard or garden, such as sweeping, vacuuming, gardening, etc.; but, not including walking); and (3) vigorous activities (such as running; aerobics; soccer; fast cycling; basketball; lifting

weights; doing heavy chores in the house, yard or garden, etc.). The information from this questionnaire was converted into total physical activity time, doubling the time spent doing vigorous activities. Individuals who did less than 150 min of physical activity per week were considered insufficiently active according to the recommendations of the World Health Organization (WHO 2010a). Consumption below the recommended level of fruits and vegetables was evaluated by asking questions about the weekly (number of days in the week) and daily (number of times per day) consumption frequency of fruits and vegetables, considering as inadequate the consumption of less than five daily servings in less than 5 days per week (WHO 2003). The sum of unhealthy behaviors was also considered, generating an explanatory variable that ranged from zero to four.

The selection of potential confounders was based on factors previously described as associated with unhealthy lifestyle factors and multimorbidity (Macinko et al. 2015; Peixoto et al. 2018; Nunes et al. 2018). The sociodemographic variables considered were: age (in years), schooling years (9 or more and 8 or less), self-reported skin color (white or nonwhite) and current marital status (married or unmarried), all data were collected by an interviewer using a questionnaire. In addition, individuals were classified as whether or not they were overweight using the body mass index (BMI) which was calculated by dividing weight by the square of height. Weight was measured with the aid of a portable electronic scale, and height, with the aid of portable vertical stadiometer, with the individual wearing light clothing and no shoes. The anthropometric measurements were obtained in duplicate, and the mean was used in the analyses. All anthropometric variables were measured according to techniques recommended in the literature (Brasil 2015). Overweight was defined as BMI $\geq$ 25 kg/m^2, according to the cutoff point proposed by the World Health Organization (WHO 1995).

Statistical analyses

The variables analyzed in the present study were compared between individuals with and without multimorbidity, for both sexes, using Pearson's Chi-square test with Rao–Scott correction (categorical variables) and linear regression *t* test (continuous variables). Stratification by sex was performed due to the differences between the health behaviors investigated (Macinko et al. 2015; Peixoto et al. 2018) and the prevalence of multimorbidity between men and women (Violan et al. 2014; Nunes et al. 2018). Logistic regression, adjusted and unadjusted for potential confounding variables, was used to examine the association between unhealthy lifestyle factors and multimorbidity, resulting in odds ratio (OR) estimates and the corresponding 95% confidence intervals. In the association analyses between the number of unhealthy lifestyle factors and multimorbidity, these were categorized as 0–1, 2 or 3–4, due to the reduced number of individuals presenting zero or four unhealthy lifestyle factors. All estimates were performed using the svy procedure in Stata® software version 13.0 (StataCorp LLC, College Station, TX), considering the individuals' weights and the complex sample design.

Results

The mean number of chronic conditions was 2.6 (SD = 1.9), and the multimorbidity prevalence was 67.8% (95% CI 65.5–70.0); it was higher among women (75.8%, 95% CI 73.7–77.7) than among men (58.7%, 95% CI 56.0–61.3) ($p < 0.001$). Table 1 shows the sociodemographic characteristics, overweight and lifestyle factors according to the presence of multimorbidity, stratified by sex. Women with multimorbidity were older, less educated, unmarried and overweight. Regarding unhealthy lifestyle factors, it was found that women with multimorbidity presented a lower proportion of at-risk alcohol consumption when compared to those without multimorbidity. Men with multimorbidity were older, less educated, married and overweight; in addition, they had lower at-risk consumption of alcohol, were current or past smokers and were insufficiently active.

Table 2 shows the results of the univariate and multivariable analyses between unhealthy lifestyle factors and multimorbidity, for men and women. Among women, before or after adjustments for potential confounding variables, none of the unhealthy lifestyle factors had a statistically significant association with multimorbidity. Among men, alcohol consumption was associated with lower odds of multimorbidity (adjusted OR = 0.77, 95% CI 0.63–0.96). On the other hand, current or past smoking (adjusted OR = 1.31, 95% CI 1.12–1.54) and insufficient physical activity (adjusted OR = 1.27, 95% CI 1.07–1.51) were associated with greater odds of this condition.

Table 3 shows the results of the univariate and multivariable analyses between the number of unhealthy lifestyle factors and multimorbidity, for women and men. Among women, there were no statistically significant associations between the number of these behaviors and the outcome, neither in the univariate analyses nor in the adjusted analyses. In contrast, among men the presence of three or four unhealthy lifestyle factors was associated with greater odds of multimorbidity, both in the univariate analyses (OR = 1.20, 95% CI 1.01–1.44) and in the adjusted analyses (OR = 1.21, 95% CI 1.01–1.46).

Table 1 Sociodemographic characteristics, overweight and lifestyle factors, for men and women, according to the presence of multimorbidity

Variables	Women			Men		
	Multimorbidity[a]			Multimorbidity[a]		
	No	Yes	*p* value	No	Yes	*p* value
Age (mean, standard deviation)	59.34 (8.73)	63.35 (10.04)	< 0.001	59.36 (7.98)	63.05 (9.16)	< 0.001
Schooling years			< 0.001			< 0.001
9 or more	42.12	34.63		43.65	36.09	
8 or less	57.88	65.37		56.35	63.91	
Self-reported skin color			0.930			0.418
White	42.84	43.05		41.98	43.72	
Nonwhite	57.16	56.95		58.02	56.28	
Current marital status			0.011			0.048
Married	59.42	53.93		74.82	78.11	
Unmarried	40.58	46.07		25.18	21.89	
Overweight[b]			< 0.001			< 0.001
No	33.48	26.15		37.41	30.86	
Yes	66.52	73.85		62.59	69.14	
At-risk alcohol consumption[c]			0.045			< 0.001
No	92.85	95.16		77.62	84.52	
Yes	7.15	4.84		22.38	15.48	
Current or past smoking			0.781			< 0.001
No	55.14	55.66		38.83	31.68	
Yes	44.86	44.34		61.17	68.32	
Insufficient physical activity[d]			0.207			< 0.001
No	70.60	66.98		73.84	66.71	
Yes	29.40	33.02		26.16	33.29	
Below-recommended consumption of fruits and vegetables[e]			0.331			0.186
No	17.37	19.20		11.26	13.79	
Yes	82.63	80.80		88.74	86.21	

Brazilian longitudinal study of aging (ELSI-Brazil) 2015–2016

Values expressed as a percentage, unless otherwise specified

p value: Pearson's test with Rao–Scott correction or linear regression *t* test

[a]Two or more of the 19 chronic diseases

[b]Body mass index ≥ 25 kg/m^2

[c] ≥ 7 doses/week for women and ≥ 14 doses/week for men or 4 or more doses/day for women and 5 or more doses/day for men in the last 30 days

[d]Less than 150 min/week, including walking and moderate or vigorous activities

[e]Consumption of less than five servings per day in less than five days per week

Discussion

Our analyses, based on a representative sample of the Brazilian population aged 50 years and older, show that there are statistically significant associations between at-risk alcohol consumption, current or past smoking and insufficient practice of physical activity and multimorbidity among men, even after adjustment for a wide range of confounding variables. Among women, on the other hand, there were no significant associations between these behaviors and the presence of multimorbidity. These results contribute to improve knowledge about the association between lifestyle variables and multimorbidity, considering the heterogeneity of findings reported so far. In addition, they demonstrate that this diversity of results, especially when the analysis is stratified by sex, is also observed in a developing country, with a significant population of older adults.

The prevalence of multimorbidity in the population of older Brazilian adults was similar to that observed in population-based studies conducted in developed countries (Fortin et al. 2012). The higher prevalence of multimorbidity among women has already been verified by other studies (Violan et al. 2014) and may be due to the greater use of health

Table 2 Results of the univariate and multivariable analyses between unhealthy lifestyle factors and multimorbidity, for men and women

Unhealthy lifestyle factors	Multimorbidity—OR (95% CI)			
	Women		Men	
	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model
At-risk alcohol consumption[a]				
No	1.00	1.00	1.00	1.00
Yes	0.66 (0.44–0.99)	0.83 (0.54–1.26)	0.64 (0.52–0.77)	0.77 (0.63–0.96)
Current or past smoking				
No	1.00	1.00	1.00	1.00
Yes	0.98 (0.85–1.13)	1.08 (0.92–1.26)	1.37 (1.17–1.60)	1.31 (1.12–1.54)
Insufficient physical activity[b]				
No	1.00	1.00	1.00	1.00
Yes	1.18 (0.91–1.54)	1.00 (0.77–1.29)	1.41 (1.19–1.66)	1.27 (1.07–1.51)
Below-recommended consumption of fruits and vegetable[c]				
No	1.00	1.00	1.00	1.00
Yes	0.88 (0.69–1.13)	0.92 (0.71–1.18)	0.79 (0.56–1.12)	0.84 (0.59–1.21)

Brazilian longitudinal study of aging (ELSI-Brazil) 2015–2016

OR (95% CI): Odds ratio and 95% confidence interval estimated by logistic regression

Adjusted for the variables listed in the table, as well as age, schooling years, self-reported skin color, current marital status and overweight, as described in Table 1

[a] ≥ 7 doses/week for women and ≥ 14 doses/week for men or 4 or more doses/day for women and 5 or more doses/day for men in the last 30 days

[b] Less than 150 min/week, including walking and moderate or vigorous activities

[c] Consumption of less than five servings per day in less than five days per week

Table 3 Results of the univariate and multivariable analyses between the number of unhealthy lifestyle factors and multimorbidity and prevalence of the number of unhealthy lifestyle factors, for men and women

Number of unhealthy lifestyle factors*	Multimorbidity					
	Women			Men		
	Prevalence of the number of unhealthy lifestyle factors (IC 95%)	OR (IC 95%)		Prevalence of the number of unhealthy lifestyle factors (IC 95%)	OR (IC 95%)	
		Unadjusted model	Adjusted model		Unadjusted model	Adjusted model
0–1	43.9 (40.7–47.1)	1.00	1.00	26.3 (24.0–28.8)	1.00	1.00
2	40.5 (38.1–42.9)	1.11 (0.93–1.33)	1.09 (0.90–1.31)	45.6 (43.4–47.9)	1.15 (0.94–1.40)	1.11 (0.90–1.37)
3–4	15.6 (13.9–17.5)	0.97 (0.76–1.25)	0.99 (0.78–1.27)	28.0 (26.0–30.2)	1.20 (1.01–1.44)	1.21 (1.01–1.46)

Brazilian longitudinal study of aging (ELSI-Brazil) 2015–2016

OR (IC 95%): Odds ratio and 95% confidence interval estimated by logistic regression

*At-risk alcohol consumption, current or past smoking, insufficient physical activity, below-recommended consumption of fruits and vegetables. Adjusted for age, schooling years, self-reported skin color, current marital status and overweight, as described in Table 1

services by this group, which would increase the chance of receiving a medical diagnosis of chronic diseases (Mendoza-Sassi and Béria 2001). Another explanation for this result would be related to survival bias, since men have a shorter life expectancy than women, those who survive would have a better health condition (Salomon et al. 2012).

Alcohol consumption has been recognized as a risk factor for many chronic diseases and conditions (Shield et al. 2013); however, few studies have evaluated the relationship between alcohol consumption and multimorbidity, especially among older adults (Fortin et al. 2014; Dhalwani et al. 2017). Two studies conducted in similar populations did not find an association between alcohol consumption and multimorbidity in either of the sexes (Fortin et al. 2014) or for the total study population (Dhalwani et al. 2017). However, the cutoff points used to classify alcohol consumption as well as the concept of multimorbidity diverged between the studies, which may have led to discrepancies between the results.

In the present analyses, the lower odds of multimorbidity among men who had higher alcohol consumption could be explained by the reverse causality bias, that is, having more chronic diseases could lead them to consume less alcohol. Although it is not possible to define the temporality of this association due to the cross-sectional nature of this study, our results are in line with other authors who reported a possible reduction or interruption of alcohol consumption in the presence of chronic diseases (Molander et al. 2010).

Higher odds of multimorbidity found only among smokers (current or former) are in line with the results of a Canadian study conducted with individuals aged over 45 years (Fortin et al. 2014). As some studies have indicated that the diagnosis of certain chronic diseases could increase the probability of smoking cessation (Gulliford 2001; Patel et al. 2009), we evaluated smoking in three categories (non-smoker, former smokers and smokers). We verified that there was no association between current smoking and multimorbidity (former smokers OR = 1.46, 95% CI 1.2–1.76; current smokers OR = 1.05, 95% CI 0.85–1.30) in consonance with results of a cohort study carried out with the English population of older adults (Dhalwani et al. 2017). This result may suggest cessation of the behavior due to the presence of some diseases, although temporality cannot be confirmed. Despite conflicting results, and the few studies that have evaluated the relationship between smoking and multimorbidity, tobacco use has been considered a behavioral risk factor for many isolated chronic diseases, including cardiovascular diseases, diabetes and inflammatory diseases (Erhardt 2009; Wu et al. 2015). Therefore, effective interventions to reduce the prevalence of chronic diseases should consider smoking control as a priority (Beaglehole et al. 2011). In this sense, in recent years, Brazil has adopted several regulations aimed at combating smoking, but recent data still show some deficiencies, especially in the illicit cigarette trade (Portes et al. 2018).

The lack of association between at-risk alcohol consumption and current or former smoking and multimorbidity among women could be due to a greater use of health services (Mendoza-Sassi and Béria 2001), which would allow greater access to information and lower prevalence of unhealthy lifestyle factors. In this study, we verified that the number of medical consultations in the last 12 months was statistically higher for women than for men (4.2 SD = 5.8; 3.2 SD = 5.1, respectively), which reinforces the results presented above. Our results also showed that, regardless of multimorbidity, women presented a lower percentage of at-risk alcohol consumption and current and former smoking compared to men, in line with other studies (Peixoto et al. 2006; Noronha et al. 2019). These results may reflect real differences in the distribution of these factors between sexes, but are probably due to historical and sociocultural issues that influenced the behavior of women regarding the use of alcohol, tobacco and health services (Mendoza-Sassi and Béria 2001; Wolle et al. 2011). This fact would justify a lower prevalence of these behaviors compared to men and also the absence of association verified by our study, which would be due to the greater homogeneity of these behaviors among women with and without multimorbidity.

Physical activity is recommended as one of the main lifestyle changes for the prevention and management of multiple chronic diseases worldwide (WHO 2010b). However, the association between physical activity and multimorbidity has not been extensively studied, and the existing scientific evidence remains inconclusive. The association between insufficient physical activity and multimorbidity observed only among men participating in ELSI-Brazil is in agreement with other studies that evaluated older adults (Autenrieth et al. 2013; Cimarras-Otal et al. 2014). However, it diverges from the results of a study conducted with a representative sample of the English population over 50 years of age which found association for both sexes (Dhalwani et al. 2016, 2017) and a Canadian study that found no statistically significant association between physical activity and multimorbidity in men and women (Fortin et al. 2014). The different methods used to evaluate physical activity and the different classifications used to define insufficient physical activity may explain the discrepant results between these studies. Despite the differences between studies, our results show a persistence of insufficient physical activity even among those who reported having two or more chronic diseases, which should be considered in the organization and management of health services.

The evidence related to the role of food, especially fruits and vegetables, to prevent isolated chronic diseases has been demonstrated (Boeing et al. 2012); however, few studies have evaluated its association with multimorbidity (Ruel et al. 2013; Fortin et al. 2014; Dhalwani et al. 2017). The lack of association between below-recommended intake of fruits and vegetables and multimorbidity found in this study was confirmed by a study conducted with older Canadian adults (Fortin et al. 2014) but differs from other populations (Ruel et al. 2013; Dhalwani et al. 2017). An English longitudinal study found a 65.0% increase in the risk of multimorbidity associated with inadequate intake of fruits and vegetables in women and a 40.0% reduction in the risk of multimorbidity in men. However, the authors reported a potential measurement error related to food consumption data, which could explain the paradoxical reduction in the risk of multimorbidity in men (Ruel et al. 2013; Dhalwani et al. 2017). Recent analyses using data from the Jiangsu Longitudinal Nutrition Study reported a beneficial effect of consuming larger amounts of fruits and vegetables to avoid the development of multimorbidity in a Chinese cohort of adults and older adults (Ruel et al. 2013). Given the inherent

limitations in the evaluation of dietary intake, methodological differences in the measurement of fruit and vegetable intake and the cutoff points established for inappropriate consumption in these studies, more research needs to be conducted, seeking to elucidate the relationship between these foods and the presence of multimorbidity.

In spite of the discrepancies between the studies cited above and the association between consumption of fruits and vegetables and multimorbidity, it can be observed that men and women participating in the ELSI-Brazil had a high percentage (> 80.0%) of consumption below the recommended level for these foods. A study that evaluated the temporal trend of recommended consumption of fruits and vegetables among adults and older adults in the Brazilian capitals and the Federal District, from 2008 to 2016, showed that there was an increase in the percentage of recommended consumption of these foods for the age group of 55–64 years, but not among those aged 65 or older. In addition, more than 70.0% of the older adults remained below the recommended intake for these foods in the evaluated period (Silva and Claro 2019). Despite the efforts of the Brazilian government to confront non-communicable diseases and their risk factors (Malta et al. 2011), we verified that a relevant percentage of the population of older adults did not reach the recommended consumption of fruits and vegetables evidencing the need to promote and incentivize the consumption of these foods in this population.

Our study showed that the presence of three or four unhealthy lifestyle factors among older men led to higher odds of multimorbidity when compared to those without any of these behaviors, which is in line with the results of international studies conducted with similar populations (Fortin et al. 2014; Dhalwani et al. 2017). Corroborating these findings, previous studies have reported that the accumulation of healthy lifestyle factors has shown to be protective against mortality and multimorbidity (Matheson et al. 2012; Sasazuki et al. 2012), demonstrating that investment in prevention is one of the best ways to counter the growing prevalence of multimorbidity. In this sense, more government efforts are needed to prevent and manage the risk factors present in the older adult population, which includes nationwide health promotion campaigns, emphasizing the importance of a lifestyle suitable for healthy aging.

The main limitation of the present study is its cross-sectional design, which makes it impossible to establish a temporal relationship between the variables and impairs the understanding of the direction of some associations. Thus, further research is necessary, especially longitudinal analyses that seek to understand the temporal relationship between lifestyle factors and multimorbidity. The explanatory variables in this study were self-reported and are therefore susceptible to measurement errors (Silsbury et al. 2015). For physical activity, seeking to reduce misclassification, we used the IPAQ, an instrument that was validated for the Brazilian population and that evaluates the activities performed in all domains. Regarding the measurement of multimorbidity, the lack of standardization of the concept and operationalization of this construct, as well as definitions and cutoff points for evaluation of unhealthy lifestyle factors, made it difficult to compare the results. Future standardization of these variables will allow better comparability between studies conducted with different populations, as well as a better evaluation of the consistency of the results. Despite these limitations, this study was based on a large national sample of older adults, in addition to being conducted using standard procedures and trained technicians to collect information, which ensured its high internal validity.

Conclusion

The present study found associations between unhealthy lifestyle factors and multimorbidity in older men, and higher odds of multimorbidity in those with a greater number of risk behaviors. Given the cross-sectional nature of the study and the possibility of reverse causality, an interruption of smoking and alcohol consumption can be assumed in the presence of multimorbidity, but longitudinal studies are necessary to confirm this hypothesis. These results reinforce the need for interventions to promote healthy behaviors among older men with two or more chronic diseases. In addition, it is evident that the health services need to act in an attempt to modify unhealthy behaviors after medical diagnosis of chronic diseases to reduce the risk of future complications. This does not seem to be happening, at least regarding physical activity, given the results presented for the male population.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Ethical approval Brazilian Longitudinal Study of Aging was approved by Research Ethics Committee of the *Fundação Oswaldo Cruz*, Minas Gerais (Process No 34649814.3.0000.5091) (in Portuguese, Comitê de Ética em Pesquisa). The participants signed a consent form.

References

Autenrieth CS, Kirchberger I, Heier M, Zimmermann AK, Peters A, Doring A, Thorand B (2013) Physical activity is inversely associated with multimorbidity in elderly men: results from the

KORA-Age Augsburg study. Prev Med 57(1):17–19. https://doi.org/10.1016/j.ypmed.2013.02.014

Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, Baugh V, Bekedam H, Billo N, Casswell S et al (2011) Priority actions for the non-communicable disease crisis. Lancet 377(9775):1438–1447. https://doi.org/10.1016/S0140-6736(11)60393-0

Bloom DE, Chatterji S, Kowal P, Lloyd-Sherlock P, McKee M, Rechel B, Rosenberg L, Smith JP (2015) Macroeconomic implications of population ageing and selected policy responses. Lancet 385(9968):649–657. https://doi.org/10.1016/S0140-6736(14)61464-1

Boeing H, Bechthold A, Bub A, Ellinger S, Haller D, Kroke A, Leschik-Bonnet E, Müller MJ, Oberritter H, Schulze M, Stehle P, Watzl B (2012) Critical review: vegetables and fruit in the prevention of chronic diseases. Eur J Nutr 51(6):637–663. https://doi.org/10.1007/s00394-012-0380-y

Brasil (2015) Fiocruz - Fundação Oswaldo Cruz Manual de Entrevista Estudo Longitudinal da Saúde dos Idosos Brasileiros (ELSI-Brasil). http://elsi.cpqrr.fiocruz.br. Accessed 01 June 2019

Cimarras-Otal C, Calderón-Larrañaga A, Poblador-Plou B, González-Rubio F, Gimeno-Feliu LA, Arjol-Serrano JL, Prados-Torres A (2014) Association between physical activity, multimorbidity, self-rated health and functional limitation in the Spanish population. BMC Public Health 14:1170. https://doi.org/10.1186/1471-2458-14-1170

Dhalwani NN, O'Donovan G, Zaccardi F, Hamer M, Yates T, Davies M, Khunti K (2016) Long terms trends of multimorbidity and association with physical activity in older English population. Int J Behav Nutr Phys Act 13:8. https://doi.org/10.1186/s12966-016-0330-9

Dhalwani NN, Zaccardi F, O'Donovan G, Carter P, Hamer M, Yates T, Davies M, Khunti K (2017) Association between lifestyle factors and the incidence of multimorbidity in an older English population. J Gerontol A Biol Sci Med Sci 72(4):528–534. https://doi.org/10.1093/gerona/glw146

Erhardt L (2009) Cigarette smoking: an undertreated risk factor for cardiovascular disease. Atherosclerosis 205(1):23–32. https://doi.org/10.1016/j.atherosclerosis.2009.01.007

Fortin M, Stewart M, Poitras ME, Almirall J, Maddocks H (2012) A systematic review of prevalence studies on multimorbidity: toward a more uniform methodology. Ann Fam Med 10(2):142–151. https://doi.org/10.1370/afm.1337

Fortin M, Haggerty J, Almirall J, Bouhali T, Sasseville M, Lemieux M (2014) Lifestyle factors and multimorbidity: a cross sectional study. BMC Public Health 14:686. https://doi.org/10.1186/1471-2458-14-686

Gulliford MC (2001) Low rates of detection and treatment of hypertension among current cigarette smokers. J Hum Hypertens 15(11):771–773

Harrison C, Britt H, Miller G, Henderson J (2014) Examining different measures of multimorbidity, using a large prospective cross-sectional study in Australian general practice. BMJ Open 4(7):e004694. https://doi.org/10.1136/bmjopen-2013-004694

Kolb H, Martin S (2017) Environmental/lifestyle factors in the pathogenesis and prevention of type 2 diabetes. BMC Med 15(1):131. https://doi.org/10.1186/s12916-017-0901-x

Lima-Costa MF, de Andrade FB, de Souza PRB, Jr NeriAL, Duarte YAO, Castro-Costa E, de Oliveira C (2018) The Brazilian longitudinal study of aging (ELSI-Brazil): objectives and design. Am J Epidemiol 187(7):1345–1353. https://doi.org/10.1093/aje/kwx387

Macinko J, Mullachery P, Silver D, Jimenez G, Neto OLM (2015) Patterns of alcohol consumption and related behaviors in Brazil: evidence from the 2013 National Health Survey (PNS 2013). PLoS ONE 10(7):e0134153. https://doi.org/10.1371/journal.pone.0134153

Malta DC, Neto OLM, Junior JBS (2011) Presentation of the strategic action plan for coping with chronic diseases in Brazil from 2011 to 2022. Epidemiol Serv Saúde 20(4):425–438. https://doi.org/10.5123/s1679-49742011000400002

Marengoni A, Angleman S, Melis R, Mangialasche F, Karp A, Garmen A, Meinow B, Fratiglioni L (2011) Aging with multimorbidity: a systematic review of the literature. Ageing Res Ver 10(4):430–439. https://doi.org/10.1016/j.arr.2011.03.003

Matheson EM, King DE, Everett CJ (2012) Healthy lifestyle habits and mortality in overweight and obese individuals. J Am Board Fam Med 25(1):9–15. https://doi.org/10.3122/jabfm.2012.01.110164

Matsudo S, Araújo T, Matsudo V, Andrade D, Andrade E, Oliveira LC, Braggion G (2001) International physical activity questionnaire (IPAQ): study of validity and reliability in Brazil. Rev Bras Ativ Fis Saude 6(2):5–18. https://doi.org/10.12820/rbafs.v.6n2p5-18

Mendoza-Sassi R, Béria JU (2001) Health services utilization: a systematic review of related factors. Cad Saude Publica 17(4):819–832. https://doi.org/10.1590/S0102-311X2001000400016

Molander RC, Yonker JA, Krahn DD (2010) Age-related changes in drinking patterns from mid- to older age: results from the Wisconsin longitudinal study. Alcohol Clin Exp Res 34(7):1182–1192. https://doi.org/10.1111/j.1530-0277.2010.01195.x

National Institute on Alcohol Abuse and Alcoholism (NIAAA) (2010) Rethinking drinking: alcohol and your health. National Institutes of Health. http://pubs.niaaa.nih.gov/publications/RethinkingDrinking/Rethinking_Drinking.pdf. Accessed 05 June 2019

Noronha BP, Nascimento-Souza MA, Costa MF, Peixoto SV (2019) Alcohol consumption patterns and associated factors among elderly Brazilians: National Health Survey (2013). Cien Saude Colet 24(11):4171–4180. https://doi.org/10.1590/1413-812320182411.32652017

Nunes BP, Batista SRR, Andrade FB, Souza PRB, Lima-Costa MF, Facchini LA (2018) Multimorbidade em indivíduos com 50 anos ou mais de idade: ELSI-Brasil. Saúde Pública 52(2):10S. https://doi.org/10.11606/s1518-8787.2018052000637

Patel K, Schlundt D, Larson C, Wang H, Brown A, Hargreaves M (2009) Chronic illness and smoking cessation. Nicotine Tob Res 11(8):933–939. https://doi.org/10.1093/ntr/ntp088

Peixoto SV, Firmo JOA, Lima-Costa MF (2006) Health conditions and smoking among older adults in two communities in Brazil (The Bambuí and Belo Horizonte Health Surveys). Cad Saúde Pública 22(9):1925–1934. https://doi.org/10.1590/S0102-311X2006000900024

Peixoto SV, Mambrini JVM, Firmo JOA, Loyola Filho AI, Souza Junior PRB, Andrade FB, Lima-Costa MF (2018) Physical activity practice among older adults: results of the ELSI-Brazil. Rev Saude Publica 52(2):5s. https://doi.org/10.11606/S1518-8787.2018052000605

Portes LH, Machado CV, Turci SRB, Figueiredo VC, Cavalcante TM, Silva VLDCE (2018) Tobacco control policies in Brazil: a 30-year assessment. Cien Saude Colet 23(6):1837–1848. https://doi.org/10.1590/1413-81232018236.05202018

Prince MJ, Wu F, Guo Y, Gutierrez Robledo LM, O'Donnell M, Sullivan R, Yusuf S (2015) The burden of disease in older people and implications for health policy and practice. Lancet 385(9967):549–562. https://doi.org/10.1016/S0140-6736(14)61347-7

Ruel G, Shi Z, Zhen S, Zuo H, Kroger E, Sirois C, Levesque JF, Taylor AW (2013) Association between nutrition and the evolution

of multimorbidity: the importance of fruits and vegetables and whole grain products. Clin Nutr 33(3):513–520. https://doi.org/10.1016/j.clnu.2013.07.009

Salomon JA, Wang H, Freeman MK, Vos T, Flaxman AD, Lopez AD, Murray CJ (2012) Healthy life expectancy for 187 countries 1990–2010: a systematic analysis for the Global Burden Disease Study 2010. Lancet 380(9859):2144–2162. https://doi.org/10.1016/S0140-6736(12)61690-0

Sasazuki S, Inoue M, Iwasaki M, Sawada N, Shimazu T, Yamaji T, Tsugane S (2012) Combined impact of five lifestyle factors and subsequent risk of cancer: the Japan Public Health Center Study. Prev Med 54(2):112–116. https://doi.org/10.1016/j.ypmed.2011.11.003

Shield KD, Parry C, Rehm J (2013) Chronic diseases and conditions related to alcohol use. Alcohol Res 35(2):155–173

Silsbury Z, Goldsmith R, Rushton A (2015) Systematic review of the measurement properties of self-report physical activity questionnaires in healthy adult populations. BMJ Open 5(9):e008430. https://doi.org/10.1136/bmjopen-2015-008430

Silva LES, Claro RM (2019) Time trends in the consumption of fruits and vegetables among adults in Brazilian state capitals and the Federal District 2008–2016. Cad Saúde Pública 35(5):00023618. https://doi.org/10.1590/0102-311x00023618

Violan C, Foguet-Boreu Q, Flores-Mateo G, Salisbury C, Blom J, Freitag M, Glynn L, Muth C, Valderas JM (2014) Prevalence, determinants and patterns of multimorbidity in primary care: a systematic review of observational studies. PLoS ONE 9(7):e102149. https://doi.org/10.1371/journal.pone.0102149.eCollection

Wolle CC, Sanches M, Zilberman ML, Caetano R, Zaleski M, Laranjeira RR et al (2011) Differences in drinking patterns between men and women in Brazil. Rev Bras Psiquiatr 33(4):367–373. https://doi.org/10.1590/S1516-44462011000400010

World Health Organization (1995) Physical status: the use and interpretation of anthropometry. In: Report of a WHO Expert Committee. WHO Technical Report Series 854. Geneva: World Health Organization 1995. https://www.who.int/childgrowth/publications/physical_status/en/. Accessed 20 June 2019

World Health Organization (2002) Reducing risks, promoting healthy. The world health report. https://apps.who.int/iris/bitstream/handle/10665/42510/WHR_2002.pdf?sequence=1. Accessed 28 June 2019

World Health Organization (2003) Diet, nutrition and the prevention of chronic diseases. In: Report of the joint WHO/FAO expert consultation WHO Technical Report Series, No. 916. https://apps.who.int/iris/bitstream/handle/10665/42665/WHO_TRS_916.pdf;jsessionid=4FCC71377A160E6E42B9F1996AA92FD7?sequence=1. Accessed 23 June 2019

World Health Organization (2010a) Global recommendations on physical activity for health.Switzerland: World Health Organization. https://www.who.int/dietphysicalactivity/global-PA-recs-2010.pdf. Accessed 23 June 2019

World Health Organization (2010b) Global status report on noncommunicable diseases. http://apps.who.int/nmh/publications/ncd_report_full_en.pdf. Accessed 23 June 2019

World Health Organization (2016) Multimorbidity. World Health. Organization. http://www.who.int/iris/handle/10665/252275. Accessed 23 June 2019

Wu F, Guo Y, Chatterji S, Zheng Y, Naidoo N, Jiang Y, Biritwum R, Yawson A, Minicuci N, Salinas-Rodriguez A (2015) Common risk factors for chronic non-communicable diseases among older adults in China, Ghana, Mexico, India, Russia and South Africa: the study on global ageing and adult health (SAGE) wave 1. BMC Public Health 15:88. https://doi.org/10.1186/s12889-015-1407-0