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An index of Brazilian frailty and its association with social factors

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ABSTRACT

Background: The Brazilian population is aging rapidly and it is necessary to establish tools to map the elderly population regarding its frailty, which is a common adverse condition during the aging process. The National Health Survey (PNS in Portuguese) data makes it possible.

Objective: This study aimed to construct a frailty index (FI) of the elderly Brazilian population using the PNS data, in order to compare it with the index of other population and to measure its association with social factors.

Method: A set of the PNS variables was selected to carry out the index, taking into account criteria identified in the literature. The FI score was categorized as: non-frail ($FI \geq 0.10$); vulnerable ($0.10 < FI \geq 0.21$); frail ($0.21 < FI \geq 0.45$); and most frail ($FI > 0.45$). A logistic regression model was adjusted to measure the association of the FI with some risk factors and social factors.

Results: The Brazilian FI, calculated with 26 variables, presented a mean score of 0.13 and the best was a gamma distribution. Of the individuals, 53.9% were non-frail, 30.1% vulnerable, 13.6% frail and 2.5% most frail. The variables that significantly distinguished each level of the frailty were: self-perceived health status; instrumental activities of daily living (IADL); and difficulty in hearing, seeing and concentrating. Additionally, socio-demographic and sedentary lifestyle were identified as risk factors.

Conclusion: The proposed index showed a similar distribution to the ones observed in the literature and it is associated with social factors. These findings are useful to guide the planning of the Brazilian health policy for the elderly population.

1. Introduction

The Brazilian population has been facing a rapid demographic transition in recent years. The elderly population (equal or superior to 65 year old) was 8% in 2000 and it is estimated that it will reach 19% in 2030 and 34% in 2060 (Instituto Brasileiro de Geografia e Estatística, 2013). This fast aging of the population, which is a consequence of the reduction in the fertility and mortality rates, as well as the dynamics of the migratory movements in the country (Ervatti et al., 2015) was followed by inequality in income distribution and access to services (Junior, 2009).

The chronological framework attributed to senescence (age between 60–65 years) does not clearly characterize a border at which an individual should be classified as elderly (Lourenço, 2008). Aging is dynamic and progressive, with morphological, functional, biochemical and psychological modifications that determine the loss of the individual's ability to adapt to the environment, causing greater vulnerability and greater incidence of pathological processes, and culminating in death (Fried et al., 2001; Lucicesare et al., 2010; Mitnitski, Mogilner, & Rockwood, 2001).

Vulnerability is due to diminished energy, physical, cognitive and functional reserves, and the reduction of resistance to stressors, provoked by internal and external factors accumulated throughout life, and can be reflected by a condition of frailty in elderly individuals. Frailty, in physical scope, is usually identified by means of Fried´s phenotype criteria (Fried et al., 2001). Although it is very useful for the early identification of frailty in clinical practice, it seems to be limited in the screening of large population groups, for which the parameters are difficult to obtain (Blodgett, Theou, Kirkland, Andreou, & Rockwood, 2015; Cesari, Gambassi, van Kan, & Vellas, 2014; Gale & Cooper, 2018; Lucicesare et al., 2010; Volkert et al., 2006). On the other hand, the FI aims to assess the health status of individuals by the proportion of accumulated deficits, considering frailty as a result of a process and not as a state (Mitnitski et al., 2001; Rockwood et al., 2005). For this reason, it is necessary to study it using an accumulative deficits approach.

In Brazil, Fried's phenotype criteria is more widely used than the

Abbreviations: IADL, instrumental activities of daily living; FI, frailty index; PNS, Pesquisa Nacional de Saúde

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accumulated deficits approach, which requires database surveys that characterize the elderly population. Although population-based surveys in Brazil exist, data about the characteristics of the elderly of the whole country is limited. This situation has the potential to change after the publication of the National Health Survey (Pesquisa Nacional de Saúde – PNS in Portuguese), nationwide and home-based which provides data about the health condition, access to health care services, and social and demographic data, as well as the functional capacity of the elderly individuals. This data can be useful to carry out a frailty index determination for the Brazilian population (Pesquisa Nacional de Saúde, 2018b).

In this way, this study aims to obtain a frailty index of the elderly Brazilian population using the PNS data. This index will allow the comparison of the frailty profile of the Brazilian population with others that have already had their profiles established, as well as to describe its association with social factors.

2. Method

The PNS survey questionnaire is divided in three parts. The first two were answered by a resident of a particular household and covered questions about the characteristics of that house and the socio-economic and health situation of all its residents. The third was an individual questionnaire that was answered by a resident aged 18 years or older who is selected among all the adult residents of the household and focused on morbidity and lifestyles (Pesquisa Nacional de Saúde, 2018a).

Data were analyzed from a subset of the individual questionnaire answered by adults of 60 years of age or older (Pesquisa Nacional de Saúde, 2018a). Some data about the household questionnaire was also included, in order to complete data about activities of daily living, psycho-behavioral factors, lifestyles, use of health services, self-perception of health, comorbidities and symptoms. These are considered as determinant factors for frailty due to their clinical and epidemiological relevance (Bortz, 2002; Freitas & Py, 2011; Lourenço, 2008; Mitnitski et al., 2001; Vermeiren et al., 2016; Volkert et al., 2006).

There was a need to preprocess some selected variables in order to aggregate others or to reduce their category number. According to Searle, Mitnitski, Gahbauer, Gill, and Rockwood, (2008), the variables chosen to compose the index should meet the following criteria: to have a minimum of variability (1%) and a maximum of variability (80%) among individuals of 80 old years or more, and to be associated with age. This association was measured by means of the ANOVA or t-Student test, depending on the number of categories of each variable. Any redundant variable was excluded.

In order to make the Brazilian frailty index comparable with an available one, the selected set of variables was matched to a set used to estimate a North American index (Blodgett et al., 2015), called the reference set. The variables common to both sets were selected for the calculation of the Brazilian frailty index. The database used for the construction of the FI may be available by the authors to whoever is interested in it.

According to Mitnitski et al. (2001), a frailty index (FI) is a proportion of deficits accumulated by an individual among the possible deficits, where the "0″ and "1″ codes are used for the dichotomous variables; the ordinal variables undergo scale transformation and their categories are valued by their position on a scale from 0 to 1. The index is the sum of the assumed values of all the variables with response from each individual divided by the total number of variables. The closer to zero the score, the more robust the individual is and, conversely, the closer the score is to 1, the higher the degree of frailty.

A descriptive statistic of the FI score was determined and the distribution of the values was adjusted, for purposes of comparison with other populations shown in the literature (Mitnitski et al., 2001). Fitting tests were performed for the FI score on the gamma, beta, normal and exponential probabilities distributions. In addition, the FI scores were categorized according to the cutoff points described by Hoover, Rotermann, Sanmartin, and Bernier, (2013). These cutoff points defined four frailty groups, which were: “non-frail” ($FI \geq 0.10$); “vulnerable” ($0.10 < FI \geq 0.21$); frail” ($0.21 < FI \geq 0.45$) and “most frail” ($FI > 0.45$).

In order to identify the variables that differentiate between the four frailty groups, the Z test of proportions with Bonferroni adjustment was used to identify the categories that distinguish each of the frailty groups (IBM Knowledge & Center, 2018).

Finally, a logistical regression model was employed to identify the association of the Brazilian FI with other factors. The Brazilian FI was dichotomized into the presence of frailty, represented by the “frail” and “”most frail” groups, and the absence of frailty, represented by “non-frail” and “vulnerable” groups. The model co-variables were those variables that met the selection criteria and were not used to estimate the Brazilian FI, as well as the socio-demographic variables. The odds ratios were calculated from the model coefficients and the accuracy of the model was optimized through the analysis of the area under the ROC curve (Hanley & McNeil, 1982). The analyses were performed using the statistical package R version 64 3.4.1.

3. Results

For this study, from a total of 205,546 survey respondents, 11,177 individuals met the inclusion criteria of the study. Fig. 1 schematizes the variable selection process. Out of 855 variables, 54 met all the inclusion criteria. From these, 26 variables were common to the reference set, of which 12 were related to daily living activities, three to health service use, 9 were related to comorbidities and symptoms, one to psycho-behavioral factors and one to self-perception of health (Supplement 1).

The frailty index presented a mean value of 0.13, ranging from 0.00 to 0.85. According to the statistics tests (Table 1), the FI best fit was a gamma distribution, whose parameters were: shape 1.21 and scale 9.63 (Fig. 2). Considering the thresholds of the four frailty groups, 53.86% of the individuals were classified as non-frail, 30.06% as vulnerable, 13.56% as frail and 2.51% as most frail.

All 26 variables distinguished at least one of the frailty groups. The variables that differentiated all of the four groups were all related to instrumental activities of daily living, “self-perceived health status” (Fig. 3a), “difficulty in concentrating at usual activities” (Fig. 3b), “heart disease”, “difficulty seeing” and “difficulty hearing”. The variables that distinguished "non-frail" and "vulnerable" groups from the others were all related to basic activities of daily living (Fig. 3c). The "frail" and "most frail" groups were distinguished from the others by “stroke” and “cancer” (Fig. 3d), “arthritis” and “hospitalization” (Fig. 3e). The "non-frail" group was distinguished from the others by the “occurrence of falls” (Fig. 3f), “visits to physicians” (Fig. 3g) and “indication for cataract surgery”. The “vulnerable” and “frail” groups were distinguished from each other by “diabetes” and “hypertension” (Fig. 3h). The details about this analysis can be seen in the Supplement.

The regression model showed statistical significance ($p < 0.05$) for

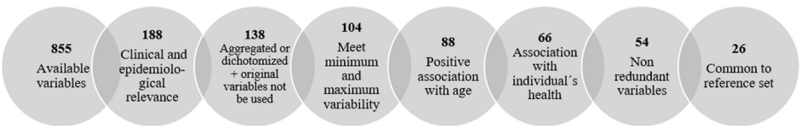

Fig. 1. Scheme of the variable selection process.

Table 1
Goodness-of-fit statistics of the FI tests.

Test	Gamma	Beta	Exponential	Normal
Kolmogorov-Smirnov	0.05	0.08	0.09	0.14
Cramer-von Mises	5.36	17.17	21.98	88.16
Anderson-Darling	Infinity	Infinity	Infinity	519.92

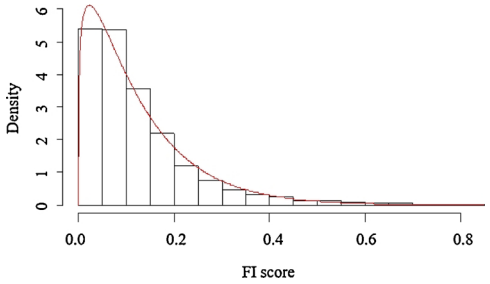

Fig. 2. Frailty index histogram and the corresponding adjusted Gamma curve.

11 out of 28 variables initially used. The odds ratios and the 95% confidence intervals of these variables are presented in Table 2.

For instance, an individual with medium difficulty of locomotion has a 7.09 times greater chance to be frail than one who has no difficulty of locomotion; to someone who has high difficulty, this chance increased by 13.56 times, and by 9.32 for the individuals who cannot move at all.

In order to optimize the accuracy of the model, a ROC curve was constructed and presented a sensitivity of 86.80% and a specificity of 82.70% for the cutoff point of 0.13. In this way, the area under the ROC curve was 0.93 (Fig. 4).

4. Discussion

This paper showed that it was possible to construct a frailty index using data from the PNS and the accumulative deficits approach (Blodgett et al., 2015; Mitnitski et al., 2001; Searle et al., 2008) to identify the profile and the determinants of frailty in the elderly Brazilian population.

The Frailty Index analysis showed that the Brazilian population presented a mean value of 0.13 and the best fitting for FI score was a gamma distribution, which is in line with the findings in the literature

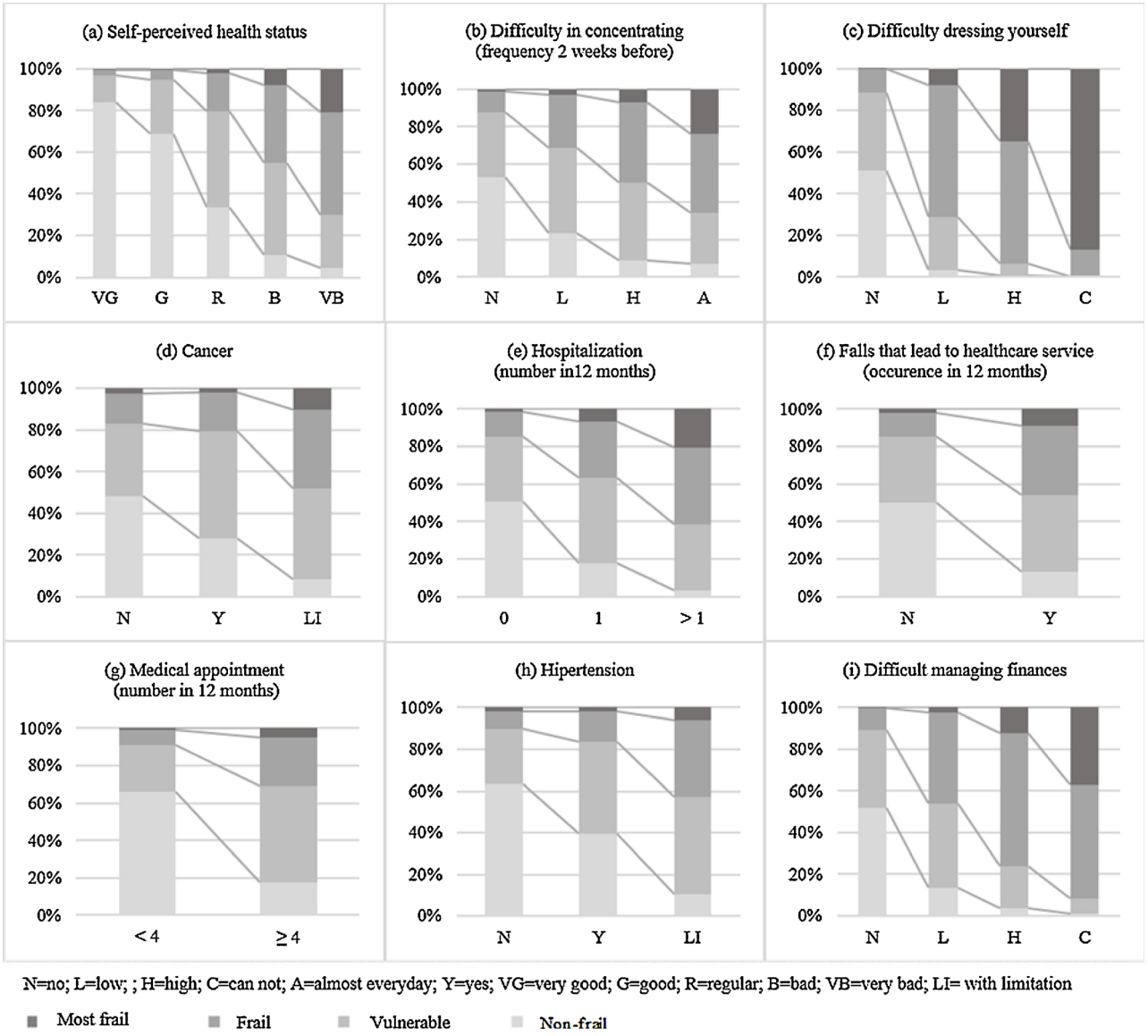

Fig. 3. Percentage distribution of some variables through the frailty groups.

Table 2
Relative frequency, odds ratios and the 95% confidence intervals of significant variables of the model.

Categories	RF (%)	OR		CI 95%		Categories	RF (%)	OR		CI 95%	
				BL	UL					BL	UL
Intercept		0.00	*	0.00	0.00	Slowness or agitation to move or speak:					
Age:						Less than half the days	9.20	1.72	*	1.37	2.14
70 to 79 years old	30.79	1.35	*	1.12	1.62	More than half the days	2.75	2.49	*	1.73	3.58
80 or more	13.40	2.63	*	2.10	3.29	Almost everyday	3.81	3.37	*	2.37	4.80
Education:						Physical activity levels:					
9 to 11 years	13.15	1.26		0.86	1.84	Some activity (until 150 minutes/week)	18.40	1.37	*	1.07	1.76
1 to 8 years	41.80	1.73	*	1.28	2.38						
No education	34.54	2.71	*	1.99	3.75	No physical activity	51.00	2.32	*	1.89	2.85
Marital status:						Emergency care at home	2.76	4.08	*	2.82	5.89
Widowed	30.65	1.54	*	1.29	1.85	Saphenous bypass/ stenting/angioplasty	2.77	8.61	*	6.26	11.85
Never married	16.20	1.1		0.86	1.40						
Separated/divorced	10.14	1.22		0.92	1.60	Physical deficiency	3.42	2.68	*	1.89	3.81
Region:						Cataract	36.91	2.57	*	2.19	3.02
North	15.05	0.88		0.68	1.15	High cholesterol	24.96	1.82	*	1.54	2.15
Northest	30.37	1.19		0.97	1.45	Locomotion difficult level:					
South	14.54	0.83		0.64	1.07	Low	12.01	3.48	*	2.87	4.21
Midwest	11.33	1.55	*	1.19	2.01	Medium	7.49	7.09	*	5.67	8.86
Lack of interest or pleasure in doing things (through previous 2 weeks):						High	4.24	13.56	*	9.94	18.62
						Cannot	2.16	9.32	*	6.01	14.44
Less than half the days	13.64	1.63	*	1.33	2.00	Any chronic disease:					
More than half the days	3.66	2.14	*	1.52	2.98	Yes, without limitation	20.00	1.32	*	1.07	1.63
Almost everyday	4.95	2.71	*	2.00	3.66	Yes, with limitation	18.46	3.84	*	3.22	4.58
						Failing to perform usual activities (yes or no) and / or being bedridden by health problems (yes or no):					
						Yes; No	7.31	1.85	*	1.46	2.04
						Yes; Yes	4.91	2.71	*	2.33	3.59

RF = Relative frequency; OR = Odds ratio; CI = Confidence interval; BL = Below limit; UL = Upper limit; (*) statistical significance ($p < 0.05$).

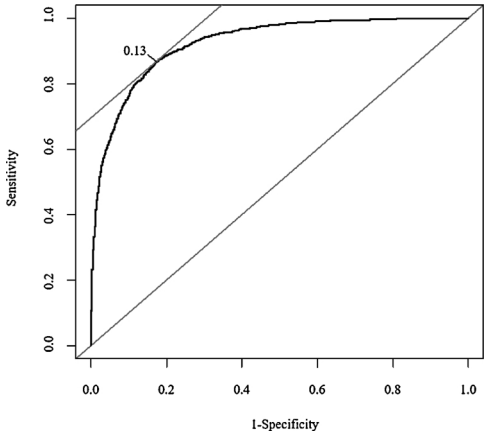

Fig. 4. The ROC curve from logistic regression model.

(Goggins, Woo, Sham, & Ho, 2005; Mitnitski et al., 2001; Searle et al., 2008).

The FI mean value observed in this study is similar to the ones observed in a rural Italian population (0.14) (Lucicesare et al., 2010) and an English population (0.15) (Gale & Cooper, 2018). Nevertheless, this mean was different from one obtained in the Canadian Study of Health and Aging (0.21), which is the source of the approach used to estimate the index (Mitnitski et al., 2001). The difference identified among the values of FI in these studies can be a result of differences in the studies populations, particularly with regard to the age profile. For instance, the studied Brazilian population has an average age of 70 years old, which is similar to the Italian (74.70 years old) and the English population (69.80 years old). In contrast, the Canadian population presented a higher average (82.00 years old) compared to the Brazilian, Italian and British ones.

As observed in the literature, there is no consensus regarding the age cutoff point to delimit the studies of the frailty of the elderly. However, a chronological delimitation is widely used, although the aging process is considered to be multifactorial and not a purely chronological boundary when defining it (Lourenço, 2008). This study considered a population of 60 years of age or above to characterize the Brazilian frailty profile, and also considered various other factors related to aging.

The prevalence of frailty in the Brazilian population was 16.1% among those over 60 years old, and it was estimated for the percentage of individuals in the "frail" and "most frail" groups. The international literature pointed out a prevalence of 11.9% for English elderly over 60 years of age after 4 years of follow-up (Gale & Cooper, 2018); 24.0% among those over 65 years of age in Canada (Hoover et al., 2013) and 34.0% among those over 50 years of age in the United States (Blodgett et al., 2015).

For Latin America countries, as described for Cesari et al. (2016), there are few studies that describe frailty and, from the best of our knowledge, no study was identified about the national prevalence of frailty in the elderly Brazilian population using a frailty index. Thus it is not possible to compare them with local or more regional populations. However, Neri et al. (2013), using Fried's phenotype criteria (Fried et al., 2001), identified an average prevalence of 9.0% of frailty in the elderly of seven Brazilian municipalities, ranging from 7.7% to 10.8%. The difference between the studies' results can be attributed to the different approach adopted to estimate the index (deficits accumulation versus Fried's phenotype criteria). Neither approach is considered to be a gold standard, but they are considered complementary (2016, Cesari et al., 2014). The better suited instrument will depend on the aim of each frailty investigation and the associated factors (Blodgett et al., 2015).

In this study, the factors that differentiated the presence of frailty from absence of frailty were the difficulty to perform basic activities of daily living, while the difficulty to perform instrumental activities of daily living distinguished the four groups among themselves. The relationship between frailty and difficulties to perform daily living activities has already been described in the literature. In a longitudinal study, Chamberlain et al. (2016) observed an increase in the prevalence of limitations for activities of daily living, accompanied by an increase

in the FI mean in 12,270 elderly people from 60 to 89 years of age. Likewise, a meta-analysis (Vermeiren et al., 2016) set up by prospective studies evaluating frailty and potential health outcomes included studies that identify frail individuals by different approaches (physical focus, multi-domain and deficits accumulation) and different follow-up periods. In relation to the increased risk of presenting difficulties to perform activities of daily living, Vermeiren et al. (2016) did not identify studies using the deficits accumulation approach. But for other approaches, this association was observed, which is in line with the results of this study. This suggest the importance of functional capacity maintenance to prevent frailty among the elderly.

The variables related to comorbidities and symptoms could distinguish the "vulnerable" group from the "non-frail" group, as well as the "self-perceived health status". In a systematic review, Mello, de, Engstrom, and Alves, (2014) identified eight studies that indicated a positive association between self-assessment of health and frailty – identified by Fried's phenotype criteria (Fried et al., 2001). This suggests that information about the perception by the elderly of their own health may be determinant for the identification of individuals more vulnerable to frailty.

It was observed that the initial stage of frailty ("vulnerable") could be identified by the hospitalization profile of the individuals, while the frailty itself can be identified by the occurrence of falls and a higher frequency of visits to physicians. The findings of Vermeiren et al. (2016) corroborate these, identifying that individuals in the frail and pre-frail stages present a higher risk of hospitalization and institutionalization compared with robust individuals. The association between hospitalization and frailty was also identified in a longitudinal study (Chamberlain et al., 2016) for age groups evaluated (60–69 years old, 70–79 and 80–89 years old).

In this way, it was possible to construct an FI for the Brazilian elderly population considering its peculiarities, which are still little explored. In this sense, this study modelled the association of frailty with other potential risk factors for frailty such as lifestyle, mobility and socio-demographic factors. A logistic regression model was applied and it identified the presence of frailty (FI above 0.21) associated with low physical activity as well as other social demographic factors.

According to the World Health Organization (2010), the practice of sufficient physical activity for the elderly should have a duration of 150 min per week of moderate activities for an individual to be considered active. In our model, individuals who practice less than 150 min of physical activity per week (intermediate level of physical activity) presented a 1.37 times greater chance of being frail in relation to active individuals, and the chance increases to 2.32 times between active and inactive individuals. The relationship between low physical activity and frailty has already been described in the literature. Fried et al. (2001) consider this parameter to be among the five determinants of the frailty phenotype. Xue, Bandeen-Roche, Varadhan, Zhou, and Fried, (2008), using Fried's phenotype criteria, observed that, among the five proposed items, physical activity is a marker of the early stage of frailty since it precedes factors such as weight loss and exhaustion that are markers of the advanced stage. While using other approaches, Hoogendijk, Heymans, Deeg, and Huisman, (2017) also identified low physical activity as a marker of frailty. This suggests the importance of the practice of physical activities as a protective factor, and that it should be considered in intervention actions to prevent frailty.

With regard to the socio-demographic factors, the identification of frailty was associated with individuals with less than 8 years of education, widows, and those residing in the Center-West region of Brazil. Our results were similar to a longitudinal study (Hoogendijk et al., 2017) that described a significant association between low education (equivalent to 8 years of study) with frailty in elderly men in the Netherlands, but not for women. In relation to marital status, our results are similar to a study of an American population (Blodgett et al., 2015), in which an increase of the proportion of widowed individuals in the frail groups was observed. Some studies (Chamberlain et al., 2016; Mello et al., 2014; Vermeiren et al., 2016) also use socio-demographic factors as adjustment variables of the models that aim to explain frailty in the elderly. In Brazil, these factors should be carefully analyzed, taking into account the social disparities and the social vulnerability of part of the population (Gale & Cooper, 2018; Hoogendijk et al., 2017; Vieira et al., 2013).

In this sense, future studies should be developed in order to incorporate into the Brazilian FI other factors that could reflect the specificities of the elderly Brazilian population. In addition, there is a need to have the proposed FI validated by experts in age, in order to test its value in clinical practice as a screening tool.

5. Conclusion

Considering frailty in the Brazilian population, the study identified that 16.1% were frail and 30.1% were vulnerable. The analysis also indicated that some parameters are important in distinguishing individuals with frailty. Evaluation of the difficulty to perform basic daily living activities is determinant in identifying individuals who are already affected, such as by strokes, cancer and arthritis, as well as hospitalization profiles. These parameters are important, therefore, in planning public policies for the care and health promotion of the elderly. In addition, annual use of health services (such as the occurrence of falls and the number of visits to physicians) pointed to some level of frailty, and can be a screening tool, to prevent the triggering of the frailty process. Such factors as difficulty in performing instrumental activities of daily living, as well as perceiving one´s own health status, and difficulty in hearing and seeing and concentrating, all permit the detection of frailty through its different levels, from vulnerable individuals to the most frail ones. These can be very useful in both approaches: the prevention of frailty and the promotion of health among the elderly. Therefore, the findings of this study could be used to improve the public health policies for the elderly in Brazil.

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Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.archger.2018.09.007.

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