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Rua São Francisco Xavier, 524 – 10º andar - bloco F - Maracanã

20 559-900 – Rio de Janeiro – RJ, Brasil

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Knowledge and attitudes regarding sexuality according to sociodemographic and economic characteristics of older adults

Regiane Lopes Takaoka¹ 

Lígia de Fátima Machado² 

Ana Paula Fernandes³ 

Pollyana Cristina dos Santos Ferreira^{2,3} 

Abstract

Objective: To evaluate the knowledge and attitudes of older adults regarding sexuality according to sociodemographic and economic factors. **Methods:** This quantitative, observational, cross-sectional study was conducted with 219 older adults in Uberaba, Minas Gerais, Brazil, through telephone contact between October 2020 and May 2021. Data were analyzed using statistical software. **Results:** Among all respondents, the mean age was 74.5 years, with a predominance of women; individuals who were married or living with a spouse or partner; those with incomplete primary education; Catholics; White individuals; and those with a household income below two minimum wages. Knowledge and attitudes regarding sexuality were associated with sex, marital status, and educational level. Male participants, those who were single, and those with higher levels of education demonstrated greater knowledge about sexuality. Regarding attitudes, women, widowed individuals, and those with lower educational levels exhibited a more conservative stance. **Conclusion:** The findings indicate that older adults' knowledge and attitudes regarding sexuality are associated with their sociodemographic characteristics. Healthcare professionals should be attentive to factors such as sex, marital status, and educational level, considering group differences related to sexuality. Health education initiatives and multidisciplinary, holistic approaches, free from stigma and prejudice, may contribute to the advancement of health policies directed at older adults, including the right to discuss the topic and experience sexuality with quality across different stages of life.

Keywords: Health of the Elderly. Sexuality. Sexual Health. Health Knowledge, Attitudes, Practice. Older Adults.

¹ Universidade Federal do Triângulo Mineiro, Curso de Medicina. Uberaba, MG, Brasil.

² Universidade Federal do Triângulo Mineiro, Pós-Graduação em Atenção à Saúde. Uberaba, MG, Brasil.

³ Universidade Federal do Triângulo Mineiro, Departamento de Saúde Coletiva. Uberaba, MG, Brasil.

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Correspondence
Pollyana Cristina dos Santos Ferreira
pollyana.ferreira@uftm.edu.br

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INTRODUCTION

Certain physiological changes that naturally occur with advancing age, such as weight changes, reduced skin elasticity, and slowed metabolism, are commonly associated with a negative connotation of old age within the social context¹.

Although sexuality in later life can promote well-being and improve quality of life, it is often viewed solely as an attribute associated with youth and fertility, which leads to the neglect of the sexual needs of older adults^{2,3}.

When addressing this complex and challenging topic, it is essential to deconstruct the prejudices and stereotypes surrounding expressions of sexuality, recognizing them as a human right regardless of age group³.

However, due to limited understanding of the physiological changes that occur during this stage of life, many older adults may withdraw from maintaining an active sexual life. The lack of understanding of these changes can result in misinterpretations regarding their capabilities⁴.

Moreover, beyond biological factors, psychological, cultural, and social elements may influence how older adults experience and perceive sexuality⁴. Understanding these determinants contributes to the development of health actions aimed at reducing the negative impacts related to sexuality and encouraging older adults to discuss the topic, thereby demystifying existing taboos⁴.

Conversely, limited knowledge about sexuality may lead to more negative attitudes and conservative views⁵.

From this perspective, studies assessing the knowledge and attitudes of older adults regarding sexuality have predominantly focused on sexually transmitted infections (STIs) and their impact on health^{5,6}. However, there is a scarcity of studies addressing sexuality while considering the sociodemographic and economic characteristics of older adults. These aspects are relevant because they may directly affect self-esteem, relationship quality, and sexual satisfaction⁷.

Therefore, addressing this gap in the scientific literature may provide insights into how older adults experience sexuality, contributing to a broader understanding within this group, society, and healthcare professionals regarding sexual aptitude and desire during this stage of development⁸. This will enable healthcare professionals to better equip themselves to meet the needs of this age group more comprehensively, rather than limiting their focus solely to biological changes⁹.

Thus, the present study aims to describe the sociodemographic and economic characteristics of the participants and to assess the knowledge and attitudes of older adults regarding sexuality according to sociodemographic and economic factors.

METHODS

This was a quantitative, observational, cross-sectional study. Data were collected in the urban area of Uberaba, Minas Gerais, Brazil, between October 2020 and May 2021.

The sample is part of a larger project titled “Survey on sexuality in older adults – ISI Project.” A preexisting list was used from the project “Active Aging, Global Functionality, and Quality of Life among Older Adults in the Uberaba (MG) Health Microregion,” conducted between May 2017 and June 2018, which provided contact information for 803 older adults who were able to answer telephone calls and respond to questions.

Individuals of both sexes aged 60 years or older were included in the study. In total, 219 older adults participated. The reasons for exclusions and losses were: 31 individuals had died; 45 were not in condition or were unable to respond by telephone due to illness, hearing impairment, or inability to verbalize; 98 chose not to participate; 195 could not be contacted due to phone number changes or invalid numbers; and 215 were not reached after at least six attempts made by interviewers on different days and at different times, even though the phone number existed and belonged to the individual.

Data were obtained through telephone contact conducted by 10 trained interviewers, and responses

were recorded directly on an online electronic form. After data collection, the information was transferred to an electronic spreadsheet. The questionnaire, which included sociodemographic and economic variables (sex, age, marital status, educational level, household income, number of individuals dependent on the income, race/ethnicity, and religion or belief), was developed by the researchers.

The Aging Sexual Knowledge and Attitudes Scale (ASKAS) is an instrument designed to better understand how older adults perceive and experience sexuality based on physiological and sociopsychological aspects. It contains 28 statements with response options structured on a Likert-type scale. Of these, 20 statements refer to the “knowledge” domain (true = 1, false = 2, do not know = 3), and the remaining eight statements correspond to “attitudes” (responses ranging from strongly disagree = 1 to strongly agree = 7). Lower scores indicate a higher level of knowledge on the subject. Regarding attitudes, lower scores suggest a more liberal perspective, whereas higher scores indicate a tendency toward more conservative views. The scale does not aim to identify the sexual profile of the older adult but to assess knowledge and attitudes toward sexuality at this stage of life.¹⁰

The study considered sociodemographic and economic variables, including sex (classified as female and male); age in years; and marital status (with or without a partner). Educational level was assessed based on formal schooling, including those who had never attended school, those with incomplete primary education, and those with complete primary education or higher.

Household income was expressed in minimum wages (MW) and categorized as less than two, two to three, and four or more. Self-reported race/ethnicity included the following options: Black and mixed-race (“Pardo”) population, White, Asian, and Indigenous. Religion or belief included the categories Catholic, Spiritist and Kardecist, other religions or beliefs, no religion/belief, or agnostic. For all variables, the option “not reported” was available when the older adult preferred not to answer, with occurrences in marital status, educational level, number of individuals dependent on income, and religion/belief ($n = 1$), and in household income ($n = 2$).

Knowledge and attitudes were measured using the total score obtained on the ASKAS, allowing the evaluation of participants’ level of information and whether their views were conservative or liberal.

For data analysis, categorical variables were presented using absolute and relative frequencies. Numerical variables were analyzed using measures of central tendency and dispersion with R software, version 4.0.0. Considering a finite population of 803 individuals and a 5% margin of error, a minimum of 261 participants was estimated to ensure statistically reliable estimates. However, due to restrictions imposed by the COVID-19 pandemic, responses were obtained from 219 individuals. With this sample size, the margin of error increased to 5.66%, as determined by statistical calculation.

Statistical analyses were conducted in R (RStudio). After assessing data normality through statistical tests and visual inspection of Q-Q plots, the Mann-Whitney test (or Wilcoxon test for independent samples) and the Kruskal-Wallis test were applied for comparisons between two or more groups, respectively. For multiple comparisons following the Kruskal-Wallis test, Dunn’s post hoc test was used to identify which groups differed from one another. To control Type I error due to multiple comparisons, p-values were adjusted using the Bonferroni method. Effect size for the Mann-Whitney test was calculated as r (`wilcox_effsize()`, `rstatix` package) and converted to Cohen’s ($d = 2r/\sqrt{1-r^2}$) to estimate test power using `pwr.t2n.test()` (`pwr` package). For the Kruskal-Wallis test, effect size was estimated using eta-squared ($\eta^2 = (H - k + 1)/(n - k)$), where H is the test statistic, k is the number of groups, and n is the sample size. Test power was estimated by approximation to an ANOVA using the effect size converted to f ($f = \sqrt{\eta^2/(1-\eta^2)}$) and the function `pwr.anova.test()` (`pwr` package). Effect size r for the Mann-Whitney test was interpreted as small ($r \approx 0.10$), moderate ($r \approx 0.30$), and large ($r \geq 0.30$). For the Kruskal-Wallis test, eta-squared values were interpreted as small ($\eta^2 \approx 0.01$), moderate ($\eta^2 \approx 0.06$), and large ($\eta^2 \approx 0.14$). A significance level of 5% was adopted, and tests with power greater than 80% were considered capable of detecting true differences between groups.

The project was approved by the Human Research Ethics Committee of the Universidade Federal do Triângulo Mineiro (UFMT), CAAE 07786819.2.0000.5154, under ruling no. 4,342,951. It complied with the recommendations set forth in Resolutions No. 466/2012 and No. 510/2016 of the National Health Council. The informed consent statement was read and subsequently sent via email or WhatsApp. At the time of the initial contact, the telephone number and email address of the principal investigator were also provided. Participants received prior information regarding the study objectives and procedures, data confidentiality, and the anonymity of their participation. Any questions raised were then addressed. Interviews began only after verbal consent was obtained from the participants.

DATA AVAILABILITY

The dataset supporting the findings of this study is available upon request from the corresponding author.

RESULTS AND DISCUSSION

Among the 219 participants, females predominated (62.1%) (Table 1), corroborating studies conducted in Brazilian cities^{11,12}. The higher participation of older women may be related to their greater life expectancy, resulting from behavioral differences between sexes, considering that men often exhibit higher-risk behaviors such as alcohol and drug use, involvement in traffic accidents, and lower attention to health care¹³.

The mean age was 74.5 years, with $SD = \pm 7.9$ years, median = 73 years, $CV = 11\%$, $Q1 = 69$ years, and $Q3 = 80$ years, consistent with the increased longevity of Brazilians over recent decades, achieved through advances in health promotion policies, which include protective, preventive, and early disease detection measures¹⁴.

Regarding marital status, most participants (53.7%) reported not having a partner (Table 1), diverging from studies conducted in Brazil with older adults^{7,12}. This finding may be explained by the fact that, in the present study, participants

without partners included individuals who had never married or cohabited, single individuals, widowed, separated, legally separated, or divorced. When assessed separately, following national trends, there is typically a predominance of married individuals. A literature review identified that partnership is associated with the experience of sexuality among older adults. Among older women, the lack or loss of a partner, such as in widowhood, appears to negatively affect engagement in sexual practices¹⁵.

Participants had a low educational level, with the highest percentage reporting incomplete primary education (64.7%) (Table 1), similar to findings from studies conducted in Brazil^{7,12}. The low educational level among older adults may be attributed to cultural influences prevalent during their childhood and youth. At that time, education was often undervalued in comparison with priorities such as marriage, family formation, early entry into the labor market, and limited access to educational institutions¹⁶.

A total of 65.6% of respondents identified as Catholic (Table 1), a profile similarly observed in the Brazilian Northeast.¹⁷ Older adults who follow Catholicism may often hold more traditionalist views about sexuality, reflecting principles that guide conservative attitudes among these adherents^{5,15}. In this sense, religion may act as a guiding authority, as it establishes norms that define what is considered acceptable or unacceptable behavior and shapes individuals according to predetermined rules¹⁸, which may influence, although not investigated in this study, their perspectives on sexuality.

Analysis of the race/ethnicity variable showed that 55.7% of participants self-identified as White. Regarding household income, most respondents reported an income below two minimum wages (43.1%). In addition, 42.5% of the participants belonged to families in which two individuals depended on the primary income (Table 1). It is worth noting that socioeconomic status influences the degree of knowledge about sexuality. Individuals with lower incomes have fewer opportunities and resources to acquire in-depth knowledge on the subject, and this limited access to appropriate information results in reduced understanding of sexual matters¹⁹.

Table 1. Sociodemographic and economic profile of older adults participating in the study. Uberaba, Minas Gerais, Brazil, 2020–2021.

Variables	n (%)	95% CI*
Sex		
Female	136(62.1)	56.4 - 67.8
Male	83(37.9)	32.2 - 43.6
Marital status		
Without partner	117(53.7)	48.0 - 59.3
With partner	101(46.3)	40.7 - 52.0
Educational level		
No formal education	16(7.3)	1.7 - 13.0
Incomplete primary education	141(64.7)	59.0 - 70.3
Complete primary education or higher	61(28.0)	22.3 - 33.6
Household income (in minimum wages)		
< 2	93(43.1)	37.4 - 48.7
2 - 4	87(40.3)	34.6 - 45.9
4 or more	36(16.7)	11.0 - 22.3
Number of people who depend on the household income		
1	47(21.6)	15.9 - 27.2
2	93(42.5)	36.8 - 48.2
3	44(20.2)	14.5 - 25.8
4 or more	34(15.6)	9.9 - 21.3
Race/ethnicity		
Black population (Black and Mixed-race)	84(38.4)	32.7 - 44.0
White	122(55.7)	50.0 - 61.4
Asian and Indigenous	13(5.9)	0.3 - 11.6
Religion or belief		
Catholic	143(65.6)	59.9 - 71.3
Spiritist / Kardecist	34(15.6)	9.9 - 21.3
Other religions/beliefs	30(13.8)	8.1 - 19.4
No religion/belief or Agnostic	11(5.0)	0.0 - 10.7

*CI: Confidence interval. **Source:** Survey data.

The Mann–Whitney U test showed a significant difference in knowledge scores between sexes ($W = 7734$, $p < 0.001$). The effect size, calculated as r , was 0.31, classified as moderate. When converted to Cohen's d , the effect corresponded to $d \approx 0.65$, reinforcing that the magnitude of the difference is of moderate intensity. Specifically, female participants had significantly higher knowledge scores compared with male participants. Considering that lower scores indicate greater knowledge about sexuality, older men demonstrated greater knowledge than

older women (Table 2). This finding aligns with the literature, showing that cultural and social norms have historically allowed men greater freedom to discuss and express issues related to sexuality and sex⁷.

The way parents address sexuality varies according to the child's gender. Women receive more restrictive messages surrounding this topic, often conveyed through euphemisms, vague terms, and risk-based narratives such as pregnancy, and are subjected to stricter moral standards than men. Consequently,

differentiated communication can significantly affect the level of knowledge on the topic, leading to a reduced understanding of their own bodies and a limited repertoire of knowledge about pleasure, consent, and other important aspects of sexuality²⁰.

In contrast, men, who receive more positive and informative messages, are more likely to develop a broader and more balanced understanding of sexual matters. Promoting equitable and informative communication for both genders may help reduce these disparities and contribute to a more robust and equitable understanding of sexuality among men and women²⁰.

Regarding older adults' attitudes toward sexuality, there was a significant difference in scores when comparing sexes ($W = 7254$, $p < 0.001$). The effect size was small ($r = 0.24$), indicating that although statistically significant, the difference had limited magnitude. When converted to Cohen's d , the effect corresponded to $d \approx 0.49$, reinforcing that the difference is small to moderate. Older women had slightly higher attitude scores than men. In other words, older men demonstrated a more liberal attitude toward sexuality than older women (Table 2), consistent with findings from a study conducted in Montenegro²¹.

This discrepancy may be attributed to inconsistent social norms applied to genders, in which female sexuality is considerably more repressed than male sexuality. As a result, women may be reluctant to express their attitudes toward sexuality in order to avoid judgments based on cultural stigmas²¹.

There was a significant difference in knowledge scores between participants with and without partners ($W = 4136$, $p < 0.001$), with a small effect size ($r = 0.26$), indicating limited magnitude. When converted to Cohen's d , the effect was $d \approx 0.53$, suggesting a small to moderate difference. Older adults without partners had slightly higher knowledge scores than those with partners, indicating lower knowledge about sexuality (Table 2).

A significant difference was also observed in attitude scores between participants with and without partners ($W = 4459.5$, $p = 0.002$). The

effect size ($r = 0.21$; $d \approx 0.44$) indicates a small to moderate difference, suggesting that participants without partners had slightly higher attitude scores than those with partners, demonstrating more conservative attitudes.

A study conducted in Germany showed that widowed men are more likely to remarry than widowed women²². Older widowed women may experience reduced sexual activity and demonstrate disinterest in issues related to sexuality, mainly due to the absence of a steady partner after the loss of their spouse²³.

After the death of their husband, many older women choose not to engage in new relationships. For cultural, religious, and social reasons, they are not encouraged to have other partners. Considering that, for many older women, sex is predominantly understood as a marital union associated with reproductive function, once they become widowed and do not have a steady partner, sexual activity is often eliminated from daily life¹⁵. Therefore, resistance to establishing new sexual relationships influences the development of more conservative attitudes among women without a partner, due to cultural expectations imposed on their behavior²⁴.

A significant difference was found in median knowledge scores among educational-level groups ($H = 8.29$, $df = 2$, $p = 0.016$). The effect size of 0.03, estimated by eta-squared ($\eta^2 = 0.03$), was small, and the test power, estimated at 62%, indicates a moderate probability of detecting a true difference among groups with the sample used. The Dunn post hoc test, adjusted by the Bonferroni method, showed that participants with incomplete primary education had lower knowledge about sexuality than those with complete primary education or higher (adjusted $p = 0.020$) (Table 2), consistent with a study conducted with older adults in Northeastern Brazil¹⁵.

Individuals with fewer years of schooling tend to have limited access to basic healthcare services and, consequently, may not sufficiently acquire technically grounded information that could be obtained in these settings. Additionally, they face greater challenges in correctly understanding the guidance provided by the healthcare team²⁵.

Educational level and gaps in knowledge regarding the modes of transmission, prevention, and treatment of sexually transmitted infections (STIs), for example, emerge as contributing factors to increased vulnerability in this population. Thus, insufficient educational measures may result in a greater propensity for risk behaviors and delays in seeking medical care, considering that in this age group unsafe sexual health practices are often adopted, increasing the likelihood of acquiring diseases^{26,27}.

Significant differences were also observed in attitude scores among educational-level groups ($H = 19.22$, $df = 2$, $p < 0.001$). The effect size ($\eta^2 = 0.08$) suggests a medium effect, indicating that approximately 8% of the variability in attitude scores can be attributed to educational level. The Dunn post-hoc test, adjusted using the Bonferroni method, showed that those with higher levels of education also demonstrated a more liberal attitude toward sexuality (adjusted $p < 0.001$) (Table 2).

In this regard, knowledge about the aging process, its particularities, and strategies to maintain healthy sexuality in this stage of life tends to foster more permissive attitudes^{5,28}. A liberal orientation is characterized by critical and independent thinking, flexibility in considering divergent perspectives, and willingness to question traditions or norms established by society. It also involves valuing inclusion and diversity, as well as respecting cultural and individual differences, aligned with principles of equality and inclusion²⁹.

This can be explained by the fact that, when exposed to a greater amount of reliable information acquired in educational settings, individuals encounter diverse ideas and perspectives that may help develop critical thinking, which in turn can reduce misconceptions and misunderstandings regarding the possibility of sexual satisfaction in older age³⁰. Such knowledge is crucial to demystify the stereotypical belief that sexuality is unimportant in old age and to influence the adoption of less conservative attitudes⁷.

Household income was not associated with knowledge about sexuality ($H = 1.48$, $df = 2$, $p = 0.476$), but differences were observed among income groups regarding attitudes ($H = 8.36$, $df = 2$, $p = 0.015$). The effect size ($\eta^2 = 0.03$) indicates a small difference, and test power was limited (44%), suggesting a low probability of detecting true differences with the sample used. The Dunn post-hoc test, adjusted by the Bonferroni method, showed that participants with household income between two and less than four minimum wages had significantly higher attitude scores than those with income below two minimum wages (adjusted $p = 0.040$), reflecting a more conservative stance (Table 2). This finding is consistent with a national study conducted with older adults ($p < 0.002$)⁵ and with a study conducted in Minas Gerais, which identified that higher income among older women was associated with the continuation of sexual activity³¹.

Table 2. Knowledge and attitude scores of older adults regarding sexuality, according to sociodemographic and economic factors. Uberaba, Minas Gerais, Brazil, 2020–2021.

Variables	Attitudes and Knowledge about Sexuality in Aging (ASKAS)			
	Knowledge***	p / effect size	Attitudes	p / effect size
Sex		<0.001*		<0.001*
Female (n=136)	35 (30; 45)	r=0.31	22 (17; 25)	r=0.24
Male (n=83)	30 (26; 36)	(moderate)	18 (14; 21)	(small)
Marital status		<0.001*		0.012*
Without partner (n=117)	35 (30; 45)	r=0.260	22 (18; 25)	r=0.210
With partner (n=101)	30 (28; 36)	(small)	19 (15; 23)	(small)
Educational level		0.016**		<0.001**
No formal education (n=16)	35 (28; 47)	h ² =0.030	22 (15; 25)	h ² = 0.080
Incomplete primary education (n=141)	34 (29; 42)	(small)	22 (17; 25)	(moderate)
Complete primary education or higher (n=61)	31 (26; 37)		17 (12; 21)	
Household income (in minimum wages)		0.476 **		0.015**
Less than 2 (n=93)	34 (29; 39)	-	22 (17; 26)	h ² = 0.030
Between 2 and < 4 (n=87)	32 (28; 39)		19 (15; 24)	(small)
4 or more (n=36)	33 (27; 41)		20 (16; 22)	
Number of individuals dependent on household income		0.324**		0.669**
1 (n=47)	32 (27; 39)	-	19 (15; 24)	-
2 (n=93)	33 (28; 40)		19 (15; 24)	
3 (n=44)	36 (30; 43)		21 (17; 24)	
4 or more (n=34)	30 (27; 38)		21 (17; 24)	
Race/ethnicity		>0.900**		0.523**
Black and Mixed-race (n=84)	33 (29; 29)	-	21 (16; 25)	-
White (n=122)	33 (28; 41)		21 (15; 24)	
Asian and Indigenous (n=13)	36 (30; 38)		19 (18; 25)	
Religion or belief		0.382**		0.182**
Catholic (n=143)	34 (28; 40)	-	20 (16; 24)	-
Spiritist / Kardecist (n=34)	31 (28; 38)		21 (15; 24)	
Other religions/beliefs (n=30)	32 (28; 41)		24 (17; 26)	

*Mann–Whitney U test; **Kruskal–Wallis test; ***Median (1st quartile, 3rd quartile). **Source:** Study data.

Given the accelerated population aging, research is essential to enhance care and to emphasize actions aimed at preventing diseases and injuries, as well as promoting and maintaining health. A study conducted with older adults in Mexico found that participants wished for the topic of sexuality to be addressed by the healthcare team during consultations. They recognized the importance of receiving guidance from reliable and specialized sources that demonstrate an empathetic understanding of issues involving

sexuality in later life and that are capable of providing advice on ways to experience it with quality¹⁸.

In another study conducted with 411 older adults, 71.29% agreed that having knowledge about sexuality was relevant, and 61.07% reported being sexually active. These findings indicate that, despite the particularities of this phase of life, such as menopause, hormonal changes, and metabolic alterations, older adults are fully capable of engaging in sexual relations

and experiencing pleasure³². However, healthcare professionals do not always discuss these topics with individuals in this age group, either due to reluctance to introduce the subject or because of the stereotype that sexuality is no longer part of older adults' lives^{33,34}.

Strategies can be developed to make conversations about sexuality more natural, for example by providing specific instructions that highlight the use of routine, confidential questions and encourage individuals to feel comfortable sharing information³⁵. By offering appropriate support, healthcare professionals can help reduce stigma and promote a holistic, inclusive, and humanized approach²⁶.

This study presents limitations related to the data collection method, which relied on telephone contact and resulted in reduced sample representativeness due to several factors, such as refusals to participate and difficulties in reaching potential participants. However, this was the feasible approach adopted to conduct the study, in order to comply with safety measures imposed during the COVID-19 pandemic and to safeguard the integrity of the collected data. Regarding refusals, most older adults stated that they declined due to the time required to participate by telephone or because of other difficulties, such as hearing problems. The topic itself does not appear to have been a barrier to participation. This contrasts with the ASKAS scale validation study, in which respondents demonstrated difficulty and embarrassment in speaking openly about the subject¹⁰. It is inferred that telephone-based data collection may have had a positive influence, since participants did not need to be face to face with the interviewer, which may have facilitated dialogue and the expression of responses.

CONCLUSIONS

The findings indicate that older women, individuals without a steady partner, and those with incomplete primary education had lower levels of knowledge about sexuality than the other groups. In addition, female sex, lower educational level, and higher income were associated with more conservative attitudes.

This study has limitations related to the high number of refusals and other losses, such as difficulties reaching part of the older population by telephone, which may affect the generalizability and interpretation of the findings. These factors reinforce the exploratory nature of the results, which should be interpreted in light of the participating population. Nonetheless, methodological rigor was maintained, following ethical principles and the recommendations in place at the time for conducting research with older adults during the COVID-19 pandemic.

Despite these limitations, the study advances knowledge in the field of Public Health by bringing to light specific data on socioeconomic and demographic factors related to the knowledge and attitudes of older adults regarding sexuality in later life. The findings are also aligned with the Sustainable Development Goals: Good Health and Well-Being, target 3.8, which calls for access to essential and high-quality health services, and Gender Equality, target 5.1, which aims to end all forms of discrimination against women, and target 5.6, which seeks to ensure universal access to sexual health.

In this regard, it is important that multiprofessional teams implement sexual health education practices, especially within the scope of primary health care (PHC), in order to promote dialogue and qualified listening, understand older adults' level of knowledge and attitudes about sexuality and the multiple factors surrounding it, and foster health care while reducing situations of vulnerability. This is fundamental to ensuring the implementation of health policies.

For future research, studies with larger samples are recommended, with emphasis on investigating the social determinants of health related to older adults' knowledge and attitudes about sexuality in different cultural and regional contexts.

AUTHORSHIP

- Regiane L. Takaoka – Formal analysis; interpretation of results; writing and review.
- Lígia F. Machado – Interpretation of results; writing and review.

- Ana Paula Fernandes – Data analysis and interpretation; review; approval of the final version for publication.
- Pollyana C. S. Ferreira – Study conception and design; writing; review; critical revision; funding acquisition; approval of the final version for publication.

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Most prevalent morbidities among older Brazilian adults according to sex, age groups, and major regions

Emily da Silva Eberhardt¹ 
Sara Calumbi Nachipindo Kawalende¹ 
Idiane Rosset¹ 

Abstract

Objective: To identify the most prevalent morbidities among older Brazilian adults in 2013 and 2019 and their percentage variation according to sex and age groups in the country's major regions. **Method:** This cross-sectional study used data from the 2013 and 2019 National Health Survey, including older adults aged 60 years or over who answered the selected resident questionnaire (2013: n=11,177; 2019: n=22,728). Complex sample analyses with sampling weights were performed, estimating prevalences and confidence intervals to ensure the representativeness of the results. Percentage variation was calculated using the formula $[(\text{value at the later time} \div \text{value at the earlier time}) - 1] \times 100$. Associations between variables were assessed using Pearson's chi-square test ($p < 0.05$). **Results:** The most prevalent morbidities in both years were hypertension, chronic back problems, hypercholesterolemia, diabetes mellitus, and arthritis or rheumatism. These conditions were more prevalent among younger older adults, females, and residents of the Southeast region. Overall, an increase in the percentage variation of morbidities among older adults was observed across the years analyzed, according to the Brazilian regions, although with important disparities by sex and age groups. **Conclusion:** The distribution of morbidities revealed inequalities according to sex, age groups, and regions, reflecting disparities in the aging process of the Brazilian population. These findings enhance the understanding of regional inequalities and support managers and healthcare professionals in organizing equitable care for older adults, guiding the development of public policies and clinical practice in geriatrics and gerontology.

Keywords: Morbidity.
Chronic Disease. Aging.
Health of the Elderly.
Geriatrics.

¹ Universidade Federal do Rio Grande do Sul, Departamento de Enfermagem. Porto Alegre, RS, Brasil.

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Correspondence
Emily da Silva Eberhardt
enfemilyeberhardt@gmail.com

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INTRODUCTION

An increase in noncommunicable chronic diseases (NCDs) has been observed among the older population, concurrently with population aging and the epidemiological transition¹. Noncommunicable chronic diseases are among the leading causes of disability and premature mortality worldwide, accounting for approximately 71% of all deaths. In this context, older adults are the most affected, resulting in significant impacts on their quality of life and generating substantial costs for healthcare systems². In Brazil, in 2019, noncommunicable chronic diseases accounted for more than 734,000 deaths, representing approximately 55% of all deaths in the country¹.

Previous studies have highlighted the importance of investigating the health of older adults, particularly regarding the most prevalent morbidities³⁻⁶. International^{3,4} and national^{5,6} research has shown differences according to sex and age groups, with the oldest old (80 years of age or older) women exhibiting higher prevalence of multimorbidity (two or more morbidities in the same individual) when up to 25 diseases and greater life expectancy are considered.

Within the context of Brazil's demographic transition, the older population has increased markedly, especially among those aged 80 years or over, compared with other age groups⁷. This phenomenon has triggered significant changes in morbidity and mortality patterns, with substantial regional diversity influenced by socioeconomic, cultural, and racial disparities, access to healthcare services, urbanization, and other factors⁷.

Clarifying potential regional differences is essential for improving understanding and for developing effective strategies aimed at preventing health conditions and organizing healthcare delivery. This enables the recognition of specificities that are often rendered invisible by regional inequalities, contributing to the promotion of health and quality of life among older adults⁶.

Few studies have examined the epidemiology of the most prevalent morbidities among older Brazilian adults within a regional framework,

particularly considering sex, age groups, and temporal comparisons. This study seeks to address this gap in the literature, as understanding such diversity is essential for formulating more equitable public health policies and for delivering comprehensive healthcare to this population, especially considering Primary Health Care (PHC) as the main entry point into the Unified Health System (SUS)^{5,6}.

Thus, comparative analysis enables healthcare professionals to identify the most relevant aspects to be addressed in the assessment and monitoring of older adults' health, while also supporting decision-makers in developing or adjusting public policies. Therefore, this study aims to identify the most prevalent morbidities among older Brazilian adults in 2013 and 2019 according to sex and age groups across the country's major regions.

METHODS

This was a cross-sectional study using individual data from the Brazilian National Health Survey (PNS). This is the most comprehensive health survey conducted in Brazil and consists of a nationally representative household-based survey carried out in 2013 and 2019 across the country's major regions. It was developed by the Brazilian Institute of Geography and Statistics (IBGE) in partnership with the Ministry of Health. The methodology of the National Health Survey is internationally validated and allows for statistically rigorous comparison of regional realities in Brazil⁸. This study followed the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies.

The study population consisted of older adults aged 60 years or older residing in all Brazilian states. The sample included older adults who completed the selected resident questionnaire (2013: 11,177; 2019: 22,728). In both editions of the National Health Survey, sampling followed a three-stage cluster design. In the first stage, the primary sampling units were census tracts randomly selected. In the second stage, a random number of households was selected

within each tract, and in the third stage, one resident was randomly selected in each sampled household⁸.

Publicly available data were obtained between April and June 2023 from the 2013 and 2019 National Health Survey databases, accessible on the IBGE website.

To assess the most prevalent morbidities, 14 noncommunicable chronic diseases included in both editions of the National Health Survey were considered, according to the survey's specific modules. Morbidities were identified using Module H on noncommunicable chronic diseases. The questions and their respective codes were: hypertension (Q002), diabetes mellitus (Q030), hypercholesterolemia (Q060), heart disease (Q063), cerebrovascular disease (Q068), asthma (Q074), arthritis/rheumatism (Q079), chronic back problem (Q084), work-related musculoskeletal disorder (Q088), depression (Q092), lung disease (Q116), cancer (Q120), and chronic kidney failure (Q124).

The identification of noncommunicable chronic diseases was based on the question: "Has any physician ever given you a diagnosis for this disease?", with dichotomous response options (yes/no). For chronic back pain, the survey relied on participants' self-reports, whereas for depression and mental health, previous diagnoses made by a mental health professional (psychiatrist or psychologist) were considered.

Based on a ranking derived from the prevalence analysis of all morbidities included in both editions of the National Health Survey, the five most prevalent morbidities in Brazil were selected for analysis (hypertension, chronic back problem, hypercholesterolemia, diabetes mellitus, and arthritis or rheumatism), as these accounted for more than 50% of all morbidities among older Brazilian adults.

Sociodemographic variables were drawn from different modules of the National Health Survey. Sex was identified in Module A – General Characteristics of Household Residents, question Q001: "What is your sex?" (male; female). Age was obtained from question Q002 of the same module: "How old are you in completed years?", and categorized into three age

groups (60–69, 70–79, and ≥80 years). The region of residence was derived from the geographic location of the household, recorded in the identification and territorial classification block of the questionnaire, following the official IBGE division into five major regions: North, Northeast, Southeast, South, and Central-West. Educational level was obtained from Module C – Education Characteristics, question Q025: "What is the highest level of schooling you attended and completed?", categorized as no schooling, primary education, secondary education, and higher education. Perceived health status was extracted from Module J – Lifestyle and Health Perception, question Q001: "In general, how would you rate your health?" The response options were very good, good, fair, poor, and very poor; for analysis, categories were grouped as very good/good, fair, and poor/very poor.

For sample characterization, two groups of older adults were considered: a younger group (60–79 years) and an older group (80 years or over), following previous research on aging and morbidity distribution^{9–13}. Variables were analyzed by sex and age group within the regional context. Considering the complex sampling design, sampling weights for the primary sampling unit, individual, and stratum were applied in all analyses, ensuring the representativeness of data for older Brazilian adults. For sample characterization, categorical variables were presented using relative frequencies (%) and 95% confidence intervals (95% CI). Morbidity prevalences and their respective 95% CIs were estimated according to survey year, sex, and age group across Brazil's major regions.

Associations between variables were analyzed using Pearson's Chi-square test with a 95% confidence level. Associations were considered statistically significant when the p-value was <0.05. Percentage variation was calculated as follows: $[(\text{value at the later time} \div \text{value at the earlier time}) - 1] \times 100$, in accordance with a previous study comparing percentages across the two editions of the National Health Survey¹⁴.

This study used only secondary, public, and anonymized data from the National Health Survey, whose data collection was approved by the National

Research Ethics Commission (CONEP) under opinions N° 328,159/2013 and N° 3,529,376/2019, in compliance with National Health Council Resolution N° 466/12. The present analysis, involving public data with no possibility of participant identification, also complies with the guidelines of National Health Council Resolution N° 510/2016.

DATA AVAILABILITY

The full dataset supporting the results of this study is publicly available on the National Health Survey website and can be accessed at <https://www.pns.icict.fiocruz.br/bases-de-dados/>

RESULTS

Table 1 presents the proportional distribution of the relative frequencies of sociodemographic and health-related variables of older adults in 2013 and 2019, as well as the percentage variation for Brazil and its major regions. In both years, higher proportions of women, individuals aged 60-79 years, and those with incomplete primary education were observed in Brazil and in its regions. A greater proportion of very good/good perceived health status was found in the Southeast, South, and Central-West regions, whereas fair perceived health was more prevalent in the North and Northeast regions.

Table 1. Characteristics of older adults in 2013 (N = 11,177) and 2019 (N = 22,728), in percentages and 95% Confidence Intervals (95% CI). National Health Survey, Brazil, 2013 and 2019.

Variables	2013 % (95% CI)	2019 % (95% CI)	Percentage variation
BRAZIL			
Sex			
Female	56.4 (54.8-57.9)	56.7 (55.6-57.7)	0.5
Male	43.6 (42.1-45.2)	43.3 (42.3-44.4)	0.6
Age			
60-79 years	86.4 (87.2-89.5)	86.4 (85.7-87.2)	0
80 years or over	13.6 (12.6-14.7)	13.6 (12.8-14.3)	0
Educational Attainment			
No formal education	22.7 (21.4-24)	16.8 (16-17.7)	-35.1
Incomplete primary education	48 (46.3-49.7)	46.5 (45.3-47.6)	-3.2
Complete primary education or higher	29.3 (26-33.2)	36.7 (34-39.7)	25.2
Self-rated Health Status			
Very good/good	44.4 (42.1-46.8)	47 (45.4-48.9)	5.8
Fair	43.5 (42-45)	41.7 (40.6-42.9)	-4.3
Poor/very poor	12.1 (10.8-13.6)	11.3 (10.3-12.2)	-8
NORTH REGION			
Sex			
Female	53 (47.3-58.6)	53.7 (51-56.4)	1.3
Male	47 (41.4-52.7)	46.3 (43.6-49)	-1.5
Age			
60-79 years	90.4 (87.5-92.8)	87.2 (85.2-88.9)	-3.6
80 years or over	9.6 (7.2-12.5)	12.8 (11.1-14.8)	33.3

to be continued

Continuation of Table 1

Variables	2013 % (95% CI)	2019 % (95% CI)	Percentage variation
Educational Attainment			
No formal education	27.4 (23.8-31.5)	25 (22.4-27.8)	10
Incomplete primary education	48.6 (43.9-53.2)	46.5 (43.7-49.3)	4.5
Complete primary education or higher	24 (17.5-33.1)	28.5 (23.3-34.9)	18.7
Self-rated Health Status			
Very good/good	35.6 (30-41.7)	39.7 (36.2-43.4)	11.5
Fair	48.2 (43.6-52.8)	47.4 (44.7-50.1)	-1.6
Poor/very poor	16.2 (12.3-21.4)	12.9 (10.9-15.6)	-26.3
NORTHEAST REGION	25.2 (24.1-26.4)	25.4 (24.6-26.2)	0.7
Sex			
Female	55.9 (53.1-58.6)	56.5 (54.7-58.3)	1
Male	44.1 (41.4-46.9)	43.5 (41.7-45.3)	-1.3
Age			
60–79 years	85.1 (83-87.1)	84.2 (82.7-85.6)	-1
80 years or over	14.9 (12.9-17)	15.8 (14.4-17.3)	6
Educational Attainment			
No formal education	39.2 (36.5-42)	34.5 (32.6-36.5)	-13.6
Incomplete primary education	41.6 (38.8-44.5)	40.9 (39-42.8)	-1.7
Complete primary education or higher	19.2 (15.4-23.7)	24.6 (21.5-28.2)	28.7
Self-rated Health Status			
Very good/good	34.7 (31.7-38)	35.1 (32.9-37.5)	1.1
Fair	48.3 (45.7-50.8)	48.8 (47-50.6)	1.2
Poor/very poor	17 (14.6-19.9)	16.1 (14.5-18)	-5.5
SOUTHEAST REGION	48.3 (46.8-49.8)	46.4 (45.4-47.5)	-4
Sex			
Female	57.1 (54.6-59.6)	57.6 (55.7-59.5)	0.8
Male	42.9 (40.4-45.4)	42.4 (40.5-44.3)	-1.1
Age			
60–79 years	85.6 (83.8-87.3)	86.6 (85.3-87.9)	1.1
80 years or over	14.4 (12.7-16.2)	13.4 (12.1-14.7)	-7.4
Educational Attainment			
No formal education	15.5 (13.6-17.5)	9 (7.9-10.2)	-72.2
Incomplete primary education	48.9 (46.1-51.8)	46.4 (44.4-48.3)	-5.3
Complete primary education or higher	35.6 (23-33.1)	44.6 (39.7-50.3)	25.2
Self-rated Health Status			
Very good/good	50.3 (46.3-54.5)	53.5 (50.3-56.7)	0.4
Fair	40.9 (38.5-43.4)	37.5 (35.5-39.5)	-9
Poor/very poor	8.8 (6.9-11.3)	9 (7.5-10.9)	2.2
SOUTH REGION	15.1 (14.2-16)	15.7 (15.1-16.4)	3.9
Sex			
Female	56.8 (52.8-60.7)	55.8 (53.7-57.9)	-1.7
Male	43.2 (39.3-47.2)	44.2 (42.1-46.3)	2.3

to be continued

Continuation of Table 1

Variables	2013 % (95% CI)	2019 % (95% CI)	Percentage variation
Age			
60–79 years	88.6 (86-90.8)	88.2 (86.7-89.6)	-0.4
80 years or over	11.4 (9.2-14)	11.8 (10.4-13.3)	3.5
Educational Attainment			
No formal education	14.7 (12.3-17.6)	8.3 (7-9.8)	-77.1
Incomplete primary education	56.7 (52.7-60.5)	55.3 (52.9-57.7)	-2.5
Complete primary education or higher	28.6 (22.5-36.5)	36.4 (31.1-42.5)	27.1
Self-rated Health Status			
Very good/good	45.6 (40.8-51)	50.5 (47.1-54.3)	10.7
Fair	42.2 (38.8-45.6)	40.2 (37.8-42.6)	-4.9
Poor/very poor	12.2 (9.2-16.2)	9.3 (7.5-11.3)	-31.1
CENTRAL-WEST REGION			
Sex			
Female	55.1 (51.3-58.9)	55.4 (52.2-58.6)	-0.5
Male	44.9 (41.1-48.7)	44.6 (41.4-47.8)	-0.6
Age			
60–79 years	89.1 (86.8-91.1)	88.9 (86.8-90.7)	-0.2
80 years or over	10.9 (8.9-13.2)	11.1 (9.3-13.2)	1.8
Educational Attainment			
No formal education	25.5 (22.5-28.7)	17 (14.9-19.4)	-50
Incomplete primary education	45.4 (41.7-49.1)	47.3 (44.1-50.4)	3.9
Complete primary education or higher	29.1 (22.6-37.8)	35.7 (29.5-43.3)	22.6
Self-rated Health Status			
Very good/good	43.3 (38.2-49.1)	46.5 (42.1-51.3)	7.3
Fair	43.4 (39.9-47)	42.9 (40-46)	-1.1
Poor/very poor	13.3 (10-17.4)	10.6 (8.5-13.3)	- 24.5

Percentages estimated using sampling weights; V: percentage variation between 2013 and 2019 [(value at the later time ÷ value at the earlier time) - 1] × 100. **Source:** National Health Survey, 2013 and 2019.

Figure 1 shows the proportional distribution of morbidity prevalences among older adults in the major Brazilian regions in 2013 and 2019. The most prevalent morbidities were, respectively: hypertension, chronic back problem, hypercholesterolemia, diabetes

mellitus, and arthritis or rheumatism. Morbidities were consistently more prevalent in the Southeast, Northeast, and South regions. Hypertension was the leading chronic condition nationwide, with the highest percentage observed in the Southeast.

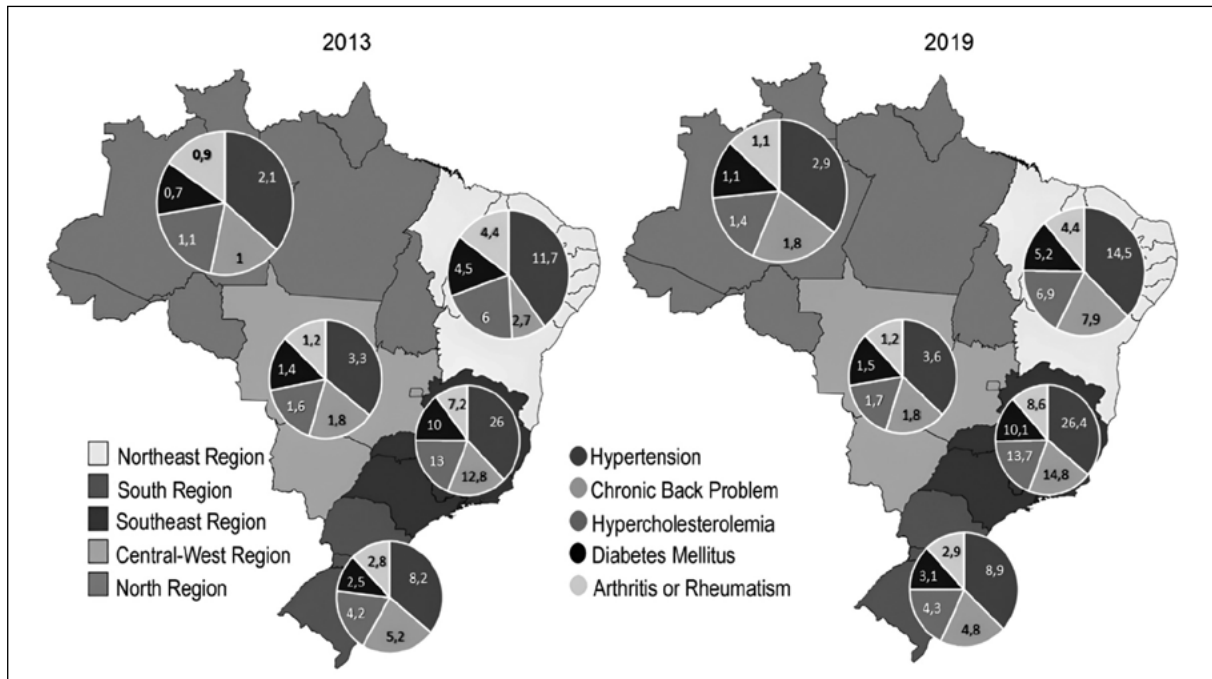


Figure 1. Distribution of morbidity prevalences among older adults in the major Brazilian regions. National Health Survey (2013: n = 11,177; 2019: n = 22,728), Brazil.

According to Table 2, hypercholesterolemia and diabetes mellitus showed significant percentage increases among men, whereas arthritis or rheumatism showed a percentage decrease in Brazil (-19.4%) and across all regions, especially in the Northeast (-40.6%). Conversely, among women, a significant increase in arthritis or rheumatism was observed, followed by chronic back problem and hypertension.

Important differences in percentage variation of morbidities between sexes were observed: in the North, the largest difference was the increase in chronic back problem among men; in the Northeast, hypercholesterolemia increased mainly among men; in the Southeast, arthritis or rheumatism increased among women and decreased among men; in the South, diabetes mellitus increased primarily among

women; and in the Central-West, hypertension increased substantially among men. Furthermore, the Southeast and South regions presented percentages of hypertension higher than those observed in Brazil overall, according to sex, in both years.

Regarding age groups (Table 3), the Central-West region showed morbidity percentages higher than those identified in Brazil in both 2013 and 2019, whereas the Southeast and South regions showed higher percentages only in 2013. The greatest percentage variations were found in the increase in chronic back problem among younger older adults and in hypercholesterolemia among the oldest old in the North region. In the Northeast region, a substantial increase in chronic back problem was observed among the oldest old. 60-79 years.

Table 2. Distribution of prevalences and 95% Confidence Intervals (95% CI) of morbidities among older Brazilian adults according to sex and percentage variation between the years 2013 (n = 11,177) and 2019 (n = 22,728) in the major Brazilian regions. National Health Survey, Brazil, 2013 and 2019.

Variables	Male 2013 % (95% CI)	Male 2019 % (95% CI)	V*	Female 2013 % (95% CI)	Female 2019 % (95% CI)	V*	p* 2013	p* 2019
BRAZIL								
Hypertension	19.9 (18.6-21.2)	21.5 (20.6-22.4)	8	31.3 (29.8-32.8)	34.9 (33.9-36)	11.5	<0.001	<0.001
Chronic Back Problem	10.5 (9.5-11.6)	11.1 (10.4-11.7)	5.7	17.6 (15.5-18.9)	20 (19.1-21)	136	<0.001	<0.001
Hypercholesterolemia	7.7 (6.8-8.7)	8.9 (8.2-9.5)	15.5	18.2 (16.9-19.5)	19.1 (18.2-20.1)	4.9	<0.001	<0.001
Diabetes Mellitus	7.4 (6.5-8.4)	8.4 (7.8-9)	13.5	11.8 (10.7-12.9)	12.4 (11.7-13.2)	5	0.021	0.022
Arthritis or Rheumatism	4.3 (3.6-5.1)	3.6 (3.2-4)	-19.4	12.2 (11.2-13.3)	14.6 (13.7-15.5)	19.6	<0.001	<0.001
NORTH REGION								
Hypertension	17 (13.6-21)	19 (17-21.2)	11.7	26.7 (22.3-31.6)	29.3 (26.9-31.9)	9.7	0.013	<0.001
Chronic Back Problem	8.4 (5.9-11.9)	12.8 (11.2-14.6)	52.3	11.6 (8.4-15.7)	16 (14.1-18)	37.9	0.385	0.379
Hypercholesterolemia	7 (5-9.9)	7.3 (6.1-8.7)	4.2	15.6 (11.9-20.1)	16.9 (15-19)	8.3	0.008	<0.001
Diabetes Mellitus	5.2 (3.2-8.3)	7 (5.8-8.5)	34.6	10.6 (7.7-14.4)	10.7 (9.2-12.5)	0.9	0.049	0.072
Arthritis or Rheumatism	6 (3.7-9.7)	5 (4-6.4)	-20	13.2 (10.2-17)	13.7 (12.1-15.5)	3.7	0.006	<0.001
NORTHEAST REGION								
Hypertension	16.1 (14.2-18.1)	21.4 (20-22.9)	32.9	30.5 (28-33.1)	35.9 (34.2-37.5)	17.7	<0.001	<0.001
Chronic Back Problem	11.2 (9.6-13.2)	11.6 (10.5-12.8)	3.5	17.4 (15.4-19.7)	19.4 (17.9-21.1)	11.4	0.036	<0.001
Hypercholesterolemia	5.4 (4.3-6.6)	7.8 (6.8-8.9)	44.4	19.7 (17.7-21.9)	19.9 (18.5-21.3)	1	<0.001	<0.001
Diabetes Mellitus	5.7 (4.5-7.2)	7.4 (6.6-8.4)	29.8	12.9 (10.9-15.2)	13.2 (12.1-14.5)	2.3	0.001	<0.001
Arthritis or Rheumatism	4.5 (3.4-5.9)	3.2 (2.7-3.9)	-40.6	13 (11.2-15)	14.1 (12.9-15.5)	8.4	<0.001	<0.001
SOUTHEAST REGION								
Hypertension	21.7 (19.5-24.1)	21.6 (20-23.2)	-0.4	31.8 (29.4-31.4)	35.1 (33.3-37)	10.3	0.052	<0.001
Chronic Back Problem	9.5 (7.9-11.4)	10.6 (9.5-11.8)	11.5	17 (15-19.1)	21.2 (19.6-23)	24.7	0.005	<0.001
Hypercholesterolemia	8.5 (7-10.4)	9.3 (8.2-10.5)	9.4	17.7 (15.7-20)	19.8 (18.2-21.5)	11.8	<0.001	<0.001
Diabetes Mellitus	8.4 (6.9-10.1)	9.1 (8-10.3)	8.3	11.8 (10.2-13.8)	12.4 (11.2-13.7)	5	0.654	0.930
Arthritis or Rheumatism	4 (2.9-5.5)	3.5 (2.8-4.2)	-14.2	10.9 (9.4-12.6)	15 (13.4-16.8)	37.6	<0.001	<0.001

to be continued

Continuation of Table 2

Variables	Male 2013 % (95% CI)	Male 2019 % (95% CI)	V*	Female 2013 % (95% CI)	Female 2019 % (95% CI)	V*	p* 2013	p* 2019
SOUTH REGION								
Hypertension	21.5 (18.4-24.8)	22 (20.2-23.8)	2.3	32.6 (29.1-36.3)	35 (32.8-37.4)	7.4	0.049	<0.001
Chronic Back Problem	13.2 (10.7-16)	11.1 (9.9-12.4)	-18.9	21.5 (18.8-24.4)	19.7 (17.7-21.8)	-9.1	0.021	<0.001
Hypercholesterolemia	8.7 (6.6-11.3)	9.7 (8.5-11)	11.5	18.2 (15.6-21.1)	17.7 (15.9-19.6)	-2.8	0.001	<0.001
Diabetes Mellitus	7.2 (5.2-9.9)	8.2 (7.1-9.4)	13.9	9.4 (7.5-11.6)	11.3 (9.8-13)	20.2	0.703	0.425
Arthritis or Rheumatism	4.1 (2.8-6)	3.9 (3.2-4.7)	-5.1	14.6 (12.4-17.1)	14.4 (12.8-16.2)	-1.4	<0.001	<0.001
CENTRAL-WEST REGION								
Hypertension	19.1 (16.4-22.2)	22.2 (19.7-25)	16.2	31.6 (28.1-35.4)	34.7(31.9-37.7)	9.8	0.001	<0.001
Chronic Back Problem	9.9 (7.8-12.6)	10.5 (8.9-12.4)	6.1	18.6 (15.9-21.6)	17.9 (15.6-20.5)	-3.9	0.001	0.002
Hypercholesterolemia	8.2 (6.1-10.9)	9.1 (7.4-11.1)	11.0	17.6 (14.9-20.7)	17.1 (14.9-19.6)	-2.9	0.002	0.001
Diabetes Mellitus	7.9 (6-10.5)	8.7 (7-10.8)	10.1	13.2 (10.7-16.2)	14.4 (12.3-16.8)	9.1	0.150	0.024
Arthritis or Rheumatism	4.7 (3.3-6.6)	4 (3-5.4)	-17.5	13.3 (11.3-15.5)	14.1 (12.1-16.2)	6	<0.001	<0.001

Estimated percentages using sampling weights. V: percentage variation in prevalences between 2013 and 2019 [(value at later time ÷ value at earlier time)–1] × 100. *Chi-square test for the association between sexes. **Source:** National Health Survey, 2013 and 2019.

Table 3. Distribution of prevalences and 95% Confidence Intervals (95% CI) of morbidities among older Brazilian adults according to age groups and percentage variation between the years 2013 (n = 11,177) and 2019 (n = 22,728) in the major Brazilian regions. National Health Survey, Brazil, 2013 and 2019.

Variables	60–79 years 2013 % (95% CI)	60–79 years 2019 % (95% CI)	V	80 years or over 2013 % (95% CI)	80 years or over 2019 % (95% CI)	V	p* 2013	p* 2019
BRAZIL								
Hypertension	43.8 (42.1-45.5)	48.1 (47-49.2)	9.8	7.4(6.6-8.3)	8.3 (7.7-8.9)	12.2	0.135	<0.001
Chronic Back Problem	24.4 (23-25.8)	27.1 (26.1-28.2)	11.1	3.8 (3.2-4.5)	3.9 (3.5-4.4)	2.6	0.840	0.139
Hypercholesterolemia	23.3 (21.9-24.7)	25.1 (24.1-26.1)	7.7	2.6 (2.1-3.1)	2.9 (2.5-3.3)	11.5	<0.001	<0.001
Diabetes Mellitus	16.6 (15.4-17.9)	18.1 (17.3-19)	9.0	2.5 (2.1-3.1)	2.7 (2.4-3.1)	8.0	0.702	0.630
Arthritis or Rheumatism	13.7 (12.7-14.8)	15.6 (14.7-16.5)	13.9	2.8 (2.3-3.3)	2.6 (2.3-3)	-7.7	0.007	0.329
NORTH REGION								
Hypertension	17.2 (13.4-21.9)	15.6 (13.9-17.6)	-10.3	2 (1.2-3.4)	3.1 (2.4-4.1)	55.0	0.712	0.023
Chronic Back Problem	18.4 (14.5-23.1)	25.8 (23.3-28.4)	40.2	1.6 (0.9-2.6)	3 (2.3-3.9)	87.5	0.445	0.067
Hypercholesterolemia	21.9 (17.9-26.5)	21.5 (19.4-23.7)	-1.9	0.7 (0.3-1.5)	2.7 (1.9-3.7)	285.7	0.001	0.236
Diabetes Mellitus	14.4 (10.8-19)	16.1 (14.1-18.2)	11.8	1.4 (0.8-2.4)	1.7 (1.2-2.4)	21.4	0.790	0.046
Arthritis or Rheumatism	17.2 (13.4-21.9)	15.6 (13.9-17.6)	-10.3	2 (1.2-3.4)	3.1 (2.4-4.1)	55.0	0.712	0.023
NORTHEAST REGION								
Hypertension	40 (37.3-42.7)	48 (46.2-49.8)	20.0	6.6 (5.4-8)	9.3 (8.2-10.5)	40.9	0.552	0.476
Chronic Back Problem	24.4 (21.9-27.1)	27.1 (25.3-28.9)	11.1	1.3 (3.2-5.6)	4 (3.2-4.9)	207.7	0.978	0.007
Hypercholesterolemia	22.5 (20.4-24.8)	24.2 (22.6-25.8)	7.6	2.6 (1.8-3.7)	3.5 (2.9-4.3)	34.6	0.018	0.009
Diabetes Mellitus	15.7 (13.8-17.8)	17.4 (16.2-18.7)	10.8	2.9 (2.1-4.1)	3.2 (2.5-4.1)	10.3	0.819	0.878
Arthritis or Rheumatism	14.3 (12.4-16.4)	14.5 (13.3-15.8)	1.4	3.2 (2.3-4.4)	2.8 (2.3-3.5)	-14.3	0.142	0.690
CENTRAL-WEST REGION								
Hypertension	45 (42.2-48)	48.6(46.6-50.5)	8.0	8.5 (7.2-10.1)	8.2 (7.2-9.3)	-3.7	0.113	0.068
Chronic Back Problem	22.5 (20.3-24.9)	27.5 (25.7-29.4)	22.2	4 (3-5.2)	4.3 (3.6-5.1)	7.5	0.690	0.945
Hypercholesterolemia	23.4 (21.1-25.8)	26.4 (24.5-28.3)	12.8	2.9 (2.2-3.8)	2.7 (2.2-3.3)	-7.4	0.023	<0.001
Diabetes Mellitus	17.4 (15.5-19.5)	18.7 (17.2-20.3)	7.5	2.9 (2.1-3.8)	2.7 (2.2-3.4)	-7.4	0.847	0.685
Arthritis or Rheumatism	12.1 (10.5-13.9)	15.9 (14.3-17.6)	31.4	2.8 (2-3.8)	2.6 (2-3.3)	-7.7	0.045	0.654

to be continued

Continuation of Table 3

Variables	60–79 years 2013 % (95% CI)	60–79 years 2019 % (95% CI)	V	80 years or over 2013 % (95% CI)	80 years or over 2019 % (95% CI)	V	p* 2013	p* 2019
SOUTHEAST REGION								
Hypertension	47.5 (43.9-51.2)	48.9 (46.4-51.3)	2.9	6.6 (4.9-8.8)	8.1 (7-9.5)	22.7	0.650	<0.001
Chronic Back Problem	31 (27.6-34.6)	27.1 (25-29.2)	14.4	3.6 (2.5-5.2)	3.7 (2.9-4.8)	2.8	0.565	0.778
Hypercholesterolemia	24.5 (21.5-27.8)	24.8 (22.9-26.8)	1.2	2.4 (1.4-3.9)	2.5 (1.9-3.3)	4.2	0.212	0.032
Diabetes Mellitus	15.3 (12.5-18.4)	17 (15.2-18.8)	11.1	1.3(0.7-2.3)	2.5 (1.9-3.4)	92.3	0.357	0.463
Arthritis or Rheumatism	16.2 (13.8-19)	16.1 (14.5-17.9)	0.6	2.4 (1.6-3.5)	2.2 (1.6-3)	9.1	0.515	0.965
SOUTH REGION								
Hypertension	44.8 (40.9-48.7)	49.8 (46.9-52.8)	11.2	6 (4.5-7.9)	7.1 (5.6-9)	18.3	0.731	0.066
Chronic Back Problem	26.3 (23-29.8)	25.6 (23.1-28.4)	2.7	2.2 (1.5-3.3)	2.8 (2-3.9)	27.3	0.068	0.431
Hypercholesterolemia	23.6 (20.4-27.2)	23.3 (20.8-26)	1.3	2.1 (1.4-3.3)	2.9 (2-4)	38.1	0.126	0.858
Diabetes Mellitus	18.9 (15.8-22.5)	20.7 (18.2-23.5)	9.5	2.2 (1.4-3.4)	2.4 (1.4-4)	9.1	0.897	0.750
Arthritis or Rheumatism	15.2 (12.7-18.1)	15.7 (13.6-17.9)	3.3	2.7 (1.9-3.9)	2.4 (1.7-3.4)	12.5	0.048	0.278

Estimated percentages using sampling weights. V: percentage variation in prevalences between 2013 and 2019 $[(\text{value at later time} \div \text{value at earlier time}) - 1] \times 100$. *Chi-square test for the association between age groups. **Source:** National Health Survey, 2013 and 2019.

DISCUSSION

The present study provides a comprehensive and representative analysis of the most prevalent morbidities among older Brazilian adults across regions. The analysis of proportional distributions according to sex and age groups at two distinct time points offers a broad understanding of the complexities of aging and contributes to advancing knowledge in geriatrics and gerontology.

Accelerated population aging in Brazil and its regions is evident, with the Southeast, Northeast, and South presenting the highest proportions of older adults in both years analyzed. The highest proportion of younger older adults was identified in the North region in 2013 and in the Central-West region in 2019, whereas the highest proportion of the oldest old was observed in the Northeast region in both years. This study reaffirms the country's regional disparities, especially in health, underscoring the need for regionally tailored actions⁷.

Although chronic diseases have increased in the population, the perception of “very good/good” health also increased across all regions (especially in the North and South), whereas the perception of “poor/very poor” health decreased (except in the Southeast). However, studies show that the presence of chronic diseases is associated with worse self-rated health among older adults, particularly women, suggesting that this indicator remains highly subjective^{15,16}.

Corroborating the results of this study, a cross-sectional study conducted in Minas Gerais with 1,691 older adults aged 60 years and over, considering 25 noncommunicable chronic diseases, found the most prevalent morbidities to be hypertension (61.9%), followed by chronic back problem (48.6%)¹⁷. In the present study, these two morbidities were proportionally more prevalent in most Brazilian regions in both years, except in the North and Southeast regions in 2013, where hypertension and hypercholesterolemia were more prevalent.

Hypertension was also identified as the morbidity with the highest percentage of self-report among older adults in national^{17,18} and international^{19,20} studies. A time-series study using data from the

Brazilian Surveillance System of Risk and Protective Factors for Chronic Diseases showed that self-reported hypertension increased significantly among older adults according to sex and age groups²¹.

Cardiovascular diseases are the leading causes of death in Brazil and worldwide, with hypertension, diabetes mellitus, and hypercholesterolemia being the main risk factors²¹. Significant differences were observed in the prevalence of diabetes mellitus across regions and between sexes, with higher prevalence among men in the Southeast region and among women in the Central-West region in both years. Hypercholesterolemia showed the greatest percentage increase between the years in the oldest old in the North region, although this is the region with the lowest overall proportion of older adults²².

These regional differences may be influenced by sociocultural specificities, which should be considered in the planning of public policies and health actions^{8,11}. These morbidities require continuous control to prevent cardiovascular complications, which is directly related to patient adherence to treatment. In this regard, healthcare professionals must understand the factors that hinder adequate treatment, particularly among the oldest old, and develop health education strategies for correct medication use, educational groups that promote healthy lifestyles, and longitudinal and multidimensional follow-up of morbidities²³.

Chronic back problem showed the largest increase from 2013 to 2019 in the North region among both sexes and in the younger older adult age group. According to the IBGE, in 2019, spine-related diseases were the most common among residents of Rondônia and may be related to work activities characteristic of the North region, such as extractivism and agriculture/livestock²⁴. This morbidity is highly prevalent and is associated with demographic, socioeconomic, and lifestyle factors¹⁷. It results in negative impacts on health conditions and requires intensified prevention, especially among younger age groups, as the severity of this problem increases with advancing age¹⁷.

Arthritis or rheumatism showed a substantial reduction between the years among men, both nationwide and across all regions, whereas an increase

was observed among women, except in the South region. Although no other studies with this specific focus were identified, it is important to consider that the occurrence of this condition in older adults may be influenced by several factors, such as genetics, obesity, diet, and activities/occupation, which differ across sexes, age groups, and regions and may lead to decreased functional capacity²⁵.

The Southeast region presented the highest prevalence of morbidities. It stands out as the most populous and urbanized region, with the greatest population density in the country, in addition to being considered the region with the highest Gross Domestic Product (GDP)²⁶. Aging in large urban centers is heterogeneous and shaped by factors such as average income and urban development processes, which demand distinct public policies. Furthermore, there is a feminization of aging in urban settings, marked by greater female migration from rural to urban areas, combined with women's greater longevity²⁷.

Brazilian regions present significant sociocultural disparities that may influence the different prevalence of morbidities among sex and age subgroups. The literature indicates that territorial, social, economic, and cultural inequalities significantly affect the socioeconomic and demographic conditions of the older population, reinforcing its heterogeneous distribution in Brazil¹¹. Moreover, longevity is associated with social inequalities, resulting in distinct patterns of population growth and aging across Brazilian regions²⁸.

The morbidities investigated were more prevalent among older women, who also represent the majority of the population assessed. In general, women show greater concern with health conditions than men, resulting in more frequent use of healthcare services, which may partially explain the higher percentage of diagnoses of noncommunicable chronic diseases. However, according to studies using public data, women experience higher life expectancy with functional disability compared with men, across all ages and regions of Brazil²⁹.

Additionally, the distribution of morbidities was proportionally higher among younger older adults,

as this group is considerably larger. This result may also be partially explained by the fact that most diagnoses of noncommunicable chronic diseases occur in the younger older adult age group. This may be due to the earlier onset of several chronic conditions and improved access to healthcare in this group, whereas monitoring and treatment levels tend to be lower among the oldest old³⁰. Other studies assessing the presence of morbidities across older adult age groups have also found higher prevalence in the oldest age group¹¹.

It is important to consider the remarkable heterogeneity of biological age among individuals within the same age category. Furthermore, social disparities, which are already evident among older adults in Brazil, become even more pronounced among individuals aged 80 years and over¹². These findings reinforce the importance of health promotion strategies adapted by sex and age group, while addressing social inequalities.

One limitation of this study relates to potential recall bias due to the use of self-reported information, as well as disparities in educational levels across regions, which may have influenced morbidity estimates. Another limitation concerns the absence of objective clinical measures to confirm diagnoses and other variables. Additionally, it was not possible to directly control the quality and standardization of data collection procedures or variable categorization, as previously collected secondary data were used. The exclusion of socioeconomic status from the main analyses may also have restricted the understanding of socioeconomic inequalities associated with morbidities.

Nevertheless, this study provides relevant data on the morbidity profile of older Brazilian adults, stratified by sex, age groups, and regions, based on a nationally representative sample. The findings contribute to the planning of actions aimed at preventing and managing chronic diseases, particularly within the context of Primary Health Care. The comparative analysis between 2013 and 2019 enables the identification of trends and the prioritization of strategies adapted to the epidemiological and regional context of the country, promoting greater equity.

CONCLUSION

The most prevalent morbidities were, respectively, hypertension, chronic back problem, hypercholesterolemia, diabetes mellitus, and arthritis or rheumatism, both in Brazil and across its regions. The distribution of morbidities was more prevalent among younger older adults, women, and residents of the Southeast region, despite notable differences across subgroups. Overall, we observed an upward trend in the percentage variation of morbidities among older adults between 2013 and 2019 across the Brazilian regions.

This study makes an important contribution to public health research, particularly in geriatrics and gerontology, by providing data on the distribution of morbidities among older Brazilian adults according to sex- and age-specific subgroups, as well as regional disparities. Identifying regional patterns and inequalities highlights the need for more tailored and integrated public health strategies to address the health challenges faced by this population.

For future studies, the monitoring and follow-up of these morbidities within regional contexts is recommended, considering their specific characteristics, to obtain a longitudinal understanding of the health profile of older adults in Brazil, given the importance of identifying health needs to promote quality of life and equitable healthy aging.

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AUTHORSHIP

- Emily da Silva Eberhardt — conception, design, data analysis and interpretation; drafting and critical revision; final approval of the version; responsibility for all aspects of the work; project administration; formal analysis; conceptualization; data curation; writing – original draft; writing – review and editing; investigation; methodology; resources; approval of the version to be published.
- Sara Calumbi Nachipindo Kawalende — data analysis and interpretation; drafting and critical revision; final approval of the version; responsibility for all aspects of the work; formal analysis; conceptualization; writing – original draft; writing – review and editing; approval of the version to be published.
- Idiane Rosset — conception, design, data analysis and interpretation; drafting and critical revision; final approval of the version; responsibility for all aspects of the work; project administration; formal analysis; conceptualization; writing – original draft; writing – review and editing; investigation; methodology; resources; supervision; approval of the version to be published.






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Self-perceived health among older adults at risk of clinical-functional vulnerability in an Open University

Natália Agostinho dos Santos¹ 
Josefa Raquel Luciano da Silva² 
Ana Claudia Torres de Medeiros³ 
Josevânia da Silva² 
Fabíola de Araújo Leite Medeiros² 

Abstract

Objective: To identify and understand the self-perceived health of older adults at risk of clinical-functional vulnerability who participate in an Open University within a public higher education institution in Northeastern Brazil. **Method:** This analytical, qualitative study was based on secondary data from the project titled “Assessment of Frailty in Older Adults Participating in the Open University for Maturity.” Inclusion criteria were being an older adult, participating in the university, presenting no cognitive impairment, and presenting vulnerability risk according to the Clinical-Functional Vulnerability Index (CFVI-20). Thus, of the 102 participants, 34 were included and 68 were excluded from the sample. Data were analyzed using thematic categorical analysis, and categories were established inductively. **Results:** Three thematic categories were identified: Health as the absence of disease; Health as a state of biopsychosocial and spiritual well-being; and Health as the ability to overcome clinical-functional vulnerabilities and how the Open University contributes to this process. **Conclusion:** Continuous clinical-functional assessment of older adults is essential for the early detection of vulnerabilities and the implementation of educational interventions. In Open University programs, the social interaction promoted by institutional initiatives fosters discussion on quality of life and contributes to self-awareness in health promotion and maintenance during aging.

Keywords: Aging. Health of the Elderly. Health Promotion. Self-Perception.

¹ Universidade Estadual da Paraíba, Departamento de Enfermagem (DE/UEPB). Campina Grande, PB, Brasil.

² Universidade Estadual da Paraíba, Programa de Pós-Graduação em Psicologia da Saúde (PPGPS/UEPB). Campina Grande, PB, Brasil.

³ Universidade Federal de Campina Grande, Unidade Acadêmica de Enfermagem (UAENF/UFCG). Campina Grande, PB, Brasil.

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Correspondence
Natália Agostinho dos Santos
natisantos2302@gmail.com

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INTRODUCTION

Aging is a gradual and dynamic process that occurs universally among all human beings and is accompanied by biological, functional, biochemical, psychological, and sociocultural changes that result in a significant loss of an individual's ability to adapt to the environment over time. Functional decline increases the risk of frailty, which may arise from the aging process itself or from disabling diseases or falls that may ultimately lead to death¹.

As age advances, the disabilities accumulated over the years contribute to increased vulnerability among older adults. Geriatric syndromes (iatrogenesis, cognitive impairment, family insufficiency, sphincter insufficiency, immobility, communication impairment, and postural instability), together with the loss of social roles and experiences of loneliness, pose potential risks to active or healthy aging²⁻⁴. Within the context of demographic transition, studying functional profiles and the extent to which they affect the health of older adults becomes an essential parameter for guiding healthcare practices in response to population aging^{5,6}.

Positive self-perceived health among older adults is directly related to social determinants and health behaviors, which substantially shape the orientation of care. Self-perception is recognized as an important indicator of well-being and can guide prevention and health promotion strategies in accordance with the guidelines of the National Policy for the Health of Older Adults (PNSPI). By considering both organic and non-organic factors that affect functionality, findings from previous studies reinforce the importance of integrated multiprofessional interventions focused on quality of life⁶.

Thus, the well-being of older adults is understood to be determined by the maintenance of autonomy and independence, including the potential for social engagement and participation^{7,8}. To this end, assessing activities of daily living (ADLs) and instrumental activities of daily living (IADLs) and using validated scales that evaluate functionality and the risk of frailty and vulnerability constitute essential prerequisites for planning care-oriented actions within older adult health programs⁹.

Frailty in aging is a multidimensional condition associated with multiple factors and is characterized by reduced energy reserves and decreased resilience to stressors, which increase vulnerability and the risk of adverse clinical outcomes such as functional decline, falls, institutionalization, hospitalization, and mortality¹⁰. Recognizing that older adults have the right to access higher education institutions and participate in lifelong educational activities is a crucial component for advancing the guidelines of healthy aging. One notable example is that of Open Universities, which promote greater social interaction and shared experiences within academic environments, providing opportunities for diverse experiences, skill development, and settings that foster intergenerational encounters^{2,11-14}.

The Open University fulfills its social role by developing educational activities for older adults, guided by the fundamental principle of promoting intergenerational exchange among academics (professors and students) and older participants, fostering dialogue between academic knowledge and the lived experiences of those involved. In this context, it seeks to promote discussions that emphasize the value of knowledge, the preservation and improvement of communication, and the encouragement of the active integration of aging individuals into society¹²⁻¹⁴.

The main justification for the present study was based on the observation that academic programs within Open Universities must also incorporate clinical-functional assessment, particularly in institutions that provide training in the health sciences. Furthermore, when considering older adults who participate in such programs and are at risk of frailty, it becomes necessary to understand how they perceive their own health and how these academic environments may contribute to promoting healthy aging. Thus, the general objective was to identify and understand the self-perceived health of older adults at risk of clinical-functional vulnerability who participate in an Open University within a public higher education institution in Northeastern Brazil.

METHOD

The study was submitted to and approved by the Ethics and Research Committee of the

Universidade Estadual da Paraíba (UEPB), under opinion number 6.297.534 and Certificate of Ethical Review Submission (CAAE): 73350323.6.0000.5187. All ethical procedures followed Resolution No. 510/2016¹⁵ of the National Health Council of the Ministry of Health. Accordingly, the Informed Consent Form (ICF) and the Authorization Form for the use of secondary data were used in this study.

This is an analytical, qualitative, cross-sectional study based on secondary data from a larger umbrella project conducted between September 2023 and September 2024, titled “Assessment of Frailty in Older Adults Participating in the Open University for Maturity.” The study was conducted in two stages. In Stage I, participants were recruited, and a sociodemographic questionnaire was administered for participant characterization, followed by the Mini-Mental State Examination (MMSE) and the Clinical-Functional Vulnerability Index (CFVI-20). In Stage II, interviews were conducted using an established qualitative interview technique.

The study was carried out at the Open University for Maturity (UAMA). UAMA/UEPB is an institutional program headquartered on Campus I of the Universidade Estadual da Paraíba, located in the municipality of Campina Grande, Paraíba, in Northeastern Brazil. Data collection occurred from November 2023 to April 2024 during sessions held throughout the program’s regular academic period.

UAMA aims to address the educational needs of older adults without requiring previous academic degrees. Its institutional mission is to contribute to the improvement of personal, functional, and sociocultural capacities through educational and social activities that enhance quality of life. The initiative also seeks to promote academic integration among older adults, enabling them to deepen their knowledge in various areas, including health, leisure, general knowledge, culture, aging studies, law, and quality of life. Upon completing the course, participants submit a final assignment titled “Life History Narrative” and receive a certificate in Education for Human Aging.

The study population consisted of older adults regularly enrolled in UAMA who attended classes and participated in all activities developed during

the study period, totaling 102 regular morning participants at the time.

Inclusion criteria were being an older adult, participating in the university, not presenting cognitive impairment, and being at risk of vulnerability according to the Clinical-Functional Vulnerability Index (CFVI-20). Exclusion criteria were older adults who self-perceived their health positively in comparison to others of the same age, that is, those who answered excellent, very good, or good based on the CFVI-20.

Thus, of the 102 participants, 34 were included in the sample and 68 were excluded. This exclusion was necessary to understand the phenomenon of self-perceived health among those at risk of vulnerability who did not self-perceive their health as positive. It is important to note that self-perceived health is a subjective health indicator among older adults and is related to social determination^{6,14}. Therefore, the analytical focus resulted in a sample of 34 older adults at risk of vulnerability with negative self-perceived health. Based on this sample, the following guiding questions were analyzed: How do you self-perceive your health? How does the Open University influence your health perception?

The Mini-Mental State Examination (MMSE) is a widely used screening scale for cognitive impairment among different populations, including adults and older adults. It proposes different scoring thresholds according to the individual’s years of schooling. Cut-off points between 19 and 20 are recommended for older adults with no formal education, and between 23 and 24 for those with prior schooling, such that scores below these thresholds indicate cognitive impairment¹⁶.

The Clinical-Functional Vulnerability Index (CFVI-20) is a Brazilian rapid screening tool that identifies clinical-functional vulnerability among older adults and may be administered by any trained healthcare professional. It contains 20 items addressing different health domains, with a total possible score of 40 points. Scores from 0 to 6 indicate a robust older adult, scores from 7 to 14 indicate moderate risk of frailty, and scores above 15 indicate high frailty, classifying the individual as frail¹¹.

Interviews were audio-recorded using an Android smartphone and transcribed verbatim with the support of pre-tested headphones. Three rounds of transcript revision were conducted based on repeated listening to the recordings. Narrative identification was performed through a coded organization of the interviews, using the letter “i” (older adult) followed by the ordinal code of each transcript. Thus, the participant labeled as i.1 refers to the transcript of the first interviewee. This procedure enabled the construction of the interview *corpus*.

The narratives were organized and methodologically assessed using thematic categorical analysis. Bardin (2009)¹⁷ defines a set of content analysis techniques comprising the following stages: (1) pre-analysis, involving initial reading and corpus organization; (2) exploration of the material, categorization, and coding; and (3) treatment of the results, inference, and interpretation. The thematic categories were established inductively.

DATA AVAILABILITY

All datasets supporting the findings of this study are available upon request to the corresponding author, given that they contain information that could compromise the privacy of the research participants.

RESULTS AND DISCUSSION

A total of 34 older adults were analyzed, classified as being at risk of clinical-functional vulnerability according to the CFVI-20 and who self-perceived their health as poor or very poor. This characterization highlights the need to deepen the understanding of how they perceive their own health, as well as how participation in the Open University influences their well-being. Three thematic categories were identified: Category I, Health as the absence of disease; Category II, Health as a biopsychosocial and spiritual state of well-being; and Category III, Health as the ability to overcome clinical-functional vulnerabilities and how the Open University supports this process.

The category identified as “Health as the absence of disease” was recognized in the statements of seven participants, whose self-perceived health was

described by directly associating health with the absence of illness. When health is defined as the absence of disease, a limited awareness emerges regarding the possibilities of managing aging based on the pillars of health promotion, prevention of health conditions, stabilization, supported self-care, and continuous assessment of potential risk stratification, as recommended in the guideline for older adult care¹¹.

The narratives in this thematic category highlight the predominance of the hegemonic biomedical model, which fragments care and hinders a comprehensive health approach. This perspective reflects long-standing challenges in healthcare systems regarding the management of chronic conditions and reinforces the need to broaden debate and incorporate this topic into the agendas of the health sciences. Representative statements include:

“Health is being well cared for when illness appears; it is not feeling pain, not needing to take so much medication, and not having diseases. It is going to the physician and being attended; it is going to the clinic and having physicians and medications for our problems, and we do not have that. Health is being treated and undergoing treatment; for this reason, my health is poor as an older adult.” (i.1)

“I think health is everything as a whole, right? It is having a physician to provide care; it is not having disease. Health is living without illness, without having many types of diseases like I do. There is hypertension, taking medication, diabetes, osteoporosis, so many ailments.” (i.17)

There is a clear need to expand health-education spaces that include older adults, with the purpose of promoting new conceptions that guide individuals toward understanding healthy aging. Similarly, there is a need for gerontological and geriatric training in healthcare, considering that many curricula still do not include mandatory components focused on older adult care¹⁸.

Open Universities expand discussions on topics such as health education; however, there remains a need for educational spaces that enable the general population to understand self-perceived health

not merely as the absence of disease and curative pharmacological treatments, but as an integral perspective of well-being and maintenance of functional capacity, even when illness is present.

The World Health Organization (WHO) defines health as a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity⁶. This supports the current debate highlighting the need to contextualize aging within the framework of the chronic disease care model, demystifying aging from the perspective of being treated as a disease¹¹.

The health of older adults must be understood broadly, considering not only the absence of disease but also the physiological and mental changes, the environmental and cultural contexts of aging, the social determinants of health, and the role of healthcare training in the quality of care provided¹⁸.

Health conditions in aging are shaped by multiple health indicators, particularly physical, cognitive, and muscular strength deficits. Thus, the onset of disease is understood as a form of wear that may occur in various ways and at different points in the human lifespan, not only among those who grow old. However, confronting these conditions is inherent to the physiological changes attributed to the aging process itself^{19,20}.

Considering this thematic category analyzed in an open university setting, where health promotion is grounded in dialogue with older adults, it became evident that there is a need for further advancement in strategies to reach the aging population, with the aim of optimizing effective health practices according to the guidelines for healthy aging. Such resources may support lifestyle changes, strengthen self-perceived self-care, and contribute to disease prevention, thereby optimizing active aging and enhancing longevity and quality of life among older adults¹⁹⁻²². Therefore, the open university is recognized as an educational space for the promotion of health among older adults, as well as a setting for the exchange of experiences among academics (faculty and students), older participants, and the broader community.

In the second thematic category, “Health as biopsychosocial and spiritual well-being,” 17 participants referred to health as a balance of biopsychosocial and spiritual dimensions. In this context, findings indicate that these individuals cultivate healthy lifestyle practices, even while perceiving their health as fair or poor. Examples include the following statements:

“Health is living with tranquility, having love, having peace, always receiving a hug that cures any illness. That, for me, is health. Even today, I am not feeling very well because I woke up with knee pain, but even so, I feel balanced; I just wish the pain would improve a little more.” (i.9)

“In my view, health is peace of mind. I think health has no price, right? It is the most important thing you must have in your life—first health, and then peace. Because when you do not have these two things, you have nothing. Everything you try to do, if you have a problem, you cannot manage it. I, thank God [...] have my ailments, and although today I feel a little shaken in terms of my health, I am seeking balance each day, following my diets, praying daily, and also following the recommendations of the regimens.” (i.32)

In this category, it is possible to observe that even in the presence of health complaints and situations initially classified as poor or very poor, health is understood as well-being and as biopsychosocial and spiritual balance. This understanding emerges in the context of confronting challenges through resilience and lifestyle reorganization, within the limitations inherent to aging. Therefore, health is recognized as a path of ongoing pursuit of balance, even amid the complaints resulting from the human aging process and its trajectory of risks for vulnerability and frailty.

Health is understood as a state of well-being that must be continuously constructed, requiring willingness, self-care, self-knowledge, and adequate socioeconomic conditions, as well as access to essential services. Thus, there is a need to foster new perspectives on health aimed at more comprehensive models of care that restore autonomy and independence in care practices, together with incentives for disease prevention and health promotion.

In this regard, when examining the self-perceived health of participants at risk of vulnerability in health, it becomes evident that quality of life remains a reference point for the basic health needs of the group analyzed. It is also noteworthy that education, cultural factors, basic sanitation, and spiritual, physical, mental, psychological, and emotional well-being, across various domains including existential, personal fulfillment, family, environmental, social, and professional spheres, are essential for a resilient view of healthy aging with quality of life²⁰⁻²².

Thus, quality of life in aging requires an empowered understanding of health among this population with regard to health promotion, enabling social participation, recognition, and social support. For this reason, health policies and initiatives that encourage active aging, with attention to the biopsychosocial and spiritual dimensions of the individual, become essential²⁰.

In the third thematic category, titled “Health is being able to overcome clinical-functional vulnerabilities and how the open university helps in this process,” ten participants mentioned in their responses that the open university serves as a collaborative space for coping with clinical-functional vulnerability. The open university promotes social interaction and health education, contributing to a realistic and positive view of health and of overcoming challenges, as expressed in the statements below, in which participants describe their efforts to overcome difficulties and seek knowledge to face the human aging process:

“I consider my health poor because I have diabetes and hypertension, but UAMA has brought me better quality of life through learning. At this stage of life, being able to study and meet committed professors from whom I have learned a great deal is invaluable. Even though I think my health is poor, what saves me is having friendships that I will carry throughout my life. Seeking to improve my self-esteem, this is what happens to us here at UAMA.” (i.7)

“I do not consider my health good because I have a lot of pain and fatigue, but I overcome all of this with faith in God by coming to UAMA. That is what matters, sharing with friends the pains of

aging. Here at UAMA it is very good. We learn a lot, and that helps me overcome my problems.” (i.8)

“For me, health is taking care of myself. For example, I need several treatments, and one of them is urgent, physical therapy, which I have not been able to do because of a fall I had, and this arm no longer lifts. I also have balance problems, so I really need assistance. Even so, I overcome all of this with my knowledge. I always seek improvement and never give up. I learned from life, but UAMA also helps us gain more understanding about overcoming age-related challenges.” (i.10)

Although the statements refer to negative aspects that corroborate the problems experienced, they are framed from a positive perspective, since these older adults participate in a space that provides health education, opportunities for socialization, and support from a professional team in carrying out activities. Group-based practices for older adults foster continuity of autonomy and independence and also contribute to reducing the risks of loneliness and social isolation^{22,23}.

In this sense, the narratives of older adults help elucidate how they perceive changes in their daily lives and in their own life trajectories when they are included in an educational environment for older learners. Open Universities are thus understood as fundamental institutions that influence improved self-esteem, self-knowledge, the establishment of affective bonds, and the sharing of experiences. Through these processes, they justify how essential such programs are for empowering this population and fostering satisfaction in acquiring new knowledge^{4,12,13}.

Self-perceived health, as well as the aging process, are intrinsically interconnected and reflect the ongoing pursuit of understanding quality of life, thereby expanding the continuity of efforts to promote and implement actions that benefit this age group. In this perspective, previous studies indicate that older adults participating in an Open University for Mature Adults seek to remain up to date, engage in memory exercises, reduce anxiety, and take an active role in decision-making related to health matters, pursuing meaningful engagement that promotes active aging^{12,13,22,23}.

Accordingly, open universities bear the responsibility of reframing actions related to aging and ensuring that older adults remain actively integrated into their communities and society. This enables them to feel useful and valued, allows their knowledge to be recognized in enriching environments, and promotes well-being and satisfaction. Moreover, it respects their life experiences and diversity of perspectives while supporting the maintenance of functional capacity and cognitive abilities^{11,12}.

It is important to emphasize that the role of professionals in these environments includes providing assistance and care to older adults, assessing their health, establishing humanized care plans, and fostering relevant themes for shared discussion. Such professionals and their socioeducational interventions offer encouragement and contribute to modifying life habits, with the aim of promoting functional independence and autonomy²⁰.

The study also identified that a minority, seven participants, perceived their health as fair or poor, associating their self-perceived health exclusively with the presence of diseases. Divergent paradigms emerged, as seventeen participants understood health as well-being rather than the mere absence of disease, recognizing that physical, social, mental, and spiritual well-being are essential components for feeling well throughout the human aging process. Given the heterogeneity of the group, expanding spaces for dialogue on health within the open university may stimulate creative and targeted initiatives that support healthy aging.

Considering the benefits observed among older adults participating in UAMA, the importance of such environments for human development and for understanding this stage of life becomes clear. This underscores the urgent need for effective public policies that promote the creation of similar initiatives aimed at meeting the needs of this population. These spaces not only provide new knowledge but also ensure the promotion of health.

The bonds, learning experiences, and social interactions fostered by UAMA gave new meaning to the lives of the participants, including those facing adversities inherent to aging, contributing to a more fulfilling older age. The expansion of open university

programs, understood as spaces that promote social interaction, health, and intergenerational encounters, represents significant progress for gerontological discussions in both academia and society.

A limitation of this study was its conduct in only one open university unit, highlighting the need for further investigations that broaden the discussion of self-perceived health in other academic and geographic contexts to deepen understanding of this topic.

CONCLUSION

It was observed that some participants perceived health as the absence of disease, while most associated it with biopsychosocial and spiritual well-being. It was also evident that the open university contributes to health discussions within the context of social interaction among older adult participants, as well as to the training of students, and serves as a platform for promoting health education for the aging community.

Accordingly, self-perception may vary among individuals, while the construction of knowledge and the ongoing pursuit of independence aim to broaden understanding, preventing self-perceived health from being limited to a single, isolated definition. Continued research on this topic is necessary to strengthen scientific knowledge and to support the robustness of functional capacity, given the evident growth of this population.

It is essential to continuously assess the health of older adults to prevent vulnerabilities and promote educational actions, especially in environments such as open universities, which foster care and self-awareness in the aging process.

AUTHORSHIP

- Santos, N. A. – initial drafting, conceptualization, data curation, writing, investigation, methodology.
- Silva, J. R. L. – formal analysis, investigation, visualization, review and writing.

- Medeiros, A. C. T. – review and editing, visualization.
- Silva, J. – review and editing, funding acquisition, visualization.
- Medeiros, F. A. L. – formal analysis, project administration, investigation, methodology, funding acquisition, review and editing, validation, and visualization.

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Retirement leisure: association of loneliness and social support network with depression in older adults – a cross-sectional study

Miriam de Lima Mohallem¹ 

Julia Brandão Vaz Cipriano¹ 

Deruchette Danire Henriques Magalhães¹ 

Rogério Donizeti Reis¹ 

Abstract

Objective: To determine whether loneliness and social support network characteristics are associated with depression among retired older adults. **Method:** An observational, cross-sectional, analytical study was conducted. The sample comprised 144 older adults. The inclusion criterion was being an older adult with preserved communication ability and cognition, assessed using the Kahn Mental Status Questionnaire. Participants not meeting the criteria established by this instrument were excluded. The instruments used were the UCLA Loneliness Scale (UCLA-BR), the Geriatric Depression Scale (GDS-15), and the Medical Outcomes Study Social Support Scale (MOS-SSS). Sociodemographic variables included age, sex, religion, education, monthly income, marital status, falls in past month, polypharmacy, comorbidities, length of retirement, and self-rated health. **Results:** Mild-to-moderate levels of loneliness ($p < 0.001$), low emotional support ($p < 0.003$), low affective support ($p < 0.002$), and low positive social interaction ($p < 0.001$), as well as the predictors presence of comorbidities ($p < 0.021$), fair or poor perceived health ($p < 0.001$), monthly income below the minimum wage ($p < 0.022$), and being single ($p < 0.041$), were significantly associated with depressive symptoms. **Conclusion:** The study revealed that loneliness, low emotional, affective and positive social interaction support, as well as comorbidities, poor perceived health, low income, and being single, increased vulnerability to depression among the retired older adults.

Keywords: Older Adults.
Loneliness. Depression.
Social Support.

¹ Faculdade de Medicina de Itajubá, Curso de Medicina. Itajubá, MG, Brasil.

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Correspondence
Rogério Donizeti Reis
rogerio.reis@afya.com.br

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INTRODUCTION

The most marked growth in the Brazilian population has occurred among the stratum of older adults, which showed an annual growth of over 4% between 2012 and 2022. The national population aged 60 years or older, estimated at 14.2 million in 2000, is projected to reach 73.5 million by 2060. Over the next 10 years, an annual increase of over 1 million older adults is expected¹.

The demographic change seen today has a significant impact on society, raising concerns about the sustainability of health and social welfare systems, while also posing new challenges for the development of public policies². In this scenario, understanding the determinants that influence rate of cognitive decline and ways of preserving cognitive performance during late life has become increasingly relevant³.

The "use it or lose it" theory suggests that cognitive performance tends to deteriorate when the individual is not mentally challenged or stimulated. Thus, retirement may increase the risk of more rapid cognitive decline due to the reduction in cognitively demanding activities after stopping working. However, this negative effect of retirement can vary among different occupational groups. People in professions with high intellectual demands are expected to experience less age-related decline while still working, compared to those in occupations with lower mental demands^{3,4}.

Retirement typically causes people to lose access to social contacts, lifestyles and daily routines, as well as potential stimuli, activities and purpose, which may lead to depressive symptoms such as loneliness and hopelessness⁵. In addition to these aspects, given the value that work holds in contemporary society as a means of achieving recognition and social status⁶, the post-retirement period directly impacts the social valorization of older adults, as well as their self-esteem, which may also contribute to the development of depression.

Leisure, in this context, becomes a relevant factor to be considered. Although it may represent an opportunity for rest and recreation, excessive leisure without meaningful activities can intensify the feelings of loneliness and isolation already present in

the post-retirement period. The loss of routine and social contacts, coupled with a lack of engagement in activities that promote interaction and purpose, can make free time a negative experience, increasing the risk of psychological distress and depression. Therefore, it is crucial that leisure be balanced with social and recreational activities that promote belonging, thereby helping to preserve the mental health of older adults⁷.

Given that loneliness, weakening of the social support network and depression are common in older adults, the rationale behind this study was to address a prevalent problem that significantly compromises quality of life and also increases the risk of comorbidities and mortality. In this context, strategies that promote social engagement, cognitive stimulation and maintenance of life purpose after retirement, become fundamental for mitigating the negative effects of cognitive decline and depressive disorders in this population. Understanding these factors is essential to inform public policies and support the development of effective interventions to foster healthy aging and improve quality of life of older adults.

Against this backdrop, the objective of the present study was to determine whether loneliness and social support network characteristics are associated with depression in retired older adults.

METHOD

An observational, cross-sectional, analytical study, involving older adults from a city in the interior of Minas Gerais state, was conducted. The sample size calculation was based on an estimated prevalence of depression of 6% in older adults, an alpha error of 5%, one-tailed test, normal distribution, and a minimum statistical power of 80%, giving an estimated sample of 144 participants. The reference rate adopted for the calculation was based on data from the World Health Organization, which estimates that depression affects 4.8% of the world population and 5.8% of the Brazilian population.

Mental status assessment was used as an inclusion criterion. Thus, retired older adults with preserved communication and cognitive abilities were

included, as measured by the Kahn Mental Status Questionnaire, a validated instrument adapted for use in Brazil. Individuals scoring below the cutoff point, indicating the presence of signs of cognitive impairment, as well as those who could not read, a requirement for understanding the scales applied, were excluded.

Given the cross-sectional design of the study, the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)⁸ were followed.

Data collection was carried out between March and April 2025 by a previously trained team, ensuring standardization of procedures and uniformity in the application of the instruments. The training consisted of theoretical alignment activities and interview simulations, in order to minimize disparities among evaluators. Individual interviews were conducted in community locations with high circulation, such as squares, parks, and bus stops. The cognitive assessment did not involve clinical examinations or specialized medical evaluation, being based solely on the validated instrument, an aspect taken into account as a study limitation.

The cognitive assessment was the first procedure, entailing application of the Kahn Mental Status Questionnaire, originally developed by Kahn et al. in 1960 in "Brief Objective Measures for the Determination of Status in the Aged" and culturally adapted and validated for Brazil⁹. This abbreviated 10-item questionnaire assesses temporal-spatial orientation and memory for remote facts. Participants had to answer at least 7 questions correctly to meet the basic criteria of temporal-spatial orientation for inclusion in the study¹⁰.

Subsequently, sociodemographic and clinical information was collected using a structured questionnaire devised by the authors for the purposes of this study, containing closed items probing sex, age, religion, education, monthly income, marital status, history of falls in last month, use of multiple medications (polypharmacy), self-reported comorbidities, length of retirement, and perceived health.

Depression among the retired older adults was measured using the Geriatric Depression Scale (GDS-15)¹¹. The GDS is a widely used validated diagnostic instrument for depression in older adults¹². This scale has 15 negative affirmative questions, scoring 1 or 0 points. A total sum of scores of 0-5 is deemed normal; 6-10 indicates mild-to-moderate depression, and 11-15 severe depression.

Loneliness was assessed using the UCLA-BR Loneliness Scale¹³. The scale, originally called the University of California Los Angeles (UCLA) Loneliness Scale, has been adapted and validated for use in Brazil. The UCLA-BR consists of 20 questions, probing social interaction (how the person relates) and isolation (withdrawal from social interaction); with responses scored as 0-3 for each item. Regarding scale scores: 0-22 points indicates minimal loneliness; 23-35, mild loneliness; 36-47, moderate loneliness; and 48-60, intense loneliness¹⁴.

Social support network was assessed using the Portuguese version of the Medical Outcomes Study (MOS) Social Support Scale¹⁵ validated for Brazil⁹. The questionnaire contains 19 items covering the following functional dimensions of social support: material, affective, positive social interaction, and emotional/informational. Participants must indicate their perceived frequency of each type of available support: never, rarely, sometimes, almost always, or always⁹.

For each item, the participant must indicate how often they consider each type of support available: never, rarely, sometimes, almost always, or always, and the interpretive scores are⁹: Material support: ≤6: Low perception; 7-13: Medium perception; ≥14: High perception. Affective support: ≤4: Low perception; 5-10: Medium perception; ≥11: High perception. Emotional/informational support: ≤12: Low perception; 13-28: Medium perception; ≥29: High perception. Positive social interaction: ≤6: Low perception; 7-13: Medium perception; ≥14: High perception.

The project was approved by the Research Ethics Committee (CEP) of the Medical School of Itajubá (FMIT), under approval No. 7.416.538, and

complied with all recommendations of Resolution Nos. 466/2012¹⁶ and 510/2016¹⁷, which provide for ethics guidelines applicable to research involving humans in Brazil.

Descriptive statistics were employed for data analysis, with categorical variables expressed as frequency and percentage. The following statistical procedures were used for associations: chi-square, Cramer's V, and Wald test. An error measure of 5% (0.05) was adopted for statistical significance, with a 95% confidence interval.

Inferential analysis was performed using a multivariate logistic regression model. Parameter estimation of the model was based on the Maximum Likelihood Estimation (MLE) method, using the Newton-Raphson optimization algorithm to maximize the log-likelihood function and fit the logit link function to the data. For the selection of independent variables, an automated stepwise methodology (hybrid) was adopted. The decision criterion for iterative inclusion and exclusion of predictors was based on the Wald test statistic. Thus, the final model retained only variables that had statistically significant coefficients, ensuring a parsimonious and well-fitting multivariate model.

DATA AVAILABILITY

The full data set underpinning the study results is available from Figshare.com at <https://doi.org/10.6084/m9.figshare.30924161>.

RESULTS

The sociodemographic and health profile of the older adults evaluated, as well as the relationship of these variables with the presence of depressive symptoms, are presented in Table 1. The results show which characteristics were most strongly associated with depression in the group studied, highlighting the major differences across the categories analyzed.

Table 2 provides a summary of the distribution of loneliness levels among participants and their association with depressive symptoms. Increased loneliness shows an association with higher rate of depression, highlighting the role of this variable in the context analyzed.

The nature of the associations between the social support network domains and the presence of depressive symptoms are presented in Table 3. The data set reveals those social support dimensions which had the greatest influence on the mental health of the retired older adults.

The odds ratios of the predictors found to be statistically significant are shown in Table 4, allowing estimation of the magnitude of risk associated with each category analyzed in terms of depressive symptoms.

The multivariate model with the predictors that remained significant after adjustment are presented in Table 5. This shows the strength of association between each variable and depressive symptoms, identifying independent factors with the greatest impact.

Table 1. Sociodemographic and health characteristics and association with depression (N=144). Itajubá, Minas Gerais state, 2025.

Predictor	No depression		Mild/Moderate depression		Severe depression		Total	<i>p</i> -value	
	AF	RF (%)	AF	RF (%)	AF	RF (%)	AF	RF (%)	
Sex									
Female	57	74.0	17	22.1	3	3.9	77	53.5	0.473
Male	53	79.1	14	20.9	0	0.0	67	46.5	
Age (years)									
60 - 69	41	73.2	12	21.4	3	5.4	56	38.9	0.380
70 - 79	50	82.0	11	18.0	0	0.0	61	42.4	
≥ 80	19	70.4	8	29.6	0	0.0	27	18.8	

to be continued

Continuation of Table 1

Predictor	No depression		Mild/Moderate depression		Severe depression		Total	<i>p</i> -value	
	AF	RF (%)	AF	RF (%)	AF	RF (%)	AF	RF (%)	
Religion									
Catholic	85	79.4	20	18.7	2	1.9	107	74.3	0.571
Catholic, Spiritist	1	100.0	0	0.0	0	0.0	1	0.7	
Spiritist	3	60.0	2	40.0	0	0.0	5	3.5	
Evangelical	15	65.2	8	34.8	0	0.0	23	16.0	
Other	1	100.0	0	0.0	0	0.0	1	0.7	
No religion	5	71.4	1	14.3	1	14.3	7	4.9	
Education (years)									
1-4	15	93.8	1	6.2	0	0.0	16	11.1	0.170
5-8	25	73.5	9	26.5	0	0.0	34	23.6	
> 9	68	73.9	21	22.8	3	3.3	92	63.9	
No education	2	100.0	0	0.0	0	0.0	2	1.4	
Monthly income (MW)									
1-2 MW	55	73.3	18	24.0	2	2.7	75	52.1	0.647
> 3 MW	52	80.0	12	18.5	1	1.5	65	45.1	
< 1 MW	3	75.0	1	25.0	0	0.0	4	2.8	
Marital status									
Married	60	83.3	11	15.3	1	1.4	72	50.0	0.166
Divorced	15	71.4	6	28.6	0	0.0	21	14.6	
Single	12	60.0	7	35.0	1	5.0	20	13.9	
Widowed	23	74.2	7	22.6	1	3.2	31	21.5	
Falls in last month									
No	98	79.0	24	19.4	2	1.6	124	86.1	0.077
Yes	12	60.0	7	35.0	1	5.0	20	13.9	
Polypharmacy									
No	63	82.9	12	15.8	1	1.3	76	52.8	0.052
Yes	47	69.1	19	27.9	2	2.9	68	47.2	
Comorbidities									
No	29	90.6	3	9.4	0	0.0	32	22.2	0.021
Yes	81	72.3	28	25.0	3	2.7	112	77.8	
Length of retirement (years)									
2-5	19	73.1	7	26.9	0	0.0	26	18.1	0.707
> 6	80	76.2	23	21.9	2	1.9	105	72.9	
< 1	11	84.6	1	7.7	1	7.7	13	9.0	
Perceived health									
Poor	1	50.0	1	50.0	0	0.0	2	1.4	<0.001
Fair	13	40.6	17	53.1	2	6.2	32	22.2	
Good	65	85.5	10	13.2	1	1.3	76	52.8	
Excellent	31	91.2	3	8.8	0	0.0	34	23.6	

Source: Authors, 2025. N= Sample size, AF: Absolute Frequency, RF (%): Relative Frequency (percentage), *p*-value= Level of statistical significance ($p < 0.05$), MW: minimum wage.

Table 2. Regression analysis of loneliness versus depression (N=144). Itajubá, Minas Gerais state, 2025.

Predictor	No depression		Mild/moderate depression		Severe depression		Total	<i>p</i> -value	
	AF	RF (%)	AF	RF (%)	AF	RF (%)	AF	RF (%)	
Loneliness scale									
Minimal loneliness	103	85.1	17	14.0	1	0.8	121	84.0	<0.001
Mild loneliness	5	33.3	9	60.0	1	6.7	15	10.4	
Moderate loneliness	2	25.0	5	62.5	1	12.5	8	5.6	

Source: Authors, 2025. N= Sample size, AF: Absolute Frequency, RF (%): Relative Frequency (percentage), *p*-value= Level of statistical significance ($p < 0.05$).

Table 3. Regression analysis of social support network domains versus depression (N=144). Itajubá, Minas Gerais state, 2025.

Predictor	No depression		Mild/moderate depression		Severe depression		Total	<i>p</i> -value	
	AF	RF (%)	AF	RF (%)	AF	RF (%)	AF	RF (%)	
Emotional/informational support									
Perceived low	5	71.4	1	14.3	1	14.3	7	4.9	0.003
Perceived medium	23	57.5	15	37.5	2	5.0	40	27.8	
Perceived high	82	84.5	15	15.5	0	0.0	97	67.4	
Material support									
Perceived low	10	47.1	2	41.2	0	11.8	12	8.3	0.06
Perceived medium	23	80.3	12	18.9	2	0.8	37	25.7	
Perceived high	77	81.1	17	17.9	1	1.1	95	66	
Affective support									
Perceived low	3	42.9	4	57.1	0	0	7	4.9	<0.002
Perceived medium	32	69.6	11	23.9	3	6.5	46	31.9	
Perceived high	75	82.4	16	17.6	0	0	91	63.2	
Social interaction support									
Perceived low	4	57.1	3	42.9	0	0.0	7	4.9	<0.001
Perceived medium	15	50.0	12	40.0	3	10.0	30	20.8	
Perceived high	91	85.0	16	15.0	0	0.0	107	74.3	

Source: Authors, 2025. N= Sample size, AF: Absolute Frequency, RF (%): Relative Frequency (percentage), *p*-value= Level of statistical significance ($p < 0.05$).

Table 4. Odds Ratio analysis, significant predictors for depression (N=144). Itajubá, Minas Gerais state, 2025.

Predictor	cat_A	cat_B	Odds (A/B)	Lower bound	Upper bound
Marital status	Divorced	Single	0.50	0.06	4.12
	Divorced		1.96	0.22	17.69
	Single	Widowed	3.93	0.47	32.88
Perceived health	Fair	Fair	-	-	-
	Fair	Excellent	7.22	5.51	59.13
	Poor	Excellent	-	-	-
Monthly income	> 3 MW	< 1 MW	0.68	0.01	48.99
Affective support	Perceived low	Perceived low	2.17	0.09	19.36
Emotional/informational support	Perceived low	Perceived medium	0.38	0.01	17.78
Loneliness scale	Moderate loneliness	Minimal loneliness	11.41	0.69	187.90

Source: Authors, 2025. cat-A: category A (reference for comparison); cat-B: category compared to category A, Odds (A/B): odds ratio between categories, lower bound: confidence interval lower limit (95%), Upper bound: confidence interval upper limit (95%). MW: minimum wage.

Table 5. Multivariate regression analysis, significant predictors versus depression (N=144). Itajubá, Minas Gerais state, 2025.

Predictor	Regression coefficient (β)	Confidence interval		<i>p</i> -value	Chi ²	Cramer's V
		Lower	Upper			
Monthly income (MW)						
1-2 MW	-	-	-	0.022	7.611	0.077
> 3 MW	1.60	-0.54	3.73			
< 1 MW	7.11	2.06	12.16			
Marital status						
Married	-	-	-	0.041	8.246	0.191
Divorced	0.5	-1.89	2.89			
Single	3.10	0.72	5.47			
Widowed	-1.12	-3.58	1.35			
Perceived health						
Good	-	-	-	0.009	11.662	0.465
Fair	3.96	1.54	6.38			
Poor	25.80	*	*			
Excellent	-1.41	-4.26	1.43			
Loneliness scale						
Minimal loneliness	-4.78	-7.93	-1.64	0.001	13.213	0.473
Mild loneliness	-	-	-			
Moderate loneliness	3.62	-0.54	7.78			
Emotional/ informational support						
Perceived low	-9.33	-15.81	-2.84	0.018	8.067	0.284
Perceived medium	-1.54	-3.86	0.78			
Perceived high	-	-	-			
Affective support						
Perceived low	3.87	0.14	7.59	0.047	7.38	0.194
Perceived medium	0.65	-1.35	2.65			
Perceived high	-	-	-			

Source: Authors, 2025. (β): Regression coefficient, *p*-value: Level of statistical significance ($p < 0.05$); Chi²: chi-square test statistic; Cramer's V: measure of association strength, MW: minimum wage.

DISCUSSION

The aim of this study was to determine whether loneliness and social support network characteristics are associated with the presence of depressive symptoms in retired older adults. The results confirm this initial hypothesis, showing that mild-to-moderate levels of loneliness, low emotional, affective and positive social interaction support, as well as the presence of comorbidities, negative perceived health and income below the minimum wage, exhibited a significant association with depressive symptoms. These findings reinforce the importance of construing aging not only as a biological process, but also as a social and relational phenomenon, marked by the quality of bonds with others and living conditions.

The relationship between loneliness and depression identified in this study corroborates robust evidence from the literature, showing that older adults who experience chronic loneliness tend to have a higher probability of developing mental disorders and physical conditions, such as hypertension and cardiovascular diseases¹⁸. Loneliness negatively impacts emotional health, reduces psychological resilience, and interferes with the maintenance of brain activity, as the absence of emotional support and low social interactions deprive the individual of essential relational stimuli. This scenario renders older adults more vulnerable to stress and adverse psychological outcomes, including depression¹⁸. In studies involving similar samples, higher levels of loneliness correlated with greater presence of depressive symptoms and lower perceived social support¹³. These previous results are consistent with the findings of the present investigation, showing that loneliness is a central variable in understanding emotional distress in retired older adults.

Broader scientific evidence on the topic reveals a consistent association of loneliness and social withdrawal with depressive symptoms in older adults¹⁹. In general, the more intense the feelings of isolation and lower the affective support network, the greater the incidence of depressive disorders. This relationship pervades different sociocultural contexts, indicating that human interaction, affection,

and belonging are universal needs, whose deprivation contributes to psychological illness.

In the national scenario, a study conducted at a specialist clinic for older adults in São Paulo showed that users with high perceived emotional support and positive social interaction had higher levels of psychological well-being, while those reporting low support exhibited a higher rate of depressive symptoms²⁰. This data directly converges with the results of this study, reinforcing the protective role of social support in aging.

In a complementary manner, during the COVID-19 pandemic, the American study "All of Us Research Program", involving over 69,000 adults, found that high levels of emotional support and positive social interaction were associated with lower levels of depressive symptoms²¹. The methodological consistency of these studies reinforces that, even under adverse conditions, social support has an attenuating effect on psychological distress.

In studies conducted in other countries, such as Jordan (Middle East), a negative correlation was found between affective support and depression among institutionalized older adults, demonstrating that the absence of affective support exacerbates emotional distress²². Similar findings show that emotional support has a robust protective effect against depression²¹ and that psychosocial interventions focused on strengthening support networks can significantly reduce depressive symptoms in older adults²³.

Furthermore, longitudinal studies show that a greater number of confidants and the availability of practical help are associated with lower depressive symptoms, a relationship mediated by decreased loneliness²⁴. This evidence supports the "buffering" theoretical model, according to which social support networks act as a psychological buffer that reduces the impact of stress through emotional protection, instrumental support, and strengthening of interpersonal bonds²⁵.

The humanistic perspective of psychiatrist Nise da Silveira offers an important conceptual contribution to understanding the findings of this

study. Contrary to the coercive and exclusionary practices of traditional psychiatry, Nise defends the centrality of affection, creativity, and human bonding as fundamental therapeutic elements²⁶. In her experiences at Pedro II Hospital and the Museum of Images of the Unconscious²⁷, she showed that affective coexistence, symbolic expression, and engagement in creative activities favor social reintegration and emotional balance of people affected by psychological distress^{27,28}. Thus, her vision converges with the results of this study by confirming that affection, human contact, and feelings of belonging are essential elements in preserving mental health²⁷, especially in periods marked by changes in identity and reorganization of daily life, as occurs with retirement.

In addition to loneliness and support network, this study found that other factors were significantly associated with depression, such as the presence of comorbidities. In a study of 22,728 Brazilian older adults, 11.8% had depressive symptoms and 8.46% multiple chronic diseases, and individuals with multimorbidities had up to double the risk of developing depression²⁹. The authors also found that older adults with more restricted support networks and less involvement in community activities exhibited higher rates of depression. These results reaffirm that physical health and mental health are interdependent dimensions, especially in aging.

Another relevant aspect concerns perceived health. Studies show that older adults who rate their health as poor or very poor have a significantly higher risk of developing depressive symptoms³⁰. A study of 185 older adults found that participants with negative perceived health had up to ten times greater chance of presenting depressive symptoms compared to those with positive perceived health³⁰. Thus, the present study confirms this association, demonstrating that the way older adults perceive their health plays a determining role in the subjective experience of emotional well-being.

Socioeconomic status also stood out as a factor associated with depression. Older adults whose income was below the minimum wage had a higher rate of depressive symptoms, a relationship widely documented in the literature. In a study involving

133 older adults, 32.4% lived on insufficient income, a situation associated with a higher rate of depressive symptoms²⁰. Similar results were found in the SABE Study, which showed that older adults whose income was insufficient to meet daily needs had a higher prevalence of depression²⁰. Additionally, single marital status proved to be a factor associated with depression: among female older adults residing in rural areas of Mato Grosso do Sul state, 23.29% had depressive symptoms, especially among those who were single and had negative perceived health³¹.

These findings align with the DSM-5 guidelines, which characterize depression as a multifactorial disorder, involving psychological, biological, genetic, and environmental aspects²⁴. In the older population, depression has a major impact, being associated with a higher risk of disability, worsening chronic diseases, suicide, and mortality. Leisure resulting from retirement can negatively impact the social and emotional structure of older adults, reducing significant interactions and weakening support networks. In this sense, the social support network constitutes a central space of emotional support, representing the interface between the individual and society³². Such networks directly influence how older adults perceive their world, face adversities, and establish relationships, being potentiated by family, community, and affective bonds. These bonds, when strengthened, act as protective elements against the vulnerabilities inherent to the aging process.

This study has some limitations that should be noted. The cross-sectional design precludes any causal inference between the analyzed variables and limits the study to identifying associations. The use of self-report instruments may have introduced bias regarding individual perceptions, while the sample of retired older adults from a specific geographic context restricts the generalization of the study results. Future studies should adopt longitudinal designs and more diversified samples to further understanding on the role of loneliness, support networks, and perceived health in the development of depressive symptoms among retired older adults. Investigations should also explore community interventions, coexistence programs, and psychological strategies that promote social integration, affective strengthening, and positive perceived health.

CONCLUSION

The present study provides consistent evidence that the main factors associated with depression in retired older adults are mild-to-moderate loneliness, and low emotional, affective, and positive social interaction support. Furthermore, the presence of comorbidities, negative perceived health, monthly income below the minimum wage, and single marital status were found to increase vulnerability to depressive symptoms. This study is innovative in so far as it integrates both psychosocial and socioeconomic dimensions in elucidating emotional illness during retirement, a period marked by changes in identity and social bonds. The results underscore the role of interdisciplinary strategies for promoting mental health, especially through strengthening support networks and affective relationships, fundamental elements for preventing depression and enhancing quality of life in late adulthood.

AUTHOR CONTRIBUTIONS

- Miriam de Lima Mohallem – Conceptualization; study design; data analysis and interpretation; writing – original draft.
- Julia Brandão Vaz Cipriano – Conceptualization; study design; data analysis and interpretation; writing – original draft.
- Deruchette Danire Henriques Magalhães – Data analysis and interpretation; writing – review and editing; approval of the version to be published; responsibility for all aspects of the work.
- Rogério Donizeti Reis – Conceptualization; study design; data analysis and interpretation; data curation; writing – first review; writing – review and editing; final approval of the version to be published; responsibility for all aspects of the work.

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Evolution of the Population Aging Index in Brazil (1991–2022): temporal analysis and sociodemographic determinants

Samuel de Carvalho Dumith¹ 
Eduarda da Cunha Policarpo² 
Letícia Vitória Mourão Meira Pereira² 
Marcos Cirilo Sana Monteiro² 
Eduardo Caldas Costa³ 

Abstract

Objective: To analyze the evolution of the Population Aging Index (PAI) in Brazil from 1991 to 2022 and to evaluate its association with selected demographic and socioeconomic indicators. **Methods:** This is an ecological time-series study using data from the Brazilian Demographic Censuses and intercensal estimates from the Brazilian Institute of Geography and Statistics (IBGE). The PAI was calculated as the number of individuals aged ≥ 60 per 100 aged 0–14. Annual percent change (APC) in PAI was estimated through Prais-Winsten regression. Selected variables included sex ratio, population density, population growth rate, life expectancy, fertility, infant mortality, urbanization, Palma ratio, Gini index, gross domestic product and Human Development Index. **Results:** The PAI increased from 16.7 in 1991 to 68.4 in 2022, constituting a 300% rise over 30 years. Higher values were concentrated in the South and Southeast, and lower values in the North. The fertility rate and Gini index were negatively associated with PAI-APC in the final model, while GDP showed a positive association. These factors explained 84% of PAI variation across states. **Conclusion:** Population aging in Brazil has rapidly and unevenly advanced, with faster growth in more developed states. The findings should be interpreted considering that some of the analyzed indicators constitute direct demographic determinants of population aging. Nevertheless, the results highlight the need for intersectoral and regionally tailored public policies to address the challenges posed by accelerated and unequal population aging.

Keywords: Aging. Population Dynamics. Socioeconomic Factors. Health Inequality Indicators. Brazil.

¹ Universidade Federal do Rio Grande, Faculdade de Medicina, Programa de Pós-graduação em Ciências da Saúde. Rio Grande, RS, Brasil.

² Universidade Federal do Rio Grande, Faculdade de Medicina. Rio Grande, RS, Brasil.

³ Universidade Federal do Rio Grande do Norte, Departamento de Educação Física, Programa de Pós-graduação em Ciências da Saúde. Natal, RN, Brasil.

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Correspondence
Samuel de Carvalho Dumimth
scdumith@yahoo.com.br

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INTRODUCTION

Population aging is a demographic phenomenon characterized by an increase in the proportion of older adults in relation to younger age groups in the population's age structure¹. This process has intensified particularly rapidly in recent decades in Brazil. The older adult population increased from approximately three million people in 1960 to about 20 million in 2008, corresponding to a growth of almost 700% in less than 50 years². This movement occurred in line with the demographic transition, characterized by replacement of a regime of high fertility and mortality rates with another marked by the sustained reduction of these indicators^{1,2}. From this perspective, the Brazilian demographic transition stood out for its speed and scope when compared to that observed in high-income countries², contributing to imbalances in the dynamics of the country's social and economic institutions.

This aging process reflects social and economic transformations that occurred throughout the 20th century, including the greater insertion of women into the labor market, associated with a reduction in fertility rates; an expansion of education, with increased average schooling and access to higher education; and advances in public health and technology, which improved living conditions and raised life expectancy at birth^{3,4}. Together, these factors have shaped the country's current demographic profile characterized by low population growth and greater longevity, posing significant challenges to social and economic development.

The analysis of population aging can be operationalized through the Population Aging Index (PAI), defined as the ratio between the number of people aged 60 or older and the number of individuals aged between zero and 14 years. This indicator allows us to synthesize changes in the age structure and compare aging patterns between regions and over time, being particularly useful for territorial analyses in contexts of accelerated demographic transition.

Population aging in Brazil poses challenges to economic and social systems, with repercussions on the labor market, social security, consumption patterns, and the organization of health systems^{3,5–8}.

However, these impacts manifest themselves unevenly among the regions of the country, reflecting differences in demographic and socioeconomic profiles. In this sense, investigating the evolution of the PAI and its association with demographic and socioeconomic indicators allows us to understand how these inequalities are expressed in the dynamics of Brazilian population aging. Given this context, it becomes relevant to analyze the temporal evolution of the Population Aging Index in Brazil and its association with selected demographic and socioeconomic indicators in an integrated way considering the regional heterogeneity of the country. Despite the relevance of the topic, studies that explore these associations over extended periods, especially at the state level, are still limited.

Thus, the objective of this study was to analyze the evolution of the Population Aging Index in Brazil between 1991 and 2022 and to evaluate its association with selected demographic and socioeconomic indicators.

METHODS

This is an ecological time-series study. The data source was the Brazilian Institute of Geography and Statistics (*IBGE* – <https://www.ibge.gov.br/en/home-eng.html>). We collected data from the Brazilian Demographic Censuses conducted in the years 1991, 2000, 2010, and 2022, and from estimates for their intervals (1996, 2006, 2016).

The PAI in Brazil is measured as the number of older adults aged 60 or older per 100 children and adolescents aged 0 to 14. We calculated the PAI for each of the 27 Brazilian states for these seven years mentioned (1991, 1996, 2000, 2006, 2010, 2016, and 2022). Next, we used Prais-Winsten regression to estimate the variation in the PAI between 1991 and 2022 (32 years) considering the autocorrelation of the residuals. This analysis generates an annual percentage variation coefficient (APC) with its respective 95% confidence interval (95%CI). When the 95%CI does not include the value zero, it means that the APC is increasing (if positive) or decreasing (if negative); when the 95%CI includes the value zero, it means that the APC is stable during this period.

The contextual factors (covariates) included in the analysis were: sex ratio (number of men divided by the number of women); population density (number of inhabitants per square kilometer); geometric population growth rate (constant rate at which a population changes from one period to the next); life expectancy at birth (average number of years a newborn can expect to live); fertility rate (number of children per woman); infant mortality rate (number of deaths before one year of age divided by the total number of live births); urbanization index (percentage of the population living in urban areas); Palma ratio (ratio of income of the richest 10% to the poorest 40%); Gini coefficient (a statistical measure of dispersion designed to represent income inequality, wealth inequality, or consumption inequality); Gross Domestic Product (GDP – a standard measure of the value added created through the production of goods and services); and Human Development Index (HDI – a statistical index composed of indicators of life expectancy, education, and per capita income).

These covariates were analyzed for the most recent year for which they were available. Most were extracted from the latest *IBGE* Demographic Census (*IBGE*, 2022). Otherwise, if the variable was not available in the latest Census, it was extracted from the year 2016 (namely: life expectancy at birth, infant mortality rate, urbanization index, and Palma index).

The analyses were performed in the first half of 2025. Simple and multiple regressions were performed to test the association between each covariate and the variation in the PAI. We categorized each covariate into tertiles for analysis purposes and tested them in both forms (continuous and categorical). Next, we present only the significant association for the variables in tertiles in the Results section, as these explained the greatest variability (R^2 coefficient) of the outcome. Variables with a p -value less than 0.20 were kept in the final model, and those with a p -value less than 0.05 had statistical significance. Linear trend tests were also performed.

The study used exclusively secondary, aggregated, and publicly accessible data, without the possibility of individual identification. Therefore, it is exempt from review by a Research Ethics Committee, in accordance with Resolution No. 510 of the National Health Council, of April 7, 2016.

DATA AVAILABILITY

The entire dataset supporting the results of this study is available upon request from the corresponding author, Samuel C. Dumith.

RESULTS

The PAI in Brazil changed from 16.7 in 1991 (ranging from 8.5 in Roraima to 32.5 in Rio de Janeiro) to 68.4 in 2022 (ranging from 27.1 in Roraima to 115.4 in Rio Grande do Sul). This represents an absolute increase of 51.7 percentage points (pp) or a relative increase of 300% over 30 years (Table 1). Among the 27 Brazilian states, the average annual percentage change (APC) for the PAI from 1991 to 2022 was 1.8 (95%CI 1.6 to 2.1), ranging from 0.7 (in Roraima) to 3.2 (in Rio Grande do Sul).

Considering the Brazilian regions, the APC-PAI ranged from an average of 1.1 (SD=0.4) in the North region to 2.8 (SD=0.4) in the South region (Figure 1). It increased almost fourfold between 1991 and 2022 for all five regions, rising from 10 to 40 in the North region, and from 24 and 23 to 96 and 97 for the Southeast and South regions, respectively. This means that there is virtually one older adult (60 years or older) for every child or young person under 15 years old in the Southeast and South regions, as based on the last Census (2022). However, considering the North region (lowest PAI in Brazil), there are approximately two individuals under 15 years old for every individual 60 years or older.

Table 1. Description of the population aging index (PAI) and the annual percentage change (APC) for each Brazilian state (n=27), 1991 to 2022.

State	PAI _1991	PAI _1996	PAI _2000	PAI _2006	PAI _2010	PAI _2016	PAI _2022	APC (pp)	APC (95%CI)
Rondônia	9.4	12.1	15.2	20.3	26.6	35.3	56.4	1.7	0.8; 2.5
Acre	10.8	12.7	14.1	15.0	19.0	22.6	35.3	0.8	0.3; 1.3
Amazonas	9.6	11.4	12.5	15.0	18.2	22.8	33.3	0.8	0.4; 1.3
Roraima	8.5	9.3	10.5	13.1	16.6	21.7	27.1	0.7	0.4; 1.0
Pará	11.5	13.6	15.5	18.4	22.7	29.3	44.1	1.2	0.5; 1.9
Amapá	8.6	9.4	10.4	12.0	15.5	19.7	31.1	0.8	0.3; 1.4
Tocantins	13.5	16.3	19.3	23.5	29.5	37.7	53.9	1.5	0.7; 2.2
Maranhão	13.7	16.8	19.3	23.1	28.0	34.7	49.8	1.3	0.6; 1.9
Piauí	16.2	20.6	24.8	31.3	40.0	49.3	72.6	1.9	1.2; 2.7
Ceará	19.9	23.0	26.4	32.8	41.6	52.3	71.7	1.9	1.1; 2.8
Rio Grande do Norte	22.1	25.0	28.5	34.7	43.6	52.9	76.3	1.9	1.1; 2.8
Paraíba	23.9	27.8	32.4	38.6	47.4	57.1	74.5	1.8	1.2; 2.5
Pernambuco	21.3	25.1	28.6	33.8	41.6	50.3	70.3	1.7	0.9; 2.5
Alagoas	15.9	18.3	20.6	24.4	30.4	39.7	57.5	1.5	0.6; 2.4
Sergipe	17.3	19.7	22.0	26.9	33.4	42.9	62.7	1.7	0.7; 2.6
Bahia	17.3	21.5	25.8	32.3	40.4	52.2	75.7	2.1	1.1; 3.1
Minas Gerais	22.3	27.3	32.0	41.0	52.6	71.9	98.3	2.8	1.4; 4.2
Espírito Santo	19.3	23.8	29.1	35.3	44.9	58.9	85.5	2.4	1.2; 3.6
Rio de Janeiro	32.5	38.2	42.6	50.0	61.5	79.3	105.6	2.7	1.3; 4.1
São Paulo	25.1	29.6	34.0	42.5	53.9	68.1	95.6	2.6	1.4; 3.8
Paraná	20.5	24.9	29.5	38.0	49.0	65.5	85.9	2.4	1.4; 3.5
Santa Catarina	20.4	24.3	28.5	37.2	48.2	66.5	89.8	2.6	1.4; 3.9
Rio Grande do Sul	29.7	34.8	40.1	50.8	65.5	87.4	115.4	3.2	1.7; 4.7
Mato Grosso do Sul	16.5	20.5	24.7	31.1	39.1	49.6	64.5	1.8	1.1; 2.4
Mato Grosso	11.5	14.7	18.1	23.8	30.7	40.1	52.0	1.5	1.0; 2.0
Goiás	16.7	20.5	24.5	31.0	39.0	49.2	67.5	1.8	1.1; 2.6
Distrito Federal	11.8	15.1	14.2	24.6	32.5	45.2	68.4	2.1	1.2; 3.0
Brasil	16.7	20.5	24.7	24.5	39.1	49.3	68.4	1.9	0.9; 2.9

pp: percentage points; 95%CI: 95% confidence interval.

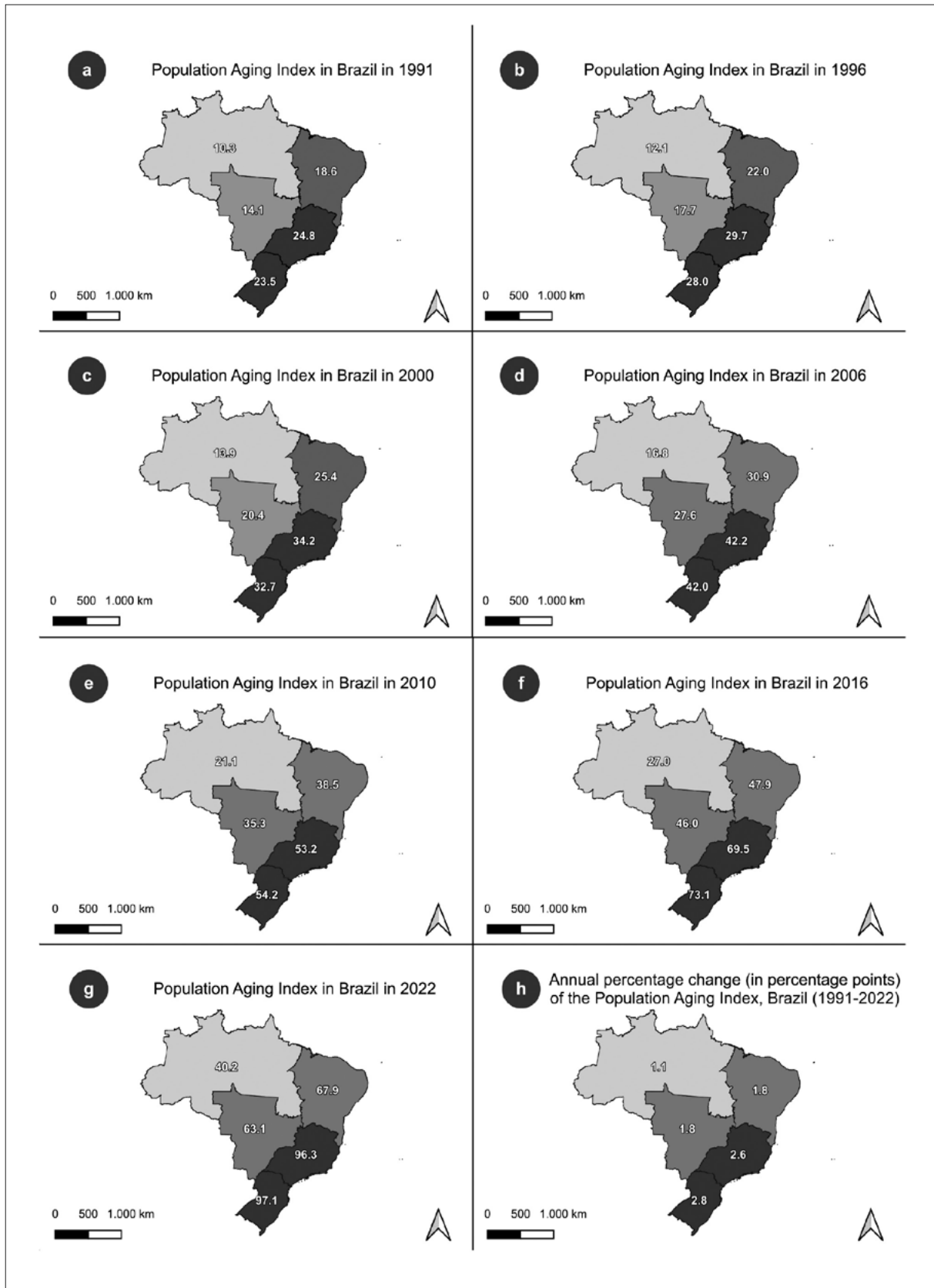


Figure 1. Description of the population aging index (PAI) according to the regional division of Brazil, 1991 to 2022.

The variables associated with the APC-PAI (Annual Percentage Change in the Population Aging Index) in the final statistical model were: fertility rate, Gini coefficient, and GDP (Table 2). We observed a negative association with the fertility rate and the Gini coefficient, meaning that an increase in their tertiles resulted in a lower APC-PAI. On the other hand, there was a positive association with GDP, meaning that each increase in its tertile resulted in a higher APC-PAI. Together, these variables explained 84% (adjusted R^2 coefficient) of the variability in the outcome (APC-PAI). The exposure variable most associated

with the outcome was the fertility rate, meaning that states in the third tertile (highest fertility rate) showed an average of a 1.2 percentage point (pp) smaller increase in APC-PAI compared to the first tertile (states with the lowest fertility rate).

The other variables included in the statistical analyses (sex ratio, population density, geometric population growth rate, life expectancy at birth, infant mortality rate, urbanization index, Palma index, HDI) did not reach statistical significance (p -value >0.20) and were excluded from the final model.

Table 2. Crude and adjusted analyses of the annual percentage change (APC) in the population aging index (PAI) associated with contextual factors for the 27 federative units of Brazil – 1991 to 2022.

Contextual variables (tertiles)	Crude analysis		Adjusted analysis*	
	Beta (95%CI)	P-value**	Beta (95%CI)	P-value**
Fertility rate		<0.001		<0.001
1 st (lower)	Reference (0)		Reference (0)	
2 nd (intermediate)	-0.38 (-0.82; 0.07)		-0.47 (-0.77; -0.16)	
3 rd (higher)	-1.14 (-1.58; -0.69)		-1.23 (-1.55; -0.92)	
Gini coefficient		0.2		<0.01
1 st (lower)	Reference (0)		Reference (0)	
2 nd (intermediate)	-0.87 (-1.42; -0.32)		-0.42 (-0.73; -0.11)	
3 rd (higher)	-0.40 (-0.95; 0.15)		-0.56 (-0.91; -0.21)	
Gross Domestic Product (GDP)		0.01		0.01
1 st (lower)	Reference (0)		Reference (0)	
2 nd (intermediate)	-0.13 (-0.66; 0.40)		0.16 (-0.17; 0.49)	
3 rd (higher)	0.74 (0.21; 1.27)		0.45 (0.10; 0.79)	

CI: confidence interval; * Adjusted for each of the other variables presented in this table; ** p -value for linear trend

DISCUSSION

This study provides a comprehensive analysis of trends in the PAI across all Brazilian states from 1991 to 2022, as well as its association with key contextual factors. Key findings reveal that the PAI quadrupled during this period (from 17% to 68%), reflecting an average increase of almost two percentage points (pp) per year. Furthermore, the PAI growth was inversely associated with the fertility rate and the Gini coefficient, and directly associated with GDP. Moreover, the distinct demographic stages of the states are reflected in the PAI of the state of Rio Grande do Sul (for example), which was already higher in 1991 (29.7) than the value presented in Roraima in 2022 (27.1). Taken together, these results highlight the demographic intensification of population aging in Brazil and emphasize the influence of reproductive patterns, social and economic factors on its progression. By identifying the contextual determinants of aging, this study provides evidence that can guide regional planning and formulation of equitable public policies for healthy aging.

A study⁹ analyzing the period from 1970 to 2010 identified a 268% increase in PAI in Brazil, providing a different temporal perspective from our study, which also highlights the country's rapid population aging. The authors reported the highest PAI values in the South (54.9) and Southeast (54.6) regions in 2010, while the North had the lowest (21.8), with this regional pattern also being observed in the present study. Although the study did not directly examine variables associated with aging, the authors observed that more developed regions tend to have higher PAI values⁹. This was confirmed in our analysis, which found a direct relationship between PAI and GDP, and an inverse relationship with the Gini coefficient. The study also presents estimates from the United Nations Population Division, which projected that Brazil would reach a PAI of 68.3 by 2025, a threshold already surpassed in 2022 according to our data.

The fertility transition, one of the components of the demographic transition, represents the shift from a pattern of high and poorly controlled fertility levels to a scenario of birth planning, with a reduction in births and also in neonatal deaths. According to

a Brazilian study¹⁰, the fertility transition process occurred in different ways both intra- and inter-regionally, highlighting the uniqueness of the country's demographic dynamics. Some Brazilian states with greater urban and economic development, such as Rio de Janeiro, São Paulo, and Rio Grande do Sul, experienced a slow fertility transition, beginning in 1930 or earlier (given the lack of sufficient records), which is consistent with what occurred in European countries.

However, many states experienced the fertility transition phenomenon in an accelerated manner, starting in the 1960s or 1970s¹⁰, when the reduction in the fertility rate was recorded throughout the national territory in a sustained and uninterrupted way. Furthermore, at the inter-regional level, this study¹⁰ indicated that the state of Santa Catarina presented homogeneous variation in the fertility rate throughout its territory over the study period, while Minas Gerais was the state with the greatest heterogeneity in its municipalities, being divided into five parts. In other words, even in a socioeconomically developed state, demographic changes occur at different rates according to the microregion.

Another national study¹ which also presents an overview of the Brazilian demographic transition indicated that the national fertility rate began to decline from the end of the 1960s, reaching the replacement threshold (which produces zero population growth) in the 2000s. Furthermore, this same study¹ compared the decline in the fertility rate in Brazil with that of England: while in England it took 100 years to show a 58% decline (from 5.3 in 1870 to 2.2 in 1970), in Brazil there was a 60% reduction in 30 years (from 5.8 in 1970 to 2.3 in 2000). This study¹ reinforces how quickly this rate decreased in Brazil, a middle-income country which has seen rapid narrowing of the age pyramid compared to high-income countries, implying super-accelerated population aging.

Previous studies have shown that population aging in Brazil is more pronounced in states with higher socioeconomic development levels, which is reflected in indicators such as GDP per capita, urbanization, and access to health. In this context, a study⁴ highlighted the geographically heterogeneous

nature of population aging in Brazil. Based on GDP, the most economically developed regions (South and Southeast) have the highest proportions of older adults, in contrast to the lower rates observed in the North and Northeast. A study published in 2021¹¹ examined the relationship between income inequality and aging in Brazil. Similarly, the authors identified regional heterogeneity in sociodemographic dynamics. Furthermore, their findings revealed an inverse association between income inequality and aging indicators, reinforcing that municipalities with greater income disparities tend to have less favorable aging profiles¹¹.

As reported, our APC-PAI data can be explained by about 80% by the inverse relationship between the fertility rate and the Gini coefficient and positively by GDP. These findings suggest and reinforce the secondary and paradoxical effects of successful economic advancement, such as increased education and economic inclusion of women, rising cost of living, loss of value as an economic reserve for children, and greater access to birth control.¹² A global study shows that improvements in female education and access to contraceptives, strongly linked to wealth, are the main drivers of declining birth rates, accelerating the relative aging of the population.¹³ Thus, this process leads to a reduction in the birth rate across all social strata in wealthier regions with less income disparity, which, combined with better sanitation, urban infrastructure, nutrition, education, and access to healthcare, pulls the age pyramid into an “age rectangle”^{14–16}.

Furthermore, it is important to highlight that the public policies developed in the country were essential to leverage improvement in the quality of life throughout Brazil, serving as a basis for the increase in longevity and the demographic transition. From this perspective, it is crucial to emphasize projects such as the National Immunization Program of 1973, the Unified Health System (*Sistema Único de Saúde*) and the expansion of the Family Health Strategy (*Estratégia Saúde da Família*) since 1994, as well as the expansion of access to essential medicines through the National Pharmaceutical Assistance Policy and the Popular Pharmacy Program of Brazil (*Política Nacional de Assistência Farmacêutica e do Programa*

Farmácia Popular do Brasil) created in 2004, given that they constituted fundamental pillars for improving health indicators, increasing longevity and the quality of life of the Brazilian population^{17,18}. Furthermore, expansion and improvement in the education system, also supported by public policies, contributed to increasing human capital, reducing inequalities, and directly influencing demographic dynamics by acting on the determinants of fertility and age structure, postponing entry into the labor market and family formation, and promoting changes in reproductive patterns¹⁹.

Alongside population aging, social assistance policies serve as a foundation for mitigating socioeconomic inequalities in advanced ages²⁰, highlighting the Organic Law of Social Assistance (*Lei Orgânica da Assistência Social (LOAS)* – Law No. 8,742/1993), which established the Continuous Benefit Payment (*Benefício de Prestação Continuada - BPC*) as a guarantee of minimum income for older adults in vulnerable situations, regardless of social security contributions. Furthermore, the Statute of Older Adults (*Estatuto do Idoso*) established by Law No. 10,741/2003, constitutes a landmark in the institutional adaptation of the Brazilian State to population aging resulting from the demographic transition by consolidating rights and social protection mechanisms for the population aged 60 or over²⁰.

To our knowledge, this is the first study to quantify the magnitude of variation in the PAI in the Brazilian population over the last three decades. Our estimates included data from all Brazilian states, revealing striking differences and disparities in the population aging process among geographic regions. Furthermore, we identified the contextual factors most strongly associated with population aging in the country. The Gini coefficient was no longer significant, and the association with the fertility rate was reversed. This reversal may reflect that the states with the greatest reductions in fertility were among the poorest, while the richest states experienced slower declines.

The present study suggests that if the APC-PAI (Annual Percentage Change in the Population

Aging Index) remains constant, the number of older adults in Brazil will exceed the number of children and adolescents (0 to 14 years) within the next 15 years, which is already observed in some states. These findings emphasize the importance of anticipating demographic transitions and adapting health and social systems to the new population profile. The World Health Organization (WHO)²¹ defines healthy aging as the process of maintaining functional capacity which enables well-being in old age, highlighting that health systems must be reorganized to meet the needs of aging populations. In this context, population aging not only represents a demographic change, but also a structural challenge for public health planning.

A study using data from the National Health Survey (*Pesquisa Nacional de Saúde*, 2013) showed how strongly the accumulation of chronic diseases is associated with functional dependence among older adults, reinforcing the need for integrated prevention and care strategies²². Similarly, regional analyses in the Americas indicate that the rapid increase in the proportion of older adults substantially contributes to the burden of non-communicable diseases and to a greater demand for long-term care^{8,13}.

Taken together, these findings highlight that managing population aging requires coordinated measures focused on maintaining functionality and autonomy in old age. This includes strengthening primary healthcare, expanding rehabilitation and long-term care services, and developing community environments that support active and independent living. Viewing population aging from this perspective underscores the need for strategic planning to ensure that increased longevity is accompanied by improved quality of life and system sustainability.

Some limitations of this study should be considered. We did not assess annual changes in PAI over the entire period due to the use of demographic censuses and intercensal population estimates. Thus, we selected seven points in time to ensure more reliable accuracy for trend analysis²³. Contextual factors were assessed at a single point in time at the end of the time series (2022), except for life expectancy at birth, infant mortality rate,

urbanization index, and Palma index, which were not available in the 2022 census and were obtained from the 2016 census. Furthermore, we used the age of 60 as the cut-off age for calculating PAI, while high-income countries adopt 65, which may compromise the comparability of our estimates with these countries.

CONCLUSION

The results of this study demonstrate a demographic transition process occurring heterogeneously among Brazilian states given their respective singularities in development and urbanization marked by a generalized acceleration over the last few decades. These issues converge with the findings based on the almost 300% increase in the Population Aging Index (PAI) over just three decades, in addition to the disparity in values recorded among the states, reinforcing the existence of distinct scenarios occurring simultaneously in the country. Regarding the analyzed indicators, both the fertility rate and the Gini coefficient showed an inverse association with the PAI, while the Gross Domestic Product of each state showed a positive association. Therefore, it is crucial to understand the different sociodemographic dynamics to effectively meet the specific population demands of each region, uniting public policies and studies focused on the analysis of structural factors in the fields of health, education, and social assistance as a fundamental strategy to understand and respond to the challenges posed by the rapid aging of the Brazilian population.

AUTHORSHIP

- Samuel C. Dumith: study conception, data analysis and interpretation, article writing, approval of the final manuscript version.
- Eduarda C. Policarpo: data tabulation, article writing, approval of the final manuscript version.
- Letícia V.M.M. Pereira: data tabulation, article writing, approval of the final manuscript version.

- Marcos C.S. Monteiro: data tabulation, article writing, approval of the final manuscript version.
- Eduarda C. Costa: critical review of the article, approval of the final manuscript version.

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Estimation of glomerular filtration rate: an evaluation of the use of different equations in the clinical context of older patients

Andreson Félix da Cruz¹ 
Matheus Eduardo do Nascimento Barreto¹ 
Francisca Sueli Monte Moreira¹ 
Renally Cristina Lima da Silva² 
Ricardo Brandão² 
Erika Michelle do Nascimento Facundes Barbosa¹ 

Abstract

Objective: To verify the level of agreement between the Chronic Kidney Disease Epidemiology Collaboration 2021 (CKD-EPI 2021) and Cockcroft-Gault (CG) equations regarding medication dose adjustment for renal function in older patients, and to analyze whether these estimates imply changes in clinical management. **Methods:** Observational study with a longitudinal and prospective design, including individuals aged 60 years or older, followed during hospitalization. Agreement between dose adjustments based on CKD-EPI 2021 and CG was assessed using the Kappa (κ) test. **Results:** A total of 54 medical records were analyzed, of which the majority were male (53.7%) and younger than 73 years (57.4%). The level of agreement ranged from very good to excellent for atenolol, spironolactone, morphine, metformin, and escitalopram. However, medications such as meropenem, domperidone, piperacillin tazobactam, vancomycin, metoclopramide, regular insulin, and enoxaparin showed moderate to low agreement. In addition, the results indicate that a change in clinical management would occur in 40.40% of the medications that did not present a good level of agreement when one equation or the other was selected. **Conclusion:** There is potential interchangeability between CKD-EPI 2021 and CG for medications that demonstrated a good level of agreement. However, caution is warranted when selecting the equation for medications not included in this group, as the choice may alter clinical management and affect therapeutic effectiveness or increase the risk of toxicity.

Keywords: Kidney Function Tests. Chronic Kidney Disease. Drug Utilization. Elderly.

¹ Universidade Federal de Pernambuco, Hospital das Clínicas, Departamento de Farmácia Clínica. Recife, PE, Brasil.

² Universidade Federal de Pernambuco, Centro de Ciências da Saúde, Departamento de Ciências Farmacêuticas. Recife, PE, Brasil.

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Correspondence
Andreson Félix da Cruz
andre.son.f@hotmail.com

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INTRODUCTION

The demographics of aging are changing rapidly as a result of increased life expectancy. It is estimated that by 2030 approximately 12% of the world population will consist of individuals aged 60 years or older. In Brazil, data from the 2022 census conducted by the Brazilian Institute of Geography and Statistics (IBGE) estimated that the population aged 60 years or older reached 32,113,490 individuals (15.6%), representing an increase of 56.0% compared with 2010^{1,2}.

Aging can be described as a process of irreversible deterioration of physiological activities related to survival and fertility, resulting in impaired tissue and organ function over the life course. This process is one of the most relevant risk factors for the development of a large proportion of chronic diseases, as demonstrated in major population-based studies^{3,4}.

Systemic changes resulting from prolonged human lifespan range from alterations in body composition to bioenergetic imbalance and neurodegeneration. These changes may lead to reductions in resting cardiac output, maximal respiratory capacity, nerve conduction velocity, and glomerular filtration rate (GFR), which are among the most frequently observed alterations^{3,4}.

In this context, nephrosenescence refers to the progressive decline in renal function associated with aging, which occurs even in healthy individuals. As life advances, the likelihood of developing chronic kidney disease (CKD) increases. For patients in the hospital setting, estimating renal function is essential, whether for diagnostic purposes and/or CKD management, or for dose adjustment of medications excreted via the renal route⁵⁻⁷.

In clinical practice, renal function is estimated using equations based on serum creatinine (sCr). The first equation developed was the Cockcroft-Gault equation, in 1976, which estimates creatinine clearance (CrCl) rather than GFR. This is because both glomerular filtration and tubular secretion contribute to creatinine clearance. Tubular secretion of creatinine may account for up to 50% of its total clearance, particularly in the presence of impaired

renal function and comorbidities such as obesity. Consequently, GFR may be overestimated when calculated using this equation. The Cockcroft-Gault formula estimates renal clearance based on body weight, age, and sex^{5, 8-10}.

In 2009, the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) research group in the United States conducted a study aimed at developing and validating a new sCr-based estimation equation. The first version of this equation considered, in addition to sCr, factors such as sex, age, and race. Adopted by the Kidney Disease Improving Global Outcomes (KDIGO) initiative since 2012, it has become the most widely used method worldwide. In 2021, the CKD-EPI formula was updated following a publication by the National Kidney Foundation (NKF) and the American Society of Nephrology (ASN), which removed race-based modifiers, as they are not biological parameters¹⁰⁻¹².

Within this framework, the predictive performance of drug pharmacokinetics may differ depending on whether the estimated glomerular filtration rate (eGFR) or estimated CrCl is calculated using an equation different from that employed in the original pharmacokinetic study. In both clinical pharmacology and drug development, the Cockcroft-Gault (CG) equation has served as the reference standard for decades. Therefore, to consider equivalence between estimation methods, the same medication must be evaluated using different formulas to calculate GFR and demonstrate similar performance within the same previously established population pharmacokinetic model⁵.

The objective of this study was to assess the level of agreement between the CKD-EPI 2021 and Cockcroft-Gault equations, based on estimated glomerular filtration rate (eGFR) and estimated creatinine clearance (CrCl), respectively, regarding medication dose adjustment for renal function in older patients, and to determine whether these estimates imply changes in clinical management.

METHODS

This was an observational study with a longitudinal and prospective design involving older adults followed

during hospitalization at Hospital das Clínicas of the Federal University of Pernambuco (HC-UFPE), Brazil. Data were collected through review of patients' medical records using the *Aplicativo de Gestão para Hospitais Universitários (AGHUx)*, the electronic health record system used in Brazilian federal university hospitals, between August and November 2023. The convenience sample comprised older adults of either sex, aged 60 years or older, who were hospitalized during the study period and were using at least one medication listed in their prescription.

Exclusion criteria were as follows: absence of at least one recent serum creatinine (sCr) test result in the medical record, defined as a test performed within 72 hours before or after hospital admission; electronic prescriptions containing only medications prescribed as needed or at the physician's discretion; and absence of recorded body weight during hospitalization, as this information is essential for calculating estimated glomerular filtration rate (eGFR). Patients admitted directly to the Intensive Care Unit (ICU) or to the surgical block immediately after hospital admission were excluded. Patients initially admitted to a general ward and subsequently transferred to the ICU or surgical block were followed only until the time of transfer, as clinical instability and rapid fluctuations in clinical status in these settings could increase sample heterogeneity.

The following sociodemographic, clinical, and laboratory variables were recorded: sex, age in years, educational level, body weight in kilograms (kg), height in meters (m), body mass index (BMI), calculated as weight divided by height squared (kg/m^2), comorbidities, medication-related information (name, dose, route of administration, and total number of prescribed medications), and sCr (mg/dL), used to calculate eGFR and estimated creatinine clearance (CrCl).

After data collection, eGFR and estimated CrCl were calculated for all included patients using the CKD-EPI 2021 and CG equations, respectively, as available electronically on the National Kidney Foundation® platform. Prescriptions were analyzed regarding indication, dose, and dosing regimen, as well as evaluated in relation to renal function

impairment. Medication-related information was obtained from the UpToDate® database, institutional protocols, and manufacturer prescribing information.

Data analysis was conducted using descriptive and inferential statistics. Qualitative variables were expressed as frequencies and proportions, whereas quantitative variables were presented as mean, median, range, and standard deviation. Agreement between dose adjustments based on CKD-EPI 2021 and Cockcroft-Gault was assessed using the Kappa (κ) test. This test, proposed by Cohen in 1960, uses the Kappa agreement coefficient. A κ value equal to 1 indicates perfect agreement between the evaluated methods, whereas values closer to zero indicate agreement attributable to chance. In this study, the following thresholds were adopted: values above 0.80 excellent, between 0.79 and 0.60 very good, between 0.59 and 0.40 moderate, and below 0.39 low¹³. Analyses were performed using a significance level of 0.05.

The study was submitted to and approved by the Research Ethics Committee of the Hospital das Clínicas of Pernambuco, under Certificate of Presentation for Ethical Consideration (CAAE) No. 69009823.4.0000.8807 and approval opinion No. 6045723, in accordance with Resolution No. 466/2012 of the Brazilian National Health Council (CNS), with a waiver of written Informed Consent Form (ICF). Ethical principles were observed throughout the study, and participant confidentiality and anonymity were strictly maintained.

HC-UFPE is managed by the *Empresa Brasileira de Serviços Hospitalares* (Ebserh), a federal public company that supports teaching, research, and extension and outreach activities at affiliated federal universities. The hospital is a medium and high complexity referral center for the Brazilian Unified Health System (SUS) in the state of Pernambuco and provides outpatient and inpatient care, including services in nephrology. The equations evaluated in this study were already used in routine hospital practice; however, there was no standardized guidance regarding which calculator should be used or the specific contexts for selecting one equation over the other.

DATA AVAILABILITY

The entire dataset supporting the results of this study is available upon request to the corresponding author.

RESULTS

During the study period, data were obtained from 88 patient medical records, of which 34 were excluded. Among these, 30 (88.2%) did not have creatinine results within 72 hours before or after hospital admission; 2 (5.9%) had prescriptions containing only medications prescribed as needed; 1 (2.9%) underwent surgery almost immediately after admission; and 1 (2.9%) did not have body weight recorded in the medical record by any professional category. Consequently, 54 medical records were analyzed, and their sociodemographic and clinical characteristics are described in Table 1.

The most prevalent comorbidities were systemic arterial hypertension and diabetes. CKD was present in a small proportion of the study population. Regarding BMI, 19 patients (35.2%) had values at

the extremes of the classification, either underweight or with some degree of obesity. With respect to medications, a total of 504 drugs included in the institution's standardized formulary were prescribed (median = 8, mean = 9.3, standard deviation = ± 5.3). Of these, 130 (25.8%) had recommendations for dose adjustment based on renal function.

The analysis of the level of agreement between the CKD-EPI 2021 and Cockcroft-Gault equations regarding the need for medication dose adjustment is presented in Table 2.

Table 3 presents the percentage of dose adjustment recommendations according to both equations for medications that showed moderate to low levels of agreement. Considering eGFR, 18 patients required dose adjustment for at least one medication. Among these patients, a total of 141 dose adjustments would have been required, taking into account the days on which the medications remained prescribed. Furthermore, considering this latter aspect, 57 adjustments (40.40%) would have resulted in different clinical management decisions depending on whether one equation or the other was used.

Table 1. Demographic, social, and clinical characteristics of the older adults included in the study (N = 54). Recife, Pernambuco, Brazil, 2023.

Characteristics	Values
Male sex – n (%)	29.0 (53.7)
Age (years) – m (\pm SD)	72.5 (8.8)
Age group – n (%)	
60-73	31.0 (57.4)
73 \geq	23.0 (42.6)
Body weight (kg) – m (\pm SD)	67.2 (17.9)
Height in meters (m) – m (\pm SD)	1.6 (0.1)
BMI, kg/m ² – n (%)	
≤ 18.5 – Underweight	5.0 (9.3)
18.6–24.9 – Normal weight	19.0 (35.2)
25.0–29.9 – Overweight	16.0 (29.6)
30.0–34.9 – Obesity class I	10.0 (18.5)
35.0–39.9 – Obesity class II	2.0 (3.7)
≥ 40.0 – Obesity class III	2.0 (3.7)

to be continued

Continuation of Table 1

Characteristics	Values
Educational level – n (%)	
No formal education	21.0 (38.9)
Incomplete elementary education	14.0 (25.9)
Complete elementary education	9.0 (16.7)
Incomplete high school	1.0 (1.9)
Complete high school	7.0 (13.0)
Incomplete higher education	1.0 (1.9)
Complete higher education	1.0 (1.9)
Non-smokers and non-alcohol users – n (%)	50.0 (92.6)
Comorbidities* – n (%)	
Systemic arterial hypertension	46.0 (26.4)
Diabetes	28.0 (16.1)
Oncological diseases	16.0 (9.2)
Cardiac system diseases	15.0 (8.6)
Vascular diseases	15.0 (8.6)
CKD	6.0 (3.4)
Other**	48.0 (27.6)
No reported drug allergy – n (%)	52.0 (96.3)
Number of prescribed medications – m (\pm SD)	10.3 (5.5)
Length of hospital stay – m (\pm SD)	12.4 (12.7)
eGFR – CKD-EPI 2021 – n (%)	
≥ 90	14.0 (25.9)
60-89	21.0 (38.9)
30-59	15.0 (27.8)
≤ 29	4.0 (7.4)
CrCl – CG*** – n (%)	
≥ 90	10.0 (18.5)
60-89	14.0 (25.9)
30-59	24.0 (44.4)
≤ 29	6.0 (11.1)

Source: Study data, 2023; SD = standard deviation; CKD = chronic kidney disease; BMI = body mass index; kg = kilogram; kg/m² = kilograms per square meter; m, SD = mean and standard deviation; n, % = absolute and relative frequency; eGFR = estimated glomerular filtration rate expressed in mL/min/1.73 m²; CrCl = creatinine clearance expressed in mL/min. *Considering n = 174 as the sum of comorbidities across all patients. **“Other” includes conditions such as hypothyroidism, dyslipidemia, respiratory, gastrointestinal, hepatic, hematological, neurological, urological, and bone diseases. ***Cockcroft-Gault.

Table 2. Agreement between the CKD-EPI 2021 and Cockcroft-Gault equations regarding the need for medication dose adjustment according to the Kappa test. Recife, Pernambuco, Brazil, 2023.

Medication	n	κ	<i>p</i>	Level of agreement
Atenolol	33	1.000	< 0.001	Excellent
Spirolactone	19	0.883	<0.001	Excellent
Morphine	13	0.843	0.002	Excellent
Metformin	12	0.750	0.007	Very good
Escitalopram	18	0.640	0.004	Very good
Meropenem	12	0.500	0.079	Moderate
Domperidone	24	0.357	0.022	Low
Piperacillin + Tazobactam	17	0.354	0.056	Low
Vancomycin	19	0.336	0.050	Low
Metoclopramide	13	0.316	0.120	Low
Regular insulin	24	0.149	0.459	Low
Enoxaparin	91	0.109	0.120	Low

Source: Study data, 2023; κ = Kappa coefficient; n = sample size; *p* = significance level.

Table 3. Percentage of dose adjustment recommendations based on estimated glomerular filtration rate calculated using the CKD-EPI 2021 and Cockcroft-Gault equations for medications with κ values below 0.6. Recife, Pernambuco, Brazil, 2023.

Medication	CKD-EPI 2021			Cockcroft-Gault		
	n (%)	m*	CI	n (%)	m**	CI
Meropenem	7 (58.3)	44.0	3.4	6 (50.0)	38.2	11.3
Domperidone	4 (16.7)	24.5	5.9	1 (4.2)	28.0	***
Piperacillin + Tazobactam	4 (23.5)	27.0	9.5	10 (58.8)	32.3	4.1
Vancomycin	12 (63.2)	17.9	6.9	17 (89.5)	25.6	4.6
Metoclopramide	1 (7.7)	52.0	***	4 (30.4)	46.3	11.1
Regular insulin	13 (54.2)	35.3	6.0	15 (62.5)	42.2	9.8
Enoxaparin	2 (2.2)	26.5	31.8	12 (13.2)	25.1	2.0

Source: Study data, 2023; n = absolute frequency; % = relative frequency; m = mean; CI = confidence interval. *Mean estimated glomerular filtration rate expressed in mL/min/1.73 m²; **Mean estimated creatinine clearance expressed in mL/min; ***Confidence interval could not be calculated due to the sample size consisting of only one observation.

DISCUSSION

The results of the present study show that the level of agreement between the CKD-EPI 2021 and Cockcroft-Gault (CG) equations for medication dose adjustment based on renal function varies according to the medication being adjusted. Complementarily, the choice of equation for this purpose may alter clinical management, which can positively or negatively affect treatment safety or effectiveness.

The κ values for atenolol, spironolactone, morphine, metformin, and escitalopram indicate a degree of variation between the two equations that may be considered negligible. This finding opens the possibility of discussing renal dose adjustment for these medications regardless of which of the two equations is used.

In 2011, the KDIGO initiative published a statement addressing recommendations on this topic, focusing on chronic kidney disease (CKD)

and acute kidney injury (AKI). According to this document, no specific equation is defined as the best option for this purpose. The recommendation is to use the method that provides the greatest accuracy, regardless of whether it is estimated creatinine clearance (CrCl), estimated glomerular filtration rate (eGFR), or measured creatinine clearance obtained from a 24-hour urine collection¹⁴.

There is no evidence confirming the superiority of any single method for medication dose adjustment across all patient populations or clinical situations. In its most recent update, the KDIGO practical guidelines for CKD adopt a less favorable position regarding the use of the CG equation; however, they emphasize that, to date, few studies have compared different eGFR equations in the context of medication dosing¹⁵.

Two equations, known as the Berlin Initiative Study equations 1 and 2 (BIS 1 and BIS 2), were developed and validated with the aim of estimating GFR specifically in older adults. This work consisted of a cross-sectional study conducted in Germany with 600 patients and used creatinine as the biomarker¹⁶. Despite the relevance of the initiative and its contributions, the sample comprised only White individuals older than 75 years, which limits extrapolation to other populations, including the one evaluated in the present study.

In addition, the KDIGO statement addresses the controversies surrounding the main equations, including CKD-EPI and CG. Methodological differences between equations strongly influence estimated values. In this regard, KDIGO recommends selecting a single formula for estimation, patient follow-up, and medication dose adjustment, as this approach may provide greater safety with respect to changes occurring in renal function¹⁵.

Some pharmacokinetic studies evaluating drug clearance across different levels of renal function do not clearly specify which equation was applied in their methodology. These studies underpin clinical reference tools widely used in practice, such as UpToDate®, and this lack of clarity may represent a confounding factor in equation selection. Furthermore, the way adjustment ranges are presented in these tools, whether based on

estimated CrCl or eGFR and expressed in mL/min or mL/min/1.73 m², respectively, may induce preference for a particular equation.

Additionally, the publication date of an article may be another factor influencing the choice of calculator. It is known that the first version of the CKD-EPI equation, which included race as a modifier, was created and validated in 2009¹¹. Prior to that, few calculators were available, including the CG equation, originally published in 1976⁹. It is also noteworthy that pharmacokinetic testing related to renal function only became an official requirement in 1998, following guidance issued by the United States Food and Drug Administration¹⁶. This historical context may further influence equation selection, particularly regarding the use of CG for the purpose addressed in this study; however, it cannot be definitively stated that this was the equation used in studies conducted prior to the development of CKD-EPI.

As an example of the issues discussed above, atenolol was the medication with the highest κ value in this study, with the following dose adjustment recommendation described in UpToDate®: a maximum dose of 50 mg for CrCl between 10 and 30 mL/min and 25 mg for CrCl below 10 mL/min^{17,18}. Pharmacokinetic studies evaluating the renal clearance of this drug do not specify which equation was used for estimation; however, they predate the development of the CKD-EPI equation.

From a practical standpoint, the greatest concern involves medications that showed moderate or poor agreement, that is, κ values below 0.60. In this study, antimicrobial agents, antiemetics, anticoagulants, and hypoglycemic agents, which are frequently used in hospital clinical practice, exhibited this pattern.

Among the antiemetic and gastrointestinal prokinetic agents identified in this study are domperidone and metoclopramide, medications that are often prescribed to oncology patients and that have potential cardiotoxicity¹⁹. In this study, oncological and cardiac diseases ranked third and fourth, respectively, in terms of prevalence. The routine use of these agents in this population is justified both by the patients' underlying clinical condition and by adverse reactions resulting from the

use of chemotherapeutic agents, which are essential for the treatment of several oncologic conditions²⁰.

Given the vulnerability of patients undergoing cancer treatment, it is essential to adopt assertive measures, such as medication dose adjustment based on renal function. The objectives of these measures are to reduce and prevent complications, such as loss or worsening of effective renal function due to the use of potentially nephrotoxic medications, including some chemotherapeutic agents. For patients who already have concomitant CKD at any stage, the goal is to minimize the impact of drug accumulation for medications that rely primarily on the renal route for clearance¹⁴.

It is also noteworthy that metoclopramide is classified as potentially inappropriate for older adults according to the Beers Criteria²¹, both when used alone, due to associated extrapyramidal effects, and when used concomitantly with other medications, because of drug drug interactions. Therefore, metoclopramide is a medication for which cautious use is recommended in older patients²¹.

Another medication with low κ agreement was regular insulin, which is also frequently prescribed in the hospital setting, mainly for glycemic correction, but also in other conditions, such as hyperkalemic emergencies²². Used in the treatment of diabetes, this disease is one of the main causes of CKD and was the second most prevalent comorbidity in this study¹⁷.

In the case of regular insulin, the issue lies in the fact that, in addition to its clearance, insulin is metabolized by the kidneys. This may lead to drug accumulation in patients with impaired renal function, potentially resulting in hypoglycemia²². However, dose adjustment based on renal function for this medication is not routinely performed in the hospital context, as capillary blood glucose is typically monitored frequently, and dose variations are generally guided by point of care glucose testing results.

With regard to antimicrobial agents, several studies have addressed safety and effectiveness in patients with impaired renal function. Meropenem, piperacillin with tazobactam, and vancomycin were also among the medications showing low agreement between formulas in the present study.

A key consideration for these drugs is the influence of pharmacokinetic and pharmacodynamic factors (PK/PD) on the selection of dosing regimens used to treat infections, particularly those associated with healthcare delivery and caused by resistant microorganisms²³.

Further regarding these therapeutic agents, factors such as molecular hydrophilicity, volume of distribution (VD), clearance pathway, half-life, sepsis, infection focus, tested minimum inhibitory concentration (MIC), as well as renal function itself, among others, guide the choice of antibiotic dose. In addition, the risk of nephrotoxicity associated with these agents also influences therapeutic decision making, especially for vancomycin and piperacillin with tazobactam when used alone or concomitantly^{17,23}.

Finally, the medication with the poorest κ value in this study was enoxaparin, an anticoagulant used both for the treatment and prophylaxis of thromboembolic events. This drug tends to accumulate when CrCl is below 30 mL/min, in which case dose reduction or switching to unfractionated heparin is generally recommended²⁴.

It was also observed that, among the medications with an indication for dose adjustment included in this study, enoxaparin was the most frequently prescribed, appearing almost three times as often as the second most prescribed medication. This finding should be interpreted cautiously, as it raises the question of whether agreement results might have differed if prescription frequencies had been balanced across medications. Conversely, it is important to highlight that there was a considerable proportion of differing clinical decisions regarding dose adjustment depending on whether one equation or the other was adopted.

Thus, it is essential that the equation used be the one that ensures the most appropriate dose adjustment for treatment. Studies referenced by the UpToDate® tool for dose adjustment of meropenem, vancomycin, piperacillin, and enoxaparin used the CG equation to estimate CrCl²⁴⁻²⁷. In contrast, for domperidone, dose adjustment is based on expert opinion; for metoclopramide, studies do not specify which calculator was used; and for regular insulin, no reference is provided.

In this study, for most medications that showed moderate or low agreement, CG was the equation associated with higher percentages of dose adjustment. These findings suggest a potentially more conservative stance of the CG equation, in the sense of recommending dose modifications to preserve current renal function or to reduce the risk of toxicity resulting from decreased excretory capacity, despite the limitations reported. Conversely, meropenem and domperidone showed a higher number of dose adjustments when CKD-EPI 2021 was used, which also supports a conservative role of this latter equation for these two medications.

As discussed above, the equations used in this study have inherent limitations. For CKD-EPI, when comparing eGFR between obese and non-obese individuals with the same sCr value, results tend to be similar, as the equation uses a standard body surface area (BSA) of 1.73 m², based on the average BSA of Americans in 2009. In contrast, the CG equation is more closely related to estimating measured CrCl than to true GFR, as creatinine undergoes tubular secretion. Moreover, the development of the CG equation predates the standardization of creatinine measurement using isotope dilution mass spectrometry (IDMS) by the National Institute of Standards and Technology (NIST) in 2005, which may lead to overestimation of CrCl when CG is applied using current standardized assays^{9,14}.

Among the limitations of this study, the small number of participants should be highlighted. This was mainly due to the short period available for data collection and the absence of sCr measurements within the time frame established in the inclusion criteria, the latter being the primary reason for the exclusion of potential candidates. Another limitation was the performance of a single body weight measurement for all patients at the beginning of the study, without longitudinal follow-up aligned with sCr assessments, particularly among patients with longer hospital stays. Body weight is a variable that may undergo significant changes during hospitalization, especially in individuals with fluid retention secondary to cardiovascular conditions, CKD, and AKI.

Nevertheless, it is noteworthy that this study presents an important strength by addressing a topic

that remains underexplored in the Brazilian scientific literature, despite its high relevance to clinical practice. In the context of older adults, the findings underscore the importance of conscious, careful, and rational healthcare, contributing to more effective therapies and to the reduction of health-related complications, with an emphasis on patient safety. In addition, the study may support healthcare services in minimizing patient harm, reducing length of hospital stay, and lowering healthcare costs. It also contributes to improving clinical reasoning and promoting the alignment of interprofessional practices within the institution where the study was conducted.

CONCLUSION

The findings reveal the existence of disagreements among the various stakeholders involved in the medication use process regarding the estimation of kidney function and dose adjustment. Significant uncertainty persists as to which equation should be preferred or which provides the most appropriate support for clinical decision making. In this study, the CKD-EPI 2021 and Cockcroft-Gault equations demonstrated levels of agreement ranging from very good to excellent for dose adjustment of certain medications, suggesting the possibility of interchangeability between them in these cases. This may represent a favorable aspect for patients using such medications.

It should be emphasized that the considerations presented in this study are not intended to define clinical conduct nor to allow extrapolation beyond the institutional setting in which the research was carried out. However, the findings highlight the need for further investigations on this topic, given that renal function-based medication dose adjustment has direct implications for both treatment effectiveness and patient safety.

AUTHORSHIP

- Anderson Félix da Cruz – responsibility for all aspects of the study; project administration; conceptualization; data curation; writing – review & editing; methodology; funding acquisition; resources; and software.

- Matheus Eduardo do Nascimento Barreto – study conception and design; critical revision; project administration; conceptualization; data curation; writing – review & editing; methodology; funding acquisition.
- Francisca Sueli Monte Moreira – study conception and design; critical revision; approval of the final version; supervision; validation; visualization; formal analysis.
- Renally Cristina Lima da Silva – conception; data analysis; critical revision.
- Ricardo Brandão – study conception and design; critical revision; approval of the final version; supervision; validation; visualization; formal analysis.
- Erika Michelle do Nascimento Facundes Barbosa – supervision; validation; visualization; formal analysis.

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Prevalence of frailty in hospitalized older adults with diabetes mellitus: systematic review and meta-analysis

Márcia Marrocos Aristides¹ 

Maria Helena Lenardt¹ 

Clovis Cechinel¹ 

João Alberto Martins Rodrigues¹ 

María del Carmen Rodríguez-Martínez² 

Abstract

Objective: To identify the prevalence of frailty in hospitalized older adults with diabetes mellitus based on a synthesis of evidence from the literature. **Method:** A systematic review was conducted, with searches performed in the MEDLINE, EMBASE, Virtual Health Library (VHL), Scopus, SciELO, and Web of Science databases, as well as in the reference lists of the selected studies. The inclusion criteria were hospitalized older adults diagnosed with diabetes mellitus and physical frailty, with no temporal restrictions. Searches were carried out in January 2025. The guidelines established by the Joanna Briggs Institute for evidence synthesis were followed. A meta-analysis model was used to estimate the prevalence of frailty, and a random-effects model was applied for data synthesis. **Results:** A total of 2,261 articles were identified, and 12 studies were included in the meta-analysis. Despite the variability observed in the instruments used to assess frailty, a high prevalence of frail individuals (40.4%; 95% CI: 23.0% to 60.5%; $I^2 = 97.7\%$, $\tau^2 = 2.2149$, $p < 0.0001$) and pre-frail individuals (34.8%; 95% CI: 22.3% to 49.8%; $I^2 = 97.7\%$, $\tau^2 = 0.6700$, $p < 0.0001$) was identified among hospitalized older adults diagnosed with diabetes. **Conclusion:** The findings reinforce the importance of systematic frailty assessment in hospitalized older adults diagnosed with diabetes mellitus as a basis for therapeutic planning and for improving care centered on functional status.

Keywords: Aged. Frailty. Diabetes Mellitus. Meta-analysis. Inpatients.

¹ Universidade Federal do Paraná, Programa de Pós-graduação em Enfermagem. Curitiba, PR, Brasil.

² Universidad de Málaga, Facultad de Ciencias de la Salud. Málaga, Espanha.

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Correspondence
João Alberto Martins Rodrigues
morgadinho70@hotmail.com

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INTRODUCTION

Physical frailty is one of the main contributors to functional decline and premature mortality in older adults, as it is characterized as a clinical state marked by increased individual vulnerability when exposed to internal and external stressors^{1,2}. It has become increasingly evident that the risk of frailty in older adults may increase in the presence of chronic diseases, and this association has been demonstrated for diabetes mellitus (DM)³.

Older adults living with DM present high rates of mortality, functional disability, and comorbidities, in addition to a higher risk of falls, cognitive impairment, and polypharmacy⁴. Global estimates report that DM affects nearly 589 million people aged 20 to 79 years, and if this trajectory persists, it is estimated to affect 853 million individuals by 2050⁵. The Diabetes Statistics Report linked to the United States Centers for Disease Control and Prevention (CDC) indicates that the prevalence of DM increases with age, reaching 29.2% (26.4% to 32.1%) among those aged 65 years or older⁶.

The high prevalence of DM among older adults, together with the substantial rates of physical frailty, significantly compromises the health of hospitalized older adults, resulting in complex clinical interactions and challenging therapeutic management. DM is a risk factor for frailty⁷, as both conditions share pathophysiological mechanisms, such as insulin resistance and the progressive loss of muscle mass and strength (sarcopenia)⁸. Insulin resistance, associated with hyperglycemia, diabetic complications, inflammatory cytokines, and endocrine alterations, may contribute to reductions in musculoskeletal mass and muscle weakness, thereby increasing the risk of frailty⁹. Using genetic data from large European cohorts, a study employing Mendelian randomization investigated the bidirectional causal relationship between DM and frailty. The findings showed that frailty significantly increases the risk of developing type 2 diabetes mellitus, while type 2 diabetes mellitus also increases the risk of frailty¹⁰.

Although the literature includes studies addressing the relationship between frailty and DM, an important gap remains regarding the lack of consistent estimates

of the prevalence of physical frailty in hospitalized older adults with DM, particularly in contexts of greater clinical vulnerability. The relevance of the present study is grounded in progressive population aging and the high global burden of diabetes mellitus, conditions that together intensify clinical complexity and the risk of adverse outcomes. Thus, estimating the prevalence of frailty in this group is essential to improve therapeutic planning, guide early interventions, and support clinical decision-making, contributing to enhanced hospital care, reduced complications, and the advancement of future research in this field.

In light of the above, this systematic review aimed to identify the prevalence of physical frailty in hospitalized older adults with diabetes mellitus based on a synthesis of evidence from the literature.

METHOD

This study was conducted in accordance with the recommendations of the Joanna Briggs Institute (JBI) Evidence Synthesis Groups¹¹. The study protocol is published on the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY 202510016), doi: 10.37766/inplasy2025.1.0016.

To formulate the research question and guide the literature search, the CoCoPop strategy was used (Co – Condition: frailty; Co – Context: hospital setting; Pop – Population: older adults diagnosed with diabetes mellitus). After applying this strategy, the following research question was defined: What is the prevalence of frailty in hospitalized older adults diagnosed with diabetes mellitus?

The inclusion criteria for study selection were observational studies, including prospective and retrospective cohort studies, case-control studies, cross-sectional studies, and clinical trials; application of validated instruments to assess the variable of interest frailty; inclusion of hospitalized older adults aged 60 years or older of any nationality; publication in any language, with no restriction on publication date; and diagnosis of diabetes mellitus in accordance with the World Health Organization (WHO) diagnostic criteria published in 2018¹².

The exclusion criteria were lack of categorization regarding frailty status, duplicate studies indexed in more than one database, case reports, letters to the editor, conference abstracts, dissertations, theses, and monographs. The authors chose not to include gray literature due to the potential risk of compromising the validity and reproducibility of the results, as such materials do not undergo peer review.

The search strategy was tailored to each database and applied in January 2025 in the following sources: the National Library of Medicine (PubMed) via the Medical Literature Analysis and Retrieval System Online (MEDLINE); the Virtual Health Library (VHL); Scientific Electronic Library Online (SciELO); EMBASE; Scopus; and Web of Science. The following Medical Subject Headings (MeSH) terms were used: *Aged*, *Frailty*, *Frail Elderly*, *Inpatients*, *Hospitalization*, and *Diabetes Mellitus*. Boolean operators OR and AND were applied to structure the search strategy based on PubMed MeSH descriptors, as recommended to ensure efficient and accurate retrieval of scientific evidence from biomedical databases.

The search strategy was systematically developed with the support of a specialized librarian, who assisted in the selection of descriptors and the standardization of search combinations, thereby ensuring greater methodological rigor and reproducibility.

Accordingly, the search strategy was as follows: “Aged”[Mesh] OR (Elderly) AND “Frailty”[Mesh] OR (Frailties) OR (Frailness) OR (Frailty Syndrome) OR (Debility) OR (Debilities) OR “Frail Elderly”[Mesh] OR (Elderly, Frail) OR (Frail Elders) OR (Elder, Frail) OR (Elders, Frail) OR (Frail Elder) OR (Functionally Impaired Elderly) OR (Elderly, Functionally Impaired) OR (Functionally Impaired Elderly) OR (Frail Older Adults) OR (Adult, Frail Older) OR (Adults, Frail Older) OR (Frail Older Adult) OR (Older Adult, Frail) OR (Older Adults, Frail) AND “Inpatients”[Mesh] OR (Inpatient) OR “Hospitalization”[Mesh] OR (Hospitalizations) AND “Diabetes Mellitus”[Mesh] OR (Diabetes Mellitus). This strategy was translated into the specific controlled vocabularies of the other search sources and is described in the INPLASY registration (INPLASY 202510016).

Searches were conducted independently by two researchers, who applied the predefined eligibility criteria to the titles and abstracts retrieved. The search results were imported into the Rayyan® reference management software, in which the references were stored, organized, and classified¹³. After duplicate removal using the reference manager, ineligible studies were excluded.

The number of articles identified, including their distribution by database and aggregated totals, was systematized using the PRISMA flow diagram¹⁴. The flow diagram comprehensively details the screening stages, eligibility criteria, and reasons for study exclusion.

To minimize potential selection bias, after the initial refinement performed by the two reviewers, a meeting was held to discuss the selected articles. Disagreements were referred to a third reviewer, and consensus was reached regarding study inclusion or exclusion.

Following full-text reading of the eligible studies, data extraction was performed independently and in duplicate. Extracted data were compiled into a Microsoft Excel® table designed to cover the eligibility criteria. The table was based on JBI instruments¹¹ and included the following variables: author name, year of publication, country, sex, sample size, study design, frailty assessment instrument, and prevalence of frailty. The reference lists of the included primary studies were also manually reviewed in an attempt to identify potentially relevant articles not indexed in the searched databases.

To describe the level of agreement between reviewers, the Kappa statistic was used, which is based on the number of concordant responses, that is, the frequency with which reviewers reached the same decision¹⁵. In this study, the kappa agreement index was 0.98, indicating strong or almost perfect agreement between the researchers.

Eligible studies were fully appraised using the Joanna Briggs Institute critical appraisal tools. For cross-sectional studies, the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies was applied, whereas for cohort studies, the JBI Critical Appraisal Checklist for Cohort Studies was used¹¹.

For the meta-analysis, heterogeneity among studies was assessed using Cochran's Q test and the I² statistic, which enabled the selection of the most appropriate statistical model for estimating the pooled effect. Due to significant variability in study populations and methodologies, a random-effects model was applied, yielding the overall estimates of the prevalence of frailty and pre-frailty.

The results were graphically presented using forest plots, illustrating individual and pooled effects, and funnel plots to assess publication bias using Egger's test. The robustness of the estimates was evaluated through sensitivity analyses, in which individual studies were sequentially removed to assess their impact on the overall results.

The logit transformation was used to stabilize variance and to transform proportions onto a symmetric and unbounded scale [0,1]. In addition, the inverse-variance method was applied to combine study-specific estimates, assigning greater weight to studies with smaller standard errors. Hypothesis tests were conducted with a significance level of 5%.

As this study used articles retrieved from databases and did not involve human participants, approval by a Research Ethics Committee was not required. The study complies with current ethical standards. In addition, artificial intelligence was not used for writing, data analysis, or the preparation of this study.

DATA AVAILABILITY

The complete dataset supporting the results of this study has been made available in the Figshare repository and can be accessed via the doi: 10.6084/m9.figshare.30907523¹⁶.

RESULTS

The database searches yielded 2,261 studies; 653 were excluded as duplicates, and 1,608 were selected for title and abstract screening. Of these, 1,589 articles were excluded based on title and

abstract review, resulting in 19 studies selected for full-text reading. After completion of this stage, 11 articles were excluded and four new studies were added through other methods, namely reference checking of primary studies, resulting in a total of 12 articles included in the review. Figure 2 presents the Preferred Reporting Items for Systematic Reviews and Meta-Analyses PRISMA flow diagram used to illustrate the study selection process for this systematic review¹⁴.

The reviewers included all studies that met the inclusion criteria and discussed the methodological limitations identified. A total of 3,542 participants were included in the meta-analysis, with sample sizes ranging from 101 to 1,652 participants. A predominance of males was observed in 50% of the studies, followed by females in 33.3%, while sex was not reported in 16.6% of the studies.

Methodological quality assessment scores indicated that most articles were of moderate to high quality. All articles, regardless of their methodological quality ratings (Chart 1), were subjected to data extraction and synthesis.

Among the countries in which the studies were conducted, China predominated (33.3%), followed by Vietnam (16.6%). The most frequently used instrument to assess frailty was the Frail Scale (53.8%), followed by the Clinical Frailty Scale (15.3%), the Frailty Index (7.7%), the Frailty Risk Score (FRS) (7.7%), the combined use of the Frail Scale and the Clinical Frailty Scale (7.7%), and the Fried Phenotype combined with the Reported Edmonton Frail Scale (REFS) (7.7%). Regarding study design, 58.3% were cross-sectional studies, 8.3% were multicenter cross-sectional studies, 8.3% were retrospective cohort studies, 8.3% were prospective cohort studies, and 16.6% were multicenter prospective cohort studies.

Table 1 presents the distribution of the characteristics of the studies that comprised the corpus of the systematic review, including the following variables: author and year, country of origin, sample size, sex, study design, frailty assessment instrument, and prevalence of frailty and pre-frailty.

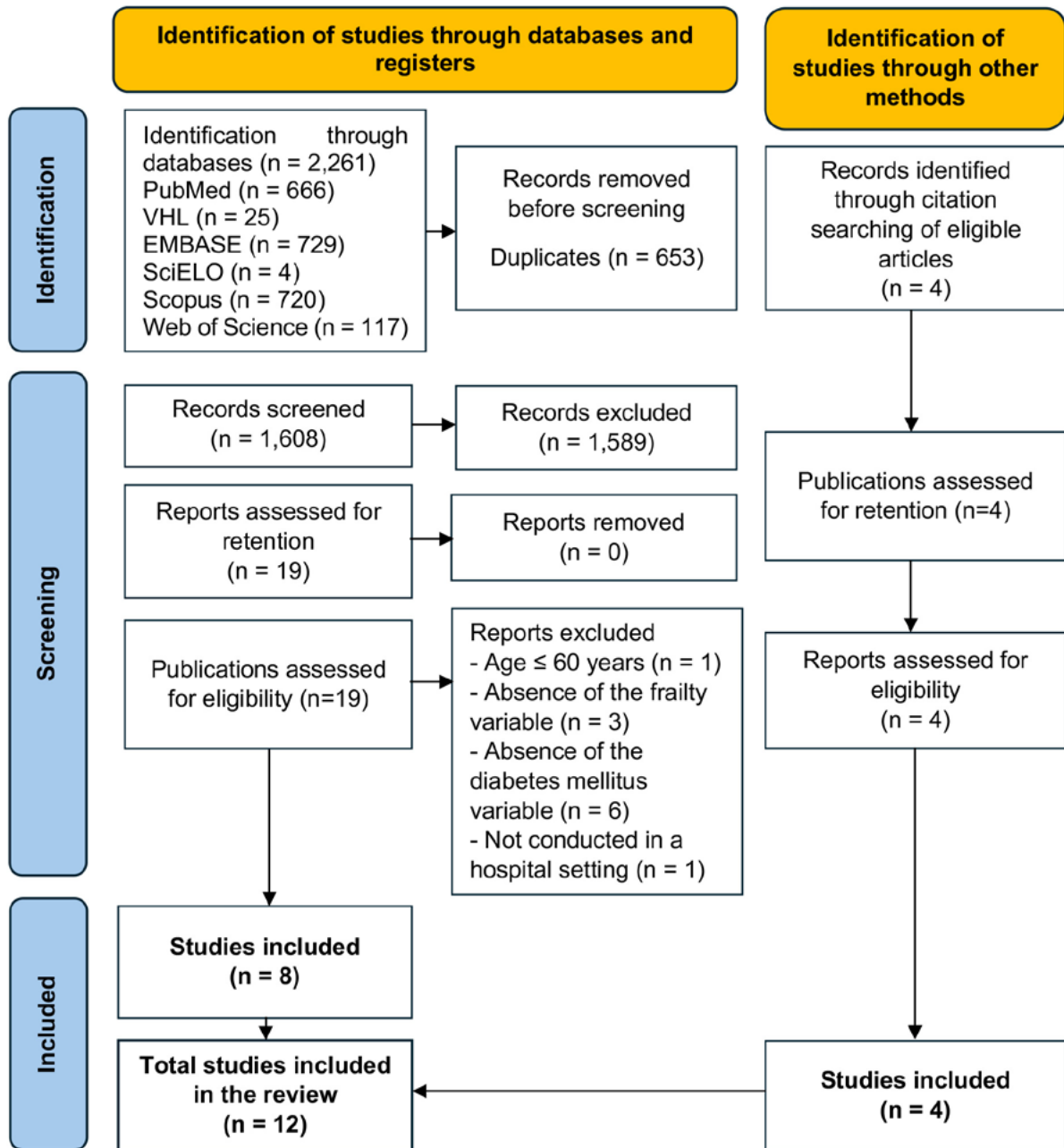


Figure 1. PRISMA flow diagram of study selection. Curitiba, PR, Brazil, 2025.

Source: Adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses¹⁴.

Chart 1. Distribution of the results of the methodological quality assessment of the articles included in the study. Curitiba, PR, Brazil, 2025.

CROSS-SECTIONAL STUDIES*												
Author, year	1. Were the two groups similar and recruited from the same population?	2. Were exposures measured similarly to assign individuals to exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were objective and standardized criteria used to measure the condition?	5. Were strategies to address confounding factors described?	6. Were strategies implemented to deal with confounding factors?	7. Was the condition measured in a standardized and reliable manner?	8. Was appropriate statistical analysis used?	Total			
Li <i>et al.</i> , 2015 ¹⁷	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	8			
Vu <i>et al.</i> , 2017 ¹⁸	(+)	(+)	(-)	(+)	(+)	(+)	(+)	(+)	7			
Wenxiu <i>et al.</i> , 2019 ¹⁹	(+)	(-)	(-)	(+)	(+)	(-)	(-)	(+)	4			
Mackenzie <i>et al.</i> , 2015 ²⁰	(I)	(+)	(-)	(+)	(+)	(-)	(-)	(+)	4			
O'neil <i>et al.</i> , 2022 ²¹	(+)	(+)	(-)	(-)	(+)	(-)	(-)	(-)	3			
Khuc <i>et al.</i> , 2021 ²²	(I)	(+)	(-)	(+)	(+)	(+)	(-)	(+)	6			
Wang <i>et al.</i> , 2023 ²³	(+)	(+)	(-)	(+)	(+)	(-)	(-)	(+)	5			
Zhang <i>et al.</i> , 2024 ²⁴	(+)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	4			
COHORT STUDIES **												
Author, year	1. Were the two groups similar and recruited from the same population?	2. Were exposures measured similarly to assign individuals to exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were confounding factors identified?	5. Were strategies to address confounding factors described?	6. Were the groups or participants free of the outcome at the start of the study or at the time of exposure?	7. Were outcomes measured in a valid and reliable way?	8. Was follow-up time reported and sufficient for outcomes to occur?	9. Was follow-up complete and, if not, were the reasons for loss to follow-up described and explored?	10. Were strategies used to address incomplete follow-up?	11. Was appropriate statistical analysis used?	Total
Lekan and McCoy, 2018 ²⁵	(I)	(+)	(-)	(-)	(+)	(+)	(+)	(+)	(-)	(-)	(+)	6
Yanagita <i>et al.</i> , 2018 ²⁶	(I)	(+)	(-)	(-)	(+)	(+)	(-)	(+)	(+)	(+)	(+)	5
Rodríguez-Queraltó <i>et al.</i> , 2010 ²⁷	(I)	(+)	(+)	(-)	(-)	(+)	(+)	(+)	(+)	(-)	(+)	7
Fung <i>et al.</i> , 2021 ²⁸	(I)	(+)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(+)	(+)	6

(-) did not meet this criterion; (+) met this criterion; (I) unclear or not clear. Scores range from 1 to 8 or from 1 to 11, and higher scores indicate better methodological quality. *JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies¹⁰. **JBI Critical Appraisal Checklist for Cohort Studies¹¹.

Table 1. Distribution of the characteristics of the studies included in the corpus of the systematic review. Curitiba, PR, Brazil, 2025.

Author, year	Country of origin	Sample size	Female sex	Study design	Frailty assessment instruments	Prevalence of pre-frailty	Prevalence of frailty
Rodríguez-Queraltó <i>et al.</i> , 2010 ²⁷	Spain	199	38%	Multicenter prospective cohort study	FRAIL Scale	41.2%	33.6%
Mackenzie <i>et al.</i> , 2015 ²⁰	Canada	141	52.5%	Cross-sectional study	FRAIL Scale	NI	84.4%
Li <i>et al.</i> , 2015 ¹⁷	China	146	21.9%	Cross-sectional study	FRAIL Scale	37.7%	15.1%
Vu <i>et al.</i> , 2017 ¹⁸	Vietnam	110	NI	Cross-sectional study	Fried Phenotype Reported Edmonton Frail Scale	40.1% NI	35.4% 31.9%
Lekan and McCoy, 2018 ²⁵	United States	136	57.2%	Retrospective cohort study	Frailty Risk Score ≥ 9	NI	73.5%
Yanagita <i>et al.</i> , 2018 ²⁶	Japan	132	48%	Prospective cohort study	Clinical Frailty Scale	NI	41.6%
Wenxiu <i>et al.</i> , 2019 ¹⁹	China	126	NI	Cross-sectional study	FRAIL Scale	35.4%	36.5%
Fung <i>et al.</i> , 2021 ²⁸	Hong Kong	215	NI	Multicenter prospective cohort study	Frailty index	NI	88.3%
O'neil <i>et al.</i> , 2022 ²¹	United Kingdom	101	55.4%	Cross-sectional study	Clinical Frailty Scale	34.6%	65.3%
Khuc <i>et al.</i> , 2021 ²²	Vietnam	379	46.5%	Cross-sectional study	FRAIL Scale	8.7%	2.1%
Wang <i>et al.</i> , 2023 ²³	China	1652	36.4%	Multicenter cross-sectional study	FRAIL Scale	59.7%	26.5%
Zhang <i>et al.</i> , 2024 ²⁴	China	205	51.9%	Cross-sectional study	FRAIL Scale	NI	26.3%

NI – Not informed.

The pooled prevalence of frailty among hospitalized older adults with diabetes across all included studies was 40.4% (23.0% to 60.5%), I^2

= 97.7%, $\tau^2 = 2.2149$, $p < 0.0001$, and the pooled prevalence of pre-frailty was 34.8% (22.3% to 49.8%), $I^2 = 97.7%$, $\tau^2 = 0.6700$, $p < 0.0001$ (Figure 2).

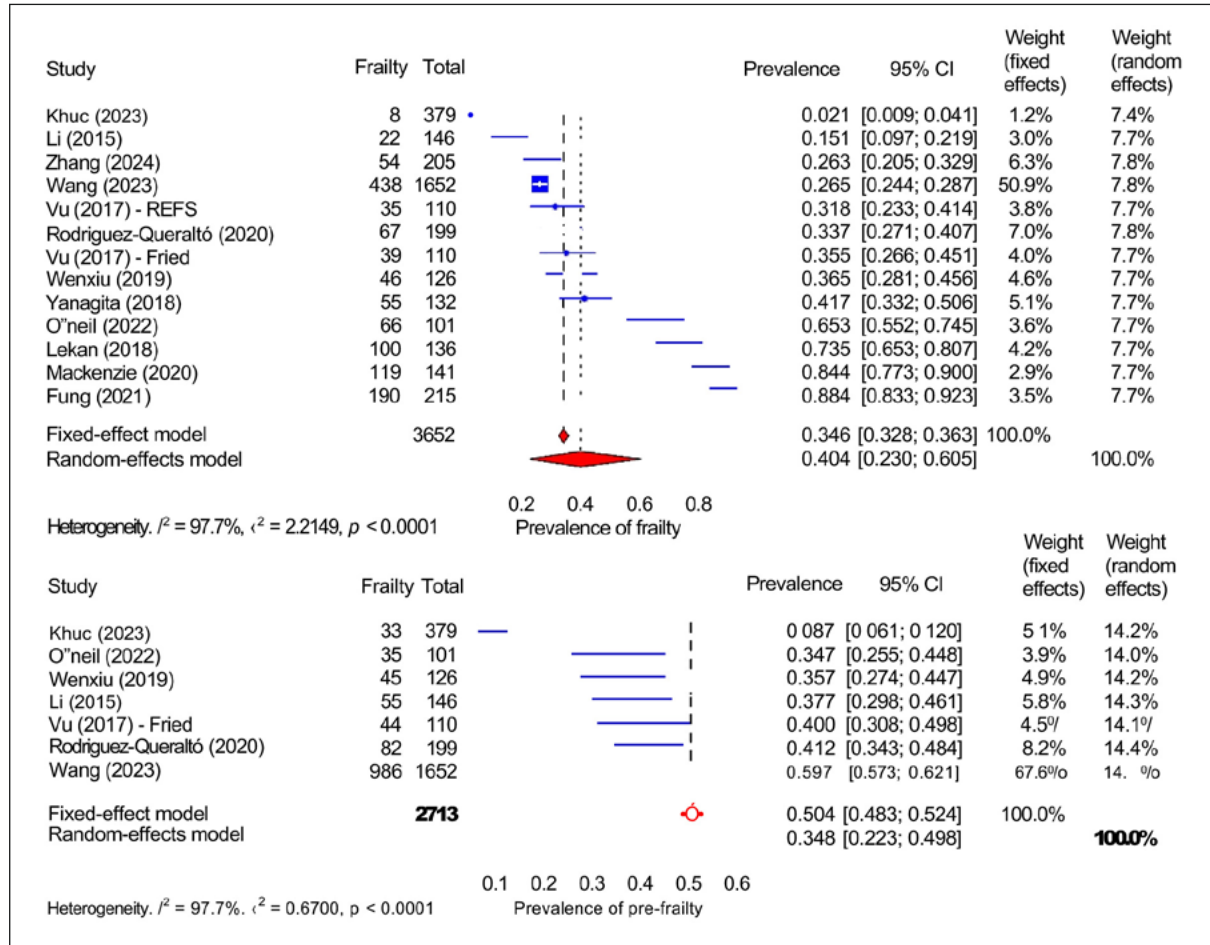


Figure 2. Estimated prevalence of frailty among hospitalized older adults with diabetes mellitus. Curitiba, PR, Brazil, 2025.

Source: Figshare, accessible via doi: 10.6084/m9.figshare.30907523¹⁶

The funnel plot for frailty prevalence shows asymmetry, with a greater concentration of studies on the right side representing higher prevalences and fewer studies on the left side representing lower prevalences,

with no statistically significant evidence of asymmetry ($t = 1.33, p = 0.2113$). In the funnel plot for pre-frailty prevalence, there was statistically significant evidence of asymmetry ($t = -3.22, p = 0.0234$) (Figure 3).

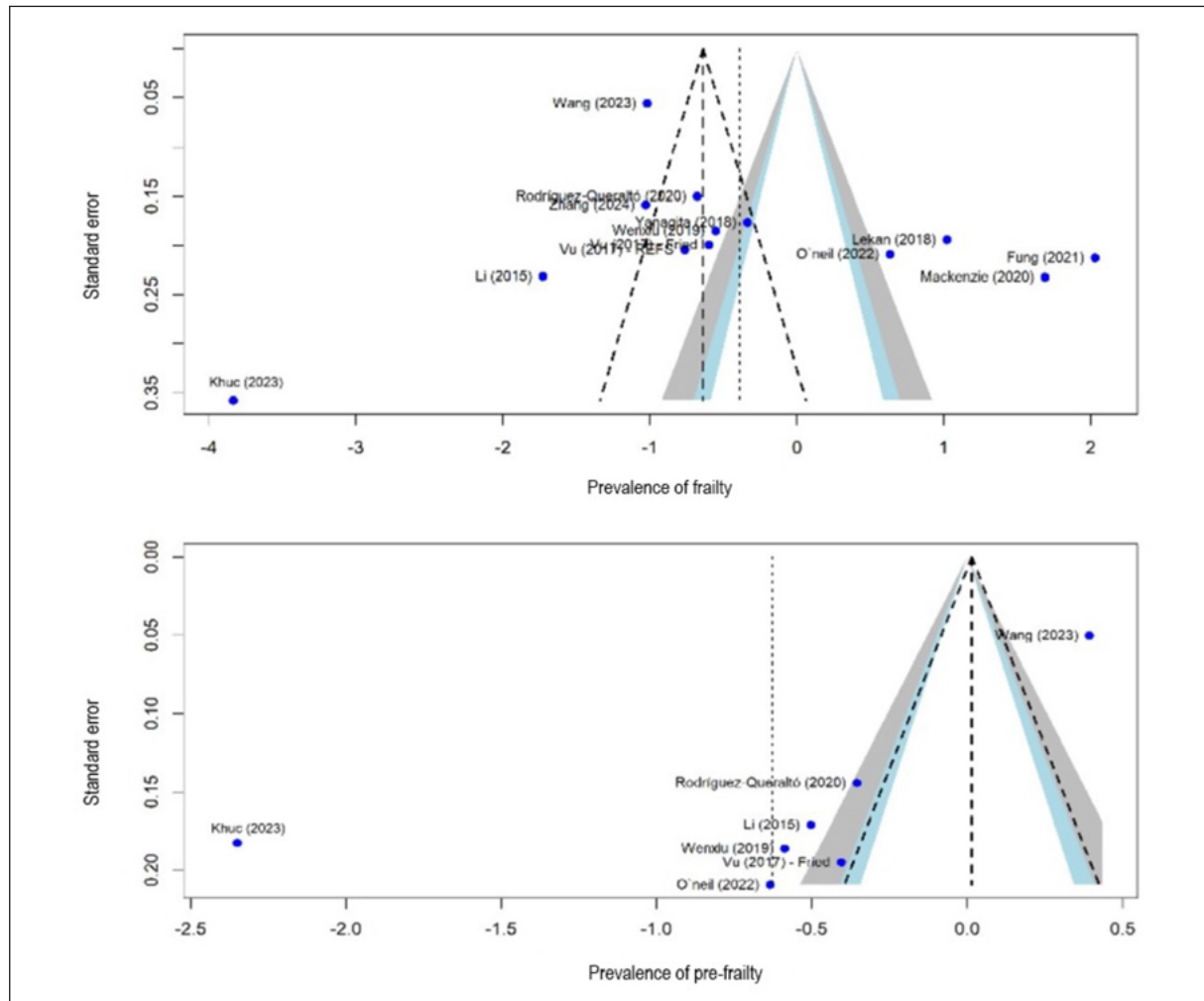


Figure 3. Funnel plot for the assessment of publication bias. Curitiba, PR, Brazil, 2025.

Source: Figshare, accessible via doi: 10.6084/m9.figshare.30907523¹⁶

DISCUSSION

The present systematic review with meta-analysis demonstrated a high prevalence of frailty (40.4%) and pre-frailty (34.8%) among hospitalized older adults with diabetes mellitus, indicating that most individuals in this population exhibit some degree of physiological vulnerability during hospitalization. These findings exceed the prevalences observed in community-based settings²⁹, supporting the hypothesis that the combination of diabetes and hospitalization increases frailty risk.

Other marked differences in frailty status are observed between community-dwelling and hospitalized older adults. Community-dwelling

older adults show a lower prevalence of physical frailty and a higher prevalence of pre-frailty³⁰. It is evident that the coexistence of diabetes mellitus and frailty acts as a strong predictor of hospitalization, which explains the higher proportion of frail older adults with diabetes in the hospital setting. This profile reflects more severe health conditions among hospitalized individuals, as they already present reduced physiological reserves and lower resistance to stressors, with an increased risk of severe complications and recurrent hospitalizations³¹.

The substantial heterogeneity among the estimates of the included studies, with prevalences ranging from 2.1%²² to 88.4%²⁸, suggests a strong influence of methodological and conceptual factors.

Such discrepancies may stem from differences in assessment instruments, adopted cutoff points, classification strategies that are dichotomous or multilevel, as well as from the clinical and sociodemographic characteristics of the samples. This pattern is widely discussed in the literature, which recognizes the lack of standardization in frailty measurement as one of the main determinants of variability in prevalence estimates.

The heterogeneity observed across studies may reflect differences in frailty status, morbidity profiles, and nutritional and functional status, elements associated with the progression of frailty in the hospital setting. Although these characteristics were not the primary focus of the present investigation, they contribute to the interpretation of the observed discrepancies. Among older adults diagnosed with diabetes mellitus, an association was observed between pre-frailty or frailty and female sex²², older chronological age^{18,23,26,28}, lower income²², and low educational attainment^{18,22}.

In addition, frailty was associated with longer duration of diabetes diagnosis²², a higher number of morbidities²², poor nutritional status^{18,19}, lower body weight and systolic blood pressure²⁶, the presence of cardiovascular diseases^{18,23,27}, cancer and gastrointestinal diseases²³, cerebrovascular and renal diseases^{23,28}, cognitive impairment¹⁹, lower scores for instrumental activities of daily living^{17,19}, as well as impaired mobility and diabetic nephropathy¹⁷.

These results corroborate previous studies on the relationship between these conditions and frailty in older adults with diabetes²⁹ and in those with multimorbidity³⁰. The presence of these factors may influence transitions in frailty status, particularly among hospitalized older adults, while also highlighting certain modifiable characteristics that can be incorporated into care management and treatment strategies for hospitalized older adults²⁹.

Although the studies reported data on frailty in older adults with diabetes, their objectives were highly heterogeneous, including assessment of functional fitness in frail older adults²⁴; evaluation of the association between diabetes mellitus and associated factors^{18,19,22}, specifically multimorbidities²⁶, acute coronary syndrome²⁷, and hospital outcomes^{17,20,25};

assessment of the relationship between dysglycemia and frailty in older adults using insulin²⁸; and evaluation of risk factors for frailty, including glycated hemoglobin²⁶, as well as hypoglycemic treatment in relation to therapeutic targets and hospital outcomes²¹.

The funnel plot for frailty prevalence did not demonstrate publication bias. It was observed that two studies^{17,22} were outside the expected funnel limits, indicating that their estimates may be under- or overestimated. Studies with more precise frailty estimates and smaller standard errors were located closer to the top of the plot²³ and or clustered around the central line of the funnel²⁷.

The main strengths of this study include the adoption of a systematic and comprehensive search strategy, methodological quality assessment, a standardized data extraction process, as well as the quantitative synthesis of results, presented using forest plots, and the application of statistical tests to assess publication bias. Nevertheless, some limitations should be considered when interpreting the findings. These include heterogeneity among the analyzed populations, sample sizes that are not always representative of the target population, the diversity of instruments used to assess frailty, variability in the classification of frailty status—either dichotomous or tripartite—and the exclusion of gray literature.

CONCLUSION

The prevalence of frailty among hospitalized older adults with diabetes mellitus was high, affecting 75.2% of the analyzed population, of whom 40.4% were classified as frail and 34.8% as pre-frail. The identification of both the prevalence and the coexistence of these two conditions highlights the clinical risks faced by hospitalized older adults.

This study provides an original contribution by consolidating prevalence estimates specifically for hospitalized older adults with diabetes, thereby addressing an important gap in the literature and support therapeutic planning. The findings also contribute to the improvement of care protocols and to the guidance of interdisciplinary strategies centered on functionality, in line with guidelines for older adult care in the hospital setting.

The results of this review indicate the need for future studies with longitudinal and multicenter designs capable of monitoring the progression of frailty among hospitalized older adults diagnosed with diabetes mellitus. The importance of standardizing frailty assessment instruments is emphasized, as well as conducting studies that investigate the association of frailty with clinical, functional, and economic outcomes. Furthermore, research evaluating multidimensional interventions and the systematic incorporation of frailty assessment into care protocols may contribute to improved clinical decision-making and to the qualification of care centered on functionality.

AUTHORSHIP

- Márcia Marrocos Aristides - writing or critical revision; final approval of the version; accountability for all aspects of the work; formal analysis; conceptualization; data curation; investigation; methodology; validation; visualization.
- Maria Helena Lenardt - writing or critical revision; final approval of the version; accountability for all aspects of the work; project administration; formal analysis; methodology; supervision; validation; visualization.
- Clovis Cechinel - writing or critical revision; final approval of the version; accountability for all aspects of the work; conceptualization; data curation; investigation; methodology; software; validation; visualization.
- João Alberto Martins Rodrigues - writing or critical revision; final approval of the version; accountability for all aspects of the work; formal analysis; conceptualization; data curation; investigation; methodology; software; validation; visualization.
- María del Carmen Rodríguez-Martínez - writing or critical revision; final approval of the version; accountability for all aspects of the work; investigation; supervision; validation; visualization.

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Construction and content validation of the patient safety practices self-assessment form for Long-Term Care Facilities

Taís Fernanda da Silva Anelo¹ 
Daniela Fortes Parizotto² 
Julia Braga da Silveira¹ 
Janete de Souza Urbanetto¹ 

Abstract

Objective: To describe the methodological application of constructing a self-assessment form for safety practices in Long-Term Care Facilities in the city of Porto Alegre (RS), Brazil, and its content validation by experts. **Method:** Methodological study conducted in two stages. The first consisted of developing the Form through a focus group with 12 professionals from the Sanitary Surveillance service. The second involved content validation by eight experts in patient safety, sanitary surveillance, and gerontology, using the criteria of clarity, practical pertinence, and theoretical relevance. The Content Validity Index was applied to calculate item validity. **Results:** The construction process resulted in an instrument composed of 81 items organized into eight thematic domains, covering aspects such as structure, processes, safety of care, and indicators. Content validation showed high levels of agreement regarding clarity, practical pertinence, and theoretical relevance of the items. The initial Content Validity Index was 0.98, and after adjustments suggested by the experts, the final index value reached 1.0. **Conclusion:** This investigation enabled the development and validation of the form, based on national regulations and international guidelines, with a high content validity index, ensuring technical and semantic consistency. The form shows potential for application in institutional management and sanitary surveillance, supporting self-assessment, monitoring, and improving quality of care for institutionalized older adults.

Keywords: Patient Safety. Homes for the Aged. Public Health Surveillance. Total Quality Management.

¹ Pontifícia Universidade Católica do Rio Grande do Sul, Escola de Medicina, Programa de Pós-Graduação em Gerontologia Biomédica. Porto Alegre, RS, Brasil.

² Pontifícia Universidade Católica do Rio Grande do Sul, Escola de Ciências da Saúde e da Vida, Curso de Enfermagem. Porto Alegre, RS, Brasil.

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Correspondence
Taís Fernanda da Silva Anelo
t.anelo@edu.pucrs.br

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INTRODUCTION

Population aging has occurred rapidly on a global scale, posing challenges to health, care, and social security systems¹. The state of Rio Grande do Sul, Brazil, has the highest percentage of older adults in the country. Porto Alegre, the state capital, has fourth largest proportion of older adults among Brazil's cities, representing 15.76% of the local population².

The World Health Organization's (WHO) Global Strategy on Aging and Health proposes that countries adopt measures and make investments, including the provision of long-term care³. In the Americas, although life expectancy has increased, healthy years of life have not kept pace, resulting in approximately 12 years lived with disabilities. This scenario increases the demand for continuous complex care. In response, the Pan American Health Organization (PAHO) published the Long-Term Care Policy 2025-2034, containing guidelines to support countries in strengthening sustainable, safe, and person-centered systems⁴.

In this context, Long-Term Care Facilities for Older Adults (LTCFs) play a strategic role in protecting and providing this population with comprehensive care, ensuring quality, safe assistance. These institutions are characterized by providing collective housing for older adults in situations of vulnerability or with functional limitations requiring long-term care⁵. Understanding the structure, processes, and practices of these institutions is essential to guarantee safe quality care for this population⁶.

In Brazil, the National Health Surveillance Agency (Anvisa) is responsible for the inspection and regulation of LTCFs⁷, defining them as health services according to current regulations⁸. According to Anvisa records, Porto Alegre has 325 LTCFs in operation⁹. According to the Demographic Census, approximately 161,000 older adults live in LTCFs nationwide, 24.8% in the southern region, reflecting the demand for long-term care in areas with greater population aging².

Thus, patient safety guidelines are fundamental to prevent adverse events and avoidable harm in LTCFs, given the multiple risks present in caring

for institutionalized older adults⁶. This scenario became even more evident during the COVID-19 pandemic, when many of these facilities struggled in adopting effective protective measures for the older population. According to estimates, in the initial phases of the health crisis, almost half of all deaths recorded globally occurred in these institutional contexts¹⁰.

Anvisa published the Integrated Plan for Sanitary Management of Patient Safety, with the aim of assessing hospitals and guiding priority patient safety actions¹¹. However, there are currently no systematized assessments available using tools specifically for LTCFs. The implementation of LTCF-adapted assessments are expected to stimulate and support preventive actions for the institutionalized older population. Additionally, the WHO's Global Patient Safety Action Plan 2021-2030 establishes Clinical Process Safety as its third strategic objective, toward promoting patient safety in all care settings, including LTCFs⁶.

For patient safety assessments in the LTCF context to be adequate, obtaining valid and representative data constitutes a fundamental step in designing scientific investigations. Forms and questionnaires are widely used, and the quality of results depends on instruments with solid evidence of validity and reliability^{12,13}. Thus, the methodological construction and improvement of instruments is essential to ensure precision and consistency in evaluating theoretical constructs. Content validity is of particular importance, verifying whether an instrument's items clearly, coherently, and comprehensively represent the concepts and domains to be measured¹⁴.

Given the relevance of Patient Safety practices, specifically for older adults in long-term care, the growth of this population, the significant number of LTCFs, and the need to foster adherence to safe practices of high quality, the following research question was formulated: What is the process of constructing and validating a Patient Safety practices self-assessment form for Long-Term Care Facilities for Older Adults in the municipality of Porto Alegre/Rio Grande do Sul state (RS)?

The objective of this investigation was to describe the methodological application of devising a self-

assessment form for older adult safety practices in the city of Porto Alegre (Rio Grande do Sul state), Brazil, and report its content validation by experts.

METHOD

A methodological study was carried out in two stages. Methodological studies aim to develop, improve, or evaluate scientific methods, contributing to the quality and reproducibility of research. In the health field, these studies are essential for constructing and validating measurement instruments, while ensuring their reliability, validity, and adequacy in relation to the theoretical constructs under analysis^{14,15}.

The first stage consisted of devising the Patient Safety Practices Self-Assessment Form for LTCFs (FAPSP-LTCF), using the Focus Group Technique. The second stage involved content validation of the instrument by a panel of experts. This study is part of a research project entitled “*Efeitos de um ciclo de melhoria nos indicadores relacionados à segurança do paciente em instituições de longa permanência para pessoas idosas: um ensaio clínico randomizado*” (Effects of an improvement cycle on patient safety-related indicators in long-term care facilities for older adults: a randomized clinical trial).

Stage 1: The task of devising the Patient Safety Practices Self-Assessment Form for LTCFs (FAPSP-LTCF) was performed at the facilities of the Health Surveillance Directorate (DVS) of the Municipal Health Secretariat of Porto Alegre, Rio Grande do Sul state, Brazil.

Study participants were professionals from the Health Services Surveillance Team (EVSIS) of DVS who met the inclusion criteria of working in LTCF inspection or being part of the Center for Patient Safety of the Health Surveillance agency (NSP VISA). Exclusion criteria included professionals who had not been active for at least one year. Members of this team, according to their interest in participating, composed the focus group. The focus group sessions were held within the participants' work environment, with the consent of those responsible, justified by the need to develop a diagnostic form of interest to the service.

The focus group consisted of 12 Health Surveillance specialists: six inspection agents, three NSP VISA professionals (three nurses and one physician), and three Health Services Health Surveillance managers (one nurse, one veterinarian, and one inspection agent). Two group sessions were held, with scheduling agreed upon by the participants, in March and in April 2024.

The Focus Group procedure entailed stages that included planning, creating the setting, recruiting, and holding of group session, as described in the study by Kinalski¹⁵.

The devising of evaluative items on patient safety practices in the LTCF setting that make up the form was carried out participatively by the focus group. These items were developed based on Anvisa's Collegiate Board Resolutions (RDC) No. 36/2013 and No. 502/2021^{16,17}, the National Patient Safety Program (PNSP)¹⁸, the WHO Global Patient Safety Action Plan 2021-2030⁶, and the International Patient Safety Goals¹⁸. These Goals represent a global reference, based on Joint Commission International recommendations, strongly supported by WHO and validated by the PNSP through its protocols¹⁸.

To finalize this stage, the resultant form was sent to the focus group participants for them to assess the correspondence of the items with the earlier discussions and decisions of the group.

In stage 2, content validation of the FAPSP-LTCF version was performed by a committee of expert judges. For data collection, the phases for content validation recommended by Davis¹⁹ were followed: preparing form, selecting review panel of experts, conducting content validation, reviewing domain and items, provision of scoring for each evaluated item, and calculating the Content Validity Index (CVI).

Content validity corresponds to the degree to which the items of an instrument are considered appropriate and representative in relation to the construct evaluated²⁰. According to Lynn, this involves two stages: instrument development grounded in theoretical and conceptual precepts, followed by critiquing of the items by experts²¹. Content validation was conducted based on the criteria of clarity and comprehension, practical

pertinence, and theoretical relevance, as suggested by Yusoff and outlined below²⁰.

- Degree of clarity and comprehension: the clarity of instructions and language is related to the absence of ambiguity and precision in item formulation to avoid multiple interpretations, while comprehension concerns respondents' ability to adequately interpret the words and sentences used²⁰. A four-point Likert scale was provided for experts: 1 = the item is not clear or comprehensible; 2 = the item is somewhat clear and comprehensible; 3 = the item is clear and comprehensible; 4 = the item is very clear and comprehensible.
- Degree of practical pertinence: practical pertinence aims to analyze whether the item is actually important in constituting the instrument²⁰. A four-point Likert scale was provided for experts: 1 = the item has no practical pertinence; 2 = the item has little practical pertinence; 3 = the item has practical pertinence; 4 = the item has great practical pertinence.
- Degree of theoretical relevance: theoretical relevance seeks to evaluate the degree of association between the item and the supporting theory²⁰. A four-point Likert scale was provided for experts: 1 = the item is not relevant; 2 = the item needs revision to assess relevance; 3 = the item is relevant, needs minor changes; 4 = the item is highly relevant.

An important aspect in this evaluation is the number and qualifications of expert judges. Participation of five to ten experts is recommended, considering the instrument's characteristics as well as the training, qualifications, and availability of the professionals involved²¹. Yusoff recommends a minimum of six experts, and not exceeding ten participants²⁰.

In the present study, the judge committee comprised eight experts who met the adapted Fehring²² criteria of at least seven points for the items: Master's degree (2 points); Doctoral degree (4 points); dissertation/thesis (2 points); residency and/or specialization (2 points); professional practice in gerontology, patient safety, or health services surveillance for at least two years (2 points); teaching

experience (1 point); and publication of articles in indexed journals and/or book chapters (1 point). Experts working in LTCFs located in the city of Porto Alegre (RS) were not invited. Notably, among those selected, two had expertise in patient safety, three in health services surveillance, two in gerontology, and one had experience in both gerontology and patient safety areas.

The CVI calculation enables examination of the clarity, relevance, and pertinence of the items comprising the instrument, ensuring conceptual coherence and semantic adequacy for the research objectives. Regarding the CVI score, in the case of five or fewer experts, unanimous agreement on each item's relevance is required²⁰. With six or more evaluators, a minimum agreement score of 0.78 is recommended²¹. Yusoff adds that the CVI must be at least 0.80, preferably reaching 0.90 or more, to ensure greater robustness in content validity²⁰.

The content validity index score²¹ was calculated by summing the score of each expert's response who indicated score "3" or "4", divided by the total number of expert responses. Hence, the formula used was $CVI = \text{number of "3" or "4" responses} / \text{total number of responses}$. The CVI was initially calculated for each item, according to clarity and comprehension, practical pertinence, and theoretical relevance. Subsequently, the CVI was calculated for each domain and, finally, for the total FAPSP-LTCF. Items rated with a score of "1" or "2" were revised, a new evaluation round by experts conducted, and the CVI recalculated for each item, domain, and for the final FAPSP-LTCF version.

The present study is nested within a larger project, approved by the Research Ethics Committee under number 6,608,476 and permit CAAE 74671523.7.3001.5338, according to Resolutions No. 466/2012²³ and No. 580/2018²⁴, duly authorized by the responsible parties of the institutions involved. All participants in the two stages signed the Informed Consent Form.

DATA AVAILABILITY

The full data set supporting the results of this study is available upon request from the

corresponding author. The complete FAPSP-LTCF was made available in the figshare® repository and can be accessed at: <https://figshare.com/s/5487913f0e544e6b5633?file=61003045>, DOI: <https://doi.org/10.6084/m9.figshare.31045477>.

RESULTS

In stage 1, during the focus group meetings, the FAPSP-LTCF was devised, composed of closed-ended questions. The focus group used the stages based on the study by Kinalski¹⁵ as described below:

a) Planning

The Focus Group planning envisaged the dimension of participants composing a thematic and methodological group, considering their prior experiences. This was coordinated by a moderator (PhD candidate, study author) and an observer (supervising professor heading the study). The tools used for conducting the group sessions included setting familiarization at study sites for participant recruitment and a structured theme guide centered around three main objectives, each serving as the central focus of a session. The synthesis of key moments from each meeting is presented in Chart 1.

Chart 1. Key moments of group sessions. Porto Alegre, Rio Grande do Sul state, 2024

FOCUS GROUP SESSIONS		
Key moments	Session 1	Session 2
Session opening	Reception, presentation of researchers and research objective.	Synthesis of previous session and clarification of this session's objective.
Presenting participants	Formal presentation of all participants.	Presentation of a participant absent from previous session
Clarifying participative dynamic and discussion	Information on session development and theme guide.	
Establishing setting	Agreement on logistical and dynamics aspects of sessions and electronic equipment use. Commitment to research confidentiality. Signing of Informed Consent Form.	
Debate	Theme defined for Session 1: general data, infrastructure, and work processes in institutions.	Theme defined for Session 2: older adult care safety, continuing and permanent education, and care indicators.
Synthesis	Review and validation of central discussion ideas.	
Session closing	Thanks and arrangements for next session.	Thanks for participation.

Source: adapted¹⁵

b) Setting

The researcher conducted a preliminary visit to the field to identify the most appropriate strategy for participant recruitment and selection. At this time, a formal invitation was presented to the team, seeking to map the number of interested parties and, consensually, define the most suitable location, date, and time for the first group session.

c) Recruitment

After the exploratory visit to the study field, the researcher sent institutional invitations to the team's work email, clarifying doubts and gauging interest in participating.

d) Theme Guide

Structured theme guides were prepared, containing a script that guided the conduct of meetings, outlining the key moments of each session to favor directed and productive discussion. Two distinct thematic guides were developed, each aligned with the specific objectives of their respective session.

e) Group Sessions

All stages were meticulously organized and set up to mediate the dimension of the task. During the sessions, the moderator facilitated group dynamics and recorded the narratives. The observer, acting as a participant, joined the group, helping conduct meetings, as well as observe and control time.

The sessions took place in March and April 2024, each lasting 2 hours. The group debated issues

related to institutional structure and processes, with a focus on health care safety. Eight domains were listed: general LTCF data, legal constitution, human resources, infrastructure, older adult care safety, work processes, continuing and permanent education, and care indicators; constituting a form with 92 questions. After review by the authors, 11 questions were removed due to similarity, for a total of 81 questions in the final version of the form in this stage.

Lastly, the final FAPSP-LTCF version was sent electronically to focus group participants, together with an invitation for critical review and feedback on the need for further adjustments. All participants confirmed the adequacy of content and the form of the FAPSP-LTCF, with no new suggestions or modification requests. Thus, the qualitative review of the construction phase was concluded, approving the final version in stage 1.

In stage 2, for FAPSP-LTCF content validation, the following phases were used:

a) Preparing content validation form: initial step consisting of preparing the instrument containing the FAPSP-LTCF, to ensure the expert judges committee clearly understood the task of analyzing the 81 items for clarity and comprehension, practical pertinence, and theoretical relevance criteria, as proposed by Yusoff²⁰.

A sample of the instrument containing the FAPSP-LTCF sent to the expert judges committee for content validation is presented in Chart 2.

Chart 2. Sample of instrument containing the FAPSP-LTCF sent to expert judges committee for content validation. Porto Alegre, Rio Grande do Sul, state 2025.

DOMAIN 5 – SAFETY IN CARING FOR OLDER ADULT (RESIDENT)			
Form Questions (Items Tested)	Clarity and Comprehension	Practical Pertinence	Theoretical Relevance
35) Does the institution have a mechanism of identifying residents? If yes, check which mechanism(s) is(are) used: <input type="checkbox"/> Wristband with resident's name <input type="checkbox"/> Name plate on resident's bed <input type="checkbox"/> Name plate on wall <input type="checkbox"/> Name plate on room door <input type="checkbox"/> No resident identification mechanism <input type="checkbox"/> Others _____	1 () Not clear or comprehensible 2 () Somewhat clear and comprehensible 3 () Clear and comprehensible 4 () Very clear and comprehensible	1 () No practical pertinence 2 () Little practical pertinence 3 () Has practical pertinence 4 () Great practical pertinence	1 () Not relevant 2 () Needs revision to assess relevance 3 () Relevant, needs minor changes 4 () Highly relevant
Comments or suggestions			
36) Does the LTCF have visual guidelines (posters, folders) or reminders encouraging hand hygiene practice for staff, residents, and families? If yes, check which guideline(s) is(are) used: <input type="checkbox"/> Correct hand hygiene technique <input type="checkbox"/> WHO's 5 moments for hand hygiene <input type="checkbox"/> Messages about hand hygiene importance <input type="checkbox"/> LTCF has no visual guidelines/reminders at present <input type="checkbox"/> Others _____	1 () Not clear or comprehensible 2 () Somewhat clear and comprehensible 3 () Clear and comprehensible 4 () Very clear and comprehensible	1 () No practical pertinence 2 () Little practical pertinence 3 () Has practical pertinence 4 () Great practical pertinence	1 () Not relevant 2 () Needs revision to assess relevance 3 () Relevant, needs minor changes 4 () Highly relevant
Comments or suggestions			

Source: Author elaboration, 2025

b) Selecting expert review panel: based on adapted Fehring²² criteria, which considered individual experience on the topic to be studied. The committee comprised eight expert reviewers.

c) Conducting content validation: after initial contact presenting the proposal, the FAPSP-LTCF version was sent to experts by email together with clear instructions.

d) Reviewing domains and items: experts were requested to provide a critical review of each domain and its items according to the established criteria. They were also encouraged to provide written comments to improve item relevance in relation to the target domain. All comments were taken

into consideration toward refining the domains and their respective items.

e) Provision of scoring for evaluated items: after reviewing each item in their respective domains, experts were asked to assign scores independently, using a 4-point Likert Scale, for each of the three criteria.

f) CVI calculation: after receiving the instrument containing the FAPSP-LTCF from each expert, a database was created in an Excel® spreadsheet containing all evaluations by item and domain. Excel® software was used for CVI calculation. The calculation was performed by item, by domain, and for the final form score. Subsequently, the scoring

classification was recoded as 1 (for scores 3 or 4) or zero (for scores 1 or 2).

The synthesis of scores according to each domain, by expert and criteria, conducted in the first stage of the Expert Committee is presented in Table 1.

Considering that the domains General Data, Infrastructure, Patient Safety, and Work Processes received suggestions for changes and scores of 1 or 2 in the clarity and comprehension dimension by experts A, E, and F, individual meetings were

held with these reviewers in January and February 2025. The meetings were to validate the proposed modifications and allow re-evaluation of the items. After re-evaluation, the experts assigned new scores, resulting in a CVI calculation of 1.0 for all items and their respective domains, as shown in Table 2.

The complete final version of the FAPSP-LTCF is presented in Appendix A, Available from: <https://figshare.com/s/5487913f0e544e6b5633?file=61003045>. The structure of the eight domains and their respective 81 items are presented in Table 3.

Table 1. Content Validity Index of FAPSP-LTCF domains from first evaluation by the Expert Judges Committee, according to clarity and comprehension, practical pertinence, and theoretical relevance criteria (N=8 experts). Porto Alegre, Rio Grande do Sul state, 2025.

Expert Committee/ Criteria	FAPSP-LTCF DOMAINS								
	General and demographic data	Legal constitution	Human resources	Infrastructure	Safety of Patient/Older Adult	Work Processes	Continuing and Permanent Education	Indicators	CVI Total
CC	1.0	1.0	1.0	0.81	0.75	0.75	1.0	1.0	0.91
E1 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CC	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0
E2 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E3 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CC	1.0	1.0	1.0	1.0	0.94	1.0	1.0	1.0	0.99
E4 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CC	1.0	1.0	1.0	1.0	0.94	0.87	1.0	1.0	0.96
E5 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CC	0.84	1.0	1.0	1.0	0.94	1.0	1.0	1.0	0.96
E6 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E7 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E8 PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CVI by domain	0.99	1.0	1.0	0.99	0.98	0.98	1.0	1.0	0.98

E1 to E8 = Participating Experts; FAPSP-LTCF = Patient Safety Practices Self-Assessment Form for LTCFs; CC = Clarity and Comprehension; PP = Practical Pertinence; TR = Theoretical Relevance; CVI = Content Validation Index. **Source:** Author elaboration, 2025

Table 2. Content Validity Index of FAPSP-LTCF domains from final evaluation by the Expert Judges Committee, according to clarity and comprehension, practical pertinence, and theoretical relevance criteria (N=8 experts). Porto Alegre, Rio Grande do Sul state, 2025.

Expert Committee/ Criteria	FAPSP-LTCF Domains								
	General and demographic data	Legal constitution	Human resources	Infrastructure	Safety of Patient/Older Adult	Work Processes	Continuing and Permanent Education	Indicators	CVI Total
E1 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E2 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E3 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E4 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E5 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E6 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E7 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E8 CC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PP	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CVI by domain	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

E1 to E8 = Participating Experts; FAPSP-LTCF = Patient Safety Practices Self-Assessment Form for LTCFs; CC = Clarity and Comprehension; PP = Practical Pertinence; TR = Theoretical Relevance; CVI = Content Validation Index. **Source:** Author elaboration, 2025.

Table 3. FAPSP-LTCF structure according to domain and respective number of items. Porto Alegre, Rio Grande do Sul state, 2025.

FAPSP-LTCF Domains	No. of items
Domain 1 - General and Demographic Data	13
Domain 2 - Legal Constitution	4
Domain 3 - Human Resources	6
Domain 4 – Infrastructure	11
Domain 5 – Safety of Patient/Older Adult	33
Domain 6 - Work Processes	8
Domain 7 - Continuing and Permanent Education	3
Domain 8 – Indicators	3
Total FAPSP-LTCF items	81

FAPSP-LTCF = Patient Safety Practices Self-Assessment Form for Long-Term Care Facilities for Older Adults. **Source:** Author elaboration, 2025.

DISCUSSION

The PAHO Long-Term Care Policy emphasizes the importance of comprehensive, consistent, and culturally sensitive assessments in LTCFs, allied with the formulation of quality standards and implementation of monitoring and management mechanisms⁴. Such assessments should support continuous improvement of care practices, from preventive actions to end-of-life care³. Another fundamental element for strengthening LTCFs is the strategic use of information through consistent, transparent systems that represent the needs of institutionalized older adults, guide decision-making, and support evidence-based public policies⁴.

In applied research, there remains a significant gap in the availability of specific instruments for measuring patient safety in LTCFs. A recent scoping review identified 47 tools targeting different care settings, such as hospital, emergency, pre-hospital, and primary care; but none designed specifically for LTCFs²⁵.

A 2024 methodological study on the construction and content validation of a care quality self-assessment instrument in LTCFs, although focusing on multidimensional standards, considering safety as one of the dimensions of quality, addressed issues related to environmental safety, older adult care, technical routines, and use of indicators²⁶. Although

both instruments share underlying domains related to care quality, the FAPSP-LTCF differs by exploring aspects directly linked to safety in care provision for older adults. This specific emphasis reinforces the instrument's relevance for continuous monitoring, improving quality of care practices, and promoting safer environments within LTCFs.

International studies corroborate the relevance of evaluative instruments in LTCFs, while initiatives have been run for this purpose. The Nursing Home Survey on Patient Safety Culture by the Agency for Healthcare Research and Quality assesses safety culture in LTCFs²⁷ but fails to assess care practices, infrastructure, and institutional processes according to national regulations, a gap that the instrument validated in the present study seeks to fill. In South Korea, authors validated a questionnaire for assessing safety and care quality in LTCFs, covering domains such as emergency response, comfort management, infection prevention, staff training, material resources, and personnel adequacy²⁸. Similarly, the FAPSP-LTCF was designed to evaluate care safety in Brazilian LTCFs, considering the particularities of the national regulatory scenario aligned with international guidelines.

A study conducted in the Netherlands validated the Quality Evaluation Questionnaires – Nursing Homes (QEQ-NH) for measuring care quality from three complementary perspectives: residents,

families, and professionals, with good validity and reliability ($\alpha > 0.70$), but focused on subjective dimensions²⁹. Although the QEQ-NH captures multiple care quality dimensions, its main focus is on subjective perceptions, while the FAPSP-LTCF incorporates objective and normative dimensions, grounded in regulatory mechanisms. Both tools share the same goal of supporting quality management and fostering organizational culture focused on quality and safety of care for institutionalized older adults.

In Italy, a study highlighted that measuring patient safety in LTCFs is strategic for fostering quality interventions and consolidating an institutional culture based on transparency, accountability, and participation of professionals and families³⁰. This rational converges with the FAPSP-LTCF's aim of promoting an organizational environment committed to care safety.

In Brazil, the LTCF Quality Assessment Matrix³¹ applied to entities participating in the Unified Social Assistance System Census represents progress in institutional evaluation, based on a multidimensional model covering care and social aspects. However, its approach differs from the FAPSP-LTCF scope, which was specifically designed to assess health care safety, focusing on practices and indicators directly linked to adverse event prevention and compliance with health regulations.

Promoting patient safety in LTCFs requires specific instruments attuned to the Brazilian institutional and regulatory context. The FAPSP-LTCF excels in this scenario by filling a methodological gap and providing a tool to support management practices, evaluation, and continuous quality improvement of care. Application of the tool can strengthen safety culture, articulated with public policies and aligned with international guidelines. Additionally, the FAPSP-LTCF demonstrates the importance of expanding applied research on long-term care as an essential strategy to ensure the safety, integrity, and well-being of institutionalized older adults.

Although the structuring of the themes that composed the focus group discussion was grounded in robust references related to Patient Safety, Gerontology, and Health Surveillance, the lack of a systematic literature review was identified as

a weakness. Another limitation that may hamper generalization of the form to other regions of the country, due to structural, regulatory, and cultural differences, involves the profile of focus group participants and the expert judges committee, predominantly composed of professionals from the city of Porto Alegre, with the exception of one judge working in another Brazilian state.

CONCLUSION

This study presented the methodological description for constructing and validating the Patient Safety Practices Self-Assessment Form for Long-Term Care Facilities for Older Adults, based on national regulations and international guidelines, allowing the formulation of items contextualized to institutional practices. Content validation revealed clarity and comprehension, practical pertinence, and theoretical relevance, with an initial Content Validity Index of 0.98 and final index of 1.0 after adjustments suggested by experts. These results confer semantic consistency and technical foundation to the instrument for application in care safety management.

Given the scarcity of specific instruments for Long-Term Care Facilities for Older Adults, the Patient Safety Practices Self-Assessment Form for LTCFs represents a valuable tool to help support self-assessment, monitoring, and improvement of institutional practices, favoring a safety culture focused on the institutionalized older population. The form also shows potential for use by municipal and state Health Surveillance agencies, supporting inspection actions and promoting improvements in care and safety standards. This investigations may serve to stimulate new studies and integrated actions involving academia, public management, and services, promoting evidence-based practices centered on safety and quality of care.

AUTHORSHIP

- Taís Fernanda da Silva Anelo – conception, article writing and critical review, study design, data analysis and interpretation, approval of version for publication, responsibility for all aspects of

the study, vouching for matters related to the accuracy or integrity of any part of the work.

- Daniela Fortes Parizotto -article writing and critical review, approval of version for publication.
- Julia Braga da Silveira – study design, data analysis and interpretation, article writing and critical review, approval of version for publication.

- Janete de Souza Urbanetto - conception, article writing and critical review, design, data analysis and interpretation, approval of version for publication, and responsibility for all aspects of the study, vouching for matters related to the accuracy or integrity of any part of the work.

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Factors associated with adverse drug reactions in community-dwelling older adults

Alícia Carolina da Silva Medeiros¹ 

Manuel do O de Souto Neto² 

Matheus dos Santos Batista² 

Helen Caroline Silva de Medeiros² 

Ana Carolina Patrício de Albuquerque Sousa³ 

Abstract

Objective: To evaluate the factors associated with adverse drug reactions (ADR) in older adults in the context of primary health care (PHC). **Method:** An epidemiological, cross-sectional, analytical study was conducted in Basic Health Units in the cities of Caicó and Currais Novos, Rio Grande do Norte state, Brazil. Sociodemographic variables, behavioral habits, presence of comorbidities, medication use, perceived health, and occurrence of ADRs were investigated. The exposure variables investigated were: polypharmacy (use of five or more medications), and use of PIM; the outcome variable was the occurrence of potentially life-threatening or disabling adverse reactions (*delirium*, sedation, gastrointestinal hemorrhages, falls, fractures). Data analysis entailed descriptive statistics followed by bivariate analysis (chi-square) to investigate the association of variables, and multivariate analysis (binary logistic regression). **Results:** Overall, 100 participants aged 60 or older were included in the study. Polypharmacy was identified in 44% of the interviewees, PIM use in 28%, while 41% reported ADR, with falls being the most prevalent adverse event (26%). Bivariate analysis revealed ADR was associated with comorbidity, polypharmacy, and PIM ($p < 0.001$). On the multivariate analysis model, polypharmacy remained the only associated independent risk factor ($p < 0.01$). **Conclusion:** Polypharmacy constituted the main factor associated with ADRs in the community-dwelling older adults. The strengthening of rational prescribing practices, clinical protocols, and interprofessional work (physician-pharmacist) are essential to mitigate risks and ensure therapeutic safety in PHC.

Keywords: Primary Health Care. Older Adult. Potentially Inappropriate Medication List. Drug Prescriptions. Polypharmacy.

¹ Universidade Federal do Rio Grande do Norte, Escola Multicampi de Ciências Médicas, Programa de Residência Multiprofissional em Atenção Básica. Caicó, RN, Brasil.

² Universidade Federal do Rio Grande do Norte, Escola Multicampi de Ciências Médicas, Curso de Medicina. Caicó, RN, Brasil.

³ Universidade Federal do Rio Grande do Norte, Escola Multicampi de Ciências Médicas. Caicó, RN, Brasil.

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Correspondence
Ana Carolina Patrício de Albuquerque Sousa
ana.carolina.albuquerque@ufrn.br

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INTRODUCTION

Rapid population aging and the consequent changes in the demographic and epidemiological profiles of Brazilian society call for a new vision of care to address the increased prevalence of noncommunicable chronic diseases (NCDs), especially in the older adult population^{1,2}.

In older adults, the prevalence of polypharmacy and use of potentially inappropriate medications (PIMs) is high². Polypharmacy is characterized by the concomitant use of five or more medications^{1,3}. PIMs, in turn, are drugs whose risks outweigh the benefits of their use when there are therapeutically equivalent alternatives with safer scientific evidence³.

Both polypharmacy and PIM use are risk factors for the occurrence of negative outcomes, which may result from adverse drug reactions (ADRs) and/or drug-drug interactions^{1,4,5}.

In this context, the American Geriatrics Society (AGS) established the Beers Criteria in 2012 as a list of PIMs for older adults⁶. These criteria were created by specialists with the aim of increasing prescription safety by identifying drugs to avoid in specific situations⁷. In Brazil, the Beers Criteria formed the basis for the creation of the Brazilian Consensus on Potentially Inappropriate Medications (CBMPI)⁸ as an essential tool for classifying medications, rationalizing prescriptions, and reducing ADRs³.

The Brazilian National Health System (SUS) promotes the rational use of medications through the formulation of an action plan to reduce polypharmacy⁹. The role of the multidisciplinary team in Primary Health Care (PHC), specifically the work of pharmacists, can have positive impacts in the prevention and resolution of medication-related problems, resulting in greater adherence to pharmacotherapy and improved control of chronic diseases¹⁰.

The scenario of high prevalence of polypharmacy and PIMs in older adults prompted the present study, considering PHC as the organizer of care and comprehensive assistance to older adults. The objective of this study was to evaluate the factors associated with ADRs in older adults within the PHC setting.

METHOD

An epidemiological, cross-sectional, analytical study was conducted. The target population of the study was individuals aged 60 years or older, registered and attended at Basic Health Units (BHUs), with medication dispensing or basic pharmacy in the cities of Caicó and Currais Novos – Rio Grande do Norte (RN) state. According to data from the Brazilian Institute of Geography and Statistics (IBGE), the city of Caicó - RN, has approximately 61,146 inhabitants, of which 17.22% are aged 60 years or older¹¹; and has 24 BHUs, five of which offer a medication dispensing service. The city of Currais Novos - RN has approximately 41,313 inhabitants, of which 18.36% are aged 60 or older¹¹. The city has 18 BHUs, and medication dispensing is performed via basic pharmacy services.

The study participants were selected at time of picking up prescribed medications at BHU pharmacies. These units should make available resident professionals from the Family and Community Medicine Program and the Basic Care Residency Program of the Multicampus School of Medical Sciences of Rio Grande do Norte (EMCM/UFRN). The sample size was obtained by convenience. A total of 100 interviews were planned, considering the constraints for implementing the study within an appropriate timeframe.

Thus, the inclusion criteria were being aged 60 years or older and holding a document with a record of medications used (medical prescription, SUS user card, or Older Adult Health Booklet). None of the participants were subsequently excluded. Data were collected from March to August 2025 by medical students/EMCM (Caicó) and by the resident pharmacist in Basic Care/EMCM (Currais Novos), duly trained to apply the semi-structured data collection questionnaire. All participants were invited to take part in the study and sign the Informed Consent Form (TCLE).

The information for the following variables was collected: sociodemographic characteristics, behavioral habits, presence of comorbidities, medication use, perceived health, and occurrence of adverse drug reactions.

The exposure variables were: polypharmacy (use of five or more medications) and use of potentially inappropriate medications; the outcome variable was the occurrence of potentially life-threatening or disabling adverse reactions (*delirium*, sedation, gastrointestinal hemorrhages, falls, fractures).

The sociodemographic information collected included: sex, age, race/ethnicity, marital status, education, religious practice, and monthly income. Behavioral habits were investigated by asking whether the individual consumed alcohol and/or tobacco, whereas physical activity (PA) was investigated by asking about engagement in physical exercise in the last three months. The presence of comorbidities was assessed based on clinical diagnosis of the following chronic diseases: heart diseases, arterial hypertension, diabetes mellitus, malignant tumor, arthritis or rheumatism, pulmonary diseases, depression, osteoporosis, and stroke.

Perceived health was assessed using a Likert-type scale with response options very good, good, fair, poor, or very poor.

Regarding the presence of polypharmacy and PIMs, medication use was investigated by collecting name and dosage of the prescribed medication. Each medication reported was classified according to the Anatomical Therapeutic Chemical classification system (ATC), recommended by WHO, at levels 1 (anatomical group) and 2 (therapeutic subgroup). Also, medications were checked for inclusion in the National List of Essential Medicines (RENAME)⁵.

The occurrence of polypharmacy was defined as reported concomitant use of five or more medications¹. The occurrence of PIMs was characterized, regardless of clinical condition, according to the CBMPI, which consists of 118 criteria: 43 to be avoided regardless of clinical condition; and 75 depending on specific health conditions³.

ADRs were investigated by asking the participant about the occurrence (within last year) of falls, fractures, hospitalizations, constipation, heart failure, depression, cognitive deficit, and renal dysfunction³.

Data were stored and processed using statistical software. Descriptive analysis (absolute and relative

frequency, measures of central tendency, and measures of dispersion) was performed to characterize the sample, and the confidence interval [95% CI] of the proportions observed among the categories analyzed was calculated. Bivariate analysis (Pearson's chi-square test) was then performed to investigate the association of variables. Finally, multivariate analysis (binary logistic regression) was conducted to adjust for possible confounding variables and identify factors associated with ADR occurrence. The 95% CI and significance level $\alpha=5\%$ were estimated.

For the regression model, variables were grouped into blocks: 1) sociodemographic characteristics (sex and age group); 2) health conditions (presence of comorbidities, use of polypharmacy, and use of PIMs). Sociodemographic variables were included in the binary logistic regression regardless of the p-value from bivariate analysis, given their importance for adjusting the analysis. The remaining variables were selected according to the statistical significance on bivariate analysis, adopting inclusion criterion of p -value < 0.20.

The present study was approved by the Research Ethics Committee of the Faculty of Applied Social Sciences (CEP FACISA—UFRN), in accordance with the determinations of Resolution No. 466/12 of the National Health Council (CNS), which defines the regulatory guidelines and norms governing research involving humans, and Resolution No. 510/2016 of the National Health Council (CNS). CAAE: 85766424.0.0000.5568 / Approval no.: 7.392.508.

DATA AVAILABILITY

The full data set underpinning the study results is available from *figshare* at <https://doi.org/10.6084/m9.figshare.31231507>.

RESULTS

A total of 100 participants aged 60 years or older were interviewed (50 in Caicó and 50 in Currais Novos), registered and attended under the Family Health Strategy of these cities.

The characteristics of the sample, according to sociodemographic variables, behavioral habits, and health conditions, together with the 95% CI of the proportions in each category analyzed, are given in Table 1. The mean age was 71.41 ± 7.88 years. Participants were predominantly female, aged 70 years or older, married or in a stable union, brown,

practicing a religion, with educational level below complete elementary school, and income less than two minimum wages. Regarding behavioral habits, only regular physical activity was reported by the majority of respondents. With regard to health conditions, most participants reported having comorbidities and a perceived health status of fair.

Table 1. Sample characterization according to sociodemographic variables, behavioral habits, and clinical and health conditions. Caicó and Currais Novos, Rio Grande do Norte, 2024.

Variables	Relative Frequency (%) N= 100	Confidence Interval [95%] of proportions observed
Sociodemographics		
Age: $\mu = 71.41 \pm 7.88$ years [Min = 60; Max = 97]		
Age Group (years)		
60-69	44	[35.0 – 54.0]
≥ 70	56	[46.0 – 65.0]
Sex		
Female	79	[70.0 – 87.0]
Male	21	[13.0 – 30.0]
Education		
Incomplete primary	71	[63.3 – 80.6]
Complete primary	12	[5.1 – 17.3]
Complete secondary or greater	15	[8.2 – 21.4]
Not known or no response given	2	[1.1 – 3.1]
Income (minimum wages)		
≤ 1	40	[28.0 – 47.0]
>1 and ≤ 2	31	[22.0 – 41.0]
> 2	29	[17.0 – 33.0]
Marital Status		
Single	16	[9.0 – 24.0]
Married/Stable union	48	[38.0 – 58.0]
Separated/Divorced	10	[5.0 – 16.0]
Widowed	26	[17.0 – 35.0]
Race/Ethnicity		
Yellow / Asian	2	[0 – 5.0]
White	39	[29.0 – 48.0]
Brown / Mixed	47	[37.0 – 58.0]
Black	12	[6.0 – 19.0]
Religion		
Yes	98	[95.0 – 100.0]
No	2	[0 – 5.0]

to be continued

Continuation of Table 1

Variables	Relative Frequency (%) N= 100	Confidence Interval [95%] of proportions observed
Behavioral Habits		
Alcohol use		
Yes	6	[2.0 – 11.0]
No	94	[89.0 – 98.0]
Tobacco use		
Yes	7	[2.0 – 12.0]
No	93	[88.0 – 98.0]
Physical activity		
Yes	52	[43.0 – 62.0]
No	48	[38.0 – 57.0]
Clinical characteristics		
Presence of comorbidities		
Yes	70	[61.0 – 79.0]
No	30	[21.0 – 29.0]
Perceived health		
Very good/Good	40	[21.2 – 50.6]
Fair	52	[42.4 – 61.0]
Poor / Very poor	8	[2.0 – 11.1]
Polypharmacy use (≥ 5 medications)		
Yes	44	[34.0 – 53.0]
No	56	[47.0 – 66.0]
Potentially Inappropriate Medications use		
Yes	28	[20.0 – 38.9]
No	67	[61.1 – 90.0]
Missing data	5	-
Adverse Reactions reported		
Yes	41	[50.0 – 69.0]
No	59	[28.0 – 47.0]

The main diseases and adverse reactions reported are presented in Table 2. The most prevalent main comorbidities were systemic arterial hypertension, arthritis, and diabetes. The most prevalent adverse effects were falls.

The results of the bivariate analysis of presence of adverse reactions and age group, sex, physical activity, presence of comorbidities, use of polypharmacy, and PIMs are presented in Table 3. Pearson's chi-square test revealed a

significant association between adverse reactions and comorbidity ($p < 0.001$), polypharmacy ($p < 0.001$), and PIMs ($p < 0.001$).

Following bivariate analysis, multivariate analysis was performed using binary logistic regression to control for possible confounding variables and to evaluate factors associated with ADRs (Table 4). Only polypharmacy remained as an associated factor, independently of age, sex, presence of comorbidities, or use of PIMs.

Table 2. Comorbidities and adverse drug reactions in community-dwelling older adults. Caicó and Currais Novos, Rio Grande do Norte, 2024.

Variables	Relative Frequency (%) N= 100	Confidence Interval [95%] of proportions observed
Comorbidities		
Arterial Hypertension		
Yes	84	[77.0 – 91.0]
No	16	[9.0 – 23.0]
Heart Disease		
Yes	30	[21.0 – 39.0]
No	70	[61.0 – 79.0]
Diabetes Mellitus		
Yes	41	[31.0 – 51.0]
No	59	[49.0 – 69.0]
Tumor		
Yes	3	[0.0 – 7.0]
No	97	[93.0 – 100.0]
Arthritis		
Yes	42	[32.0 – 52.0]
No	58	[48.0 – 68.0]
Pulmonary Disease		
Yes	8	[3.0 – 14.0]
No	92	[86.0 – 97.0]
Depression		
Yes	18	[11.0 – 26.0]
No	82	[74.0 – 89.0]
Osteoporosis		
Yes	23	[15.0 – 32.0]
No	77	[68.0 – 85.0]
Stroke		
Yes	1	[0 – 3.0]
No	99	[97.0 – 100.0]
Adverse Reactions		
Falls		
Yes	26	[18.0 – 34.0]
No	74	[66.0 – 82.0]
Hospitalization		
Yes	6	[2.0 – 11.0]
No	94	[89.0 – 98.0]
Fractures		
Yes	5	[1.0 – 10.0]
No	95	[90.0 – 99.0]
Constipation		
Yes	14	[8.0 – 22.0]
No	86	[78.0 – 92.0]

to be continued

Continuation of Table 2

Variables	Relative Frequency (%) N= 100	Confidence Interval [95%] of proportions observed
Heart Failure		
Yes	4	[1.0 – 8.0]
No	96	[92.0 – 99.0]
Depression		
Yes	7	[2.0 – 12.0]
No	93	[88.0 – 98.0]
Cognitive Deficit		
Yes	5	[1.0 – 10.0]
No	95	[90.0 – 99.0]
Renal Dysfunction		
Yes	8	[3.0 – 13.0]
No	92	[87.0 – 97.0]

Table 3. Bivariate analysis of the presence of adverse reactions and sociodemographic variables, behavioral habits, and clinical and health conditions. Caicó and Currais Novos, Rio Grande do Norte, 2024.

Variables	Adverse Reactions		<i>p</i> -value
	Yes	No	
Age Group (years)			
60-69	14	30	0.09
≥70	27	29	
Sex			
Female	34	45	0.42
Male	07	14	
Physical Activity			
Yes	19	33	0.34
No	22	26	
Presence of Comorbidity			
Yes	36	34	< 0.001
No	05	25	
Polypharmacy			
Yes	30	14	< 0.001
No	11	45	
Potentially Inappropriate Medication			
Yes	17	11	0.01
No	21	46	

Table 4. Binary logistic regression model to identify factors associated with adverse drug reactions in community-dwelling older adults. Caicó and Currais Novos, Rio Grande do Norte, 2024.

Variables	Odds Ratio [95%CI]	<i>p</i> -value
Model 1: Health Conditions		
Presence of Comorbidity		
No	1.00	0.23
Yes	2.15 [0.62 – 7.51]	
Polypharmacy		
No	1.00	0.004
Yes	4.69 [1.63 – 13.52]	
Potentially Inappropriate Medication		
No	1.00	0.09
Yes	2.46 [0.87 – 6.98]	
Model 2: Health Conditions adjusted for age group and sex		
Presence of Comorbidity		
No	1.00	0.23
Yes	2.19 [0.62 – 7.71]	
Polypharmacy		
No	1.00	0.01
Yes	4.31 [1.42 – 13.10]	
Potentially Inappropriate Medication		
No	1.00	0.07
Yes	2.63 [0.90 – 7.71]	
Age Group (years)		
60-69	1.00	0.57
≥70	1.35 [0.48 – 3.77]	
Sex		
Male	1.00	0.76
Female	0.83 [0.26 – 2.70]	

DISCUSSION

The main finding of this study revealed that polypharmacy was an independent risk factor for ADR occurrence, even after adjusting the model for confounding variables such as age, sex, presence of comorbidities, and use of PIMs. This result confirms the premise that the number of drugs used may be a determining factor for the occurrence of adverse events that, taken alone, exerts a greater influence than age or specific therapeutic classes. The finding corroborates robust evidence in the literature showing that concomitant use of multiple drugs

plays a key role in drug interactions and negative clinical outcomes, especially among older adults^{7,15,22}.

Although the adjusted multivariate analysis identified polypharmacy as a factor contributing to ADRs, the findings on bivariate analysis are noteworthy showing that ADR occurrence was also associated with the presence of comorbidities and use of PIMs. This result suggests a triad of clinical vulnerability: comorbidities, PIM use, and polypharmacy, which should not be overlooked, especially given the high prevalence of these conditions in PHC^{3,19,20}.

In the present study, findings regarding health conditions reaffirm the high burden of chronic diseases in the older adult population. The majority of participants (70%) had comorbidities, a finding similar to that observed in other studies involving PHC users^{15,16}. Polypharmacy was identified in 44% and PIM use in 28% of respondents, corroborating the international panorama where polypharmacy ranges from 13.9% to 64.5%^{1,4,7,14,17,18}, and PIM use mirrors studies that applied both the Beers criteria and the CBMPI, reporting rates from 27.6% to 32.9%^{3,21}. Adverse reactions were reported by 41%, with falls being the most reported event.

This scenario highlights the complexity of clinical management in PHC. Although some medications are classified as inappropriate for older adults, in many cases they are essential for the appropriate management of chronic conditions, given that each condition may require one or more medications for treatment and control^{7,15,20}.

Placing these results in context, the profile of the study sample (low educational level, low income, and high prevalence of chronic diseases) mirrors that of other investigations conducted in the Brazilian Northeast and within PHC in general^{1,12,13,14}, where unfavorable socioeconomic factors compromise self-care and therapeutic adherence, exacerbating the risk associated with polypharmacy¹⁴.

It should be reiterated that polypharmacy played a key role in ADR occurrence, having a greater influence than the other factors assessed, representing a priority risk marker. This points to the need for policies and protocols defining periodic review of prescriptions in PHC, as well as the adoption of non-pharmacological measures for the treatment and control of chronic diseases. Studies show that interventions centering on medication review, based on shared decision-making, and professional training, are effective in reducing medication burden²³.

In this context, quaternary prevention serves as a vital tool for mitigating excessive medicalization²⁴, in which the pharmacist is key in carrying out medication reconciliation, identifying problems related to prescribing, and potentially preventing readmissions and avoidable costs to the health system^{1,25}.

However, these results should be interpreted within the constraints of the study limitations: cross-sectional design precluding the establishment of direct causality between variables; selection bias due to convenience sampling; and measurement bias from self-reports.

Of these limitations, self-reports of ADRs are of most note, given they are susceptible to both recall bias (forgetting past events or medication names) and information bias (lack of knowledge on the patient's clinical condition). Hence, these factors may have led to an underestimation of the actual prevalences of ADRs.

Despite its cross-sectional design, relatively small sample size, and non-probabilistic selection, the study has several strengths, including the methodological rigor applied (use of validated instruments and standardization in data collection) and adjusted statistical analysis.

Therefore, given the importance of this topic and exploratory nature of the present investigation, future studies with probabilistic, representative sampling, longitudinal designs, and both quantitative and qualitative data should be conducted. Additionally, studies evaluating interventions, such as systematic review of prescriptions, multiprofessional integration, and health education, can help inform effective strategies for safe care.

CONCLUSION

In summary, polypharmacy constituted the main factor associated with adverse drug reactions in the community-dwelling older adults, representing a priority challenge for Primary Health Care. The strengthening of rational prescribing practices and clinical protocols, coupled with interdisciplinarity, is fundamental to mitigate risks and ensure greater therapeutic safety for the older adult population.

Although some medications classified as inappropriate are necessary for the management of chronic conditions, their prescription should be accompanied by periodic review, considering number of drugs, administration times, and potential interactions.

Interprofessional work (physician-pharmacist) and patient-centered care are essential to promote rational prescribing and reduce adverse events associated with medication use.

AUTHORSHIP

- Alicia Carolina da Silva Medeiros: Writing and critical review; Final approval of the version; Data interpretation; Data curation; writing - first draft; writing - review and editing; investigation and methodology.
- Manuel do O de Sousa Neto: Conception of the work; Writing and critical review; Conceptualization; Investigation; Methodology.
- Matheus dos Santos Batista: Writing and critical review; Conceptualization; Investigation; Methodology.

- Helen Caroline Silva de Medeiros: Writing and critical review; Conceptualization; Investigation; Methodology.
- Ana Carolina Patrício de Albuquerque Sousa: Writing and critical review; Final approval of the version; Data analysis and interpretation; Responsibility for all aspects of the work; Writing - first draft; Writing - review and editing; Investigation and Methodology; Obtaining Funding; Supervision.

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Level of advanced glycation end products in older adults: association with diet and body composition

Maria Cecília Ferreira¹ 
Camila Santos Lemos¹ 
Júlia Constantino Aun¹ 
Juliana Alves Macedo² 
Gabriela Alves Macedo² 
Alessandra Gambero^{1,2} 

Abstract

Objective: To evaluate dietary intake of advanced glycation end products (AGEs) in older adults and potential correlations with body composition and muscle health. **Methods:** A cross-sectional observational study involving individuals aged 60 and older (n=72) was conducted. Data collection included application of a food frequency questionnaire for AGE-rich foods (FFQ-AGE). Skin autofluorescence (SAF) was measured as a marker of AGE accumulation. Body composition was assessed using body mass index (BMI), bioimpedance, and calf circumference, while sarcopenia risk was evaluated using handgrip strength, Timed Up and Go (TUG) Test, and SARC-F score. **Results:** The average dietary AGE intake was $12,104 \pm 5,719$ kU/day, with no significant differences by sex or marital status. No correlation was found between dietary AGE intake and SAF, BMI, or physical performance. However, SAF positively correlated with BMI, fat mass, and sarcopenic obesity index, indicating an association with unfavorable body composition. Only 2.8% of participants were sarcopenic according to SARC-F, although 20.8% had low handgrip strength and 37.5% had impaired mobility on the TUG test. **Conclusion:** Although dietary AGE intake did not correlate with AGE accumulation or physical performance, SAF was associated with obesity-related measures. These findings suggest that AGE accumulation in older adults may be more influenced by body composition or endogenous production than dietary intake. Monitoring SAF could be useful for assessing cardiovascular risk and health outcomes in aging populations.

Keywords: Advanced Glycation end Products. Obesity. Older Adults. Diet.

¹ Pontifícia Universidade Católica de Campinas (PUC-Campinas), Escola de Ciências da Vida. Campinas, SP, Brasil.

² Universidade Estadual de Campinas, Departamento de Alimentos e Nutrição, Faculdade de Engenharia de Alimentos. Campinas, SP, Brasil.

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Correspondence
Alessandra Gambero
alessandra.gambero@puc-campinas.edu.br

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INTRODUCTION

The term "glycation products" refers to numerous compounds with different structures that form from the Maillard reaction, a chemical reaction between reducing carbohydrates and amino compounds during food processing and cooking. Initially, reducing sugars such as glucose and fructose react with the ϵ -amino group of lysine, which is most abundant in foods, a reaction known as "glycation" of lysine. Subsequently, these products undergo Amadori rearrangements, forming Amadori rearrangement products (ARPs) such as fructosyllysine (FL) from glucose, and also Heyns rearrangement products (HRPs) such as glucosyl- and mannosyllysine from fructose. Because they are unstable, ARPs undergo degradation reactions during food processing and preparation, forming 1,2-dicarbonyl compounds such as glyoxal (GO), methylglyoxal (MGO), and 3-deoxyglucosone (3-DG), which are highly reactive. Advanced glycation end products (AGEs) exert harmful effects because they activate receptors for advanced glycation end products (RAGEs) present in different cells or bind to biomolecules, leading to loss of their function¹.

RAGE is a cell surface receptor of the immunoglobulin superfamily. The binding of AGEs to RAGE triggers a series of downstream signaling events, such as activation of nuclear factor kappa B (NF- κ B), which in turn promotes production of inflammatory cytokines such as tumor necrosis factor alpha (TNF- α), interleukin-6 (IL-6), and interleukin-1 β (IL-1 β), creating a pro-inflammatory environment characteristic of pathological aging². Glycation of enzymes and insulin receptors contributes to insulin resistance and mitochondrial dysfunction, reducing efficiency in energy production. Lastly, AGEs create cross-links in collagen fibers and contractile muscle proteins, making these more rigid and less functional, accelerating loss of strength and muscle mass. Thus, an increase in expression of RAGEs and AGEs is observed in conditions such as type 2 diabetes mellitus (DM), cardiovascular disorders, sarcopenia and frailty in chronic kidney disease, cancer, and Alzheimer's disease³.

Given the role of AGEs in diseases associated with aging, research suggests that dietary patterns, such as diets rich in ultra-processed foods, meats grilled at high temperatures, fried foods, and low-moisture foods that have high concentrations of pre-formed AGEs, besides diets with high glycemic index that increase postprandial glycemia and accelerate glycation of endogenous proteins (such as hemoglobin and collagen), increasing the internal load of AGEs independently of direct intake, may act as a direct modulator of the biochemistry of aging⁴.

However, studies exploring the potential association between AGE-rich diets and health outcomes are hampered by a lack of quantitative information and insufficient structural characterization of AGEs in foods. The traditional Brazilian diet is vegetable-based, with rice, beans, and small amounts of meat. However, this pattern has been changing rapidly, with inclusion of breads, oils, fats, soft drinks, pizzas, and snacks. Older adults living alone eat increasingly less traditional Brazilian food and may be exposed to an AGE-rich diet⁵, promoting the development of age-associated diseases.

The objective of this study was to evaluate dietary intake of AGEs and their accumulation among older adults seen under a university program, and to investigate potential associations with body composition and muscle health.

METHODS

A cross-sectional observational study was conducted involving 72 participants from the Vitalità Center for Aging and Longevity at PUC-Campinas aged ≥ 60 years, who consented to take part in the investigation. The study was approved by the Institutional Research Ethics Committee (CEP – PUC - CAAE: 75683723.2.00005481; Report Number: 6.529.820). Data collection was carried out between March and December 2024 and met the requirements of Resolution No. 466/2012.

Basic sociodemographic information collected included age, sex, educational level, and marital

status. Medications being used were recorded and participants were asked to self-declare their skin phototype using the Fitzpatrick scale. A semi-quantitative self-administered questionnaire of 67 food items containing AGE-rich foods (FFQ-AGE) was completed by participants. The FFQ-AGE was created based on the AGE-rich food table devised by Uribarri et al.⁶ and adapted for the Brazilian diet, substituting foods of similar composition in terms of amount of AGE, drawing on the Food Frequency Questionnaire used in the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil)⁷. Food portions were expressed in household measures (tablespoon, cup) or traditional food portions (piece, unit). Participants reported the number of times and frequency with which they consumed a food (more than 3x/day, 2-3x/day, 1x/day, 5-6x/week, 2-4x/week, 1x/week, 1-3x/month, never/rarely) and reported seasonal consumption. Level of AGE intake was calculated by multiplying the amount of AGE per food portion by the frequency of consumption.

The mean of three consecutive skin autofluorescence (SAF) measurements on participants' right forearms was obtained using the Diagnostics® AGE Reader device. The AGE Reader also calculates cardiovascular risk by stratifying the SAF value by participant age, giving a score of 1 to 4, indicating low, mild, moderate, and high cardiovascular risk, respectively.

Body composition was analyzed by calculating body mass index (BMI; kg/m²) from weight and height data obtained using a mechanical medical scale. Obesity was defined as a BMI ≥ 32 kg/m² for older female individuals and ≥ 28 kg/m² for older male individuals. The amount of fat mass was estimated by electrical bioimpedance (Biodynamics, 310e, TBW). The cut-off values for percentage fat mass indicating obesity was $\geq 35\%$ for women and $\geq 24\%$ for men. Calf circumference was measured for the dominant leg using a non-elastic tape in the standing position, at the maximum circumference in the plane perpendicular to the longitudinal line of the calf. Calf circumference ≤ 34 cm for men and ≤ 33 cm for women can be considered a surrogate marker of low muscle mass. Sarcopenic obesity was calculated using the ratio of the diagnostic variables for obesity

(fat mass) and sarcopenia (calf circumference). Handgrip strength (kg) was evaluated using a digital dynamometer (Instrutherm, DM-90). The cut-off value indicating low muscle strength was ≤ 27 kg for men and ≤ 16 kg for women. Functional capacity was evaluated using the Timed Up and Go test (TUG test)⁸. The time taken to rise from the chair, walk 3 meters, and sit back down again on the chair was timed by the observer with the aid of a stopwatch. For the TUG test, a time of ≤ 10 s was considered normal, whereas ≥ 11 s was defined as frailty with greater risk of impaired mobility. Participants answered the SARC-F questionnaire, which evaluates strength, mobility, and falls in the last year. Each item has three severity levels, with scores ranging from zero to two points. A SARC-F score ≥ 4 out of 10 is recommended in International Guidelines as the value to identify individuals at risk of sarcopenia⁹.

Anthropometric data, bioimpedance, handgrip strength, and the TUG test were performed by the same researcher. The weighing scales, handgrip, and bioimpedance equipment were duly calibrated by their manufacturers or representatives before study initiation.

Exploratory data analysis was performed by calculating descriptive statistics (mean, confidence interval, and percentage). Bivariate correlation analyses were performed using Spearman or Pearson Correlation Coefficients, for non-parametric or parametric variables, respectively. Multivariate linear regression analysis was performed on variables with $p < 0.20$ in the bivariate analysis. P-values < 0.05 were considered significant.

DATA AVAILABILITY

The full anonymized data set underpinning the study results is available from **FIGSHARE** at <https://figshare.com/s/8b6b1b2b7f1b5384100e>.

RESULTS

Of the 72 participants, the majority declared gender as female and had completed higher education.

Regarding marital status, half of the sample reported living with a partner and half lived alone. Participant age ranged from 60 to 81 years. Roughly one-third of the sample took no medications routinely for chronic diseases (Table 1). Among participants using medications, the main groups reported included statins (15.7%), angiotensin blockers (13.1%), and metformin (11.8%).

Male and female weight and height differed, but BMI was the same across genders. However, in terms of percentage fat mass, calculated by electrical bioimpedance, more women had a body composition characterized as obese than men (Table 2). There was no gender difference for calf circumference or skin autofluorescence. Skin autofluorescence could not be determined for 6 participants (3 women and 3 men) who self-reported a skin phototype of 5-6 on the Fitzpatrick scale. No gender difference was evident

for performance on the TUG test. As expected, handgrip test performance was significantly higher among men. Sarcopenic obesity was determined by calculating fat mass divided by calf circumference. The results reveal a higher index in females than males (Table 2).

Applying the cut-off point stated in the Methods section, the sample showed risk of impaired mobility and low muscle strength. Only one man and two women were considered at high risk of sarcopenia on the SARC-F questionnaire. Obesity was also observed, as measured by BMI and by percentage fat mass using electrical bioimpedance, based on the cut-off parameter defined. For the overall sample, obesity was more prevalent when using the percentage fat mass parameter than for BMI. There were no statistically significant gender differences for the scores evaluated (Table 3).

Table 1. Sociodemographic characteristics and number of medications used for chronic conditions by older adults attending the Vitalità Center for Aging and Longevity at PUC-Campinas (N=72). Campinas, São Paulo state, 2024.

Variable	n (%)
Gender	
Female	57 (79.2)
Male	15 (20.8)
Educational level	
No formal study	1 (1.4)
Primary	6 (8.3)
Secondary	25 (34.7)
Higher	34 (47.2)
Post-graduate	6 (8.3)
Marital status	
Single	9 (12.5)
Married	37 (51.4)
Divorced	9 (12.5)
Widowed	17 (23.6)
Medications used routinely	
None	22 (30.6)
1 medication	14 (19.4)
2-4 medications	24 (33.3)
≥5 medications	12 (16.7)

Table 2. Age, body composition, skin autofluorescence, and physical performance of older adults attending the Vitalità Center for Aging and Longevity at PUC-Campinas (N=72). Campinas, São Paulo state, 2024.

Variable	Total mean (Confidence interval*)	Male mean (Confidence interval*)	Female mean (Confidence interval*)	Correlation coefficient	<i>p</i> #
Age (years)	68.1 (66.7-69.4)	70.9 (68.4-73.4)	67.3 (65.8-68.9)	0.273	0.020
Body weight (Kg)	72.4 (69.5-75.3)	79.4 (73.5-85.3)	70.6 (67.4-73.8)	0.292	0.013
Height (m)	1.63 (1.6-1.65)	1.73 (1.69-1.78)	1.59 (1.58-1.62)	0.575	0.0001
Body Mass Index (BMI)	27.3 (26.3-28.2)	26.3 (24.7-27.9)	27.5 (26.4-28.7)	-0.110	0.35
Fat mass (%)	32.3 (30.6-34.1)	22.8 (19.8-25.9)	34.7 (33.17-36.23)	-0.578	0.0001
Fat mass (kg)	23.4 (21.6-25.2)	17.9 (15.1-20.7)	24.8 (22.9-26.8)	-0.376	0.001
Calf circumference (cm)	37.5 (36.9-38.0)	37.9 (37.0-38.8)	37.4 (36.8-38.0)	0.123	0.305
Skin autofluorescence (A.U.)	2.64 (2.52-2.75)	2.8 (2.5-3.0)	2.6 (2.5-2.7)	0.107	0.390
Skin phototype (Fitzpatrick scale)	2.7 (2.4-3.0)	3.5 (2.8-4.2)	2.6 (2.2-2.9)	0.268	0.022
TUG test (seconds)	10.3 (9.8-10.8)	10.6 (9.1-12.1)	10.2 (9.7-10.7)	-0.044	0.710
Handgrip strength (kg)	26.7 (23.4-30.0)	38.3 (29.4-47.2)	23.7 (20.7-26.7)	0.442	0.0001
Sarcopenic obesity (fat mass/calf circumference)	0.62 (0.58-0.67)	0.47 (0.40-0.55)	0.66 (0.61-0.71)	-0.409	0.0004

TUG test = Timed Up and Go test. *95% confidence interval. # *p*-value for Spearman correlation coefficient.

Table 3. Physical performance scores and body composition of older adults attending the Vitalità Center for Aging and Longevity at PUC-Campinas (N=72). Campinas, São Paulo state, 2024.

	Total n (%)	Male n (%)	Female n (%)	Correlation coefficient	* <i>p</i>
TUG test				-0,114	0,336
Normal	45 (62.5)	11 (73.3)	34 (60.0)		
Higher risk of impaired mobility	27 (37.5)	4 (26.7)	23 (40.0)		
Handgrip strength				-0.179	0.132
Normal	57 (79.2)	14 (93.3)	43 (75.0)		
Low muscle strength	15 (20.8)	1 (6.7)	13 (25.0)		
SARC-F				0.064	0.592
Healthy	69 (96.0)	14 (93.3)	55 (96.0)		
Sarcopenia	3 (4.0)	1 (6.7)	2 (4.0)		
Calf circumference					
Normal	72 (100)				
BMI				-0.180	0.130
Normal	58 (80.6)	10 (66.7)	48 (84.2)		
Obese	14 (19.4)	5 (33.3)	9 (15.8)		
Fat Mass				0.185	0.119
Normal	35 (48.6)	10 (66.7)	25 (43.9)		
Obese	37 (51.4)	5 (33.3)	32 (56.1)		

TUG test = Timed Up and Go test. SARC-F. BMI = body mass index. **p*-value for Spearman correlation coefficient.

The FFQ-AGE revealed that, overall, average dietary AGE intake was $12,104 \pm 5,719$ kU/day. For AGE consumption by gender, men consumed $12,317 \pm 5,554$ kU/day, while women consumed $11,695 \pm 6,499$ kU/day. Regarding marital status, men living alone consumed $13,590 \pm 6,007$ kU/day ($n=10$) and married women $11,898 \pm 5,763$ kU/day ($n=36$), with no significant difference by marital status. The foods frequently consumed that contributed to level of dietary AGE intake were fast food hamburgers and French fries, pizza with baked crust, avocado, nuts in general, butter, and margarine. There was no correlation

between SAF measurements and participant age, calf circumference or physical performance (TUG test and handgrip strength performance), dietary AGE intake, or number of medications taken routinely. However, a positive correlation was found between BMI, fat mass, and sarcopenic obesity on bivariate correlation analysis (Table 4). Skin autofluorescence reader scores indicating higher cardiovascular risk (Mean = 2.42; CI = 2.11-2.73) correlated positively with BMI ($p=0.0022$) and fat mass ($p=0.0027$). In the multivariate model ($R^2=0.9732$), only BMI remained an independent predictor of SAF values (Table 5).

Table 4. Correlation coefficients between skin autofluorescence (SAF) and anthropometric, dietary, and clinical variables in older adults attending the Vitalità Center for Aging and Longevity at PUC-Campinas (N=72). Campinas, São Paulo state, 2024.

Variable	SAF	*p
Age	-0.05	0.6884
BMI	0.44	0.0002
Fat Mass	0.39	0.0010
Calf circumference	0.12	0.3293
TUG test	-0.05	0.6540
Handgrip strength	0.21	0.0776
Sarcopenic obesity	0.38	0.0014
Dietary AGE	0.03	0.7740
Number of medications	-0.09	0.4421

TUG test = Timed Up and Go test. SARC-F. BMI = body mass index. Dietary AGE = dietary advanced glycation end products. *p-value for Spearman correlation coefficient.

Table 5. Multivariate analysis between skin autofluorescence (SAF) and anthropometric and strength variables in older adults attending the Vitalità Center for Aging and Longevity at PUC-Campinas (N=72). Campinas, São Paulo state, 2024.

Variables	β	Confidence Interval	*p
BMI	0.089	0.0565 - 0.1216	<0.0001
Fat mass	0.020	-0.0083 - 0.0487	0.1616
Handgrip strength	0.006	-0.0031 - 0.0152	0.1946
Sarcopenic obesity	-1.029	-2.210 - 0.1515	0.0864

BMI = body mass index. *p-value for multiple linear regression analysis (Least Squares).

DISCUSSION

Studies in the literature have reported an association of accumulation of AGEs in skeletal muscle with reduced muscle regeneration and structural alterations in the extracellular matrix of skeletal muscle. In a cross-sectional study involving 2,744 European participants with a mean age of 74.1 years, cutaneous AGE levels, measured using skin autofluorescence, were high and associated with a higher prevalence of sarcopenia¹⁰.

Thus, one of the main questions of this study was whether AGE accumulation is associated with changes in body composition, such as the presence of sarcopenia or obesity during aging, thereby predisposing individuals to reduced quality of life and the development of chronic diseases. A non-invasive method for detecting and quantifying the accumulation of fluorescent AGEs in tissues is by reading skin autofluorescence (SAF) using ultraviolet (UV) technology. SAF has been increasingly used as a surrogate for more complex methodologies and has been validated against measurements of collagen-bound fluorescent AGEs such as pentosidine, low-molecular-mass cross-links (LMC), and N ϵ -carboxyethyl-lysine (CEL), for example, in patients with diabetes mellitus¹¹. The challenges of employing SAF in an older population with a wide range of skin phototypes (1 to 6 on the Fitzpatrick scale) and the lack of established reference values were also encountered in the present study. The results revealed no correlation between skin autofluorescence and calf circumference, TUG test score, or handgrip strength in the sample assessed, suggesting that AGE accumulation was not associated with physical performance or muscle health of participants. Age was also found not to correlate with skin autofluorescence, and there was no correlation between SAF values and different skin phototypes.

A study of people with type 1 diabetes and healthy young adults (mean age 31 years) showed that skin autofluorescence values increased with age and that the values in individuals with diabetes were only reached later in life by healthy individuals. The authors reported an increase in SAF of 0.029 ± 0.003 arbitrary

units (AU) per year in diabetic individuals versus 0.022 ± 0.002 AU per year in healthy individuals, who had SAF values of 1.66 ± 0.02 AU and 1.48 ± 0.03 AU, respectively¹². Notably, by comparison, the mean SAF value (2.5 ± 0.5) detected in the present study population (mean age 68.1 years) was higher. However, in a more recent study of a Brazilian population with type 2 diabetes with and without chronic kidney disease (mean age of 58 ± 7 years), SAF values were 3 ± 0.8 AU and 2.5 ± 0.7 AU, respectively¹³.

In another study including healthy individuals and participants with chronic diseases such as diabetes, chronic kidney disease, or cardiovascular disease SAF values were 1.90 ± 0.42 and 2.27 ± 0.51 , respectively. The mean ages of the healthy and chronically ill groups were 43.58 ± 11.77 and 55.51 ± 12.07 years, respectively¹⁴. These findings suggest that the older population assessed in the current investigation had higher SAF values due to age and the presence of both healthy and chronic conditions, given that only 30.6% of participants did not routinely take medications. In addition, a Spanish study recently proposed reference SAF values for individuals ≥ 60 years of 2.28 ± 0.56 ¹⁵, suggesting that Brazilian older adults may have relatively higher SAF values.

The present results showed that SAF values, as a proxy of AGE accumulation, were positively correlated with BMI, percentage fat mass, and sarcopenic obesity on the bivariate analysis. Cardiovascular risk, as calculated by the SAF reader, also correlated positively with BMI and fat mass. Multivariate analysis confirmed BMI as a predictor of AGE accumulation during aging.

Lifestyle changes, particularly in dietary patterns, are essential for preventing and controlling obesity. Recent studies have shown that consumption of AGE-rich foods may promote obesity and the development of chronic cardiovascular diseases.

A positive association between dietary methylglyoxal (MGO) and body-weight gain was demonstrated in a European cohort study¹⁶. The present cross-sectional study failed to show any correlation between dietary AGE intake and BMI, fat mass, or muscle performance score in the older adults assessed. No correlation was found between

skin autofluorescence and dietary AGE intake. It is important to note that the dietary assessment tool employed focuses on AGE-rich foods, and that high glycemic-load diets may also favor AGE accumulation in the body. The FFQ applied showed that the participants consumed $12,104 \pm 5,719$ kU/day of dietary AGEs. Although no reference value for AGE intake has been established, some studies report a wide range of 4,000 to 24,000 kU/day, without taking the health status of participants into account¹⁷. The disparity among studies is large because different methods of data collection were used. Uribarri et al., using a three-day food record, reported a baseline intake of $12,400 \pm 1,000$ kU/day in an intervention study involving participants aged over 60 years, with no differences between men and women¹⁸. In another study, AGE intake in middle-aged individuals was $9,754 \pm 3,936$ kU/day versus $9,893 \pm 3,784$ kU/day in older adults, and no correlation was found between dietary intake, body composition, or metabolic parameters using data from 24-hour recalls and an FFQ¹⁹. In a Dutch study, high dietary AGE intake was not associated with physical frailty²⁰.

Limitations of the present study include its cross-sectional design, lack of a control group, and the absence of a detailed clinical assessment of participants' health status. Other limitations were the small sample size, the possibility of recall bias when completing questionnaires, and the fact that the sample does not fully reflect the Brazilian older population, as illustrated below.

According to data published in 2022 by the Brazilian Institute of Geography and Statistics (IBGE), the total number of people aged 60 years or older (32,113,490) corresponded to 15.6% of the national population, representing a 56.0% increase compared to the 2010 census. Of these older adults, 55.7% were women and 44.3% were men. The present sample did not mirror this distribution, suggesting that older women may be more socially active and more likely than men to seek activities offered by university outreach programs. Regarding educational level, 20.7% of women aged 25 years or older had completed higher education versus 15.8% of men. In the age group of 65 years or

older, literacy was 93.5% for women and 92.5% for men²¹. The sample was also not representative of the Brazilian older population with respect to education, suggesting that opportunities to return to university are more accessible to older Brazilians with higher educational level²¹.

The presence of sarcopenia in aging populations is common and poses a major problem, as it dramatically increases the risk of falls, frailty, disability, hospitalization, and mortality among older adults. In 2019, the European Working Group on Sarcopenia in Older People (EWGSOP) updated the original definition of sarcopenia as a muscle disease (muscle failure) in which low muscle strength overtakes low muscle mass as the primary determinant and predictor of adverse outcomes²². A systematic review and meta-analysis including 9,416 participants from 31 studies of Brazilian older adults found that the prevalence of sarcopenia was 16.0% when both low muscle mass and low muscle function were criteria compared with 17.0% when based solely on low muscle mass²³. All participants in the current sample had calf circumferences above the cut-off for low muscle mass, and only 4% had SARC-F scores indicating risk of sarcopenia. However, 20.8% had low performance on the handgrip test, indicating loss of strength, which is considered more important than muscle mass alone. Moreover, 37.5% of participants failed to attain normal performance on the TUG test and therefore had a higher risk of falls. Loss of muscle strength, not attributable to neurological or primary muscular disease, is known as dynapenia, although the distinction between dynapenia and sarcopenia may not be clinically relevant²⁴.

The presence of obesity has a major impact on negative health outcomes. A recent study that sought to determine the optimal BMI range for older adults suggested that an ideal BMI is 31–32 kg/m² for older women and 27–28 kg/m² for older men²⁵. By contrast, another study showed that a BMI ≥ 30 kg/m² was associated with a 60% increased risk of mobility limitations, regardless of lifestyle habits²⁶. If applying these geriatric-specific ranges rather than the cut-offs proposed for younger adults (overweight > 25 kg/m²), 19.4% of the current sample would be classified as obese. Based on a healthy body-fat

percentage for women aged 60-79 years of 24–35% and for men of 13–24%, the fat mass values obtained by bioimpedance for the sample assessed indicate that 48.6% of the participants were obese, underscoring the need for early interventions to prevent obesity in older adults in Brazil.

CONCLUSION

Accumulation of advanced glycation end products, evaluated by skin autofluorescence, was associated with unfavorable body composition, particularly obesity, indicating an increased risk of cardiovascular diseases. A diet rich in advanced glycation end products was not correlated with the observed accumulation of these products, suggesting that increased endogenous production or reduced excretion capacity are the main factors associated with AGE accumulation during aging. New therapeutic strategies need to be developed and may be useful in the future to control AGE accumulation that occurs with aging, especially in obese adults.

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AUTHORSHIP

- Maria Cecília Ferreira – Data collection; data analysis and interpretation; approval of the version to be published.
- Camila Santos Lemos – Data collection; approval of the version to be published
- Júlia Constantino Aun – Data collection; approval of the version to be published.
- Juliana Alves Macedo – Project conception; data analysis and interpretation; approval of the version to be published.
- Gabriela Alves Macedo – Project conception; data analysis and interpretation; approval of the version to be published.
- Alessandra Gambero – Project conception; funding acquisition; data analysis and interpretation; manuscript writing

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