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Keywords: multimorbidity, multiple long-term chronic conditions, socioeconomic positions, inequality measures, health inequalities, brazil.

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I. INTRODUCTION

Global population is growing, particularly in lower-middle-income countries (LMICs), expected to reach 10. 3 billion by the mid-2080s [1]. Additionally, people are living longer, with the percentage of individuals aged 60 and older estimated to double from 12% to 22% between 2015 and 2050 [2]. This ageing population will result in more individuals living with chronic non-communicable diseases (NCDs) and multiple long-term conditions [2-4].

Non-communicable diseases (NCDs) have a significant impact globally, especially in LMICs, resulting in millions of deaths every year, 42% of which occur before the age of 70, and of all NCDs deaths, 77% are in LMICs [5]. These chronic diseases are slow onset, long duration, and irreversible, for which there is no cure, and are managed with medications and other treatments/therapies [6-9]. These diseases are associated with a rapid and unplanned urbanization, ageing population, unhealthy lifestyles and improved diagnostic capabilities by health services [1,10].

The WHO defines multi-morbidity as having two or more chronic health conditions in one individual [11]. Critics argue that this definition may include conditions that may not significantly impact the individual, leading to calls for alternative definitions [12]. The term has been redefined as "multiple long-term conditions "(MLTC) by the National Institute for Health and Care Research (NIHR, UK) to address concerns about negative connotations and narrow biomedical care approaches [6,13-15]. Then, MLTC was defined as having two or more long-term conditions, including physical and mental health conditions, or single conditions

with multisystem impacts [13]. The MLTC implies longevity and highlights the interaction between co-existing conditions, which is necessary for clinical management and research of long-term conditions [6]. The study will use "MLTC" to describe the coexistence of two or more chronic conditions in one person, aligning with the shift from "multi-morbidity" to "multiple long-term conditions," while respecting alternative terminology from other sources.

The prevalence of multiple long-term conditions is increasing, being more prevalent in older people, women and socio-economic disadvantaged groups across most countries [4,7,16]. Furthermore, recent studies have demonstrated that in LMICs, the prevalence of MLTC is increasing in younger age groups, reaching that observed in high-income countries (HICs)[17-23]. A recent systematic review and meta-analysis (2023) found that the overall global prevalence of MLTC was 37.2%. South America (45.7%) had the highest prevalence of multi- morbidity, followed by North America (43.1%), Europe (39.2%), and Asia (35.0%) [24].

People living with multiple long-term conditions are more prone to declines in functional and mental health, resulting in disability, decreased quality of life, polypharmacy and increased premature mortality [3,10,25]. Moreover, the MLTC significantly impacts the healthcare system, increasing the demand, utilization of healthcare services and healthcare expenses compared to single diseases [4,7]. These indicators continue to rise as the population ages [24].

The negative effects of globalization, rapid urbanization and economic and social consequences of neoliberal policies -increasing income inequalities and poverty- leading to the socioeconomically disadvantaged groups living life stressors and unhealthy behaviours, resulting in higher rates of chronic diseases and multi-morbidity. This is dramatically true in LMICs, where NCDs are increasing at a faster rate and represent the largest cause of death in these countries [26-28]. Individuals with low education levels and living in deprived areas have higher rates of MLTC, and income inequalities impact multi-morbidity prevalence based on country development [29].

Economic experts stress the importance of assessing countries based on not just economic growth and productivity but also efforts to decrease poverty and inequality [30]. Health equity is a critical aspect of health systems performance, with measuring and monitoring health inequalities-observable differences in health between different population subgroups-being essential for achieving it [31,32].

Research on multiple long-term conditions has been identified as an urgent global priority. A better understanding of the dynamics of the multi-morbidity prevalence, their determining and risk factors among adults, mainly across vulnerable populations, particularly in LMICs, is a crucial piece of information for achieving Sustainable Development Goal 3.4 (SDG 3.4), which calls for reducing premature death due to NCDs by one-third through prevention and treatment by 2030 [10,24].

There is no consensus on the ideal measure for expressing the magnitude of inequalities, so multiple methodological issues must be considered when selecting measures [32]. The choice of inequality measurements can impact policy assessments due to their influence on the magnitude and direction of inequality changes, with different summary measures leading to varying conclusions about inequality [32,33]. The Slope Index of Inequality (SII) and Relative Index of Inequality (RII) are commonly recommended regression-based indices for monitoring health inequalities in ordered health indicators [32,33]. The SII compares health indicator values between advantaged and disadvantaged subgroups, taking into account the whole stratification of the socioeconomic indicators. The RII compares indicator ratios between the most advantaged and disadvantaged subgroups, also considering all subgroups of the socioeconomic indicators [32].

In Brazil, the prevalence of multi-morbidity among adults increased from 18. 7% to 29. 9% between 2013-2019 [34,35]. Delpino et al. (2021)

reported rates for individuals aged 18-29 and 30-59 were 6. 4% and 24. 4% in 2013, increasing to 8. 5% and 27. 7% in 2019, while Silva de Silveira et al. (2024) showed rates of 9.3% among those aged 18-29 and 28.6% among those aged 30-59 in 2019. Disparities in multi-morbidity rates exist by age, gender, and region, with higher rates in older individuals, women, and those with lower education and income [22,34-44].

Understanding the association between multiple long-term conditions or multi-morbidity and socioeconomic positions in sub-populations is crucial to addressing the growing burden of chronic diseases. This research examines education and household income inequalities associated with MLTC in Brazilian adults, focusing on gender and age differences. The objective is to identify socioeconomic patterns associated with multiple long-term conditions and provide empirical evidence to improve public health policies to prevent chronic diseases in at-risk populations.

II. METHOD

2.1 Design, Data and Sample Population

This observational cross-sectional study is based on the Brazilian National Health Survey 2019 (NHS-2019) conducted by the Brazilian Institute of Geography and Statistics (IBGE) in partnership with the Ministry of Health. The NHS-2019 is a household-based survey representative of the Brazilian noninstitutionalized population at the national, regional, state, and major metropolitan area levels. The selected sample originated from an IBGE master sample, stratified into three cluster stages: census tracts selected with proportional probability, households selected by simple random and individuals aged 15 or over selected within each household. The interviews were carried out between August 2019 and March 2020 by trained teams using smartphone devices programmed with the survey questionnaire and the processes of criticizing the variables. A total of 90,846 households and 275,323 individuals were interviewed. The response rate for households was 93.6% [45,46]. The present study included participants aged 18 years or over who were considered capable of responding and who answered the questionnaire independently and with complete information for the variables of interest. The samplecomprised 86,831 individuals.

2.2 Dependent Variable

Multiple long-term conditions were assessed using a list of 14 diseases included in the Q module "Chronic Diseases" of the NHS-2019. The list includes the following conditions: hypertension, diabetes, dyslipidaemia (high cholesterol), heart problems, stroke, asthma or wheezing, arthritis or rheumatism, chronic back problems, work-related musculoskeletal disorders (WMSD), depression, other mental diseases, chronic obstructive pulmonary disease (COPD), cancer and chronic kidney failure. Most diseases were identified by asking, "Has any doctor ever given you the diagnosis of...?". In the case of depression and other mental diseases, the question was: "Has any doctor or mental health professional (psychiatrist or psychologist) ever given you a diagnosis of depression?". To identify chronic back problems, the question was: "Do you have a chronic back problem, such as chronic back or neck pain, low back pain, sciatica, vertebrae or disc problems?" The answer option to these questions was yes or no [47]. The individual self-reported all the diseases. MLTC or multi-morbidity was categorized as a dichotomous variable (1= multiple long-term conditions; 0=none or one chronic disease).

2.3 Independent Variables

Measures of socioeconomic position (i.e., education and household income) were the independent variables of interest. These variables correspond to variables derived by IBGE NHS-2019 analysts. The level of education corresponds to the highest level of education achieved standardized for Elementary Education (9-year system). Education was categorized into seven categories: illiterate, unfinished elementary school, finished elementary school, unfinished high school, finished high school, unfinished undergraduate and graduated. Household income corresponds to the sum of the gross monthly

income of the household's residents who work. It excludes the income of people whose status in the household unit was pensioner, domestic employee, or relative of the domestic employee. Income deciles categorized the household income.

2.4 Confounder Variables

The relationship between multiple long-term conditions and level of education or income can be affected by various individual, demographic, economic or social factors, causing biased estimates of the association. To minimize the effect of these factors, it seems necessary to control for some potential confounders. MLTC models will be adjusted for demographic factors (age, geographic regions, residence area) and health factors (private insurance and behaviours risk factors).

Age was categorized into three groups: young adults (18-39 y-olds), middle adults (40- 59 y-olds), and older adults (aged 60 or more). Age was included as a discrete variable in the analyses of each subpopulation –by gender and age group. By grouping the federative units, Brazil is divided into five regions: North, Northeast, Central-West, Southeast and South. The regions were included in the models as categorical variables. The Central-West region was considered a reference group because it has Brazil's best economic, social and quality of life indicators [48]. In addition, the region best represents the national average regarding the population's subscription to health insurance plans (28,9%) [49]. Residence area was included as a dichotomous variable (1=urban; 0=rural).

According to the WHO, the major behavioural risk factors of chronic diseases include tobacco use, the harmful use of alcohol, sedentariness and an unhealthy diet [50]. However, in postmodern Brazil, corporality plays a central role. Individuals are strongly concerned about the presentation and shape of their bodies in an attempt to adapt them to a hegemonic ideal of beauty and youth. Thus, the cult of the body involves not only the practice of physical activity but also diets and plastic surgery [51]. In this cultural context, including a physical activity variable as a protector factor in the analysis was considered relevant.

According to the WHO Guidelines on Physical Activity, it is recommended that adults should do at least 150– 300 minutes of moderate-intensity aerobic physical activity, at least 75–150 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of both [52]. The questions measured physical activity: 1) "In a typical week, on how many days do you do sports, fitness or recreational (leisure) activities? (number of days)" and 2) "How much time do you spend doing sports, fitness or recreational (leisure) activities on a typical day? (hrs and min)". The time in physical activity was aggregated in total min/week. For the current analyses, this variable was arranged into a dichotomic variable: physically inactive (0=<150 min/week) and physically active (1= ≥150 min/week).

Due to a wide range of age in the sample and considering different preferences by age, sedentary behaviours were measured considering time spent watching television and using a computer or other electronic devices. The questions measuring sedentary behaviours were: 1) "How much time do you usually spend watching television on a typical day?" and 2) "How much time do you usually spend using a computer tablet or cell at home on a typical day?" The response options were: 1) less than one hour, 2) one hour to less than two hours, 3) two hours to less than three hours, 4) three hours to less than six hours, 5) six hours or more and 6) does not watch television or does not usually use computer, tablet or cell phone in free time at home. For the current analyses, this variable was arranged into three ordinal categories by each dimension of sedentary behaviour: little time (does not watch TV/ does not use computer, tablets or cell at home or less than 2 hr/day), moderate time (two hours to less than 6 hours/day) and many time (six hours or more/day). Little time served as the reference group for the analysis.

The behavioural risk factors, tobacco use, and harmful alcohol use were included as

dichotomous variables (1=yes; 0=non). The NHS-2019 questionnaire asks about the previous day's consumption of 12 natural foods and 10 ultra-processed foods. The unhealthy diet was defined as the proportion of daily intake of ultra-processed foods and was included as a continuous variable.

2.5 Statistical Analysis

Data analyses included describing the sample and the multiple long-term conditions distribution according to the socioeconomic position measures. Considering the complex sample and aiming to make inferences about the whole population, all analyses used expansion factors and sample weights with the *svyset* and *svy* commands. The variables of the primary sampling unit, individual weight, and stratum were used.

The association between socioeconomic position and multiple long-term conditions was performed using the svy command with Poisson regression models with linearized standard error, adjusting for potential confounders. Analyses of each socioeconomic position for gender and age groups were done separately, using the *subpopulation* command (*subpop*) to compute the estimates for these specific subpopulations [53].

Two models were run for each subpopulation: a crude model including only socioeconomic categories and another adjusted model for potential confounders to isolate the association between socioeconomic position and multiple long-term conditions. Because the outcome variable reflects existing cases of MLTC in a given time—2019-, the Incidence rate ratios (IRR) from Poisson regression represent cumulative incidence or prevalence rate ratios (PRR) [54-56]; however, for a better understanding and communication of the association MLTC with socioeconomic positions, we use *margins* command with the *vce* (unconditional) to estimate prevalence rates (PR) for all categories of education and household income deciles within specific subpopulations [57].

Socioeconomic inequalities related to MLTC were assessed using regression-based measures: the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII). The SII represents the absolute difference in estimated socioeconomic indicator values between those at the highest level of socioeconomic status and those at the lowest level while taking into consideration the entire socioeconomic distribution rather than just comparing the two most extreme groups. In turn, the RII represents the ratio of estimated indicator values of those at the highest level of socioeconomic status and those at the lowest level while taking into consideration the entire socioeconomic distribution [32,58].To calculate the SII, each category of the socioeconomic position measure (i.e. education, income) is assigned a relative position score based on the midpoint of the range of the cumulative distribution from 0 to 1 ("*ridit*" score) of the population of participants in each category of the socioeconomic position. Individuals were ranked according to ascending socioeconomic position [59].

Because multiple long-term conditions have a high prevalence rate in the population, the outcome variable is binary, and assuming a non-linear relationship with socioeconomic position, the SII was estimated with Poisson regression, entering the *"ridit"* score as an independent variable in the MLTC regression model (Crude model). Then, the predicted values of the indicator are calculated for the two extremes of the socioeconomic position. The difference between the highest socioeconomic position and those at the lowest generates the SII value, and his ratio leads to RII [32]. The crude model was also adjusted based on socio-demographic and health behaviour risk factors (Adjusted model).

The statistical analysis was performed using Stata version 14.0. The statistical significance was tested using Wald's chi-square statistic for binary and categorical variables and t-test for discrete variables, and a level of significance of 5% in the test was accepted.

III. RESULTS

3.1 Descriptive

In 2019, 86,831 adults between 18 and 104 years old, with an average age of 46.9 (SD: 16.83), were interviewed. In the expanded sample, 29.5% (95%CI: 29.2; 29.7) reported multiple long-term conditions. Most of them were women (53.0%), with an average age of 56.1 (SD: 15.43) and a MLTC prevalence of 35.9% (95%CI: 35.5; 36.3), while in men, the average age was 57.0 years (SD: 14.86), with a MLTC prevalence of 22.1% (95%CI: 21.7; 22.4). The overall prevalence rate of MLTC increases across age groups, from 12.5% (95%CI: 11.9 ;13.2) in young adults, 34.5% (95%CI: 33.5; 35.4) in middle-aged adults, and 56.2% (95%CI: 55.0; 57.3) in older adults. Table 1 describes demographic, socioeconomic, and health behaviour characteristics according to sex and multiple long-term conditions in Brazilian adults included in the analysis.

Table 1: Sample characteristics according sex and multiple long-term conditions in adults. NHS-2019

Characteristics	Women		Men	
	MMB (n:16,660)	non-MMB (n:29,328)	MMB (n:9,099)	non-MMB (n:31,744)
Age groups, Avg. (SD), years **				
18-39 year-olds	31 (5.79)	29 (6.14)	32 (5.77)	30 (6.18)
40-59 year-olds	51 (5.69)	48 (5.71)	51 (5.61)	49 (5.71)
60 or more year-olds	70 (7.48)	69 (7.56)	70 (7.20)	69 (7.37)
**Education levels (%) ** **				
Illiterate	10,8%	5,5%	12,1%	7,9%
unfinished ElemSch	38,5%	24,6%	40,0%	31,6%
finished ElemSch	6,8%	7,4%	6,9%	7,9%
unfinished HighSch	4,3%	6,8%	3,9%	7,4%
finished HighSch	21,7%	31,2%	18,9%	27,4%
unfinished GradSch	2,8%	5,6%	3,2%	4,8%
graduated	15,1%	18,9%	15,1%	13,0%
Household income decils (%) (monthly avg. Reais$) **				
1st decile	9.3% (402)	13.3% (445)	7.7% (394)	11.7% (449)
2nd decile	16.3% (1,035)	14.0% (1,052)	12.7% (1,036)	12.5% (1,056)
3rd decile	8.3% (1,429)	9.6% (1,424)	7.0% (1,432)	9.2% (1,433)
4th decile	13.7% (1,934)	10.9% (1,902)	13.7% (1,943)	11.7% (1,912)
5th decile	8.9% (2,294)	8.9% (2,296)	8.4% (2,290)	9.4% (2,304)
6th decile	8.7% (2,848)	8.3% (2,840)	8.5% (2,850)	8.9% (2,850)
7th decile	8.9% (3,531)	8.7% (3,5009)	9.1% (3,524)	9.2% (3,515)
8th decile	8.5% (4,588)	8.9% (4,579)	9.7% (4,588)	9.3% (4,562)
9th decile	8.7% (6,621)	8.7% (6,675)	10.3% (6,643)	9.0% (6,616)
10th decile	8.6% (16,088)	8.7% (16,458)	13.0% (18,194)	9.3% (16,821)
Region (%) **				
north	14,5%	20,8%	15,9%	21,2%
northeast	34,7%	35,5%	30,8%	34,6%
central west	11,1%	11,9%	10,7%	11,7%
southeast	25,3%	20,4%	26,0%	20,5%
south	14,3%	11,4%	16,7%	12,1%
Urban residence (%) n.s.	82,0%	80,4%	74,3%	72,0%
Health insurance plans (%) **	27,4%	22,4%	26,9%	20,0%
**Physical activity (= o >150 min/week) ** **	22,3%	27,0%	23,2%	27,1%
**Sitting time watching television ** **				
little time (do not - < 2 hours/day)	51,0%	58,2%	53,8%	60,7%
moderate time (2 hours - < 6 hours/day)	40,4%	36,3%	39,4%	35,5%
many time (≥ 6 hours/day)	8,6%	5,6%	6,8%	3,8%
**Sitting time using computer at home ** **				
little time (do not - <2 hours/day)	76,2%	62,0%	78,9%	67,6%
moderate time (1hour - < 6 hours/day)	18,5%	28,9%	16,5%	24,8%
many time (≥ 6 hours/day)	5,3%	9,1%	4,6%	7,6%
**Tobacco use ** **	10,5%	9,0%	14,8%	16,8%
**Harmful alcohol use ** **	14,8%	20,0%	33,6%	39,5%
Consumption of ultra-processed foods	21,7%	24,8%	22,1%	25,2%

MMB: multimorbidity ; **non-MMB**: non multimorbidity. **ElemSch**: Elementary School ; **HighSch**: High School ; **GradSch** : Graduate School

** :p-value < 0,001 ; **n.s.**: non significant

3.2 Prevalence Rate of the MLTC Among Socioeconomic Positions

Regarding education levels, in the expanded sample, the overall prevalence rate of multiple long-term conditions followed the next pattern: decreased from illiterate (44.3%) to unfinished high school degree (20.1%), then is steady in finished high school and unfinished graduate levels (around 21%) to increase in graduated (27.9%). Concerning household income deciles, the overall prevalence rate of multiple long-term conditions increased from 23.4% in the first deciles to 31.3% in the tenth deciles.

Figures 1 and 2 display MLTC rates by gender and age groups, categorized by education levels and household income deciles. Prevalence rates (PRs) indicate observed, crude, and adjusted probabilities of MLTC in each subpopulation group. Average monthly household income is included to underscore economic differences among socioeconomic positions.

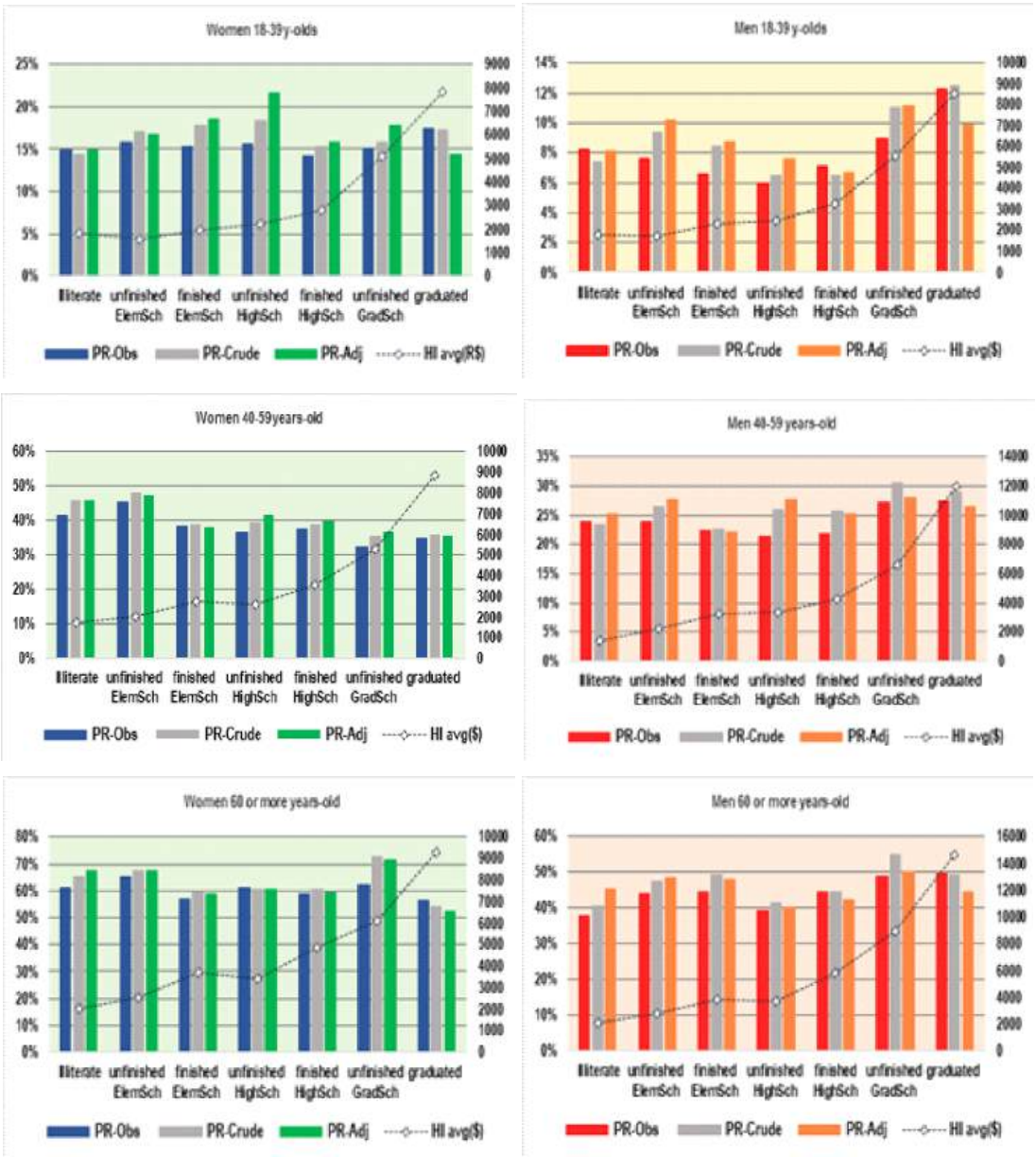

Figure 1: The prevalence rates of multiple long-term conditions by sex and age groups for education levels. NHS-2019

Figure 1 shows marked differences in the prevalence rates of MLTC associated with educational attainment between women and men across age groups. Overall, this difference is more pronounced in young adults and decreases in older adults.

Overall, in both genders and all the age subpopulations, except graduates and some other education categories, the adjusted prevalence rate of multiple long-term chronic conditions - the expected probability - is higher than the observed prevalence rate from the raw sample. Excluding young adults in both sexes, the observed and adjusted prevalence rates of MLTC in middle-aged and older women tend to decrease at higher education levels. On the contrary, in middle-aged men, both prevalence rates of MLTC tend to increase with better levels of education. In contrast, older men present a slight decrease in the adjusted prevalence rate and an increasing trend in the observed prevalence rate of MLTC across the educational levels.

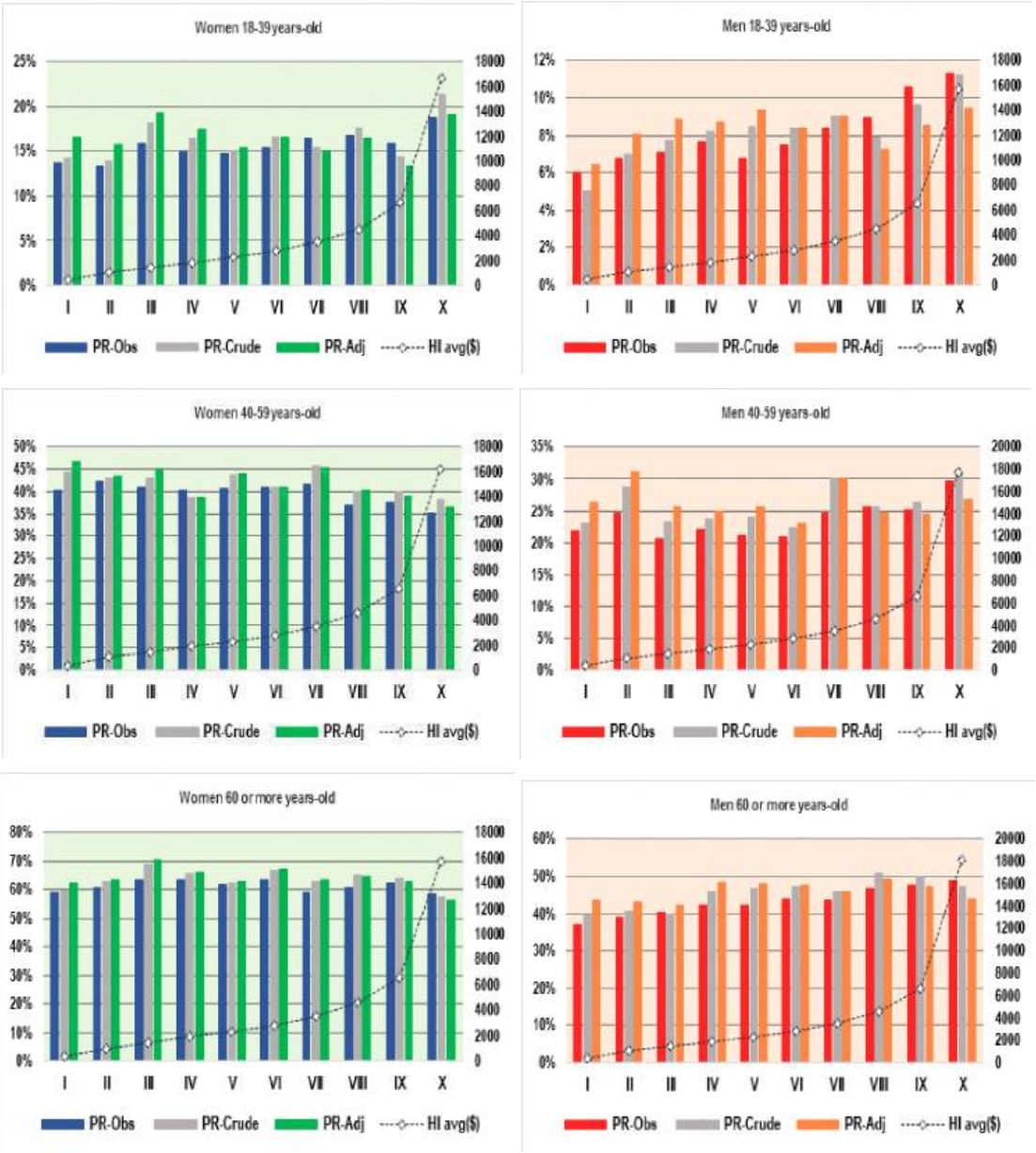

Figure 2: The prevalence rates of multiple long-term conditions by sex and age groups for household income deciles. NHS-2019

Regarding household income deciles, Figure 2 shows marked differences in the prevalence rates of multiple long-term conditions associated with household income deciles between women and men across age groups. This difference is more pronounced in young adults and decreases in older adults.

The observed and adjusted prevalence rates of MLTC in young adults of both sexes tend to increase toward higher income deciles. On the other hand, in middle-aged and older women, these prevalence rates decrease toward the highest income deciles, although this decrease is slight in older women. In contrast, the observed prevalence rate of MLTC tends to increase in middle-aged and older men toward higher income deciles. However, adjusted prevalence rates of MLTC in middle-aged and older men tend to become steady toward higher income deciles.

Except for middle-aged women, the observed prevalence rate is higher than the adjusted prevalence rate in the highest deciles in both sexes, indicating a possible overestimation of the MLTC prevalence rate when the raw data is used. The opposite is noted in the lowest deciles, where the observed prevalence rate is lower than the adjusted prevalence rate, suggesting a potential underestimation of the MLTC prevalence rate in the raw data.

3.3 Inequalities Index

The Slope Index of Inequality (SII) and the Relative Index of Inequality (RII) were used to quantify, across the whole population, the absolute and relative inequality gap between the most-advantaged and least-advantaged groups in the analysed socioeconomic positions. Overall, the magnitude and direction of socioeconomic inequalities showed different patterns across gender and age groups. Positive values indicate that MLTC is more prevalent in the most advantaged groups, and negative values indicate that it is more prevalent in disadvantaged groups.

Regarding education levels in the women's population, Table 2 shows that SII in an adjusted model of the young adults is close to "zero" and RII close to "one", indicating no inequality in MLTC prevalence rate between graduated and illiterate groups. On the other hand, in the adjusted models of middle-aged and older adults, the SII had negative values, meaning that the MLTC prevalence in the graduated group is lower than in the illiterate group across these age groups. As SII and RII are multiplicative measures, their reciprocal values are equivalent in magnitudes [18]. Then, the difference in MLTC prevalence between the illiterate group and the graduated group was 14.7 and 8.9 percentage points in middle-aged adults and older adult women, respectively. Additionally, the RII indicates that MLTC prevalence is 42.5% (1/0.702) and 15.3%(1/0.867) higher among illiterate than among the graduate groups across middle-aged and older adult women, respectively.

Regarding household income deciles in the adjusted models, Table 2 shows that the MLTC prevalence difference is 4.2 percentage points and 30.0% higher in the tenth decile group than the first decile group in young adult women. On the contrary, in the adjusted models of middle-aged adults, the SII had negative values, but, using the reciprocal value, the difference between the first decile and tenth decile groups was 3.7 percentage points, and by the RII MLTC prevalence is 9.6% (1/0.912) higher in the first decile group than the tenth decile group in middle-aged adult women. Finally, in the older adult women, the SII in the adjusted model was close to "zero" and the RII close to "one", indicating no inequality in the MLTC prevalence rate between the first and the tenth decile groups in this age group.

Table 2: SlI and RII of Multiple long-term chronic conditions by Education Level and Income deciles in Women Brazilian Adult.

	18-39 y-olds		40-59 y-olds		60+ y-olds	
Education Levels	**SII** (95% CI)	**RCI**	**SII** (95% CI)	**RCI**	**SII** (95% CI)	**RCI**
Model 1	**-0,006**	**0,964**	**-0,147**	**0,705**	**-0,105**	**0,847**
	(-0,006 - -0,006)		(-0,147 - -0,147)		(-0,105 - -0,105)	
Model 2	**-0,001**	**0,993**	**-0,147**	**0,700**	**-0,091**	**0,864**
	(-0,009 - 0,006)		(-0,154 - -0,141)		(-0,096- -0,086)	
Household Income deciles	**SII** (95% CI)	**RCI**	**SII** (95% CI)	**RCI**	**SII** (95% CI)	**RCI**
Model 1	**0,033**	**1,159**	**-0,043**	**0,902**	**-0,030**	**0,954**
	(0,033 - 0,033)		(-0,043 - -0,043)		(-0,030 - -0,030)	
Model 2	**0,042**	**1,299**	**-0,039**	**0,907**	**0,001**	**1,001**
	(0,038 - 0,046)		(-0,046 - -0,033)		(-0,008 - 0,09)	

* Comparison groups: **Education levels**: graduated vs illiterate ; **Household income**: 10th decile vs 1st decile

***Model 1**: Crude model including only mmb and "ridit" of education levels and of the income decils, respectively.

***Model 2**: Model 1 adjusted by demographics, socieconomic and health behaviours factors.

Regarding education levels in the men's population, Table 3 shows that SII indicates a slightly higher difference in MLTC prevalence in the graduated group than in the illiterate group across all age groups: from 2.6 percentage points in young adults, 2.9 in middle-aged adults and 6.6 percentage points in older adult men in the adjusted models. On the other hand, from adjusted models, the RII indicates that MLTC prevalence is 32,3%, 12.3%, and 16.2% higher among graduates than among the illiterate groups, across young adults, middle-aged adults and older adult men, respectively.

As presented in Table 3, regarding household income deciles in the adjusted models, the SII shows that MLTC prevalence is higher in the tenth decile group than the first decile group across all age groups of men: differences of 4.4, 5.2 and 9.8 percentage points in young adults, middle-aged adults and older adults, respectively. On the other hand, from adjusted models, the RII indicates that MLTC prevalence is 69.0%, 23.1%, and 25.4% higher among the tenth decile than among the first decile groups, across young adults, middle-aged adults and older adults, respectively.

Table 3: SII and RII of Multiple long-term chronic conditions by Education Level and Income deciles in Men Brazilian Adult

	18-39 y-olds		40-59 y-olds		60+ y-olds	
Education Levels	SII (95% CI)	RCI	SII (95% CI)	RCI	SII (95% CI)	RCI
Model 1	0,029	1,423	0,031	1,126	0,051	1,118
	(0,029 - 0,029)		(0,031 - 0,031)		(0,051 - 0,051)	
Model 2	0,026	1,319	0,029	1,123	0,066	1,162
	(0,022 - 0,030)		(0,024 - 0,034)		(0,060 - 0,072)	
Household Income deciles	SII (95% CI)	RCI	SII (95% CI)	RCI	SII (95% CI)	RCI
Model 1	0,041	1,654	0,052	1,224	0,088	1,213
	(0,041 - 0,041)		(0,052 - 0,052)		(0,088 - 0,088)	
Model 2	0,044	1,690	0,053	1,235	0,102	1,266
	(0,041 - 0,046)		(0,048 - 0,058)		(0,092 - 0,113)	

* Comparison groups: **Education levels**: graduated vs illiterate ; **Household income**: 10th decile vs 1st decile

*Model 1: Crude model including only mmb and "ridit" of education levels and of the income decils, respectively.

*Model 2: Model 1 adjusted by demographics, socieconomic and health behaviours factors.

IV. DISCUSSION

Using a nationally representative data, this study examined educational and household income inequalities associated with MLTC in Brazilian adults, with a focus on gender and age groups differences. Understanding these associations is crucial to addressing the growing burden of multiple long-term chronic conditions.

The prevalence rate of MLTC in Brazilian adults in the present study was 29.5%. This prevalence increases with age and is higher among women. These results are consistent with recent systematic reviews and meta-analyses in community-based adults, showing varying prevalence of multi-morbidity across different income countries. In LMICs, the multi-morbidity prevalence has fluctuated in the range of 29.7-36.4% [20,24,60], while in HICs, the prevalence fluctuated between 37.9-38.6% [20,24], respectively. South America (45.7%) had the highest prevalence of multi-morbidity, followed by North America (43.1%), Europe (39.2%), and Asia (35%) [24]. Another study reported an overall pooled multi-morbidity prevalence of 43% in Latin America and the Caribbean [61]. These results also corroborate recent research in Brazil, which found similar multi-morbidity prevalence rate-29.3% and 29.9%- affecting women and older persons [35,44]. It must be noted that the prevalence of MLTC in the adult Brazilian population is increasing over time, as reported by national authors [34,35,39,44]. Rzewuska et al. (2017) from NHS-2013 showed a multi-morbidity prevalence in the adult population of 24.2% [39].

The prevalence of MLTC in Brazilian adults was found to be inversely associated with educational level and directly with household income when not stratified by age and sex. Different patterns emerge when considering age groups and sex. These results are similar to those by Costa et al. (2020), who reported a higher prevalence of multi-morbidity among Brazilian adults aged 20-59, with lower educational levels and belonging to wealthy quintiles [22].

Gender and age significantly affect the association between education and multi-morbidity. In the study, women over 40 with lower education levels showed higher rates, while men over 40 with higher education levels had slightly increased

rates. Even in young adults, women were twice as prevalent as men; however, it is difficult to identify a trend pattern in the prevalence of MLTC across educational levels in both sexes. The educational attainment differences between genders can be explained by a greater interest and concern of women in their health status, thus reducing their exposure to risk factors for chronic diseases. On the other hand, men, for various reasons, adopt behaviours or lifestyles that expose them to more significant risks of getting ill and tend to postpone medical care. The relation between lower education levels and multi-morbidity prevalence is well-established in the literature [12,29,62]. However, in a systematic review by Feng et al. (2021), higher education levels had mixed effects on multi-morbidity likelihood in Southeast Asia due to diverse study contexts and methodologies [63].

The study confirms findings from other Brazilian studies with the same data, showing a high prevalence of multi-morbidity in adults with less than 7 years of schooling [35]. Those with lower education levels had more severe multi-morbidity profiles, with a notable increase in prevalence from 2013 to 2019 for individuals without education or incomplete schooling [34]. Those with incomplete high school or graduate education had lower prevalence ratios compared to graduates, particularly among men [44].

The study found that women over 40 years of age had decreasing MLTC prevalence rates as household income deciles increased, particularly those aged 40 to 59 years. Men ages 40 to 59 showed a similar trend but with a smaller slope, while men ages 60 and older had a slightly increasing rate. Among young adults, women were twice as prevalent as men; however, the prevalence of MLTC showed an increasing trend across income deciles in both genders.

While education consistently influences multi-morbidity, income varies widely in different studies. Recent reviews and a multi-cohort study reveal that socioeconomic deprivation (measured by household income, total household wealth or household area) correlates with increased multi-morbidity rate in HICs. Conversely, several studies in LMICs reported an increased multi-morbidity rate associated with increasing incomes [29,62,64].

These findings suggest a complex effect – on the magnitude and direction of income on MLTC, mediated by educational and cultural factors and purchasing power among individuals, determining engagement in risky health behaviours and limited access to the healthcare system for a timely diagnosis and treatment, especially for the less advantaged population groups with mental disorders [22,63,65,66]. Studies in Brazil show mixed results on the relationship between income and multi-morbidity prevalence. Costa et al. (2020) found higher rates in wealthier individuals [22], while Bof de Andrade et al.(2022) found lower rates in older, higher-income Brazilians with regional disparities [43]. Silva de Silveira et al.(2024) noted increased prevalence in the unemployed and uninsured [35].

The prevalence of Multiple Long-Term Conditions is increasing among younger adults world wide. The study found a 12. 5% prevalence of MLTC in 18-39-year-olds, rising from 9. 0% in 18-29-year-olds to 16. 2% in 30-39-year-olds, with women showing higher rates than men in both age groups. Previous research in Brazil and globally supports these findings. Pereira CC et al. (2023) and Silva de Silveira et al. (2024) showed rates of 11. 1% and 12. 7% among young aged 18-39, respectively [35,44]. Carvalho et al. (2017) found rates of 5. 6% and 12. 3% of the young aged 18-29 and 16. 2% in 30-39, respectively [38], while Rzewuska et al. (2017) reported a 5. 5% rate in young aged 18-24 [39]. Delpino et al. (2021) noted an increase in multi-morbidity from 6. 4% to 8. 5% among 18-29-year-olds from 2013 to 2019 [34]. Similar trends were observed in Australia and the U. S., where prevalence rates ranged from 4. 4% to 22. 2% among young aged 20-39 [19,67, 68]. Furthermore, Canadian cohort studies have shown a rise in multi-morbidity rates in younger cohorts [69-71]. These results highlight the need to understand multi-morbidity in young adults as a key to shaping effective health policies and reducing costs [71-73].

Overall, the raw data indicates a lower prevalence of MLTC in both socioeconomic positions than expected rates from adjusted models in those with lower education and income levels. Despite a universal National Health System in Brazil, these findings suggest an under-diagnosis of chronic diseases, potentially due to a lack of awareness, access to health facilities, or issues in healthcare supply in the public health system. On the other hand, both male and female graduates and men in the highest household income deciles in the three different age groups overestimated the observed prevalence of MLTC. These results suggest that chronic diseases in these socioeconomic groups could be over-diagnosed.

The study found significant inequalities in the prevalence of MLTC among different education levels and genders. Among women, illiterate individuals had a higher prevalence rate compared to graduated, especially among middle-aged and older adults. However, there were no disparities among young adult women. Among men, graduates had a higher prevalence rate of MLTC than illiterates across all age groups. However, younger men who graduated had higher relative differences with illiterates than graduates in other age groups. These results suggest that education plays an important role in people's health and well-being. Educated women tend to have better knowledge, practices, and economic resources to obtain health services than uneducated women. On the contrary, educated men may be facing situations of more significant work stress or health-risk lifestyles and do not have financial restrictions to access health services, in contrast to men with low levels of education.

Previous studies show a clear relationship between education levels and multi-morbidity, especially among women, with variations by country [68,71,74]. In Europe and HICs, lower education is consistently associated with higher multi-morbidity rates. Studies in Portugal and Denmark support this trend [75,76], while research in LMICs and South Asia shows mixed results [63]. Recent studies in Brazil reveal gender-specific disparities, with higher-educated men having higher rates and lower-educated women having higher rates of multi-morbidity [63]. Less-educated individuals in Brazil's Southeast and South regions show higher multi-morbidity prevalence [43]. From 2013 to 2019, there was a general rise in multi-morbidity prevalence across all education levels in Brazil, identifying inequalities in the prevalence of multi-morbidity among less educated [34]. These results correspond with the present research.

This study found slight variations in the prevalence of MLTC by gender and age groups concerning household income inequalities. Younger adult women had a slight absolute difference and a moderate relative difference in detriment of the tenth income decile, while middle-aged had a detriment of the poorest income decile, and older adult women showed no inequality. In all age groups, men presented increasing absolute differences in detriment of the highest income levels. The relative difference was higher in younger adults than in other age groups, to the detriment of the tenth income decile. Differences in the risk of MLTC among genders and age groups may be due to education's role in labour conditions and household income. The risk of MLTC in women is less affected by income differences, while wealthy men are at higher risk may be due to better and affordable access to health services.

Studies worldwide have shown mixed results in the rates of multi-morbidity among economically disadvantaged populations, particularly in LMICs [77-79]. Pathirana and Jackson's (2018) systematic review highlighted conflicting findings, with some studies linking lower income to increased multi-morbidity risk [66,80-82], while others, like a South African study contradicted this finding [83], and a Brazilian study, found no significant association [84]. Income impacted multi-morbidity risk differently by age group and gender, suggesting income may not be a reliable indicator of socioeconomic status, especially in retired individuals [19,29,66]. Despite this, the trend of higher multi-morbidity prevalence in economically disadvantaged individuals remains consistent over time [69-72]. In recent studies in Brazil, Costa AK et al. (2020) found income inequalities linked to multi-morbidity among men

in higher income groups [22]. De Andrade et al. (2021) identified income inequalities affecting lower income levels with regional variations [43].

The present study has several limitations. The study was conducted between 2019 and 2020, and the current association of MLTC with socioeconomic positions could have changed over time. Self-reported chronic diseases may introduce recall bias, especially in older adults and those with lower education. To reduce bias, only individuals aged 18 and over who could respond independently were included. Additionally, the cross-sectional data restricts understanding of causality, and as an observational study, may have a bias from unmeasured confounding, so caution is suggested when concluding socioeconomic positions association with MLTC prevalence.

Despite the above limitations, the study has certain strengths. The study findings can be generalized as the data collected and analyzed are nationally representative. A larger sample size guarantees the accuracy of the results. The study measured MLTC based on 14 chronic conditions similar to other Brazilian research, providing a consistent comparison. IBGE expert analysts derived the socioeconomic position variables. The analysis includes a fully ordered listing of education levels. Controlling by relevant confounding factors offers reliable estimates of measures of inequalities. Separately, subpopulation-by age group and gender- provided a more precise and detailed analysis of the association between SEP and MLTC in Brazilian adult populations.

Future studies in Brazil, should consider longitudinal study design including clinical data, to avoid misreporting of the diagnoses, to capture severity and clinical evolution of diseases over time. Further research is necessary to analyse in more detail and refine the understanding of risk factors, incidence, case mix, and clinical evolution of child and youth MLTC, particularly in disadvantaged populations. Additionally, it is necessary to investigate the impact of specific combinations of chronic diseases determining MLTC on healthcare expenditures to contribute to evaluating the SUS health coverage policies on reducing inequalities.

In conclusion, this study shows that education and income inequalities influence the risk of multiple long-term conditions in the Brazilian adult population. The magnitude and direction of this association differ across gender and age groups. In women, a high risk of MLTC is associated with lower education and varies according to income. On the contrary, in men, a high risk of MLTC is associated with higher education attainment and is consistently determined by income level. This study highlights the role of education over income in health inequalities. It provides evidence of the risk of multiple long-term conditions in younger adults, underscoring the importance of implementing promotion and preventive public policies for this age group to mitigate social inequalities in the later life cycle.

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