Does Residing in Environments of Different Metropolises in a Developing Country have an Impact on Disability after Stroke?

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ABSTRACT

Purpose: *The study aimed to analyse the association between the environment in two different Brazilian metropolises (São Paulo and Belo Horizonte) and disability after a stroke.*

Method: *A cross-sectional study was conducted involving individuals with chronic hemiparesis resulting from a stroke and residing in either São Paulo or Belo Horizonte. The environment (city of residence) was considered an independent variable and disability (modified Rankin scale) was the dependent variable. The following clinical and demographic covariates were considered: age, number of comorbidities, socio-economic class, motor impairment (Fugl-Meyer scale), emotional functioning (Geriatric Depression Scale) and walking ability (10-metre walk test).*

Results: *A total of 114 individuals were analysed - 51 from São Paulo (SP) and 63 from Belo Horizonte (BH). No association was found between the environment in which the individual resides and the degree of disability (OR = 1.436; 95%CI: 0.547 - 3.770; p = 0.46). However, the following variables were predictors of post-stroke disability: motor impairment (OR = 0.216; 95% CI: 0.090 - 0.520; p <0.001) and walking ability (OR = 0.066; 95% CI: 0.005 - 0.912; p = 0.04). The overall correctness of the model was 77.9%.*

Conclusion: *Living in different Brazilian cities had no impact on post-stroke disability. In contrast, motor impairment and walking ability were responsible*

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for 77.9% of the disability found in the sample. The study findings identify possible causes of disabilities after stroke; these could facilitate the most appropriate actions to be taken during rehabilitation.

Key words: *stroke, International Classification of Functioning, Disability and Health, environment*

INTRODUCTION

Projections show that about 3.4 million adults worldwide will have a stroke by 2030, which is a 20.5% increase in prevalence compared to 2012 (Mozaffarian et al, 2015). In a study on the burden of disease considering 369 health conditions, stroke was ranked the second major cause of disability in individuals older than 50 years of age (Vos et al, 2020). Leite et al (2015) estimated the causes of disability-adjusted life years (DALYs) in Brazil, highlighting the predominance of chronic non-communicable diseases, especially cardiovascular disease, in all regions of the country. In the southeastern region, cardiovascular disease accounts for 79.5% of DALYs which is the highest percentage of disability due to this type of disease among the five macro-regions (Leite et al, 2015).

Stroke is the fourth leading cause of DALYs across Brazil and the fifth leading cause in the southeastern region (Leite et al, 2015). Due to the high prevalence of stroke, it was one of the first health conditions to receive attention of different research groups who seek to study functioning according to the structure of the International Classification of Functioning, Disability and Health (ICF) (Barak & Duncan 2006; Tempest & McIntyre, 2006). This classification is based on the biopsychosocial approach, which integrates the different dimensions of health (biological, individual and social). In this model, disability and functioning are conceived as the dynamic interaction of body functions and structures, activity and social participation, considering contextual (personal and environmental) factors (World Health Organisation, 2001).

According to the ICF, the environment is directly related to disability and functioning. However, this relationship needs to be explored from different perspectives, including the comparison of different cities and states. Several international studies have identified environmental factors as risk factors for stroke or mortality, the most widely investigated of which are pollution, climatic conditions/seasonal effects, working hours and exposure to lead (Chang et al, 2014; Wilker et al, 2014; Han, Yi, Kim & Kim, 2015; Kivimäki et al, 2015; Hammel et al, 2015, Zhang, Yan, You & Li, 2015; Cawood & Visagie, 2015; Feigin et al, 2016). A few studies have linked environmental factors to post-stroke disability; however, the study found on this topic was carried out in Canada, which is a country with very different socio-economic and cultural characteristics from those found in Brazil (Rochette, Desrosiers & Noreau, 2001).

In the Brazilian context, two large metropolises in the southeastern region - São Paulo (SP) and Belo Horizonte (BH) - are among the 10 largest cities in the country. The states of São Paulo (SP) and Minas Gerais (MG) are among the most populous states in Brazil and have a higher income in comparison to the national average (Instituto Brasileiro de Geografia e Estatística, 2018). Despite the similarities, a significant difference in life expectancy is found that cannot be explained by socio-economic factors (Chiavegatto Filho & Laurenti, 2013). Differences in lifestyle and risk factors may explain this divergence. Residents of SP are generally more sedentary than those of MG, whereas income per capita and level of education are higher in SP compared to MG (Chiavegatto Filho & Laurenti, 2013). These divergences may also contribute to differences in the degree of post-stroke disability.

Objective

Contextual characteristics related to the environment are often inherent to the decision-making process regarding rehabilitation and therefore need to be identified and considered, especially if such characteristics exert an influence on functioning and disability in health conditions as impactful as a stroke. Therefore, the aims of the present study were to evaluate the association between the environment in different cities (SP and BH) and disability following a stroke and determine predictors of post-stroke disability.

METHOD

Study Design

A cross-sectional study was conducted, involving residents of São Paulo (SP) and Belo Horizonte (BH) with chronic hemiparesis due to a stroke. The participants were evaluated at the physical therapy outpatient clinics of Universidade Nove de Julho and Universidade Federal de Minas Gerais located in São Paulo and Belo Horizonte, respectively.

Study Sample

All the participants had to be residents of either SP or BH and have mental competence, which was determined using the Mini Mental State Examination with the cutoff points described by Bertolucci, Brucki, Campacci & Juliano, 1994.

Inclusion criteria:

Individuals aged 18 years or older, with a clinical diagnosis of primary or recurrent stroke for more than six months that resulted in hemiplegia/paresis.

Exclusion criteria:

Individuals with any other neurological condition beyond stroke, and those with motor or comprehension aphasia (assessed by the ability to speak during a simple conversation).

The final sample was composed of 114 participants (51 from the city of SP and 63 from BH).

Variables

Dependent variable - Disability was the dependent variable and was measured using the modified Rankin scale (Salgado, Ferro & Oliveira, 1996). Two categories were considered for the analysis in the present study: no disability/mild disability versus moderate/severe disability (Salgado, Ferro & Oliveira, 1996).

Independent variable - The environment (residing in SP or BH) was the major independent variable.

Covariables

Factors that could be related to post-stroke disability were considered covariables. For this study, the covariables were described considering the framework of the ICF biopsychosocial model based on references that related this model to stroke (Salter et al, 2005a; Salter et al, 2005b; Salter, Jutai, Teasell, Foley & Bitensky, 2005; Barak & Duncan 2006; Silva et al, 2015): **Body functions component** - motor impairment and emotional functioning, measured using the Fugl-Meyer scale and Geriatric Depression Scale, respectively (Salter, Jutai, Teasell, Foley & Bitensky, 2005); **Activity component** - walking ability and mobility, measured using the 10-metre walk test and the Timed Up and Go test, respectively (Salter et al, 2005b); **Participation component** - Stroke-Specific Quality of Life score (Silva et al, 2015);and **Personal factors** - sex, age, number of comorbidities, marital status and socio-economic class (see Figure 1).

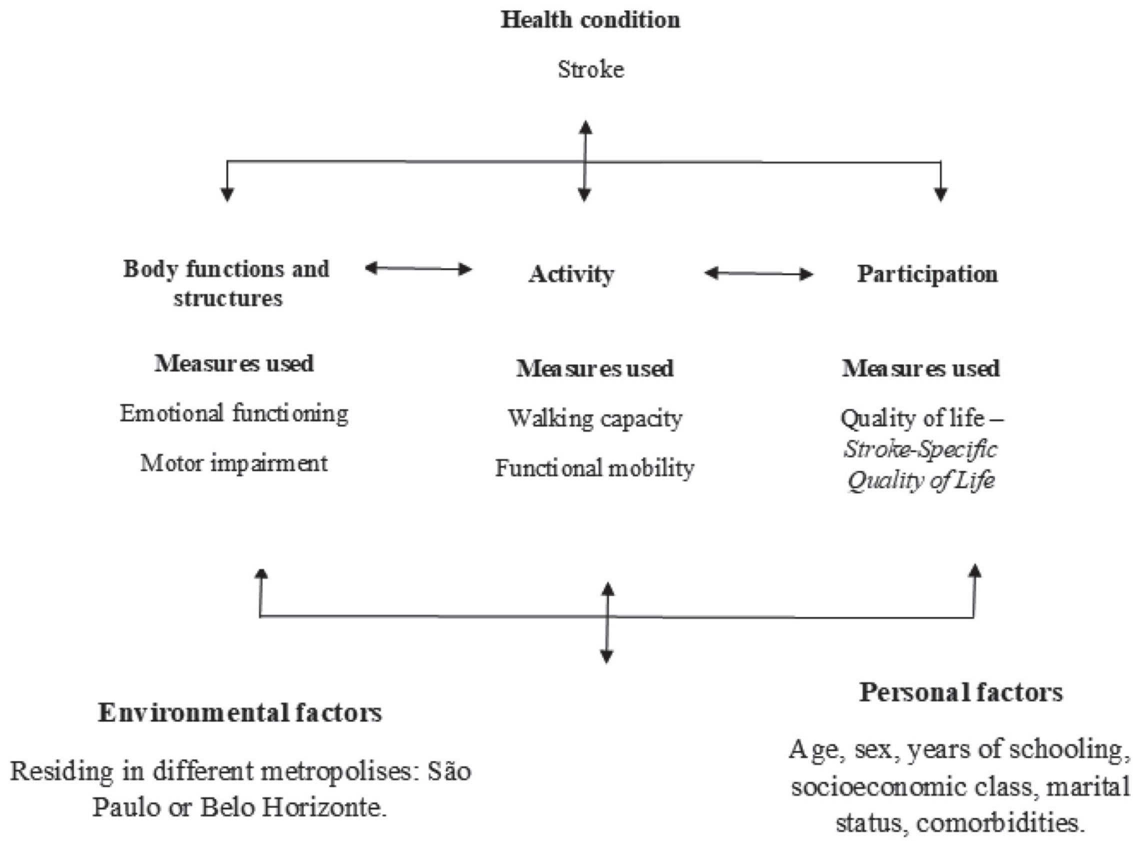

Figure 1: Data organised according to the Framework of International Classification of Functioning, Disability and Health applied to Stroke (Adapted from World Health Organisation (WHO)/Pan American Health Organisation (PAHO)

Causal Diagram of Association between Environment and Disability

Among the variables in Figure 1, were selected those that could conceptually be involved in confounding mechanisms according to a theoretical model represented in a directed acyclic graph (DAG). The DAG was created using the DAGitty programme and enables the identification of sets of variables to perform a conceptually valid adjustment in the estimation of the exposure-outcome association of interest (Textor, Van Der Zander, Gilthorpe, Li Skiewicz & Ellison, 2016). The DAG is preferable to the traditional model for identifying confounding variables, especially when the research question is complex (Suttorp, Siegerink, Jager, Zoccali & Dekker, 2015).

The DAG establishes a causal link between variables. When two variables are not directly connected, this implies independence which may be conditional or not to other variables. Following this assumption, a causal diagram was created to identify the adjustment variables in the analysis of the association between disability and environment (SP or BH). To be included in the causal diagram, a variable should have been previously associated with disability after stroke and measured using an appropriate measurement instrument for the population in question.

Before modelling, consistency between the DAG and the data was evaluated by testing the implications of independence suggested by the diagram (Textor, Van Der Zander, Gilthorpe, Li Skiewicz & Ellison, 2016). To test these implications, the significance level was set at ≤0.005 (significance adjusted by the Bonferroni correction for 10 tested independence implications) as a criterion for revising the DAG. Covariables that did not alter the estimate of interest by more than 10% and those not associated with the outcome were removed from the causal model. The variables that remained associated with the outcome were age, emotional health, number of comorbidities, motor impairment, socio-economic class and ability to walk. Thus, these variables were considered in the final model of the analysis between environment and disability.

Data Collection

Anthropometric, demographic and clinical data were collected using a standard assessment form containing information on personal and environmental factors. The participants were then submitted to evaluations by properly trained examiners.

Assessment Tools

All instruments employed have adequate measurement properties (validity and reliability) for use on stroke survivors (Fugl-meyer, Jaasko, Leyman, Olsson & Steglind, 1975; de Haan, Limburg, Bossuyt, van der Meulen & Aaronson, 1995; Almeida & Almeida, 1999; Salbach et al, 2001; Caneda, Fernandes, Almeida & Mugnol, 2004; Flanbsjer, Holmback, Downham, Patten & Lexell 2005; Marc, Raue & Bruce, 2008; Michaelsen, Rocha, Knabben, Rodrigues & Fernandes, 2011). All questionnaires had been adapted to Portuguese-Brazil (Almeida & Almeida, 1999, Caneda, Fernandes, Almeida & Mugnol, 2004; Michaelsen, Rocha, Knabben, Rodrigues & Fernandes, 2011) and all procedures recommended for the application of the assessment instruments were duly followed (Fugl-meyer, Jaasko, Leyman, Olsson & Steglind, 1975; de Haan, Limburg, Bossuyt, van der Meulen & Aaronson, 1995; Almeida & Almeida, 1999; Salbach et al, 2001; Caneda, Fernandes, Almeida & Mugnol, 2004; Flanbsjer, Holmback, Downham, Patten & Lexell 2005; Marc, Raue & Bruce, 2008; Michaelsen, Rocha, Knabben, Rodrigues & Fernandes, 2011).

Geriatric Depression Scale

The Brazilian version of the Geriatric Depression Scale (GDS) was administered in the form of an interview and was used to assess emotional health, screening for depressive symptoms and mood disorders. The short 15-item version was used, which has adequate reliability and validity for the Brazilian population (Almeida & Almeida, 1999). A score above 5 points was considered positive screening for depression and a score above 11 points was considered indicative of severe depression (Marc, Raue & Bruce, 2008).

Modified Rankin Scale

Modified Rankin Scale (mRS) was created to measure the degree of disability and dependence on activities of daily living following a stroke (de Haan, Limburg, Bossuyt, van der Meulen & Aaronson, 1995). The scale is scored as follows: 0 = no symptoms, 1 = no significant disability; 2 = mild disability; 3 = moderate disability; 4 = moderately severe disability; and, 5 = severe disability (de Haan, Limburg, Bossuyt, van der Meulen & Aaronson, 1995). The mRS has satisfactory validity and clinical reliability for the Brazilian population (Caneda, Fernandes, Almeida & Mugnol, 2004). For the purpose of analysis, two categories were considered: no disability/mild disability versus moderate/severe disability (Salgado et al, 1996).

Fugl-Meyer Scale

The Fugl-Meyer Scale (FMS) was used as a measure of upper and lower extremity motor impairment (Fugl-meyer, Jaasko, Leyman, Olsson & Steglind, 1975). It has satisfactory reliability and validity for the Brazilian population (Michaelsen, Rocha, Knabben, Rodrigues & Fernandes, 2011). The maximum score is 100 points: 66 points for the upper limb and 34 for the lower limb (Fugl-meyer, Jaasko, Leyman, Olsson & Steglind, 1975; Michaelsen, Rocha, Knabben, Rodrigues & Fernandes, 2011). The classification of global motor impairment is based on the total, with 50 points indicating severe motor impairment; 51-84 = marked impairment, 85-95 = moderate impairment, 96-99 = mild impairment, and 100 = no motor impairment (Fugl-meyer, Jaasko, Leyman, Olsson & Steglind, 1975; Michaelsen, Rocha, Knabben, Rodrigues & Fernandes, 2011).

10-metre Walk Test

The ability to walk was analysed using the 10-metre Walk Test (10mWT) (Salbach et al, 2001), which is considered an important measure of functional performance and has adequate reliability for use on individuals with hemiparesis (Salbach et al, 2001). The protocol proposed by Flansbjer et al (2005) was used and gait speed was calculated as metres per second (m/s) considering the average of three repetitions at each speed (comfortable and maximum) (Flanbsjer, Holmback, Downham, Patten & Lexell 2005).

Statistical Analysis

The Shapiro-Wilk normality test was used to analyse the distribution of the data. Variables with normal distribution were expressed as mean and standard deviation, categorical variables were expressed as frequency, and nonparametric variables were expressed as median and interquartile range. The statistics of the following variables were presented according to the environment (city of SP or BH): sex (male or female), number of comorbidities, socio-economic class (A1, A2, B1, B2, C1, C2, D and E), motor impairment (no impairment, mild, moderate, marked and severe impairment) and disability (no/mild disability and moderate/severe disability).

The sample size was calculated considering the inclusion of 6 covariables associated with the causal relationship between disability and environment determined in the causal model/diagram proposed in this study: age, emotional health, number of comorbidities, socio-economic status, motor impairment and walking ability. The formula P= (n+1)*10 was used, in which "n" represents the number of independent variables (Stevenson, 2021). Therefore, a minimum of 70 participants were needed for the present study.

Binary logistic regression was used to estimate the association between the environment (SP or BH) and disability (no/mild disability versus moderate/severe disability). In the first model, only the direct association between disability and environment was considered. In the second model, covariables identified in the causal diagram that could affect the association between environment and disabilities were included: walking ability, motor impairment, socio-economic condition, comorbidities, age and emotional health.

After selecting the variables, multicollinearity was tested, considering a tolerance value>0.1 and VIF <10. After analysing these requirements, the association between environment and disability was adjusted considering the following quality tests: $\chi 2$, Nagelkerke's R^2 and Hosmer-Lemeshow. The results were expressed in odds ratios (OR) and 95% confidence intervals (CI).

All statistical analyses were performed using SPSS for Windows (SPSS Inc., Chicago, IL, USA), version 20. All tests were bilateral and a significance level of $\alpha = 0.05$ was considered in all inferential analyses.

Ethical Approval

This study received approval from the Human Research Ethics Committee of Universidade Nove de Julho, São Paulo, Brazil (protocol number: 3.381.555). All participants signed a statement of informed consent and were made aware of the possibility of withdrawing from the study at any stage, without penalty.

RESULTS

In São Paulo, 97 stroke survivors were recruited but 22 of them were excluded for cognitive impairment, 15 for aphasia and 9 for having another disabling clinical condition besides stroke. In Belo Horizonte, 109 stroke survivors were recruited but 18 of them were excluded for cognitive impairment, 14 for aphasia and 14 because they were unable to perform all the tests. Thus, the final sample was composed of 114 participants (51 from the city of SP and 63 from BH).

The distribution of the sexes was even in both cities. However, the BH sample was slightly older and had more chronic post-stroke sequelae (Table 1). The BH participants also had a larger number of comorbidities; most individuals reported 4 or more comorbidities (82.3%), while the SP individuals had an average of 2.54 comorbidities and 35.3% reported only one comorbidity. The other clinical-demographic characteristics were similar in the two cities. The most frequent socio-economic class was C1 in BH (39.7%; n = 25) and C1 and C2 in SP (59%; n = 30). No individuals were categorised in classes A1 and A2 in either metropolis. The most prevalent level of education in both cities was complete primary education.

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Table 1: Demographic and Clinical Characteristics of Sample

Variables	**São Paulo n= 51**	**Belo Horizonte n=63**
Male	28 (54.9%)	30 (47.6%)
Female	23 (45.1%)	33 (52.4%)
Age	55.17 ± 13.9	65.34 ± 11.68
Time since stroke event (years)	4.05 ± 4.18	5.03 ± 4.50
Marital status		
Married	30 (58.8%)	27 (42.9%)
Single	11 (21.6%)	10 (15.9%)
Divorced	7 (13.7%)	5 (7.9%)
Widowed	3 (5.9%)	21 (33.3%)
Number of comorbidities	2.54 ± 1.45	3.71 ± 0.65
Number of medications	4.28 ± 2.54	4.21 ± 2.38
Disability		
None	7 (13.7%)	18 (28.6%)
Mild	13 (25.5%)	16 (25.4%)
Moderate	18 (35.3%)	17 (27.0%)
Moderately severe	7 (13.7%)	6 (9.5%)
Severe	6 (11.7%)	3 (4.8%)
Motor impairment		
None	7 (13.7%)	5 (7.9%)
Mild	9 (17.7%)	9 (14.3%)
Moderate	12 (23.5%)	18 (28.6%)
Marked	15 (29.4%)	20 (31.7%)
Severe	8 (15.7%)	11 (17.5%)
Emotional health (GDS score)	4.5 (6.0)	6.0 (6.5)
Walking capacity (10mWT-m/s)	0.86 ± 0.32	0.75 ± 0.30

GDS: Geriatric Depression Scale; 10mWT: Ten-Metre Walk Test; m/s: metres per second.

Data expressed as absolute and relative frequency, mean and standard deviation or median and interquartile range.

In the simple model, the environment was not significantly associated with disability [x2 (1) = 0.542; p = 0.46, Nagelkerke's R^2 = 0.011] (OR = 1.436; 95% CI: 0.547 to 3.770; p = 0.46). In the multiple model which includes age, socioeconomic class, emotional health, motor impairment and ability to walk, the environment also showed no association with the outcome [x2 (14) = 36.282; p = 0.46, Nagelkerke's R^2 = 0.551]. In this model, motor impairment (OR = 0.22; 95% CI: 0.09 to 0.52, p <0.001) and walking capacity (OR = 0.07; 95% CI: 0.005 to 0.912, p = 0.04) were independent predictors of disability (Table 2), with a predictive capacity of 77.9%. The other independent variables were not retained in the model.

Table 2: Modelling for Adjustment of Association between Environment and Disability

Variables	Odds ratio	95% CI β		
		Lower	Upper	*p*
Environment (SP or BH)	2.85	0.54	15.13	0.22
Age	1.02	0.96	1.09	0.57
Emotional health	1.04	0.86	1.25	0.70
Comorbidities	1.01	0.44	2.34	0.98
Motor impairment	0.22	0.09	0.52	0.001*
Socioeconomic class	0.89	0.50	1.56	0.68
Walking capacity	0.07	0.005	0.91	0.04*

**p*<0.05; OR: odds ratio; CI: confidence interval

DISCUSSION

The present study tested whether living in different Brazilian cities (SP and BH) can exert an influence on post-stroke disability. After the analysis of the results, no association was found between the environment in which an individual resides – considering the two cities studied – and the degree of disability. In contrast, motor impairment and walking ability explained 77.9% of the disability found in the sample.

The proposed estimation model of the association between environment and disability was based on the biopsychosocial model of the ICF, therefore considering the influence of different components on disability and functioning. The analysis of the implications of independence tested in the final diagram revealed that the measure related to the participation component was not associated with the outcome. However, it should be noted that the measure employed to measure participation refers to the score on a health-related quality of life questionnaire, which has previously been used for this purpose (Salter et al, 2005a; Silva et al, 2015). Therefore, the score of the questionnaire is related to factors associated with other components of the ICF model (Pereira et al, 2019), which is likely why it was in line with other measures and was not retained in the implication test of the association diagram. Future analysis models of the association between disability and the environment should consider more specific measures of participation after a stroke, such as SATIS-Stroke, which measures satisfaction obtained in activities and participation after a stroke (Pereira et al, 2019).

According to the ICF, the environment can be either a facilitator or barrier in the process of human disability and functioning (World Health Organisation, ◎2001)◎. This subject has been recurrent for decades but remains underexplored. Rochette, Desrosiers & Noreau (2001) analysed associations between personal and environmental factors and the occurrence of situations of disability after a stroke. However, the authors employed different methods from those used in the present investigation, using the Measure of the Quality of the Environment (MQE) for the analysis of the environment and the Assessment of Life Habits (LIFE-H) for disability. The authors concluded that obstacles perceived in the environment, together with age and level of physical incapacity, explained 58.9% of the variation in the LIFE-H score (level of disability). When considered alone, however, perceived obstacles (total score) explained only 6.2% of disability. Moreover, perceived facilitators (total score) in the environment were not related to situations of disability.

These results are partially similar to the findings of the present investigation, as motor impairment and the ability to walk were identified as significant predictors for post-stroke disability, with a predictive capacity of 77.9%. Desrosiers, Noreau, Rochette, Bravo & Boutin (2002) confirm the significant association between level of disability and post-stroke physical incapacities, with the coordination of the lower limbs, duration of rehabilitation, balance, age and comorbidities explaining 68.1% of situations of disability after six months of intensive rehabilitation. However, no influence of the environment was identified in the present study, whereas Rochette, Desrosiers & Noreau (2001) reported that the perception of obstacles may help explain post-stroke disability, albeit accounting for a very low percentage. The methodological differences between the studies may have influenced these findings, as the MQE assesses the physical and attitudinal environment and, in contrast, the comparison of physical environments of different cities (SP and BH) may not be enough to detect any influence on disability.

Specifically, regarding SP, there is no data on the association between disability and the environment. However, both physical inactivity and fear of violence have been identified as factors that mediate the association between income and self-perceived health (Chiavegatto Filho, Lebrão & Kawachi, 2012). In BH, more data is available on disabilities. Felicíssimo et al (2017) investigated associations with socio-economic status and comorbidities. The prevalence of self-reported disability was 10.43% and disability was associated with age, two or more comorbidities and socio-economic status. Thus, a poorer socio-economic position and the occurrence of diseases seem to contribute to the occurrence of motor, visual and hearing impairments. In the present study, however, no association was found between socio-economic status and disability. This may be explained by the homogeneity of the SP and BH groups with regard to socioeconomic class. Perhaps different results would be found in the comparison of these findings with different regions of Brazil, particularly the northern and northeastern regions, due to the considerable socio-economic and cultural differences.

Giacomin, Peixoto, Uchoa & Lima-Costa (2008) estimated the prevalence of functional disability among older people living in the metropolitan region of BH and analysed associated characteristics. The prevalence of disability was 16% (8% mild and 8% severe). Age and a poorer self-perception of health were positively and independently associated with mild and severe disability. Chronic diseases, such as hypertension and arthritis, were associated with mild or moderate disability, whereas diabetes and stroke were associated with severe disability. In contrast, no associations were found between post-stroke disability and age or number of comorbidities in the present study, despite the fact that the BH residents were older and had more comorbidities.

Regarding emotional health, Clarke, Black, Badley, Lawrence & Williams (1999) found that depressive symptoms were associated with disability 3 and 12 months after the stroke. In contrast, emotional health did not exert an influence on post-stroke disability in the present study, although the BH residents had a median of 6.0 points on the GDS, which is considered a positive sign of depression, whereas the median among the SP residents was 4.5 points (without depressive signs).

Limitations

The main limitation of this study pertains to the cross-sectional design, which does not enable the establishment of temporal relationships between the independent variables and disability. Another limitation is the division of the groups into "no/mild disability" vs. "moderate/severe disability", which, although guided by the literature (Salgado et al, 1996), can limit the analysis of different levels of disability. This was done due to the sample size which was not sufficient to divide the participants into five groups. Another important limitation refers to the fact that, although the authors have been guided by the ICF biopsychosocial model, the use of mRS can limit the findings, since this scale is not based on the ICF concepts for assessing disability and does not consider the influence which the environment has on disability. Moreover, no measure of activity related exclusively to upper limb function was evaluated; only total motor impairment of the lower and upper limbs (measured using the FMS) was considered.

Despite these limitations, the present findings are extremely relevant, since motor impairment and the ability to walk explained 77.9% of post-stroke disability in the chronic phase, which is higher than the predictive value reported in previously published studies with similar objectives (Rochette, Desrosiers & Noreau, 2001; Pereira et al, 2019).

CONCLUSION

In conclusion, although no significant association was found between the two metropolises evaluated and disability, the model proposed herein identified motor impairment and the ability to walk as predictors of disability after stroke, with an overall correctness of the model of 77.9%. Future studies should investigate whether similar results are observed in other cities that have different socio-economic characteristics from those considered in the present study.

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