Aging and Urbanization: The Neighborhood Perception and Functional Performance of Elderly Persons in Belo Horizonte Metropolitan Area—Brazil

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ABSTRACT *Currently, half of the world population resides in cities. The percentage of world population that is elderly is expected to double from 11% to 22% by 2050 and will be concentrated in urban areas of developing countries. The purpose of this study was to evaluate the functional status of elderly who live in the Belo Horizonte Metropolitan Area, Minas Gerais State, Brazil. The International Classification of Functioning, Disability and Health (ICF) was employed as the theoretical model. Probabilistic sampling was used to select 1,611 elderly persons (defined as ≥ 60 years) for the study. The response variable “functional performance” was developed by counting the number of basic and instrumental activities of daily living (ADL) that subjects found difficult to carry out. A zero-inflated negative binomial (ZINB) regression model was fitted to the data. The prevalence of disability was 47.1%. Neighborhood self-perception revealed that 84.0% of the elderly were satisfied with their neighborhood, although only 18.4% trusted people around them. Concerns about walking around the neighborhood were: fear of being robbed (78.0%) and fear of falling due to sidewalk defects (48.2%), which caused a 62% increase in the number of ADL carried out with difficulty. It is well known that there is a continuous tendency for functional results to improve as the frequency of walking increases. Thus, urban infrastructure interventions, such as improving public sidewalks, might influence the frequency of elderlies walking in their neighborhoods. Making walking possible—or even pleasant—could increase their social participation and use of services.*

KEYWORDS *Health of the elderly, Urban health, Functional performance, International classification of functioning, disability and health, Zero-inflated negative binomial model*

INTRODUCTION

Studies to identify the mechanisms by which a neighborhood context affects aging will prepare us better for the coming decades,¹ which will be characterized by a high

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urbanization rate and an increased number of people over 60 years of age.² Currently, half of the world population lives in cities. It has been estimated that this proportion will reach 60% by 2030.^{2,3} At the same time, the world population of elderly persons may double from 11% to 22% by 2050 and will be concentrated in urban areas of developing countries, representing 25% of the urban population of those countries.^{2,4}

Brazil, to some extent, foreshadows this future. In 2000, the percentage of the population living in cities in Brazil was already 81.2%.³ Today, there are 18 million people age 60 years and older in Brazil, nearly 10% of the population.⁵ By 2020, the elderly will represent 13.8% of the population, and Brazil will have the sixth largest elderly population in the world.⁶

The elderly have the neighborhood as their main or only diameter of living space.¹ According to Glass and Balfour,¹ neighborhood attributes may define whether the elderly will participate in a community. Neighborhoods with good physical and social structures and services that help maintain the well being and productivity of its inhabitants foster such participation.⁴ Changes associated with normal aging, or aging with diseases, may make the elderly more vulnerable to deterioration of their physical and social environment. When the resources of the environment and the ability of individuals interact and negatively affect dependency levels and mobility, the result is a process of disability.⁷

Many risk factors for disability have been identified, such as comorbidities, inactivity, social withdrawal, poor self-rated health, poverty, and lifestyle.⁸ All of these factors have been investigated almost exclusively at an individual level.⁸⁻¹⁰ Few studies have assessed the influence of the environment on elderly function and disability.⁸ In a cohort study, Balfour and Kaplan¹¹ investigated the association between adverse features of the neighborhood and the health of elderly persons in the USA and found that neighborhoods with multiple problems (for example, excessive noise and heavy traffic) are associated with loss of function and depression, regardless of individual economic status, health, and behavioral risk factors. Gen Lin¹² used data from the 1990 US census to examine the geographical distribution of disability among the elderly and found significant regional differences in the prevalence of disability, with higher rates in the southwestern area of the country. These differences persisted after adjusting for age, social, and economic status.

Kalache and Kirkbusch's model¹³ about functional capacity over the life course, states that functional capacity (for example, muscular strength) declines with aging and that the rate of decline is largely determined by individual behaviors, but also by external and environmental factors. Therefore, the rate of decline can be influenced and may be reversible in any age through individual and public measures.

In their causal model on the effects of neighborhood on aging, Glass and Balfour¹ pointed to certain neighborhood-related domains that could affect the outcome of the interaction between subjects and the environment, for example, the physical aspect of neighborhood, such as the state of sidewalks and road paving, conservation of houses, and traffic. This model recognizes the duality of the effect that the environment may have on individuals, facilitating or hindering their activities.

The 2001 International Classification of Functioning, Disability and Health model of the World Health Organization (WHO)¹⁴ states that individual ability or disability in carrying out activities of daily living (ADL) is not related only to the presence or absence of disease. According to ICF, individual disability is the result of

a complex interaction between health conditions, impairment in body functions and structures, activity limitations, participation restrictions, and personal and environmental factors, all of which may affect—either facilitating or hindering—the performance of activities and participation.^{14,15} The model also differentiates the constructs “capacity” and “performance” in which performance is a description of what individuals do in their usual environments, and capacity is measured within a standard or uniform environment.¹⁴

If a neighborhood is an environment within which people live and conduct their daily activities, its features may be measured based on the perception of the individuals therein.^{16–18} The physical and social attributes of a neighborhood are typically external to individuals, albeit dependent on them, and are potentially modifiable.^{16,19} Achieving a balance between personal preferences or needs and environmental pressures fosters satisfaction with the neighborhood and psychological well-being.²⁰

Few studies have been conducted in developing countries about aging and urban life. Thus, the purposes of this study were: (1) to understand the health and functional status of elderly persons who aged in the Belo Horizonte Metropolitan Area (BHMA); (2) to identify those factors associated with independence for carrying out ADL; and (3) to identify those factors concerning the perception of their neighborhood that might be related with their functional status.

MATERIALS AND METHODS

Source of Data

In 2003, we conducted a comprehensive health survey in 20 of the 24 municipalities that comprised the BHMA, Brazil's third largest metropolitan area, both in terms of population (estimated at 5,031,438 people in 2008) and economic output.²¹

The survey sample aimed at yielding estimates for a noninstitutionalized population aged 10 years and above. A probabilistic, two-step stratified cluster sampling method was used: the census tract as the primary selection unit and the household as the sampling unit. Face-to-face interviews were done for the inhabitants of 5,922 (79.0%) of 7,500 households initially selected, and the final sample size was 13,701 individuals. For this study, all 1,611 subjects age 60 and older were included.

The study was approved by the Rene Rachou Research Center IRB (number 011, December 20, 2001). Further details may be found in Lima-Costa.²¹

Study Variables

The response variable “functional performance” was developed based on the number of basic and instrumental ADL that the elderly found difficult to accomplish. Fifteen ADL were investigated: getting out of bed, eating, combing, brushing teeth or washing one's face, walking from one room to another within the same floor, bathing, dressing, toileting, climbing ten steps, taking medication, walking two or three blocks, going out shopping, preparing one's own meal, cutting the nails of the feet, taking a bus, and undertaking household chores. These ADL have been validated and used in studies of the elderly Brazilian population.^{10,22,23}

The explanatory variables and potential confounders were grouped into three domains. The first domain consisted of social and economic variables, the second domain contained demographic variables, and the third domain comprised health-

related variables. A fourth domain represented the main variables of interest “perception of the neighborhood”: satisfaction with the neighborhood, place of residence, trust in people, and concerns about leaving home, such as fear of being robbed and fear of falling due to sidewalk defects. The variable “satisfaction with the neighborhood” was based on nine questions: Do you feel comfortable in your neighborhood, that is, do you feel at home?/Are you satisfied with how the block in which you live is cared for?/Is your neighborhood a good place to live?/Do you like your neighbors and your house?/Are you proud when you tell others where you live?/Would you like to move away from where you live?/Do your neighbors help each other?/Do children and young people in your neighborhood treat adults with respect?/Is your neighborhood a good place for children to play and for teenagers to be brought up? Those questions came from several different studies and were adapted by our research team.²⁴ The variable was categorized as satisfied (five to nine “yes” answers) and less satisfied (four or less “yes” answers). The variable trusting others was based on two questions: Do you believe that you can trust most people?/Do you think that people would take advantage of you or “trick you” if they had the chance? This variable was categorized into “do not trust” (no answer for the first question and yes for the second question), “undecided” (both answers “yes” or both “no”), and “trust” (“yes” for the first question and “no” for the second question). Figure 1 shows the relation among the study variables.

Data Analysis

Sample characterization was based on the central tendency and dispersion, frequencies, and percentages. The chi-square test was applied to verify the association between the response variable and each explanatory variable. Multi-variate analysis was based on the zero-inflated negative binomial regression model (ZINB).²⁵ The variables sex, age, “who answered the survey” (the participant or a

FIGURE 1. Theoretical model of the relation among different domains included in the study. Adapted from the 2001 International Classification of Functioning, Disability and Health (World Health Organization).

proxy), and the domain containing the variables of interest were maintained in the model during all modeling steps.

The response variable was operationalized as the number of ADL that an elderly person found difficult to accomplish. Score variables such as this generally do not satisfy the required assumption of normality when adjusting the linear regression model. The alternatives for analysis are attempts of transformation to normality or categorization of variables, which may result in loss of information.^{26,27}

A possible approach is to assume a Poisson distribution. In applying the Poisson regression model (PRM), we found that the data was overdispersed (the mean number of ADL done with difficulty differed from the variance). As an alternative, the negative binomial regression model (NBRM) was applied. Both models, however, do not take into account the significant proportion of subjects with zero scores for the event under study (52.9% of the sample). Overdispersion and zero inflation needed to be taken into account.²⁸ The options were: (1) the zero-inflated Poisson model (ZIP), which controls only excess zeros; and (2) the ZINB model, which controls excess zeros and the mean heterogeneity not explained by explanatory variables.

The ZINB model was chosen as that with the best countfit function²⁵ compared with the PRM, NBRM, and ZIP models (Figure 2). The ZINB model assumes that the study population may be characterized by two latent groups: one containing subjects with a high propensity to be independent (no difficulty in accomplishing

FIGURE 2. Assessing model fit, difference in observed proportion and mean predictive probability using Poisson (PRM), negative binomial (NBRM), zero-inflated Poisson (ZIP), and zero-inflated negative binomial (ZINB) models. The ZINB model is the best fitting model with fewer points above and below zero on the y-axis.

any ADL), and the second consisting of subjects with a substantial probability of having difficulties in carrying out at least one ADL.

The component of the ZINB model that concerns independent subjects predicts the probability of an individual belonging to this group as compared with the group with some difficulty. It is a logistic model in which each regression coefficient describes the logarithm of the odds ratio associated with the corresponding explanatory variable.

In the negative binomial component of the model—related to subjects with difficulty in carrying out at least one ADL—the assumption is that the mean number of ADL undertaken with some difficulty is associated with relevant explanatory variables according to a log-linear model. In this component, a regression coefficient represents the natural logarithm of the ratio among the variable response means, associated with a unit change of the explanatory variable. Thus, the ZINB model estimates: (1) the odds ratio of being independent; (2) the expected increment in the number of ADL carried out with difficulty among those that are not fully independent (ratio of means (RoM)). Stata software version 10.0 was used for the data analysis.²⁵

RESULTS

The mean age of study participants was 69.6 years. Most were female (59.5%) and married or living as married with a partner (52.9%). Eighteen percent were illiterate; 57.5% of those who attended school did not complete basic education. At least one chronic illness was reported by 70.8%; hypertension was the most prevalent (53.0%). Regular use of medication was reported by 70.9%. Sedentary leisure was reported by 71.4%; fewer than one in five (19.2%) practiced some form of leisure physical activity three times a week. Difficulty in carrying out at least one ADL was reported by 47.1% (Table 1). The mean number of activities done with difficulty was 2.6 and the variance 17.7.

Most participants (64.6%) resided in the capital city of Belo Horizonte. Regarding “perception of the neighborhood,” 84.0% were satisfied with their neighborhood, although only 18.4% trusted people around them. Concerns about going out were: fear of being robbed (78.0%) and fear of falling due to sidewalk defects (48.2%).

Table 2 shows the results of the multivariate analysis. The logistic component presents the odds ratio of subjects performing ADL with no difficulty (independent group) compared with those that accomplished ADL with difficulty. For instance, being female decreased the chance of belonging to the independent group (OR= 0.54; 95% CI=0.33–0.88); that is, women had 54% of the chance of men of belonging to this group. Being independent is associated with being male, under 80 years, having completed basic education or above, working in a job, being the head of household, not having comorbidities, not having used healthcare services within the past 15 days, not using medication regularly, and not being concerned about leaving home due to fear of falling because of sidewalk defects.

The negative binomial component shows the RoM estimates for the group of subjects with difficulties in carrying out at least one ADL. In this group, being age 80 years or older increased by about 60% the number of ADL that were accomplished with difficulty, compared with those aged 60 to 69. Practicing some form of physical activity decreased by about 30% the expected number of ADL found difficult to carry out, compared with sedentary subjects. The variables

TABLE 1 Frequency distribution according to selected variables for 1,611 elderly individuals—Belo Horizonte Metropolitan Area, 2003

Variables	% or mean
Mean age (years)	69.6
Sex	
Female	59.5
Age (years)	
60–69	57.7
70–79	30.1
80 or +	12.2
Education	
Illiterate	18.1
Incomplete basic education	57.5
Complete basic education or more	24.4
Job (occupation)	
Working	17.2
Not working	82.8
Role in the household	
Head	67.6
Spouse	20.2
Other relations	12.2
Number of comorbidities	
None	29.2
1 to 3	64.1
More than 3	6.7
Physical activity during leisure time	
Sedentary leisure ^a	71.4
Little activity (less than 3 times a week)	9.5
Physically active (at least 3 times a week)	19.1
Use of healthcare services within the past 15 days	
Yes	32.9
Regular use of medication	
Yes	70.9
Satisfaction with the neighborhood	
Satisfied	84.0
Place of residence	
Belo Horizonte	64.6
Metropolitan Belo Horizonte	35.4
Trust people	
Do not trust	42.3
Undecided	39.3
Trust	18.4
Concern when leaving the home: fear of being robbed	
Yes	78.0
Concern when leaving the home: fear of falling on the sidewalks	
Yes	48.2

^aNo physical activity during leisure time, considering physical activity as any bodily movement produced by skeletal muscles that results in energy consumption

TABLE 2 Zero-inflated negative binomial regression of functional performance (see “Materials and Methods” section for definition of functional performance) according to selected variables, for 1,611 elderly individuals—Belo Horizonte Metropolitan Area, Brazil, 2003

Variables	Logistic component			Negative binomial component		
	OR	95% CI	P value	RoM	95% CI	P value
Sex						
Male	1.00			1.00		
Female	0.54	0.33–0.88	0.01*	0.82	0.67–1.03	0.08
Age (years)						
60–69	1.00			1.00		
70–79	0.76	0.48–1.21	0.26	1.18	0.97–1.43	0.11
80 or +	0.27	0.13–0.55	0.00*	1.59	1.30–1.94	0.00*
Education						
Illiterate	1.00			1.00		
Incomplete basic education	2.68	0.62–1.95	0.73	1.00	0.84–1.21	0.95
Complete basic education or more	2.54	1.27– 5.08	0.01*	1.09	0.79–1.51	0.59
Job (occupation)						
Working	1.00			1.00		
Not working	0.48	0.23–1.01	0.05*	2.04	1.20–3.49	0.01*
Role in the household						
Head	1.00			1.00		
Spouse	1.09	0.63–1.90	0.76	1.25	1.02–1.53	0.03*
Other relations	0.40	0.19–0.20	0.02*	1.12	0.92–1.39	0.25
Number of comorbidities						
None	1.00			1.00		
1 to 3	0.50	0.30–0.83	0.01*	1.08	0.84–1.40	0.55
More than 3	0.15	0.04–0.66	0.01*	1.22	0.92–1.64	0.17
Physical activity during leisure time						
Sedentary leisure	1.00			1.00		
Little activity (less than 3 times a week)	1.36	0.63–2.94	0.44	0.69	0.50–0.99	0.04*
Physically active (at least 3 times a week)	1.57	0.87–2.83	0.13	0.78	0.57–1.09	0.15
Use of healthcare services within the past 15 days						
No	1.00			1.00		
Yes	0.52	0.33–0.82	0.01*	1.01	0.86–1.20	0.84
Regular use of medication						
No	1.00			1.00		
Yes	0.57	0.32–0.98	0.04*	1.82	1.38–2.41	0.00*
Satisfied with the neighborhood						
Satisfied	1.00			1.00		
Less satisfied	0.64	0.36–1.12	0.12	1.19	0.97–1.48	0.11
Pace of residence						
Belo Horizonte	1.00			1.00		
Municipal Belo Horizonte	1.05	0.68–1.61	0.82	1.14	0.96–1.35	0.13
Trust people						
No trust	1.00			1.00		
Undecided	0.77	0.49–1.22	0.27	1.10	0.92–1.33	0.30
Trust	0.91	0.50–1.65	0.75	0.98	0.78–1.25	0.90
Concern when leaving the home: fear of robbery						
No	1.00			1.00		
Yes	0.98	0.60–1.60	0.95	0.86	0.71–1.06	0.17
Concern when leaving the home: fear of falling on the sidewalks						
No	1.00			1.00		
Yes	0.31	0.20–0.49	0.00*	1.62	1.34–1.97	0.00*

Model adjusted according to the type of informant (variable “who answered the survey”, the participant or a proxy)

OR odds ratio (indicates the chance of belonging to the group of subjects that did not experience the event, that is, the chance of being independent), RoM ratio of means (indicates increases in the number of activities of daily living (ADL) carried out with difficulty)

*P values ≤0.05

occupation, role in the household and regular use of medication also increased the number of ADL carried out with difficulty.

In the final model, for the variables pertaining to perception of the neighborhood, only fear of falling due to sidewalk defects was significantly associated to the response variable, and implied a 62% increase in the expected number of ADL carried out with difficulty. The remaining variables in Table 2 and their respective odd ratios and RoM may be interpreted as above.

DISCUSSION

We investigated the health profile and functional performance of elderly persons living in the BHMA, and their association with the perception of the neighborhood. Elderly subjects were mostly female, about 70 years of age, married or living as married with a partner and of low educational level. Most reported at least one chronic illness (more frequently hypertension), used medication regularly, were sedentary in leisure time, resided in Belo Horizonte City and were satisfied with their neighborhood, but did not trust people around them.

Independence in ADL was associated with the male sex, lower age groups, better education, working in a job, being the head of household, no report of chronic illness, not using healthcare services, not using medication regularly, and not being concerned about going out of home due to fear of falling because of sidewalk defects. Increasing in the number of ADL carried out with difficulties was associated with more advanced age, not having a job, being the spouse within the family, little physical activity, using medication regularly, and being concerned about going out of home due to fear of falling because of sidewalk defects.

The percentage of elderly with some difficulty in carrying out ADL was 47.1%, a high percentage compared with other Brazilian studies.^{9,29,30} In this study however, basic and instrumental ADL were taken into account jointly. Care should be exercised when comparing these studies, as there is no consensus in the literature about operationalizing the variable functional performance.²² Adding instrumental activities of daily living (IADL), which are considered more complex than basic activities of daily living (BADL), probably increases the proportion of activities that the elderly find difficult to carry out.^{9,23} We considered inclusion of IADL important because perception of the neighborhood was our main domain of interest, and such activities are closely linked to social participation. Furthermore, even those confined to their home and that carry out BADL with difficulty, may encounter obstacles to participation, particularly due to environmental, physical and social factors. If such factors are modified, these individuals may change their disability status. Thus, simultaneously assessing BADL and IADL allows a more encompassing approach of multiple levels of disability and the potential for change; this approach is also aligned with the functioning theoretical model applied in this study, in which activity and participation are addressed jointly.¹⁴

Aside from the high prevalence of functional disability, another relevant finding was the significant number of individuals that did not experience the event being investigated (52.9%; Figure 3). This finding is not rare in epidemiological studies, including those investigating functional ability,^{9,30} and should be considered in the data analysis.²⁸ The response variable is usually categorized in studies of functioning, which may result in loss of information.²⁷ The response variable in this study was assumed to be a count variable, and the choice of the best adjusted model followed steps recommended in the literature.^{25–28}

FIGURE 3. Distribution of the response variable “functional performance” base on counting the number of basic and instrumental activities of daily living (ADL) that elderly subjects found difficult to carry out. Fifteen ADL were taken into account.

Among the variables of the domain “perception of the neighborhood”, fear of falling because of sidewalk defects was significant in both components of the model. Among elderly subjects that had difficulty in carrying out ADL, the presence of this concern meant a 62.0% increase in the expected number of ADL accomplished with difficulty. The physical environment of the neighborhood is directly related with the diameter of living space and certainly can be a barrier limiting participation by elderly persons.¹⁴ We may consider fear of falling because of sidewalk defects as a proxy for the quality of public sidewalks. In absolute terms, fear of falling was reported by about 50% of the participants. Interventions aiming at improving the quality of streets and sidewalks could impact functionality, since certain IADL, such as walking a few blocks and going shopping, would become easier or even possible. A relevant challenge for urban health is measuring the impact on individual and collective health of interventions on the physical and social environment implemented by the health and other public sectors.³

Overall, the feeling of insecurity was an important concern in our study population, although the variable “fear of being robbed” was not statistically significant in the final model. It was probably the result of the high frequency (78.0%) of fear of crime among the elderly independent of their functional performance. Such insecurity experienced by the vast majority of the elderly has probably major implications, as it prevents socialization, decreases the level of physical activity at leisure times, prevents independence, and, ultimately, impacts on functionality levels.^{31–33} However, a recent study reported that among urban elderly, fear of crime increases neighborhood attachment such as friendships, neighboring, social cohesion and trust, informal social control, and participation in neighborhood watch programs.³²

The decline of social networks in later life tends to generate greater dependency on social contact with neighbors.³⁴ These ties turn into a vital informal support

when older people need help, for example, in emergency assistance. In this study, we found that 18.4% of the elderly trusted in people around them. The high frequency of fear of crime encountered in this study probably contributed to the finding of poor trust. Strong trust among neighbors is expected to reduce fear of crime³⁵ and thus improve neighborhood satisfaction.³³

Neighborhood attributes have received empirical support in relation to neighborhood satisfaction. Research using the construct of neighborhood satisfaction has stimulated investigators to devise different ways to measure it.²⁴ There is currently no standardized satisfaction scale suitable for application to every area in a city or to different cities.³⁶ In our study, although satisfaction with the neighborhood was not statistically significant in the final model, the elderly not satisfied with their neighborhood reported a higher frequency of ADL carried out with difficulty. The result of adjustments between individuals and their environment is one of the main factors that may affect satisfaction with the neighborhood¹⁹; it may also define disability or functional status.¹ People living in different neighborhoods take into account different aspects to define their satisfaction level; those residing in areas considered unsatisfactory focus mainly on social issues, while individuals in more satisfactory areas base their conclusion on physical and social aspects.³⁶ Furthermore, among elderly, neighborhood features appear to impact their quality of life more than the state of their own household.¹⁹

One of the main limitations of this study is its cross-sectional design, since temporality cannot be established, and asymmetry between explanatory variables and functional performance cannot be assured. Another important limitation is using responses by proxies, which composed 21.2% of the sample. However, recent studies have shown good agreement between answers provided by a proxy and the elderly themselves about functional issues, including ADL.^{37,38} Same-source bias is another limitation, that is, the possibility that the use of self-reported data for both the outcome and the neighborhood characteristic generates a spurious association between the two because the measurement error in both reports is correlated or because the outcome affects the perception or report of the neighborhood attribute.³⁹

CONCLUSION

Given the dynamic nature of the ICF model, intervening in any of the aspects that permeate the disability or functioning process has the potential to change its result. Thus, urban infrastructure interventions, such as improving public sidewalks, may make walking in their neighborhood possible, or even pleasant, and thus increase the frequency of walking and thus increase their social engagement and use of services. There is a continuous tendency for functional results to improve as the frequency of walking increases.^{13,40} This change in life habits might avoid or attenuate the consequences of morbidities by influencing physical activity levels.⁴¹ Our results show that not being completely sedentary in leisure time has a positive impact decreasing the number of ADL accomplished with difficulty. An improved clinical status for some diseases due to changes in a sedentary lifestyle might alter the use of both medication and healthcare services.

From a methodological standpoint, the theoretical and analytical models applied in this study raise the possibility of a dualistic view of functional status. The ZINB modeling yield functioning perspectives (logistic component) and

disability perspectives (negative binomial component), both of which are predicted in the ICF model.

A global objective is to keep urban environments as quality living places within easy access for all individuals, regardless of age.^{3,4} The degree to which older adults feel safe, trust their neighbors, and can navigate through the streets of their city is of critical importance for public health.

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