

Biomedical factors associated with hospitalization of older adults: The Bambuí Health and Aging Study (BHAS)

Projeto Bambuí: fatores biomédicos associados à ocorrência de internações hospitalares entre idosos

Henrique L. Guerra ¹
Pedro G. Vidigall ¹
Maria Fernanda Lima-Costa ¹

¹ Núcleo de Estudos em Saúde Pública e Envelhecimento, Centro de Pesquisas René Rachou, Fundação Oswaldo Cruz/ Universidade Federal de Minas Gerais. Av. Augusto de Lima 1715, Belo Horizonte, MG 30190-002, Brasil.

Abstract *The objective of this study was to identify biomedical factors (body mass index, blood pressure, blood glucose, total cholesterol and fractions, triglycerides, and albumin) associated with hospitalization of older adults. All residents of the town of Bambuí, Minas Gerais State, ages ≥ 60 years ($n = 1,742$) were selected for the study, of whom 1,494 (85.2%) participated. None of the biomedical factors studied was independently associated with occurrence of 1 hospitalization during the previous 12 months. Body mass index $< 20\text{Kg/m}^2$ and total cholesterol = 200-263mg/dl and $\geq 264\text{mg/dl}$ were independently associated with ≥ 2 hospitalizations. The introduction of biomedical factors did not modify the previously identified associations between hospitalization and indicators constructed from information obtained in a questionnaire survey. The results show that data easily obtained through interviews can be useful both for identifying older adults at risk of hospitalization and thus for assisting in prevention.*

Key words Aging Health; Aging; Hospitalization

Resumo *O objetivo deste estudo foi identificar fatores biomédicos (índice de massa corporal, pressão arterial, blood glucose, colesterol total e fracionado, triglicérides e albumina) associados com a ocorrência de internações hospitalares em idosos. Foram selecionados para o estudo todos os residentes na cidade de Bambuí (Minas Gerais), com idade ≥ 60 anos ($n = 1.742$). Desses, 1.494 (85,2%) participaram. Nenhum dos fatores biomédicos estudados apresentou associação independente com a ocorrência de uma internação hospitalar nos últimos 12 meses. Índice de Massa Corporal $< 20\text{kg/m}^2$ e colesterol total = 200-263mg/dl e $\geq 264\text{mg/dl}$ apresentaram associações independentes com a ocorrência de ≥ 2 internações hospitalares. É importante salientar que, a introdução de fatores biomédicos não modificou as associações previamente encontradas na mesma população entre a ocorrência de internações hospitalares e indicadores construídos com base em informações obtidas por meio de questionários. Este resultado mostra que dados de fácil obtenção por intermédio de entrevistas podem ser úteis para identificar idosos sob risco de hospitalização, para prevenção.*

Palavras-chave Saúde do Idoso; Envelhecimento; Hospitalização

Introduction

Numerous health problems frequently accompany the later decades in life. The elderly are thus extensive consumers of health services, and this is reflected in the demand for hospital admissions. In Brazil in 1996, hospitalization of the elderly (60 years of age or older) cost 23% of the total health care budget for hospital admissions under the Unified National Health System (SUS). This proportion was 2.9 times the relative contribution of this age group (8%) to the country's total population (Lima-Costa et al., 2000b). The majority of hospital expenditures are on a relatively small group (approximately 15-20%) of older adults with chronic illnesses (Freeborn et al., 1990; McCall & Wai, 1983; Roos & Shapiro, 1981; Roos et al., 1989; Zook & Moore, 1980). Frequently hospitalized elderly could enjoy better health if they were identified early and treated preventively (Boult et al., 1993).

Recent studies in developed countries based on data from questionnaires and using the behavioral model proposed by Andersen (Aday & Andersen, 1974; Andersen, 1995; Andersen & Newman, 1973) have shown that predisposing and enabling factors and need are powerful predictors of hospitalization of the elderly (Boult et al., 1993; Hurd & McGarry, 1997; Pacala et al., 1997). Predisposing factors precede the onset of illness (e.g., gender, age, or beliefs regarding treatment efficacy). Enabling factors make health services available to the individual (e.g., salary and health plan coverage). Need indicators represent the most immediate cause of health services utilization (e.g., self-rated health and diagnosis of a disease or chronic condition) (Aday & Andersen, 1974; Andersen & Newman, 1973; Branch et al., 1981).

Population-based studies to determine factors associated with hospitalization among the elderly are rare in developing countries (Guerra et al., 2001). These factors were investigated at the baseline of a prospective study on aging in Bambuí, Minas Gerais State, Brazil, using data obtained through a questionnaire. Variables significantly associated with two or more admissions in the previous 12 months were: (1) worse self-rated health, more visits to doctors, use of more prescription medication, history of medical diagnosis of coronary disease, having interrupted routine activities during the previous two weeks due to health problems, having been bedridden during past two weeks, and inability to walk 1.5km without tiring (indicators of need); (2) age \geq 80 years, male gender, and living alone (predisposing factors); and (3) fi-

nancial problems in obtaining medication (enabling factors). The results were similar to those observed in developed countries (Boult et al., 1993; Branch et al., 1981; Hurd & McGarry, 1997).

In general, need indicators, based on information obtained through interviews, are those presenting the strongest association with hospitalization and use of other types of health care by older adults (Borges-Yáñez & Gómez-Dantés, 1998; Boult et al., 1993; Branch et al., 1981; Coleman et al., 1998; Evans et al., 1988; Guerra et al., 2001; Hurd & McGarry, 1997; Pacala et al., 1997; Pinheiro & Travassos, 1999; Satish et al., 1996; Wolinsky et al., 1992).

Need indicators constructed from objective measurements of biomedical factors have been used infrequently to investigate prediction of hospitalization of the elderly. Tayback et al. (1990) performed a prospective study to verify the effect of body mass index (BMI) on mortality and hospitalization among older Americans (aged 55-74 years). After a mean follow-up period of 8.7 years they concluded that low BMI was associated with increased mortality but not with risk of hospitalization. In another population-based study in the United States, a sample of 6,461 adults over 45 years of age was followed for 12-16 years. According to the study, risk of hospitalization among older individuals was associated with hypertension, low serum albumin, current smoking, diabetes, lung disease, and ischemic heart disease but not with serum cholesterol (Miller et al., 1998). Hanlon et al. (1998) studied a cohort of 8,349 women and 7,057 men 45-64 years of age in Central Scotland. After a 23-year follow-up they showed that risk of hospitalization was associated with low forced expiratory volume, low and elevated BMI, greater age, male gender, current smoking, hypertension, hyperglycemia, and low serum cholesterol.

The present study was conducted on the baseline of a cohort study of older adult residents in Bambuí, Minas Gerais State (Lima-Costa et al., 2000a). Objectives of the study were to identify associations between hospitalization in the previous 12 months and selected biomedical measurements (BP, BMI, blood glucose, and serum cholesterol, triglycerides, and albumin) and to verify whether the inclusion of biomedical variables modified the associations previously observed in this cohort (Guerra et al., 2001) pertaining to hospitalization of older adults and predisposing, enabling, and need factors.

Material and methods

Study area

The present study was conducted in the municipality of Bambuí, situated in western Minas Gerais State. The municipality had approximately 20,000 inhabitants in 1991, 70% of whom lived in the urban area (IBGE, 1992). The human development index in the municipality was 0.70, life expectancy at birth was 70.2 years, and 75% of deaths occurred among people \geq 50 years (DATASUS, 1997). The principal causes of death in 1996 were cerebrovascular disease (ICD-10: I60-I69), Chagas disease (ICD-10: B57), and coronary heart disease (I20-I25) (mortality rates = 113.3, 61.4, and 42.5 per 100,000 inhabitants, respectively) (DATASUS, 1998). The high mortality rate from Chagas disease among residents of this community resulted from chronic *Trypanosoma cruzi* infection. Although transmission appears to have been interrupted some 20 years previously, seropositivity rates among older inhabitants remain high due to the cohort effect (Lima-Costa et al., 2001).

Bambuí has a general hospital with 62 beds and a municipal polyclinic that offers primary health care 24 hours a day. In 1996 there was one physician per 1,000 inhabitants. In that same year, 545 public hospital admissions were recorded among residents \geq 60 years (MS, 1997). Among these, the principal causes were heart failure (ICD-9: 428) and bacterial pneumonia (ICD-9: 482, 485, 486) (hospitalization rates = 28.9 and 25.2 per 1,000 inhabitants, respectively).

Study population

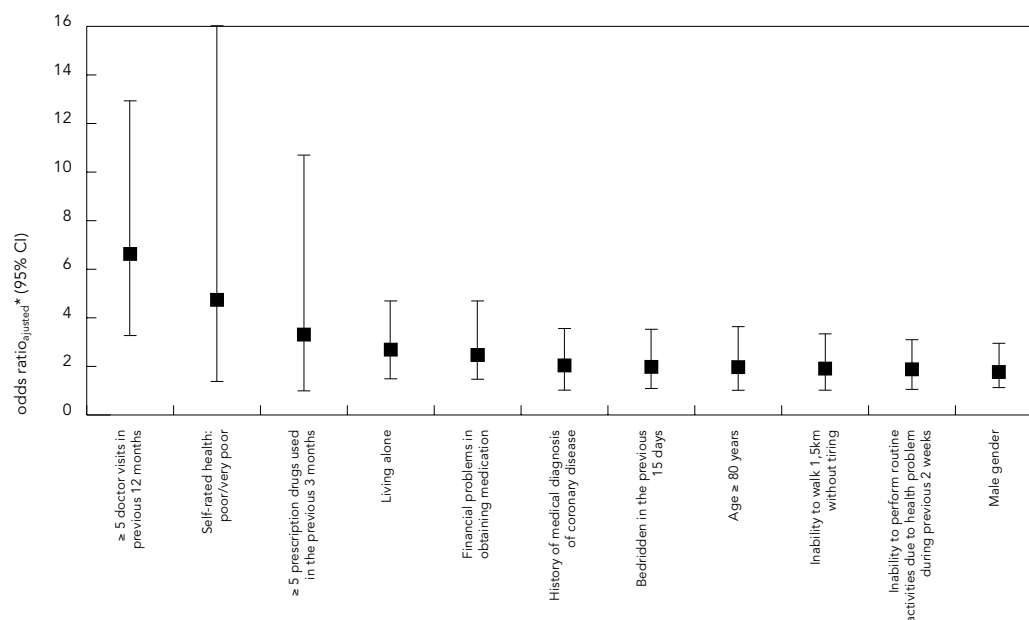
Our team conducted a complete census of the town of Bambuí in November and December 1996 to identify study participants. All residents \geq 60 years of age ($n = 1,742$) on January 1, 1997, were selected to participate in the baseline of the cohort study. Of 1,742 elderly individuals identified, 1,606 (92.2%) were interviewed and 1,495 (85.8%) were examined (laboratory tests, blood pressure, and anthropometric measurements); the latter group of 1,495 were selected for the present study. The individuals examined were similar to the general population \geq 60 years with respect to all the characteristics investigated (gender, age, marital status, number of residents per domicile, family income, and schooling). Further details are presented in Lima-Costa et al. (2000a).

Study variables

The dependent variable in this study was the number of hospitalizations in the previous 12 months (none, one, and two or more). A hospitalization was defined as at least one night spent by the patient admitted to hospital (Coroni-Huntley et al., 1986). Exploratory biomedical variables in this study were blood pressure, BMI (weight/height²), and total serum cholesterol, HDL cholesterol, triglycerides, albumin, and fasting blood glucose. The following variables were also included: (1) smoking, the association of which with increased risk of hospitalization had been observed among the elderly in some previous studies (Halon et al., 1998; Miller et al., 1998) and (2) seropositivity for *T. cruzi*, due to high prevalence of the infection in the target community (Lima-Costa et al., 2001). Current smokers were defined as those who reported having smoked \geq 100 cigarettes during their lifetime and who currently smoked. In a second stage, all the predisposing, enabling, and need variables identified as being independently associated with 1 or \geq 2 hospitalizations among older adults (Guerra et al., 2001) were included in the study. The following variables (all need indicators) were found to be independently associated with one hospitalization in the previous 12 months: number of doctor visits in the past 12 months, number of prescription drugs used in the past 3 months, inability to perform routine activities due to health problems in the previous two weeks, having been bedridden in the previous two weeks, and inability to walk 1.5km without tiring. Variables independently associated with two or more hospitalizations were: predisposing factors (age, gender, living alone), enabling factors (financial problems in obtaining medication), and need (self-rated health during the previous six months, number of doctor visits in the previous 12 months, number of prescription drugs used in the previous three months, history of medical diagnosis of coronary disease, having ceased to perform routine activities due to health problems in the previous two weeks, having been bedridden in the previous two weeks, and ability to walk 1.5km without tiring) (Figure 1). Family income measured as number of time the prevailing Brazilian minimum wage (< 2 and ≥ 2) at time of interview was used to stratify the analysis of association between hospitalization and BMI $< 20\text{Kg/m}^2$.

Figure 1

Predisposing, enabling, and need variables previously associated with two or more hospitalizations in the previous 12 months among older adults. Bambuí, Minas Gerais State, Brazil, 1997.



** Adjusted for age, gender, and all variables listed in the figure.
Source: Guerra et al. (2001).

Data collection

Blood pressure (BP) and anthropometric measurements and blood samples were taken in the Emmanuel Dias Health Post, an extension service of the Oswaldo Cruz Foundation in Bambuí. BP was measured no less than 30 minutes after caffeine intake or smoking. The first measurement was taken after five minutes' rest and the second and third at two-minute intervals (JNC, 1993). BP was measured by specially trained technicians, using a mercury column sphygmomanometer (Tyco 5097-30, United States) and stethoscope (Littman Cardiology II, United States). BP was defined as the arithmetic mean of the second and third measurements (Lima-Costa et al, 2000a). Anthropometric measurements (weight and height) were taken with the subjects without shoes and wearing light clothing. These measurements were also taken by specially trained technicians using standardized equipment (CMS Weighing Equipment Ltd, United Kingdom).

Blood samples were taken by trained technicians in the morning after a recommended 12 hours' fasting. Serum cholesterol, triglyc-

erides, albumin, and glucose were processed using an automatic analyzer (Eclipse Vitalab, Merck, Netherlands).

Presence of antibodies to *T. cruzi* was investigated using hemagglutination and ELISA (Bi-lab and Abbot, Brazil, respectively). Individuals were considered positive and negative when both reactions gave positive and negative results, respectively. Results were defined as undetermined when the two reactions were discordant (Lima-Costa et al., 2000a).

Data on predisposing, enabling, and need variables previously identified as independently associated with hospitalization of older adults were obtained through interviews, using the Bambuí Health and Aging Study (BHAS) questionnaire (Guerra et al., 2001). Participants were interviewed at home. Interviewers were selected from community residents with at least 11 years of schooling. Proxy respondents were used when the study participant was incapable of answering due to a cognitive deficit or other health problem. Proxy respondents did not respond to questions that involved personal judgment, such as self-rated health (Lima-Costa et al., 2000a).

The project was approved by the Research Ethics Committee of the Oswaldo Cruz Foundation (Lima-Costa, 2000a).

Data analysis

In the bivariate analysis, biomedical factors were treated as continuous variables, and their association with hospitalization was determined using the Kruskal-Wallis test (Zar, 1984). Biomedical factors that presented associations with 1 or ≥ 2 hospitalizations at $p < 0.20$ (Greenland, 1989) in the bivariate analysis were transformed into discrete variables and were included in the multivariate analysis: BMI (< 20 , 20-24, and ≥ 25 kg/m²) (National Heart, Lung, and Blood Institute, 1998), total cholesterol (< 200 , 200-263, and ≥ 264 mg/dl, corresponding to their distribution in quartiles of the population), and blood glucose (< 126 and ≥ 126 mg/dl) (Halter, 1999). Multivariate analysis was performed using multinomial logistic regression (Hamilton, 1993; Hosmer & Lemeshow, 1989). Age, gender, seropositivity to *T. cruzi*, and smoking were considered *a priori* confounding variables in this study. The variables that remained associated with 1 or ≥ 2 hospitalizations at $p < 0.05$ were kept in the final model.

A second logistic model was constructed including the biomedical variables associated with 1 or ≥ 2 hospitalizations, plus the predisposing, enabling, and need variables previously identified as independently associated ($p < 0.05$) with 1 or ≥ 2 hospitalizations (Guerra et al., 2001). Biomedical and other variables

that remained associated with 1 or ≥ 2 hospitalizations at $p < 0.05$ were kept in the final logistic model.

Results

In all, 1,495 of the 1,742 Bambuí residents ≥ 60 years of age (85.8%) participated in the current study. Of these, 101 (6.8%), 226 (15.1%), and 1,168 (78.1%) had ≥ 2 , 1, or no hospitalizations in the 12 months preceding the interview, respectively.

Table 1 shows the distribution of biomedical factors according to hospitalizations in the previous 12 months. BMI ($p = 0.013$), blood glucose ($p = 0.055$), triglycerides ($p = 0.061$), and albumin ($p = 0.050$) were associated with hospitalization at $p < 0.20$.

In the bivariate analysis, seropositivity to *T. cruzi* was associated with 1 (OR = 1.52; 95% CI: 1.14–2.03) and ≥ 2 hospitalizations (OR = 1.93; 95% CI: 1.28–2.90), but this association disappeared after adjustment for confounding. Smoking was not associated with prior hospitalization according to the bivariate analysis.

Table 2 shows the statistically significant results from the multivariate analysis of biomedical factors associated with 1 or ≥ 2 hospitalizations. Only serum cholesterol ≥ 264 mg/dl showed a negative and independent association with 1 hospitalization (OR = 0.58; 95% CI: 0.38–0.90). Biomedical factors independently associated with ≥ 2 hospitalizations were: BMI < 20 kg/m² (OR = 2.64; 95% CI: 1.49–4.69), total

Table 1

Distribution of selected biomedical factors according to hospitalizations in the previous 12 months among older adults. Bambuí, Minas Gerais State, Brazil, 1997.

Factors	Number of hospitalizations			p value
	None Median (Q1-Q3) n = 1,168	One Median (Q1-Q3) n = 226	Two or more Median (Q1-Q3) n = 101	
BMI (Kg/m ²)	25.0 (21.9–28.0)	24.8 (21.0–27.9)	23.7 (19.8–27.1)	0.013
Systolic pressure (mmHg)	135.0 (122.0–149.0)	137.0 (122.0–155.0)	134.0 (121.0–150.0)	0.646
Diastolic pressure (mmHg)	82.0 (75.0–91.0)	83.0 (75.0–91.0)	80.0 (72.0–89.0)	0.489
Pulse pressure (mmHg)	51.0 (43.0–62.0)	52.0 (41.0–66.0)	53.0 (44.0–62.0)	0.844
Blood glucose (mg/dl)	99.0 (91.0–111.0)	97.0 (88.0–108.0)	98.0 (91.0–117.0)	0.055
Total cholesterol (mg/dl)	228.0 (220.0–263.0)	220.0 (192.0–254.0)	239.0 (212.0–277.0)	0.006
HDL Cholesterol (mg/dl)	47.0 (39.0–57.0)	48.0 (39.0–57.0)	49.0 (38.0–56.0)	0.977
Triglycerides (mg/dl)	130.0 (90.0–182.0)	125.5 (92.0–175.0)	160.0 (95.0–226.0)	0.061
Albumin (mg/dl)	4.6 (4.2–5.0)	4.6 (4.2–4.9)	4.5 (4.1–4.8)	0.050

p value: Kruskal-Wallis test.
BMI = body mass index.

Table 2

Statistically significant results of multivariate analysis of biomedical factors associated with occurrence of hospitalizations among older adults. Bambuí, Minas Gerais State, Brazil, 1997.

	One versus no hospitalizations OR (95% CI)	Two or more versus no hospitalizations OR (95% CI)
BMI		
20-24kg/m ²	1.00	1.00
< 20kg/m ²	1.29 (0.82-2.03)	2.64 (1.49-4.69)
≥ 25kg/m ²	0.98 (0.70-1.3)	0.77 (0.45-1.31)
Total cholesterol		
< 200mg/dl	1.00	1.00
200-263mg/dl	0.77 (0.54-1.10)	1.94 (0.99-3.79)
≥ 264mg/dl	0.58 (0.38-0.90)	2.97 (1.45-6.07)
Blood glucose		
< 126mg/dl	1.00	1.00
≥ 126mg/dl	1.06 (0.67-1.68)	2.30 (1.27-4.16)

OR (95%) = Odds ratio (95% confidence interval) adjusted by age and gender, seropositivity for *T.cruzi*, smoking, and all variables listed in the table using multinomial logistic regression (1,439 individuals participated in the final analysis).
BMI = body mass index.

cholesterol ≥ 264 mg/dl (OR = 2.97; 95% CI: 1.45-6.07), and blood glucose ≥ 126 mg/dl (OR = 2.30; 95% CI: 1.27-4.16).

The following variables showed independent associations with 1 hospitalization: number of doctor visits in the previous 12 months (OR = 1.80; 95% CI: 1.21-2.67 and OR = 2.92; 95% CI: 1.58-5.43 for 3-4 and ≥ 5 as compared to no doctor visits, respectively), number of prescription drugs used in the previous three months (OR = 1.89; 95% CI: 1.07-3.35, OR = 1.96; 95% CI: 1.08-3.57 and OR = 2.92; 95% CI: 1.58-5.43 for 1-2, 3-4 and ≥ 5 versus none, respectively), having ceased to perform some routine activity due to health problems in the previous two weeks (OR = 1.88; 95% CI: 1.27-2.80) and inability to walk at least 1.5km without tiring (OR = 1.49; 95% CI: 1.05-2.11). None of the biomedical factors remained associated with 1 hospitalization after adjustment for the above-mentioned variables.

Table 3 shows the statistically significant results from multivariate analysis of biomedical factors and predisposing, enabling, and need variables associated with two or more hospitalizations. The following variables were independently associated with ≥ 2 hospitalizations: BMI < 20kg/m², total cholesterol ≥ 200mg/dl, age ≥ 80 years, living alone, financial or other problems in acquiring medication, poor/very poor self-rated health, more doctor visits in the previous 12 months, more prescription drugs

used in the previous three months, report of medical diagnosis of coronary disease, and having ceased to perform routine activities due to health problems in the previous two weeks.

Table 4 shows the odds ratios for ≥ 2 hospitalizations according to BMI and family income. There was a strong association between BMI < 20kg/m² and hospitalization among older adults with higher family income (OR = 4.91; 95% CI: 1.84-13.09), but this association disappeared among those with lower incomes (OR = 0.92; 95% CI: 0.32-1.81). A possible interaction between family income and BMI was not statistically significant.

Discussion

Among the biomedical parameters considered in the present study, only lower BMI (< 20kg/m²) and higher total serum cholesterol (≥ 200mg/dl) were independently associated with two or more hospitalizations. These associations remained after adjustment for predisposing, enabling, and need variables previously identified as associated with multiple hospitalizations among older adults (Guerra et al., 2001). None of the biomedical parameters was independently associated with one hospitalization in the previous 12 months.

The potential association between BMI and hospital admissions in older adults is contro-

Table 3

Statistically significant results of multivariate analysis of biomedical factors and predisposing, enabling, and health care need variables previously identified* as independently associated with two or more hospitalizations among older adults during the previous 12 months. Bambuí, Minas Gerais State, Brazil, 1997.

	Two or more versus no hospitalizations OR ^a (95% CI)
Biomedical factors	
BMI (Ref: 20-24kg/m ²)	
< 20kg/m ²	2.34 (1.21-4.54)
≥ 25kg/m ²	0.68 (0.38-1.22)
Total cholesterol (Ref: < 200mg/dl)	
200-263mg/dl	2.38 (1.14-4.97)
≥ 264mg/dl	3.21 (1.44-7.18)
Predisposing variables	
Age in years (Ref: 60-69)	
70-79	0.93 (0.52-1.68)
≥ 80	2.22 (1.07-4.61)
Living alone (Ref: no):	
Yes	2.81 (1.51-5.23)
Enabling variables	
Principal problem in obtaining medication (Ref: no problem)	
Financial problem	2.27 (1.25-4.15)
Other problems	2.47 (1.02-6.00)
Need variables	
Self-rated health in previous 6 months (Ref: very good/good)	
Fair	1.55 (0.44-5.51)
Poor/very poor	4.40 (1.26-15.41)
Not reported ^b	4.01 (0.76-21.12)
Number of doctor visits in previous 12 months (Ref: < 2):	
3-4	2.89 (1.37-6.08)
≥ 5	4.40 (2.09-9.25)
Number of prescription drugs used during previous 3 months (Ref: none):	
1-2	3.55 (0.72-17.48)
3-4	5.82 (1.23-27.53)
≥ 5	7.30 (1.52-34.98)
History of coronary disease (Ref: no):	
Yes	2.44 (1.30-4.61)
Stopped performing routine activities for health reasons during previous 2 weeks (Ref: no)	
Yes	2.65 (1.54-4.56)

^a OR (95% CI) = odds ratio (95% confidence interval) adjusted for all variables listed in the table as well as for gender and ability to walk at least 1.5 km without tiring, using multinomial logistic regression (1,431 individuals participated in the final analysis); the results referring to the occurrence of one versus no hospitalizations are not presented in the table.

^b When it was necessary for the respondent to be accompanied by a proxy during the interview.

*Guerra et al. (2001)

BMI = body mass index.

Table 4

Odds ratios for two or more versus no hospitalizations during the previous 12 months among older adults according to BMI and family income (Bambu , 1997). Bambu , Minas Gerais State, Brazil, 1997.

	< 2 times minimum wage OR (95% CI) n = 416	≥ 2 times minimum wage OR (95% CI) n = 1,006
BMI		
20-24kg/m ²	1.00	1.00
< 20kg/m ²	0.92 (0.32-1.81)	4.91 (1.84-13.09)
≥ 25kg/m ²	0.77 (0.33-1.81)	0.70 (0.29-1.71)

OR (95% CI) = odds ratio (95% confidence interval)
The odds ratios were adjusted for gender, age, and all the variables listed in Table 3 to investigate interactions using the multinomial logistic regression method.
BMI = body mass index.

versial. Tayback et al. (1990) found an association between low BMI and increased mortality in individuals over 65, but no such association between BMI and hospitalization. Another study found that both low BMI and obesity were associated with increased risk of hospitalization (Hanlon et al., 1998). On the other hand, Miller et al. (1998) found an association between low BMI and greater risk of hospitalization in males over 65. In the current study, an association between low weight and multiple hospitalizations among the elderly could be the result of: (1) deficient nutrient intake (associated at the socioeconomic level) and/or (2) some underlying disease or chronic condition. Analysis of these results stratified by family income showed that the association between low BMI and hospitalization was only present among older adults with higher incomes. This finding reinforces the latter of the two hypotheses mentioned above.

Utilization of serum cholesterol as a predictor of hospitalization among older adults is also controversial. Miller et al. (1998) found that serum cholesterol levels were not associated with risk of hospitalization. By contrast, Hanlon et al. (1998) showed that higher serum cholesterol reduced the risk of hospitalization in this population. The authors explained this finding on the basis of the known association between low cholesterol and some types of cancer as well as respiratory and digestive diseases (Jacobs et al., 1992; Sharp & Pocock, 1997). In the current study, after adjustment for confounding (Guerra et al., 2001), serum cholesterol was positively associated with two or more hospitalizations.

Some studies have shown that hyperglycemia (Hanlon et al., 1998) and a history of diabetes (Miller et al., 1998) increase the risk of

hospitalization among older adults. On the other hand, no association between history of diabetes and hospitalization was observed in other studies (Boult et al., 1993; Hurd & McGarry, 1997). A previous study developed from baseline data in the Bambu  cohort demonstrated an association between clinical diabetes and hospitalization in the crude analysis, which disappeared after adjustment for confounding (Guerra et al., 2001). The current study showed similar results for the initial association between higher fasting blood glucose and hospitalization, which disappeared after adjustment for confounding.

Higher systolic and/or diastolic arterial pressure among older adults has been described consistently in association with risk of hospitalization in cohort studies (Hanlon et al., 1998; Miller et al., 1998). The current study found no association between pulse, systolic, or diastolic pressure and hospitalization. Differences between our results and those of the two studies mentioned above could be explained at least partially by methodological differences. Our results were obtained in a cross-sectional study of an elderly population, in which survival bias should always be taken into account (Lima-Costa et al., 2000a). Hypertensive individuals would have a higher probability of premature death, and one effect of this bias would be to dilute the force of potential associations (Kaplan et al., 1992).

Our results showed that the previously identified associations between multiple hospitalizations and indicators constructed from interview information were relatively unaffected by the introduction of indicators based on the results of physical examination and blood tests. Only three of the eleven variables previously identified in this population as associated with two or more hospitalizations (male gender, having been bedridden in the previous two weeks, and inability to walk at least 1.5km without tiring) ceased to present this association after adjustment for the biomedical variables (Guerra et al., 2001).

Every effort was made to avoid possible sources of bias in the methodology by promoting standardization of procedures and equipment and exhaustive training of the field team. The study participation rate was high, and participants were similar to the general population of older adult residents in Bambu  with respect to all socio-demographic study variables (Lima-Costa et al., 2000a). Recall bias, which could affect measurement of the target events, did not occur, i.e., the overall hospitalization rate in the study population (21.5%) was close

to that estimated for all Bambuí residents over 60 years of age registered in the SUS (26%) (DATASUS, 1997). On the other hand, survival bias should always be considered in cross-sectional studies of older adults (Kaplan et al., 1992; Lima-Costa et al., 2000a), i.e., individuals in more precarious overall health and with the greatest probability of being admitted to hospital could die earlier and would thus not be included. This type of bias would tend to dilute the strength of the associations, therefore tending to confirm the associations identified.

In summary, the study results show that indicators identifying elderly people at risk of hospitalization and obtained through questionnaires did not suffer great impact by the in-

roduction of some objective measurements of biomedical variables. Characteristics such as living alone, self-reported financial difficulty in acquiring medication, worse self-rated health, more doctor visits and prescription drugs, history of coronary disease, and having ceased to perform routine activities due to health problems in the previous two weeks remained strongly associated ($OR > 2$) with multiple hospitalizations. These results confirm observations made in developed countries (Boult et al., 1993; Pacala et al., 1997), that simple, easily obtained data may be useful in identifying older adults at increased risk of hospitalization who could be referred to preventive programs.

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