Predictors of 10-year mortality in a population of community-dwelling Brazilian elderly: the Bambuí Cohort Study of Aging

Determinantes da mortalidade em 10 anos de idosos brasileiros residentes na comunidade: Estudo de Coorte de Idosos de Bambuí

Abstract

We used data on 1,399 participants aged 60 and over from the Bambuí Cohort Study of Aging to examine predictors of mortality in a socioeconomically disadvantaged population. From 1997 to 2007, 599 participants died and 6.2% were lost to follow-up, leading to 12,415 person-years (pyrs) of observation. The death rate was 48.3 per 1,000 pyrs. Age (adjusted hazard ratio [HR] = 1.40), male gender (HR = 1.80), never married (HR = 1.78) or a widow (HR = 1.26), poor self-rated health (HR = 1.31), inability to perform four or more activities of daily living (HR = 3.29), number of cardiovascular risk factors (HR = 1.51 for two and HR = 1.91 for three or more), Trypanosoma cruzi infection (HR = 1.27), and number of medications (HR = 1.06) were each significantly (p < 0.05) and independently associated with mortality. The Mini-Mental State Examination score showed a protective effect (HR = 0.96). Except T. cruzi infection, other predictors of mortality were highly consistent with those found in more affluent elderly populations.

Mortality; Aged; Cohort Studies

Introduction

More than half (51%) of an estimated 59 million deaths that occurred globally in 2004 involved persons aged 60 years and over 1. In the same period, 59% of total deaths in Brazil were of elderly persons (Departamento de Informática do SUS. Informações de saúde. http://www.datasus.gov.br, accessed on 07/Jul/2010). This proportion tends to increase with the aging of the population. As observed in most middle income countries 1, cardiovascular diseases are leading causes of death in elderly Brazilians, with stroke as the most frequent cause followed by ischemic heart disease 2.

Predictors of mortality in old age have received much attention in the last two decades. Research on the issue has focused on different domains, such as socio demographic characteristics, lifestyle, functioning, mental health and physical health. Life expectancy at birth is higher for females than for males and this advantage persists in old age 3,4,5,6,7,8. Studies have documented a protective effect of having a spouse on the risk of mortality 8,9,10. Self-rated health is a universal predictor of mortality in both young and older adults. Hazard ratios (HR) for all-cause mortality associated with poor self-rated health range between 1.5 and 2.0 11. There is also evidence that depressive symptoms predict mortality in old age. A meta-analysis of 17 cohort studies of elderly persons showed a crude relative risk of
dying associated with depression of 1.62 (95% CI: 1.44-1.82) 12.

Disability increases the risk of death. Population-based cohort studies have consistently reported increased risks of mortality associated with the inability of elderly persons to complete activities of daily living (ADL) and/or instrumental activities of daily living (IADL) 5,6,8,9,13,14. Cognitive impairment or dementia is also associated with increased risks of mortality 5,13,15,16,17,18,19,20. A review of population-based cohort studies showed that even mild levels of impairment predict subsequent death. A meta-analysis of six studies of dementia reported an age and sex adjusted odds ratio (OR) of 2.63 (95% CI: 2.17-3.21) 16.

We used data from 10 years of follow-up of the Bambuí Cohort Study of Aging to examine predictors of mortality in a socioeconomically disadvantaged elderly population.

Methods

Study area and population

The Bambuí Cohort Study of Aging has been conducted in Bambuí, a town of approximately 15,000 inhabitants, located in southeastern Brazil. The cohort study procedures have been described in detail elsewhere 21,22. Briefly, the baseline cohort population consisted of all residents age 60 and over on January 1st, 1997 who were identified by means of a complete population census in the city. Of 1,742 older residents, 1,606 (92.2%) participated in the baseline survey, and 85.8% participated in other procedures (e.g. anthropometric measures, phlebotomy, electrocardiograms). Bambuí is a former endemic area for Chagas disease, an infectious disease caused by the protozoan Trypanosoma cruzi. The transmission of the infection by the insect vector was interrupted in the 1970s, but serologic evidence indicates that its prevalence remains high in the elderly due to a cohort effect 23. The leading causes of death among elderly residents of Bambuí were stroke, Chagas disease and ischemic heart disease (death rates = 110, 61, and 42 per 100,000, respectively) 23.

Baseline data collection was performed from February to May, 1997, including standardized interviews, blood tests, blood pressure measurements and other procedures. Cohort members undergo annual follow-up visits, which consist of an interview and verification of death certificates. The Bambuí cohort study was approved by the Ethics Research Committee of the Oswaldo Cruz Foundation (Fundação Oswaldo Cruz), Brazil. Participants signed an informed consent and authorized death certificate verification.

Mortality data source

Deaths occurring between the study enrollment and December 31, 2007 were included in this analysis. Deaths were reported by next of kin during the annual follow-up interview and confirmed through the Brazilian Mortality Information System (SIM), with the permission of the Brazilian Ministry of Health (Ministério da Saúde). Death certificates were obtained for 98.9% of individuals. Death assigned to any cause was the outcome variable in this study.

Baseline measures

Baseline measures considered in this study included: socio-demographic characteristics (age, gender, number of complete years of schooling, and marital status), self-rated health, mental health (common mental disorders), functioning (cognitive function and ability to carry out ADL), conventional cardiovascular risk factors (systolic blood pressure, diabetes mellitus, smoking, and HDL cholesterol), the number of prescribed medications currently used, and T. cruzi infection. The presence of common mental disorders was defined as a score of five points or higher in the 12-item General Health Questionnaire, as previously recommended for the study population 24. Self-rated health was assessed by the answer to the question “How would you rate your own health” (very good, good, fair, poor). Cognitive functioning was assessed using a Portuguese version of the 30 item Mini-Mental State Examination (MMSE) 25. ADL disability was defined by the report of much difficulty or inability to perform the following activities: feeding oneself, dressing oneself, bathing or showering, using the toilet, getting in and out of the bed to a chair, and walking across a room. Systolic blood pressure was defined by the mean of two out of three measures, by using standard protocol 26. Diabetes mellitus was defined as a fasting blood glucose level equal or higher than 126mg/dL or current use of hypoglycemic medication. Current smokers were those who had smoked at least 100 cigarettes in their lifetimes and were still smokers. Fasting glucose and HDL cholesterol were determined at the Bambuí project laboratory with standardized enzymatic methods. The number of conventional cardiovascular risk factors were defined by the sum (yes = 1) of systolic blood pressure equal to or higher than 140mmHg, diabetes mellitus, smoking, and HDL cholesterol below the median (< 47mg/dL). Infection with T. cruzi was assessed...
by three different assays: a hemagglutination assay (Biolab Mérieux, Rio de Janeiro, Brazil), and two enzyme-linked immunoabsorbent assays (Abbott Laboratories, USA, and Wiener Laboratories, Argentina). Current medication use was ascertained during the home interview by reviewing prescriptions and/or the medication packaging. Further details are described elsewhere 21,22.

### Statistical analysis

The univariate analysis of the association between the explanatory variables and gender was based on the Pearson's chi square test, Student’s t test and Mann-Whitney rank-sum test for differences between frequencies, means and medians, respectively. Kaplan-Meier estimates were used to compute cumulative survival probabilities by age and gender. The analysis of predictors of mortality was based on HR and 95% CI estimated using the Cox proportional hazards model after confirming that the assumption of proportionality among the hazards was met. Gender, schooling, conjugal status, self-rated health, common mental disorders, number of ADL disabilities, number of cardiovascular risk factors and T. cruzi infection were used as categorical measures in this analysis. Age was stratified into five year increments, the MMSE score was transformed into deciles (increments of ten percentile units), and the number of prescribed medications was a count variable. First we estimated the mutually adjusted association between socio-demographic variables and mortality, and then adjusted incrementally for: (1) self-rated health and common mental disorders, (2) MMSE score and ADL disability, and (3) other measures of health or future health (diseases and risk factors). All variables were maintained in the final adjusted model because no pairs exhibited collinearity. The significance of multiplicative interactions between gender and each explanatory variable on mortality was examined by using cross-product terms in Cox proportional regression models. Since there was no evidence of interaction for any study variable (p-values for interaction > 0.05), the analyses of predictors of mortality were carried out for both men and women with sex included as a covariate.

Statistical analyses were conducted using Stata 11.0 statistical software (Stata Corp., College Station, USA). All p-values were 2-tailed ($\alpha = 0.05$).

### Results

Of the 1,606 cohort subjects enrolled, 1,399 (87.1%) for whom complete data was available for all study variables were included in this analysis. Subjects were excluded from the analysis if biological measures, such as laboratory tests, blood pressure or anthropometric measures, were not performed (n = 111) or if data for any other study variable was missing (n = 4).

During a mean follow-up of 8.8 years, 599 participants died and 6.2% were lost to follow-up, leading to 12,415 person-years (pyrs) of observation. Those who were lost were younger than those followed [mean age (SD) = 67.4 (5.8) and 69.4 (7.5) years, respectively; p = 0.011]. Women and men were similarly represented in both groups (only 5.4% and 6.6% were lost, respectively; p = 0.227).

Table 1 shows the distribution of baseline characteristics of participants by sex. The mean age was 68.8 years (SD = 7), and 62% were women. Very low levels of schooling predominated (63.3%). Half (49.4%) of participants had a spouse. The prevalence of poor self-rated health, common mental disorders, any ADL disability, and the number of prescribed medications was 63.3%. Half (49.4%) of participants had a spouse. The prevalence of poor self-rated health, common mental disorders, number of ADL disabilities, and the number of prescribed medications was 63.3%.

As shown in Figure 1, there was a graded univariate association between baseline age and 10-year survival probability. Among those aged 60-64 years to 116.1 per 1,000 in the oldest group (80 years and over). There was an excess risk of mortality among men in relation to their counterpart women in all age groups. The difference between absolute risks ranged from 9.9 to 12.8 per 1,000 pyrs in the younger groups (60-64 years), and increased by 55.2 per 1,000 in those aged 75-79 years and 24.3 per 1,000 pyrs in the oldest (80 years and over). As shown in Table 2, mortality rates increased from 28.8 per 1,000 in the youngest group (60-64 years) to 116.1 per 1,000 in the oldest group (80 years and over). There was an excess risk of mortality among men in relation to their counterpart women in all age groups. The difference between absolute risks ranged from 9.9 to 12.8 per 1,000 pyrs in the younger groups (60-64 years), and increased by 55.2 per 1,000 in those aged 75-79 years and 24.3 per 1,000 in those aged 80 years and over (Table 2).

As shown in Figure 1, there was a graded univariate association between baseline age and 10-year survival probability. Among those aged 60-69 and 70-79 years, gender difference on survival probability increased over time. Among those aged 80 years and over, gender differences on survival probability increased for some time, but converged at the end of the follow-up period.
Adjusted HR for 10-year mortality by baseline characteristics are shown in Table 3. In the fully adjusted analysis, age (HR = 1.40; 95%CI: 1.32-1.47 for each increment of five years), male gender (HR = 1.80; 95%CI: 1.47-2.21), had never been married (HR = 1.78; 95%CI: 1.34-2.35) and being widowed (HR = 1.26; 95%CI: 1.03-1.56), poor self-rated health (HR = 1.31; 95%CI: 1.02-1.69), inability to perform four or more ADL (HR = 3.29; 95%CI: 2.17-5.00), number of cardiovascular risk factors (HR = 1.51; 95%CI: 1.20-1.92 for two and HR = 1.91; 95%CI: 1.40-2.62 for three or more), T. cruzi infection (HR = 1.27; 95%CI: 1.06-1.52), and number of prescribed medications (HR = 1.06; 95%CI: 1.02-1.20 for increases of one additional medication) were all positively and independently associated with subsequent mortality. The MMSE score showed a graded protective effect (HR = 0.96; 95%CI: 0.93-0.99) for each increase in units of 10 percentiles. With few exceptions (schooling and common mental disorders), adjustments for other variables had little or no impact on the associations initially found.
Discussion

In this community-based cohort study conducted in a well-defined elderly population during ten-year follow-up, increasing age, male gender, absence of a spouse, poor self-rated health, lower cognitive functioning, ADL disability, number of cardiovascular risk factors, number of medications and T. cruzi infections were each significantly and independently associated with mortality.

Table 2

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
<th>Difference between males and females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of deaths</td>
<td>Deaths rates per 1,000 pyrs</td>
<td>Number of deaths</td>
<td>Deaths rates per 1,000 pyrs</td>
</tr>
<tr>
<td>60-64</td>
<td>133</td>
<td>28.8</td>
<td>66</td>
<td>36.3</td>
</tr>
<tr>
<td>65-69</td>
<td>140</td>
<td>41.8</td>
<td>59</td>
<td>50.1</td>
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<tr>
<td>70-74</td>
<td>123</td>
<td>52.6</td>
<td>50</td>
<td>58.9</td>
</tr>
<tr>
<td>75-79</td>
<td>105</td>
<td>82.9</td>
<td>50</td>
<td>119.9</td>
</tr>
<tr>
<td>80 and over</td>
<td>98</td>
<td>116.1</td>
<td>37</td>
<td>132.3</td>
</tr>
<tr>
<td>Overall</td>
<td>599</td>
<td>48.3</td>
<td>262</td>
<td>57.7</td>
</tr>
</tbody>
</table>

pyrs: person-years at risk.

Figure 1
Kaplan-Meier survival estimates by age group (60-69 years, 70-79 years and 80+ years) and gender. The Bambuí Cohort Study of Aging, 1997-2007.
Among the variables considered in the present analysis, only level of schooling and common mental disorders did not show an independent effect on mortality. The study population had small differences in the schooling level, and this might explain the absence of association between this variable and the outcome in our study. However, most population-based cohort studies of elderly persons have not shown an association between schooling and mortality. The absence of an association was observed in different settings and contexts, such as large urban areas in Brazil and in India, in Mexican Americans residing in different cities of the United States, in Taiwanese elderly and in Danish nonagenarians. In our study, an initial association between low schooling level and increased risk of mortality was found, but the hazard ratio lost statistical significance after adjustments for self-rated health and common mental disorders. Common mental disorders were found to be a predictor of mortality in our study in the analysis adjusted by socio-demographic variables and self-rated health. But this association disappeared after adjustments for cognitive functioning and ADL disability.

Cohort studies have documented a positive relationship between marriage and longer life expectancy. In the United States, two of the above mentioned studies categorized conjugal status into four groups, and used “having been widowed” or “unmarried elderly” as the reference category. We also categorized conjugal status in four groups, but we used “having a spouse” as the referenc
reference category. Both “had never been married” and “being widowed” were found to be independent predictors of mortality in this analysis.

Self-rated health is well established as a universal predictor of mortality. Self-ratings of health represent a key measure of health status, and reflects the states of the human body and mind. In the Bambuí cohort population, the perception of one’s own health was multidimensional in structure, reflecting socioeconomic conditions, social support, health status (mainly mental health), and access to/use of health services. This structure resembles the definition of health adopted by the World Health Organization (WHO): an individual’s physical, mental, and social well-being. In the present study, poor self-rated health was a predictor of mortality, and the association remained significant even after adjustments for demographic characteristics, mental health, functioning, and other measures of health and future health status.

Among the predictors of mortality in old age, low cognitive functioning and dementia have been one of the most consistently reported risk factors. However, the definition of the exposure variable varies in important ways between studies, making precise comparisons difficult. As an example, three studies conducted in the past decade used the MMSE score as a measure of cognitive functioning. One of these compared the highest score with the lowest, a second compared the lowest quintile with higher values, and the third had considered changes over time. We computed hazard ratios for baseline 10 percentiles unit increments of the MMSE, and found an inverse and graded association between this measure and the risk of mortality.

Limitations in the ability to perform ADL or IADL have been reported to be consistent predictors of mortality in the elderly. We found a very strong association between baseline ADL disability and mortality, and this association showed a J shaped pattern. Persons with four or more impaired functions had a three-fold higher risk of death than those without any ADL limitations, and this association remained highly significant even after adjustments for several potential confounding factors.

Although we collected data on a large number of biological measures, in the present analysis we used those related to the leading causes of death in the study area, that is, cardiovascular diseases and Chagas disease. Cardiovascular risk factors and diseases are leading causes of death worldwide, particularly in middle and old age. Furthermore, it is well established that the concomitance of risk factors increases the risk of cardiovascular events. Our results are consistent with the body of knowledge on this issue.

The health profile of the study population is characterized by the concomitance of degenerative conditions that predominate in most elderly populations worldwide, and a highly prevalent parasitic disease, characterizing a population in epidemiological transition. Chagas disease is endemic to South and Central American countries with about 8 million infected. Since the early 1990s, successful multi-country interventions have been undertaken to interrupt the transmission of the infection by insect vectors, and Brazil has been declared free of the transmission caused by the main vector, Triatoma infestans. Chagas disease in old age is an emerging issue in this context. The aging of the population, together with a cohort effect observed in endemic areas where the household insect transmission has been interrupted, will lead to increases in the number of older adults who are already infected by T. cruzi. This effect was first described in Bambuí, where the interruption of the transmission anteceded by several decades that of the rest of Brazil. The consequences of the disease in the elderly are impressive. An earlier cross-sectional study showed that infected elderly in Bambuí were more likely to report worse self-rated health, to have stayed in bed recently, to use more prescribed medications, and to be hospitalized independently of other relevant factors.

Another cross-sectional study showed a strong and graded relationship between T. cruzi infection and cognitive impairment, which is biologically plausible. A recent cohort study showed that T. cruzi infection is a predictor of all-cause mortality among the elderly Bambuí cohort independent of age, sex and conventional cardiovascular risk factors. Furthermore, T. cruzi infection is an independent predictor of deaths to stroke, probably in a causal pathway. Thus, T. cruzi infection was included as a health parameter in the present study, and this variable was considered as a potential confounding factor for the association between other explanatory variables and mortality. As expected, infection with T. cruzi was found to be an independent predictor of mortality in this analysis.

As commented elsewhere, strengths of the Bambuí Cohort Study of Aging include the fact that it is a long term population-based cohort study with high response rates at baseline and minimal loss of participants to follow-up, the standardized and systematic measurement of parameters at baseline and at follow-ups, and the ongoing measurements of several outcome variables, including mortality. Nonetheless, this study has some limitations. Although we have...
collected information at the follow-up visits for several explanatory variables used in the present analysis, we used only those obtained at baseline. This research strategy was adopted to allow comparisons of results with previous studies on the issue. This strategy has two main consequences: first, our results are subject to the effects of regression to the mean that tend to underestimate the strength of the associations found; second, changes in exposure status over time were not captured. With regard to *T. cruzi* infection, changes of infection status overtime is unlikely for two reasons: first, the transmission of the infection was interrupted in the study area decades ago and incident cases are not expected; second, as the safety and the benefit of the treatment of chronic infection in old age remains uncertain, no cohort participants were treated with antitrypanosomal medication at baseline or at the follow-ups.

In this cohort study with more than 12,000 pyrs of observation, we modelled the predictors of mortality in a population of socioeconomically disadvantaged elderly, and with double burden of non-communicable diseases and a parasitic chronic infection. With exception of an increased risk associated with *T. cruzi* infection, other predictors of mortality were highly consistent with those found in more affluent elderly populations in Brazil and other countries. Our results support the hypothesis that most predictors of mortality in old age do not vary across populations.

Resumo

Foram utilizadas informações de 1,399 participantes (≥ 60 anos) do Estudo de Coorte de Idosos de Bambuí, para examinar os determinantes da mortalidade em uma população com nível socioeconômico baixo. Entre 1997 e 2007, 599 participantes faleceram e 6,2% foram perdidos para acompanhamento, resultando em 12.415 pessoas-ano de observação. A taxa de mortalidade foi de 48,3 por mil pessoas-ano. Idade (hazard ratio ajustada [HR] = 1,40), sexo masculino (HR = 1,80), ser solteiro (HR = 1,78) ou viúvo (HR = 1,26), pior autoavaliação da saúde (HR = 1,31), incapacidade para realizar quatro ou mais atividades da vida diária (HR = 3,29), número de fatores de risco cardiovascular (HR = 1,51 para dois e HR = 1,91 para três ou mais), infecção pelo Trypanosoma cruzi (HR = 1,27) e número de medicamentos (HR = 1,06) apresentaram associações significantes (p < 0,05) e independentes com o evento. O escore do Mini-Exame do Estado Mental mostrou efeito protetor (HR = 0,96). Exceto a infecção pelo *T. cruzi*, os outros preditores da mortalidade foram consistentes com o observado em populações idosas com melhor situação socioeconômica.

Mortalidade; Idoso; Estudos de Coortes
Contributors

M. F. Lima-Costa contributed to the conception and design, acquisition of data, analysis and interpretation of data, drafting the article, and final review of the version to be approved. S. V. Peixoto, D. L. Matos, J. O. A. Firmo and E. Uehôa collaborated on conception and design, acquisition of data, revision of the manuscript, and approval of the version to be published.

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