

A time-series analysis of the relation between unemployment rate and hospital admission for acute myocardial infarction and stroke in Brazil over more than a decade



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ABSTRACT

Background: The effect of socioeconomic stressors on the incidence of cardiovascular disease (CVD) is currently open to debate. Using time-series analysis, our study aimed to evaluate the relationship between unemployment rate and hospital admission for acute myocardial infarction (AMI) and stroke in Brazil over a recent 11-year span.

Methods and results: Data on monthly hospital admissions for AMI and stroke from March 2002 to December 2013 were extracted from the Brazilian Public Health System Database. The monthly unemployment rate was obtained from the Brazilian Institute for Applied Economic Research, during the same period. The autoregressive integrated moving average (ARIMA) model was used to test the association of temporal series. Statistical significance was set at $p < 0.05$. From March 2002 to December 2013, 778,263 admissions for AMI and 1,581,675 for stroke were recorded. During this time period, the unemployment rate decreased from 12.9% in 2002 to 4.3% in 2013, while admissions due to AMI and stroke increased. However, the adjusted ARIMA model showed a positive association between the unemployment rate and admissions for AMI but not for stroke (estimate coefficient = 2.81 ± 0.93 ; $p = 0.003$ and estimate coefficient = 2.40 ± 4.34 ; $p = 0.58$, respectively).

Conclusions: From 2002 to 2013, hospital admissions for AMI and stroke increased, whereas the unemployment rate decreased. However, the adjusted ARIMA model showed a positive association between unemployment rate and admissions due to AMI but not for stroke. Further studies are warranted to validate our findings and to better explore the mechanisms by which socioeconomic stressors, such as unemployment, might impact on the incidence of CVD.

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1. Introduction

Despite advances in diagnosis and treatment, the prevalence of cardiovascular disease (CVD) still represents a major public health problem [1]. In addition to traditional well-known risk factors for CVD, particularly acute myocardial infarction (AMI), psychosocial stressors such as job stress, financial problems, and psychological distress are considered contributors to atherosclerosis [2–7]. Recently, a cohort study conducted in the United States demonstrated that unemployment status is an independent risk factor for acute cardiovascular events [8].

In Brazil, despite some lingering inequalities, the unemployment rate has decreased drastically in recent years [9]. In this country, the

unemployment rate as well as the number of hospital admissions due to AMI and stroke are evaluated on a monthly basis, which allows a time-series analysis. However, data are limited for testing the association between psychosocial stressors, such as employment status, and CVD.

The autoregressive integrated moving average (ARIMA) model is a valuable tool for ecologic studies, as it allows the testing on a population level of the association of different variables in a time series [10–12]. Through the use of the ARIMA methodology, we evaluated the relation in Brazil between the unemployment rate and hospital admissions due to AMI and stroke, during the March 2002–December 2013 timespan.

2. Methods

2.1. Population

Brazil had an estimated population of 190,755,799 in 2010 [13]. Extraction of the data for the monthly frequency of hospital admissions for AMI and stroke was performed using the Brazilian Public Health System Database (DATASUS) [14]. In 1998, approximately 63% of hospital admissions were covered by the Brazilian Public Health System [15]. The

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extraction criteria were: patients age > 20 years, admitted for AMI or stroke in any location in Brazil from March 2002 to December 2013 and where the AMI or stroke met the criteria of the International Classification of Diseases (ICD-10) [16] chapter IX (diseases of the circulatory system) codes I21 (AMI), I63 (cerebral infarction), or I64 (stroke).

2.2. Unemployment rate

The data for monthly average unemployment rate in metropolitan areas of the country were obtained from the Brazilian Institute for Applied Economic Research (IPEA) for the same period. The IPEA is a federal public foundation linked to the Strategic Affairs Secretariat of the Brazil Presidency [9]. The data are gathered on a monthly basis, after a survey that is applied in the six more populous metropolitan areas in Brazil. Each month approximately 40,000 homes are visited in these areas, and the unemployment rate is calculated from the percentage of people who were looking for work at the time of the survey, among all those considered active in the labor market (persons aged 10 or older) at the time [9]. Missing data (only 2 months/142 monthly values) were handled using a regression imputation method based on an ARIMA model.

2.3. Statistical analysis

The Box-Jenkins ARIMA model was used to test the association of the temporal series [12]. A p value < 0.05 was considered statistically significant. The ARIMA model was adjusted for each of the temporal series evaluated. The ARIMA model determines the temporal component between different months or even periodic patterns (seasonality). The autoregressive component of the model considers the correlation between different months, while the moving average considers the relationship between the errors of estimation due to time lags (months). The integration of the models brings stability to the series over time (stationary series).

In our study, the process of modeling consisted of three main steps: first, the temporal effect of the series of cardiovascular events was removed by using the ARIMA model, then model parameters were chosen according to the autocorrelations and partial autocorrelations (p and q parameters, respectively; formula below), and after that, we used only the *white noise* or stationary time series. For each series in the study, a regression parameter was added to test the influence of the unemployment rate on the cardiovascular events.

The models can be described by the formula:

$$(1-B)y_t = \frac{(1-\theta B^q)}{(1-\phi B^p)} \cdot w_t + \beta(\text{unemployment rate})$$

where:

y_t	number of cardiovascular events to be considered over time t
B	backshift operator
w_t	residues of cardiovascular events not considered in the model over time t
ϕ	autoregressive parameters
θ	moving-average parameters
p and q	orders of the autoregressive (p) and moving-average (q) parameters in the models

β estimate coefficient of the influence of the unemployment rate on cardiovascular events. Final results of the ARIMA model are expressed in estimate coefficient and standard error.

3. Results

From March 2002 to December 2013, there were 778,263 hospital admissions for AMI and 1,581,675 for stroke. The unemployment rate had a decreasing trend, from 12.9% in 2002 to 4.3% in 2013, while in the same period, there was an increasing trend for hospital admissions due to AMI and stroke (Fig. 1). However, after the temporal effect of the series was removed by using the adjusted ARIMA model, unemployment rate was positively associated with admissions for AMI but not for stroke (estimate coefficient = 2.81 ± 0.93 ; $p = 0.003$ and estimate coefficient = 2.40 ± 4.34 ; $p = 0.58$, respectively). Considering the results for AMI, an increase of 1% in the rate of unemployment was associated with almost three extra admissions for AMI.

Fig. 2 shows different points in time, one in 2006 (A) and the other in 2008/09 (B), when the tendencies for unemployment rate and AMI were similar, which might have contributed to the results of the ARIMA.

4. Discussion

ARIMA models have historically found applications in the financial sector, and to our knowledge no studies have tested the effect of unemployment using a time-series analysis. Our study is unique in that it uses the ARIMA model to test the association between unemployment and CVD over time at a national level. In this context, the main findings of our study are that 1) the Brazilian unemployment rate decreased over the last decade, 2) hospital admissions due to AMI and stroke both increased during that time, and 3) an adjusted ARIMA model showed there was an association between the unemployment rate and hospital admissions due to AMI but not due to stroke.

Between 1970 and 2000, Brazil underwent a demographic transition; the proportion of the population older than 60 years (10% in 2009) doubled, and urbanization increased from 55.9% to 80% [17]. In addition, between 1991 and 2008, Brazil's gross domestic product doubled, and the poverty index decreased from 68% in 1970 to 31% in 2008 [17]. As demonstrated in our study, the unemployment rate followed this socioeconomic growth, decreasing drastically during the past 10 years. Meanwhile, there was a notable increase in the number of

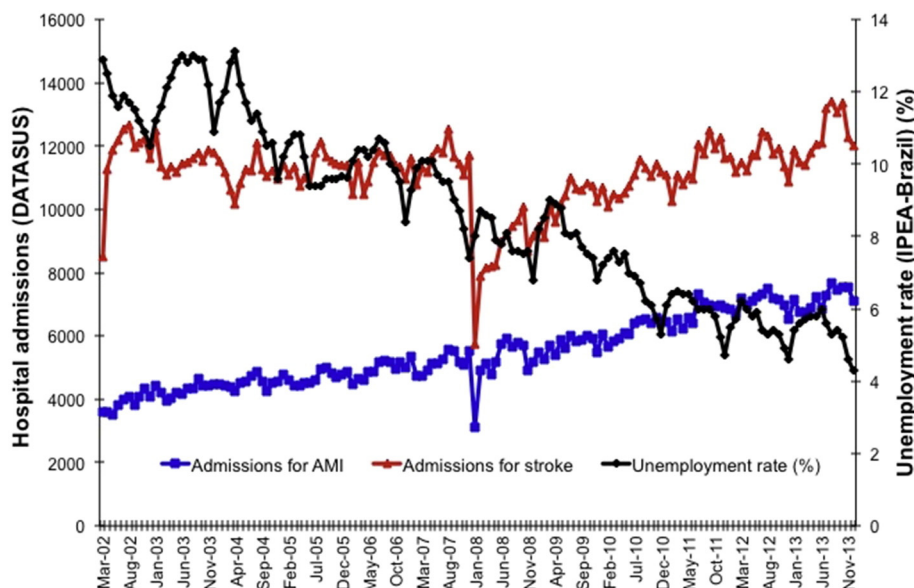


Fig. 1. Unemployment rate and hospital admissions for AMI and stroke from 2002 to 2013.

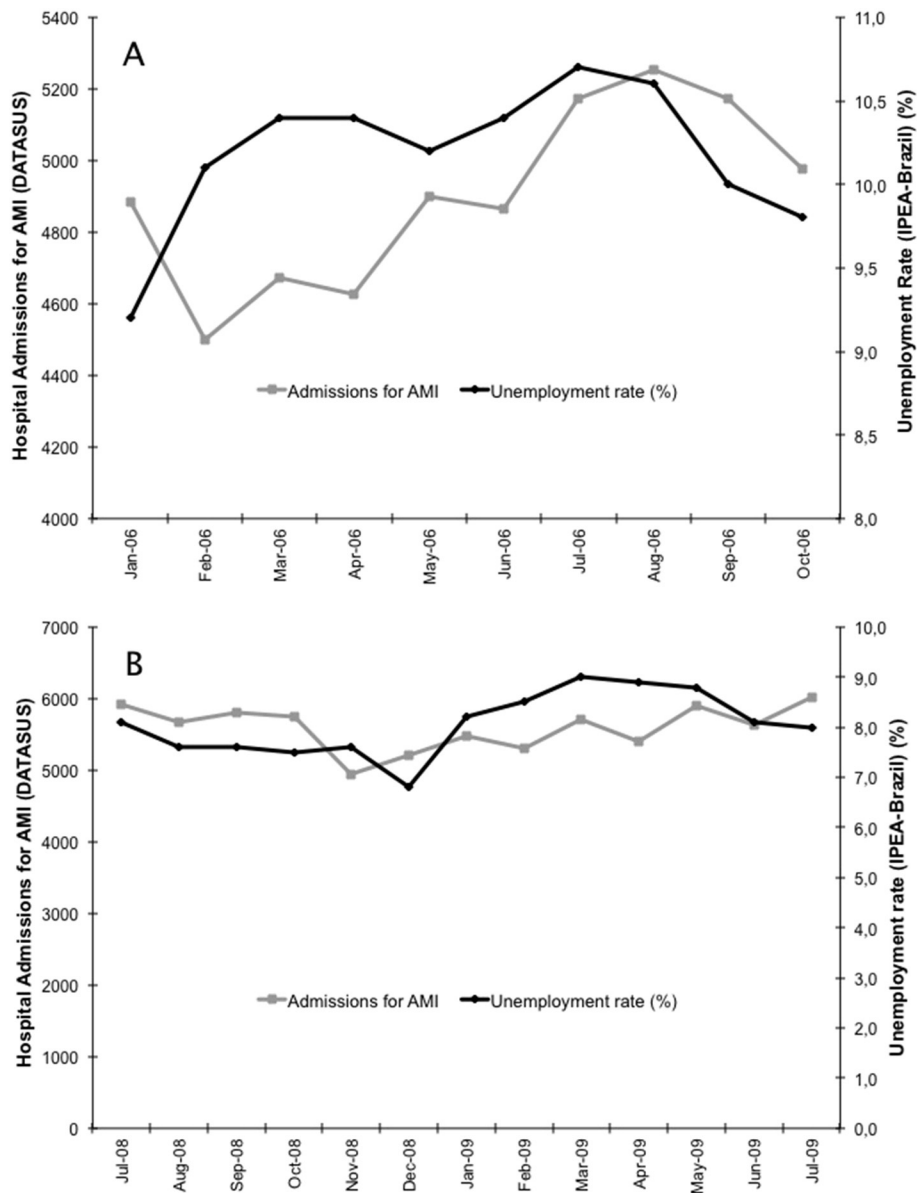


Fig. 2. Examples of points in time that drive the association between unemployment and AMI: (A) January 2006–October 2006 and (B) July 2008–July 2009.

hospital admissions for AMI and stroke during this period. Various factors may explain this phenomenon—first, the aging of the Brazilian population: according to the Brazilian census in 2010, the mean age went from 26.5 in 1991 to 32.1 in 2010, and an increase in the proportion of the population over 65 years old was also observed [13]. In addition, there was an improvement in the quality of information collection and data management of health-related information. Finally, the incidence of CVD is still growing, despite the attempt to control risk factors. In fact, CVD is the leading cause of death worldwide and also in Brazil [14,18,19].

The identification and treatment of traditional risk factors are key strategies in preventing and attenuating the incidence of CVD. However, additional influences are emerging as contributors for atherosclerosis and acute cardiac events. Employment or occupational status, as well as criteria such as the human development index, income, and education level, can be considered a new class of risk factors associated with the onset of CVD; these are the so-called *socioeconomic stressors* or *psychosocial stressors* [3]. Recently, a cohort study conducted in the United States examined the association between job loss and the incidence of AMI [8]. Individuals who were unemployed or had accumulated job

losses during their lifetime had higher rates of AMI. The magnitude of this association was similar to the increased risk associated with smoking or diabetes [8]. Previously, Gallo et al. [20] demonstrated that job loss is an independent risk factor for adverse cardiovascular events. In their study, over the 10-year frame of the study and after controlling for established predictors of the outcomes, displaced workers had a more than twofold increase in the risk of subsequent AMI and stroke relative to working persons [20].

Our study is the first to demonstrate a positive association between unemployment rate and AMI hospitalizations. Despite the apparent inverse relation depicted in Fig. 1, it is possible to observe points in time where the trends of unemployment rate and AMI are in the same direction, and it is possible that these points could have contributed to the results. Additionally, as discussed above, there might be other factors associated with the increasing trend for AMI, apart from the association with unemployment rate, which could explain the apparent inverse trends.

Unemployment is associated with CVD in a multifactorial pattern, and it is possible that the stress associated with job loss leads to higher-risk behaviors, including smoking, poor sleep habits, and

increased alcohol intake. INTERHEART, a case control study that evaluated four domains of stress, demonstrated that psychosocial stressors are associated with increased risk of AMI [3]. Moreover, we speculate that risky behavior has a greater effect on the incidence of AMI than it does on stroke. In fact, some data suggest that the traditional risk factors may have different impacts on CVD, depending on the population that is being considered [21,22]. Additionally, stroke occurs at later ages than AMI, and from this point of view, in the Brazilian population, the risky behaviors that result from being unemployed might include factors that are more associated with AMI than with stroke.

This study has the following limitations: 1) This was an observational study, and despite statistical adjustments, a cause-and-effect relationship cannot be determined between the unemployment rate and hospital admissions due to AMI or stroke. 2) Data on unemployment rate included individuals aged 10 or older, while extraction for AMI was limited to ages 21 and older, and it was not possible to know employment status on an individual level among patients admitted for AMI and stroke. 3) DATASUS started to collect more consistent information during recent years, and the Brazilian Public Health System Database covers approximately 63% of hospital admissions in the country, but we measured tendencies in a macro level (using the ARIMA model), the effect of some inconsistency is only partially corrected. 4) The unemployment rates were for metropolitan areas in Brazil, but the hospital admission data were for both rural and metropolitan areas; these areas concentrate most of the economic active population and most of the hospitals in Brazil. 5) The unemployment rate is a generalized, indirect measure of stress. The real psychosocial status could not be determined on an individual level. 6) Unfortunately, in the way the data were collected in our study, it was not possible to differentiate people who were unemployed from those who were retired at the time of hospital admission for AMI or stroke. Thus, it is possible that some of our results might have been impacted by people who were retired and not necessarily unemployed at the time of AMI or stroke. 7) Finally, the codes for disease classification used in the Brazilian Public Health System Database did not include transient ischemic attack, and so these cases could have been missed.

In conclusion, from 2002 to 2013, hospital admissions for AMI and stroke increased in Brazil, whereas the unemployment rate decreased. However, the adjusted ARIMA model showed a positive association between unemployment rate and admissions due to AMI but not for stroke. Further studies are warranted to validate our findings and to better explore the mechanisms by which socioeconomic stressors, such as unemployment, might impact the incidence of CVD.

Conflicts of interest

Dr. Bosworth reports grants from MeadWestvaco, grants from Sanofi, personal fees from Walgreens, personal fees from Genetech, grants from Takeda, personal fees from Blue Cross/Blue Shield, grants from Johnson & Johnson, grants from Improved Patient Outcome, and personal fees from CVS/Caremark outside the submitted work; Dr. Lopes reports personal fees from Bayer, personal fees from Boehringer Ingelheim, grants from GlaxoSmithKline, personal fees from Merck, personal fees from Pfizer, personal fees from Portola, and grants and personal fees from Bristol-Myers Squibb outside the submitted work; all other authors have nothing to disclose.

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