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Are heart attacks deadlier on weekends? Evidence of weekend effect in Brazil

Os ataques cardíacos são mais letais nos fins de semana? Evidência do "efeito final de semana" no Brasil

Pedro Henrique Soares Leivas (https://orcid.org/0000-0003-1466-4476) [1]
Lívia Madeira Triaca (https://orcid.org/0000-0001-7192-6554) [2]
Anderson Moreira Aristides dos Santos (https://orcid.org/0000-0003-4234-8665) [3]
Paulo de Andrade Jacinto (https://orcid.org/0000-0002-8563-9190) [4]
César Augusto Oviedo Tejada (https://orcid.org/0000-0002-8120-5563) [2]

Abstract *This article aims to examine the effects of weekend admission on in-hospital mortality for patients with acute myocardial infarction (AMI) in Brazil. Information from the Hospital Information System of the Unified Health System (SIH/SUS) of urgently admitted patients diagnosed with acute myocardial infarction (AMI) between 2008 and 2018 was used, made available through the Hospital Admission Authorization (AIH). Multivariable logistic regression models, controlling for observable patient characteristics, hospital characteristics and year and hospital-fixed effects, were used. The results were consistent with the existence of the weekend effect. For the model adjusted with the inclusion of all controls, the chance of death observed for individuals hospitalized on the weekend is 14% higher. Our results indicated that there is probably an important variation in the quality of hospital care depending on the day the patient is hospitalized. Weekend admissions were associated with in-hospital AMI mortality in Brazil. Future research should analyze the possible channels behind the weekend effect to support public policies that can effectively make healthcare equitable.*

Key words *Acute myocardial infarction, In-hospital mortality, Brazil*

Resumo *O objetivo deste artigo é examinar os efeitos da internação no final de semana na mortalidade hospitalar de pacientes com infarto agudo do miocárdio (IAM) no Brasil. Foram utilizadas informações do Sistema de Informação Hospitalar do Sistema Único de Saúde (SIH/SUS) de pacientes internados em urgência com diagnóstico de infarto agudo do miocárdio (IAM) entre 2008 e 2018, disponibilizados por meio da Autorização de Internação Hospitalar (AIH). Foram usados modelos de regressão logística multivariada, controlando as características observáveis do paciente, características do hospital e efeitos fixos de ano e hospital. Os resultados foram consistentes com a existência do efeito fim de semana. Para o modelo ajustado com a inclusão de todos os controles, a chance de óbito observada para indivíduos internados no final de semana é 14% maior. Nossos resultados indicaram que provavelmente existe uma variação importante na qualidade da assistência hospitalar dependendo do dia em que o paciente fica internado. Internações em finais de semana foram associadas à mortalidade por IAM intra-hospitalar no Brasil. Pesquisas futuras devem analisar os possíveis canais por trás do weekend effect para subsidiar políticas públicas que possam efetivamente tornar o atendimento equitativo.*

Palavras-chave *Infarto agudo do miocárdio, Mortalidade hospitalar, Brasil*

[1] Programa de Pós-Graduação em Economia Aplicada, Fundação Universidade Federal do Rio Grande. Av. Itália km 8. 96203-900 Rio Grande RS Brasil. pedroleivas@furg.br
[2] Programa de Pós-Graduação em Organizações e Mercados, Universidade Federal de Pelotas. Pelotas RS Brasil.
[3] Programa de Pós-Graduação em Economia, Universidade Federal de Alagoas. Maceió AL Brasil.
[4] Programa de Pós-Graduação em Desenvolvimento Econômico, Universidade Federal do Paraná. Curitiba PR Brasil.

Introduction

According to data from World Health Organization – WHO[1], heart diseases have remained as the leading cause of death in the world in the last 20 years, representing about 16% of the total deaths. In Brazil, the scenario is no different. Heart diseases, especially acute myocardial infarction (AMI), the main cause of death by heart disease, are responsible for a large portion of cases of disability, morbidity, and mortality, with one of the highest mortality rates in the world (183.3/100,000 inhabitants)[2,3].

Studies that seek a better understanding of AMI patterns are important for public health, since deaths and disabilities associated with this disease have an important weight on society and generate individual and family costs, as well as direct and indirect economic costs that reflect both in public health and in the aggregate production of the economy[4].

AMI is a myocardial injury that results from an obstruction of a coronary artery, popularly known as a heart attack. Most AMI cases result in death in a short period of time – about 80% of deaths occur within the first 24 hours[2,5]. Appropriate and timely medical intervention is essential to obtain better results. It is estimated that adequate care, within one hour of the onset of the disease, results in an improvement of up to 50% in the survival rate[6].

Given the need for immediate intervention, access to and quality of care must always be available. However, studies suggest that patients admitted on weekends are more likely to have adverse outcomes compared to those admitted during the week – the so-called weekend effect[7-16]. Despite being a widely discussed topic in the literature, the results observed are still not agreed upon. Most studies observe some variation in the outcome of patients according to the time of admission, but there are studies that do not find results in this direction[17-22].

To explain these differences, two hypotheses have been suggested by the literature. The first is related to the provision of care, according to which hospitals provide less care on weekends, a period in which many diagnostic services are not available, and the medical staff tends to be less experienced. The second hypothesis is that the weekend effect would be the result of unobservable differences in disease severity, in the sense that patients in worse health conditions would be hospitalized during the weekend.

In view of the weekend effect, improving the quality/quantity of care provided by hospitals during weekends has been suggested to mitigate the higher incidence of adverse outcomes of hospitalized patients during this period. However, there is controversy as to whether the availability of routine services seven days a week would be cost-effective[23].

Although the subject has been receiving increasing attention internationally[12], in Brazil the it remains to be further investigated[9,21,24]. The few existing works can hardly be generalized, as they focus on just one hospital or on hospitals in only a single state. The little attention that has been directed to the subject in Brazil, together with the impossibility of generalizing existing results, raises the need for additional studies that seek to identify some variation in the results of patients hospitalized on weekends. Thus, the aim of this article is to examine the effects of weekend admission on in-hospital mortality for patients with acute myocardial infarction (AMI) in Brazil.

Therefore, patients hospitalized between 2008 and 2018 on an emergency basis with a diagnosis of AMI will be considered. The choice for this condition was made for several reasons. Evangelista et al.[9] point out that the weaknesses and inequalities of access to health care can be investigated by analyzing mortality from diseases whose health outcome for patients depends on adequate medical intervention at the right time. AMI requires immediate and complex care, and the delay and inadequacy of care can lead to adverse results. These factors make AMI an appropriate measure to analyze the quality of care, being a measure widely used in the literature[8,16,25-27]. In addition, AMI is a common condition for hospitalization, so it allows us to generate estimates for a relatively large sample. Furthermore, patients with AMI have less discretion in choosing hospitals compared to patients with other common diseases, which would reduce the selection bias. This happens because the time between the onset of symptoms and hospitalization is fundamental for the prognosis, therefore, patients are referred to hospitals as soon as possible[16,28].

Thus, the main question that this article proposes to answer is the following: is there a difference in the health outcomes of patients admitted on weekends when compared to patients admitted during the week? When considering all cases that occurred in the country, over a considerable period, the results of this study will support the discussion and possible implementation of public policies for the hospital sector in Brazil, in case any variation in the outcome of patients is evidenced.

Methods

Data

Our main source of data is information from the Hospital Information System of the Unified Health System (SIH/SUS) of urgently admitted patients diagnosed with acute myocardial infarction between 2008 and 2018, made available through the Hospital Admission Authorization (AIH). The AIH guide is a SUS document that identifies patients and services provided under the hospital admission regime. It is filled out by hospitals, whether public or private, that have an agreement with SUS, and is intended to support the management of billing and reimbursement of hospital medical procedures and/or hospitalizations provided to patients financed with public resources.

Only patients with a first infarction were included (ICD-10: I-21.X). In addition, seeking to minimize possible problems of selection bias and unobserved heterogeneity between patients hospitalized on weekends and those hospitalized during the week, only those whose hospital discharge occurred on an urgent basis were considered[7].

The indicator that was used to assess the variation in health outcomes was in-hospital mortality. Other indicators, such as mortality in 30 days and one year, for example, would be more adequate and informative, but they were not available. The Agency for Healthcare Research and Quality[29] points out, however, that mortality is a valid indicator to assess the quality of hospital care.

The AIHs present information about patient characteristics, which can be used as controls in the models to be estimated. Thus, the following controls were used: age; sex; procedure performed; length of stay; use of the Intensive Care Unit (ICU); and Charlson comorbidity index[30]. Table 1 below presents the description of all the variables.

The analysis of descriptive statistics was performed using two tests: for continuous variables, the difference in means test was used, and for discrete variables, the test of proportion was used. This and all other statistical and econometric analyzes were performed using the Stata 15 software.

Empirical strategy

Consider a municipality m during the year $t = 1, ..., T$, thus, the effect of admission on the weekend on the health outcome of patients $I = 1, ..., N_{mt}$ who were admitted to the hospital h with an AMI episode was analyzed. Each patient has a vector of observed characteristics X_{it}: age, sex, procedure to which s/he was submitted, length of stay, use of ICU and Charlson comorbidity index. The Charlson Comorbidity Index (CCI) is composed of 20 clinical conditions, which are weighted from 1 to 6 according to the risk of death and the severity of the disease, and then added together to compose the total CCI score. Likewise, each hospital has a vector of observed characteristics H_{ht}: average length of stay of hospitalized patients, number of beds and number of patients treated. Such controls seek to mitigate possible variations in the outcome of patients due to the heterogeneity of individuals and hospitals.

In-hospital mortality is the health outcome that was used to check the effect of the patient being admitted to the hospital over the weekend. Thus, the empirical strategy starts from the specification of a logistic model, in which the dependent variable y_{it} is a dichotomous variable that indicates whether the patient i, in year t, died ($y_{it} = 1$) or not ($y_{it} = 0$) when s/he was hospitalized with AMI. The basic specification of the model to be estimated will then be as follows:

$$P(y_{it} = 1) = \Lambda(\alpha_0 + \alpha_h\tau + \rho_t T_m\varphi + X_{it}\gamma + H_{ht}\lambda + W_{it}\beta) \quad (1)$$

where α_h is a fixed effect of hospital, ρ_t is a fixed effect of year, which may vary according to T_m, a vector of indicators that represent the size (in population terms) of the municipality where patient i lives, X_{it}, as mentioned above, $H_{ht}$is a vector of observable patient characteristics, is a vector of characteristics of the hospital, W_{it} is a binary variable that indicates whether the patient was hospitalized over the weekend, Saturday or Sunday, ($= 1$) or during the week ($= 0$), and $\Lambda(.)$ is the logistic distribution function.

By including a fixed effect of hospital, we sought to control both the variation in standards of practice between hospitals and the non-random distribution of patients between hospitals[7].

Although this work does not use exogenous sources of variation to assess the effect of weekend hospitalization, the strategies and controls allow us, at least in part, to interpret the results in terms of impact. Restricting the analysis to

Table 1. Description of variables.

Variables	Description
Death	Binary variable equal to 1 when the patient died after the procedure
Weekend	Binary variable equal to 1 if the patient was admitted to the hospital during the weekend
Women	Binary variable equal 1 when the patient is female
Charlson Index	Categorical variable ranging from 0 to 6 according to the severity of the patient's comorbidity
Age	Categorical variable with five categories, indicating patient age in years
Lenght of stay (days)	Categorical variable with five categories, indicating the length of stay of patients in days
Days in the ICU	Categorical variable with four categories, indicating the length of stay of patients in the ICU in days
Volume	Categorical variable with five categories, indicating the number of consultations performed, under the diagnosis of AMI, in the hospital where the patient was seen
Hospital bed	Categorical variable with five categories, indicating the number of beds available in the hospital where the patient was treated
Patients treated	Categorical variable with five categories, indicating the number of visits at the hospital where the patient was treated
Average lenght of stay	Categorical variable with five categories, indicating the average length of stay of admissions in the hospital where the patient was treated
Year fixed effect	Binary variables that indicate the year the procedure was performed
State fixed effect	Binary variables that indicate the State where the hospital is located
Procedure performed	Binary variables that indicate procedures performed by the patient when hospitalized with AMI.
Hospital fixed effect	Binary variables that indicate the hospital where the patient was admitted

Source: Authors.

urgently admitted patients only helps to mitigate the unobserved heterogeneity among patients hospitalized during the week and on weekends. In addition, when controlling the comorbidities that patients have, through the Charlson comorbidity index, the severity of the patient's health status is controlled, at least in part. At the hospital level, control for fixed effects, as pointed out above, captures any variations that may exist in standards of care across hospitals.

Thus, six models were estimated in the empirical analysis, always adding variables in relation to the previous model. In model (1), which is simpler, only the variable indicating hospitalization during the weekend was included. In (2), year and state fixed effects were included. Model (3) adds variables related to patient characteristics, such as sex, comorbidities (Charlson Index), age, length of stay, number of days spent in the ICU. Model (4) aggregates hospital characteristics, namely: amount of patients treated with an AMI diagnosis, number of beds, total number of patients treated, average length of stay of patients treated. Model (5) controls for the main procedure performed during hospitalization. Finally, model (6) includes a hospital fixed effect.

Results

Table 2 presents some statistics to assess the differences between admissions on the weekend and during the week. We can see that patients hospitalized on the weekend tend to be older ($p = 0,0082$) and have a longer length of stay ($p < 0,001$) than patients hospitalized during the week. In addition, patients hospitalized on weekends stay longer in the intensive care unit ($p < 0,001$). Also, the mortality rate on weekends is higher than during the week ($p < 0,001$).

Table 3 shows the odds ratios, estimated through logistic regression, of the factors associated with in-hospital death in patients admitted on an emergency basis with an AMI episode between 2008 and 2018. In model (1), only the variable that indicates whether the patient was hospitalized on the weekend (Weekend) is included in the estimation. In model (2), the year of fixed effect is also included – which can vary according to the size of the population in the municipality where the patient lives – and the State of fixed effect. In model (3), a vector of patient characteristics is added. In model (4), a vector of hospital characteristics is included. In model (5), the

Table 2. Differences between patients hospitalized on weekends and during the week (2008-2018)

Variable	Weekend (n = 165,239)	During the week (n = 513,636)	P-value
Patient characteristics			
Age, years, mean (SD)	63.04 (13.46)	62.94 (13.17)	0.0082
Woman, n (%)	61.611 (37.29)	189.271 (36.85)	0.0014
Length of stay (days), mean (SD)	7.55 (8.13)	7.42 (8.12)	<0.001
Charlson Index, n (%)			
0	159.581 (96.58)	497.445 (96.85)	<0.001
1	4.970 (3.01)	14.388 (2.80)	<0.001
2	657 (0.40)	1.722 (0.34)	<0.001
3	6 (0.00)	10 (0.00)	0.2200
6	25 (0.02)	71 (0.01)	0.6976
Days in the ICU, mean (SD)	1.83 (3.85)	1.77 (3.72)	<0.001
Hospital characteristics			
Volume, mean (SD)	283 (326)	295 (327)	<0.001
Patients treated, mean (SD)	9.648 (8.202)	9,694 (8,424)	0.0522
Average length of stay, mean (SD)	5.89 (2.24)	5.89 (2.27)	0.5599
Hospital beds, mean (SD)	253 (209)	261 (221)	<0.001
In-hospital mortality, number (%)	28.674 (17.35)	76.166 (14.83)	<0.001

For continuous variables, the P-value refers to the difference in means test performed by the Stata *ttest* command. For discrete variables, the P-value refers to the test of proportions performed by the Stata *prtest* command.

Source: Authors.

procedure performed by the patient is controlled. Finally, model (6) includes a hospital fixed effect.

The results presented in Table 3 are consistent with the existence of the weekend effect; it can be observed in all estimated models that the chance of death is significantly higher when hospitalization occurs on weekends. This result is robust to the inclusion of a series of controls, including hospital fixed effect.

In the unadjusted model (Model 1), the odds ratio of 1.2060 indicates that the chance of death is 20.60% greater when the individual is hospitalized on the weekend. This result remains practically unchanged with the inclusion of the fixed effect of year and of State (Model 2), indicating that these variables are not related to hospitalization on weekends. The results of the year and State fixed effect (not shown in the table) indicate that there is no difference in mortality over time or between States. The inclusion of patient characteristics (Model 3) considerably increases the association between the time of admission and in-hospital death since the chance of death is 32.29% higher when the patient is admitted during the weekend. The inclusion of the characteristics of the hospital, the procedure performed, and the hospital fixed effect somewhat mitigates the relationship, but even so the chance of death is significantly higher (14.10%) at the weekend.

Other factors have also been shown to be associated with in-hospital death. In the complete model (Model 6), for example, women have a 20.74% higher chance of death than men. Regarding age, the chance of death increases systematically as age increases, regardless of the model. The same occurs with days in the ICU, in which the chance of death is 7.83 times greater in patients who are hospitalized for 4 to 162 days in the ICU compared to patients who were not hospitalized for even one day.

Discussion

In this article, we examined the relationship between the day of admission of patients and the health outcomes they achieve. Specifically, we sought to analyze whether the chance of death is greater when the patient is hospitalized during the weekend – weekend effect. Therefore, we used data from 2008 to 2018 of urgently admitted patients with an episode of Acute Myocardial Infarction.

The observed results point to the existence of the weekend effect in Brazil. The chance of death is significantly greater when the patient is hospi-

Table 3. Odds ratio – Weekend Effect (2008-2018)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Weekend	1.2060***	1.2066***	1.3229***	1.2681***	1.1684***	1.1410***
	(1.1762 - 1.2365)	(1.1773 - 1.2367)	(1.2746 - 1.3731)	(1.2321 - 1.3052)	(1.1408 - 1.1966)	(1.1148 - 1.1678)
Woman			1.2486***	1.2376***	1.1973***	1.2074***
			(1.2242 - 1.2735)	(1.2143 - 1.2614)	(1.1751 - 1.2199)	(1.1848 - 1.2304)
Charlson Index						
1			1.4138	1.5819***	1.5185***	1.8045***
			(0.7550 - 2.6473)	(1.1219 - 2.2306)	(1.1071 - 2.0827)	(1.5100 - 2.1565)
2			2.9752***	2.6654***	2.5268***	3.0066***
			(2.4359 - 3.6338)	(2.1533 - 3.2994)	(2.0403 - 3.1294)	(2.5272 - 3.5771)
3			14.8034***	13.9708***	11.0017***	10.9436***
			(4.5531 - 48.1302)	(4.1558 - 46.9666)	(3.4228 - 35.3626)	(3.3650 - 35.5902)
6			2.0289**	1.6530	1.4138	1.6066
			(1.0452 - 3.9386)	(0.8464 - 3.2286)	(0.7294 - 2.7403)	(0.8176 - 3.1572)
Age						
53 to 60			1.4551***	1.4973***	1.5612***	1.5833***
			(1.4058 - 1.5061)	(1.4501 - 1.5461)	(1.5147 - 1.6092)	(1.5356 - 1.6325)
61 to 66			2.1033***	2.1781***	2.2585***	2.3093***
			(2.0285 - 2.1808)	(2.1062 - 2.2525)	(2.1864 - 2.3331)	(2.2344 - 2.3867)
67 to 75			3.2422***	3.3650***	3.4302***	3.5604***
			(3.1256 - 3.3632)	(3.2550 - 3.4787)	(3.3205 - 3.5434)	(3.4475 - 3.6771)
76 to 117			5.8730***	6.0394***	5.8932***	6.2274***
			(5.6533 - 6.1011)	(5.8272 - 6.2595)	(5.6817 - 6.1125)	(6.0046 - 6.4585)

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talized over the weekend and this result remains significant even after the inclusion of a series of controls. For the model adjusted with the inclusion of all controls (model 6), the chance of death observed for individuals hospitalized on the weekend is 14% higher – a similar magnitude was observed by Lin et al.[16] in a study for China and by the meta-analyses of Pauls et al.[31] and Chen et al.[15]

These results corroborate the findings of numerous other studies[8-11,14,16,24,32-41]. However, some studies do not show a significant relationship between the time of hospitalization and the health outcomes of patients[17-22]. Among them, it is worth mentioning the work of Walker *et al.*[22], in which the authors point out that taking the results of clinical examinations into consideration can cause the relationship to be significantly reduced, or even disappear.

After observing the existence of the Weekend Effect for Brazil, ideally the next step would be to seek to understand the mechanisms behind this relationship, however, given our knowledge, the available databases still do not make it possible to carry out this investigation for Brazil. The first is related to provision of care on weekends. The level of professionals and availability of interventions may be lower on these days[7,8,16]. Many diagnostic and therapy services may not be available on weekends. Another factor related to the pro-

Table 3. Odds ratio – Weekend Effect (2008-2018)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Length of stay (days)						
4			0.1437***	0.1365***	0.1190***	0.1079***
			(0.1330 - 0.1552)	(0.1282 - 0.1453)	(0.1114 - 0.1270)	(0.1007 - 0.1156)
5 to 6			0.0995***	0.0903***	0.0763***	0.0652***
			(0.0899 - 0.1102)	(0.0828 - 0.0984)	(0.0700 - 0.0831)	(0.0595 - 0.0715)
7 to 10			0.0865***	0.0740***	0.0586***	0.0479***
			(0.0766 - 0.0977)	(0.0668 - 0.0820)	(0.0530 - 0.0647)	(0.0431 - 0.0531)
11 to 336			0.1174***	0.0952***	0.0710***	0.0560***
			(0.1024 - 0.1347)	(0.0852 - 0.1063)	(0.0636 - 0.0794)	(0.0502 - 0.0624)
Days in the ICU						
1			1.4419***	1.8345***	2.3681***	3.1766***
			(1.1098 - 1.8732)	(1.5749 - 2.1369)	(2.0969 - 2.6744)	(2.8025 - 3.6006)
2 to 3			1.1154*	1.2905***	1.4000***	1.8433***
			(0.9829 - 1.2658)	(1.1643 - 1.4305)	(1.2807 - 1.5304)	(1.6649 - 2.0407)
4 to 162			4.5571***	5.2502***	5.5824***	7.8305***
			(4.0335 - 5.1488)	(4.7406 - 5.8146)	(5.0569 - 6.1626)	(6.9576 - 8.8129)
Volume						
62 to 131				0.7040***	0.7901***	0.8210***
				(0.6460 - 0.7671)	(0.7310 - 0.8539)	(0.7734 - 0.8716)
132 to 227				0.4910***	0.6283***	0.6989***
				(0.4358 - 0.5531)	(0.5619 - 0.7026)	(0.6401 - 0.7632)
228 to 444				0.3110***	0.4753***	0.6161***
				(0.2692 - 0.3594)	(0.4165 - 0.5425)	(0.5513 - 0.6886)
445 to 1977				0.2237***	0.3914***	0.5449***

it continues

vision of care is the medical staff, which tends to be less experienced on weekends. These staff may not have experience in performing invasive procedures, which are normally needed in patients with AMI[16]. The second hypothesis refers to the severity of the disease. Patients admitted on weekends can arrive at hospitals in worse health conditions, with more severe AMI, which would make treatment difficult and increase the risk of death[16].

There is some evidence in the literature that sought to elucidate this channel[7,14,26,42-45]. Becker[7], analyzing data from the USA, sought to understand the mechanisms by which hospitalization on weekends affects the odds of death and showed that patients admitted on weekends were less likely to receive immediate intensive cardiac care. In a study for England, Jayawardana et al.[14] sought to test the provision of medical care hypothesis and examined whether admissions made outside normal hours for primary percutaneous coronary intervention would be associated with higher mortality and whether differences in door-to-Balloon (DTB) time would explain the

Table 3. Odds ratio – Weekend Effect (2008-2018)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
				(0.1801 - 0.2778)	(0.3243 - 0.4724)	(0.4637 - 0.6404)
Hospital bed						
106 to 174				0.8342***	0.8940*	0.9591
				(0.7372 - 0.9440)	(0.7988 - 1.0005)	(0.8756 - 1.0505)
175 to 244				0.6693***	0.7959***	0.9472
				(0.5585 - 0.8022)	(0.6837 - 0.9266)	(0.8283 - 1.0832)
245 to 344				0.5829***	0.7468***	0.9590
				(0.4721 - 0.7198)	(0.6246 - 0.8929)	(0.8162 - 1.1270)
345 to 1980				0.4360***	0.6521***	0.9899
				(0.3374 - 0.5634)	(0.5255 - 0.8093)	(0.8067 - 1.2147)
Patients treated						
3496 to 6410				1.5857***	1.4363***	1.0008
				(1.4167 - 1.7748)	(1.2993 - 1.5877)	(0.9149 - 1.0948)
6415 to 9283				1.9699***	1.7076***	1.0367
				(1.6699 - 2.3239)	(1.4879 - 1.9598)	(0.9084 - 1.1832)
9294 to 13494				2.4658***	1.9606***	1.0397
				(2.0212 - 3.0082)	(1.6631 - 2.3114)	(0.8968 - 1.2052)
13495 to 73438				3.6352***	2.7090***	1.0858
				(2.7934 - 4.7306)	(2.1991 - 3.3372)	(0.9058 - 1.3016)
Average length of stay						
4.02 to 5.01				1.3353***	1.3539***	1.1144***
				(1.1942 - 1.4932)	(1.2270 - 1.4939)	(1.0399 - 1.1942)
5.01 to 6.03				1.8210***	1.7409***	1.2157***
				(1.5907 - 2.0847)	(1.5563 - 1.9475)	(1.1022 - 1.3409)
6.03 to 7.50				2.0875***	2.0359***	1.2980***
				(1.8056 - 2.4133)	(1.8011 - 2.3012)	(1.1570 - 1.4561)
7.50 to 23.25				2.4811***	2.2756***	1.4598***
				(2.0562 - 2.9938)	(1.9482 - 2.6580)	(1.2654 - 1.6841)
Observations	678.875	678.875	678.875	678.875	678.875	678.875
Year FE	NO	YES	YES	YES	YES	YES
State FE	NO	YES	YES	YES	YES	YES
Procedure performed	NO	NO	NO	NO	YES	YES
FE of hospital	NO	NO	NO	NO	NO	YES

Cluster-robust standard errors at the hospital level in parentheses. The dependent variable in the models is a dummy that indicates whether the patient died (=1) or not (=0) after being urgently admitted with a diagnosis of Acute Myocardial Infarction (AMI). Reference categories: Charlson index, 0 – no comorbidities; age, 0 to 52 years; length of stay, 0 to 3 days; days in the ICU, 0 days; volume, 10 to 61; hospital bed, 5 to 105; patients treated, 101 to 3495; average length of stay, 1.61 to 4.02 days. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Authors.

association. The authors noted that the mean DTB time is higher outside regular hours and that this difference would partially explain the association between admissions outside regular hours and a higher risk of mortality. On the other hand, the evidence observed by Aldridge et al.[42] and Fiorentino et al.[26] showed no evidence that the provision of medical care was behind the weekend effect. Also, for England, Aldridge et al.[42] analyzed the association between pecialist staff on weekends and the risk of mortality in emergency admissions and found no relationship. Fiorentino et al.[26], in a study for Portugal, reported that there was a delay in invasive cardiac procedures in admissions on the weekend, but they found no association between the delay and hospital mortality.

Other studies sought to test the hypothesis of greater severity in cases admitted on weekends[43-46]. Anselmi et al.[43] used the arrival of ambulances to hospitals as a measure of disease severity and observed that the association between admission outside regular hours and hospital mortality becomes statistically insignificant when controlling for this measure of severity. Other studies also report similar results using other proxies to measure severity[44-47].

From this perspective, considering that we restricted our analysis to urgently admitted patients, we controlled for the patient's health status (Charlson comorbidity index) and differences in the hospitals' standard of care (hospital fixed effect); our results indicated the existence of a weekend effect, possibly due to the existence of an important variation in the quality of hospital care depending on the day the patient is hospitalized.

However, this work has limitations. It is possible that the existence of differences in terms of severity between those admitted during the week and on weekends persists even after this care. Unfortunately, we cannot directly test the care provision hypothesis. We use administrative data and not clinical data, which would give us much more detailed information regarding the patient's health condition, for example, variables such as duration of pain during hospitalization and professional pre-hospital care could be important controls. This lack of information is what prevents us from determining the causes of the higher mortality observed for patients admitted on the weekend. Another limitation related to the use of administrative data is the concern regarding data quality, as these were not designed for research purposes. Despite that, there is no reason to expect these errors to vary systematically between weekend and weekday admissions [26]. Finally, we only analyzed hospital death as an outcome. Other outcomes related to functional results could be more sensitive to the quality of care and may present different results. Despite the limitations, mainly related to the availability of data, the inclusion of important controls for the characteristics of patients and hospitals, and among them mainly the hospital fixed effect, make this work important for the literature.

To the best of our knowledge, this is the first study that analyzes the relationship using hospital data from all over Brazil, thus, the results shown, which point to the existence of the weekend effect in the country, are important to foster the debate on the subject. However, our results are based only on data from procedures performed in hospitals via the Unified Health System (SUS), allowing their generalization to the entire public health system.

The SUS aims to grant full and equal access to health services. The results observed in the present study are against the objectives of the SUS by showing that the service to the population differs according to the day of the week of admission. This finding may indicate the existence of disparities in the quality and availability of health services throughout the week. Future studies must necessarily evaluate the causal mechanisms behind the effect found, thus providing valuable information that can support the formulation of policies that seek to consistently increase the quality of service delivery.

Collaborations

Conceptualization: PHS Leivas and PA Jacinto. Methodology: PHS Leivas and PA Jacinto. Formal analysis and investigation: PHS Leivas. Writing – original draft preparation: PHS Leivas, LM Triaca and AMA Santos. Writing – review and editing: PHS Leivas, LM Triaca, AMA Santos, PA Jacinto and CAO Tejada.

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References

1. Organização Pan-Americana da Saúde (OPAS). OMS revela principais causas de morte e incapacidade em todo o mundo entre 2000 e 2019 [Internet]. 2020. [acessado 2021 ago 11]. Disponível em: https://www.paho.org/pt/noticias/9-12-2020-oms-revela-principais-causas-morte-e-incapacidade-em-todo-mundo-entre-2000-e
2. Silva AS, Ferraz MOA, Biondo CS, Oliveira BG. Características sociodemográficas das vítimas de Infarto Agudo do Miocárdio no Brasil. *Enferm Bras* 2018; 17(6):568-575.
3. Santos J, Meira KC, Camacho AR, Salvador PTCO, Guimarães RM, Pierin ÂMG, Simões TC, Freire FHMA. Mortalidade por infarto agudo do miocárdio no Brasil e suas regiões geográficas: análise do efeito da idade-período-coorte. *Cien Saude Colet* 2018; 23(5):1621-1634.
4. Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet* 2007; 370(9603):1929-1938.
5. Avezum Junior A, Feldman A, Carvalho AC, Sousa AC, Mansur Ade P, Bozza AE, Falcão Bde A, Markman Filho BM, Polanczyk CA, Gun C, Serrano Junior CV, Oliveira CC, Moreira D, Précoma DB, Magnoni D, Albuquerque DC, Romano ER, Stefanini E, Santos ES, God EM, Ribeiro EE, Brito FS, Feitosa-Filho GS, Arruda GD, Oliveira GB, Lima GG, Dohman H, Liguori IM, Costa Junior Jde R, Saraiva JF, Maia LN, Moreira LF, Santos MA, Canesin MF, Coutinho MS, Moretti AM, Ghorayeb N, Vieira NW, Dutra OP, Coelho OR, Leães PE, Rossi PR, Andrade PB, Lemos Neto PA, Pavanello R, Costa RV, Bassan R, Esporcatte R, Miranda R, Giraldez RR, Ramos RF, Martins SK, Esteves VB, Mathias Junior W; Brazilian Society of Cardiology. V diretriz da Sociedade Brasileira de Cardiologia sobre tratamento do infarto agudo do miocárdio com supradesnível do segmento ST. *Arq Bras Cardiol* 2015; 105(2 - Suppl. 1):1-121.
6. Cascaldi BG, Lacerda FM, Rodrigues A, Arruda GV. Infarto agudo do miocárdio sob a ótica da população brasileira. *Rev Bras Cardiol (Impr)* 2014; 27(6):409-417.
7. Becker DJ. Do hospitals provide lower quality care on weekends? *Health Serv Res* 2007; 42(4):1589-1612.
8. Kostis WJ, Demissie K, Marcella SW, Shao YH, Wilson AC, Moreyra AE; Myocardial Infarction Data Acquisition System (MIDAS 10) Study Group. Weekend versus weekday admission and mortality from myocardial infarction. *New Eng J Med* 2007; 356(11):1099-1109.
9. Evangelista PA, Barreto SM, Guerra HL. Hospital admission and hospital death associated to ischemic heart diseases at the National Health System (SUS). *Arq Bras Cardiol* 2008; 90(2):130-138.
10. Clarke MS, Wills R-A, Bowman RV, Zimmerman PV, Fong KM, Coory MD, Yang IA. Exploratory study of the 'weekend effect' for acute medical admissions to public hospitals in Queensland, Australia. *Int Med J* 2010; 40(11):777-783.

11. Funenga ISA. *Efeito fim-de-semana e noite: impacto do momento de admissão sobre a mortalidade e a demora média no internamento* [dissertação]. Lisboa: Escola Nacional de Saúde Pública da Universidade Nova de Lisboa; 2014
12. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Dabrh AM, Prokop L, Kent DM, Shah ND, Murad MH, Ting HH. Off-hour presentation and outcomes in patients with acute ischemic stroke: a systematic review and meta-analysis. *Eur J Intern Med* 2014; 25(4):394-400.
13. Shah M, Patnaik S, Patel B, Arora S, Patel N, Lahewala S, Figueredo VM, Martinez MW, Jacobs L. The day of the week and acute heart failure admissions: relationship with acute myocardial infarction, 30-day readmission rate and in-hospital mortality. *Int J Cardiol* 2017; 249:292-300.
14. Jayawardana S, Salas-Vega S, Cornehl F, Krumholz HM, Mossialos E. The relationship between off-hours admissions for primary percutaneous coronary intervention, door-to-balloon time and mortality for patients with ST-elevation myocardial infarction in England: a registry-based prospective national cohort study. *BMJ Qual Saf* 2020; 29(7):541-549.
15. Chen Y-F, Armoiry X, Higenbottam C, Cowley N, Basra R, Watson SI, Tarrant C, Boyal A, Sutton E, Wu CW, Aldridge CP, Gosling A, Lilford R, Bion J. Magnitude and modifiers of the weekend effect in hospital admissions: a systematic review and meta-analysis. *BMJ Open* 2019; 9(6):e025764.
16. Lin X, Green JC, Xian H, Cai M, Skrzypek J, Tao H. Holiday and weekend effects on mortality for acute myocardial infarction in Shanxi, China: a cross-sectional study. *Int J Public Health* 2020; 65(6):847-857.
17. Albright KC, Raman R, Ernstrom K, Hallevi H, Martin-Schild S, Meyer BC, Meyer DM, Morales MM, Grotta JC, Lyden PD, Savitz SI. Can comprehensive stroke centers erase the 'weekend effect'? *Cerebrovasc Dis* 2009; 27(2):107-113.
18. Kim C, Jang MU, Oh MS, Park JH, Jung S, Lee JH, Yu KH, Han MK, Kim BJ, Park TH, Park SS, Lee KB, Cha JK, Kim DH, Lee J, Kim SH, Lee SJ, Ko Y, Park JM, Kang K, Cho YJ, Hong KS, Cho KH, Kim JT, Kim DE, Choi JC, Jang MS, Bae HJ, Lee BC; CRCS-5 investigators. Off-hour effect on 3-month functional outcome after acute ischemic stroke: a prospective multicenter registry. *PLoS One* 2014; 9(8):e105799.
19. Magid DJ, Wang Y, Herrin J, McNamara RL, Bradley EH, Curtis JP, Pollack CV Jr, French WJ, Blaney ME, Krumholz HM. Relationship between time of day, day of week, timeliness of reperfusion, and in-hospital mortality for patients with acute ST-segment elevation myocardial infarction. *JAMA* 2005; 294(7):803-812.
20. Mascarenhas LB, Albuquerque II JBD, Vieira RS, Salim R, Paccola CAJ, Kfuri Júnior M. Correlation between timing of surgery and the occurrence of perioperative complications in the treatment of trocantheric femoral fractures. *Rev Bras de Ortop* 2011; 46(Suppl. 1):44-47.
21. Takada JY, Roza LC, Ramos RB, Avakian SD, Ramires JA, Mansur AP . Emergency service admission time and in-hospital mortality in acute coronary syndrome. *Arq Bras Cardiol* 2012; 98(2):104-110.
22. Walker AS, Mason A, Quan TP, Fawcett NJ, Watkinson P, Llewelyn M, Stoesser N, Finney J, Davies J, Wyllie DH, Crook DW, Peto TEA. Mortality risks associated with emergency admissions during weekends and public holidays: an analysis of electronic health records. *Lancet* 2017; 390(10089):62-72.
23. Meacock R, Doran T, Sutton M. What are the Costs and benefits of providing comprehensive seven-day services for emergency hospital admissions? *Health Econ* 2015; 24(8):907-912.
24. Barros JB, Goulart AC, Alencar AP, Lotufo PA, Bensenor IM. The influence of the day of the week of hospital admission on the prognosis of stroke patients. *Cad Saude Publica* 2013; 29(4):769-777.
25. Isogai T, Yasunaga H, Matsui H, Tanaka H, Ueda T, Horiguchi H, Fushimi K. Effect of weekend admission for acute myocardial infarction on in-hospital mortality: a retrospective cohort study. *Int J Cardiol* 2015; 179:315-320.
26. Fiorentino F, Ascenção R, Rosati N. Does acute myocardial infarction kill more people on weekends? Analysis of in-hospital mortality rates for weekend admissions in Portugal. *J Health Serv Res Policy* 2018; 23(2):87-97.
27. Han L, Sutton M, Clough S, Warner R, Doran T. Impact of out-of-hours admission on patient mortality: longitudinal analysis in a tertiary acute hospital. *BMJ Qual Saf* 2018; 27(6):445-454.
28. Cannon CP, Gibson CM, Lambrew CT, Shoultz DA, Levy D, French WJ, Gore JM, Weaver WD, Rogers WJ, Tiefenbrunn AJ. Relationship of symptom-onset-to--balloon time and door-to-balloon time with mortality in patients undergoing angioplasty for acute myocardial infarction. *JAMA* 2000; 283(22):2941-2947.
29. AHRQ – Agency for Healthcare Research and Quality. *AHRQ Quality Indicators – Guide to Inpatient Quality Indicators: Quality of Care in Hospitals – Volume, Mortality, and Utilization*. Version 3.1. Rockville: AHRQ; 2007.
30. C Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987; 40(5):373-383.
31. Pauls LA, Johnson-Paben R, McGready J, Murphy JD, Pronovost PJ, Wu CL. The weekend effect in hospitalized patients: a meta-analysis. *J Hosp Med* 2017; 12(9):760-766.
32. Barnett MJ, Kaboli PJ, Sirio CA, Rosenthal GE. Day of the week of intensive care admission and patient outcomes: a multisite regional evaluation. *Med Care* 2002; 40(6):530-539.
33. Barba R, Losa JE, Velasco M, Guijarro C, García de Casasola G, Zapatero A. Mortality among adult patients admitted to the hospital on weekends. *Eur J Int Med* 2006; 17(5):322-324.

34. Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on weekends as compared with weekdays. *New Eng J Med* 2001; 345(9):663-668.
35. Bell CM, Redelmeier DA. Waiting for urgent procedures on the weekend among emergently hospitalized patients. *Am J Med* 2004; 117(3):175-181.
36. Bendavid E, Kaganova Y, Needleman J, Gruenberg L, Weissman JS. Complication rates on weekends and weekdays in US hospitals. *Am J Med* 2007; 120(5):422-428.
37. Campbell JT, Bray BD, Hoffman AM, Kavanagh SJ, Rudd AG, Tyrrell PJ; Intercollegiate Stroke Working Party. The effect of out of hours presentation with acute stroke on processes of care and outcomes: analysis of data from the Stroke Improvement National Audit Programme (SINAP). *PLoS One* 2014; 9(2):e87946.
38. Roberts SE, Thorne K, Akbari A, Samuel DG, Williams JG. Mortality following Stroke, the weekend effect and related factors: record linkage study. *PLoS One* 2015; 10(6):e0131836.
39. Saad A, Adil MM, Patel V, Owada K, Winningham MJ, Nahab F. Clinical outcomes after thrombectomy for acute ischemic stroke on weekends versus weekdays. *J Stroke Cerebrovasc Dis* 2014; 23:2708-2713.
40. Varnava AM, Sedgwick JEC, Deaner A, Ranjadayalan K, Timmis AD. Restricted weekend service inappropriately delays discharge after acute myocardial infarction. *Heart* 2002; 87(3):216-219.
41. Smith S, Allan A, Greenlaw N, Finlay S, Isles C. Emergency medical admissions, deaths at weekends and the public holiday effect cohort study. *Emerg Med J* 2014; 31(1):30-34.
42. Aldridge C, Bion J, Boyal A, Chen YF, Clancy M, Evans T, Girling A, Lord J, Mannion R, Rees P, Roseveare C, Rudge G, Sun J, Tarrant C, Temple M, Watson S, Lilford R; HiSLAC Collaborative. Weekend specialist intensity and admission mortality in acute hospital trusts in England: a cross-sectional study. *Lancet* 2016; 388(10040):178-186.
43. Anselmi L, Meacock R, Kristensen SR, Doran T, Sutton M. Arrival by ambulance explains variation in mortality by time of admission: retrospective study of admissions to hospital following emergency department attendance in England. *BMJ Qual Saf* 2017; 26(8):613-621.
44. Mohammed M, Faisal M, Richardson D, Howes R, Beatson K, Speed K, Wright J. Impact of the level of sickness on higher mortality in emergency medical admissions to hospital at weekends. *J Health Serv Res Policy* 2017; 22(4):236-242.
45. Sun J, Girling AJ, Aldridge C, Evison F, Beet C, Boyal A, Rudge G, Lilford RJ, Bion J. Sicker patients account for the weekend mortality effect among adult emergency admissions to a large hospital trust. *BMJ Qual Saf* 2019; 28(3):223-230.
46. Huang H, Chang W, Hsu J, Wang JH, Liu PS, Lin SM, Loh CH. Holiday season and weekend effects on stroke mortality: a nationwide cohort study controlling for stroke severity. *J Am Heart Assoc* 2019; 8(8):e011888.
47. Angerer S, Buttinger K, Stummer H. The weekend effect revisited: evidence from the Upper Austrian stroke registry. *Eur J Health Econ* 2019; 20(5):729-737.

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