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ARTICLE

Evaluation of mobile emergency service with the use of mixed method

Avaliação do serviço móvel de urgência com o uso de método misto

Evaluación de la atención móvil de urgencias con el uso del método mixto

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Abstract

This is an evaluative study, with sequential explanatory mixed methods, aimed at evaluating the performance of the Brazilian Mobile Emergency Medical Service (SAMU) in the Grande ABC region, located in the state of São Paulo, Brazil. In the quantitative approach, an analysis of interrupted time series was performed to evaluate the immediate and gradual effects of the SAMU on hospital mortality due to acute myocardial infarction. The qualitative approach was conducted via semi-structured interviews and a thematic analysis was applied for the interpretation of the results, exploring the attitudes and values of the interviewees regarding the performance of SAMU in the Grande ABC region. Interrupted time series analysis showed a -0.04% reduction in the underlying mortality rate since SAMU implementation (95%CI: -0.0816; -0.0162; p-value = 0.0040) and a reduction in the mortality level, -2.89 (95%CI: -4.3293; -1.4623; p-value = 0.0001), both with statistical significance. To improve the robustness of the results, a control region was used, showing a statistically significant difference in the post-intervention result of -0.0639 (95%CI: -0.1060; -0.0219; p-value = 0.0001). The interviews revealed that the SAMU has the potential to intervene in the prognosis of transported cases, however, challenges related to the availability of beds, expansion of telemedicine, and continuous training of professionals for qualified emergency care in the event of a heart attack must be overcome. The results indicate that the studied intervention is part of a set of factors that, together, generate more conditions to achieve a better result.

Prehospital Care; Interrupted Time Series Analysis; Qualitative Analysis; Evaluation Study

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Introduction

Cardiovascular diseases are the leading cause of death worldwide and were responsible for about 17.9 million deaths in 2015 [1]. According to the World Health Organization (WHO), more than three-quarters of these deaths occur in low- and middle-income countries [2]. In Brazil, morbidity and mortality due to cardiovascular diseases follow the worldwide trend, with acute myocardial infarction (AMI) being considered one of the most serious public health issues [3].

The *Global Burden of Disease Study 2017* estimates the considerable cost of AMI to the health system [4]. According to the study *The Costs of Heart Disease in Brazil* [2], the financial costs associated with the AMI in Brazil, in 2015, were USD 17.3 billion, out of which approximately 62.9% was supported by the public health system. Evidence shows that rapid care by emergency teams is among the factors that contribute to the reduction of mortality in AMI cases [5,6].

Emergency mobile pre-hospital care is potentially able to generate better prognosis, especially in acute cases and in the most vulnerable populations, alleviating health disparities [7,8]. In Brazil, the Mobile Emergency Medical Service (SAMU; Serviço de Atendimento Móvel de Urgência) have been providing pre-hospital assistance since 2004. This service aims to reduce the number of deaths, length of hospitalization, and sequelae due to the lack of timely assistance in the target events of the service [9]. The hypothesis is that, by promoting pre-hospital treatment and immediate removal of the patient to the referral hospital, mobile emergency care can increase the probability of a better outcome.

This study adopts a mixed methods approach to evaluate the performance of the SAMU in the Grande ABC region, located in the state of São Paulo, Brazil.

Methodology

Evaluation design and period

This is an evaluative approach that used the sequential explanatory mixed method according to the procedures of the Joanna Briggs Institute Mixed Methods Review Methodology [10]. In this mixed methods design, data from the first stage of the study (QUAN) are analyzed in connection to the data collection of the qualitative stage (QUAL), which is the sequential stage in mixed study [11,12].

Study area and setting

The object of our study is the SAMU implemented in 2004 in the Grande ABC region. This region has a population of approximately 2.72 million inhabitants and is composed of seven municipalities, forming one of the 64 regions of the state of São Paulo [13]. SAMU covers all locations within the region, with 30 basic support (composed of a rescuer and a nursing technician) and nine advanced support ambulances (the team consists of a doctor, nurse, and a driver-rescuer). The configuration of SAMU in Brazil was inspired by the French model; over time, however, it has incorporated attributes from the American model [6,9].

Data collection

- **Quantitative data management and analysis**

An interrupted time series, a quasi-experimental design, was used to evaluate level and trend changes in the hospital mortality rate of AMI after the implementation of SAMU in the region [14].

a) Measure of outcome and data source

AMI was chosen as a tracer condition due to its magnitude in the country and because it is considered a sensitive problem in the assessment of technologies incorporation. Moreover, AMI has a protocol with well-established clinical guidelines to standardize care and to enable access for all patients to

therapies with demonstrated potential efficacy [6,15]. The data on AMI mortality (codes I21 to I24 in the 10th revision of the International Classification of Diseases – ICD-10) were extracted from the Brazilian Mortality Information System (SIM), from the Brazilian Health Informatics Department (DATASUS). This system covers about 95% of all deaths in public and private hospitals. These records include all patients who died in hospitals, as well as those who died while in transit to the hospital. The values were converted into rates per 100,000 inhabitants for comparison purposes. The rates use population estimates based on census data from the Brazilian Institute of Geography and Statistics (IBGE) [13].

b) Analysis period

Our data analysis used a pre-intervention period from January 2000 to December 2003. As the intervention scaled up in Grande ABC over the course of 2004, we defined our post-intervention period as 2005-2011. The analysis ended in 2011 due to the expansion of the Health Care Network for Urgencies and Emergencies policy that started in 2012 [9].

c) Control region

Since the possibility of confounding bias with simultaneous interventions represents an important threat to internal validity in this method, a control region was defined in this study as an area where the evaluated intervention (SAMU) had not been implemented [16]. To estimate the effect in the pre- and post-implementation period of SAMU with a control region, the region of Baixada Santista was the one eligible among potential regions in the state of São Paulo since it presented a higher similarity according to selected criteria. The region with socioeconomic and organizational health status, similar to the study targeted area, was identified based on the following indicators: socioeconomic level (illiteracy rate of the population aged 15 or older, average per capita income in Brazilian Reais (BRL), and percentage of the population covered by supplemental health plans and insurance) and indicators of primary care medium and high complexity (estimated population coverage of primary care teams, family health physicians or community physicians per 100,000 inhabitants, percentage of admissions for sensitive conditions to primary care, total SUS (Brazilian Unified National Health System) inpatient beds per 1,000 inhabitants, adult/coronary intensive care unit (ICU) beds per 100,000 inhabitants and angioplasty rate standardized by sex and age, in the population aged 20 years or more, per 100,000 inhabitants) (Table 1).

Segmented regression analysis was used to assess changes in the level and in the trend of AMI after SAMU implementation. Autocorrelation was performed using the Durbin-Watson test and graphs of autocorrelation and partial autocorrelation. Based on these tests, the appropriate moving average and/or autoregressive terms were used in a generalized least squares model to see the change in trend and level over the years due to the intervention [17]. The results of the segmented regression analysis were presented as changes in level and trend, before and after the intervention, with 95% confidence intervals (95%CI) and $p < 0.001$. The statistical analysis was performed using the statistical software R, version 3.3.1 (http://www.r-project.org). Single-series and controlled models were adjusted to assess the difference in results based on these different approaches. The segmented regression equation of the time series for the intervention region is detailed as follows [14,16,17]:

$$\gamma_t = \beta_0 + \beta_1 \text{ x time}_t + \beta_2 \text{ x level}_j + \beta_3 \text{ x trend}_{jt} + e_{jt} \qquad \text{(Equation 1)}$$

where:
γ_t is the outcome variable: hospital mortality rate due to AMI;
β_0 is the intercept – represents the reference value of the result in month zero;
β_1 *x time*: the time coefficient – β_1 indicates the change in result per month based on the underlying trend of the previous period; *time* indicates the months in sequence starting from January 1st, 2000;
β_2 *x level*: the coefficient for level change (β_2) represents the change in outcome immediately after the intervention was implemented. Number "0" indicates the previous period, from January 2000 to December 2003 and "1" indicates the post-period – period in which the SAMU was implemented

Table 1

Socioeconomic and organizational indicators for the Grande ABC and Baixada Santista regions. State of São Paulo, Brazil, 2000, and 2010.

Analysis indicator	Baixada Santista (control region)		Grande ABC (intervention region)	
	2000	2010	2000	2010
Population aged 40 years and over	1,476,820	1,664,136	2,354,722	2,551,328
Average income per capita (BRL)	834.16	934.48	858.19	1,026.94
Illiteracy rate of the population ≥ 15 years old	5.7	4.0	4.9	3.2
Percentage of population covered by supplementary healthcare plans and insurance	29.5	39.7	51.7	53.6
Total public expenditure on health per inhabitant (BRL)	167.3	530.5	154.2	515.7
Estimated population coverage by primary health care teams	23.41	27.36	18.07	20.43
Family health physicians or community physicians per 100,000 inhabitants	11.9	32.6	15.7	35.9
Percentage of admissions due to conditions sensitive to primary health care	6.3	5.9	6.3	6.9
Rate of SUS in-patient beds per 1,000 inhabitants	1.89	1.82	2.27	2.02
Adult/Coronary ICU beds per 100,000 inhabitants	10.3	13.8	14.8	15.9
Angioplasty rate standardized by sex and age per 100,000 inhabitants (20 years or older)	17.7	18.1	29.9	39.9

BRL: Brazilian Reais; ICU: intensive care unit; SUS: Brazilian Unified National Health System.
Source: Brazilian Health Informatics Department (DATASUS) and Health System Performance Assessment Project (PROADESS).

throughout the region, from January 2005. The year 2004 was considered policy implementation;
β_3 *x trend*: the coefficient (β_3) estimates the change in the monthly trend of the outcome in the post-period compared to the previous period. All months in the previous period were marked as "0" and the months in the post period with a "1" sequentially, starting in January 2005; and
e_{jt} is the error term that allows points to vary around linear changes.

When one or more control groups are available for comparison, the regression model in Equation 1 is expanded to include four terms (β_4 to β_7). Variable *G* represents the intervention group (G = 1) and control group (G = 0).

$$\gamma_t = \beta_0 + \beta_1 T_t + \beta_2 \chi_t + \beta_3 \chi_t T_t + \beta_4 G + \beta_5 G T_t + \beta_6 G \chi_t + \beta_7 G \chi_t T_t + e_t \qquad \text{(Equation 2)}$$

where:
γ is the outcome variable over time;
t is the variable that represents the time since the beginning of the study;
χ is the dummy variable that indicates the pre- or post-intervention period;
β_0 is the intercept for the control group, the baseline in-hospital AMI mortality rate at the beginning of the study period (level for the control group);
β_1 is the pre-existing trend (trajectory) in the in-hospital AMI mortality rate for the control group, before the intervention was implemented;
β_2 represents the intercept immediately after the introduction of the intervention and indicates whether there was a change in the outcome level, after the introduction of the intervention, for the control group;
β_3 represents the change in the slope or trajectory of the outcome in the control group after the introduction of the intervention until the end of the study;
β_4 represents the difference in the level of the outcome variable between intervention and control before the intervention;
β_5 represents the difference in trend (slope) of the outcome variable between intervention and control before intervention;

β_6 represents the difference in the outcome level between intervention and control immediately after the introduction of the intervention; and
β_7 represents the difference in the trend (slope) of the outcome between the intervention and control after the start of the intervention compared to the pre-intervention (difference between slopes).

- **Qualitative data management and analysis**

Semi-structured interviews were used to collect data from participants in the Grande ABC region in January 2018. The interviews provided the opportunity to enrich and to deepen the understanding of participants' views on SAMU performance. All interviews were individually conducted with managers and healthcare professionals identified by alphanumeric codes. The numbers represent the sequence of the interviews. The saturation point in this study seems to have been reached at 15 interviews. The interviewees who participated in the survey were: six SAMU municipal managers (MM), four regulating physicians (RP) from municipalities in the Grande ABC region, and five ambulance physicians (AP) and ambulance nurses (AN) who worked directly in the SAMU ambulance, either in the basic or life unit, as well as members of the Regional Emergency and Urgency Management Committee and representatives of the Brazilian Network for Cooperation in Emergencies.

The interviews were 30-60 minutes long and conducted with a script based on open-ended questions with the following topics: (a) program objectives; (b) action mechanisms of management, assistance, and regulation dimensions; and (c) structural conditions of the intervention. Each participant signed an informed consent form for each interview. All interviews were audio-recorded, transcribed, and coded with the Nvivo, version 12.0 (https://www.qsrinternational.com/nvivo/home). Inductive thematic analysis was adopted; this is one of the traditional approaches in qualitative analysis, in which the theme is a unit of meaning that emerges according to the criteria related to the analytical dimensions found in the literature and selected for this research [18,19]. Results organization and presentation were supported by relevant literature.

Integration of quantitative and qualitative approaches

The first interface point occurred after the quantitative study was conducted, in a phase entitled development, in which the results contributed to the construction of the semi-structured interview guide [20]. At the end of the research, there was complementarity by converging both the major numerical trends of the quantitative research and the details of the qualitative research [21], to compare convergences and divergences related to the effect of the SAMU on the AMI hospital mortality rate trend in the Grande ABC region. The mixed methods quality assessment design was evaluated by *Mixed Methods Appraisal Tool* (MMAT) [22], a standardized critical appraisal instrument. Figure 1 shows the development and integration diagram of both phases. This study was approved by the Research Ethics Committee of the University of São Paulo (CAAE: 60845516.9.0000.0065).

Results

Phase 1: analysis of interrupted time series

A pre-existing trend (β_1) indicates that in the period prior to the intervention, the change in the hospital mortality rate of AMI was negligible, corresponding to 0.0122, and without statistical significance (95%CI: -0.0138; 0.0384; p = 0.3578). Parameter estimates for level and trend (β_2 and β_3), after intervention period, are the main coefficients of interest. The level of hospital mortality rate per AMI decreased -2.89 per 100,000 inhabitants (95%CI: -4.3293; -1.4623; p = 0.0001) and the underlying trend of the intervention was decreasing -0.04, each month, both statistically significant (95%CI: -0.0816; -0.0162; p = 0.0040) (Table 2).

Figure 1

Schematic model of the Brazilian Mobile Emergency Medical Service (SAMU) performance evaluation study in the Grande ABC region, state of São Paulo, Brazil, 2018.

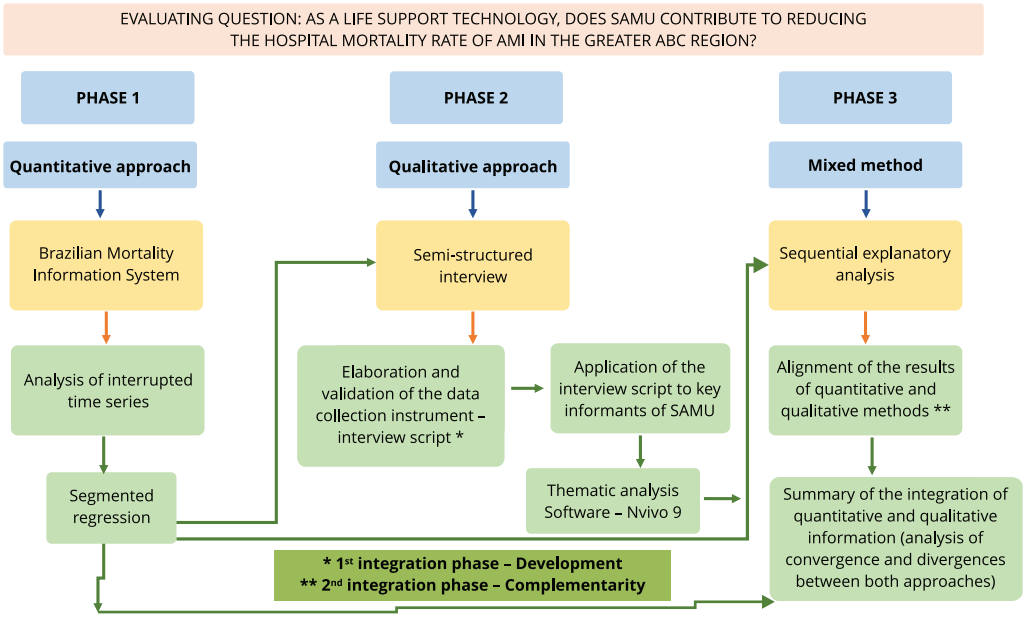


Table 2

Estimated and predicted effect of hospital mortality rate of acute myocardial infarction (AMI) for the period before and after implantation of Brazilian Mobile Emergency Medical Service (SAMU), 2000 to 2011. Grande ABC region, state of São Paulo, Brazil, 2018.

Coefficient	Parameter estimate	95%CI	p-value
β_0 Intercept	12.8714	11.9609; 13.7818	0.0000
β_1 Pre-intervention trend	0.0122	-0.0138; 0.0384	0.3578
β_2 Post-intervention level	-2.8958	-4.3293; -1.4623	0.0001
β_3 Post-intervention trend difference	-0.0489	-0.0816; -0.0162	0.0040

95%CI: 95% confidence interval.
Source: Brazilian Health Informatics Department (DATASUS).

Table 3 shows that the difference in the outcome level between intervention and control groups immediately post-intervention (β_6) was -2.4398 (95%CI: -4.2815; -0.5980), but not statistically significant (p = 0.0100). The rate of hospital mortality by AMI showed a decreasing trend (β_7) in the period after the implantation of SAMU, with -0.0639 per 100,000 inhabitants monthly (95%CI: -0.1060; -0.0219) when compared with Baixada Santista; statistical significance was found (p = 0.0001). This result suggests a changing trend between the two groups, which may strengthen the study hypothesis regarding the contribution of the intervention effect over time in the region.

Table 3

Estimated and predicted effect of hospital mortality rate of acute myocardial infarction (AMI) for the period before and after implantation of Brazilian Mobile Emergency Medical Service (SAMU), 2000 to 2011. Region of intervention and control, state of São Paulo, Brazil, 2018.

Coefficient	Parameter estimate	95%CI	p-value
β_0 Intercept – baseline level for control group	7.6187	6.7910; 8.4464	0.0000
β_1 Trend in pre-intervention control group	0.0080	-0.0156; 0.0318	0.5052
β_2 Level difference for the post-intervention control group	-0.5063	-1.8086; 0.7960	0.4468
β_3 Change in inclination in the post-intervention control group	0.0146	-0.0151; 0.0443	0.3360
β_4 Level difference in the outcome variable between intervention and control before intervention	5.2203	4.0497; 6.3909	0.0000
β_5 Difference in the outcome variable between intervention and control before intervention	0.0050	-0.0284; 0.0386	0.7664
β_6 Difference in the level of outcome between intervention groups and immediate post-intervention control	-2.4398	-4.2815; -0.5980	0.0100
β_7 Difference in the outcome trend between intervention group and post-intervention control	-0.0639	-0.1060; -0.0219	0.0001

95%CI: 95% confidence interval.
Source: Brazilian Health Informatics Department (DATASUS).

Phase 2: knowledge and perceptions of SAMU performance in the Grande ABC

We analyzed the 15 semi-structured interviews, and organized the results into three dimensions (regulation, assistance, and management), which are based on SAMU objectives and on the characteristics of pre-hospital emergency care practices. This process was important to guide the understanding of a set of actions and decisions implemented by the SAMU and their implications related to the performance of the intervention.

- **Dimension 1: regulation**

Patient calls the SAMU's Central Regulation Center dialing the number 192. The medical regulation assistant forwards the patient's call to the regulating physician, who is responsible for triage, classification, and orientation. This professional is responsible for deciding which type of ambulance – basic or advanced – will be dispatched and will follow the case until the end, when the patient is admitted to the reference unit. The interviews suggested that the evaluation of the health condition as "serious" or "urgent" provides a high mobilizing value, and the perception of the signs, from the telephone communication, causes a strong or weak mobilization for fast and timely care.

Although some regulating physicians have indicated that AMI is the only "clinical case" that generates immediate response, most interviewees perceive a deficiency in the accurate reporting of the complaint which, according to them, occurs because users do not associate the symptoms with cardiac problems. The regulating physician takes a decision to the level of emergency.

"The complaint is basic information to direct the type of service and the more accurate the information, the better the guidance that we can provide" (RP6).

"...Understand what the person reports to categorize the seriousness of the situation (...) *sometimes the person cannot get through, so you have to ask to be more precise"* (RP1).

Another theme that emerged was the significance of informing the population about the need for rapid activation of the mobile emergency medical service as soon as they notice the first symptoms. For managers and physicians, reducing the SAMU call time is essential to decrease the response time for transported patients.

"...There are several published studies that indicate the relevance of making the population aware of first aid (...) *also to publicize how important it is to quickly call SAMU* (...) *it does all the difference on the end result"* (MM5).

The second decision, "where to refer the transported patient?", seems to be a key point in regulation. Even with the existence of referral health units for AMI, the interviewees highlighted the lack of hospital beds, especially in the ICU. The long waiting time for hospitalization was a frequently mentioned factor, but this scenario seems to be heterogeneous in the municipalities, as highlighted as follows:

"...The hospital is usually overcrowded and the ambulance is sometimes stuck because it cannot guarantee access for the patient" (MM1).

"All patients diagnosed with AMI with left bundle branch block or supra-ST segment are directly referred to the Clinical Hospital within the AMI protocol..." (MM2).

Finally, another topic highlighted was the importance of the regulatory center to monitor until the end of the case to ensure the availability of the necessary means to achieve an effective response.

"*SAMU only ends the service when the patient is admitted to the unit, so it is not easy to monitor the service provided by the team and to speed up the patient's entry to the unit*" (RP5).

- **Dimension 2: assistance**

Assistance at the event site requires professionals to think quickly and systematically for maximum victim stabilization. The goal is to minimize the time between symptom onset and intervention at the event site. In the case of AMI, telemedicine and electrocardiography have proven essential for more accurate diagnosis and assessment, yet interviewee reported difficulties and risks in performing some procedures during transit.

"*Telediagnosis is extremely necessary to speed up care, but I think it will soon arrive here*" (AN2).

"...By a cardiologist at a distance, but we still have a lot of difficulty in implementing it here in the Grande ABC region" (MM5).

Although thrombolysis in the mobile unit has been reinforced as important to reverse AMI in the first hours of the onset of pain, in some municipalities the procedure is not employed routinely. The use of Metalyse, a drug indicated for thrombolytic treatment (clot dissolution) in cases of acute myocardial infarction, was controversial within the SAMU context since some ambulance physicians were concerned with the reliability of AMI diagnosis and the difficulty of intravenous drug administration in a non-hospital setting. One respondent commented on the possibility of iatrogenesis in the ambulance due to adverse conditions.

"*Depending on the situation of medical care in the mobile pre-hospital, the thrombolytic is already introduced with the knowledge and authorization of the regulating physician*" (AP5).

"*...Doctors were afraid of using it* [thrombolytic] *in the ambulance (they did not feel safe in the use of the thrombolytic)*" (MM5).

Patient safety is one of the main aspects in the healthcare context, and telemedicine, supported by a network of cardiologists in intensive care units, was a tool mentioned as essential to speed up cardiac diagnosis.

"...It would be a progress to have telemedicine here because we could exchange ideas about the diagnosis" (AP6).

- **Dimension 3: management**

The challenges faced by the management was a theme widely discussed by the interviewees that highlighted the services management, the financial resources, the professionals' qualification, as well as the work overload and the professional's health.

"*I notice that some healthcare providers feel overloaded, and I get worried about getting sick because it is not easy to replace a physician here*" (MM4).

"*People have no idea the suffering that SAMU professionals go through. You have to organize both the ambulance and the feelings*" (MM6).

Nurses, regulating and interventional physicians mentioned the need for educational programs, especially regarding the severity of AMI , emphasizing the characteristic symptoms and treatments, mainly because of the urgency of early diagnosis and risk of inappropriate actions.

Furthermore, the need to invest in the qualification of professionals based on the AMI Protocol was commented, with the aim of optimizing patient care from early diagnosis to timely treatment.

"...We need to invest more in training, especially cardiology" (AN4).

SAMU monitoring and evaluation were important themes drawn from the interviews. Currently the information system used is the e-SUS-SAMU (https://datasus.saude.gov.br/e-sus-samu/), developed by the Brazilian Ministry of Health to monitor emergency procedures; however, the interviewees mentioned that this system does not produce robust information to improve the management of mobile pre-hospital emergency care.

Some indicators mentioned as important were avoidable mortality rate, overall mortality in the context of pre-hospital care, immediate hospital mortality of transported patients (24 hours), emergency care casuistry by clinical cause, and sequelae rate.

"...It is important to have a more accurate information system to monitor what is happening with the SAMU" (MM3).

"We can't properly evaluate SAMU with this information system because it is very restricted (...) *I wanted it to monitor by clinical condition* (...) *I wanted to know exactly about the quality of care offered to the patient and it is not possible..."* (MM1).

Discussion

The use of the mixed method allowed for the combination of the results from the quantitative and qualitative approaches into new evidence, developing a deeper understanding of the performance of mobile emergency pre-hospital care on the mortality rate from acute myocardial infarction (Figure 2). When interviewing managers and professionals to understand the issues underlying the quantitative result, the potential of the intervention on the evolution of transported cases was highlighted. The qualitative approach corroborated the quantitative analysis by identifying mechanisms (regulation, assistance, and management) that support the SAMU's resolutive capacity.

A statistically significant reduction was observed in the level and trend of the hospital mortality rate due to AMI in the Grande ABC region, in the period after the implementation of the SAMU. With the use of the control region, the reduction trend remained statistically significant, which raises the hypothesis of a possible effect of mobile pre-hospital care. According to the protocol for coronary syndrome, early care is decisive when the condition is reversible and can prevent neuronal and cardiac tissue damage [15]. High-income countries have identified satisfactory results with the implementation of mobile emergency care [23,24,25].

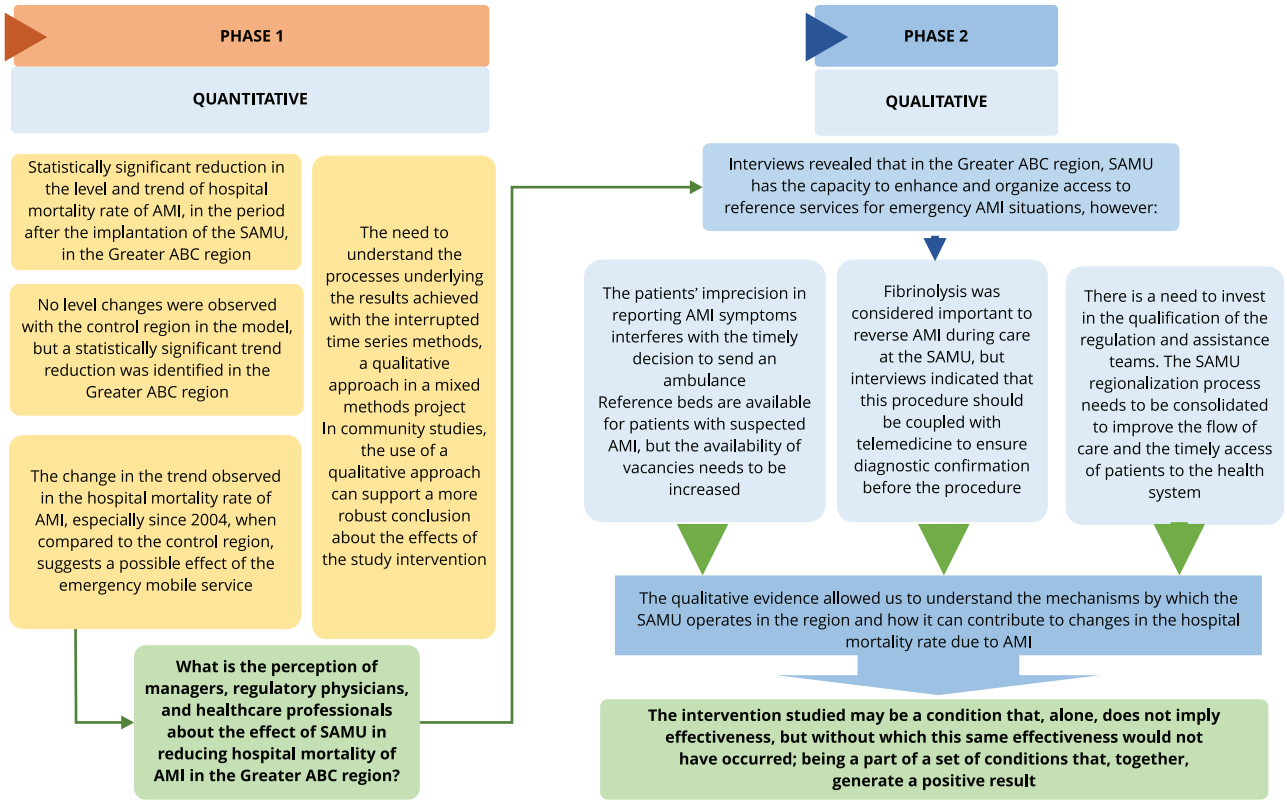
Research in Canada has suggested that mobile emergency care may improve the quality of stroke and AMI care; however, the potential clinical effects need to be studied [26]. Other investigations indicate little or no effect of this type of care on hospital mortality, suggesting different effects of the intervention in different situations, and its effectiveness cannot be considered indisputable [27,28]. The literature on the impact of SAMU is scarce in Brazil. In a study by Cardoso [29], a beneficial effect of SAMU was observed on stroke mortality and on the reduction in the average length of hospital stay, mainly for stroke and trauma.

The interviews allowed us to address the complexity of the SAMU context, clarifying a set of decisions and their implications related to the performance of the intervention. The detection of the severity of the patient's condition by telephone during the regulation process, for example, was considered a priority axis that guided the decision to send or not the assistance team. Managers and regulating physicians agreed on the difficulties experienced in the first contact with the patient and the agility required to define the diagnostic hypothesis. This is a determining factor for the opportunity to assist the AMI and, consequently, for the SAMU to act more effectively on the outcome. The inaccuracy of the patient's complaint was mentioned on several occasions as a factor that hinders decision-making, considering its impreciseness.

Fernandes & Tanaka [30] identified, in a study on the SAMU in the city of São Paulo, that regulating physicians looked for signs and symptoms indicating imminent risk of death, such as unconsciousness and breathing difficulties as warning signs of a possible cardiac arrest or pre-collapse. In the

Figure 2

Sequential explanatory design – summary of the Brazilian Mobile Emergency Medical Service (SAMU) performance evaluation results. Grande ABC region, state of São Paulo, Brazil, 2018.



AMI: acute myocardial infarction.

same study, identification of severity levels was performed using specific software that assists in the ambulance dispatch decision-making process.

Notably, we observed an inconsistency on the understanding of what is urgent among health professionals and the population. This situation generates divergences among them due to their different perceptions of severity, reinforcing the importance of disseminating information about what is urgent and in which situations the population should prioritize the activation of the SAMU.

This proved to be a priority issue in seeking the emergency service in the presence of a cardiac event. The regulating physicians signaled that the moment when the patient decides to call the Regulation Center is a prognostic indicator and, therefore, educational campaigns should be expanded due to the difficulty in recognizing the signs and symptoms of the AMI by the population. Interventions designed to help patients and their families assess symptoms more accurately and seek help more quickly are key to reducing the delay time of emergency calls [31,32].

Telemedicine has appeared as an important device for dialogue between SAMU health professionals and specialists in search of greater care capacity, qualifying access to diagnosis and delivery of health care. The transmission of the electrocardiogram, through telemedicine, helps to obtain a more accurate assessment and an earlier indication of the best conduct via the contact with the specialist physician.

This result is consistent with the literature, which highlights telemedicine as a tool to reduce distances, promote equity, and invest in quality of care [31,33]. Considering the urgent nature of AMI,

fibrinolysis was found to be important to reverse the clinical picture during SAMU care, along with telemedicine, a useful and cost-effective option that allows for overcoming geographical barriers in healthcare. These results may collaborate with the reduction of the AMI mortality rate identified in the quantitative phase of the study.

To ensure the sustainability of the SAMU, managers highlighted funding as an issue, indicating that the demand for the SAMU has increased without the concomitant support of financial resources for the maintenance and purchase of new ambulances. The literature corroborates this finding, since it is an expensive service that requires compatible financial resources for its consolidation as a life support technology [34,35].

Continued qualification was another theme widely addressed in the interviews. Despite being in the design of emergency policy, training initiatives should be restructured to improve the capacity of professionals in pre-hospital emergency mobile care.

Overcoming this gap is critical for intervention performance. The study by Ciconet [36] showed that immobilization and transport of critically ill victims, cardiopulmonary resuscitation (CPR), clinical emergencies, especially cardiology and neurology, were reported as the main challenges in emergency services. The quantitative and qualitative findings suggest SAMU's ability to act on the prognosis of outcomes over time.

However, it is necessary to overcome difficulties such as reducing the total time of care, increasing the number of hospital beds, increasing the financial contribution, strengthening the qualification of the team and telemedicine, and consolidating a regional emergency network.

These results are consistent with the literature, reinforcing that, when organized systems and regional policies exist, there can be a synergistic benefit in reducing the total mean response time in mobile emergency pre-hospital care and the early institution of technologically advanced therapies [27,28]. Although the research uses a quasi-experimental approach with control region to increase internal validity by controlling threats, such as time-varying confounding factors, more studies are needed to measure the contributions of the different mechanisms that configure SAMU on traced outcomes. Moreover, the qualitative data pertains to the participants in the study and may not reflect the experience of those who did not participate in the research.

Conclusion

Considering the performance evaluation of a complex intervention, this research sought to aggregate different aspects of quantitative and qualitative approaches involved in the mixed sequential explanatory method to reach a more robust conclusion about the effects of the studied intervention. This study reinforces the usefulness of the quasi-experimental approach to evaluate the effect of interventions, especially when randomized studies are not feasible. Evidence from both approaches provided insights focused on the mechanisms by which the SAMU operates in the Grande ABC region and how it might contribute to changes in the in-hospital AMI mortality rate.

When interviewing managers and professionals to better understand issues underlying the quantitative result, the potential of SAMU to generate a better prognosis for transported cases was highlighted, mainly due to earlier initiation of urgent care, thrombolytic therapy when indicated, and faster referral to the reference unit. A strategic issue is to match the SAMU transport with the patient's post-hospitalization outcome.

The qualitative approach corroborated some hypotheses extracted from the quantitative analysis regarding the management and assistance mechanisms that support the SAMU's resolutive capacity. The results indicate that the intervention may be a condition that by itself does not imply an impact on the reduction of hospital mortality rate due to AMI; being, instead, a part of a set of conditions that generate a positive result on the studied outcome.

Contributors

C. C. M. Oliveira contributed to the study conception and planning, data analysis and interpretation, and writing. J. L. G. Santos and H. M. D. Novaes contributed to the critical review. All the authors approved the final version of the manuscript.

Additional informations

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Resumo

Estudo avaliativo com uso de métodos mistos na tipologia explanatória sequencial cujo objetivo foi avaliar o desempenho do Serviço de Atendimento Móvel de Urgência (SAMU) na região do Grande ABC, Estado de São Paulo, Brasil. Na abordagem quantitativa, foi realizada análise de séries temporais interrompidas para testar os efeitos imediatos e graduais da intervenção sobre a mortalidade hospitalar por infarto agudo do miocárdio. A abordagem qualitativa foi realizada através de entrevistas semi-estruturadas, e a análise temática foi aplicada para a interpretação dos resultados, explorando as atitudes e valores dos entrevistados em relação ao desempenho do SAMU no Grande ABC. A análise de série temporal interrompida mostrou uma redução de -0,04% na taxa de mortalidade subjacente desde a implementação do SAMU (IC95%: -0,0816; -0,0162; p = 0,0040) e uma redução no nível de mortalidade, de -2,89 (IC95%: -4,3293; -1,4623; p = 0,0001), ambas estatisticamente significativas. Para melhorar a robustez dos resultados, foi utilizada uma região de controle, o que mostrou uma diferença estatisticamente significativa na tendência pós-intervenção de -0,0639 (IC95%: -0,1060; -0,0219; p = 0,0001). De acordo com as entrevistas, o SAMU tem o potencial de intervir no prognóstico dos pacientes transportados; entretanto, em casos de infarto agudo do miocárdio, diversos desafios precisam ser superados, relacionados à disponibilidade de leitos, expansão da telemedicina e capacitação permanente das equipes de atendimento qualificado em emergências. Os resultados indicam que a intervenção faz parte de um conjunto de fatores que, conjuntamente, geram mais condições para alcançar melhores resultados.

Assistência Pré-Hospitalar; Análise de Séries Temporais Interrompida; Análise Qualitativa; Estudo de Avaliação

Resumen

Investigación evaluativa, utilizando métodos mixtos explicativos secuenciales, cuyo objetivo fue evaluar el desempeño del Servicio de Atención Móvil de Urgencia (SAMU) en una región de Brasil, denominada Grande ABC, estado de São Paulo, Brasil. En el enfoque cuantitativo, se realizó un análisis de series temporales interrumpidas para comprobar los efectos inmediatos y graduales de la intervención sobre la mortalidad intrahospitalaria por infarto agudo de miocardio. El enfoque cualitativo se llevó a cabo a través de entrevistas semiestructuradas y para la interpretación de los resultados se aplicó un análisis temático, investigando las actitudes y valores de los entrevistados sobre el desempeño del SAMU en la región Grande ABC. Los análisis de series de tiempo interrumpido mostraron una reducción -0,04% en la tasa de mortalidad subyacente desde la implementación del SAMU (IC95%: -0,0816; -0,0162; p = 0,0040) y una reducción en el nivel de mortalidad, -2,89 (IC95%: -4,3293; -1,4623; p = 0,0001), ambos con significación estadística. Con el fin de mejorar la solidez de los resultados, se utilizó un control de región, que mostró una diferencia estadísticamente significativa en la tendencia del resultado post intervención de -0,0639 (IC95%: -0,1060; -0,0219; p = 0,0001). Las entrevistas revelaron que el SAMU tiene el potencial de intervenir en la prognosis de los casos trasportados, sin embargo, deben superarse los desafíos relacionados con la disponibilidad de camas, expansión de la telemedicina y el entrenamiento continuo de profesionales para la asistencia cualificada en emergencias, en caso de un ataque al corazón. Los resultados indican que la intervención estudiada es parte de un conjunto de condiciones que, juntas, generan más condiciones para alcanzar un mejor resultado.

Atención Prehospitalaria; Análisis de Series de Tiempo Interrumpido; Análisis Cualitativo; Estudio de Evaluación

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