Revista Contexto & Saúde
Editora Unijuí
Programa de Pós-Graduação em Atenção Integral à Saúde
ISSN 2176-7114 – v. 25, n. 50, 2025
http://dx.doi.org/10.21527/2176-7114.2025.50.14911
HOW TO CITE:
Leandro Junior J, Gurgel SJT, Baptista JMS, Giacomin VL, Dutra AM, Arruda CE. et al. Acute ST-Elevation myocardial infarction in primary hospitals: Does Tele-ECG still make a difference? Rev. Contexto & Saúde, 2025;25(50): e14911

ORIGINAL ARTICLE

ACUTE ST-ELEVATION MYOCARDIAL INFARCTION IN PRIMARY HOSPITALS:
Does Tele-Ecg Still Make a Difference?

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Highlights:
(1) TELE-ECG did not reduce transfer time for STEMI patients.
(2) Municipalities without TELE-ECG had faster patient transfers.
(3) Transfer time exceeded recommended limits in both patient groups.

ABSTRACT

Electrocardiogram Transfer Systems (TELE-ECG) may increase the survival of patients with ST-segment elevation myocardial infarction (STEMI). However, regional differences may generate disparities in this process and consequently in the final outcome of patients. Given the above, the objective of this study is to evaluate the influence of TELE-ECG on the transfer time of patients with STEMI in the state of Paraná, Brazil, based on secondary data from 76 patients transferred from a primary hospital to the reference hospital for interventional cardiology in the city of Arapongas, Paraná. Comparisons between the transfer time of municipalities with TELE-ECG (Group A) and without TELE-ECG (Group B) were performed using the Mann-Whitney test and chloropleth maps were plotted to demonstrate the route taken by the Advanced Life Support ambulances. A significant difference ($p<0.05$) was observed between the groups, with the mean transfer time being 323.82 ±59.00 minutes for group A and 284.71±96.04 minutes for group B. Therefore, respectively, 203.82 minutes and 164.71 minutes above the recommended. During the journey, patients often passed through municipalities with hemodynamic and/or chemical reperfusion centers before arriving at the referral hospital. It is concluded that the transfer time was shorter in municipalities without TELE-ECG, indicating that possibly the activation of the Mobile Emergency Care Service closest to the site of the event, speeding up the patient transfer process. Therefore, further studies on the factors associated with the delay in intervention and outcome of patients with STEMI are essential.

Keywords: Acute myocardial infarction; Telemedicine; Electrocardiography; Myocardial reperfusion; Percutaneous transluminal angioplasty.

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INTRODUCTION

More than 186,000 deaths from ischemic heart disease were recorded in Brazil between 2011 and 2021[1], possibly due to the delay in identifying those affected by acute myocardial infarction with ST-segment elevation (STEMI) in referral hospitals[2]. Thus, the use of electrocardiogram transfer systems (TELE-ECG), by allowing the rapid transmission of electrocardiograms between health centers, can reduce the time between the detection of symptoms and medical intervention, contributing to improving the quality of the service offered and patient survival[3].

In this context, previous studies demonstrate that the use of digital technologies such as WhatsApp has shown promising results in the treatment of patients with STEMI[6-7], however the use of TELE-ECG is still widely used in low and middle-income countries, mainly in rural regions, where access to health services is still scarce[8].

On the other hand, reducing the time of care in referral hospitals is challenging, due to factors such as local infrastructure limitations that can lead to an increase in the DIDO (Door-in-Door-out) time of STEMI patients in peripheral municipalities of the mesoregions[10-11], although it is recommended that the time between the first medical contact and the inflation of the balloon catheter in a referral center for interventional cardiology for patients who activate mobile emergency services or present themselves at primary hospitals does not exceed 120 minutes[12].

Among the reasons for this delay are possibly the geographical issues presented for the treatment of other heart diseases[14]. Despite this, to the best of our knowledge, there are still no studies evaluating the influence of the transfer time of patients with STEMI in Brazil. Aiming to fill this gap in the literature, the influence of TELE-ECG on the transfer time of patients with STEMI in the state of Paraná, Brazil, was evaluated, aiming to determine the route taken by advanced life support ambulances and the delay time in primary percutaneous coronary intervention in patients with acute myocardial infarction with ST-segment elevation initially treated in primary hospitals with and without tele-electrocardiography (TELE-ECG).

MATERIALS AND METHODS

Study design and location

This is an observational, cross-sectional, retrospective study based on secondary data from patients with STEMI treated at primary hospitals in the state of Paraná and transferred, via ambulance from the Advanced Life Support Unit (USA) of the Mobile Emergency Care Service, to a tertiary hospital with interventional cardiology, within 12 hours of symptom onset and subsequently undergoing primary coronary intervention, from January 1, 2017 to December 31, 2019, and developed according to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) protocol[15].

The tertiary hospital, a reference in interventional cardiology, located in the municipality of Arapongas, northern Paraná, is large and develops philanthropic services, having the largest hemodynamic center in the interior of the state, performing around 450 exams per month. According to data provided by the hospital institution, the entity currently serves around 150 municipalities in Paraná and more than 80% of the services are provided by the Unified Health System. Therefore, in addition to spontaneous search, patients are referred through the Regulatory Center and the National Center for High Complexity.

Data source

Secondary data were obtained from the tertiary hospital in Arapongas, regarding sex, age, race, city of origin, length of care at the primary hospital, transportation and balloon carrier, days of hospital

stay, type of injury and outcome of patients with STEMI transferred from primary hospitals via the Advanced Support Unit to the reference hospital for interventional cardiology in the city of Arapongas, state of Paraná, Brazil.

Information on the existence or not of hospitals with the capacity for initial transmission of TELE-ECG to interventional cardiology reference centers was obtained from primary hospitals in the patient's municipalities of origin. In addition, the cartographic bases of streets, roads and highways in the state of Paraná were obtained from the free and open source code called "Openstreetmaps", available at: https://www.openstreetmap.org/ .

Data selection

The data obtained were divided into two groups, according to the origin of the patients: A) transfer to a hospital with the capacity to perform Percutaneous Coronary Intervention (PCI) and electrocardiogram examination, using the TELE-ECG system; B) transfer to a hospital with the capacity to perform PCI and electrocardiogram examination, without using the TELE-ECG system.

Therefore, patients who were excluded from this study were: those who did not undergo non-emergency PCI, whose Door-In-Door-Out interval was greater than 12 hours; those transferred by the helicopter emergency medical service; those who had cardiorespiratory arrest and/or required intubation before reperfusion therapy, and/or those who had a history of cardiac arterial bypass, which could cause delays in care for reasons unrelated to the system.

Análise do tempo-resposta

To assess the response time[12], that is, the time from the first medical care until the balloon is inflated at the interventional cardiology reference hospital in the city of Arapongas, Paraná, three-time intervals were calculated for groups A and B: time of care in primary hospitals, time of secondary transport and time of care in interventional cardiology reference hospitals in the city of Arapongas, Paraná.

Statistical analysis

After descriptive analysis, statistical comparisons between groups A and B were performed using the chi-square test in the RStudio software, version 4.1.0[16].

The normality of the times between the first medical contact and balloon inflation at the interventional cardiology referral hospital, among patients from hospitals with and without TELE-ECG, was performed using the Shapiro-Wilk test in the RStudio software, version 4.1.0[17].

Since the results of the groups were distributed in a non-parametric manner ($p<0.05$), the Mann-Whitney test was used to assess whether there was a statistically significant difference between the variables time of care and presence or absence of TELE-ECG in the first care service, adopting a significance level of 5% ($p<0.05$). Finally, Boxplot graphs were constructed using median and quartiles[18], for better visualization of the results.

Geospatial visualization

The QGIS software version 3.16[19] was used to geolocate the 46 municipalities in the northern, northwestern and central northern regions of the state of Paraná (WITH TELE-ECG and WITHOUT TELE-ECG) that referred patients with STEMI to the tertiary cardiology referral hospital in the municipality of Arapongas, Paraná, Brazil. For this purpose, the HqGIS plugin and the "isochrone map" tool were used. The isochrome map refers to a map that shows all reachable locations from a starting point within an estimated period of time[20].

Ethical aspects

The study was approved by the Human Research Ethics Committee of the State University of Maringá under opinion 012202/2018.

RESULTS

Were analyzed 76 medical records of patients diagnosed with STEMI who were transferred from 46 cities in the state of Paraná, via ambulances with an advanced support unit of the Mobile Emergency Care Service.

As shown in Table 1, the patients analyzed in this study were predominantly male, with ages ranging from 50 to 69 years old, and white. Regarding clinical aspects, most patients were hospitalized in the tertiary hospital of Arapongas for 1 to 10 days, presented lesions in the right coronary artery and/or anterior descending artery, did not progress to mechanical myocardial revascularization, and were discharged from hospital. Among all these parameters, the only variable that presented significant differences between patients from cities with and without TELE-ECG was the type of lesion, with more cases of lesion in the right coronary artery in group B and lesion in the anterior descending artery in group A.

Table 1. Characterization of patients with acute myocardial infarction with ST-segment elevation initially treated in primary hospitals with and without tele-electrocardiography (TELE-ECG) in the state of Paraná, and transferred to the tertiary hospital in the city of Arapongas, Paraná, Brazil.

	WITH TELE-ECG (Group A)		WITHOUT TELE-ECG (Group B)		P value
	Nº of patients	%	Nº of patients	%	
Sex					0,1870
Female	14	36,84	09	23,68	
Male	24	63,16	29	76,32	
Age (years)					0,4343
00-39	00	00,00	00	00,00	
40-49	07	18,42	03	07,89	
50-59	13	34,21	10	26,32	
60-69	14	36,84	19	50,00	
70-79	02	05,26	04	10,53	
80 or more	02	05,26	02	05,26	
Race					0,7831
White	29	76,32	30	78,95	
Brown / Black	09	23,68	08	21,05	
Length of hospital stay (in days)					0,2557
01 – 05	12	31,58	18	47,37	
06 – 10	14	36,84	16	42,10	
11 – 15	06	15,79	01	02,63	
16 – 20	04	10,53	01	02,63	
More than 20	02	05,26	02	05,26	
Type of lesion					0,0324
Circumflex	01	02,63	06	15,79	
Right coronary	23	60,53	12	31,58	
Anterior descending	11	28,95	17	44,74	
Others	03	07,89	03	07,89	

Mechanical reperfusion					0,3280
Yes	07	18,42	04	10,53	
No	31	81,58	34	89,47	
Outcome					0,0888
Death	01	02,63	05	13,16	
Cure	37	97,37	33	86,84	

For group A, the mean time of care in primary hospitals was 77.79 ± 15.10 minutes and secondary transport was 147.42 ± 43.12 minutes, while for group B, the mean time of care in primary hospitals was 66.24 ± 32.68 minutes and secondary transport was 113.29 ± 54.53 minutes (**Fig. 1**).

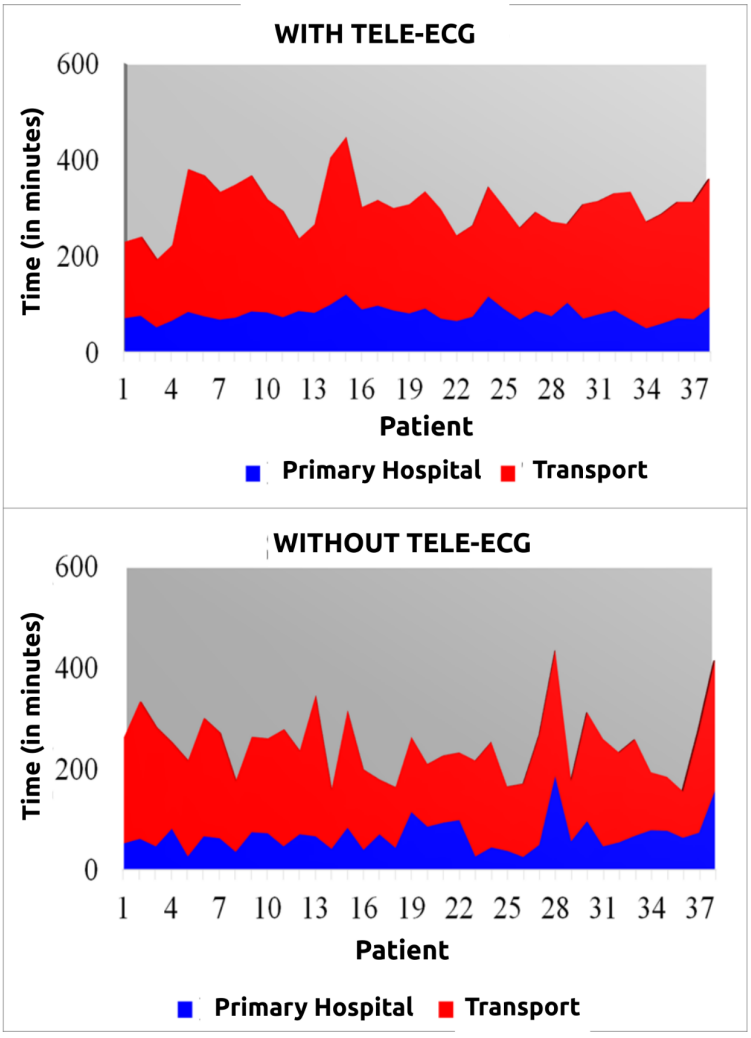

Figure 1 - Time of care in a primary hospital with and without TELE-ECG and transportation to the reference hospital for interventional cardiology in the city of Arapongas, Paraná, in patients with STEMI.

The total time between the first medical care and balloon inflation was 323.82 ± 59.00 minutes for patients from cities that had hospitals with TELE-ECG, representing 203.82 minutes above the recommended time. For patients from cities without this service, it was 284.71 ± 96.04, that is, 164.71 minutes above the recommended time.

Thus, it can be inferred that patients from cities without TELE-ECG service had a shorter time between the first medical care and door-to-balloon time compared to those from cities with this service (p = 0.0019) (Fig. 2).

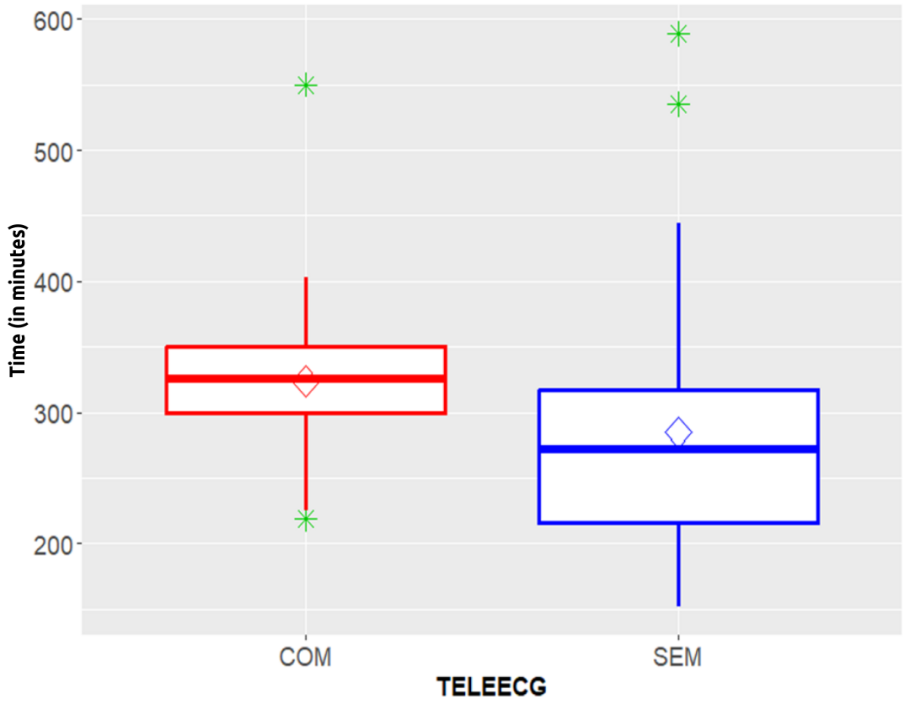

Figure 2 - Boxplot of the time between the first medical care and balloon inflation at the referral hospital in patients with STEMI from municipalities with and without TELE-ECG.

Geospatial visualization highlights a disparity in transfers between STEMI patients initially treated at primary hospitals with and without tele-electrocardiography (TELE-ECG) (**Figure 3**). It is observed that in several routes, patients transferred from their cities of origin passed through cities with hemodynamics and/or chemical reperfusion centers before arriving at the destination hospital in Arapongas. This situation probably reflects the current organization of high-complexity services in the state of Paraná.

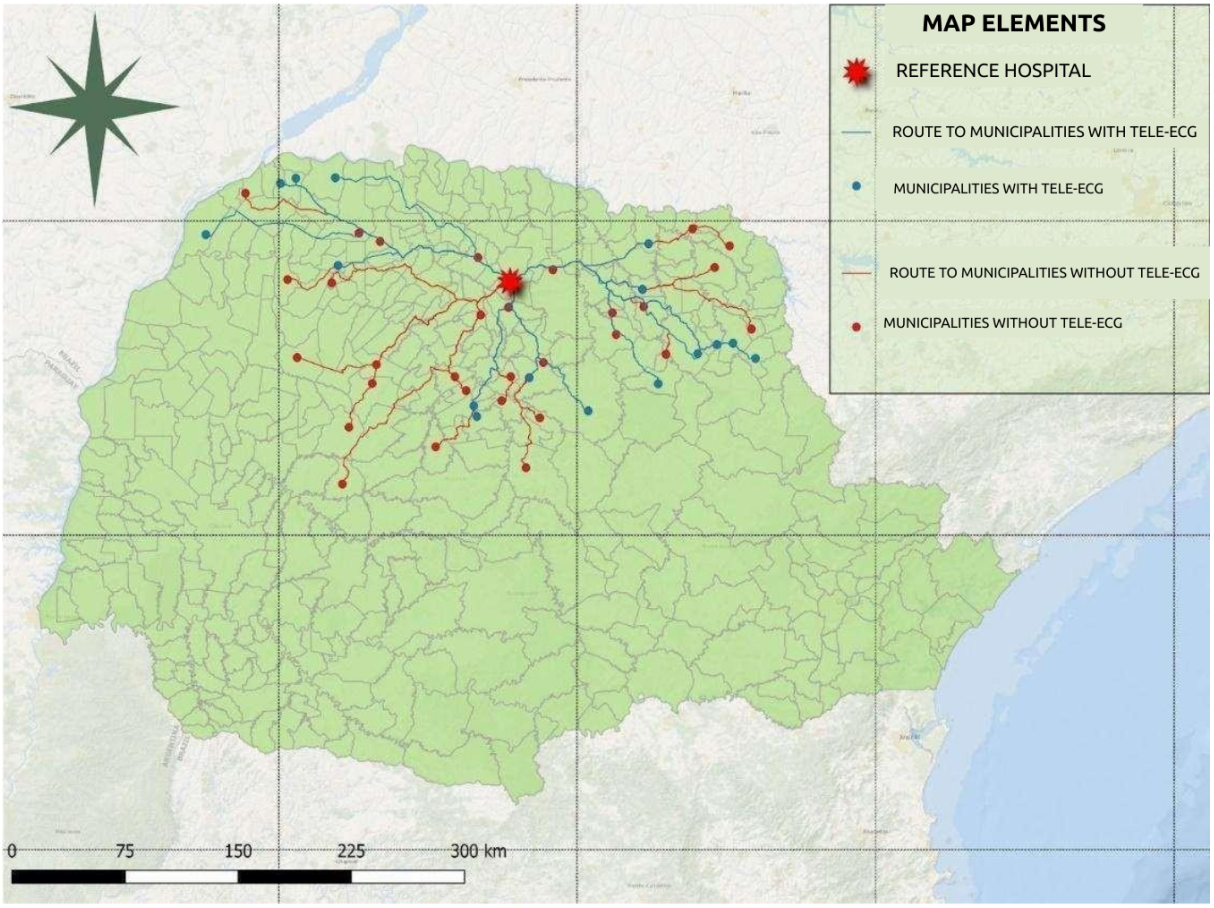

Figure 03 - Route taken by SAMU from the cities where the STEMI occurred until reaching the Reference Hospital in the city of Arapongas, Paraná.

The isochronic map (**Fig. 4**) illustrates the coverage of care with response time from the reference center. The ideal time would be up to 120 minutes, but the median was 325 minutes for patients coming from municipalities with TELE-ECG. On the other hand, for patients coming from municipalities that do not have this tool, the median was 272 minutes.

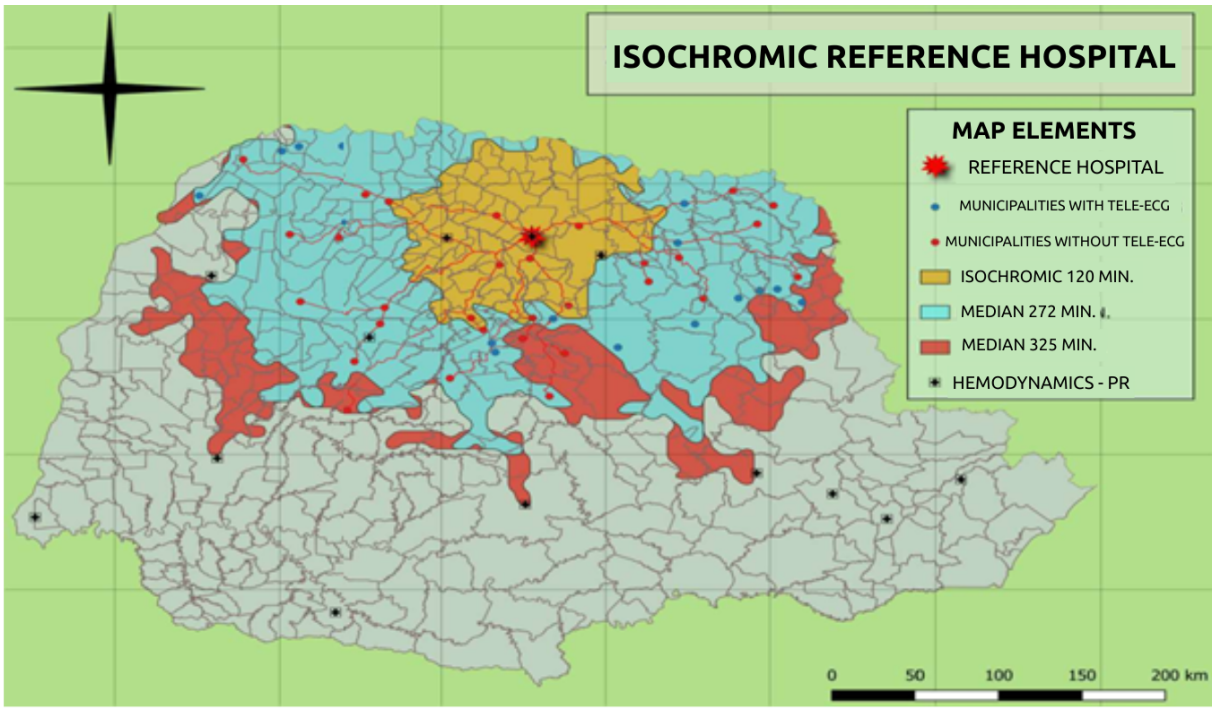

Figure 04 - Isochronic map of service coverage, with response time from the reference center and ideal time of 120 minutes.

DISCUSSION

One of the main advantages of using TELE-ECG would be the speed in making the diagnosis, which would allow for faster initiation of treatment for STEMI[21]. However, the results obtained demonstrate that for patients coming from health centers with TELE-ECG, the time between the first medical care and admission to the referral hospital in the city of Arapongas, Paraná, was significantly higher (almost an hour more) compared to those without this service, indicating that performing TELE-ECG may lead to a delay in transfer between health centers. Although this finding does not seem intuitive, some considerations should be discussed.

The use of TELE-ECG systems may not improve outcomes if the quality of medical care and emergency services is poor. This may include delays in transporting the patient to the hospital, misdiagnosis, or treatment failures.[10-11] The quality and effectiveness of the TELE-ECG system may vary depending on the type of technology used. Some technologies may not be as accurate and reliable as others, which may lead to incorrect diagnosis or inappropriate treatment.[22]

Regional differences in system implementation may affect system outcomes. For example, in some areas, there may be limited access to high-quality TELE-ECG systems or quality emergency services, which may affect the speed with which patients are diagnosed and treated.[2] Technical failures of the systems, such as delays in transmission or failures in ECG interpretation, may affect their effectiveness in identifying patients with STEMI. The quality of the TELE-ECG system and its proper maintenance are critical to ensuring diagnostic accuracy and appropriate treatment.[23]

On the other hand, when the initial assessment of the patient occurs in primary health services without TELE-ECG, the Mobile Emergency Care Service (SAMU) may be quickly activated, since these health centers do not have more complex procedures for cardiovascular diseases. Early request for SAMU allows faster access to coronary reperfusion centers[24], which may increase the survival of patients with STEMI. However, the findings regarding transfer time from one health center to another

in the group without TELE-ECG are also above what is recommended in international protocols (time from first medical care and balloon inflation at the reference center less than 120 minutes), exposing the patient to a greater risk of morbidity and mortality[25].

The implementation of telemedicine through the use of information and communication technologies, aiming to offer support in diagnosis across geographical and temporal distances, began in 2011 and became popular in 2020 with the spread of the COVID-19 pandemic in the country[21].

Despite this, the results of this study demonstrate that there is a spatial disparity in these transfers according to the city of origin, as SAMU often passed through municipalities with a hemodynamics or chemical reperfusion center before reaching its final destination, which is the tertiary hospital located in the municipality of Arapongas, Paraná.

Other studies describe this disparity in access to specialized health services in Brazil for various diseases, since many small cities, far from large urban centers, may not provide specialized techniques[2,26], despite the modern treatment of patients with myocardial infarction involving the use of reperfusion therapies and medications[12].

Finally, there are also pre-hospital and hospital factors that interfere with each patient's door-to-balloon time, such as: the patient's undervaluation of precordialgia symptoms[27], attribution of symptoms to pre-existing chronic conditions[28] or to a common illness such as flu or muscle pain, lack of knowledge of the benefits that can be obtained with rapid intervention, emergency extra-hospital care not available to everyone, delay in transportation and unavailability of the hemodynamics room[29].

Therefore, an in-depth analysis of the factors that may interfere with the implementation of TELE-ECG systems in pre-hospital care for STEMI is necessary, aiming to identify critical points and propose effective solutions. Among the possible interventions, the need for training for the professionals involved[30], improvement in the infrastructure of emergency services[10-11] and greater dissemination of the benefits of using TELE-ECG[23] stand out.

Awareness and involvement of both healthcare professionals and the general population regarding the use of TELE-ECG can improve patient adherence and engagement in treatment.[30] Therefore, it is essential to strengthen the role of technological innovations, such as TELE-ECG, in the early diagnosis of acute myocardial infarction. To this end, it is highly relevant to disseminate information about these tools to public managers, encouraging them to adopt effective measures that facilitate the installation of this technology in the public health system.

Our study has some limitations that should be taken into account. The sample size, although sufficient to demonstrate statistical differences between the groups studied, may not reflect the population as a whole. Furthermore, since the study was not designed to identify possible process failures, further studies are needed to identify them, allowing decision-making and resource allocation to be optimized.

CONCLUSION

The use of TELE-ECG in this study did not improve the transportation time of patients with STEMI from the place of origin to their tertiary referral. Although recognized as an important tool for reducing morbidity and mortality, its use in pre-hospital care requires the identification of regional factors that may interfere with its implementation, in order to ensure improvements in clinical outcomes.

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Submitted: July 26, 2023
Accepted: September 10, 2024
Published: April 10, 2025

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All authors approved the final version of the text.

Conflict of interest: There is no conflict of interest.

There is no funding.

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Editor: Dra. Eliane Roseli Winkelmann
Editor-in-Chief: Dra. Adriane Cristina Bernat Kolankiewicz