



THE ERGONOMICS AND RESILIENCE ENGINEERING IN FORMULATING GUIDELINES FOR THE AMBULANCE BOAT SERVICE OF SAMU 192

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Abstract

This article presents an application of ergonomics and the framework of Resilience Engineering to the formulation of guidelines for regulating the boat component of the Mobile Emergency Care Service (SAMU 192) in Brazil. The study originated from an ergonomic analysis conducted in five out of six regional coordinations of SAMU 192 in the country that offer boat ambulance services accredited by the Ministry of Health. The service of aquatic ambulances - called "ambulanchas" - of SAMU 192 is responsible for providing emergency care to riverside and coastal communities in Brazil. The study is part of a research project aimed at evaluating and supporting the regulation of the boat service of SAMU 192. Data collection occurred in a participatory manner through semi-structured interviews and work observation. The coding and analysis of the data collected during field visits were carried out through content analysis using an inclusion matrix, with the analysis

categories defined based on the theoretical framework of Resilience Engineering. As results, normative specifications were produced for the implementation and maintenance of the service, grouped by the following themes: composition and training of boat teams and regulation, uniforms/PPE of the teams, decentralized aquatic base, communication means, care protocols, biosafety, and intersectoral actions in the management of the "ambulancha" component, and project specifications. The study results provided guidance for the incorporation of the "ambulancha" component into the National Policy for Emergency Care.

Keywords: Ergonomics, SAMU 192, Resilience Engineering.

1. INTRODUCTION

The Mobile Emergency Care Service (SAMU 192) was created in 2003 and was officially established by Decree No. 5,055, dated April 27, 2004, proposing a standardized assistance model throughout Brazil.

SAMU 192 operates through activation to the Urgency Regulation Center (CRU), through toll-free telephone dialing nationwide to number 192. Calls are received by the Medical Regulation Assistance Technician (TARM), who records the description of what happened and the patient's health conditions, and then passes it on to the medical regulator who accesses the information and verifies the severity of the case and the need to send a USB - Basic Health Unit without a doctor, or a USA - Advanced Health Unit with the presence of a doctor.

The SAMU 192 boat modality operates in riverside and coastal areas, with the boats called "ambulanchas." This service modality faces challenges and peculiarities such as the variability of navigational conditions, the hiring and retention of qualified labor, and adverse geographic conditions. The purpose of this article was to use the resilience framework to develop a proposal for specifying the "ambulanchas" service with a focus on resilient system performance.

Using this framework allowed us to understand the misalignments between demand and capacity in the system, and how adaptations work in the as-performed work to fill these misalignments, revealing focal points for system intervention to improve alignment between capacity and demand, as well as to facilitate necessary adaptations to improve service quality.

Thus, this work sought to describe the dynamics of operation in this system, enabling an understanding of its functioning and proposing regulations that can support municipalities in the implementation and maintenance of the service, as well as an adequate structuring of this component within the emergency framework already regulated by the Ministry of Health.

This research was approved by the Ethics Committee of the Oswaldo Cruz Institute of the Oswaldo Cruz Foundation and respects the principles established by resolution 466/2012.

2. RESEARCH CONTEXT

This study is part of a research project aimed at evaluating and supporting the regulation of SAMU 192's boat service, which is responsible for providing access to emergency care for riverside and coastal communities in Brazil within the Emergency Care Network. The study involved visits to five out of the six regional coordinations of SAMU 192 where this service is implemented and accredited by the Ministry of Health: Baía de Ilha Grande in Rio de Janeiro, Salvador and Bom Jesus da Lapa in Bahia, Manaus and Alto Solimões in Amazonas, totaling nine visited municipalities with currently accredited SAMU 192 boat services.

Throughout the research, field visits were conducted to observe the work and conduct semi-structured interviews, involving a total of 101 participants, including Municipal Health Secretaries, SAMU 192 managers, professionals from Regulation Centers and boat teams, as well as professionals and managers from other levels of Health Care directly involved with SAMU 192's boat service. The research comprised approximately 270 hours of fieldwork over 34 days, visiting all participating municipalities. This enabled a detailed understanding of the operational processes, as well as the main difficulties and challenges faced by the teams operating the service.

The research was divided into two stages. The first stage involved diagnosing the service in different regional coordinations of SAMU 192, covering almost all municipalities with accredited services in Brazilian territory. This stage characterized the operation of the service in each region, including the production of regional activity maps as well as the characterization and technical designs of the boats in operation.

The second stage addressed proposals for incorporating the boat component into the National Policy for Emergency Care. Guidelines for the implementation and maintenance of the service were developed in this stage, divided into the following themes: composition and training of boat and regulation teams, uniforms/PPE of teams, decentralized aquaviary base, communication means, care protocols, biosafety, intersectoral actions in component management, and project specifications for the boat itself, including technical drawings with minimum guidance for physical arrangement and spatial standardization.

This study details and presents the results of the second stage of the research. The project diagnosed the main difficulties and challenges in the riverine emergency mobile care service - SAMU 192 through the analysis of municipalities that already have this type of service accredited by the Ministry of Health throughout the national territory. The method used to evaluate the operating units was ergonomic analysis, based on observations and semi-structured interviews with key actors and workers.

Figure 1 illustrates the research effort and the results achieved.

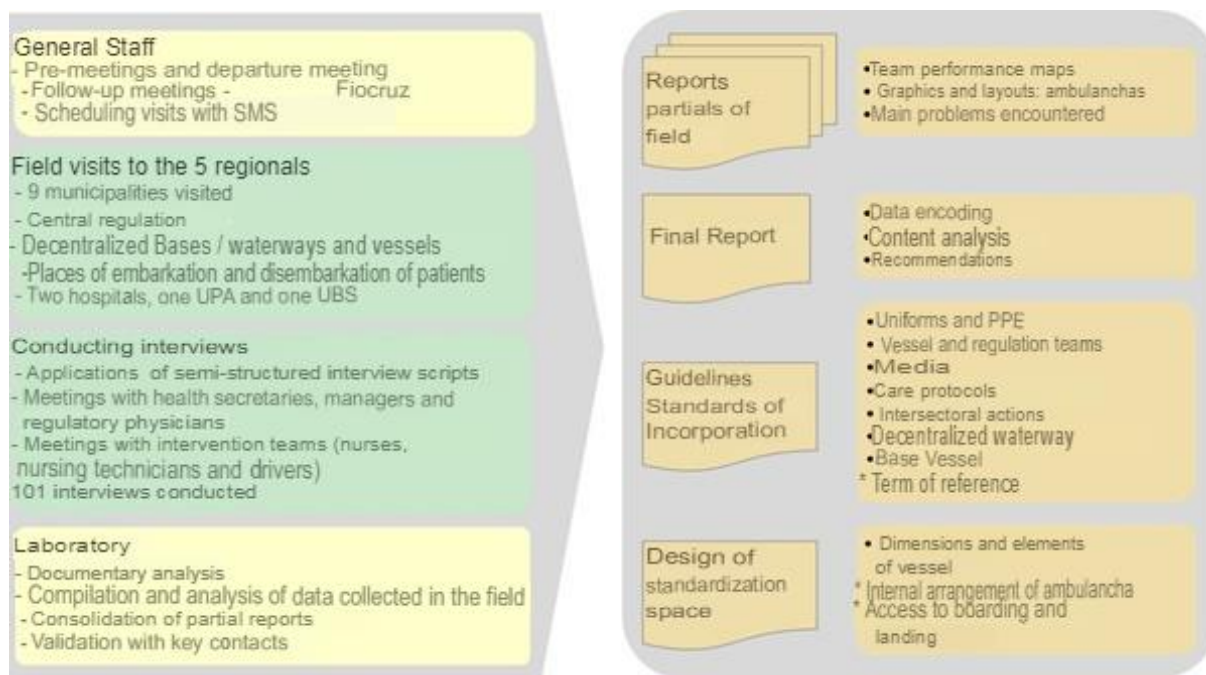


Figure 1. Research effort and productions generated in the Project (Author's elaboration, 2020)

3. METHOD

The material collected during the field visits was coded using content analysis, employing the inclusion matrix tool (MÁSCULO; VIDAL, 2011), following the content analysis model of Minayo et al. (1994) and Minayo and Costa (2019). Thus, the collected material was processed according to the following methodological steps: (1) organization of the analysis material and definition of the unit of registration; (2) categorization of discourse elements; (3) contextualization and understanding highlighting consensus, controversies, and contradictions; and (4) final analysis of results, seeking trends, characteristics, and data interpretation.

The establishment of categories aimed to adhere to the principles described by Bailey (1994), Minayo et al. (1994), and Selltiz (1974), emphasizing: (a) formalization - unity in the criterion for establishing categories, allowing clear definition and cohesive inclusion and exclusion rules; (b) exhaustiveness - coverage of categories over the totality of discourse elements to be classified; (c) exclusivity - mutually exclusive categories (maximizing variance between groups); and (d) homogeneity - categories internally as narrow as possible (minimizing variance within groups).

The unit of registration within the statements was defined as the phrase/clause described by the interviewee. Then, the categories were listed to allow alignment of the analysis with the objective of this study, considering that a significant part of the registration units dealt with the alignment or misalignment between the demands imposed on the ambulance service and the available capacity for its operation. Following this, and in line with the theoretical framework of Resilience Engineering, the definition of categories was carried out in two major groups, named Capacity and Demand (ANDERSON; ROSS; JAYE, 2016; DEKKER, 2011, chap. 7), each with a focus question that served as the sole criterion for aggregating its categories. For the Capacity group, the defined focus question was "What should be regulated elements for the SAMU 192 ambulance component?". For the Demand group, the defined focus question was "What are the elements that impact SAMU 192 indicators regarding the ambulance component?", with the indicators being

those applicable to the ambulance service as foreseen in the National Policy for Emergency Care.

Then, inspired by the Situation-Problem-Improvement (SPM) sequence (MÁSCULO; VIDAL, 2011, chap. 13), a tool was formulated to systematize the findings based on the application of the Resilience Engineering framework, identifying intersections in the field data coded into demand and capacity elements and proposing guidelines for regulating the ambulance service as solutions to address the identified misalignments. Thus, it was possible to identify which pressures (demands) on the waterborne emergency mobile care system were not adequately met by which resources available for the system's operation (capacity).

Finally, aiming to support the regulation of the waterborne component of SAMU 192, proposals for ambulance service specifications were developed to align capacity with demand and facilitate adaptations when necessary. The following section describes the results obtained in this methodological process and summarizes the proposals elaborated - originally formulated in the form of normative items - for all service elements, with the exception of the boat itself, as the proposals for it included spatial project design, deserving detailed treatment in a dedicated article.

4. RESULTS

During the content analysis, the established capacity categories (resources available to fulfill the system's mission) were: communication means; aquaviary base; care protocols; boat teams - composition and training; regulation teams - composition and training; uniforms and PPEs, acquisition procedures, development or chartering of boats; biosafety; and intersectoral actions. Table 1 details the results, originally presented in the format of normative items.

Table 1. Main categories defined from the registration units and consequent definitions (Author's elaboration, 2020)

A ergonomia e a engenharia de resiliência na formulação de diretrizes para o serviço de embarcações do SAMU 192.

Arcuri, Rodrigo.; Ferreira, Denise de Souza.; Bellas, Hugo Cesar.; Vidal, Mario Cesar Rodríguez.; Carvalho, Paulo Victor Rodrigues de.; Jatobá, Alessandro

ITEM	SITUATION		DEMAND VS. CAPACITY MISALIGNMENT	SPECIFICATION PROPOSALS FOR AMBULANCE SERVICE
	CAPACITY	DEMAND		
COMMUNICATION MEANS	Blind navigation" for much of the route; total or partial lack of cellular signal; inactive carriers; radio signal that does not cover the entire expedition route.	Full communication of the onboard team with the SAMU Regulation, both for the regulation itself	Inability to conduct regulation during patient care and transport, and to request rescue in case of incidents or accidents.	Promotion of the installation of signal relay antennas; provision of cell phones with SIM cards from all carriers for the vessel team; implementation of EPIRB (Emergency Position-Indicating Radio Beacons) equipment, to be activated in case of rescue need, sending location signals from any place to a registered central location.
AQUAVIARY BASE	Absence or presence of base without habitability conditions.	Presence of the team near the vessel and in dignified conditions; vessel protected from theft and burglary; suitable location for victim disembarkation and ambulance maintenance.	Theft of fuel, engine, and equipment; time loss during displacement and expenses for motorcycle and fuel, often borne by the team themselves; difficulties in victim disembarkation and access to and maintenance of the vessel; team fatigue.	Minimum regulation of water bases with at least five rooms plus a nautical hangar with a lifting system for repairs in a dry environment; suggestion for the installation of a joint base with other river teams such as Civil Defense, Fire Department, and Special Secretariat of Indigenous Health (SESAI).
ACQUISITION, DEVELOPMENT, OR CHARTERING OF THE BOAT	Locally drafted bidding terms without prior guidance or directives.	Specifications for the vessel and implementation process aligned with local and regional demands and peculiarities regarding the operation of the ambulance service.	Underspecified vessel and implementation process with gaps in the necessary expertise, resulting in operational difficulties in providing care and maintaining the vessels, impacting service delivery.	Formation of a working group to draft the Terms of Reference for the tenders, with participation from the vessel and regulation teams, managers, vessel maintainers, and naval engineer; inclusion of a vessel maintenance plan with defined maintenance locations, parts forecast, and temporary component replacement plan.
Care protocols	For the Basic Life Support (BLS) team - without a nurse or doctor on board - medications and many procedures need to be authorized by the Central Regulation; absence of specific protocols such as team rescue in case of incidents and self-displacement of the requester.	Scarcity of doctors and nurses in remote regions away from the capitals, resulting in a lack of medical personnel on board; long distances traveled with critically injured victims without signal for communication with the regulation center; need to reduce response time by arranging for the requester and the vessel team to meet halfway.	In the absence of communication signal, which can last for several hours during an expedition, BLS teams need to decide between acting without legal backing or witnessing the worsening condition of the victim; necessity for teams to rely on personal contacts or passing vessels for rescue in case of incidents; risk of missing the meeting point halfway between the requester and the vessel team.	Adaptation of protocols for the operation of basic support teams in regions with proven absence of doctors and scarce communication signal, formalizing procedures such as "pre-regulation" in the prescription of procedures and medications; guidelines for developing new protocols aimed at team rescue and aligning with the particularities of incidents attended by ambulances.

Table 1. Main categories defined from the units of registration and consequent definitions (continued)
(Own elaboration, 2020)

ITEM	SITUATION		DEMAND VS CAPACITY MISALIGNMENT	PROPOSED SPECIFICATIONS FOR AMBULANCE SERVICES
	CAPACITY	DEMAND		
REGULATION TEAMS - COMPOSITION AND TRAINING	Lack of training focused on regulating incidents in riverside and coastal communities; absence of guidelines for incorporating professionals into the team with experience as interventionists in the ambulance component.	Need for precise information collection about the occurrence, given distinct beaches with identical names, remote and hard-to-reach occurrence locations, lack of telephone and radio signals, and requesters with limited proficiency in the Portuguese language.	Vessel teams without sufficient information to locate victims and without "pre-regulation" support for incidents in locations without communication possibilities with the Regulation Center, opacity of the severity of the occurrence for SAMU 192.	Training for regulation teams regarding topics such as: fluvial, maritime, and island geography of the region in dry and flood seasons; profile of the communities served and coverage of healthcare networks; main docking locations for ambulances; communication signal coverage; navigation distances and average response time to communities; scenarios for typical occurrences and pre-regulation; linguistic regionalisms.
VESSEL TEAMS - COMPOSITION AND TRAINING	Multiple arrangements in team composition among different regional coordinations of SAMU 192, with teams often having only 2 members; limitation in specific training.	Need for three individuals to embark a victim; complication of care due to the nature of occurrences and long time to reach the health facility; requirement of at least two individuals for patient manipulation procedures and navigation.	Dependency on companions of the victim to embark them in the ambulance; need for a pause on the return journey (which in maritime regions can only be done in sheltered waters) to perform medical procedures; necessity for a nursing technician to stop monitoring the patient to assist in nighttime navigation, or reduction of speed.	Addition to the minimum BLS team of a healthcare professional or mariner, depending on availability for hiring in the region; implementation of intermediate teams, with a nurse but without a doctor, for regions with a shortage of physicians; dual training in seamanship and BLS procedures for all members of the vessel team.
BIOSAFETY	Guidelines and biosafety measures not differentiated from those oriented towards the land component of SAMU 192.	Exposure of vessel teams to infection by infectious diseases increased compared to land-based teams, due to extended periods in contact with victims and companions.	Higher risk of infection for vessel teams, victims, and companions due to infectious diseases; a large number of absences during the COVID-19 pandemic.	Project for a curtain system around the stretchers on board; equipping the vessel with PPE kits for teams, victims, and companions; hygiene stations at the bases; training of vessel teams in the use of PPE, good isolation practices during the expedition, and disinfection of the vessel; training of regulation teams in the identification of suspected cases of COVID-19 and other infectious diseases and in pre-regulating pre-boarding procedures for the victim.
INTERSECTORAL ACTIONS	Regional actions of SAMU 192 in management and training with limited coordination with municipal and state public agencies such as Primary Health Care, Civil Defense, Federal Police, Firefighters, and Municipal Works.	Absence of docks in most served communities; inspections of vessels by regulatory agencies; occurrences located within riverside and coastal communities; need for coordination with community health agents (ACs) from the communities.	Need for docking at beaches, rocky cliffs, and embankments, often bow-first, complicating the boarding of victims, especially when using stretchers; increased response time due to inspections on the ambulance; difficulty in finding victims and transporting them to the coast in inland occurrences; challenges in coordinating with community health agents.	Promotion of partnerships for the installation of floating docks in communities aiming at greater safety, comfort, and speed in docking and boarding of victims; implementation of communication protocols between the Regulation Center and aquaculture regulatory agencies to facilitate and expedite inspections on the ambulance; encouragement of agreements with health units or community associations to provide land vehicles for assistance to inland occurrences; training of community health agents to support the teams in providing care.

5. DISCUSSION

The utilization of the framework requiring X capacity has allowed us to identify points of misalignment between these two aspects, showing where the system needs enhancement. The process of acquiring ambulances occurs without any support from the Ministry of Health; thus, the decentralization of the purchasing process does not meet a

A ergonomia e a engenharia de resiliência na formulação de diretrizes para o serviço de embarcações do SAMU 192.

Arcuri, Rodrigo.; Ferreira, Denise de Souza.; Bellas, Hugo Cesar.; Vidal, Mario Cesar Rodriguez.; Carvalho, Paulo Victor Rodrigues de.; Jatobá, Alessandro

minimum standardization of specifications for the boats, which neither consider local construction experiences nor the supply of parts for maintenance. As a result, the outcome is often compromised because when the boats suffer damage or require replacement of certain parts, repairs cannot be carried out quickly, leading to service disruption. Another crucial point, especially in the Alto Solimões and São Francisco rivers, is the issue of telephone signal instability and many "blind spots" where boat teams cannot communicate. In most visited locations, the absence of navigation equipment such as sonar, GPS, and low-range radio on the boats also appears as a central problem, complicating the work of the conductors and increasing the likelihood of accidents and hindering the rescue process in case of damage along the route to provide assistance. The lack of clarity in the system's financing by each of the entities composing the tripartite system (federal, state, and municipal) negatively impacts its operation because smaller municipalities end up subject to local political influence, which sometimes interferes negatively with the system's operation. Although there are standardized procedural manuals for SAMU 192 patient care, the lack of standardization of boat services by the Ministry of Health has resulted in a variety of boat models with very distinct structures that have impacted the service's operation and team performance. There are boats with side, bow, and stern boarding, which in some cases add to the effort and present difficulties for patient boarding by the response teams, posing risks to both teams and patients.

The need for the implementation of river bases was emphasized, where boats can be protected from theft and vandalism, and where the team can be readily available for assistance in comfort and safety. Partnership between related entities for the sharing of a common river base, such as SAMU 192, Fire Department, Civil Defense, Special Indigenous Health Secretariat (when applicable), and others, was suggested for further study in the future. With the arrival of the COVID-19 pandemic in riverside and coastal communities in the country, the operation of ambulance services began to face unprecedented challenges nationwide. Among these challenges are a sharp increase in the volume of calls, the vulnerability of boat teams to virus infection due to prolonged contact with patients and caregivers, which can last for several hours, and the complexity of rescuing teams in case of incidents during expeditions. To address these challenges, regional SAMU 192 coordinations implemented - according to local restrictions - measures such as the use of bubble stretchers, specialized boat disinfection procedures, in accordance with ANVISA recommendations, and adaptation in the use of PPEs by boat teams, as per professional council guidelines. Additionally, as a complementary measure to support such actions, the research formulated specific guidelines to strengthen the service during pandemics and outbreaks of other infectious diseases, covering elements of boat layout and decentralized water-based base, training of boat teams and regulation, and provision of PPEs for teams, victims, and caregivers.

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