

ORIGINAL ARTICLE

REQUIREMENTS FOR A DEVICE FOR PATIENT TRANSPORT IN PRE-HOSPITAL CARE IN BUILDINGS WITH REDUCED-CABIN ELEVATORS

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Highlights: (1) Ambulance stretchers are not compatible with small conventional elevators. (2) The requirements for a multifunctional stretcher were developed. (3) It was inferred that there is a high probability of developing a technological solution.

PRE-PROOF

(as accepted)

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REQUIREMENTS FOR A DEVICE FOR PATIENT TRANSPORT IN PRE-HOSPITAL CARE IN BUILDINGS WITH REDUCED-CABIN ELEVATORS

ABSTRACT

The aim of this study was to design efficiency requirements for the development of a technological device to be used in patient transport in conventional elevators with reduced cabin dimensions. This methodological study was conducted from October 2021 to December 2022 and comprised five phases: scoping review; mapping of influencing factors and identification of requirements; definition of requirements; content validity using the Content Validity Index (CVI) by an expert committee; and synthesis and analysis of information and data. Twenty experts, including physicians, nurses, military firefighters, and a Franco-Brazilian firefighter (Paris), from the five Brazilian macro-regions (North, Northeast, Midwest, Southeast, and South), responded to a validity instrument developed using a Likert scale. Among the results, 90% of items reached the recommended level of agreement and satisfaction, considering values above 0.8 (CVI values between 0.8 and 1). Only one item obtained a CVI of 0.55 and was therefore considered statistically inadequate and excluded. Four items were added based on experts' suggestions. Additionally, ten technological devices for patient transport available in national and international markets were analyzed for benchmarking purposes, as they presented specifications closest to the established requirements, although none fully met all properties and characteristics. This study identified an opportunity to develop a new technological solution that is practical, applicable, accessible, and low-cost, as a health technology aimed at optimizing patient transport in pre-hospital care services in Brazil.

Keywords: Emergency; Technology; Emergency Medical Services; Transportation of Patients; Buildings.

INTRODUCTION

Pre-hospital care (PHC) services manage a wide range of medical emergencies, including clinical, traumatic, and other conditions.¹ Emergency teams are equipped with competencies and skills that enable rapid decision-making based on protocols and guidelines, using specific equipment and materials to ensure individuals' survival and reduce health damage and sequel.²

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In Brazil, the Mobile Emergency Care Service (SAMU - *Serviço de Atendimento Móvel de Urgência*) represents the largest and most comprehensive institution within the Unified Health System, providing immediate basic and advanced life support to more than 75% of the population.^{3,4}

Rapid, appropriate, and effective transport of patients to a receiving hospital for complementary and therapeutic care is directly related to patient outcomes and severity.^{5,6}

Patient transport is one of the most frequently performed tasks following PHC. However, it must be carefully planned to reduce errors and adverse events, such as clinical deterioration, falls, equipment malfunction, displacement of tubes and lines, and to ensure team safety.⁷

Pre-hospital transport has increased from 16,000,000 to 28,000,000 cases in emergency medical services in the United States.⁸ In Brazil, 73.2% of SAMU users in Porto Alegre were transported to healthcare facilities, while in São Paulo, the transport rate reached 81.61% of attended cases.¹

Ambulances must be equipped with a wide range of materials and devices available 24 hours a day to provide full emergency care at both basic and advanced life support levels.³

Technological devices and transport aids with various designs, standardized by federal regulations, are used in patient transport, such as stretchers, multifunctional boards, and rescue wheelchairs.³

These devices are regulated by the Ministry of Health through Ordinance GM 2048 (November 5, 2002) and SAMU intervention protocols¹⁰. Stretchers and boards are the most commonly used devices, as they allow proper alignment, spinal immobilization, prevention of secondary injuries, and rapid evacuation in hard-to-access areas.⁹

However, challenges remain regarding their operational use, including movement control, required physical effort, mechanical stability, usability, and safety for both patient and professional.¹¹ Patient-related factors, such as physical deformities and obesity, as well as environmental accessibility conditions, also interfere with transport.

When considering accessibility, an architectural environment that lacks the dimensions and measurements necessary for the mobility of transport devices used in PHC, such as buildings

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with elevators with reduced cabin dimensions, creates barriers and obstacles in the “vertical response time”.¹²

Data from the 2019 Continuous National Household Sample Survey¹³ indicate that 14.2% of Brazilian households are apartments, totaling more than ten million units. According to Otis (2023),¹⁴ elevator types in buildings are defined based on traffic calculations, floor area, building type (e.g., residential), among other factors.

Thus, patient removal and transport by PHC teams in small-cabin elevators are often performed using vertical lifting maneuvers. However, this lifting requires excessive physical effort, non-ergonomic postures, improvisation, and adaptation of care protocols, making the procedure unstable and potentially leading to musculoskeletal injuries in professionals and iatrogenic risks for patients.¹⁵

Based on the above, there is a need to characterize patient transport in PHC, including its operators, users, tools, and challenges, in order to propose practical improvements through the definition of requirements to support the conceptual design of more suitable technological devices for specific scenarios.¹⁶

It was observed that insufficient attention has been given to addressing the challenges of patient removal and transport in confined spaces, such as small elevator cabins, particularly regarding design and technical requirements of existing PHC equipment.

In this context, the study was guided by the following questions: *What are the influencing factors faced by PHC professionals during patient removal and transport in high-rise buildings with small-cabin elevators? Are the available technological devices adequate for PHC needs in this context? What requirements are necessary for a technological device to ensure safe and efficient performance in such scenarios?*

The objective of this study was to identify and validate requirements for a technological device for patient removal and transport in confined environments, such as small-cabin elevators and restricted common areas.

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METHODOLOGY

This is a methodological study¹⁷ with a mixed-methods approach, combining qualitative and quantitative components.¹⁸ The study was organized into five adapted phases:¹⁹ scoping review; mapping of intervening factors and identification of requirements; definition of requirements; content validity using the Content Validity Index (CVI) by a committee of experts; synthesis and analysis of information and data.

For the scoping review, the steps recommended by the JBI²⁰ were followed. The guiding research question was defined as: *What are the influencing factors faced by PHC professionals in the removal and transport of patients in high-rise buildings with reduced-cabin elevators, and what requirements should a technological support device operated by PHC teams have to ensure safe and efficient performance in this specific scenario?*

The PICO²¹ strategy, adapted to PIC,²² was used, where: P = population (PHC professionals); I = phenomenon of interest (patient removal and transport); C = context (common areas such as elevators with reduced dimensions in buildings).

Controlled descriptors and authorized terms were selected from Health Sciences Descriptors and Medical Subject Headings, combined for article searches (in Portuguese and English), including: patient transport, elevator, stretcher, PHC, hard-to-access areas, equipment, devices, patient handling and lifting, buildings, evacuation, and emergency medical services.

The literature search and review was conducted from October 2021 to July 2022 using the main databases: Cumulative Index to Nursing and Allied Health Literature via Information Services Technology (EBSCO); Medical Literature Analysis and Retrieval System Online via EBSCO; Virtual Health Library (VHL); Cochrane Library; *Literatura Latino-Americana e do Caribe em Ciências da Saúde* via VHL; Scientific Electronic Library Online; U.S. National Library of Medicine.

Studies included full-text articles, experience reports, theoretical and clinical studies, as well as systematic, narrative, and integrative reviews addressing the relationship between pre-hospital emergency care and patient transport in buildings using stretchers or boards in small or reduced-size elevators. No time or language restrictions were applied. Studies unrelated to

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the topic, those focusing on stair evacuation, or those unavailable in full text or free of charge were excluded.

The search identified 519 articles. After screening titles, abstracts, and removing duplicates, 32 studies were pre-selected and assessed based on inclusion and exclusion criteria.²³ Only seven studies were ultimately included from the databases. The Rayyan-Intelligent Systematic Review software was used to validate the screening process.

Additional studies were identified through snowball sampling and gray literature, including Google Scholar. Twelve studies were included based on methodological rigor, relevance, and interpretative analysis aligned with the research question, even if they did not directly address the topic.

The situational diagnosis of the problems addressed in this study regarding patient transport by PHC paramedics in high-rise buildings, using small-cabin elevators with institutionalized technological devices, was supported by the mapping of intervening factors identified in the scoping review.

The identification and definition of requirements for a technological device for patient transport in confined spaces were derived from the literature review conducted between July and December 2022. Once defined, the requirements were presented to an expert committee for analysis and validity. Experts also suggested additional requirements, which were incorporated into the final list.

The expert committee selection was based on a recommended methodological model,²⁴ in which participants were required to be at least 18 years old and to meet at least two of the five established criteria, with at least one characteristic within each criterion in which they were included.²²

Professionals with experience in the field who met the established criteria and were previously known to the researcher were also invited. For this purpose, Circular Letter 2/2021/CONEP/SECNS/MS was followed. Hence, upon acceptance and registration through the Informed Consent Form (ICF), the instrument for assessment and validity of the requirements assigned to PHC transport devices was sent via a Google Forms[®] link.

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Experts were given a period of ten days to return the invitation letter and the ICF, as well as ten days to return the completed validity instrument. Data collection occurred between March and April 2023.

A total of 30 invitation letters were sent, with 23 acceptances, 25 ICF registrations, and 20 completed responses to the form, following recommendations²⁵ for content validity quantification. The search for these specialists was done through purposive sampling and “snowball” sampling.¹⁷ The validity instrument was answered using the Likert scale,²⁶ with valuation levels adopted for judging the requirements, considered 1, 2, 3 or 4: 1 represents “inadequate”; 2 represents “partially adequate”; 3 represents “adequate”; and 4 represents “fully adequate”.

Information and data analysis was based on the calculation of CVI. Thus, the proportion or percentage of experts who agree with the content was calculated.²⁷ The index score was determined by the sum of items. Items scoring “3” or “4” were considered relevant, while those scoring “1” or “2” were revised or removed. The qualitative data were organized into tables and discussed according to the literature.^{27,28}

The study was approved by the *Universidade de Fortaleza*²⁹ Research Ethics Committee, under Certificate of Presentation for Ethical Consideration 67089322.4.0000.5052.

RESULTS AND DISCUSSION OF THE FINDINGS

From the analysis of the 19 articles included in this study, it was possible to establish a robust theoretical foundation regarding patient transport in PHC using stretchers or boards in high-rise buildings with reduced-cabin elevators, and to develop requirements for a technological device for patient transport in PHC, as presented in Chart 1.

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Chart 1 - Requirements extracted from the scoping review. Fortaleza, Ceará, Brazil, 2022

AUTHOR, YEAR	REQUIREMENTS
Fischer <i>et al.</i> , 2018 Swartz, <i>et al.</i> , 2018 Takei, <i>et al.</i> , 2021	Restricted spinal movement
Lim; Ng., 2021 Kim <i>et al.</i> , 2017	Articulated at 4 points
Lateef; Anantharaman, 2000 Kim <i>et al.</i> , 2016 Kim <i>et al.</i> , 2017 Lim; Ng., 2021	Convertible into a wheelchair
Kim <i>et al.</i> , 2016 Chi <i>et al.</i> , 2020	Reclining headboard with rigid base
Kim <i>et al.</i> , 2017	Knee and hip flexion
Beck <i>et al.</i> , 2016 Lim; Ng., 2021 Lavander <i>et al.</i> , 2000 Larouche <i>et al.</i> , 2019	Lightweight material
Lim; Ng., 2021 Lavander <i>et al.</i> , 2000 Larouche <i>et al.</i> , 2019	Easy portability
Lim; Ng., 2021	Reduced storage size for ambulance interior
Beck <i>et al.</i> , 2016 Kim <i>et al.</i> , 2017	Hooks and support bars
Wang <i>et al.</i> , 2009	Straps and belts for patient fixation

Source: Research data (2022).

Based on the constructed requirements, a form was sent to invited experts for validity. In the first section of the form, sociodemographic, academic, professional, and experience-related data regarding the study topic were collected. A sample representing all five Brazilian macro-regions (North, Northeast, Midwest, Southeast, and South) was obtained. The sample consisted of 20 participants from eight Brazilian states: one (5%) from Pará; seven (35%) from Ceará; one (5%) from Brasília; four (20%) from Maranhão; one (5%) from Pernambuco; two

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(10%) from Rio de Janeiro; three (15%) from São Paulo; and one (5%) from Paraná. All participants (100%) reported professional experience in emergency care and PHC, with experience ranging from ≥ 3 years up to 35 (5%) years.

Among the experts, nine (45%) were physicians, nine (45%) nurses, one (5%) a military firefighter, and one (5%) a Franco-Brazilian civilian/military firefighter (Paris), with a mean of 21.7 years since graduation.

Regarding academic qualifications, 18 experts (90%) held *lato sensu* postgraduate degrees, of which 15 (60%) were in emergency-related fields. Six experts (30%) held a master's degree, and three (15%) held a doctoral degree. Eight (40%) had completed theses or dissertations related to the study area (emergency care, PHC, health sciences, or technology development and/or validity).

In terms of professional activity, 15 participants (75%) worked in PHC practice, 16 (80%) in teaching, four (20%) in research, and seven (35%) reported other types of professional activity.

Regarding responses reflecting professional experience, the majority of participants (90%) reported having experienced patient transport in the context addressed in this study. Experts agreed and described that there are challenges involving material resources, human resources, non-compliance with care protocols, engineering and spatial constraints in buildings, among other factors—especially when dealing with critically ill or trauma patients: *“I have already provided care in these circumstances and they were immensely challenging”*. (J2); *“In these 30 years of pre-hospital care, these types of calls are not uncommon. And it's always very difficult, for the team and for the patients, always improvising methods for transport”*. (J5); *“I have attended to several situations in this regard. The challenges were the issue of removing the victim by elevators, and in this case, the victims were transported standing in the elevator”*. (J12)

The literature describes adverse events occurring in 34% of 100 patient transports, some of which resulted in patient complications, raising discussions about the reliability and quality of patient transport³⁰.

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All experts (100%) confirmed the existence of factors that hinder or compromise the removal and transport of patients from tall buildings using conventional elevators with reduced cabin dimensions and contextualized their perceptions: *“We couldn’t insert the rigid boards. We couldn’t transport the patient on stretchers”*. (J1); *“Lack of physical space to transport the patient on a retractable stretcher with the necessary safety”*. (J3); *“Limited size in the cabin”*. (J10); *“The stretchers are not articulated”*. (J12); *“The reduced space is what complicates things the most, depending on the patients’ condition”*. (J18)

There is a documented delay in patient transport of 1.8% in buildings compared to 0.3% in ground-level houses. High-rise buildings present between 3% and 47% of barriers, including reduced elevator cabins and limited common areas that hinder stretcher use.³¹

In fact, ambulance stretchers are not compatible with small conventional elevators for evacuation and transport of patients from high-rise buildings. The average elevator length in South Korea is 140 cm, whereas the average length of stretchers ranges from 190 to 210 cm^{32,33}.

Considering this scenario, five experts emphasized the use of vertical transport maneuvers (lifting the patient in an upright position) as an alternative to the incompatibility of dimensions.

Data from the Fire and Disaster Management Agency, from 1999 to 2016, investigating adverse events (accidents and incidents) involving emergency teams, showed that 92.7% of incidents involved stretcher falls, with the patient on the stretcher in 81.4% of cases, and 75% of these occurring during transport.³⁴

However, for the vertical lifting maneuver of the stretcher with the patient, rescuers adopt squatting positions, support on the knees, and keep the load as close as possible to the body, reducing hand force in order to maintain balance and minimize gravitational traction on the patient and devices.³⁵

The increase in required force is related to patient weight, with a median of 68 kg ($\pm 13.2 - 131.8$ kg), requiring musculoskeletal effort in 69% of cases and excessive use of thoracic musculature during the vertical lifting maneuver.³⁶

Biomechanical analyses³⁷ conducted with paramedics demonstrated that vertical lifting of patients imposes excessive musculoskeletal strain. For this maneuver, shoulder traction force

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values were 27% higher when lifting the stretcher to chin height compared to waist level. Thus, only 41% of these professionals had sufficient hand strength and only 37% had sufficient shoulder strength to lift the stretcher to chin height.

Therefore, the transported mass, the traction force applied during lifting and verticalization of patients, and the prolonged load on professionals' muscles—resulting in functional decline and reduced strength in the forearms, hands, and legs³⁶—support the non-recommendation of this practice for patient transport.

In summary, confined architectural environments cause significant delays in PHC response time (4.9 minutes \pm 4.2–5.6), which may be fatal in cases such as cardiac arrest (CA).³⁸

Four experts highlighted the vulnerability of patient transport in elevators in cases of cardiovascular instability or severity, such as acute myocardial infarction, CA, and post-CA conditions, in which “*horizontal positioning is required*” (J9), as limiting factors.

In out-of-hospital CA, patient survival depends on chest compressions and defibrillation. However, evidence³² indicates that performing cardiopulmonary resuscitation (CPR) in a seated patient, without tone or stability, or in a vertical position, may be ineffective, as the effectiveness of the maneuver is not guaranteed—even when performed by highly experienced rescuers.

In accordance with current guidelines and recommendations for CA care, better outcomes in compression rate, depth, and chest recoil were obtained during patient removal using a large and accessible elevator that allows full stretcher accommodation, ensuring horizontal chest positioning.³⁹

In an analysis⁴⁰ of chest compression effectiveness during patient transport from the 13th floor to the ground floor using a conventional small elevator, the stretcher was adjusted to a semi-reclined position (45°) and seated/upright position (90°) so that it could fit inside the elevator, and only afterward returned to the supine position. In the seated position, the horizontal force of chest compressions was transferred to the elevator, causing movement and vibration of the cabin, which resulted in shutdown of the mechanism due to perceived instability. The study concluded that chest compression performed in a semi-reclined stretcher position would be the most viable option in this scenario.

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All experts (100%) validated and confirmed the findings from the literature (CVI = 1.0) and considered that the requirements were written at a clear, appropriate, and consistent level of detail (CVI = 1.0). Moreover, 70% indicated the relevance of using transport devices compatible with reduced-cabin elevators in PHC and, within this context, validated the most relevant requirements for this technological device, as shown in Chart 2.

Chart 2. Validity of requirements by experts. Fortaleza, Ceará, Brazil, 2023

Requirements	CVI
Restricted spinal movement	0.9
Articulated at 4 points	0.8
Convertible into a wheelchair	0.8
Reclining headboard with rigid base	0.9
Knee and hip flexion	0.55
Lightweight material	1
Easy portability	1
Reduced storage size for ambulance interior	0.9
Hooks and support bars	0.95
Straps and belts for patient fixation	1

Source: Requirements developed based on the literature reviewed.

Experts were also allowed to provide suggestions and add new requirements. The judges were identified by the letter “J”, as presented in Chart 3.

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Chart 3 – Suggestions for additional requirements for a patient transport technology device in the context of the subject under study. Fortaleza, Ceará, Brazil, 2023

Expert	Suggestions and additional requirements suggested by experts
J1	“The items presented are sufficient. Perhaps a secure, network-style device with access points for locations with stairs and no elevator”.
J2	“Support for intravenous therapy”.
J3	“Some device that provides more safety in vertical transport. Need for restricted spinal movement and if there were a way to flex the hip”.
J4	“Hydraulics and battery for better handling of the device”.
J5	“Vacuum stretcher”.
J6	“Team training in the use of this equipment”.
J7	“Easy to handle. Durable. Comfortable. Easy to clean. Support for oxygen, monitor, transport ventilator. Is the material durable? How many kilograms does it support? Is it easy to clean? Is it comfortable for patients?”
J8	“Resistance and good cost x benefit”.
J9	“Vacuum stretcher system”.
J10	“Hydraulic stretcher”.
J11	“Use of a vacuum stretcher for safe transport in these small space environments”.
J12	“Comfort (referring to the vacuum mattress). Wheel locks can be by handles or pedal”.
J13	“If transport via elevator in a restricted area is impossible, knowledge of the correct technique for transport via stairs is required. Ensure the transport of obese patients. The type of material of the stretcher, in addition to being lightweight, must be highly resistant. “Differentiated” fixation to accommodate it in the elevator at an angle of approximately 45 degrees”.
J14	“Serves the special population: children, pregnant women, and people with disabilities”.
J15	“Base for fixing multi-parameter monitors, oximetry, and mechanical ventilators”.
J16	“Articulated stretcher (there are models that we do not have in Brazil but that allow patients to stand or reduce the size of the stretcher)”.
J17	“Simplified use, durability, portability, cost-effectiveness. Easy to clean, no hard-to-clean areas”.
J18	“I think it would also be interesting to look into the weight the device can support, since obesity presents an additional challenge for this patient. The device should also be suitable for this population”.

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J19	“Storage system (compact) for the technological device; quick assembly instructions flowchart; instruction manual (QR code); video (QR code) for assembly, disassembly, and use (I believe all of this is part of the requirements)”.
J20	“No more requirements”.

Source: Research data developed by the author.

In summary, for PHC transport, it is recommended to select technologically compact devices that allow movement in restricted spaces, provide safety in fixation, lifting, and inclination, are strong enough to support high loads and patient weight, and are lightweight to allow portability in the field.^{7,41,42}

In relation to the assessment of the lightweight requirement, it achieved maximum agreement among experts (CVI = 1.0). The requirement for the presence of straps and belts for patient immobilization also achieved a CVI of 1.0.

A suggestion for a “*differentiated fixation*” (J13) was considered, in order to guarantee safety when the device needs to be angled and/or tilted. “*Wheel locks, which can be by handles or pedal*” were also a safety item suggested by J12.

Equipment used to support patient care was considered an additional aspect that needed to be taken into account. According to some experts, “*support and fixation base for oxygen, monitor, ventilators, and IV therapy*” (J2, J7, J15) would be relevant and facilitating elements. Thus, the suggestion of hooks and support bars achieved a CVI of 0.95, indicating improved operational functionality of the technology.

For confined environments, the stretcher must be articulated and reducible to the size and position of a wheelchair so that it fits within the restricted space of the elevator, thus avoiding vertical lifting of patients.^{32,33,38} This requirement was validated with 80% agreement among experts (CVI = 0.8).

Regarding the reclining headrest with rigid base, agreement reached 90% (CVI = 0.9), based on evidence from the literature and CPR protocols.

Some studies consider the lack of multifunctionality in stretchers a limiting factor, leading to improvisation, inappropriate handling, and the use of unsuitable materials during transport.⁴³

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Thus, based on this theoretical relevance,⁴³ the requirements of 4-point articulation, easy portability, and reduced storage size obtained validity with $CVI \geq 0.8$.

An innovation project entitled Ambulance Stretcher Innovation of the Asian-Cardiopulmonary Resuscitation,³³ conducted in Seoul, South Korea, developed a multifunctional stretcher with articulation, size reduction, and lateral bars with locking mechanisms for CPR devices. According to the researchers, this device allows elevation of the legs in a “V” shape and flexion of patients’ knees and hips through an accessory bar, reducing gravitational force and venous return reduction. This concept may be used in confined spaces, both with and without CA, similarly to a “standard” stretcher.³³

Based on these references,³³ the requirement of knee and hip flexion was presented to experts. This item obtained the lowest CVI (0.55) and was therefore considered inappropriate and excluded.

In contrast, spinal motion restriction (SMR) achieved a high score ($CVI = 0.9$; 90%). Some participants highlighted that the nature of the patient’s condition (trauma, clinical, cardiopulmonary, etc.) should be considered before applying SMR in reduced elevator cabins.

SMR should be prioritized regarding the multifunctionality of the technological device.^{44,45} Minimizing a victim’s movements during PHC, from the initial assessment to transfer to the hospital, through neutral positioning and alignment of the head, chest, and pelvis, is desirable to reduce pain and any risk of worsening the spinal cord injury.^{44,45}

In line with the literature, elements related to knowledge, training, and operational skills of the team were identified as critical factors. Thus, a “*quick instruction flowchart; instruction manual (QR CODE); and instructional video (QR CODE)*” were considered additional requirements (J19).

Given the favorable assessments of the requirements and the suggestions and additions, some experts recommended considering the inclusion of the population with special needs such as infants, pregnant women, obese people, and people with disabilities.

Two experts explored the operation of the device with hydraulic mechanisms, and four considered incorporating a “vacuum” system in the prototype construction process. However, for these items, further scientific investigation is necessary.

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Understanding the large amount of waste, bodily fluids such as secretions and blood, and dirt to which PHC is susceptible, suggestions were made for a material that is easy to sanitize and clean as a requirement.

There was a point raised regarding the relevance of the “cost-benefit” for the prototype. This observation can be understood in PHC in terms of assessing the advantages gained, less maintenance, and fitting into a financial cost reality.

Therefore, given the favorable CVI results obtained in collaboration with the 20 participants, the validity of the requirements was considered consolidated in 90% of items, excluding the requirement of “knee and hip flexion”.

There is, in fact, a need to establish a national standard for optimized access and evacuation in high-rise buildings for the pre-hospital emergency team.³⁸ Thus, the need for stretchers with specific requirements for the evacuation and transport of patients in PHC in a confined setting becomes evident.

Ten technological devices for patient transport available on the national and international market were selected for benchmarking in this study. These products were found through expert recommendations and web searches via Google® and chosen because they presented specifications that most closely match the established assessment and recommendation requirements obtained from this study. The devices were identified by the letter “A” (Chart 4).

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Chart 4. Comparative analysis of technological devices for patient transport in the national and international markets. Fortaleza, Ceará, Brazil, 2023

REQUIREMENTS	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Restricted spinal movement	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Articulated at 4 points	✗	✗	✓	✓	✓	✓	✗	✗	✓	✗
Convertible into a wheelchair	✓	✗	✗	✗	✓	✓	✗	✗	✓	✓
Reclining headboard with rigid base	✗	✓	✓	✓	✓	✓	✓	✗	✗	✗
Lightweight material	✓	±	±	±	±	±	±	✓	✓	✓
Easy portability	✓	✓	✓	✓	✓	✓	✓	✓	±	±
Reduced storage size for ambulance interior	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓
Hooks and support bars	✗	✗	✗	±	✗	✗	✗	✗	✗	✗
Straps and belts for patient fixation	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓
Wheel locking and hitches	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
For pediatric use, obese patients, and pregnant women	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
Waterproof and washable material	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cost x benefit*	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

* Manufacturers did not display the monetary value of the products on search websites.

Legend: ✗ Does not meet; ± Meets partially; ✓ Meets.

Source: Research data (2023).

As for the comparative analysis of the ten selected devices available on the national and international market, the manufacturers describe them in their advertisements as being made of lightweight material, impermeable to fluids and secretions, washable, and easy to carry. All products feature wheel locks as a safety measure. With the exception of product A8, all other items are suitable for emergency ambulances. The chairs are foldable to a reduced size; however, the stretchers require adaptations and modifications to the vehicle's interior, such as rails and locks. None of the devices mentioned supports or hooks for equipment in their advertising descriptions. Only device A4 has a side support bar, which in practice is more commonly used for IV therapy and securing infusion pumps.

None of the devices offer SMR built-in. For all devices analyzed, SMR would be obtained by adding other accessories. It was not possible to determine the cost-benefit ratio due to the lack of specification of the commercial prices of the devices.

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FINAL CONSIDERATIONS

The purpose of this research was achieved by identifying and legitimizing the significant stakeholders in pre-hospital emergency care in high-rise buildings with exit routes via small elevators, where the dimensions are incompatible with the stretchers and backboards used by first responders to evacuate patients to ambulances and from there to the in-hospital emergency room.

Thus, thanks to in-depth research, the requirements for a multifunctional stretcher were developed and presented as a healthcare technology, ensuring both size compatibility, reduced physiological workload, and operational performance. These requirements also reflected the real needs of Brazilian emergency and PHC professionals in designing an ideal device for this scenario.

The scarcity of studies on this topic in the national literature was a considerable limiting factor and fostered a significant effort to integrate international scientific findings into this research, along with the opinions and insights of experts from different geographical locations in Brazil.

A comparative analysis was conducted through benchmarking of a variety of stretchers available in national and international markets, extracting their essential properties and characteristics in order to identify the device that best meets the established and validated requirements and offers the best functional performance in relation to the topic addressed. Based on the benchmarking results, it was inferred that there is a high probability of developing a practical, applicable, accessible, and low-cost technological solution.

A rapid and efficient response in emergencies, in this scenario of buildings with small-cabin elevators, would require permanent architectural changes and alterations to the building layout. It may not be possible to make changes to pre-existing buildings; these inherent aspects need to be considered for new buildings from now on. It is important to consider establishing a national standard for access by emergency health teams via elevators.

This research also allows for valuable contributions and benefits for emergency healthcare professionals as well as the academic and scientific community due to its

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methodological richness, development, scientific content, and validity material, in order to utilize and reference them in any future work in PHC.

REFERENCES

- 1) Almeida, P. M. V. et al. Análise dos atendimentos do SAMU 192: Componente móvel da rede de atenção às urgências e emergências. Escola Anna Nery, Botucatu, v. 20, p. 289-295, 2016.
- 2) Sousa, B. V. N.; Teles, J. F.; Oliveira, E. F. Perfil, dificuldades e particularidades no trabalho pré-profissional dos serviços de atendimento-hospitalar móvel: revisão integrativa. Enfermería Actual en Costa Rica, San José, n. 38, pág. 245-260, jun. 2020.
- 3) Brasil. Ministério da Saúde. Política Nacional de Atenção às Urgências, 3. ed. Brasília: MS, 2006.
- 4) Adnet, F; Lapostolle, F. International EMS Systems: France. Resuscitation, v. 63, n. 1, p. 7-9, 2004.
- 5) Gimenez, F. M. P. et al. Analysis of adverse events during intrahospital transportation of critically ill patients. Critical care research and practice, Paraná, 2017.
- 6) Liu, Yan-Sheng. et al. A novel first aid stretcher for immobilization and transportation of spine injured patients. PLoS One. China. v. 7, n. 7, p. e39544, 2012.
- 7) Lin, Shwu Jen. et al. Improving patient safety during intrahospital transportation of mechanically ventilated patients with critical illness. BMJ open quality, Taiwan. v. 9, n. 2, p. e000698, 2020.
- 8) Coster, J. E. et al. Por que as pessoas escolhem os serviços de atendimento de emergência e urgência? Uma revisão rápida utilizando uma pesquisa sistemática da literatura e síntese narrativa. Medicina de emergência acadêmica, v. 24, n. 9, pág. 1137-1149, 2017.
- 9) Mehta, J. P. et al. Evaluating the physical demands on firefighters using track-type stair descent devices to evacuate mobility-limited occupants from high-rise buildings. O.H., U.S.A Applied ergonomics, v. 46, p. 96-106, 2015.
- 10) .Ministério da Saúde. Portaria GM nº. 2.048, de 05 de novembro de 2002. Dispõe sobre a organização do Atendimento Móvel de Urgência. 3. ed. Brasília: MS, 2006.
- 11) Humphreys, H; Book, W. J; Deetjen, G. Advanced patient transfer assist device. In: 2018 International Symposium on Medical Robotics (ISMR). IEEE, p. 1-6. 2018.

**REQUIREMENTS FOR A DEVICE FOR PATIENT TRANSPORT IN PRE-HOSPITAL CARE IN
BUILDINGS WITH REDUCED-CABIN ELEVATORS**

- 12) Silverman, R. A et al. The “vertical response time”: barriers to ambulance response in an urban area. *Academic emergency medicine*, New York. v. 14, n. 9, p. 772-778, 2007.
- 13) IBGE. Pesquisa Nacional por Amostra de Domicílios Contínua. 2019. Disponível em <https://cidades.ibge.gov.br/brasil/pesquisa/10070/0?ano=2019>. Acesso em 19 mar. 2022.
- 14) Otis. Elevador: saiba tudo sobre este equipamento. Otis, 2023. Disponível em: <https://blog.otis.com/br/elevador-saiba-tudo-sobre-este-equipamento> . Acesso em: 10 de 2023.
- 15) Verjans, Mark et al. Postural workloads on paramedics during patient transport. *Current Directions in Biomedical Engineering*, Germany. v. 4, n. 1, p. 161-164, 2018.
- 16) Da Silva, Raimunda Magalhães; BRASIL, Christina César Praça; DE Vasconcelos Filho, José Eurico. EHealth technologies in the context of health promotion, Fortaleza: EdUECE, 2020. Livro eletrônico. ISBN: 978-65-86445-14-5 (E-book)
- 17) Polit, D. F.; Beck, C. T. Fundamentos de pesquisa em enfermagem: avaliação de evidências para a prática de enfermagem – 9. ed. –Porto Alegre: Artmed, 2019.
- 18) Gil, A. C. Como elaborar projetos de pesquisa. 6. ed. – São Paulo: Atlas, 2017
- 19) Benevides, J. L. *et al.* Development and validation of educational technology for venous ulcer care. *Revista da Escola de Enfermagem da USP* [online]. 2016, 50 (02): 0309-0316. 2016. Disponível em <https://doi.org/10.1590/S0080-623420160000200018>. Acesso em 19 mar. 2022.
- 20) Aromataris E; Munn Z. JBI Manual for Evidence Synthesis, JBI, 2020. Disponível em <https://synthesismanual.jbi.global> Acesso em 17 mar. 2022.
- 21) Santos C.M.C; Pimenta C.A.M; Nobre M.R.C. The PICO strategy for the research question construction and evidence search. *Rev Latino Am Enfermagem*, v. 15, n. 3, p. 508- 11. 2015.
- 22) Menezes, Sáskia Sampaio Cipriano de et al. Razonamiento clínico en la enseñanza de licenciado en enfermería: revisión de blanco. *Revista da Escola de Enfermagem da USP*, São Paulo. v. 49, p. 1032-1039, 2015.
- 23) Prisma. Prisma: Transparent reporting of systematic reviews and meta-analyses. Flow Diagram for a new systematic review. 2021 Disponível em: <https://prismastatement.org/PRISMAStatement/FlowDiagram>. Acesso em 22 jun. 2022.
- 24) Magalhães, V. M. P. C. Construção e validação de uma escala de autoeficácia materna na alimentação do lactente. 2018. Dissertação de Mestrado. Universidade Federal de Pernambuco.
- 25) Lynn M. R. Determination and quantification of content validity. *Nurs Res*. 1986; 35 (6): 382-385.
- 26) Santos, Maria Solange Nogueira dos. Abordagem Baseada em Tecnologia de Apoio ao

**REQUIREMENTS FOR A DEVICE FOR PATIENT TRANSPORT IN PRE-HOSPITAL CARE IN
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- Acompanhamento da Assistência de Enfermagem Na Uti Neonatal. Dissertação de Mestrado. Programa de Mestrado Profissional em Tecnologia e Inovação em Enfermagem/Universidade de Fortaleza – UNIFOR, 146 f, 2017.
- 27) Alexandre, N. M. C; Coluci, M. Z. O. Validade de conteúdo nos processos de construção e adaptação de instrumentos de medidas. *Ciência & Saúde Coletiva* [online]. 2011; 16 (7): 3061-3068. Disponível em <https://doi.org/10.1590/S1413-81232011000800006> Acesso em 19 mar. 2022.
 - 28) Davis, L.L. Instrument review: getting the most from a panel of experts. *Appl Nurs Res.* v. 5, n. 4, p. 194-197. 1992.
 - 29) Brasil, Ministério da Saúde. Conselho Nacional de Saúde (CNS). Resolução nº 466/2012, de 12 dezembro de 2012. Aprova as diretrizes e normas de pesquisas envolvendo seres humanos de pesquisas e testes em seres humanos. Brasília: MS, 2012.
 - 30) Ligtenberg, Jack J.M. *et al*, Quality of interhospital transport of critically ill patients: a prospective audit. *Critical Care*, 2005; 9(4): 1-6.
 - 31) Morrison, L. J. *et al*. Measuring the EMS patient access time interval and the impact of responding to high-rise buildings. *Prehospital Emergency Care*, Toronto. 2005; 9(1): 14-18.
 - 32) Kim, Tae. Han *et al*. Quality between mechanical compression on reducible stretcher versus manual compression on standard stretcher in small elevator. *The American Journal of Emergency Medicine*, Seoul, Korea. v. 34, n. 8, p. 1604-1609, 2016.
 - 33) Kim, Tae Han *et al*. Chest compression fraction between mechanical compressions on a reducible stretcher and manual compressions on a standard stretcher during transport in out-of-hospital cardiac arrests: the Ambulance Stretcher Innovation of Asian Cardiopulmonary Resuscitation (ASIA-CPR) pilot trial. *Prehospital Emergency Care*, Korea. 2017; 21 (5): 636-644.
 - 34) Takei, Y; Hasegawa, M; Adachi, T. Analysis of adverse events in the prehospital field activities: A quantitative study using secondary research methods. *Journal of Japanese Society for Emergency Medicine*, Japan. 2021; 24(4): 569-577.
 - 35) Lad, Uma *et al*. Comparing the biomechanical and psychophysical demands imposed on paramedics when using manual and powered stretchers. *Applied Ergonomics*, Ontario. 2018; 70: 167-174.
 - 36) Beck, B. *et al*. Jerry can carriage is an effective predictor of stretcher carry performance. *Ergonomics*, Australia 2016; 59(6): 813-820.
 - 37) Lavender, Steven A. *et al*. Biomechanical analyses of paramedics simulating frequently performed strenuous work tasks. *Applied ergonomics* EUA, 2000; 31(2): 167-177.

**REQUIREMENTS FOR A DEVICE FOR PATIENT TRANSPORT IN PRE-HOSPITAL CARE IN
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- 38) Lateef, F; Anantharaman, V. Delays in the EMS response to and the evacuation of patients in high-rise buildings in Singapore. *Prehospital emergency care*, 2000; 4(4): 327-332.
- 39) Drinhaus, H. *et al.* Rescue under ongoing CPR from an upper floor: evaluation of three different evacuation routes and mechanical and manual chest compressions: a manikin trial. *Scandinavian journal of trauma, resuscitation and emergency medicine*, Germany. 2020; 28(1): 1-8.
- 40) Chi, Chien-Yu *et al.* Comparison of chest compression quality between transfer sheet and stretcher use for transporting out-of-hospital cardiac arrest patients in a high-rise building—a randomized and open-label cross-over design. *Prehospital Emergency Care*, Taiwan. 2021; 25(3): 370-376.
- 41) Larouche, Dominique *et al.* Overall risk index for patient transfers in total assistance mode executed by emergency medical technician-paramedics in real work situations. *Applied Ergonomics*, 2019; 74: 177-185.
- 42) Wang, H. E. *et al.* Ambulance stretcher adverse events. *BMJ Quality & Safety*. Pittsburgh 2009; 18 (3): 213-216.
- 43) Lim, S. H; NG, P. K. Synthesis of design features for multifunctional stretcher concepts. *Journal of medical engineering & technology*, Malasia. 2021; 45(2): 145-157.
- 44) Fischer, P. E. *et al.* Spinal motion restriction in the trauma patient—a joint position statement. *Prehospital Emergency Care*, Tennessee. 2018; 22 (6): 659-661.
- 45) Swartz, Erik E *et al.* Prehospital cervical spine motion: immobilization versus spine motion restriction. *Prehospital Emergency Care*, E.U.A. 2018; 22 (5): 630-636.

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