

# Strategic Design for Enhanced Medical Transport Stretchers in High-Rise Residential Environments

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**Abstract.** This paper addresses critical issues surrounding the design of medical transport stretchers within the context of high-rise residential settings. It centers on the exigencies and challenges faced by medical emergency response teams operating in residential environments. Through an exhaustive analysis of medical rescue services, stretcher functionalities, and constraints posed by building spaces, this study delineates the specific design requisites imperative for stretcher optimization. It underscores that the effectiveness of both the stretcher and its operation is significantly influenced by contextual factors, such as environmental conditions and operator proficiency. Building upon these insights, this research endeavors to advance stretcher design through innovative and tailored solutions. This work aims to contribute to the evolution of stretcher technologies, ultimately enhancing the efficacy of medical emergency responses in high-rise residential scenarios.

**Keywords.** Residential housing, limited space, portable and stable, innovative optimization

## 1. Introduction

The advancement, development, and prosperity of a society hinge crucially upon the resolution of livelihood challenges faced by its populace. The nexus between people's livelihoods and national development has been a longstanding paradigm. Our nation has consistently demonstrated a commitment to addressing a diverse array of livelihood development issues, with a heightened focus on this critical domain. Yet, the imperative of devising a more advantageous and efficacious safe lifestyle, along with ensuring life security for ordinary citizens, warrants thoughtful consideration” [1]. In light of the aforementioned premise, this study embarks on an in-depth exploration and analysis of the current state of safety rescue stretcher systems, commencing with an examination of their design.

Contemporary society widely employs rescue stretchers as primary first-aid instruments. A comprehensive assessment of the prevailing landscape of first-aid rescue stretchers, both domestically and internationally, reveals a swift evolution of

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diverse new equipment in recent years. Concurrently, the design and development of rescue stretchers within our nation have witnessed substantial enhancements in the same period. Nevertheless, in comparison to the medical equipment in certain advanced European and American nations, there remains a discernible gap necessitating redress [2]. The stretcher market in China suffers from a dearth of variety and is characterized by limited functionalities, rendering it inadequately aligned with the contemporary exigencies of rescue operations. Furthermore, the technical proficiency in this domain lags behind, with promising advancements in novel materials and structural configurations yet to find robust application in stretcher design and development. The predominant employment of rudimentary shovel stretchers for transporting casualties during initial medical interventions persists [3]. This mode of utilization introduces numerous inconveniences and shortcomings, resulting in suboptimal speed and efficiency during rescue operations and impeding patient care.

## **2. Literature Review**

### *2.1. High-rise residential buildings*

Throughout the entirety of the medical emergency continuum, it is imperative that rescue equipment remains adaptable to varying spatial constraints encountered in environments such as ambulances, residential structures, and confined spaces. Notably, due to the spatial limitations inherent to ambulances and elevator compartments, there exists a requisite for ambulance personnel to have access to transfer equipment that is collapsible, easily storable, and capable of size reduction during deployment. Similarly, within residential buildings, terrain constraints necessitate that ambulance personnel possess transfer equipment characterized by optimal traffic handling capacity and efficiency throughout the medical rescue process. Furthermore, both patients and first responders necessitate stretchers with a high degree of versatility to cater to diverse conditions and circumstances.

### *2.2. R&D and design requirements for rescue stretcher equipment*

Based on a comprehensive analysis and research, we have delineated a systematic work plan for each stage of this endeavor. Firstly, the initiative begins with an assessment of rescue requisites, entailing an in-depth scrutiny of the prevailing structure and functionality of rescue stretchers. This phase aims to elucidate emergency rescue demands and the specific need for portable stretchers. Subsequently, the focus shifts towards ascertaining the stretcher's core functionality, effecting enhancements and refinements to optimize its performance, and maximizing user-centric requirements. The final step encompasses the refinement of product attributes encompassing shape, color, and material selection. This phase addresses pivotal concerns related to functional requisites, encompassing design trajectory, critical technologies, structural considerations, and aesthetic refinements, fostering innovation grounded in this rigorous inquiry, culminating in the development of the ultimate blueprint.

A critical concern at this juncture is the secure and expeditious transfer of high-risk patients from upper floors of high-rise residential buildings to awaiting ambulances stationed below, a pivotal challenge that necessitates resolution [6].

Adhering to the demands set forth in each stage of the work plan, specific requisites for the optimal design of the portable rescue stretcher have been delineated:

- Alleviate patient discomfort during movement and prevent secondary injury.
- Engineer the rescue stretcher handles for enhanced ergonomic efficiency.
- Ensure unobstructed visibility for ambulance personnel while descending stairs with the rescue stretcher.
- Facilitate smooth transport in environments marked by inconvenience and poor lighting.
- Address the challenges pertaining to the cleaning and disinfection of the rescue stretcher.
- Optimize the structural composition to reduce the stretcher's overall weight.
- Resolve the issue of maneuvering stretchers around stair corners, ensuring seamless transport.

3. Design

In designing the optimal application of high-rise residential rescue stretchers, emergency rescue products with high practicality and strong targeting should be designed. Optimal design means specifically optimizing the structure, shape, color, and material of the product.

3.1. Structural optimization design

In accordance with the principles of ergonomics, the analysis and optimization of the rescue stretcher took into full account the intricate interplay between individuals, the product, and the spatial environment. Consequently, we implemented adjustments and modifications to enhance operational efficiency and functional efficacy [4]. The stretcher's unfolded dimensions approximate 2200 mm × 520 mm × 80 mm (with a width and thickness ≤ 100 mm). When folded, its size ranges between 60-80 mm, contingent on the specific structural configuration. Furthermore, the net weight of the stretcher is constrained to be ≤ 10 kg.

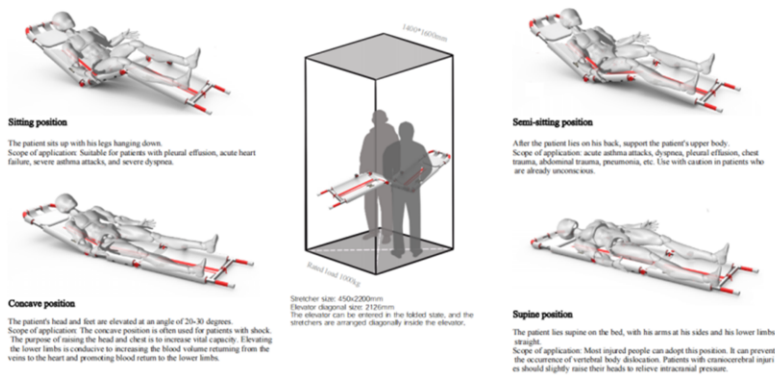


Figure 1. Usage status diagram of high-rise residential rescue stretcher.

A scrutiny of traditional rescue stretchers revealed challenges encountered by rescuers in both the transportation process and when patients were placed horizontally on the stretcher. To ameliorate the deficiencies inherent in the antiquated stretcher design, a pivotal modification was introduced - the main body of the stretcher was rendered foldable. For situations necessitating distinct patient positions, such as sitting, semi-sitting, or supine, the stretcher's design incorporates varying degrees of bendability. Notably, the stretcher's configuration featuring a lower front and elevated back serves the dual purpose of averting obstructed sightlines for the rescuer and mitigating patient discomfort [5].

In rectifying the structural inadequacies of the stretcher, it is imperative to implement an optimization and modularization of the rescue stretcher's configuration. This serves the dual purpose of streamlining high-rise rescue operations and alleviating the physical strain borne by rescue medical personnel. To enhance stability and facilitate movement around stair corners, a stair handrail connector has been integrated into the design. This connector is equipped with an internal telescopic mechanism, offering adjustable widths to accommodate stairs of varying sizes and configurations, ensuring a snug fit with the stair handrail. Furthermore, the connector incorporates a telescopic shaft, allowing the two panels to slide laterally via a geared mechanism. This telescopic shaft is firmly affixed to the central universal wheel, ensuring balanced operation of the connector. Internally, side pulleys have been installed within the stair connector, permitting precise adjustment to align with the stair handrail. When synchronized with the universal wheels, this configuration enables swift and stable descent down the stairs with the rescue stretcher. Additionally, a central universal wheel has been strategically positioned to play a pivotal role during stretcher maneuvering. This component, in tandem with the side pulleys, facilitates a smooth and stable descent down the stairs.

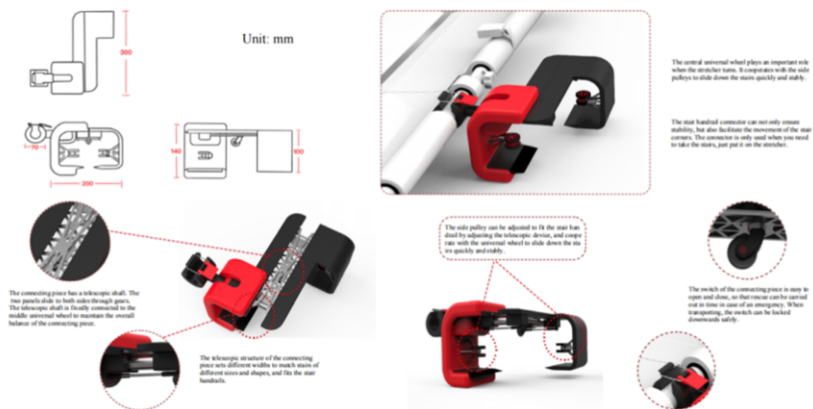
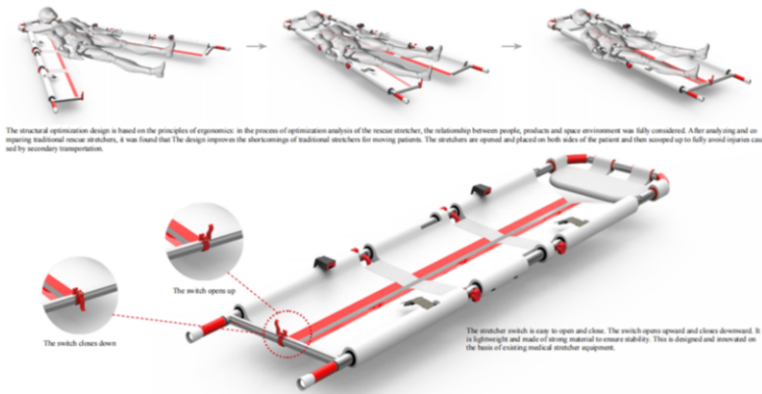


Figure 2. Usage status diagram of high-rise residential rescue stretcher.



**Figure 3.** Folding state diagram of high-rise residential rescue stretcher.

3.2. *Material optimization selection*

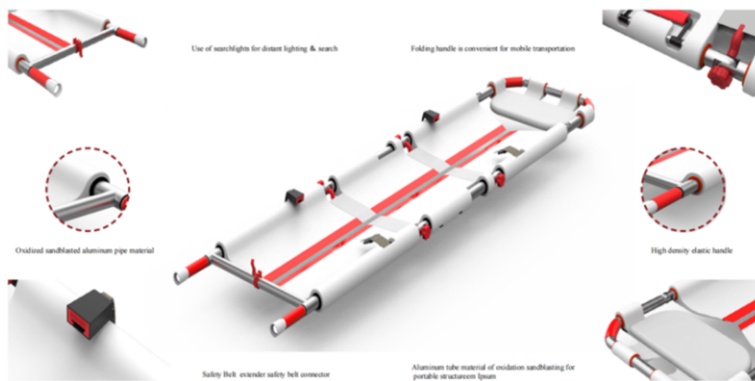
The primary framework of the stretcher has been crafted from titanium alloy aluminum, chosen for its non-toxic, lightweight, and robust properties. Additionally, this material exhibits excellent bio compatibility and possesses a low gloss reflectivity, rendering it an optimal choice for medical applications [7]. The panel material of the stretcher has been constructed from PVC, known for its snug fit, comfort, high foldability, and ease of storage and deployment. Moreover, it demonstrates a commendable degree of resilience when subjected to impacts. The stretcher's handle has been fashioned from oxidized, sandblasted aluminum tube material. This material exhibits high hydrophobicity, ensuring it repels water effectively. Furthermore, it is lightweight, facilitating ease of use, and its surface lends itself to straightforward cleaning and disinfection processes. The handle, crucial for ergonomic maneuvering, has been further enhanced by incorporating high-density elastic material. This addition serves to prevent slippage and augment friction, thereby bolstering the handling capabilities of the stretcher [8].

3.3. *Detailed optimization design*

These optimizations reinforce the stretcher's functionality, ensuring it is well-equipped to meet the demands of diverse rescue scenarios. The detailed optimization undertaken manifests in several key performance enhancements:

- **Micro-LED Illumination:** To augment nocturnal rescue efforts, micro-LED lights have been incorporated. These serve a dual purpose, providing both localized illumination for close-quarter tasks and extending long-distance visibility for search operations.

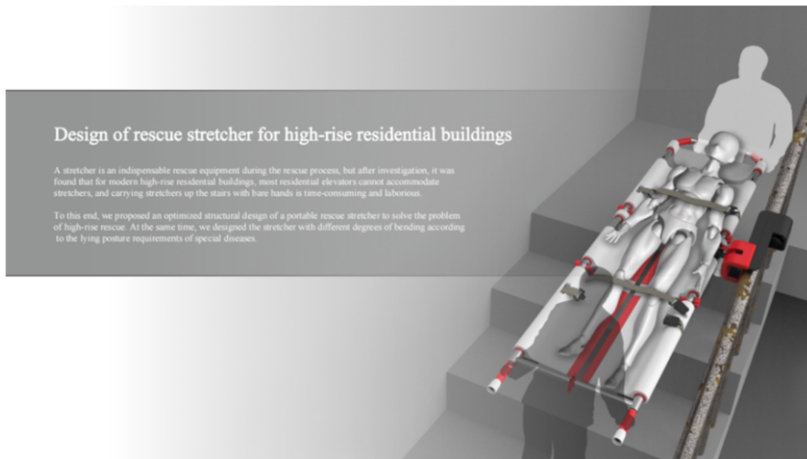
- **Retractable High-Density Elastic Handle:** The handle configuration has been innovatively redesigned to incorporate a retractable, high-density elastic material. This modification markedly reduces labor intensity while ensuring stable and secure grip. Ensure unobstructed visibility for ambulance personnel while descending stairs with the rescue stretcher.
- **Utilization of Oxidized Sandblasted Aluminum Tubing:** The material composition of the handle represents a strategic selection of oxidized, sandblasted aluminum tubing. This choice combines strength and durability with a lightweight profile, contributing to overall ease of handling.
- **Foldable Back Handle:** A folding handle has been added to the back of the stretcher. This three-fold design facilitates ease of operation and transportation, streamlining handling procedures.



**Figure 4.** Detailed display of high-rise residential rescue stretcher.



**Figure 5.** Design of high-rise residential rescue connectors.



**Figure 6.** Design of rescue stretcher for high-rise residential buildings.

#### 4. Conclusion

Emergency rescue stretchers play a pivotal role in natural disasters and accidents, serving as a crucial means to swiftly evacuate the injured from harm's way and prevent secondary injuries prior to the arrival of professional medical assistance. While there is a diverse array of stretchers available in the market, they have exhibited limitations and deficiencies in various rescue scenarios. These include limited portability, unwieldy folding and mobility, and size constraints that impede elevator access. This is particularly critical in cases of sudden cerebral hemorrhage or other acute medical events, where smooth and expeditious transportation is imperative, yet current stretcher designs fall short in this regard. In the realm of modern medicine, rescue stretchers must be versatile enough to address diverse rescue requirements across various specialized situations. They should minimize the discomfort experienced by the injured during transport, cater to the care giving needs of medical personnel, reduce the overall weight of the stretcher, and possess adaptability for transportation in varied spatial conditions. The objective of this design initiative is to maximize the efficacy and utility of high-rise residential rescue stretchers. It entails a comprehensive approach that involves innovative exploration and design, building upon the foundation of existing medical stretcher equipment. By placing emphasis on health, safety, and enhancing the quality of life through design, our aim is to seamlessly integrate design solutions into the fabric of people's daily lives.

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