

# EVACUATION CHAIRS: A SURVEY TO ASSESS THE STATE OF THE ART AND DESIRABLE FEATURES FROM THE PERSPECTIVE OF DECISION MAKERS

**Andrzej Migas<sup>1,\*</sup>, Marcin Butlewski<sup>2</sup>, Maciej Sydor<sup>3</sup>**

<sup>1</sup> Poznan University of Technology, Faculty of Engineering Management, Poznan, Poland

<sup>2</sup> Poznan University of Technology, Faculty of Engineering Management, Poznan, Poland

<sup>3</sup> Poznan University of Life Sciences, Faculty of Forestry and Wood Technology, Department of Woodworking and Fundamentals of Machine Design, Poznan, Poland

\* Correspondence: andrzej.migas@put.poznan.pl

## Abstract

The evacuation chair allows safe and efficient evacuation of people with disabilities or injuries from buildings during emergencies. Therefore, evacuation chairs need to be effective in various conditions of use. It is crucial to know how to choose the right evacuation chair and how to integrate it effectively into a specific evacuation system. The article aims to identify expectations for evacuation chairs and to evaluate the level of familiarity with how they work of people organizing an evacuation system. This goal was pursued by surveying 41 people who plan and implement evacuation systems in buildings. The analysis of the research results shows a deficit in practical knowledge concerning the operation of evacuation chairs; consequently, it justifies and suggests the need for further action in this area. The respondents chose the answer that seemed to be as safe as possible without having to go into details. They were unable to effectively define the right expectations for evacuation chairs. The training of chair use should include brake functioning, the role of the belt securing the head and a leg belt. Users have partially conflicting demands for the chair, which shows a lack of established criteria, probably due to the lack of practical experience in the use of emergency chairs. The decision-making model and the factors that affect purchase should be examined to determine their needs more precisely. The specific needs of all three groups of users should be established, and potential antinomies between features should be recognized and overcome. The study also suggests that future research should focus on the decision-making process, ergonomic quality and measuring the impact of training on the actual effectiveness of the evacuation system. In addition, the study also highlights the need for in-depth research and consideration of user needs in the design process.

**Keywords:** people with disabilities, evacuation, means of egress, evacuation chair, stair travel device, stair descend device, consumer's expectations, participatory design, ergonomic quality

---

**DOI:** [10.5604/01.3001.0053.8565](https://doi.org/10.5604/01.3001.0053.8565)

Received: 17.04.2023 Revised: 12.06.2023 Accepted: 21.07.2023

This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

The evacuation chair is intended to evacuate people with disabilities or injuries from buildings during emergencies in a safe and efficient way. The currently used evacuation chairs are a combination of the idea of using a caterpillar drive to transport disabled people up the stairs (Hale & Kenneth, 1966) and the identification of the need to evacuate people with disabilities by stairs (Hollis III, 2002; Butlewski & Tytyk, 2009). Evacuation chairs are part of the evacuation system, and their use is “built-in” into the evacuation plan, so their functionality is expected as an inherent element of any evacuation system (RESNA ED-1:2019, 2019).

Participatory design refers to a design approach where stakeholders, including users and designers, actively collaborate in the design process of a product or system (Beyer & Holtzblatt, 1998). In the context of emergency stair descend devices, this approach necessitates involving individuals who will be using the devices, building management and other relevant parties in the design and development process to ensure that the final product meets the needs and expectations of all stakeholders. The participatory design aims to create a user-centered, practical and effective product that fulfils its intended purpose. There are several stakeholders who expect the effectiveness of the evacuation chair, and namely people who decided to purchase the chair, people supplying the chair, people implementing the building evacuation system, evacuators and evacuees. Despite a seemingly common goal, each of these groups has a different decision-making scheme and a different level of knowledge to meet the needs of the other groups. It is worth highlighting that the problem of evacuating people with disabilities is a complex challenge (Koo et al., 2013; Kielch & Gromek, 2020). People responsible for adapting the facility to evacuation are usually building managers, health and safety and fire protection services, as well as accessibility coordinators, although this is not a complete list due to the organizational diversity of enterprises and institutions. Such people usually work in conjunction with building management, analyse the law and market offer with respect to stair travel devices, make a purchase decision and then cooperate with the evacuation chair supplier, creating a specific evacuation system for people with mobility disabilities, based on the evacuation chairs they choose. The effectiveness of this system during evacuation results from certain conditions, such as:

- the degree of compatibility of the evacuation system with local conditions,
- the characteristics of the evacuated person, including the number of people requiring assistance during evacuation,
- the type and intensity of the threat requiring evacuation,
- the type or stage of evacuation (which may be spontaneous, unguided, or supervised by professional services),
- the quality of training of potential evacuees,
- functional features of the evacuation chair used.

The essential elements that impact the effectiveness of the evacuation system are functional features of the evacuation chairs, given already at the design and manufacturing stage. The effectiveness of evacuation chairs has been scientifically tested, and the results of these studies are described in the literature (Fredericks et al., 2006; G. Hedman et al., 2021; Hostetter & Naser, 2022; Hunt et al., 2020; Jiang et al., 2012; Koo et al., 2013; Mehta et al., 2015; Parkin, 2005). Those scientific documents provide a detailed analysis of evacuation and point out several crucial features to consider when designing a stair travel device for use in evacuating a tall building:

- **Safety:** The device's capability to achieve an acceptable low risk - operating the device will not harm people, property or the environment. The device should meet relevant safety standards to be reliable and safe.
- **Ease of use:** The device should be easy to operate, even under stressful circumstances. It should be intuitive and require minimal training to use. The device should be easy to attach and detach from the person being evacuated, allowing rescuers to start evacuation quickly.
- **Portability:** The device should be lightweight and compact, making it easy to carry and store.
- **Speed and manoeuvrability:** The device should be able to descend stairs quickly, allowing evacuation of the building as quickly as possible, and should be able to navigate tight turns and bypass other obstacles that may be present on the stairs.
- **Durability and maintenance:** The device should be able to withstand the rigours of frequent use and be able to function correctly even after long periods of storage. The device should be easy to maintain and repair, with readily available spare parts.
- **Comfort:** The device should be comfortable for the evacuee to ride in, particularly if the evacuation is expected to take a long time.
- **Compatibility:** The device should be compatible with the type and configuration of stairs in the building. It should also be able to accommodate people of different sizes and abilities.

The topic related to the evacuation of people with disabilities (including, among others, using evacuation chairs) is quite new and unknown to a large part of the society in Poland and in the world at the moment. In Poland, this issue began to develop since the entry into force of the Act in 2019 on ensuring accessibility for people with special needs. The scientific literature also lacks studies considering purchasers' and, what is more, evacuation system co-creators expectations in relation to evacuation chairs. Knowing these expectations will make it possible to formulate research-based guidelines to improve the functional characteristics of the evacuation chair. Such knowledge also makes it possible to identify the reasons for purchasing an evacuation chair. However, obtaining structured knowledge is not easy, because it requires the interpretation of the idea of functionality of the evacuation chair. Such a "customer requirements specification" is a raw description

of the necessary capabilities of a system from the customer's perspective. Such a description is the basis for improving the product's functionality and usefulness on which human life depends. Therefore, the following research question has been formulated: "Does the evacuation chair, according to the respondents, require changes in its operation?" The immediate aim of the article is to provide an understanding of what evacuation system organisers expect from evacuation chairs.

## **2. Materials and Methods**

In order to achieve the aim of the research, a survey was carried out, which comprised open questions that allowed the respondent to express the desired features of evacuation chairs freely, and closed questions, with a limited number of possible answers. The survey sheet contained a total of 11 questions. They were developed expertly based on the previous experience of the authors of the article (the authors of the article are: (1) a former professional firefighter who has repeatedly taken an active part in the evacuation of people with special needs (e.g. (Zajac et al., 2020)) and a producer of evacuation chairs and mattresses; (2) an ergonomic researcher who also studies the ergonomics of people with disabilities and the elderly, and (3) a scientist specializing in the study of assistive technology).

The answers to the survey questions were obtained as part of telephone conversations and videoconferences with institutional purchasing decision-makers regarding the accessibility of people with disabilities. The vast majority were Coordinators and Representatives of people with special needs who deal with accessibility in the facility daily and have knowledge and experience in this area. The survey comprised 41 entities, which are various types of public institutions, mainly universities, and hospitals. A statistical analysis of the responses was carried out.

## **3. Results and Discussion**

The survey included questions that allowed the researchers to gain new knowledge as regards broadly understood evacuation of people with special needs, particularly in evacuation chairs. The questionnaire sheets included open questions in which the respondents had space for free responses and alternative questions. Closed questions limited the respondents' ability to choose answers to the indicated hints. Table 1 presents the questions that were asked to the research group.

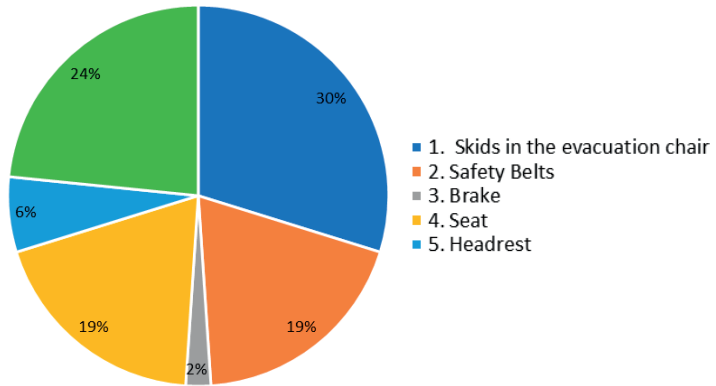
**Table 1.** Questions from the survey

No.	Content of the question
1	Which element of the evacuation chair is the most important?
2	Where can an evacuation chair be used outside of your facility?
3	What should be changed in the evacuation chair – compared to other chairs?
4	What should be increased in the evacuation chair?
5	What should be reduced in the evacuation chair?
6	What should be added to the evacuation chair?
7	What should be removed from the evacuation chair?
8	Should the evacuation chair be equipped with reflective elements?
9	Should the evacuation chair be designed and manufactured only by a plant with an implemented quality management system?
10	Should an evacuation chair have a certificate, e.g. TUV, confirming its high quality?
11	Should an evacuation chair be located in every facility where a disabled person or a person with special needs might appear or stay?

For the research, out of all 11 questions and answers, only some were selected and characterized in more detail and then combined into subject groups. When choosing a specific range of questions, we were guided primarily by the thematic scope, which has a decisive impact on safety and ergonomics of the evacuation chairs.

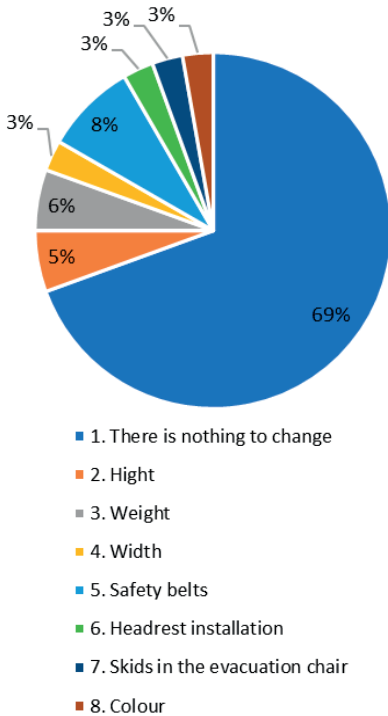
In the first stage of the survey, the respondents were asked, “What element of the evacuation chair is the most important”. This question endeavoured to determine which element in the evacuation chair they noticed and considered to be the most important. The answers are presented in Figure 1, where it can be observed that a large part of the respondents, i.e. 30%, indicated the sliding skids as an essential element of the chair responsible for the transfer up the stairs. As the second highest result, i.e. 24%, respondents indicated the entire evacuation chair as one element. In the third place, with a score of 19%, respondents indicated belts and a seat. The headrest took the last position with 6% and, to the surprise of the authors of the study; the brake had a result of only 2%.

The indication of the effectiveness of transport skids proves that the respondents know that speed is the most important element of evacuation. This answer is in line with previous scientific studies that measured the speed of stair travel devices up the stairs as a fundamental parameter of evacuation quality (G. E. Hedman, 2011; Hashemi, 2018; Szulc et al., 2022). Furthermore, a large share of answers indicating that “the entire evacuation chair is the most important” may prove ignorance about the element of the chair that has the most significant impact on its functionality. On the other hand, a surprisingly low percentage of respondents pointing to the brake as a response indicates that the respondents have no experience in operating an evacuation chair.

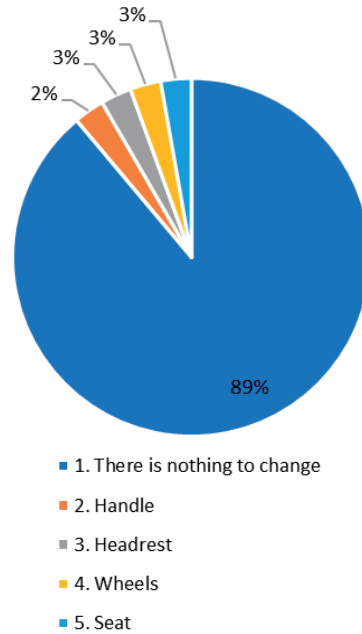


**Figure 1.** Answers to the question “What is the most important element of an evacuation chair?”

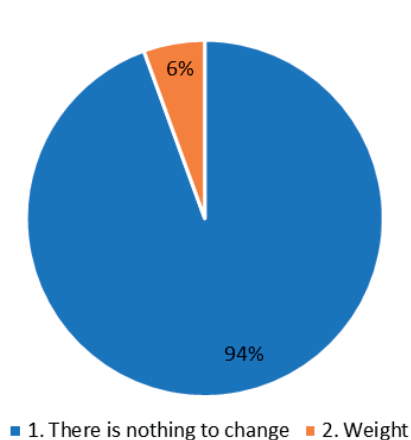
In the next stage of the study, respondents were asked questions about “what should be changed”, “reduce”, “add” or “remove” from the evacuation chair - Figures 2, 3, 4, 5, and 6 show the results of the study.



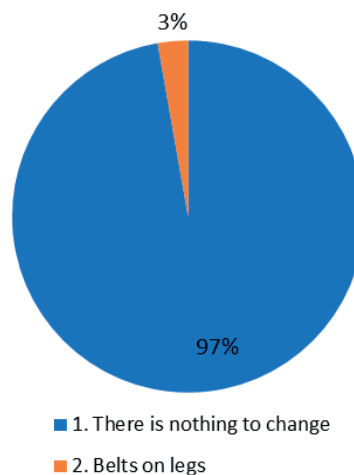
**Figure 2.** Answers to the question “What should be changed in the evacuation chair compared to those that you know?”



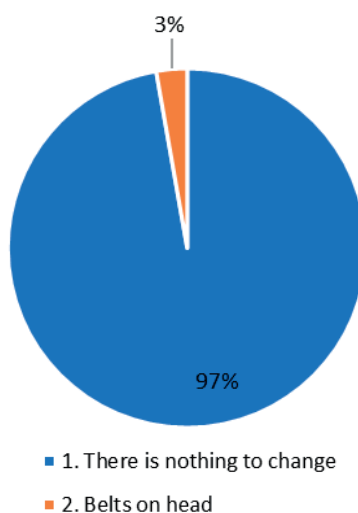
**Figure 3.** Answers to the question “What should be increased in the evacuation chair?”



**Figure 4.** Answers to the question “What should be reduced in the evacuation chair?”



**Figure 5.** Answers to the question “What should be added to the evacuation chair?”



**Figure 6.** Answers to the question “What should be removed from the evacuation chair?”

The results presented in Figures 1-6 indicate that the vast majority of respondents, i.e. ca. 69–97%, selected the answer “there is nothing to change” when asked about the broadly understood changes in the evacuation chair. Such answers may suggest that the product is practically perfect and does not require any additional modifications or changes. According to the researchers, such a situation is practically impossible to achieve due to a large group of variable features affecting the personal feelings of each person when using the chair, i.e. different degrees of disability of the evacuees, their different dimensions or different parameters of the operators handling the evacuation chair.

The pattern of respondents' answers indicates that there is a high probability that the respondents' answers were directed to one answer, "there is nothing to change", possibly due to the lack of detailed technical knowledge about evacuation chairs and little experience with their use, which supports the conclusion of the first stage of the study survey. It is assumed that the respondents chose the safest answer without going into details. The probable reason for this is the specific purpose of the evacuation chairs. These chairs are not intended for everyday use but provide protection in emergencies; therefore, their use is unusual and highly unlikely. As a result, the respondents surmised the functionality of the chairs offered by the manufacturer, assuming that the manufacturer has incorporated its proper functionality into the chair, is sufficient, and that any proposals to have the functionality modified are unnecessary due to the aforementioned "unlikeliness" of using the chair. For this reason, the "likeability" level of the stair descent device is relatively high.

The analysis of the respondents' answers gave insight into consumer's expectations regarding evacuation chairs. Users tend to maximize all demands on the chair, even contradict each other. This is an example of wishful thinking, which shows no established criteria validity, and in turn shows that there is no justification for an in-depth research in this area and the use of methods supporting the transition of needs into technical features, such as QFD or Ishikawa diagram for assessing the causes of accident risk (Górny, 2013).

#### **4. Summary and Conclusions**

The evacuation chair is used to safely and efficiently evacuate people with disabilities or injuries from buildings during emergencies. It is a part of an evacuation system and is expected to be functional in the evacuation procedure. Diverse stakeholders, such as management, building managers and health and safety services, have different decision-making schemes and knowledge levels, but share a common goal of effective evacuation. The effectiveness of the evacuation system depends on such factors as functional features of the evacuation chair, adaptation to building technical conditions, type of threat, evacuation process and quality of training. The article aimed to summarize the knowledge and opinions of people responsible for choosing evacuation chairs and identify changes they may want to make in its operation. With this in mind, a survey was conducted. The expected result of considering the survey results in the design of evacuation chairs is to achieve a better fit of the designed product to the user's needs, which supports User-Centered Design methodology. The approach presented in the article involves end users in product design (Participatory Design). Based on the analysis of the results, the following conclusions and observations can be formulated:

1. A huge predominance of answers such as "there is nothing to change" in the evacuation chair indicates that the surveyed group of experts may have solely theoretical knowledge regarding the evacuation of people with disabilities.



However, they lack practical knowledge and need some support in this area. Probably for this reason the respondents chose the safest answer without having to go into details. Additionally, presumably also for this reason, the respondents were unable to effectively define the appropriate expectations towards evacuation chairs. Respondents' expectations are assumed to be negligible or even non-existent given their current state of knowledge. The analysis of the responses shows that the following elements should be included in the training/instructions for using the chair:

- a. Testing the use of the brake and demonstrating situations where the brake works greatly significantly improves the safety of using the evacuation chair.
  - b. Presentation of the role played by the belt securing the head of the evacuee.
  - c. Demonstrating the rationale of equipping the chair with an additional belt to stabilize the lower legs.
2. Maximizing all requirements for an evacuation chair is a manifestation of wishful thinking pointing to a lack of established criteria validity. This is a further premise implying that it is necessary to familiarize those deciding of making a purchase of an evacuation chair with how it works in practice.
  3. Since it is not known what they want to change, it would be worth verifying what the decision-making model is - decision-makers, features of the perceived ergonomic quality, i.e. establishing what affects the purchase and to what extent the declared criteria for choosing a solution result from the knowledge of the needs of actual users of the solution.
  4. Having established the needs of all 3 groups of users, examining possible antinomies between the product's features, and then recognizing how to overcome them - the initial design antinomies are the need for easy access to the chair, and not its use in unauthorized situations, the visibility of the chair in various crisis conditions, and aesthetic and architectural requirements for different spaces.

## **Future outlook**

The conclusions of the research indicate that in the future, the following issues should be taken into account in the analysis of the decision-making model of an evacuation chair purchase and issues related to the study of the ergonomic quality of the evacuation system.

1. A crucial factor that affects evacuation in buildings is the level of training, so on the one hand, emphasis should be placed on practical training, including the use of an evacuation chair by people planning and implementing an evacuation system, and on the other hand, it is a factor strongly modifying research on the quality of these chairs. It is reasonable for the study to

consider the effect of learning how to use a chair by an active user, as well as a passive one, and to subject this phenomenon to a separate study.

2. Follow-up studies should be carried out and an opinion should be given on the effect of the components of the evacuation chair on its effectiveness immediately after its use by respondents..

## Acknowledgments

The research was carried out as part of the Implementation Doctorate Program of the Ministry of Education and Science implemented in 2021-2025 (Agreement no DWD/5/0544/2021).

## References

1. Beyer, H., & Holtzblatt, K., (1998). *Contextual design: Defining customer-centered systems*. Morgan Kaufmann.
2. Butlewski, M., & Tytyk, E., (2009). Ergonomic features of construction solutions to assist stair climbing by disabled people. In: A. Górny & G. Dahlke (eds.), *The ergonomics and safety in environment of human live: Monograph* (pp. 19–34). Publishing House of Poznan University of Technology.
3. Fredericks, T.K., Butt, S.E., Kumar, A.R., & Amin, S.G. (2006). Biomechanical analysis of EMS personnel using stair chairs with track systems. *Proceedings of the 11th Annual International Journal of Industrial Engineering Theory, Applications & Practice*, 330–335.
4. Górny, A., (2013). The use of Ishikawa diagram in occupational accidents analysis. In: P.M. Arezes, J. S. Baptista, M.P. Barroso, P. Carneiro, P. Cordeiro, N. Costa, R.B. Melo, A.S. Miguel, & G. Perestrelo (eds.), *Occupational safety and hygiene* (pp. 162–163). CRC Press/Taylor & Francis Group. <https://scholar.google.com/scholar?cluster=14450295474470120926&hl=en&oi=scholar>
5. Hale, N.E., & Kenneth, G., (1966). *Vehicles for invalids for travel over horizontal and inclined surfaces* (United States Patent No. US3276531A). <https://patents.google.com/patent/US3276531A/en?q=track&q=primary&q=wheels&q=vehicle&q=undercarriage&before=priority:19620424&scholar>.
6. Hashemi, M., (2018). Emergency evacuation of people with disabilities: A survey of drills, simulations, and accessibility. *Cogent Engineering*, 5(1), 1506304. <https://doi.org/10.1080/23311916.2018.1506304>
7. Hedman, G.E., (2011). Travel Along Stairs by Individuals with Disabilities: A Summary of Devices Used During Routine Travel and Travel During Emergencies. In: R.D. Peacock, E.D. Kuligowski, & J.D. Averill (eds.), *Pedestrian and Evacuation Dynamics* (pp. 109–119). Springer US. [https://doi.org/10.1007/978-1-4419-9725-8\\_10](https://doi.org/10.1007/978-1-4419-9725-8_10)
8. Hedman, G., Mehta, J., Lavender, S., Reichelt, P., Conrad, K., & Park, S., (2021). Consumer opinion of stair descent devices used during emergency evacuation from high-

- rise buildings. *Assistive Technology*, 33(5), 278–287. <https://doi.org/10.1080/10400435.2019.1634656>
9. Hollis III, W.C., (2002). Rights of people with disabilities to emergency evacuation under the Americans with Disabilities Act of 1990. *Journal of Health Care Law and Policy*, 5(2), 524–563. <https://digitalcommons.law.umaryland.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1249&context=jhclp>
  10. Hostetter, H., & Naser, M.Z., (2022). Characterizing disability in fire evacuation: A progressive review. *Journal of Building Engineering*, 53, 104573. <https://doi.org/10.1016/j.jobe.2022.104573>
  11. Hunt, A.L.E., Galea, E.R., Lawrence, P.J., Frost, I.R., & Gwynne, S.M.V., (2020). Simulating Movement Devices Used in Hospital Evacuation. *Fire Technology*, 56(5), 2209–2240. <https://doi.org/10.1007/s10694-020-00971-5>
  12. Jiang, C.S., Zheng, S.Z., Yuan, F., Jia, H.J., Zhan, Z.N., & Wang, J.J., (2012). Experimental assessment on the moving capabilities of mobility-impaired disabled. *Safety Science*, 50(4), 974–985. <https://doi.org/10.1016/j.ssci.2011.12.023>
  13. Kielch, E., & Gromek, P., (2020). Wpływ rodzaju niepełnosprawności na ryzyko ewakuacji w obliczu pożarów i innych miejscowych zagrożeń / The impact of the type of disability on the risk of evacuation in the face of fires and other local hazards. *Zeszyty Naukowe SGSP*, 76, 157–175. <https://doi.org/10.5604/01.3001.0014.5983>
  14. Koo, J., Kim, Y.S., Kim, B.-I., & Christensen, K.M., (2013). A comparative study of evacuation strategies for people with disabilities in high-rise building evacuation. *Expert Systems with Applications*, 40(2), 408–417. <https://doi.org/10.1016/j.eswa.2012.07.017>
  15. Mehta, J.P., Lavender, S.A., Hedman, G.E., Reichelt, P.A., Park, S., & Conrad, K.M., (2015). Evaluating the physical demands on firefighters using track-type stair descent devices to evacuate mobility-limited occupants from high-rise buildings. *Applied Ergonomics*, 46(Part A), 96–106. <https://doi.org/10.1016/j.apergo.2014.07.009>
  16. Parkin, B., (2005). Evacuating disabled people. *Building Engineer*, 80(8), 18–20. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-23644456564&partnerID=40&md5=503c38582e8e4147c6456289c0f56864>
  17. RESNA ED-1:2019. (2019). *Emergency Stair Travel Devices Used by Individuals with Disabilities* (RESNA ED-1:2019). Rehabilitation Engineering and Assistive Technology Society of North America.
  18. Szulc, K., Cisek, M., & Król, M., (2022). Evaluation of the Evacuation of People with Disabilities, Using an Evacuation Chair. Research Report. *Safety & Fire Technology*, 60(2), 42–59. <https://doi.org/10.12845/sft.60.2.2022.2>
  19. Zając, K., Migas, A., Sobaś, P., & Garboś, P., (2020). *Patent application PL 435164 A1 Krzesło ewakuacyjne / Evacuation Chair*. <https://lens.org/068-515-314-891-505>

## KRZESŁA EWAKUACYJNE: ANKIETA MAJĄCA NA CELU OCENĘ STANU TECHNIKI I POŻĄDANYCH FUNKCJI Z PERSPEKTYWY DECYDENTÓW

### Abstrakt

Krzesło ewakuacyjne umożliwia bezpieczną i skuteczną ewakuację osób z niepełnosprawnościami lub poszkodowanych z budynków w sytuacjach awaryjnych. Dlatego krzesła ewakuacyjne muszą być skuteczne w różnych warunkach użytkowania. Kluczowe jest, aby wiedzieć, jak wybrać odpowiednie krzesło ewakuacyjne i jak skutecznie zintegrować je z określonym systemem ewakuacyjnym. Celem artykułu jest identyfikacja oczekiwań wobec krzeseł ewakuacyjnych oraz ocena stopnia zaznajomienia się z ich działaniem przez osoby organizujące system ewakuacyjny. Cel ten zrealizowano, przeprowadzając ankiety wśród 41 osób planujących i wdrażających systemy ewakuacyjne w budynkach. Analiza wyników badań wskazuje na deficyt wiedzy praktycznej dotyczącej obsługi krzeseł ewakuacyjnych; w konsekwencji uzasadnia i sugeruje konieczność dalszych działań w tym obszarze. Ankietowani wybierali odpowiedź, która wydawała im się najbardziej bezpieczna, bez konieczności wchodzenia w szczegóły. Nie byli w stanie skutecznie zdefiniować właściwych wymagań wobec krzeseł ewakuacyjnych. Szkolenie z obsługi krzeseł ewakuacyjnych powinno obejmować działanie hamulca, rolę pasa zabezpieczającego głowę oraz pasa udowego. Użytkownicy mają częściowo sprzeczne wymagania co do krzeseł, co świadczy o braku ustalonych kryteriów, prawdopodobnie ze względu na brak praktycznego doświadczenia w użytkowaniu krzeseł. Należy zbadać model decyzyjny i czynniki wpływające na zakup, aby dokładniej określić ich potrzeby. Należy określić potrzeby wszystkich grup użytkowników oraz rozpoznać i przezwyciężyć potencjalne antynomie między cechami. Z badania wynika również, że przyszłe badania powinny koncentrować się na procesie podejmowania decyzji, jakości ergonomicznej oraz zbadaniu wpływu szkolenia na rzeczywistą skuteczność systemu ewakuacyjnego. Ponadto badanie podkreśla również potrzebę dogłębnych badań i uwzględnienia potrzeb użytkowników w procesie projektowania.

**Słowa kluczowe:** osoby niepełnosprawne, ewakuacja, środki ewakuacyjne, krzesło ewakuacyjne, urządzenie pokonujące schody, urządzenie schodowe, oczekiwania konsumentów, projektowanie partycypacyjne, jakość ergonomiczna