Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 3
Open Access

Developing A Wheelchair Prototype to Ensure People with Disabilities Can Get To Bed Independently

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Cite this paper as: Vincent Sebastian Wu1, Paulus Sukapto, Zaenal Muttaqien, Antono Damayanto (2024) Developing A Wheelchair Prototype to Ensure People with Disabilities Can Get To Bed Independently .*Frontiers in Health Informatics, 13* (3), 3931-3938

Abstract

Background: *The wheelchair, a crucial aid for individuals with disabilities in Indonesia, often presents challenges when it comes to transferring to and from a bed. Many users experience discomfort or pain during this process, prompting a research initiative to design a wheelchair tailored to address these issues*

Keywords: *Wheelchair, Ergonomic Function Deployment, Disabilities, Independently*

The collaborative design process involved users whose needs were meticulously identified, resulting in a wheelchair adhering to Indonesian anthropometric data measurements.

Aim: *This study aims to innovate design by including reclining features, foldable and adjustable armrests, and customizable footrests, utilizing the Ergonomic Function Deployment method.*

Methods: *Evaluation through direct testing with four users demonstrated the wheelchair's effectiveness in facilitating safe and comfortable transfers. However, areas for improvement, such as wheelchair size and the leg rest adjustment mechanism, were identified.*

Results: *In conclusion, the research signifies that the designed wheelchair can significantly aid individuals with disabilities in Indonesia, ensuring secure and comfortable transfers between the wheelchair and bed independently*

INTRODUCTION

A wheelchair is an assistive device that supports individuals with disabilities, especially in the legs, to overcome mobility limitations and move from one location to another. According to wheelchair use, people with disabilities are expected to experience several benefits, including improved quality of life, health, and economic conditions (Amstrong et al., 2008). The presence of wheelchairs is expected to provide significant assistance for those who experience leg defects in living daily life. The current wheelchair design still adopts the concept of "one fits all," which means that one type of wheelchair is designed to be used by everyone. This approach poses a problem because of the emergence of more specific case differences among people with disabilities. Wheelchairs designed with a "one fits all" approach can be problematic for individuals with special needs (Iksal & Darno, 2012). Differences in body size or anthropometry significantly impact wheelchair design to provide optimal comfort and safety.

There are 1,145,577 Indonesians aged five years and over who have difficulty walking or climbing stairs. Assistive devices, such as wheelchairs, can help people who have difficulty walking or climbing stairs carry out daily activities (BPS, 2022). This data shows that a phenomenon in Indonesia is the number of people with disabilities who cannot walk or climb stairs. This phenomenon is the main impetus for research to assist individuals who experience deficiencies and alleviate their problems.

The group's analysis divided people with disabilities into several categories: those who could not walk or climb stairs at all, experienced much difficulty, had little difficulty, and did not experience disabilities. The focus of research is more directed at groups that experience many challenges, as explained in data from the Indonesian Central Bureau of Statistics, that people with many problems need the help of others. This group is in the spotlight with a total of 1.145.577 people. This difference in categories suggests that the application of assistive devices can provide significant assistance to groups experiencing many difficulties, thus allowing them to live more independently. However, this can only be achieved by using adequate assistive devices, which can reduce dependence on assistance from others in the daily lives of people with disabilities.

Based on daily routines, people with disabilities often experience feelings of inferiority because of the differences they have with people who do not have limitations. Many want to live independently, without relying on the help of others in living their daily lives. Like every individual, they also need adequate rest to sleep and restore the energy required for activity the next day. One of the common challenges faced by people with disabilities is difficulty in moving from a wheelchair to another place, including moving from bed to wheelchair or vice versa, as well as moving to the toilet. In these situations, they often need the help of others to handle the process of raising or lowering the body from the bed, wheelchair, or toilet [4]. Research conducted in 2017 showed that as many as 42.6% of the samples taken in the study required the help of others to move from one place to another, and they reported discomfort or even pain in the back due to the movement process that was not done correctly by the helping party. These findings show the importance of designing wheelchair designs that consider the ease of mobility from bed to wheelchair or vice versa so that the help of others can be minimized and people with disabilities can live their daily lives more independently (Desai et al., 2017).

The design of a wheelchair that pays attention to ease of mobility and functionality requires ergonomic considerations to ensure safety and comfort for its users, especially on the body. Ergonomic studies are essential so that the dimensions of wheelchairs and other design elements can be adjusted to the user's body proportions. In this context, using anthropometric data of Indonesians is very important to assist people with disabilities in Indonesia choose the appropriate wheelchair. This anthropometric data is the primary reference for adjusting the dimensions of wheelchairs to match the size of the human body in Indonesia. Inattention to ergonomic principles and incompatibility with anthropometric data in wheelchair design can cause problems, such as incompatibility with the user's body shape, inappropriate chair height, and incompatibility of footrests. These obstacles, if not addressed, can inconvenience wheelchair users. The impact of discomfort and insecurity in a wheelchair involves pain in some areas of the body, muscle pain due to uneven loads, and aching sensations. Therefore, to prevent these disorders, wheelchair design must consider ergonomic principles and use anthropometric data as the main guideline.

Many studies discuss the design of wheelchair designs, either with automation or manual wheelchairs, with ergonomic concepts as a reference for designing wheelchair designs. The discussion of the problem will discuss benchmarking, which is a difference in research proving that the research to be carried out will be

compared with previous studies and then seen related to advantages and disadvantages so that this research can refer to previous studies related to specifications and features which will then be adjusted to user needs.

Designed a wheelchair concept to help people with disabilities move to other places, such as to bed or bathroom. This study used QFD and fuzzy-ANP methods to produce an adjustable wheelchair concept (Mistarihi, 2020). Designed a wheelchair design to support health facility services during COVID-19 with a straightenable wheelchair position. This wheelchair design is designed with a model that reclines the backrest and legs (Yulistyari & Shofa, 2021). Designed a wheelchair with consideration of user needs through a user-centered design approach, which resulted in a wheelchair design that can be reclined and a leg rest that can be straightened (Wignyosoebroto, 2008) and designed a wheelchair to increase space in people with leg disabilities. This study also found that 70% of respondents felt difficulty and experienced pain when moving from a wheelchair to a bed (Batan, 2006). Developed an evaluation measuring instrument and designed a wheelchair that suited users' wishes and evaluated how wheelchairs can help users with their needs (Jatmiko & Dharmastiti, 2018). Developed a wheelchair for the elderly and facilitated wheelchair operation by assistants moving to other places (iwano, 2014).

Based on the analysis of problems from previous studies related to user needs, it was found that no research has focused on designing wheelchairs with the concept that allows patients to move between wheelchairs and beds without the need for the help of others. In addition, no study has considered Indonesian anthropometric data in the design of the wheelchair. The design process will begin with identifying the user, which will be adjusted to Indonesian anthropometric data to ensure the size of the wheelchair fits the user's body. Based on the problems discussed and identified in the background section, the following is the formulation of issues that will be the focus of this study.

1. How can wheelchairs be designed to help people with disabilities move into bed independently and provide safety and comfort during the transfer process?
2. What are the results of evaluations from users regarding wheelchair design results?

Methods

The Ergonomic Function Deployment EFD method is suitable for wheelchair design research for people with disabilities for independence because the EFD method focuses on user safety and comfort. This method is based on ergonomic principles and uses a systematic approach in the design process. Analysis can be carried out on user needs and ensure that the wheelchair design can meet relevant ergonomic aspects, such as body size and interaction between the wheelchair and its users. In addition, the EFD method, which is the development of the Quality Function Deployment method, can connect any user needs with wheelchair elements to create a wheelchair design that suits user preferences and limitations. The EFD method also allows continuous evaluation of the design under development so improvements and iterations can be made to achieve an optimal design. Furthermore, by using the EFD method, wheelchairs that are more ergonomic and can meet the needs of users and improve the comfort and safety of wheelchair users can be well-designed (Sugiyono, 2017).

Result and Discussion

Measurement of Wheelchair

The results of the soft prototype also have a size that has been adjusted to the dimensions of the human body.

A soft prototype is an initial model or initial sketch of a product made to facilitate the manufacture of the original product; usually, soft prototypes are made with the help of applications or by sketching manual drawings by hand. This soft prototype is made with the help of Solidworks applications (Akao & Mazur, 2003). It aims to show the overall product picture, which will later be adjusted to the original product.

Table 1. Measurement of Wheelchair

Measurement	Size (cm)
Backrest length	72.03
backrest *width*	51.16
Seat Length	43.00
Seat width	39.88
footrest length	40.07
arm rest length	54.40
arm rest width	15.17
footrest length	30.87
Footrest width	11.98
handle length	17.00
Handle diameter	5.00
Rear wheel diameter	25-27 inch
Front wheel diameter	9.00

The results of the complex prototype design were carried out using anthropometric data measurements for Indonesians. These measurements produce all data as a reference for measurements ranging from backrest, armrest, leg rest, seating, etc. The design carried out also thinks about how there is a trade-off regarding wheelchair design; for example, if a folding feature is held, the use of foam as a cushion will be ineffective, so as explained in the making of the House of Ergonomics you should choose a cushion over a folding feature. The wheelchair design has other specifications, including leg rest changing mechanisms, reclining features, and armrest modifiers.

Prototype of Wheelchair

In the House of Ergonomics design process, the assessment is given in the form of symbols and is carried out subjectively by the researcher (Liansari & Febrianti, 2017). Researchers need help with subjective assessments. This is because the assessment process has no definite benchmarks, so researchers consider several factors when giving an assessment.

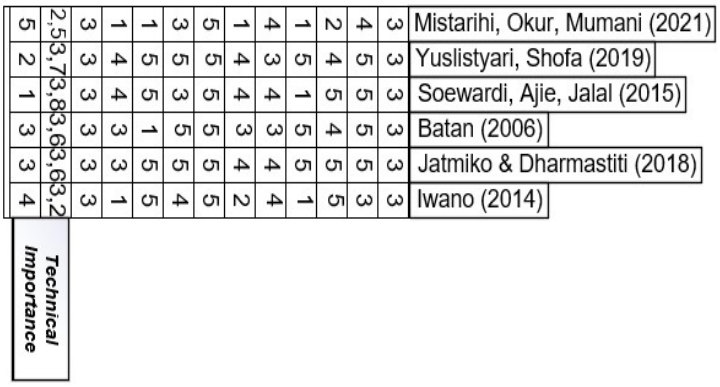
Figure 1. Soft Prototype of Wheelchair

Many factors must be regarded as the correlation of the relationship between customer needs and product specifications (Nurmianto, 1996). The obstacle in providing a correlation relationship is that you must consider whether there is a causal relationship between product specifications and customer needs and consider the causal relationship strong, medium, or weak. This makes subjective judgments must also be based on clear reasons that can strengthen the reasons for the assessment. When giving technical importance assessments for absolute values, they must be done carefully during multiplication and addition (Prasetyo & Mariawati, 2015). This will later be used as a reference for researchers when giving ratings for technical importance at relative values. The highest absolute score will be given a rating value of 1. This absolute assessment will be the top priority of researchers when designing wheelchairs.

Figure 2 Hard Prototype of Wheelchair

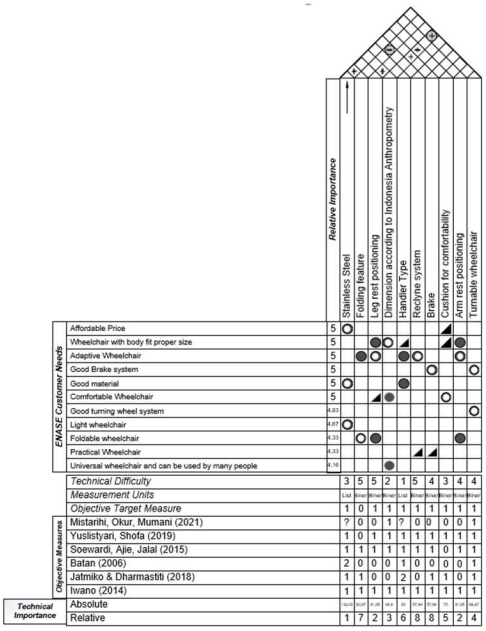
In this study, six benchmarks were taken into consideration. An assessment was made using a benchmarking matrix from the six benchmarking. This benchmarking matrix assessment is carried out subjectively. In this series of benchmarking matrix assessments, researchers experienced several obstacles. Researchers need help to conduct subjective benchmarking assessments. This is because the specifications of customer needs used as a benchmark for benchmarking product comparisons are unavailable.

Figure 3. House of Ergonomics Benchmarking Matrix



This research will redesign wheelchair design by considering the shortcomings of previously sleepable wheelchair designs and focusing on more effective solutions to help people with disabilities move from wheelchairs to beds. As a reference for the design, researchers will review previous studies conducted to understand the problems faced by individuals who have difficulty or feel pain when moving to bed (Tarwaka, 2015). Although only some previous studies have recognized such complaints, this study will explore more comprehensive solutions (Ulrich & Eppinger, 2016). In designing a new wheelchair design, this study will pay attention to ergonomic aspects as the main guideline, taking into account user comfort and safety. Indonesian anthropometric data will be used as a basis for determining the size of wheelchairs to reduce the risk of pain that may arise when moving from wheelchairs to beds (WHO, 2023). Thus, this study aims to contribute to developing wheelchairs that can not only be bedridden but also address the problem of moving patients to bed more effectively by minimizing possible discomfort (KBBI, 2016).

Table 2. House of Ergonomics



Conclusion

The following conclusions can be drawn from the research process, which has been carried out from the planning stage to the evaluation of the prototype.

1. The wheelchair design using the EFD method can help people with disabilities move to bed independently and consider comfort and safety.
2. The evaluation results of the wheelchair design state that the wheelchair is comfortable and safe to use to move to bed independently. Comfort and safety considerations are obtained directly from the evaluation results using a wheelchair prototype

Acknowlegment

We are deeply thankful to Bengkel Las Umi, Mr Teng Sui and others who have provided essential support in meeting specific needs and assisting with the prototype making. Your dedication to inclusivity has significantly contributed to the scope and impact of this research

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