



Designing a Portable Manual Prone Positioning Product for Safe and Effective Patient Handling

Siti Salwa Isa¹, Junita Shariza Mohd Nasir², Abu Ali¹, Shahrul Niza Said³, Nor Lelawati Jamaludin⁴, Siti Suriawati Isa⁵ and Muhammad Syafiq Bin Amrah¹

¹ College of Creative Arts, Universiti Teknologi MARA, Malaysia

² Faculty of Creative Multimedia, Multimedia University, Malaysia

³ School Languages, Civilisation and Philosophy, Universiti Utara Malaysia, Malaysia

⁴ Faculty of Business and Management Studies, Universiti Teknologi MARA, Malaysia

⁵ Faculty of Forestry and Environment, Universiti Putra Malaysia, Malaysia

sitisalwa@uitm.edu.my

Abstract. The use of patient lifting or carrying equipment has become ubiquitous in hospitals and other healthcare settings. While these tools have provided significant benefits in patient care, there are still limitations in their functionality, particularly in scenarios where patients require specific types of lifting or positioning. One such situation is the need to turn patients onto their stomachs, or prone positioning, which is often necessary in cases of respiratory issues or injuries. However, this maneuver can be particularly challenging as it often needs to be performed on unconscious patients, and the size and variability of patients can require a significant number of medical staff to perform the maneuver safely. This paper aims to explore the use of lifting equipment for proning patients and the manual methods used by medical staff. The goal is to develop a design solution that addresses the challenges associated with proning patients manually and provides insights into improving the functionality of lifting equipment. The research will focus on understanding the specific challenges associated with manual proning methods and the requirements for lifting equipment to safely and effectively turn patients onto their stomachs. Through this study, we hope to develop a more comprehensive understanding of the current limitations of lifting equipment and provide insights into potential solutions that can improve patient outcomes.

Keywords: Medical Product Design, Prone Positioning, Design Development.

1 Introduction

The prone positioning method toward the patient has mainly been used when they are facing a respiratory issue called acute respiratory syndrome distress (ARDS) [1]. Hence, by using this method or procedure for repositioning them, it will help to improve the breathing flow inside the lungs. Ever since the existence of this proning method, the procedure has been done manually by medical practitioners. The reason for the manual method is still preferable to use as it is simpler and cheaper than the equipment

available, but also because of the existence of new technology or inventions such as a rotating bed, which was too much more than what had been asked for [2]. As the cost of the rotating bed itself is high, it will have limitations on quantity and can only be used one at a time. In addition, the manual only required several people to run the procedure efficiently and at a lower cost than the rotating bed. The main objective of this research is to propose an idea that can change the mode or concept of manual patient-prone positioning by improving the procedure in terms of equipment but with a cheaper and simpler solution [3]. Prone or moving a patient from a lying position on the back to lying face down is a kind of therapy used to increase the chances of survival for patients with coronavirus diseases 2019 (COVID-19). The prone itself was first described as the treatment for acute respiratory distress syndrome (ARDS) in medical literature almost 40 years ago [4]. This procedure was initially used as the last option when all the treatments failed to cure, but recently, during the era of COVID-19, the recent findings suggested that the use of this act should be included as a treatment for the infected patients. This research will mainly focus on how the prone position towards patients works and whether it has an issue when used either towards the nurse or the patient. Moreover, due to the recent cases of the coronavirus disease (COVID-19), the use of this procedure for the patient has increased as the virus mainly affected the patient's breathing organs.

1.1 Research Problems

Problems identified by the researcher are based on the challenges faced by the nurse when facing the patient during positioning, which is affected by COVID-19. One of the problems identified mainly involves the presence of hospital staff and the patient. For almost two years, the world has been facing the pandemic of COVID-19 [1, 2]. Some survived the infection, and the rest have lost their lives fighting. The infection and symptoms have been classified into five stages [5]. First, category 1 does not require any treatment but is required to run a self-quarantine for precaution if it infects others. Then, categories 2 and 3 required supportive and symptomatic therapy. This category is where a monitor is required for any warning sign that things are getting worse. The 4 and 5 were considered the worst and needed crucial treatment. This category mostly involves the use of a ventilator device for the patient to support breathing as the diseases infect their lungs, making it hard for them to breathe, which is called acute respiratory distress syndrome (ARDS). If the patient's condition gets worse and they have difficulties breathing, they are required to be placed in a prone position. Prone positioning is the technique of placing a patient with difficulty breathing and is mainly used for patients who require a breathing machine known as a ventilator [5]. Therefore, the issues that have been focused on are how difficult it is for the medical staff to place the patient in a prone position, as it requires more than one staff member to get it done. The challenges in placing the patient are variable as there are many kinds of sizes of patients, and due to the shortage of staff to be in one place to complete the procedure, the process is also delayed [1, 2, 3, 4].

1.2 Research Objectives

In this study, three research objectives have been formulated:

1. To identify the issue or problem faced by medical practices when handling the prone positioning of the patient.
2. To study and identify how medical practitioners manage and undergo the prone positioning of the patient.
3. To propose a solution that can be improvised into the medical practices by creating or designing a product as a proposal for solving the issues.

1.3 Research Question

In this research study, there are three research questions that are to be answered by the research objective.

- RQ1: What are the issues that occurred when handling the prone positioning manoeuvring for the COVID-19 patient?
- RQ2: What are the procedures and steps being used by the nurse when handling the patient when moving the patient to the prone position?
- RQ 3: What solutions can be proposed that can help solve the issues and improve the nurse's work when handling the patient during the placement to prone positioning?

2 Research Methodology

In this study, digital ethnography will be employed as a research method to delve deeper into the behaviour of medical practitioners when implementing the manual prone positioning method on patients. Digital ethnography is a contemporary approach that leverages existing data sources, such as video recordings or digital documentation, to explore and document various aspects of human behaviour within a specific context [5, 6]. By utilizing digital ethnography, the researcher will have access to a rich and diverse dataset that captures the real-life interactions and practices of medical professionals in the context of performing the manually prone positioning method [5, 6]. This method allows for an in-depth examination of the intricacies involved in the application of the technique, providing valuable insights into its efficacy, challenges, and potential areas for improvement [7]. The collected data, comprising existing video recordings of medical practitioners conducting the prone positioning method, will serve as the foundation for the subsequent analysis for the researcher's further development of new product design solutions. The researcher will carefully review and observe these videos, paying close attention to the details of each interaction, the techniques employed, and any observable patterns or deviations. This thorough examination aims to identify any issues or problems that may arise during the implementation of the method, shedding light on potential areas for improvement or refinement [5, 6]. Furthermore, the analysis of the collected data through digital ethnography will enable the researcher to gain a comprehensive understanding of the manual prone positioning method.

The researcher will leverage digital ethnography as a primary research method to gather rich and contextual insights into the target users' behaviours, attitudes, and preferences within the digital environment. The digital ethnography findings will serve as a foundation for the subsequent design solution. The researcher will employ design processes as a methodological framework to develop the design solution, utilizing iterative and user-centred design approaches [8, 9]. The design process will involve several key stages, including problem definition, ideation, prototyping, and evaluation. By systematically analysing the digital ethnography findings, the researcher will identify recurring patterns, themes, and user needs that emerge from the data [8]. These insights will guide the generation of design concepts and the creation of prototypes. Throughout the design process, the researcher will prioritize user involvement and feedback, aiming to validate and refine the design solution iteratively. User testing and evaluation sessions will be conducted to gather user perspectives and insights, ensuring that the resulting design addresses their needs effectively [9]. By integrating the digital ethnography findings into the design processes, the researcher seeks to create a robust and user-centric design solution that aligns with the identified user requirements and takes into account the nuances of the digital environment.

3 FINDINGS AND ANALYSIS

3.1 Problem identification through video observation via digital ethnography method.

In accordance with Figure 1, a minimum of seven individuals were required to successfully execute the complete manual method, which involved lifting and rotating the patient. The number of personnel needed may vary depending on the patient's condition and size. Typically, the procedure is conducted using the existing bed. The crucial role played by the respiratory therapist in achieving favorable treatment outcomes is evident from the observations. The issue of personnel requirements has also been extensively discussed in the literature, highlighting the unpredictable availability of medical practices [12]. When faced with personnel shortages, it can lead to feelings of burden and discomfort as they become overworked, requiring increased effort to provide care for the patient.

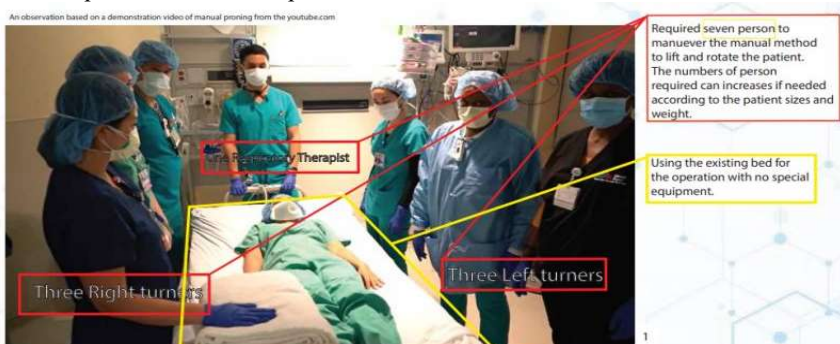


Fig. 1. Problem identification through video via digital ethnography method.

Figure 2 depicts the utilization of a conventional bedsheet as a wrap-around support system, effectively securing the patient during movement and rotation. The bedsheet serves as a reliable holder, ensuring patient stability. Additionally, pillows are employed as cushions to mitigate pressure exerted by medical practitioners when wrapping the patient with the bedsheet, as well as provide comfort in the prone position. Consequently, based on these observations, it can be inferred that the manual method employed by the practitioners exclusively relies on existing materials to execute the procedure.

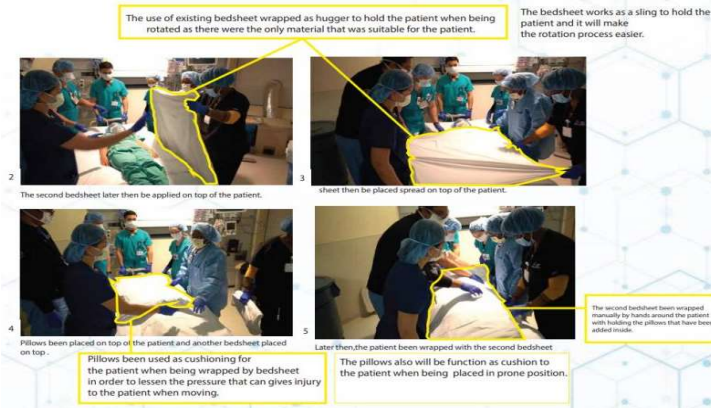


Fig. 2. Problem identification through video via digital ethnography method.

Figure 3 highlights a recurring issue in the prone positioning process, specifically regarding the strain exerted on the hand while holding the sheet during rotation. Engaging in repetitive and awkward movements can lead to stress and discomfort [13,14]. Furthermore, the larger or heavier the patient, the greater the effort required from medical practitioners, potentially resulting in injuries if not addressed using proper techniques. These challenges can be attributed to poor working ergonomics and posture, as incorrect positioning during work can lead to pain and discomfort [13,14].

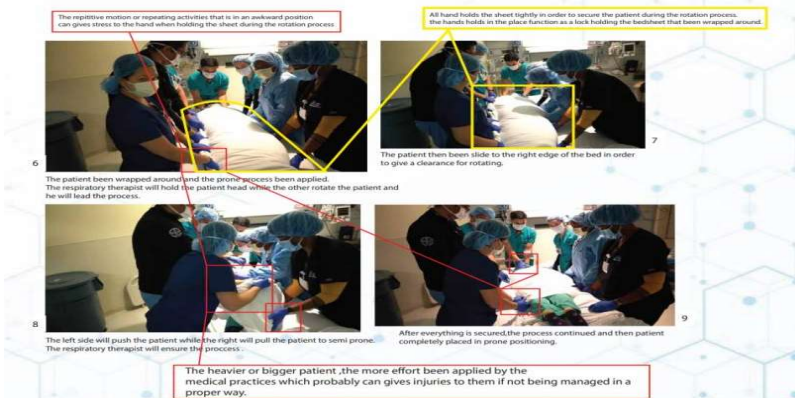


Fig. 3. Problem identification through video via digital ethnography method.

4 Conceptual of design / proposing an idea solution

The proposed product idea for equipment is to improve working by creating a solution that can help minimize the working effort of the medical staff and provide lower-cost options on equipment while maintaining the use of manual methods for patient-prone positioning. This equipment is targeted to be used during the manual patient-prone positioning method. Therefore, it acts as support equipment to lift the patient but is designed to be portable and cheaper than available equipment on the market. This product is created according to the consumer's suitability in terms of design, comfort, and affordability. This product is expected to help minimize the number of people required to be involved in manual patient-prone positioning by replacing the person needed to lift the patient.

4.1 Idea Development and Experimentation

Preliminary Concepts

Based on the issues and problems that have been analyzed from the previous findings, several ideas and concepts have been developed to overcome the issues. The purpose of this development is to improve the working ethic of the medical practitioner or healthcare provider towards the patient to be smoother and more efficient [10, 11].

Design considerations

The research findings have identified several key criteria and attributes that have been emphasized and integrated into the design process. These encompass the device's portability, compactness, functionality, affordability, and adherence to the guidelines for positioning the patient (safety precautions) [11]. The primary objective of the portable patient-prone positioner project is to develop a method for creating a product tailored to fulfill a specific function within a designated setting.

Portable and compact

Researchers have found that existing products on the market still have shortcomings in terms of design that are impractical in terms of portability for consumers, so the researchers believe that the addition of these features can improve the product to be better suited to be used for medical practices [11]. The portability of the design can facilitate them when they're on the go.

Functional and affordable

Researchers are improving the existing equipment on the market to make it specifically designed and more functional. Researchers have identified the current needs and issues that occur during manual patient-prone positioning. For the price, the available cost has been analyzed by the researcher, as the outgoing solution will be below the price of existing equipment.

Safety precautions

Creating the right tools and positioning aids: Use excellent tools and positioning aids made specifically for prone placement. To reduce the danger of problems

like pressure sores, these devices should offer adequate support, stability, and pressure relief.

Sketching for initial Ideas

The design sketch is a vital phase that comes before the creation of a product in the field of early design solutions. A design sketch is a non-formal visual representation of an organizational structure that uses sketching techniques to define its context, boundaries, features, benefits, and costs. The nature of these sketches may be intellectual, logical, or physical. Intriguing development ideas can be sparked by creating a design sketch, inspiring creativity, and assisting in decision-making before arriving at a final design solution [10].

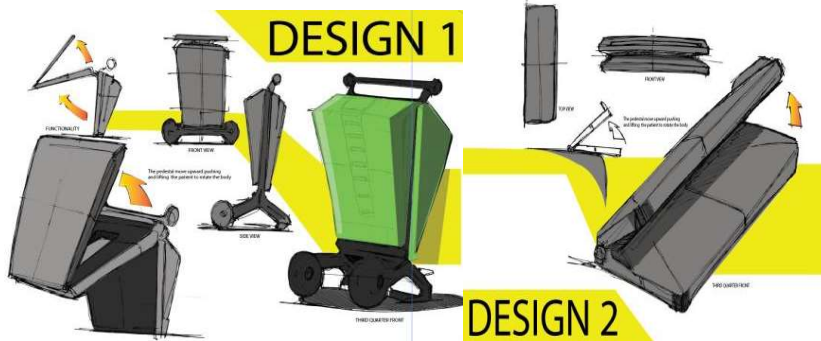


Fig. 4. Sketches design 1 & 2

Figure 4 presents the initial design concepts, with Design 1 primarily focusing on portability. The researcher proposed the concept of a trolley, enabling the product to be easily moved to any desired location. The primary aim of this design was to facilitate medical practitioners in pushing patients to use the product. On the other hand, Design 2 introduced an additional concept involving a plank. In this design, the product would be attached to the patient's bed using detachable cables.

Design development

The researcher further refined and expanded upon the initial ideas by leveraging the capabilities of 3D rendering models, as depicted in Figure 5. Utilizing 3D rendering models provides a heightened level of visual realism, enabling the accurate representation of patterns, materials, lighting, and shadows in a true-to-life manner. The intricate level of detail that these models provide improves the researcher's comprehension and visualization of the finished product or design.



Fig. 5. 3D modelling concept 1 & concept 2

This design iteration represents an enhancement of Design 1, aiming to provide a clearer understanding of its visual appearance and functionality. The concept has been translated into 3D rendering form, enabling a more comprehensive visualization of the design. Likewise, Design 2 has also undergone a transformation into a clearer 3D-dimensional rendering. The visualization demonstrates the attachment of the product to the bed using a cable or strap, which facilitates its operation. To evaluate Design 1, a simulation was created utilizing animation, allowing for an assessment of how the design can be utilized by users. Figure 6 showcases the product's interaction with a human dummy simulation, serving as a reference for patients being moved and lifted using the product.



Fig. 6. 3D modelling usability of concept 1

Prototyping

Prototypes are developed for the purpose of conducting testing with respondents. A prototype serves as a representative example of a product design, created in multiple variations to undergo testing, selection, and improvement. The prototypes, also known as low-fidelity mock-ups, are constructed at a 1/5 scale compared to the actual product. These scaled-down models are crafted using materials such as cardboard and PVC board. The primary objectives behind constructing these mock-ups are twofold: to gain

a deeper understanding of the product's real-world appearance and to assess whether the scale of the product aligns accurately with the scaled dummy.

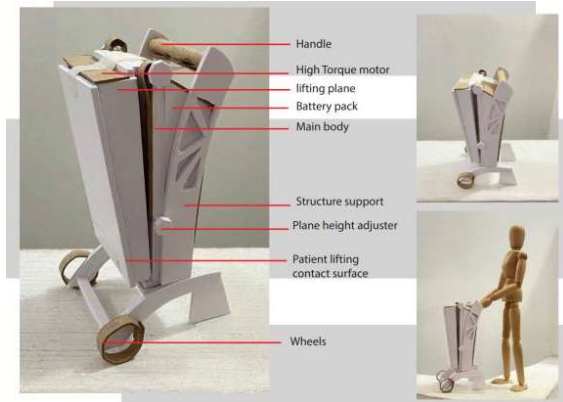


Fig. 7. low fidelity model prototype scale 1/5 to evaluate the parts

5 CONCLUSION AND RECOMMENDATIONS

The present study provides a comprehensive overview of the outcomes derived from a thorough examination of existing literature, empirical observation, and ideation during the design phase. The product was developed with the aim of mitigating the difficulties encountered by medical professionals when manually positioning patients in a prone position. It offers a portable remedy that streamlines their operations while alleviating the workload. The research was initiated due to the recognition of issues linked to the manual placement of patients in a prone position. These issues include the varying levels of assistance required by patients and the potential physical burden on healthcare professionals. Furthermore, the restricted accessibility and financial limitations of current apparatus presented additional difficulties. This study suggests the development of a compact and specialized portable prone positioner to aid healthcare professionals in the patient positioning process. The proposed device is designed to provide support during the procedure.

5.1 Recommendations

The portable prone positioner serves the function of furnishing assistance to medical professionals who are engaged in executing the manual patient prone positioning technique for patients afflicted with acute respiratory distress syndrome or experiencing respiratory difficulties. The product has been developed with an emphasis on portability and compactness, enabling convenient transportation within healthcare facilities while maintaining spatial efficiency and eliminating the need for dedicated rooms.



Fig. 8. Final recommendation of the design

Additionally, this particular product offers significant support to healthcare professionals in terms of strength while maneuvering or repositioning patients into supine postures, as depicted in Figure 9, mapped with the empirical evidence regarding the effectiveness of prone positioning in improving patient outcomes that is well-documented in the medical literature [1,2,3,4]. This concept functions as supplementary assistance, serving as a metaphorical "third hand" for the operator throughout the process. Furthermore, it is anticipated that this product will exhibit a reduced price point in comparison to analogous alternatives currently obtainable in the market. It is expected that the utilization of this product during the procedure will result in a reduced need for personnel, as illustrated in the figure, wherein the patient is moved by only two individuals.



Fig. 9. Product usability simulation

When considering the future path of prone positioning product development, it is critical to remember that advances in prone positioning devices should always be backed up by strong clinical evidence and rigorous testing to assure patient safety and effectiveness. Working with healthcare experts and incorporating their feedback into the product development process will be critical to fulfilling the changing demands of patients and physicians in this industry.

References

1. De Jong, Audrey, Daniel Verzilli, and Samir Jaber. "ARDS in obese patients: specificities and management." *Critical Care* 23 (2019): 1-9.

2. Ryan, Patrick, Cynthia Fine, and Christine DeForge. "An evidence-based protocol for manual prone positioning of patients with ARDS." *Critical Care Nurse* 41, no. 6 (2021): 55-60.
3. Ryan, Patrick, and Cynthia Fine. "Preventing Pressure Injuries During Prone Positioning for Acute Respiratory Distress Syndrome." In *CRITICAL CARE NURSE*, vol. 39, no. 2, pp. E50-E51. 101 COLUMBIA, ALISO VIEJO, CA 92656 USA: AMER ASSOC CRITICAL CARE NURSES, 2019.
4. Fourie, Anika, Maarit Ahtiala, Joyce Black, Heidi Hevia, Fiona Coyer, Amit Gefen, Kim LeBlanc et al. "Skin damage prevention in the prone ventilated critically ill patient: A comprehensive review and gap analysis (PRONetec study)." *Journal of tissue viability* 30, no. 4 (2021): 466-477.
5. Pink, Sarah. "Digital ethnography." *Innovative methods in media and communication research* (2016): 161-165.
6. Kaur-Gill, Satveer, and Mohan J. Dutta. "Digital ethnography." *The international encyclopedia of communication research methods* (2017): 1-10.
7. Pera, Rebecca, Sarah Quinton, and Gabriele Baima. "The use of embedded visual methods in unveiling consumers' values: A digital ethnography perspective." *Psychology & Marketing* 39, no. 2 (2022): 309-319.
8. Edelson, Daniel C. "Design research: What we learn when we engage in design." *The Journal of the Learning sciences* 11, no. 1 (2002): 105-121.
9. Althuizen, Niek, and Bo Chen. "Crowdsourcing ideas using product prototypes: the joint effect of prototype enhancement and the product design goal on idea novelty." *Management Science* 68, no. 4 (2022): 3008-3025.
10. Taniguchi, Shunpei. "Creative Exploration through Idea Sketches in the Product Design Process: A Case of the Designers Highly Skilled in Digital Technologies." *IIAI Letters on Informatics and Interdisciplinary Research* 3 (2023).
11. Guideline for positioning the patient. *AORN Journal*, 105(4), P8-P10. doi:10.1016/s0001-2092(17)30237-5. (2017)
12. Chen, Xiuwen, Yang Zhou, Xia Zhou, Pan Su, and Jindong Yi. "Knowledge, attitudes, and practice related to the prone positioning of patients among intensive care unit nurses working in COVID-19 units: A cross-sectional study in China." *Nursing in Critical Care* (2023).
13. Goswami, Smaranika, Swarup Ghosh, and Subhashis Sahu. "Evaluation of ergonomic risk factors in manual patient handling tasks of Indian nurses." *Ergonomics SA: Journal of the Ergonomics Society of South Africa* 29, no. 1 (2017): 2-10.
14. Keyserling, W. Monroe, M. Brouwer, and Barbara A. Silverstein. "A checklist for evaluating ergonomic risk factors resulting from awkward postures of the legs, trunk and neck." *International Journal of Industrial Ergonomics* 9, no. 4 (1992): 283-301.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

