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# A CONCEPT PAPER: THE DEVELOPMENT OF EZTRANSFER: A NOVEL MULTILAYER SLIDING TOWEL FOR SAFE PATIENT HANDLING AND TRANSFER

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**Abstract:**

Safe patient handling remains a major challenge in healthcare settings, particularly during bed-to-stretcher transfers involving bedridden, obese, or critically ill patients. Manual lifting frequently exceeds safe load limits and contributes to high rates of musculoskeletal injuries among nurses. High friction, instability, and the need for multiple staff members limit the effectiveness of existing transfer tools, such as slide boards and draw sheets. This concept paper introduces EZTransfer, an innovative multilayer sliding towel system designed to enhance safety, reduce physical strain, and improve workflow efficiency during patient transfers. It will be developed using the 4D Development Model (Define, Design, Develop, and Deliver) to provide a user-friendly, secure, and adaptable experience. EZTransfer integrates a cooling top layer, cushioning middle layer, waterproof low-friction base, non-slip backing, ergonomic handles, and stabilising belt straps. The Define stage identified ergonomic limitations in current practices; the Design stage focused on comfort, stability, and material optimisation; the Develop stage produced and refined a functional prototype; and the Deliver stage outlines planned clinical testing and implementation. This is a conceptual design/development study, not a clinical trial and this EZTransfer is expected to reduce staff requirements in transferring

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patients, minimise injury risks, and improve patient comfort and safety. This innovation offers a practical, cost-effective solution with strong potential for adoption in hospitals, emergency departments, and home care environments.

**DOI:** 10.35631/IJMTSS.933002 **Keyword:**

Ergonomics, Innovation, Nursing Technology, Safe Patient Handling, Transfer Device, 4D Development Model

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## Introduction

Patient transfers, especially those from beds to stretchers, are among the most physically demanding healthcare procedures. Poor ergonomics, inadequate equipment, and staff shortages contribute to musculoskeletal injuries among nurses and caregivers. Healthcare workers generally experience high rates of work-related injuries, particularly those related to manual patient handling (Escobar-Galindo et al., 2025). Many adult patients are manually lifted by professional caregivers, often exceeding the safe lift limit set by the National Institute for Occupational Safety and Health (NIOSH), making manual lifting both inefficient and unsafe (Sun et al., 2018). The concept of safe patient handling has garnered substantial support from a growing body of literature that emphasizes the physical and organizational implications of transfer-related tasks. Nelson and Baptiste (2006) championed evidence-based practices in patient handling, arguing that there must be systematic approaches to reduce injury risks. Conventional approaches, such as the use of 4-inch slide boards, have been criticized for their inefficiency in this regard. Sun et al. (2018) observed that these devices typically necessitate two staff members, one to pull and another to push from underneath, which underscores ergonomic limitations. Similarly, Domer Law (2021) identified friction and inadequate tools as critical contributors to unsafe transfers, which not only compromise patient safety but also increase physical strain on healthcare workers. Moreover, Darragh et al. (2014) and Shin et al. (2018) linked poor facility management and unsafe transfer practices to elevated levels of patient harm and nurse burnout, reinforcing the urgency of improved infrastructure and protocols in clinical settings.

In Malaysian clinical settings, interviews with nursing students revealed that male staff members are often relied upon for lifting tasks, leading to recurring back pain and fatigue among them. In emergency and orthopaedic departments, where rapid, safe transfers are critical, the lack of appropriate tools compromises both patient safety and staff well-being (Abas et al., 2023). Despite the availability of assistive devices, many existing tools remain

friction-dependent, unstable, or impractical in fast-paced environments, such as emergency and orthopaedic departments. There is a pressing need for innovative, low-cost, and ergonomically optimised solutions that reduce physical strain while maintaining patient safety. EZTransfer was conceptualised to address these gaps by integrating scientific principles, engineering design, and user-centred functionality.

This concept paper introduces EZTransfer, a novel sliding towel designed to facilitate the safe transfer of patients within a hospital, particularly bedridden or critically ill patients. It will be developed using the 4D Development Model (Define, Design, Develop, and Deliver) to provide a user-friendly, secure, and adaptable experience for the users. This concept paper aims to highlight the distinctive features of EZTransfer, which is engineered as an anti-friction, waterproof, layered towel system. As a result, it reduces transfer strain and minimizes related issues.

## Background of the Study

### *The Burden of Manual Patient Handling*

Manual patient handling is one of the most significant occupational hazards in healthcare, contributing to extraordinarily high rates of work-related musculoskeletal disorders (MSDs) among nursing staff. Recent systematic reviews have documented that the 12-month prevalence of musculoskeletal disorders related to nursing work ranges from 71.8% to 84% among nurses, indicating an extremely high annual burden affecting the majority of the nursing workforce (Sousa et al., 2023). These rates substantially exceed those observed in most other industries, highlighting the concentrated occupational risk inherent in-patient handling tasks (Wiggermann et al., 2016).

The physical demands imposed by patient transfer are substantial and cumulative. Institutional analyses reveal that approximately 24% of hospital injuries and 41% of skilled nursing facility injuries are directly attributable to patient repositioning and transportation (Norris, 2018). Remarkably, nursing staff may manually lift up to 2.7 tons during a single 12-hour shift, illustrating the extraordinary cumulative load nurses encounter in routine care (Norris, 2019). Manual transfers impose repeated high loads on the lower back and upper extremities during patient repositioning and lateral transfers, creating sustained exposure to biomechanical stressors that increase the risk of injury (Humrickhouse & Knibbe, 2016). Despite growing awareness of these hazards, Richardson et al. (2018) emphasized that pain and disability related to patient handling persist across healthcare settings, underscoring that injury prevalence remains substantial even in facilities with some interventions in place.

In Malaysian clinical settings, preliminary observations through interviews with nursing students have revealed patterns consistent with international findings: male staff members are often relied upon for lifting tasks, leading to recurring back pain and fatigue among them. In emergency and orthopaedic departments, where rapid, safe transfers are critical, the lack of appropriate tools compromises both patient safety and staff well-being (Abas et al., 2023). These local observations align with the global evidence documenting the widespread nature of patient-handling injuries across diverse healthcare contexts.

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### *Limitations of Current Transfer Methods*

Traditional patient transfer methods, including slide boards, draw sheets, and unassisted manual lifting, have multiple practical and biomechanical limitations that compromise both caregiver safety and patient care quality. Despite the availability of various transfer aids, manual patient handling continues to expose staff and patients to significant risks, and simple practice changes alone have proven insufficient to address the problem (Humrickhouse & Knibbe, 2016).

### *Excessive Staff Requirements*

Conventional transfer methods typically require three to four staff members to safely execute bed-to-stretcher transfers, particularly for patients who are obese, critically ill, or unable to assist (Fray & Davis, 2024). This high staff requirement creates several cascading problems: it increases labor demands, delays emergency care when multiple personnel must be assembled, and contributes to workflow inefficiencies in resource-constrained clinical environments. The need for multiple caregivers per transfer also increases the number of workers exposed to the risk of injury during each patient movement.

### *Instability and Patient Safety Concerns*

Current transfer devices often provide inadequate stability, leading to the risk of patient rolling or slipping during transfers. This instability compromises patient safety and increases caregiver anxiety and physical strain as staff members attempt to compensate for device limitations through increased manual support. For frail, bony, or critically ill patients, conventional slide boards offer minimal cushioning, resulting in patient discomfort and potential pressure-related complications during transfers (Flor-Unda et al., 2025).

Despite advances in understanding patient-handling risks and the introduction of various assistive devices, significant gaps persist in clinical practice. Many current tools fail to effectively balance friction reduction with the need for patient stability and comfort, limiting their usefulness in real-world settings (Hwang et al., 2019). Existing devices are often impractical for fast-paced environments, such as the emergency and orthopaedic departments, where rapid, safe transfers are essential. Simultaneously, ongoing staff shortages and increasing workflow demands highlight the need for solutions that reduce personnel requirements without compromising safety. There is also a pressing demand for devices that are durable, hygienic, and cost-effective, enabling their widespread adoption across diverse healthcare settings (Richardson et al., 2018).

Together, these limitations underscore a critical gap in current patient-handling practices and highlight the urgent need for an innovative transfer solution that enhances safety, reduces staffing demands, and improves patient comfort in the future.

### *Theoretical Grounding: Ergonomics and Safe Patient Handling Principles*

The development of EZTransfer is theoretically anchored in two well-established frameworks: ergonomic principles and safe patient handling standards. Ergonomics, as defined by the International Ergonomics Association, emphasises the design of systems that maximise human well-being and overall performance. In the context of patient transfers, key ergonomic principles include force reduction, neutral posture maintenance, and workload efficiency, all of

which are directly addressed by EZTransfer's layered design and integrated pulling mechanisms (de Castro et al., 2006). Complementing this, safe patient handling frameworks, such as the National Institute for Occupational Safety and Health (NIOSH) guidelines and the American Nurses Association (ANA) standards, advocate for the elimination of manual lifting above 35 lbs, the use of assistive devices, and the prioritisation of patient safety and carer injury prevention (Nelson et al., 2006). By aligning with these theoretical models, EZTransfer not only responds to practical clinical challenges but also embodies evidence-based design principles that support sustainable, safe, and efficient healthcare delivery.

**Problem Statement**

The persistence of high injury rates despite decades of awareness and intervention efforts underscores the urgent need for innovative, user-centred, and user-friendly transfer solutions. Humrickhouse and Knibbe (2016) concluded that multifactorial safe patient handling programs incorporating both training and equipment are essential, as neither component alone sufficiently reduces the risk. However, the effectiveness of such programmes depends critically on the design and usability of the provided equipment.

Implementation studies have identified practical barriers to the effective use of available transfer equipment, including inconsistent use and maintenance of lift sheets and equipment, situational instability when relying on improvised manual techniques, and lack of adherence to best practices despite the availability of devices and guidance (Norris, 2019; Wiggermann et al., 2016). These implementation gaps perpetuate risk, even in facilities that have invested in transfer equipment, suggesting that device design and usability are critical factors in achieving sustained safety improvements.

Despite the availability of transfer aids, significant gaps remain in safe patient-handling practices. Current devices often require multiple staff members, increasing labour demands and delaying emergency care. High friction and inadequate support contribute to unsafe transfers, patient discomfort, and injury among staff. In Malaysian hospitals, the lack of proper tools leads to a reliance on manual lifting, which exacerbates musculoskeletal strain (Yusof & Mohd Shalahim, 2020).

Unsafe transfer practices have consequences that extend beyond individual caregiver injuries. The persistence of manual patient handling contributes to nurse burnout, patient harm, and workflow delays (Dall'Ora et al., 2020). High injury rates create a cycle of staff absence, increased workload for the remaining personnel, and further injury risks. Patient safety is compromised when inadequate equipment forces the reliance on unstable or high-friction transfer methods. In emergency settings, delays in assembling a sufficient staff for manual transfers can impact time-critical care delivery.

There is an urgent need for transfer devices that integrate evidence-based design principles, such as friction reduction, ergonomic handles, patient stabilization, and cushioning, into a practical and affordable solution that can be rapidly implemented in diverse clinical settings. Such devices must reduce staff requirements, minimize physical strain, enhance patient comfort and safety, and support efficient workflows in both routine and emergency transfers.
EZTransfer was conceptualized to address these evidence-based needs through a multilayer ergonomic design that integrates friction reduction, stability enhancement, patient comfort, and ease of use into a single, cost-effective device suitable for widespread adoption in hospital and home care settings.

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**Significance of the Innovation Project**

The significance of the EZTransfer innovation lies in its potential to substantially improve patient comfort, caregiver safety, and healthcare system efficiency through a scientifically grounded and practical design. For patients, the device enhances comfort through cooling and cushioning layers, reduces the risk of rolling or slipping via integrated belt straps, and minimizes shear forces during movement. For healthcare providers, EZTransfer lowers musculoskeletal strain, decreases staff requirements, accelerates transfer times in high-acuity settings, and reduces the likelihood of occupational injuries. At the system level, its low cost, durability, washability, and potential to reduce injury-related expenses support widespread adoption and long-term sustainability.

The development of EZTransfer is firmly rooted in STEM integration, applying scientific principles of friction theory and biomechanics to reduce transfer forces, incorporating technological features such as low-resistance, waterproof fabrics to enhance hygiene and durability, and employing engineering methods to optimize its layered structure for strength, flexibility, and patient comfort. Mathematical modelling further validated its effectiveness by demonstrating reductions in physical effort and operational costs. Collectively, these interdisciplinary elements position EZTransfer as a robust, evidence-based solution that addresses persistent gaps in patient handling practices across diverse clinical environments.

**Research Methodology**

EZTransfer was developed using the 4D Development Model, which consists of four systematic stages: Define, Design, Develop, and Deliver. This structured approach ensures that the innovation is grounded in real clinical needs, supported by scientific principles, and refined through iterative prototyping and evaluation.

***Define Stage***

The Define stage focuses on identifying the limitations and shortcomings of existing patient transfer methods. Current tools such as slide boards, draw sheets, and manual lifting techniques pose several challenges, including:

- High friction that increases physical strain on healthcare workers
- Instability that may cause patients to roll or slip during transfers
- The need for multiple staff members to address workflow inefficiencies
- Discomfort for frail, obese, or critically ill patients
- Increased risk of musculoskeletal injuries among nurses

Through interviews with nurses, nursing students, and clinical instructors, the team identified recurring issues such as back pain, fatigue, and reliance on manual lifting due to inadequate equipment. These findings highlighted the urgent need for a safer, more ergonomic, and user-friendly transfer device. EZTransfer aims to address these gaps by reducing friction, improving stability, and minimising staff burden.

***Design Stage***

In the Design stage, EZTransfer was conceptualised with a strong emphasis on ergonomics, patient comfort, and clinical practicality. The design integrates multiple functional layers and structural components to overcome the limitations of conventional transfer tools.

Key design features include:

- Cooling Top Layer: Enhances patient comfort by reducing sweating and heat buildup.
- Middle Padding Layer: Provides cushioning for frail or bony individuals.
- Waterproof Base Layer: Creates a smooth, low-friction surface to facilitate sliding.
- Non-Slip Backing: Prevents the device from shifting during transfers.
- Pulling Handles: Positioned on both sides to allow secure, ergonomic manoeuvring.
- Belt Straps: Stabilise the patient and prevent rolling or slipping.

The selection of durable, washable, and waterproof materials ensures longevity and hygiene, reducing the need for frequent replacements and supporting sustainable clinical practices.

***Develop Stage***

During the Develop stage, a fully functional prototype of EZTransfer was constructed based on the design specifications. This phase involved:

- Material testing to evaluate friction reduction, durability, and waterproof performance
- Iterative refinement of the layered structure to optimise strength and flexibility
- Adjustment of handle placement and belt strap configuration for ergonomic efficiency
- Preliminary usability testing with mannequins and simulated patient transfers

Feedback from nursing staff and clinical educators guided improvements to ensure that the prototype met the practical needs of real-world clinical environments. This iterative process allowed the team to refine the device before moving toward broader testing.

***Deliver Stage***

In the Deliver stage, EZTransfer will be introduced into real-world clinical settings for further evaluation. Planned activities include:

- Clinical trials in emergency, orthopaedic, and medical wards to assess effectiveness, safety, and user satisfaction
- Training sessions for nurses and caregivers on proper installation and use
- Workflow integration, ensuring compatibility with existing hospital protocols
- Data collection on transfer time, staff exertion, patient comfort, and safety outcomes

Following a successful evaluation, EZTransfer will be refined for large-scale production and potential commercialisation. This stage ensures that the device is not only functional but also feasible for widespread adoption in hospitals and home-care settings.

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## Comparative Analysis

The comparative analysis clearly shows that EZTransfer outperforms conventional slide boards across all major operational, ergonomic, and patient-centred dimensions. It reduces staff burden, enhances safety, improves patient comfort, and offers a more economical and portable solution. For institutions aiming to modernize patient transfer practices, EZTransfer represents a practical, efficient, and user-friendly innovation. It was shown in Table 1.

**Table 1: Comparative Analysis Between the Conventional Slide Board and EZ Transfer**

| Feature | Conventional Slide Board | EZTransfer |
|---|---|---|
| Staff Required | 3–4 | 2 |
| Friction Level | High | Low |
| Patient Stability | Moderate | High (belt straps + non-slip backing) |
| Comfort | Limited | Cooling + cushioning layers |
| Portability | Moderate | High |
| Cost | Moderate–High | Low |

## Expected Outcomes

### *Intended Outcomes (Design Goals)*

EZTransfer was designed with the following goals in mind:

- Reduce transfer strain by incorporating an anti-friction, waterproof, layered towel system.
- Enhance patient safety and comfort through cushioning, cooling layers, and stabilising belt straps.
- Minimise staff injury risks by lowering the physical burden and enabling transfers with only two staff members instead of four.
- Improve workflow efficiency in hospital environments, particularly in emergency and orthopaedic departments where rapid transfers are critical.
- Support home-care settings by providing caregivers with a lightweight, portable, and user-friendly device.

### *Measured Outcomes (Future Work)*

Future evaluation will focus on systematically measuring EZTransfer's effectiveness in clinical and simulated settings. Planned outcomes include:

- Quantitative reduction in pulling force compared to conventional slide boards, measured using biomechanical tools.
- Decrease in musculoskeletal strain and injury incidence among nurses, assessed through occupational health surveys.
- Improved patient comfort scores, evaluated via patient feedback and observational studies.

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- Reduction in staff requirements and transfer time, measured during clinical trials in emergency and orthopaedic wards.
- Cost-effectiveness analysis, comparing EZTransfer with existing transfer devices in terms of purchase, maintenance, and injury-related absenteeism.

**Innovative Product Design**

EZTransfer incorporates practical and ergonomic features as below:

| Component | Functionality |
|---|---|
| **Cooling Top Layer** | Reduces sweating and cooling, improves patient comfort |
| **Middle Padding Layer** | Soft cushioning to protect bony or frail individuals |
| **Waterproof Base Layer** | Waterproof and smooth surface to lower friction |
| **Non-Slip Backing** | Prevents the towel from shifting during the transfer |
| **Pulling Handles** | Positioned on both sides for secure manoeuvring |
| **Belt Straps** | Prevents the patient from rolling or slipping during movement |

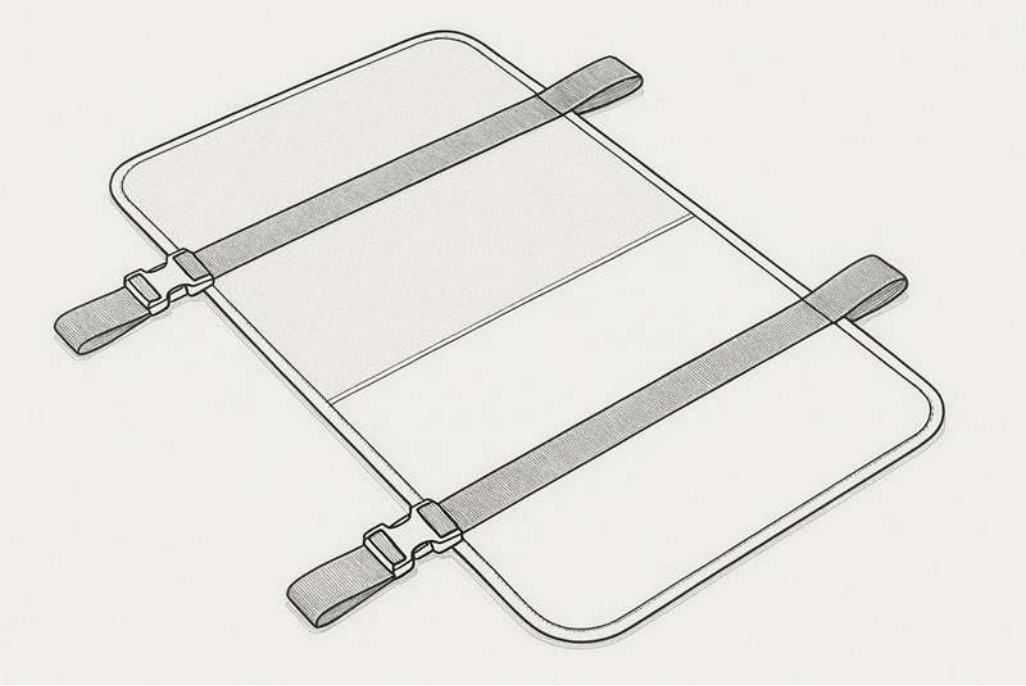

**Diagram 1: Initial Prototype**

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**Diagram 2: Final Prototype**

**Diagram 3: Smooth Padding Layer for Easy Pulling**

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**Diagram 4: Belt Straps to Secure the Patient To The Bed**

**Diagram 5: Handle At Both Ends for Easy Pulling**

## Conclusion

EZTransfer represents a significant advancement in safe patient handling. By integrating ergonomic design, STEM principles, and the 4D developmental model, the device addresses critical gaps in current transfer practices. Its potential to reduce staff injuries, enhance patient comfort, and streamline clinical workflows positions EZTransfer as a valuable innovation in

hospitals, emergency departments, and home-care settings. With further testing and refinement, EZTransfer holds strong potential for national adoption and commercialisation in the future.

| | |
|---|---|
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