Ergonomically Designed Smart Hospital Bed with Attachable – Detachable Stretchair

Sherrie Joy De Leon, Ron Jude Joshua Gripo, Benedict Ian Jimenez, Raycee Kim Tagle, Engr. Felbert Castañaday & Engr. Jesa Ornopia
College of Engineering, Computer Studies and Architecture, Lyceum of the Philippines University - Cavite

Abstract— The purpose of this study is to develop medical equipment that can help the health-care workers in transferring the patient from a hospital bed to other medical equipments such as a wheelchair and a stretcher effectively and without the very-high-risk of injury involved with it. This semi-automatic integrated medical equipment can be used as a (1) Hospital Bed (2) Stretcher (3) Wheelchair. The main objective of the study is to reduce the Musculoskeletal Disorder (MSD) that has a very-high-risk Rapid Entire Body Assessment (REBA) score of (12) among healt-hcare workers who performs the said process. The proponents used the Rapid Entire Body Assessment (REBA) to evaluate the whole-body postural MSD and risk associated with the job task. Under REBA ergonomic assessment, the REBA score was reduced from a very-high-risk score of (12) to a medium-risk-score of (7) when the proposed equipment was used. The system was tested to prove that the device is functioning effectively and safely for the target users. The Accuracy, Funtionality, and User-Friendliness Test has been conducted. The device was proven accurate, fuly functional and is user-friendly based on the test results undertaken.

Index Terms— *Ergonomics, Hospital Bed, Musculoskeletal Disorder*

INTRODUCTION

Health-care workers frequently moves patients from different medical equipments such as from hospital bed to wheelchair and stretcher for meal, hygienic or other purposes with such complicated physical job, they experience work-related issues on handling patients, majority of them experience back pains and musculoskeletal disorders. Healthcare workers are at risk for musculoskeletal disorders because of the numerous ergonomic hazards present in the workplace. Ergonomic hazards are defined as a physical factor within the environment that may cause harm to the musculoskeletal system such as repetitive movements and manual patient handling.

In the Philippines, healthcare workers like nurses, nursing assistants and hospital porters are involved on patient handling activities like lifting and transferring of patients. In 2007, according to Occupational Health and safety Issues among Nurses in the Philippines, work-related problems among a sample of nurses in the Philippines are described. A survey was collected during Philippine Nurses Association 2007 convention and measures included four categories: work-related demographics, occupational injury/illness, reporting behavior, and safety concerns. Approximately Forty percent (40%) of nurses had experienced at least one injury or illness in the past year, and Eighty percent (80%) had experienced back pain. Filipino nurses encounter considerable health and safety concerns that are similar to those encountered by nurses in other countries.

In addition to this issue, the researchers conducted a study among the healthcare workers of M.V Santiago Medical and Diagnostic Center located in Poblacion 3, Indang, Cavite which is specialized in medical consultation, fast and accurate diagnostic service, wellness services and emergency services. In this study, the researchers were able to gather data through interviews, observations and survey questionnaire. The researchers considered twenty – five (25) respondents healthcare workers who are involved in the process of lifting and transferring patient from hospital bed going to wheelchair and stretcher and they are Institutional Worker Department (IWD) and nurses. It was found out from the collected survey questionnaires that 100% of those healthcare workers revealed that the process and technique used in transferring patient from bed to stretcher and wheelchair are both manually and does not use any lifting equipment. It was determined that this process contributes a big factor on having body pains from lifting and transferring of patient from bed to stretcher or wheelchair, since the survey results tells that 100% of those healthcare workers who are involved in the said process experiencing pain on different parts of their body. By using Rapid Entire Body Assessment (REBA), Musculoskeletal Disorder factor was described on both processes, with a risk score of twelve (12) which means very high risk and need to implement change.

Thus, the researchers came up with the idea of designing an ergonomically smart hospital bed with attachable – detachable "Stretchair". The term "Stretchair" is the combination of stretcher and wheelchair, and the stretcher which is the detachable part of the hospital bed can be assembled and transformed into a wheelchair. The equipment will help lessen the risk of Musculoskeletal Disorder (MSD) and provide a safer and comfortable process of transferring patient without putting the

- *Sherrie Joy De Leon, Ron Jude Joshua Gripo, Ian Jimenez and Raycee Tagle is currently pursuing undergraduate degree program in industrial engineering, electronics engineering, computer engineering and mechanical engineering respectively in Lyceum of the Philippines University - Cavite, Philippines, E-mail: sjmdl24@gmail.com,Joshua.gripo@gmail.com,shinkuroro17@gmail.com,tagler@yahoo.com*
- *With their thesis advisers Engr. Felbert Castañaday and Engr. Jesa Ornopia Jr who are both a teaching faculy in Lyceum of the Philippines University – Cavite. Email: fillorana@gmail.com, pacorfabricationworks@yahoo.com*

healthcare worker's health at risk.

Literature Review

According to surveys from by the Department of Labor's Bureau of Labor Statistics (BLS), there are more than 35,000 back and other injuries among nursing employees every year, severe enough that they might miss work. Nursing assistant and orderlies, each suffer roughly three time the rate of back and other musculoskeletal injuries as construction laborers. In terms of number of these injuries, BLS data shows that nursing assistants are in the second to the highest Musculoskeletal Disorder (MSD) cases and rates, one reason why nursing employees get this these injuries are by doing their everyday jobs of moving and lifting patients (Zwerdling et al.,2015).

The risk of back injury is a continuing problem for nurses. Patient-handling tasks (e.g., transferring patients on and off stretchers, repositioning patients on OR beds) are a major precipitating factor to this problem. Educating nurses about body mechanics has not been the answer to preventing back injuries; however, changing the physical demands of the job (ie, using an ergonomic approach) by using assistive devices (eg, friction reducers) has been proven to decrease perceived stress and injury rates and increase patient comfort. This article focuses on the problem of nurses' back and shoulder overexertion injuries and explores the application of ergonomics in the perioperative setting (Owen. 2000).

Synthesis

The review of related literature by the researchers is a mix of foreign and local articles. Based on the past studies and literature that had been gathered, the researchers believe that there is a huge risk in terms of physical injury among healthcare workers by using the traditional way of lifting and transferring of a patient. Therefore, the researchers considered all the related articles stated on the review of related literature as a guide in designing a new ergonomically designed smart hospital bed with attachable- detachable stretchair (stretcher and wheelchair) to contribute to the improvement of the work experiences of the healthcare workers that are involve in the process of lifting and transferring of patients.

Methodology

In this research, the proponents first determine thelevel of risk and the amount pain a typical health-care worker experience during the said process of transferring a patient. The proponents had used the Rapid Entire Body Assessment tool (REBA) in determining the level of risk, Visual Analogue Scale (VAS) for determining the amount of pain of all the healthcare workers available in the hospital. Survey questionaires and interviews are used to gather and record these data.

REBA is an ergonomic assessment tool that uses systematic process to evaluate whole body postural MSD and risk associated with job task. The researchers used a single page worksheet to evaluate required or selected body posture, forceful exertions due to load, type of movement or actions, repetitions, and coupling with regard in the process of lifting and transferring patient from bed to stretcher or wheelchair. The researcher used a separated worksheet for the data in transferring patients from bed to stretcher and another datafor transferring patient from bed to wheelchair. Using the REBA worksheet, the researchers assigned a score for each of the following body regions: wrist, forearm, elbows, shoulders, neck, trunk, legs and knees. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk.

For design and technicalities, the proponents used an Arduino Mega Microcontroller to control the Stretchair's function such as inclination and declination of backrest's slope, emergency stop, magnetic locking mechanism, RFID access and registration of RFID cards. The proponents had used a linear actuator to incline or decline the backrest's slope, it can push a maximum load of 1800 N. A fail-safe magnetic lock is used to keep the Stretchair attached to the hospital bed, a 12V 26Ah battery is used to power the Stretchair and the Arduino Mega controls buttons that are connected to these functions.

After the design was completed, the proponents conducted a pretest and post-test on health-care workers that experienced the said transferring process of patients. The proponents had used the REBA assessment tool and the Visual Analogue Scale tool to compare the level of risk and the amount of paint in using the Stretchair versus the traditional way of transferring the patient.

Results and Discussion

The proponents had used the REBA worksheet and got a REBA score of (12), which means a very-high-risk score, and need to implement change (See Figure 1 and Table 1). Based on the result, the female nurses and nursing profession had the highest frequency that are involve on the process of transferring patients and are experiencing pain during transferring. Aside from profession and gender, ages of the healthcare workers were also considered, majority of age of healthcare on this activity ranges from 26 to 29 and 30 to 35. According to article entitled "Work related musculoskeletal disorders among hospital nurses in rural Maharashtra, India: A multi centre survey" , ages 25 to 35 of healthcare workers who are involved on transferring patients are more likely to carry, lift and transfer patients for they are the one who have enough strength and more capability on doing it compare to those personnel aged 35 and above.

The second part of the results shows the work experiences of forty – two (42) healthcare workers during Transferring and carrying of patients from Hospital bed going to Stretcher and to Wheelchair. It was proved that there is pain present for both processes. It was also determined that this process contributes a big factor on having body pains from lifting and transferring of patient from bed to stretcher or wheelchair, since the survey results tells that 100% of those healthcare workers who are involved in the said process experiencing pain on different parts of their body. See Table 2 and Figure 4.

To determine the effectiveness of the proposed prototype, the researchers conducted a Post and Pre – Test of the proposed Hospital bed equipment through survey questionnaire among twenty – five (25) Health care workers respondents of M.V Santiago Diagnostic and Medical Center. Some of the pre – test and post - test result was compared through statistical tool and analysis, and the interpretations will determine the effectiveness. By using the Stretchair's function the device significantly reduced the very-high-risk score of (12) to a medium-risk-score of (7) (See Fig.3), the Stretchair had eliminated the lifting process that typically injured most of our health-care workers. In terms of body pain, the device reduced the body pain specially in the lower back by 96%.

For technical testing the proponents conducted a functionatlity test, safety test and user-friendliness test. Based on the results the Stretchair is 94% functional, 100% safe and 93.33% user-friendly.

See the Stretchair's design in Fig. 3

Figures and Tables

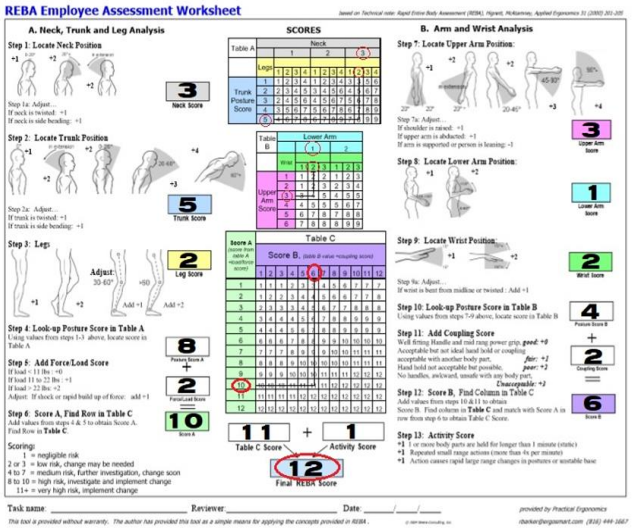


Fig 1. REBA Assessment Worksheet Score of (12) for hospital bed to wheelchair and hospital bed to stretcher process.

Table 1 REBA Score sheet

Score	Interpretation
1	Negligible risk, no action required
2-3	Low risk, change may be needed
4-7	Medium risk, further investigation and implement change
8-10	High risk, investigation and implement change
11+	Very high risk, implement change

Table 2 Level of Pain in Different Parts of the Body Experienced by the Respondents when Transferring/Carrying patients from hospital bed to Stretcher and vice versa

Body parts	Mean	Std. Deviation	Interpretation
Neck	0.69	1.158	No Hurt
Shoulder	1.81	1.311	Hurts a little bit
Upper Back	2.64	1.032	Hurts a little more
Elbow	1.02	1.220	Hurts a little bit
Lower Back	2.60	1.191	Hurts a little more
Arm Wrist	2.12	1.596	Hurts a little more
Thigh	1.71	1.367	Hurts a little bit
Knee	1.52	1.418	Hurts a little bit
Calf or Leg	1.57	1.417	Hurts a little bit
Feet or Ankle	1.38	1.481	Hurts a little bit
Finger	1.10	1.226	Hurts a little bit

Fig 3. REBA Score using Stretchair's function

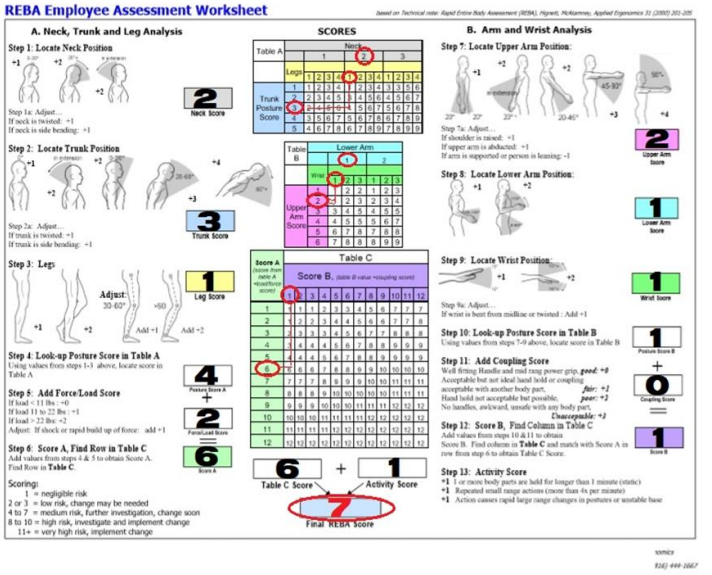
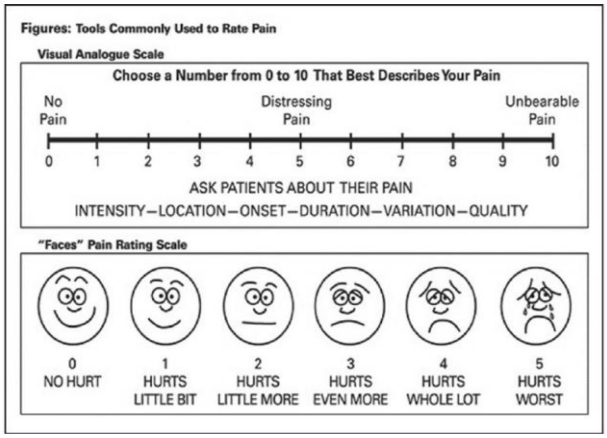


Fig 3. Stretchair Design

Fig 4. Visual Analogue Scale



Conclusion

In conclusion, using the new ergonomically design hospital bed, Testing method showed good results as the Risk of Musculoskeletal disorder was reduced from a score of 12 which means very high risk to a score of 7 which means medium risk, this comparison only tells that the proposed project is effective on reducing pain and risk of MSD among healthcare worker who are transferring patients.

The system can function normally depending on the user's desire and it is easy to use and learn, the results also shows that the system can do all its basic functions that the proponents expected that's why the functionality test has resulted to 94% functionality performance.

Recommendation

The following are the list of recommendation that would like to suggest by the researcher for future improvement and innovations of "Ergonomically Designed Smart Hospital bed with attachable – detachable Stretchair"

- For the material used, research for another lightweight stainless materials.
- For the automation, research for alternative components that would make the stretchair fully automated.
- Research for another mechanism that would make the prototype adjustable to its minimum and maximum standard height.
- Add a railing to inner side part of the stationary bed for easer attachments of the Stretchair.

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The Co-author was born in in July 9, 1997 in Manila, Philippines. The co-author is pursuing his BS Electronics Engineering Degree in Lyceum of the Philippines University – Cavite.

The co-author had been assigned as a Test Engineer at Artesyn Embedded Philippines, where most of his working time was spent developing softwares for the company. The co-author had also attended seminars such as: Technopreneurship for Engineers (2019), Trends and updates on Virtual Reality of Things (2019), Challenges and Opportunities in Biomedical Engineering Research (2019), and much more.

Ron Jude Joshua Gripo with his co-authors was awarded the prestigious award as the TESLA Award for Excellence in Research, Best Paper Presentation and most Outstanding Engineering during the 5th Research Colloquiuim that was held at Bayleaf Hotel Cavite, Philippines.

The co-author was born in September 12, 1996 in Dagupan City, Pangasinan, Philippines. The co-author earned her BS Industrial Engineering degree at the Lyceum of the Philippines University – Cavite in 2019.

The co-author had been assigned as a Quality Assurance Engineer at IM Digital Philippines. The co-author had also attended seminars such as: Technopreneurship for Engineers (2019), Six Sigma DMAIC Approach in Problem Solving (2019), TRIPLICITY: Applicationn of Industrial Engineering Core Knowledge, any many more.

Sherrie Joy De Leon with her co-authors was awarded the prestigious award as the TESLA Award for Excellence in Research, Best Paper Presentation and most Outstanding Engineering during the 5th Research Colloquiuim that was held at Bayleaf Hotel Cavite, Philippines.

The co-author was born in January 4, 1998 in Cavite City, Philippines. The co-author earned his BS Mechanical Engineering degree at the Lyceum of the Philippines University – Cavite in 2019.

The co-author had attended seminars such as: Technopreneurship for Engineers (2019), Challenges and Opportunities in Biomedical Engineering Research (2019), and much more.

Raycee Tagle with his co-authors was awarded the prestigious award as the TESLA Award for Excellence in Research, Best Paper Presentation and most Outstanding Engineering during the 5th Research Colloquiuim that was held at Bayleaf Hotel Cavite, Philippines.

The co-author was born in January 4, 1998 in Cavite City, Philippines. The co-author earned his BS Mechanical Engineering degree at the Lyceum of the Philippines University – Cavite in 2019

The co-author earned his BS Computer Engineering degree at the Lyceum of the Philippines University – Cavite in 2019.

The co-author had attended seminars such as: BIT Summit 2018: “Bringing Innovators Together” (2018), DevCon Summit 2018, Seminar on Github:”Making the most out of Git” (2017).

Benedict Ian Jimenez with his co-authors was awarded the prestigious award as the TESLA Award for Excellence in Research, Best Paper Presentation and most Outstanding Engineering during the 5th Research Colloquiuim that was held at Bayleaf Hotel Cavite, Philippines.