Australian National University

Analysis of Wheel Chair System

How can the quality of life of older (age over 65) Wheel chair users be improved by Optimising current wheelchair system?

ENGN2226 Systems Engineering Analysis

[Research portfolio]

[Natasha Disha-u5394477]

Date-17-10-2016

Abstract

There are ranges of issues arise when an individual with disability starts using wheel chairs. This report has particularly investigated the issues experienced by the older wheel chair users in Australia. The research has been conducted based on an anonymous survey carried out among older (aged over 65) wheel chair users in three different residential care facilities. Heavy weight of the wheel chair that causes difficulty in the maneuver procedure, uncomfortable seat that causes pressure injuries and inconvenient storage facility with the wheel chair are identified as the main problems in the current wheel chair system. Replacing the material of the wheel chair frame, introducing an automatic massage feature, an automatic braking feature and a compartmented storage box have been proposed in the new wheel chair design. This new improved design has been analysed using system perspective tools.

Table Of Contents

1.0 Background

The number of elderly population is growing at an increasing pace across the world (El-Shafie, 2008). According to the Australian Bureau of Statistic 2015 current population of older Australians is around 3.5 million, which is 15.1% of the total population (nearly one in seven people). Among this large older population around 1.8 million older Australians are living with disability (7.7 percent of the total population) while more than 654000 older Australians have severe disability and have the greatest need for assistance with core activities-communication mobility on self care (Disability, Ageing and Carers, Australia: First Results, 2015). Therefore, understanding the mobility and accessibility needs of this growing number of people living and maintaining active lives well into their 80s is at utter importance.

Research showed that the quality of life of older people can be improved by maximizing the function of the mobility equipment and by decreasing pain. Similarly improving the ability to self-propel, and prolonging mobility and endurance through ergonomics, selection and configuration of individualized wheelchair also improve the quality of life of the older wheel chair users (Requejo, Furumasu & Mulroy; 2015).

This paper takes a close look at the evidence on the mobility needs of individuals over 65 and the challenges associated with this. This research project has been conducted based on data collected from a survey conducted among the older wheel chair users who are from three different aged care organizations of Canberra and Queanbeyan.

Eight research methods have been used in this project to analyze the collected data and set the customer requirement. The main customer requirements are as follows: ensuing easy maneuver of the wheel chair, ensuring comfort while sitting on the wheelchair, a convenient storage system with the wheel chair and reducing the weight of the wheelchair.

Against the customer requirements the final design includes three new features in the current manual wheel chair system as such-automatic braking feature, automatic massage feature, and a compartmented storage box. The material of the wheel chair has also been replaced by different material. The validity of each feature has been analyzed using research in relevant area (Requejo, Furumasu & Mulroy; 2015). System perspective techniques have been used to analyze the validity of the proposed design.

2.0 Research Methods

2.1 Research Scope:

A research question has been used to specify the scope of this report. The research question is ***'How can the quality of life of older wheel chair users be improved by optimizing current wheel chair system?'*** The research question indicates that the focused population is the older wheel chair users. It is also indicated that the goal of the research is to improve the quality of life of the target population.

2.2 Preparation of the analysis:

2.2.1 Conducted surveys to determine issues

Formal survey has been conducted in three different organizations including **'Jindalee Aged care residence', Queanbeyan residential care' and 'Warringal Residential care'.** The responders were elderly wheel chair users aged over 65. The total number of responders was 19 who use ranges of wheel chairs including manual, electrical and automatic. The survey questionnaire was prepared after analyzing academic sources. The link of the survey questionnaire has been provided in the reference. The survey was completely anonymous.

The questionnaire consisted of eleven different questions including personal information of the responder, demographics and self-assessment, current wheelchair characteristics and driving scenarios. The questions identified the participant's sex and age, impairment/disability, the wheelchair model, length of the time they are using the current wheel chair for and list of difficulties experienced by the users in different environments. The survey also investigated the improvement preferences of the wheel chair users (Disability and Rehabilitation: Assistive Technology, 2012).

For participants to be eligible to participate, they had to meet the following inclusion criteria:

- The individual must be a wheel chair user
- The individual must be over the age of 18 yr.

The study did not focus on a specific disease or disability and no participants were excluded based on race, ethnicity, sex, or HIV status (Fowler, 2013).

2.2.2 Ethical Concerns

The survey has been carried out in ways designed to avoid risks to participants, respondents, and interviewers. Every responder has signed a consent form prior to answer the survey questions (Sieber, J. ed., 2012.). Additionally, both director of the organizations and the researcher have signed an ethical approval form. Some of the interviewees were unable to sign the consent form in that case the users' family members and in charge registered nurses have signed the consent forms.

Respect, responsibility and honesty have been ensured in the entire process of the survey.

Respect: In order to protect the survey responders the information gathered from the survey has been treated with respect, therefore confidentiality has been maintained in the entire process. Some standard procedures that careful survey researchers take to minimize the chances of a breach of confidentiality are as follows:

- Links between answers and identifiers has been minimized. Common identifies such as names, e-mail or postal addresses, and telephone numbers have not been asked to execute the survey.
- A coded id number has been used in the data organization.
- Specific identifiers from the consent forms have been readily separated from the actual survey responses.

- The survey responses have not shown to any individual who might identify the respondents from their profile of answers; for example supervisors in the case of a survey of employees,
- An ID number has been used for each responder in the actual data files. The link between the ID number and the identifiers from the consent form are not available to general users of the data file.
- During analysis, researcher was careful about presenting data for very small categories of people who might be identifiable (Fowler, 2013).

Responsibility: The interviewer has taken the responsibility that the responders are fully aware of the purpose of the survey during the survey process in order to avoid deceptive, misleading, or inaccurate response. Once the research has been completed the researcher has taken the responsibility to destruct the survey research instruments or continue secure storage (Fowler, 2013).

Honesty: All the information that has been provided to the survey interviewees and the organizations were true. The permission form has been signed by the researcher as well as the researcher to make sure both are honest in their action (Fowler, 2013).

2.3 Data Processing

2.3.1 Data organization

Organization of the collected data assisted to set the customer requirements by categorizing the number of problems wheel chair users are facing during wheel chairs usage have been shown in table 1. The following steps have been taken to organize the data:

- The data collected from the survey has been entered manually in a spreadsheet.
- The characteristics have been defined by giving an ID to each observation.
- Brief, lowercase, consistent column names have been used.
- In order to avoid error no column has been left empty. NA was used to describe a definitive empty cell.

ID Number	Gender	Current wheel chair type	How long been using it for	How much do you want to pay for a wheel chair	Preferred changes	Do you want to have more automatic features in this new wheel chair
1	Male	Manual	5 years	Below $5000	Easy maneuver	Yes
2	Female	Electric	5-10 years	Below $5000	Easy maneuver	No

Table 1: First two rows of data organization

2.3.2 Error types

It was attempted with caution to minimize the errors in the survey.

Sampling Error: Any error that arises from the unrepresentativeness of the sample taken has been minimized by only conducting survey among wheel chair users. The wording has been taken into account very carefully. The question that included time span of wheel chair users includes a range of years e.g.5-10 years instead of using specific years as For example- questions that rely on memory recall only asked about last couple of years to avoid relying on memory recall. The multiple choice type questions have included: options –A/B/C/others, so all the respondents were able to answer.

Non-Response Error: No data is included or excluded in the sample that ensured there is no coverage error. There is no non-response error as there was no failure to obtain a response. However, whether the respondents intentionally or accidentally provided inaccurate response, interviewer recorded incorrect data or any processing error - error as a result of inputting or coding has been occurred that was not been ensured. Also to minimize the error number of initiatives have been taken the survey have been conducted in an aged care residents, so the sample represented the larger group of wheel chair users.

2.4 Data Analysis (Quantitative and Qualitative Analysis)

2.4.1 Coding research data & Descriptive Statistics

The data analysis includes both the qualitative and quantitative analysis in this project. The quantitative data showed the pattern of the data while the qualitative data provided specification of the responses.

The data collected from the questionnaires were entered into a Microsoft Excel spreadsheet and analyzed with conventional descriptive statistics such as frequencies, means, and standard deviations. Descriptive analyses were performed to evaluate the distributional characteristics of the dimensions, as well as the correlation of selected dimensions by gender and chair type. From the analysis implies that 95% of the total responders use manual wheel chair. Academic research shows that those who have lower limb disabilities are often dependent on manually propelled wheelchairs for their mobility (Van der Woude, de Groot and Janssen). It means most the responders were with lower limb disabilities.

The mean time a user use the wheel chair for is 7 hours. And the standard deviation of the wheel chair use hour is 5 hours. The median wheel chair using time is 8 hours, which is a significant portion of the users' daytime. Research shows that long hours of sitting in the same equipment may cause serious pressure injuries that have serious consequences. Thus, there is a room for improvement.

To further investigation some qualitative questions have been asked to the users. Coding method has been used to analyze those qualitative data (Edwards, Lampert, 2014). The qualitative analysis includes the comment of the users about their everyday difficulties. Among 19 responders of the survey half of them addressed that they face multiple issues during using wheel chairs. For example, when the question '' what are the main issues faced

by wheelchair users?'' was asked 67% of the responders responded easy to maneuver. In response to the followed up interview question "why is it hard to maneuver?" most of them answered they feel the wheel chair is too heavy in certain situation to maneuver. Research has found that the user often is at high risk of shoulder injury and whole-body vibration due to wheelchair propulsion (Saldaña, J., 2015). Therefore, reducing the mechanical work required to maneuver the wheel chair is set to be a customer requirement of this project (Chénier, F. and Aissaoui, R., 2014).

Furthermore, to analyze the cost some qualitative and quantitative question has been asked in the survey. In the response to the question' how much are you willing to pay for an automatic wheel chair if you would have to buy one?" One of the users answered ''I want comfort, even if I can't pay my daughter will''. The answer indicates how important it is for the users to be in comfort.

In contrast, for the same question a different user who does not use the wheel chair for long hours showed strong reluctance to spend $5000 to buy a new wheel chair. Therefore, another customer requirement would be to keep a balance between the cost of the wheel chair and the benefit the user will get from using the wheel chair.

Around 70% of the wheel chair users stressed the fact that they find it hard to maneuver the manual wheel chair. But when it was asked that if they think adding more automatic feature will improve their quality of life, they answered 'No'. However, two of the responders asked if it is possible to design a manual wheel chair that will become automatic in certain circumstances such as in the curve or uneven surface to ease the maneuver procedure. This analysis indicates that the users need some more features in the current wheel chair system to improve their quality of life.

3.0 Solution Design Proposal

From the data analysis the following features of the wheelchairs have been found as potential improvement:

- Easy to maneuver feature
    - Reduction of the weight of the wheel chair by replacing the material
    - Automatic motor brake
- More comfortable feature
- Storage units

➢ The Easy to maneuver feature:

(a) Material Replacement:

The main obstacle of introducing an easy to maneuver feature is the heavy weight of the wheel chair. To reduce the wheel chair the material of the wheel chair can be replaced by Aluminium. The properties of Aluminium indicate that it will be the best replacement of the materials. The properties are as follows:

Weight: Aluminium is light in weight. The density of Aluminium is also very low. The density of Aluminium is one third that of steel, 2,700 kg/m3. Although the low density of Aluminium accounts for it being lightweight, the low density does not affect its strength.

Strength: The tensile strengths of Aluminium alloys are commonly between 70 and 700 MPa. For Aluminium the range for alloys used in extrusion is 150 – 300 MPa. Most steel grades do become brittle at low temperatures, but Aluminium does not. Instead, the strength of Aluminium increases. However, at high temperatures Aluminium's strength decreases. At temperatures continuously above 100°C, strength is affected to the extent that the weakening must be taken into account (Aluminium design, 2016).

Machining:

Aluminium is easily worked using most machining methods – milling, drilling, cutting, punching, bending, etc. Furthermore, the energy input during machining is low. This is one of the most efficient reason that Aluminium can be a suitable replacement of the material.

(b) Automatic braking motor:

According to research the manual wheel chair users feel more independent and their attempt to maneuver their wheelchair themselves often help their muscle movement (Caspall, Seligsohn, Stephen Sprigle 2013.). Therefore in order to introduce a solution offering automatic wheelchair will not be an effective solution. In this situation, introducing an automatic motor that will be turned on in certain occasion can be an effective solution. In this case a power wheelchair gear motor shown in Figure 2 will be used in the new design. The feature of the gear motor is given bellow:

- Dependable, quiet gear motors for reliable, long life operation
- Output power ranges from 150w to 1300w
- The Diameter of the motor ranges from 63mm to 105mm
- The Loading of the motor ranges from 280 lbs to 1000 lbs

*Figure 2: Power Wheelchair Gear motor (*Telco Motion http://www.telcointercon.com/Power-Wheelchair-Drive-Gearmotor-id89.html#Table96 *)*

Power Wheelchair Gear motor							
Part No	Output Power	Voltage	Current	Speed	Gear Ratio	Brake	Noise
	W	V	A	RPM		DC 24V 0.5A 20Kgf-cm	dBA
GZD082-15	150	24	2	3200±100	1:32	DC 24V 0.45A 30Kgf-cm	62
GZD071-15	150	24	2	3200±100	1:50	DC 24V 0.5A 20Kgf-cm	60
GZD082-20	200	24	2	3800±100	1:32	DC 24V 0.5A 40Kgf-cm	62
GZD124-20	200	24	2.5	2800±100	1:20	DC 24V 0.5A 20Kgf-cm	62
GZD082-25	250	24	2.5	4200±100	1:32	DC 24V 0.5A 20Kgf-cm	62
GZD082-30	300	24	3	4200+_100	1:25	DC 24V 0.5A 40Kgf-cm	65
GZD082-30D	300	24	4.5	5200+_100	1:25	DC 24V 0.5A 30Kgf-cm	62

*Table 2: Power Wheelchair Gear motor (*Telco Motion http://www.telcointercon.com/Power-Wheelchair-Drive-Gearmotor-id89.html#Table96

The table 2 shows the power distribution of the power wheel chair Gear Motor. The motor is self operated and can be turned on in certain situation. Therefore this feature won't affect the independence of the wheel chair users.

- **More comfortable features:**

As the users often sit on the wheel chair for long hours it causes muscle cramps and pressure sores. Either affliction can be a great source of discomfort. Although two of the responders mentioned that they use roho cushion (Development and evaluation of a seating aid cushion system for wheelchair bound, paralyzed people, 2014) they still need to be repositioned with the help of the carers. According to the research this manual repositioned feature often cause back injuries for the carers. Therefore, the new design included a self-operated massage option that will help the wheel chair users to avoid pressure injuries.

The first feature is to integrate the wheelchair with a massage chair that relies on a combination of motors, gears, rollers and vibrating mechanisms. Although there are some complex massage chairs available in the market, the simple massage chairs provide a massage using a series of vibrating surfaces. Using small devices that contain a weighted wheel or gear creates the

vibration. Avoiding the centralization of the weight of the wheel chair unbalances the wheel. The vibration occurs due to the rotation of the wheel rapidly that is caused by the rotation of electric motor. However, entire chair is not unbalanced, so the wheel chair is safe (massage chair, 2015).

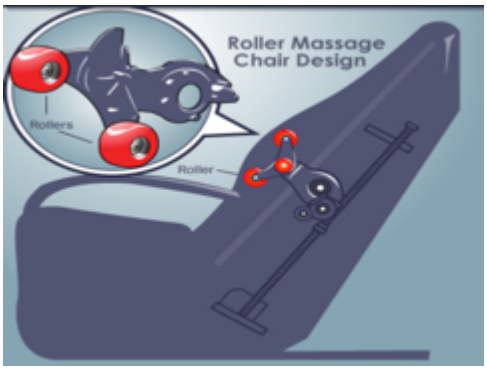

Figure 3: Massage chair mechanism
(How stuff works, 2016)

Figure 4: Electric Motor (http://electronics.howstuffworks.com/electric-motor-pictures.htm)

During the massage procedure in the chair the roller of the chair acts like a human hand. The structure of the frame determines the pattern the rollers move with. The energy of the roller is provided by the electric motor showed in figure 4. However, the massage chair mechanism is shown in figure 3.

- **Storage units:**

Storage is needed to add to this new wheel chair design. The storage should be compartmented. The necessary belongs of the wheel chair users are as follows: glasses, watches, skin protect creams, snacks, towels, washers, money or expensive belongings, water bottle. In the new design, the storage is added underneath the hand rest. The hand rest is removable. Each hand rest can be divided into three different compartments. Each hand rest can carry 0.5kg of belongings (*Chair with movable arms and tables sections, 2013)*.

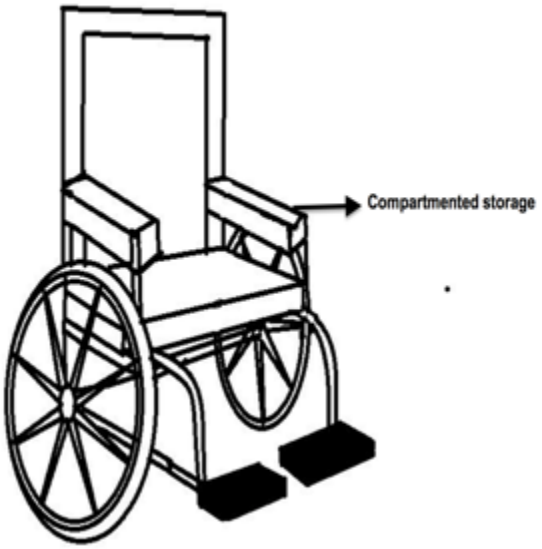

Figure 5: Storage units

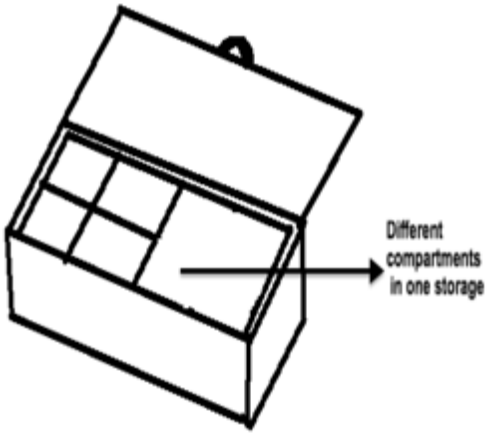

Figure 6: compartmented Storage units

A storage box comprises a rectangular bottom, a rear wall, a front wall, a first end wall closing one end of said box, a second end wall hinged to one of the front and rear walls for opening and closing the other end of the box and a cover hinged to the rear wall for opening and closing the box at the top, the box being dimensioned to permit a lawnmower or they like to be run into said box through the end with the hinged end wall swung open and then stored within the box with the hinged end and the cover closed (McCarthy, 2011).

4.0 Proposed Design Analysis Using System perspective

4.1 Time considerations

4.3.1 Planning Approaches:

The Gantt chart is a chart that is used to plan the entire project. In the following Gantt chart series of horizontal lines has been used to show how long the individual task has taken to be completed. The project work has been divided into 9 different tasks including market research, defining specification; project planning, physical model designing, wheel chair manufacturing, test plan, testing and Q/A and user documentation (Oracle International Corporation, 2016)

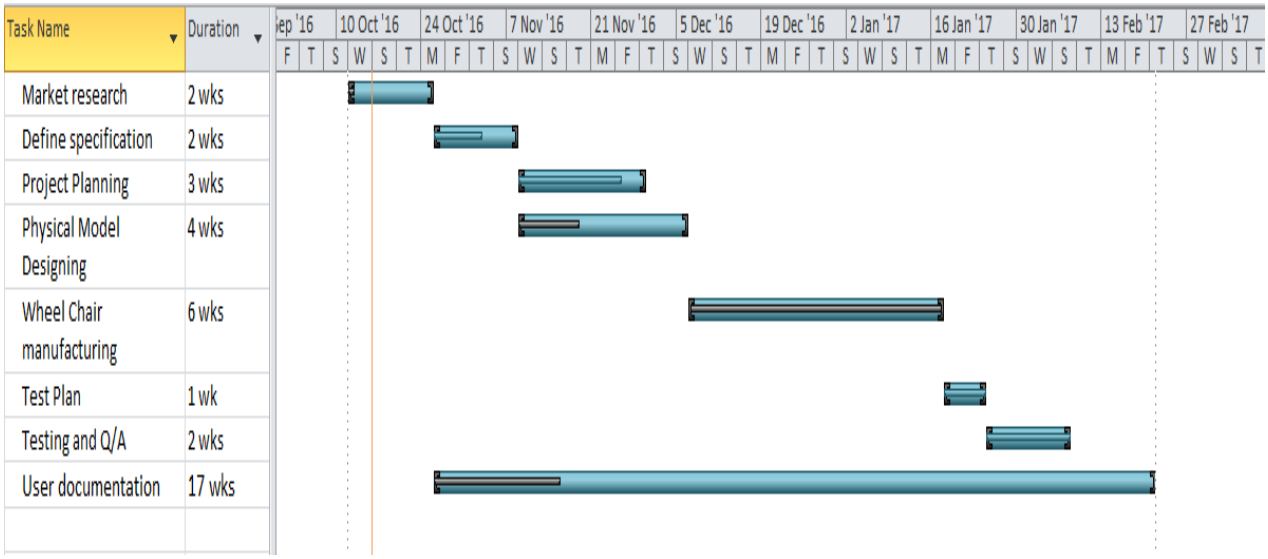

Figure 7: Gantt chart

From the Figure 7 it can be found that the user documentation will start right after market analysis and will take the entire time slot documenting the details. There is extra two weeks allocated for the documentation after the final testing is finished.

It is also found that the market research is one of the most important tasks as it shapes the initialization of the project.

The testing plan is allocated just before the final testing; however, it can be done any time after the physical model designing.

The indicated time frame is only for the very initial manufacturing of the wheel chair. Once the very initial wheel chair is manufactured only the manufacturing time will be counted for the rest of the wheel chairs.

4.2 Design Dimension Consideration

4.2.1 Anthropometrics

The need to understand anthropometrics crosses many technology interfaces (Wheelchair Measurements, 2016). Anthropometrics refers to human measurements being taken into consideration when designing a system (Paquet, Feathers; 2004). Our system in this problem consists of 19 human beings who are all aged over 65 and use wheel chairs. The height of the wheel chair is designed such that it can fit a human subject that is 2.25552m tall, where the length of the knee to feet is .70m and length of the back from waist to head is .72m (Height of wheel chair back rest and height of the wheel char from foot rest to seat= 0.76+0.76m= 1.62m) [Australian Bureau of Statistics, 2016]. According to Australian Bureau of Statistics 220 people out of 7296 had a height greater than 190cms (approximately 0.0301), this covers over 99.969% spectrum of human height range. Taking into consideration the average width of a wheelchair that is 0.76m chose this.

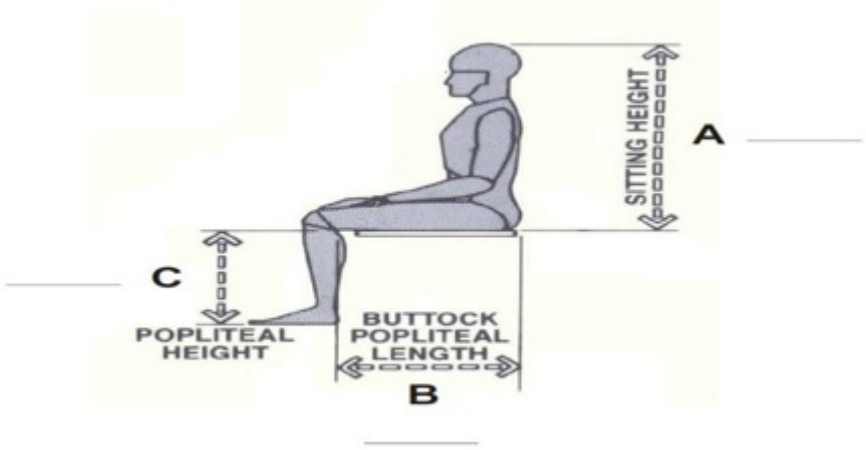

Figure 8: older people height measurements (Popliteal Length, http://www.keyword-suggestions.com/cG9wbGl0ZWFsIGxlbmd0aA/)

The Stature, sitting height and Buttlock height all three should be in acount for it. From research we find the measuremnets for both man and weman.

Male-Dimentions in millimeters												
Survey/Source	Stature				Sitting Height				Buttock-knee Length			
	Mean	Std Dev.	5th%ile	95th%ile	Mean	Std Dev.	5th%ile	95th%ile	Mean	Std Dev.	5th%ile	95th%ile
UNSW student	1757	72	1639	1875	925	49	845	1005	603	34	547	639

Table 2 : Height of male population in Australia

Feale-Dimentions in millimeters												
Survey/Source	Stature				Sitting Height				Buttock-knee Length			
	Mean	Std Dev.	5th%ile	95th%ile	Mean	Std Dev.	5th%ile	95th%ile	Mean	Std Dev.	5th%ile	95th%ile
UNSW student	1632	60	1534	1730	865	33	811	919	569	37	508	630

Table 3 : Height of female population in Australia

To accommodate the entire male and female population, a designer may choose to start the adjustment feature of the wheel chair minimum at 5th percentile female size and 95th percentile male size an the maximum (Ward, S., 2011).

Also the data from these surveys were filtered to include only subjects 19-25 years old. Research shows aging changes in bones, musles and joints; therefore, height loss is related to aging. An average human being losses 1-inch or up to 6cm in height as he ages (Minaker, 2011) (Shah K, Villareal DT, 2010). Therefore all the measurement should be adjusted to $\pm 600mm$.

4.3 Material design concerns

4.3.1 Material impact

The frames of the wheel chair are to be constructed from aluminium because of its lightweight as well as low-cost. The compartmented storage box will be some sort of plastic for the same reasons. This low-weight will also allow the user to maneuver for the users as well as the carers. In addition the new wheel chairs will reach a wider market, as it will be cheaper to transport.

Low life cycle cost encourages the customers to buy a product (Ilan & Ilan, 2013.). Therefore, the materials as well as the dimensions have been selected in order to minimize the product's life cycle cost.

The material impact has been discussed using the following table:

Part	***Material***	***Quantity***	***Mass***
Storage box	Acrylic Plastic	*200 x 200 x 100mm H*	*0.40 kg*
Frame	*Aluminium 6061*	*9 X 0.80 m*	*7.2. kg*
Massage operator			*1.5 kg*
Automatic braking motor			*1.6 kgs*
Total			*10.7 kg*

Table 4: material impact (Chénier, Aissaoui, 2014.)

From the table 4 it can be seen that the storage box uses Acrylic plastic, as it is light in weight (McCarthy, 2001). The total estimated weight of the material is 10.7kg.

4.4 Cost Analysis

4.4.1 Cost-Benefit Balance

The cost benefit balance of this project is very important, as it will determine if the user should invest money on it. Developing a Cost-Benefit Balance (EMB) to model energy use provides a starting point to underpin an effective benefit management system. A mechanical wheel chair assists understanding of the energy flows, mass flows, and other factors influencing energy use, to determine the efficiencies of processes and equipment. Thorough mechanical wheel chair system can reveal significant cost savings by identifying: In this project the cost and benefit balance has been ensured as the new design offered range of benefits.

4.4.2 Payback period

The payback period of a system is of concern when making decisions. Usually a decision involves a trade-off, where purchasing new equipment might have a higher upfront cost but allows for a lower ongoing cost, compared to the existing option that might have a higher ongoing cost. The payback period can be calculated as the time it takes for the new option to become cheaper than the existing solution. In this project the payback period has been found five years.

4.4.3: Life-cycle cost

The life cycle cost of the new design wheel chair is higher than the previous design as the previous design was only a manual wheel chair. The new design will require a charging facility for the electric motor for the massage feature and the automatic braking feature.

The life cycle cost includes the initial price that is needed to calculate. We can calculate some off the selves' product and calculate the price.

- ***Initial Cost –Non recurring cost***

Parts	Cost
A manual wheel chair cost	$300
Massage chair PU Leather M ass massage Chair Recliner Otto Human Lounge Remote Deluxe cost $	$470
Plastic box	$10 *2=$20
Total Price	$790

(https://www.disabilityshop.com.au/bariatric-transit-wheelchair-200kg-capacity-drive-btr22/?gclid=CP6SkOSF4M8CFQuVvQodiVMPZA)

The recurring cost includes charging the battery, yearly servicing of the automatic feature. The battery may need to be replaced. Most wheelchairs are covered by a warranty. Look for a chair with at least a three-year warranty.

4.5 Social & cultural

Most of the responders of this survey were local Australians who have been living here for at least few decades so cultural diversity did not make a huge difference in their perception about comfort safety and overall wheel chairs preferences. However, the social perspective played an important role while the question of the cost preferences have been asked. More than 70% of the responders answered that they are willing to pay less than $5000 to buy the wheel chair, although around 30% of the responders responded that compared to their need of the wheelchair the cost is not a concerning issue for them.

According to the Australian Government Department of Human Services the money provided by the government is only based on the eligibility for Disability Support Pension. That indicates that even if most of the users prefer having more comfortable wheel chair, the government will not provide the expenses only on the basis of the comfort or preferences of the users.

This observation gives a direction to the design of the new wheel chair that it is essential to keep the cost of the wheel chair less than $5000 otherwise not every user will be able to afford this new designed wheel chair.

5.0 Conclusion

The proposed wheelchair design is designed to determine solution to the issues found from the survey. This new design is economically feasible and cost efficient. The wheel chair can be recommended to the older wheel chair users; however, with little adjaustment it can be used by any wheel chair users regardless of their age.

However, there are some limitations of this new design. The main limitation of the new proposed design is to keep the weight as light as possible while the numbers of new features are being added. Aluminium has been identified as the most suitable replacement of the material to reduce the weight. However, the manufacturing cost of Aluminium is high and in most cases that is not affordable. This newly designed wheel chair can only be affordable if the Aluminium is used for the manufacturing is recycled.

6.0 Recommendation

Recommendation regarding Material replacement

The fact that aluminium has a relatively larger coefficient of linear expansion compared to any other metals has to be taken into account in this design. In addition, aluminium reacts with the oxygen in the air to form an extremely thin layer of oxide. This problem can be solved by using hundredths of a (my)m thick (1 (my)m is one thousandth of a millimetre layer. This layer provides excellent corrosion protection as density of this layer is very high. The most important use of this layer is it is self-repairing if damaged. Anodising should also added as it improves the strength of the natural corrosion protection by increasing the thickness of the oxide layer and thus. However, the thicknesses of between 15 and 25 is acceptable in outdoors for aluminium (Aluminium design , 2016).

Recommendation regarding Safety & risk

There is certain risk associated with the wheel chair usage, which is known as hazards. The possible hazards are muscular or skeletal injury to clients and workers from incorrect use of wheelchair and injury to clients or workers from use of poorly maintained wheelchair.

A recommendation of this project is to prevent risk of injury to workers or clients during this manual task. The following steps of this Safe Work Instruction (SWI) needs to be taken:

- Making sure that the area and route is clear of obstacles before moving wheelchair.
- In order to allow free flow of wheels forward and backward steps are needed to push
- To prevent hazards communication with the client and co- workers at every step of this task is also necessary
- Checked the condition of the wheel chair e.g. tyres are inflated, wheels roll properly and the brakes work correctly are also necessary.

- Signs of wear need to be checked if wheelchair has restraint.
- Ensuring the knowledge of wheelchair operation is necessary before using the wheelchair.
- The Standard Operating Procedure (SOP) needs to be reviewed if the user is unsure about any feature of the wheel chair. It is also acceptable to refer to the client's Support Plan or Care Plan for more specific information (Government of South Australia, 2016).

7. Reflections and Acknowledgements

This project work was done successfully with the help of Queanbeyan Aged Care Facility, Jindalee Aged Care Residence and Warringal aged care facility. I would like to thank the members of the management of those facilities who assisted me in the survey. I would specially like to thank to Bernedate and Zoe Costuna for providing their permission to carry out the survey in their organizations. I would also like to thank Marlisa (Endorse Nurse) for helping me to conduct the survey in Jindalee aged care facility.

I would also like to thank all the participant of this survey as they gave up their time to share their stories, insights and experiences of being a wheel chair user in this project. Furthermore, I would like to acknowledge and thank Dr Chris Browne and Claire Idris for helping me to make this research project a reality.

As reflecttion of the entire procudure I would say the interview process was certainly a life learning experience for me where I got to know 19 older people and their concerns. The experience drove me to think creative and realise the impact of humanitarian engineering.

8.0 References

[1] Aluminium design. (2016). Properties of aluminium. Retrieved 10 06, 2016, from aluminiumdesign.net: http://www.aluminiumdesign.net/why-aluminium/properties-of-aluminium/

[2] Australian Government Department of Human Services, *Disability Support Pension* September 2016

[3] Blach Rossen, C., Sørensen, B., Würtz Jochumsen, B. and Wind, G., 2012. Everyday life for users of electric wheelchairs–a qualitative interview study. *Disability and Rehabilitation: Assistive Technology*, *7*(5), pp.399-407.

[4] Caspall, J.J., Seligsohn, E., Dao, P.V. and Stephen Sprigle PhD, P.T., 2013. Changes in inertia and effect on turning effort across different wheelchair configurations. *Journal of rehabilitation research and development*, *50*(10), p.1353.

[5] Chénier, F. and Aissaoui, R., 2014. Effect of Wheelchair Frame Material on Users' Mechanical Work and Transmitted Vibration. *BioMed research international*, *2014*.

[6] Department of Communities and social inclusion. (2016) Government of South Australia, https://www.dcsi.sa.gov.au/services/disability-services/safe-work-instructions/use-of-wheelchair

[7] Edwards, J.A. and Lampert, M.D., 2014. *Talking data: Transcription and coding in discourse research*. Psychology Press.

[8] Electric Motor (http://electronics.howstuffworks.com/electric-motor-pictures.htm)

[9]El-Shafie, J.M., 2008. *Shoulder Pain among Rehabilitated Spinal Cord-Injured Persons who are Using Manual Propelled Wheelchairs in Gaza Strip: A Survey Study* (Doctoral dissertation, Islamic University–Gaza).

[10] Fowler Jr, F.J., 2013. *Survey research methods*. Sage publications.

[11] How massage chair works , (2016) *How stuff works* http://electronics.howstuffworks.com/gadgets/home/massage-chair1.htm

[12] Ilan, N. and Ilan, U. 2013. Motor operated wheelchair Umbrella. U.S. Patent 8,387,641.

[13] Kramer, K.L., Dahneke, M.S., Wilcox, R.N., Gaag, F., Schwanemann, D.T., Teufel, R.B., Koloski, P.A., Lothrop, T.K. and Berger, R.R., Hill-Rom Services, Inc., 2013. *Chair with movable arms and tables sections*. U.S. Patent 8,419,124.

[14] Minaker KL. Common clinical sequelae of aging. In: Goldman L, Schafer AI, eds. Goldman's Cecil Medicine. 24th ed. Philadelphia, PA: Elsevier Saunders; 2011:chap 24.

[15] McCarthy, P., Royal Group Technologies Limited, 2001. *Storage box*. U.S. Patent 6,332,554.

[16] Mohammad, I., van den Broek, H., Boots, M.L. and Wong, R., Oracle International Corporation, 2016. *Showing relationships between tasks in a Gantt chart*. U.S. Patent 9,336,502.

[17] Nagamachi, M., Ishihara, S., Hashimoto, H. and Kouchi, M., 2014. Development and evaluation of a seating aid cushion system for wheelchair bound, paralyzed people. *Gerontechnology*, *13*(2), p.265.

[18] Paquet, V. and Feathers, D., 2004. An anthropometric study of manual and powered wheelchair users. *International Journal of Industrial Ergonomics*, *33*(3), pp.191-204.

[19] Pavlidou, E., Kloosterman, M.G., Buurke, J.H., Rietman, J.S. and Janssen, T.W., 2015. Rolling resistance and propulsion efficiency of manual and power-assisted wheelchairs. *Medical engineering & physics*, *37*(11), pp.1105-1110.

[20]Popliteal Length, http://www.keyword-suggestions.com/cG9wbGl0ZWFsIGxlbmd0aA/

[21] Requejo, P.S., Furumasu, J. and Mulroy, S.J., 2015. Evidence-Based Strategies for Preserving Mobility for Elderly and Aging Manual Wheelchair Users. *Topics in geriatric rehabilitation*, *31*(1), p.26.

[22]Sakai, T., Yoshida, T., Mizuguchi, T., Yasuda, H. and Oode, K., FUJI MEDICAL INSTRUMENTS MFG. CO., LTD., 2015. *Massage chair*. U.S. Patent D730,072.

[23]Saldaña, J., 2015. *The coding manual for qualitative researchers*. Sage.

[24]Sieber, J. ed., 2012. *The ethics of social research: Surveys and experiments*. Springer Science & Business Media.

[25] Shah K, Villareal DT. Obesity. In: Fillit HM, Rockwood K. eds. Brocklehurst's Textbook of Geriatric Medicine and Gerontology. 7th ed. Philadelphia, PA: Elsevier Saunders: 2010:chap 83.

[26] Telco Motion http://www.telcointercon.com/Power-Wheelchair-Drive-Gearmotor-id89.html#Table96

[27] Van der Woude, L.H., de Groot, S. and Janssen, T.W., 2006. Manual wheelchairs: research and innovation in rehabilitation, sports, daily life and health. *Medical engineering & physics*, *28*(9), pp.905-915.

[28] Ward, S., 2011. Anthropometric data and Australian populations-do they fit. In *HFESA Annual Conference, Ergonomics Australia*.

Survey Questionnaire Link:

https://anu365-my.sharepoint.com/personal/u5394477_uds_anu_edu_au/_layouts/15/guestaccess.aspx?guestaccesstoken=pIoY6ykKw66U8ovL1t8MZiqvU2KYKgVRKhGry2846Jo%3d&docid=17bd7c0b7a59e4040b4527fb0780ec749&rev=1