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DESIGN AND FABRICATION OF ATTACHABLE WHEELCHAIR AUTOMATOR

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Abstract - Wheelchairs have been used for transporting patients as well as disabled for quite a long time. Wheelchairs are driven by manual efforts. The disabled drive wheelchairs by their hands while another person is required to push patient's wheelchair. Here we propose a simple attachable extension that can be attached to a wheelchair and can transform wheelchairs into E wheelchairs that require no manual efforts. Also the system makes use of batteries to drive the wheelchair and no fuel based engine which makes it eco-friendly. The E wheelchair attachment is designed to automate wheelchairs and thus achieve efficient and easy transportation medium to patients as well as disabled people. The attachment uses metal rods and pipe arrangement designed to be attached to a wheelchair front rods and thus clamp on the front wheelchair rods. We then use a ball bearing integrated handle fabricated with efficient support in order to achieve directional movement. We now use a chain based arrangement that connects motor to the wheel arrangement in order to drive the attachment. Our system uses batteries to power the motor and a switching arrangement in order to switch on and off the motor and achieve desired movement

***Key Words*:** Wheel chair, parking locks, push rims, rigid frame, rear axle position.

1. INTRODUCTION

Wheelchairs have used for transporting patients as well as disabled for quite a long time. Wheelchairs are driven by manual efforts. The disabled drive wheelchairs by their hands while another person is required to push patient's wheelchair. Here we propose a simple attachable extension that can be attached to a wheelchair and can transform wheelchairs into E wheelchairs that require no manual efforts. Also the system makes use of batteries to drive the wheelchair and no fuel based engine which makes it ecofriendly. The E wheelchair attachment is designed to automate wheelchairs and thus achieve efficient and easy transportation medium to patients as well as disabled people .The wheelchair is a complex piece of equipment that has been extensively engineered and studied. Most individuals with SCI become wheelchair experts because doing so increases their chances of getting a wheelchair that truly meets their needs. However, there are numerous options when considering a manual wheelchair, so it is critical to get help (see the SCI Model System Consumer Information guide *Getting the Right Wheelchair: What the SCI Consumer Needs to Know*).While it is not possible to teach you all there is to know in a single handout, this factsheet includes some of the most important information. If you have enough function to propel a manual wheelchair, it is probably the best form of mobility. Manual wheelchairs are easy to transport, need fewer repairs, and provide a form of exercise. However, they are not for everyone; you need to have the ability to propel. Most people with an injury level below C6 can propel a manual chair and some individuals with a C6 level can as well; this will be dependent on your weight, fitness, strength, level of pain, and the environment in which you need to push. While manual wheelchair propulsion can be a form of exercise, it can also lead to arm injuries from repetitive use. This risk makes it critical to get the right chair, to set it up correctly and to learn how to effectively propel.

1.1. The basic wheelchair

The configuration and dimensions of the adult basic chair are shown .The dimensions and components that must be specified in a prescription of a wheelchair are:

Seat: Dimensions, type Back: Dimensions, type Arms: Type, dimensions, in some cases

Footrest: Type

Legrest: Type

Wheels and Tires: Type and size of wheel, type and size of tire, type of driving rim

Casters: Type and size

Other considerations are weight, amount and type of use expected, upholstery material and colour, and seating inserts.

1.2. Seat Width and Depth

Chairs are regularly available in widths ranging from 10 inches to 22 inches in 2-inch increments.* Chairs with seats 24 inches wide are available but they do not fold. Wider chairs can be obtained by floor vary with the width approximately as shown. Selection of the proper seat width is important to comfort and stability. A seat too narrow is not only uncomfortable, but access to the chair is made difficult. Furthermore, the chances of pressure sores developing are increased. A seat that is too wide encourages the user to lean toward one side, thus promoting scoliosis and increased pressure over the buttocks on one side. In addition, a seat wider than is necessary makes propulsion more difficult. A seat that is too shallow reduces the area in contact with the seat and causes more pressure on the soft tissues in contact with the seat than is necessary. Furthermore, the footrests do not support the feet and legs properly, and balance of the user is affected. A seat that is too deep or longer than it should be, can restrict circulation in the legs, and causes the patient either to sit with his legs extended or to slide forward in the chair.

1.3. Seat Height

The height of the seat above the ground of the basic adult chair is 19 1/2 – 20 1/2 inches. The tall person will require a seat that is higher and deeper; a shorter person will require a seat that

is lower. Usually these requirements can be met by a stock chair; if not, properly dimensioned units can be had on special order. Obviously, the cushion or seating system to be used will affect the end result.

1.4. Seat Type

Seat types available from wheelchair manufacturers are sling, or hammock, made of a flexible material, and solid seats which are generally removable. The sling seats are by far the type used most. A solid seat installed so that folding is still possible is available, or a removable solid wooden seat may be purchased or made, when such a seat is indicated for posture control or some other reason. For many patients, especially those with lack of sensation in the buttocks and legs, special cushions or inserts are required. Cushions and inserts should not be considered as "add-ons" but as an important part of an overall mobility system. While cushions and inserts are used to obtain the lowest pressures possible over the soft.

1.5. Wheels and Tires

The basic chair has two 24-inch diameter rear wheels and two 8-inch diameter caster wheels in the front as shown in Figure 1. Overall length without the front rigging varies between 30 5/8 and 32 inches, depending upon model and manufacturer. The standard rear wheel for many years has been a wire spoke wheel, but wheels of cast metal alloy and wheels of cast plastic have been made available recently to overcome the maintenance problems inherent in the wire wheel design, yet not weigh any more. Pneumatic tires provide a more cushioned ride and the shock absorber action tends to prolong the life of a wheelchair when kept inflated properly.

1.6. Hand rims

Hand rims are attached to the driving wheels of wheelchairs to permit control without soiling the hands. The standard hand rim is a circular steel tube. For users who have problems gripping the smooth surface of a metal ring, there are available vinyl coated rings and a variety of knobs and projections that can be added to the ring.

1.7. Parking Locks

Most users need some means of securing one or more wheels to keep the chair from rolling down inclines or to provide stability during transfer to and from the chair. Two types of parking locks are available for the large wheel (as shown in figure 1) toggle and lever. Selection depends upon user preference which is usually based on the residual function of the upper limb and hand. These devices are designed strictly as locks to hold the chair in place and should never be used to slow down a chair because the abrupt stop that would be provided can cause the chair to overturn. Pin type locks are available for retaining a caster in the trail position and to prevent swivelling during lateral transfer Extensions are available so that users with limited function can operate the locks.

A report by Stephen Hales of the Independent Living Centre of Queensland in 2001 assessed the use of the world made 3-wheel rural wheelchair as a possible option for use in rural and remote areas of Australia. (Hales S, 2003) However some limitations of this option were identified; the inability to transport people in the chairs, difficulties with transfers and insufficient orders to achieve a low cost option. It is clear from survey questionnaire responses and discussion with clinicians and manufacturers, that investigating a modular wheelchair option will not provide a viable solution for Western Australia. A preference was expressed by the steering committee and suppliers who attended the supplier's forum in January 2006, for modification of existing products to fit the needs of the clients in Aboriginal communities. The alternative of producing a new chair for use in remote locations would be a costly option. As with all wheelchair users each client has individual needs and the right to live as normal a life as possible within their home environment.

The factors identified through discussion at the steering committee meetings and results of the survey are;

- Clinician knowledge of suitable wheelchairs and options for environment
- Wheelchair selection and design suitability to the remote WA terrain and Aboriginal life style
- Access to wheelchairs for trial purpose
- Access to and standard of repair and maintenance services
- Knowledge of entitlements and equipment funding programs
- Coordination between agencies; and
- Transitory nature of allied health therapist, general service providers, clients and the general workforce considering the above factors, the project sets out to identify wheelchair choices, options, adaptations and recommendations to assist in the prescription and maintenance of wheelchairs in these remote locations.

2. DESCRIPTION OF EQUIPMENTS

2.1. Features and Components

- Weight

Wheelchairs are generally classified by Medicare (which sets the industry standards) as *lightweight* (less than 34 lbs.) and *ultra light* (less than 30 lbs.). (These weights do not include footrests or armrests.) Lightweight chairs are often not adjustable and are not recommended for SCI. Ultra light chairs are more expensive than the lightweight chairs, are highly adjustable, and incorporate many design features that improve mobility and comfort. Adjustability allows the wheelchair to be set up for optimal propulsion efficiency, which can reduce the risk of injury. It is harder to get insurance companies to pay for this type of wheelchair. Clinical practice guidelines recommend the lightest chair possible. Titanium and aluminium chairs can weigh less than 20 lbs.

- **Frames**

Frames may be folding or rigid. Rigid frames tend to perform better when maneuvering. Folding frames are often easier to transport, although many rigid chairs can get to a very small size by removing the wheels and folding down the backrest.

- **Components**

Many components (Figure 1) are important for wheelchair function. These components come in a variety of styles, and selection depends on your needs, preferences and lifestyle.

Footrests support your feet and lower legs. They can be fixed, folding or swing-away and come in many different styles.

Armrests are places to rest your arms when you're not moving. They can be wraparound, full-length or desk-length;

fixed or height-adjustable; removable or flip- back. It is important because armrest position can alter the way you propel your wheelchair. Many individuals choose not to have armrests because they don't like the way they look or they get in the way of propulsion.

Wheel locks act as parking brakes to stabilize your wheelchair when you transfer to other seats or want to remain in a particular spot. They may be push-to-lock or pull-to-lock, positioned low or high on the wheelchair, and retractable or not, depending on what the user finds easier. Wheel locks can get in the way during propulsion and add weight to the wheel-chair. For this reason many individuals choose not to have wheel locks, relying on their hands to keep their chair still. Not having wheel locks can increase the risk of the chair moving during a transfer, however, which you should consider when making this decision.

Tires are most commonly air-filled (pneumatic) and therefore lightweight. They also require maintenance and can puncture. If you maintain them, this is usually the best choice. Pneumatic tires may instead be filled with solid foam inserts; these won't puncture but are slightly heavier and don't perform as well. Solid tires are low-cost and no-maintenance, but make for an uncomfortable ride and are not usually recommended.

Backrest: Sling backrests are the most common, but provide little postural support. Adjustable tension backrests can provide more support and can be adjusted over time. Rigid backrests provide the best support, but may make it more difficult to collapse the chair. The weight and height of the backrest are important. In general, the lighter the better, with carbon fibre backrests being a nice option. If support is not needed, a lower backrest is better as it does not get in the way of pushing.

Cushions come in a huge and ever-changing array of different types and materials and com- prise a major topic unto itself. While pressure relief is an important consideration when selecting a cushion, you should also keep in mind that you want a firm base and a light-weight cushion. A firm base refers to feeling stable, not sliding on the cushion when reaching for an object or propelling your chair.

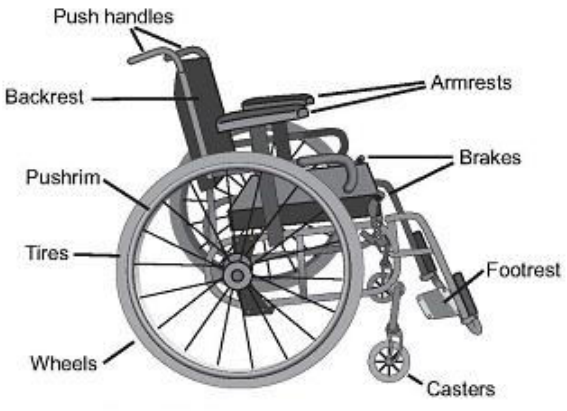

Fig-1 Wheel chair components

Push rims: There are a variety of push rims with different friction coatings and shapes that may assist with propulsion and reduce the risk of injury to the hand.

Additional features include anti-tippers, wheels and caster wheels of various styles, push handles and grade-aids (which keep the chair from rolling backward).

Seat height and width: If the fit is too tight, it can cause pressure sores; too wide, and it may cause problems with stability, posture and fitting through doorways. The seat height should make it easy to access the push rim as well as transfer surfaces. To test this, let your hands dangle at your side when sitting in the chair: your finger- tips should extend just past the chair's axle.

Seat slope is the difference between the front seat-to-floor height and the rear seat-to-floor height. It is common to have a slight seat slope (so buttocks are lower than your knees) to keep your body stable in your wheelchair.

Rear axle position is important as it impacts how easy it is to push and tip your chair. In general you want the rear axle as far forward as possible (this will make it easier to push) without making the chair too easy to tip over backwards.

Camber is the angle of the wheel with respect to the chair (Figure 2). A little camber is a good thing as it will protect your hands and increase your base of support. Too much camber will make it hard to fit through doorways.

- **Propulsion**

Your therapist will train you on the best way to propel your wheelchair to be efficient and avoid injury. Long smooth strokes are better than short strokes, and the hand should drop below the push rim during the recovery (non-pushing) part of the stroke.

- **The Wheelie**

Ask your physician for a referral to a therapist who can teach you how to "pop" and hold a wheelie. This skill can help you get through uneven terrain and over curbs. It can give you greater awareness of your balance point, which may decrease your chances of tipping over. When performing a wheelie, if your front wheels are more than two or three inches off the ground, your rear axle is probably too far back and could be adjusted forward.

2.2. Common wheelchair design, selection and failures

The project did not identify one specific wheelchair to meet user requirements. This is due to the wide range of abilities and needs of clients, the variety of wheelchair options on the market that suit their personal needs and the type of terrains/environments the wheelchair will need to access. The project was able to identify various wheelchairs and options that may suit different client's requirements. These are presented in a wheelchair matrix designed to assist therapists in the selection and prescription of suitable wheelchairs.

- **Brakes**

The brake assembly becomes loose due to being engaged and disengaged many times during the day, combined with wheelchair frame movement over rough terrain.

- ***Possible Solutions***

Provide training for user/carer on maintenance of the brake assembly Implement initiatives to increase local supplies of spare parts; and reinforce the need for good tyre maintenance to achieve optimal brake function.

- **Tyres**

Due to the harsh and varied terrain, tyres were reported as having the second greatest failure rate in the survey. Pneumatic tyres whilst being the most popular choice require the highest degree of maintenance due to an increased probability of incurring flat tyres if a fair proportion of time is spent outdoors.

Tyres are available in different tread designs and widths to accommodate most terrains, as well as the users' mobility needs. For Outdoor all terrain, a wider tyre with a medium knobbly tread will provide better traction on rough surfaces. Refer to the Wheelchair Design Matrix Appendix 9.3 for detailed options.

- **Possible Solutions**

There are special tread designs and widths available for traversing over dirt, sand and grass.

Consider BMX tyres, Slick Offside, Real fats; and another option is to use a tyre sealant (a fluid or foam product see appendix 9.3) designed to seal punctures in the inner tread of a pneumatic tyre.

- **Castors**

Castors range in size from 5cm to 20cm. Castor assemblies has been known to break and twist with frontal impact from running into curbs or obstacles.

- **Possible Solutions**

The larger 15cm (6 inch) and 20cm (8 inch) castor provide greater ease of movement when wheeling over changes in surface height**;** and this area requires further investigation into suitable castor assembly materials and design.

- **Spokes**

The most common spokes used on every day use wheelchair are aluminium, stainless steel and wire spokes. These can demand more maintenance in harsh terrain in contrast to Mags', which require less maintenance.

- **Possible Solution**

Spoke wheels are available at lower cost to MAG wheels but require more maintenance. Where funding allows MAG wheels should be considered; and Spoke protectors are recommended as a protection during impact and provide protection to users' fingers. The loss of footplates is a common problem resulting in damage to feet, and poor maintenance of good posture.

- **Possible Solutions**

Foot hangers attached to the main frame, with swing away or flip up footplates for transfers are a preferred option; and Footplates made of plastic to prevent burning of desensitised feet.

- **Upholstery**

In remote areas upholstery needs to withstand daily use in all kinds of conditions.

- ***Possible Solutions***

Discussion of the individual's requirements with the supplier is recommended pre prescription; and Sail cloth upholstery offers a more durable option for consideration than other materials as is remains cool in hot climates and is easy to clean.

- **Rigid frame or folding wheelchairs**

Due to weight, design, and fewer moving parts, the performance of a rigid wheelchair is usually better than a folding wheelchair in harsh environmental conditions. This difference may become even more noticeable as the wheelchair ages. The choice between rigid frame and folding is dependent upon the client's life style and the importance of ease of transportability.

2.3. Service Maintenance Issues

The lack of resources is a major issue due to lack of or no maintenance services resulting in long delays for equipment and supplies.

- **Possible Solutions**

Wheelchair Design Matrix to be used as an information resource for therapists prescribing for clients living in rural and remote locations Remote and metropolitan based therapists to be offered training in wheelchair prescription for people living in rural and remote locations Increase the use and prescription of rigid wheelchairs in rural and remote locations Suppliers to provide greater opportunity for therapist and users to trial rigid frame chairs in remote locations Use of wheelchair maintenance checklist (Appendix 9.4); and Access the Independent Living Centre of WA as a resource for assistive equipment information specific to use in rural and remote locations

3. DESIGN OF EQUIPMENT AND DRAWING

The basic components or parts of the wheel chair are given below (shown in figure 2).

a) Driving Motor

b) Shafts

c) Chain & Sprocket

d) Wheel Hub

e) Bearing & Mounts

f) Supporting Frame & Handle

g) Fixtures

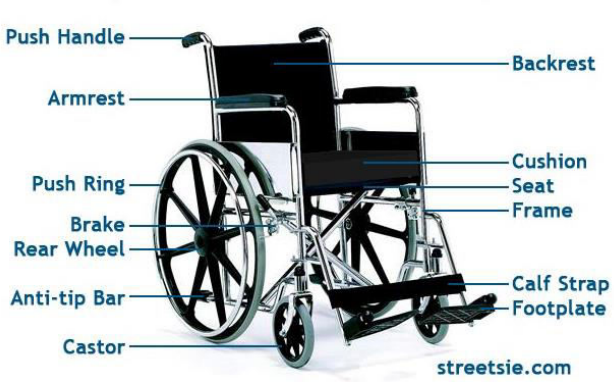

Fig-2.Basic manual wheel chair parts

3.1. Working principle

Wheelchairs have been used for transporting patients as well as disabled for quite a long time. Wheelchairs are driven by manual efforts. The disabled drive wheelchairs by their hands while another person is required to push patient's wheelchair.

Here we propose a simple attachable extension that can be attached to a wheelchair and can transform wheelchairs into E wheelchairs that require no manual efforts. Also the system makes use of batteries to drive the wheelchair and no fuel based engine which makes it eco-friendly. The E wheelchair attachment is designed to automate wheelchairs and thus achieve efficient and easy transportation medium to patients as well as disabled people. The attachment uses metal rods and pipe

arrangement designed to be attached to a wheelchair front rods and thus clamp on the front wheelchair rods.

3.2. Service and maintenance

In remote locations the community members face many daily challenges. These challenges are amplified for individuals living with a disability and their careers. The lack of resources is a major issue due to lack of or no maintenance services resulting in long delays for equipment and supplies. In addition, lack of equipment and suppliers at a local level and inadequate wheelchair maintenance record programmes, can result in wasted therapist time and lengthy user isolation in the home. Some remote locations report lack of flexibility between different services when the wheelchair user is affected by cross boarder location issues. The multiple issues are complex and include lengthy waiting time for simple parts and repairs and no availability of a replacement wheelchair either via a hire service or spare stock. At present there is no access to loan or replacement chairs, no local resources to hire from and reluctance from suppliers in Perth to hire chairs out to rural and especially remote locations; due to transportation costs, time factors and the lack of appropriate chairs available for remote terrains.

The limited survey results indicate that at present wheelchairs are not routinely maintained or serviced; they are repaired when a fault develops often by cannibalizing other wheelchairs. Breakdowns are reported when something major has gone wrong which requires replacement of a chair and not just maintenance. Some repairs are performed by “mobile technicians” who come out from Perth to the users’ home or community. Generally minor repairs like tyre punctures are carried out by local bike shops, garages, occupational therapy departments or hospital maintenance departments in rural locations.

A comparison is drawn between rural and remote areas in Scotland and Western Australia as wheelchair users residing in remote areas of Scotland (such as the Highlands and the Western Isles) reported facing similar difficulties in obtaining services as remote and rural communities in WA. These included the lack of an adequate range of spare parts; difficulties in hiring equipment; inadequate service and maintenance of equipment; long travel distances to the centres; diverse weather conditions; isolated island communities; funding restrictions, and low retention rates of staff. The outcome of the review suggested the introduction of a planned preventive maintenance service. The service would employ an officer to routinely visit the user and carryout a maintenance check on their wheelchair; provide a central wheelchair service coordinating roles, and introduce common standards and policies and procedures to assist in eliminating regional variations in funding and services. A recently conducted investment study on the planned maintenance service has shown, if not cost neutral, there is only a modest cost increase occurring, with the added benefit for user of a reduction in breakdowns and repairs.

4. ADVANTAGES AND DISADVANTAGE

- **Advantages**

a) E Wheelchair Conversion

b) Easily Attachable

c) Environment Friendly

d) No Noise

e) Low cost

f) Unskilled persons easily handling this product

- **Applications**

Applicable in all four wheeler vehicles

4.1. Factors determining the choice of materials

The various factors which determine the choice of material are discussed below.

4.1.1. Properties

The material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environmental attack from chemicals, service life, reliability etc.

The following four types of principle properties of materials decisively affect their selection

- Physical
- Mechanical
- From manufacturing point of view
- Chemical

The various physical properties concerned are melting point, thermal Conductivity, specific heat, coefficient of thermal expansion, specific gravity, electrical conductivity, magnetic purposes etc.The various Mechanical properties Concerned are strength in tensile, Compressive shear, bending, torsional and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit, and modulus of elasticity, hardness, wear resistance and sliding properties.

The various properties concerned from the manufacturing point of view are,

- Cast ability
- Weld ability
- Forge ability
- Surface properties
- Shrinkage
- Deep drawing etc.

4.1.2. Manufacturing case

Sometimes the demand for lowest possible manufacturing cost or surface qualities obtainable by the application of suitable coating substances may demand the use of special materials.

4.1.3. Quality Required

This generally affects the manufacturing process and ultimately the material. For example, it would never be desirable to go casting of a less number of components which can be fabricated much more economically by welding or hand forging the steel.

4.1.4. Availability of Material

Some materials may be scarce or in short supply, it then becomes obligatory for the designer to use some other material which though may not be a perfect substitute for the material designed. The delivery of materials and the delivery date of product should also be kept in mind.

4.1.5. Space consideration

Sometimes high strength materials have to be selected because the forces involved are high and space limitations are there.

5. CONCLUSION

Aboriginal communities. However the scope of the project broadened from studying wheelchair options to include cultural consideration when prescribing wheelchairs, funding issues, service and maintenance needs, the delivery of support services within these communities, as well as environmental factors that influence wheelchair mobility and performance. The findings from the questionnaire were based on a relatively small sample size and these needs to be considered when interpreting the results of the survey and the possible solutions that have been identified. The findings indicated the requirement of a greater understanding of the different beliefs, values and cultural customs within the Aboriginal communities when it comes to understanding the term 'disability'. This needs to be addressed through cross cultural education and training to provide a more effective disability service and a wider appreciation of the importance of cultural competence within general agencies providing disability services.

Other findings identified were the challenges and obstacles that occur when prescribing, trialling, servicing and maintaining wheelchairs in rural and remote areas. There still remains an enormous diversity in the design, servicing and delivery of wheelchairs to these locations. The wheelchair design matrix was developed to assist with wheelchair choice and options on chairs that are possibly suited for these environments. Service and maintenance issues are constantly highlighted as a significant barrier to users' satisfaction and clinicians' prescribing practices in regard to wheelchair prescription and use.

Additional research and evaluation is required on a number of possible solutions identified in this project;

a) improved training in wheelchair prescription needs for these locations

b) the trial of various wheelchair options in remote and rural locations

c) Further investigation into the development of a planned preventative maintenance service.

d) improvement of service and support from suppliers and manufactures

e) investigation into more localised service and maintenance centres; and

f) Improve data collection on the use and maintenance of wheelchairs.

Two final points the project has recognised are,

a. The need for ongoing development of policy and planning for funding of equipment in remote and rural locations; and

b. The need to develop initiatives to inform clinicians and suppliers of the guidelines and eligibility of the CAEP program as applied to Aboriginal users in remote and rural areas.

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