DEVELOPMENT, IMPLEMENTATION, AND DISSEMINATION OF A WHEELCHAIR MAINTENANCE TRAINING PROGRAM

by

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Wheelchair breakdowns are one cause of users being injured or stranded, and the incidence of these breakdowns is increasing. Evidence suggests that wheelchair users who routinely maintain their wheelchairs are less likely to be injured. Unfortunately, no structured program exists to promote maintenance, and thus the goal of this dissertation was to develop and evaluate a wheelchair maintenance training program (WMTP). In the US, 62% (n=616) of wheelchair users with spinal cord injury reported needing ≥1 repairs within a six month period, 27.4% experience an adverse consequence, 7.1% did not complete the repairs, and most repairs were completed by a vendor for power wheelchairs and by users themselves for manual wheelchairs. In Indonesia, at a 6-month follow up after receiving a new wheelchair, 34% of participants (n=142) self-reported needing ≥1 repairs. The majority (70%) reported not completing the repairs; also most of the repairs that were completed were done by the user/caregiver. Suggesting that regardless of context/population it is common that repairs are not completed, potentially due to lack of wheelchair maintenance training. The WMTP was designed to educate clinicians to train wheelchair users to perform maintenance. The Wheelchair Maintenance Training Questionnaire (WMT-Q) was developed to assess the impact of the WMTP and reached acceptable test-retest reliability for clinicians (ICC(3,1)>0.498), manual (ICC(3,1)>0.578), and power wheelchair users (ICC(3,1)>0.506). The Wheelchair Maintenance Assessment Tool (W-MAT) was developed to objectively assess maintenance state and reached an intra and interrater reliability for the manual and power W-MATs were ICC(3,1)<0.89 and ICC(2,1)<0.96 and ICC(3,1)< 0.95 and ICC(2,1)<0.93 respectively. Fifteen clinicians received WMTP training resulting in a significant increase in WMT-Q. Preliminary results of power wheelchair users (n=24) randomly assigned to a waitlist control and a training group suggest that the WMTP increased maintenance knowledge and performance. Last, the manual wheelchair content of the WMTP, W-MAT, and WMT-Q were translated to Spanish and the clinicians training adapted online. Forty professionals in Mexico participated and positively evaluated the program. Main contributions of this work include the WMTP, W-MATs, and WMT-Qs, their Spanish translation, and the further understanding on wheelchair repairs.

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PREFACE

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Nomenclature:

WMTP: Wheelchair Maintenance Training Program

W-MAT: Wheelchair Maintenance Assessment Tool

WMT-Q: Wheelchair Maintenance Training Questionnaire

1.0 INTRODUCTION

Approximately one percent of the world's population require a wheelchair as their primary means of mobility (World Health Organization, 2008a). Access to an appropriate wheelchair positively impacts the level of independence and participation that people with disabilities can achieve (United Nations, 2006; World Health Organization & World Bank, 2011). The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) recognizes both access to an appropriate wheelchair and its associated services as human rights (United Nations, 2006). The World Health Organization (WHO) defined an appropriate wheelchair as one that: meets the user's needs, fits him/her well, and can be maintained and repaired at an affordable price in the country (World Health Organization, 2008a). Despite the benefits of an appropriate wheelchair, it is estimated that less than 20% of those who need one have access to an appropriate wheelchair, particularly in less-resourced settings (World Health Organization, 2008a). Yet, barriers to wheelchair access are also prevalent in high-resource settings. For example, in the US, coverage for wheeled mobility is under continuous scrutiny (American Association for Healthcare, 2013). In recent years denial rates for standard power wheelchairs have been reported as greater than 70% (Hanna, 2010). Even when there is access to an appropriate wheelchair, wheelchair-related problems such as maintenance and repairs may negatively impact a user's life (Mann, Hurren, Charvat, & Tomita, 1996). Poor wheelchair quality can lead to secondary disabilities as a result of injuries caused by wheelchair failures and/or tips and falls (Kirby & Ackroyd-Stolarz, 1995). In addition, an unreliable wheelchair can leave the user stranded and is more likely to be abandoned (B Phillips & H Zhao, 1993). To decrease these risks the WHO recommends routine wheelchair maintenance as a strategy to improve wheelchair reliability (World Health Organization, 2008a). Regrettably, it is rare that users receive formal training in wheelchair maintenance (Best, Routhier, & Miller, 2014; Garber, Bunzel, & Monga, 2002). Despite WHO's recommendations there is no training package on basic wheelchair maintenance.

1.1 WHEELCHAIR-RELATED ACCIDENTS AND INJURIES

Community-dwelling manual and power wheelchair users experience wheelchair-related accidents each year; leading to injuries or even death (Calder & Kirby, 1990; W-Y Chen et al., 2011; K. Edwards & Mccluskey, 2010; Kirby & Ackroyd-Stolarz, 1995; Nelson et al., 2010; Ummat & Kirby, 1994; H. Xiang, A.-M. Chany, & G. A. Smith, 2006). Unfortunately, wheelchair-related injuries are on the rise—in 2003, more than 100,000 wheelchair-related injuries were treated in emergency departments in the US, which was twice the number reported in 1991 (H. Xiang, A. Chany, & G. Smith, 2006). Factors influencing wheelchair-related incidents include poor wheelchair maintenance (Calder & Kirby, 1990) and wheelchair design leading to component failure (Kirby & Ackroyd-Stolarz, 1995; Young, Belfield, Mascie-Taylor, & Mulley, 1985). Neglecting to perform maintenance has been found to increase the likelihood of a wheelchair-related accident by ten-fold (W-Y Chen et al., 2011). Hence, it is not surprising to find that improved wheelchair maintenance is recommended as a strategy to reduce wheelchair-related accidents and injury rates ("Chariots of fear: wheelchair-related accidents," 1992; Young et al., 1985). A randomized control trial that compared wheelchair-related accidents between a clinician-provided maintenance intervention and a control group found that the intervention group had significantly fewer accidents than the control group (Hansen, Tresse, & Gunnarsson, 2004). Maintenance provided by an expert may be ideal, but it is unrealistic both in high and less resourced settings. In the U.S, support to provide this type of technical assistance is constantly under attack to try to reduce health care costs (American Association for Healthcare, 2013). While in less resourced settings availability of wheelchair professionals is limited and in many places non-existent (World Health Organization, 2008a). Therefore, it is necessary to study whether users who receive wheelchair maintenance training perform more maintenance and thus are less likely to face adverse consequences, such as being injured, due to a wheelchair breakdown.

1.2 WHEELCHAIR RELIABILITY

The importance of routine maintenance is even higher because of the decline in wheelchair reliability. Many wheelchairs in the US are not meeting minimum performance and durability standards (Cooper, Boninger, & Rentschler, 1999; Cooper et al., 1997; Cooper et al., 1996; M.V. Fass et al., 2004; S. G. Fitzgerald, Cooper, Boninger, & Rentschler, 2001; Gebrosky, Pearlman, Cooper, Cooper, & Kelleher, 2013; Kwarciak et al., 2005; H. Liu et al., 2010; H. Y. Liu, Cooper, Pearlman, Cooper, & Connor, 2008; Rentschler et al., 2004b). While higher-cost wheelchairs tend to do better in standards testing, they still failed early. A recent meta-analysis confirmed these findings and provides further evidence that manufacturers are not producing wheelchairs that comply with the standards, which makes attention to maintenance that much more important (Wang et al., 2010).

In the US, researchers have surveyed individuals with spinal cord injuries who use a wheelchair about the frequency of repairs needed and adverse events associated with these wheelchair repairs. Results found that 52.6% of those surveyed (n=726) reported at least one wheelchair repair in the prior 6 months (Worobey, Oyster, Nemunaitis, Cooper, & Boninger, 2012). This was an increase of a previous study that reported 44.7% of participants (n=2167) completed at least one wheelchair repair in the past six months (L. McClure et al., 2009). Of those who reported at least one repair, between 19.7% (L. McClure et al., 2009) and 30.5% (Worobey et al., 2012) reported at least one adverse consequence, which include injury, missing work or school, missing medical appointments or being stranded (L. McClure et al., 2009). Those who use power wheelchairs have been found to have twice as many component failures compared to manual wheelchair users (Gaal, Rebholtz, Hotchkiss, & Pfaelzer, 1997). Furthermore, power wheelchair users with seat functions (e.g. tilt, recline, elevating leg rests) reported being injured in greater numbers than those who did not have them (Worobey, Oyster, Pearlman, Gebrosky, & Boninger, 2014). The prevalence of these consequences have been reported to be increasing (Worobey et al., 2012). Reduced satisfaction and increased likelihood of abandonment have also been associated with a higher number of wheelchair repairs (S. Fitzgerald et al., 2005; B Phillips & H Zhao, 1993). Further details on the type and extent of required repairs is needed to better understand the nature of the failures (Worobey et al., 2014). In addition, who completes the repairs and the number of repairs left uncompleted is yet to be determined. Understanding in better detail what components fail and how they relate to adverse consequences would better inform the path towards reducing the high prevalence of wheelchair repairs such as improved designs and more prevalent routine maintenance. In addition, given the current high wheelchair repair rates it is also clear that an immediate intervention is needed.

1.3 WHEELCHAIR MAINTENANCE TRAINING

As mentioned in the previous sections, wheelchair maintenance and repairs could reduce component failure, and further enhance wheelchair safety; therefore, it should be recommended from the beginning of wheelchair use (W-Y Chen et al., 2011; World Health Organization, 2008a). There are several resources available that provide information on how to maintain wheelchairs. First, as required by ANSI/RESNA Wheelchair Standards Section 15 (ANSI/RESNA, 2009), wheelchair manufacturers are required to include instructions on how to maintain the wheelchair in the user manual provided with the device. Second, maintenance checklists are available online (Cooper, 2013; Denison, 2006) including some at Spinlife[1], a popular online wheelchair retailer (Koontz, NA). Rehabilitation engineering books also dedicate sections to wheelchair maintenance (Cooper, 1998; Cooper, Ohnabe, & Hobson, 2006). In fact, the book "Wheelchair selection and configuration" was translated to Japanese, Korean, Turkish, Romanian, and Bulgarian and used as the guide to train wheelchair users in group settings in wheelchair provision, including maintenance (Cooper, 1998; Soydan, Koksal, & Ciobanu, 2012). The course, however, was not openly available online. Third, professional organizations' wheelchair provision and prescription guides recommend maintenance as a vital component of the wheelchair provision and include a brief maintenance checklist for the clinician (Arledge et

[1] www.spinlife.com

al., 2011; Lukersmith, Radbron, & Hopman, 2013). Finally, the WHO has launched the Wheelchair Service Training Package which includes a section on wheelchair maintenance training (Khasnabis & Mines, 2012). This package is designed to train wheelchair service providers, such as clinicians, with six basic wheelchair maintenance and repairs skills. The maintenance tasks included in this package are only for manual wheelchairs. The training curriculum includes power-point slides, a video of a live demonstration, and an in-person demonstration. It explains why each maintenance task should be done, how often it should be done, and how to execute it. The WHO does not plan to test the efficacy of this maintenance training. In addition, the WHO training does not include a formal training curriculum for wheelchair users and caregivers, and does not cover power wheelchair maintenance.

Although these resources are available, performing routine wheelchair maintenance is not a common practice by either wheelchair users or caregivers (S. Fitzgerald et al., 2005; Young et al., 1985). Preventive maintenance services are not common and users have reported seeking professional intervention only when the needed repair reaches crisis levels (Nosek & Krouskop, 1995). A study in Sweden found that 99% (N=216) of wheelchairs had maintenance issues that required attention (Hansen et al., 2004). A pilot study in the US found less than half of the sample (N=130) reported performing general maintenance in the past 6 months (S. Fitzgerald et al., 2005). Rehabilitation length of stay has been reduced over the years (Eastwood, Hagglund, Ragnarsson, Gordon, & Marino, 1999) and it is rare that clinicians are trained on wheelchair maintenance (Best, Miller, & Routhier, 2014); which could explain why wheelchair users are infrequently trained on how to take care of their wheelchairs at home (Best, Routhier, et al., 2014). There is a need for a wheelchair maintenance training program that educates clinicians how to teach wheelchair users (and caregivers) in a realistic setting (e.g. group class) how to perform basic wheelchair maintenance. Because there is a global shortage on wheelchair professionals, exploring the feasibility of delivering this professional training program through a distance education format is also necessary.

1.4 RESEARCH GOALS

The goal of this work was to develop, implement and evaluate the impact of a wheelchair maintenance program to train clinicians on how to educate wheelchair users (manual and power) in a group setting to perform basic maintenance at home. First, the prevalence and type of wheelchair repairs needed as self-reported by wheelchair users who receive rehabilitation-related services at excellence sites was studied. Specifically, Chapter 2 presents the self-reported wheelchair repairs results of adult full time wheelchair users who received rehabilitation services at nine Spinal Cord Injury Systems Model Systems Sites in the US. Chapter 3 presents self-reported wheelchair repairs at a six-month follow up of adults and children who received a new wheelchair at a site in Indonesia that provides services according to the WHO 8-step guidelines on wheelchair provision as an attempt to compare with the US population to determine whether repair situations are similar. Both of these chapters present descriptive information on who completed the most significant repair and how frequently repairs were not completed. Results from these studies were used to inform the development and evaluation of the Wheelchair Maintenance Training Program (WMTP). Chapter 4 describes the iterative process of the development of the WMTP and Wheelchair Maintenance Training Questionnaires (WMT-Q) – clinician, manual wheelchair user, and power wheelchair user versions. The WMT-Qs were developed to assess maintenance knowledge and self-reported capacity and performance of wheelchair maintenance tasks. This chapter also presents the pre- and post-training questionnaire scores and course evaluation of clinicians who received training with the WMTP at four sites in the US. Chapter 5 presents the iterative development process and psychometric properties evaluation of the two versions (manual and power wheelchairs) of the Wheelchair Maintenance Assessment Tool and accompanying illustrated instructions guide. The W-MAT was developed as an outcome measure of the WMTP. The development of the WMTP, WMT-Qs, and W-MATs was followed by the implementation of the program. Chapter 6 presents preliminary results of the impact of the wheelchair maintenance program in a group of power wheelchair users as measured by quality of life, W-MAT and WMT-Q scores, and self-reported repairs needed at pre- and six- month post-training and compared to a waitlist control group. Chapter 7 presents the adaptation and translation of the manual wheelchair portion of the WMTP, WMT-Q, and W-MAT to an online training program in Spanish. This chapter also presents the program evaluation results by 40 training participants at 11 pediatric rehabilitation centers in Mexico. This dissertation work concludes in Chapter 8 with the summary of the findings, the contributions to the current body of literature, and directions for future work.

2.0 TYPE AND FREQUENCY OF REPORTED WHEELCHAIR REPAIRS AND ADVERSE CONSEQUENCES AMONG PEOPLE WITH SPINAL CORD INJURY[2]

2.1 BACKGROUND

Data from the 2010 United States (U.S.) census report estimates that approximately 3.6 million people older than 15 years of age use wheelchairs (Matthew W. Brault, 2012). In 2014, approximately 189,000 were wheelchair users who had sustained a spinal cord injury (SCI) (National Spinal Cord Injury Statistical Center, 2014). For people with mobility impairments, access to a wheelchair that meets their needs is often the first step to the realization of other human rights (World Health Organization, 2008a). However, when a wheelchair is not functioning secondary to breakdown, it is not able to function as an enabler and can expose the user to adverse consequences. Survey data collected since 2004 at several Spinal Cord Injury Model Systems (SCIMS) sites in the U.S. report that up to 53% of wheelchair users completed at least 1 wheelchair repair in the past 6 months (L. McClure et al., 2009; Worobey et al., 2012). As a consequence to this repair(s), up to 30% of users faced at least one adverse consequence such us being injured, missing school/work/appointments, and being stranded (L. McClure et al.,

[2]This chapter under review in the journal Archives of Physical Medicine and Rehabilitation by Maria Luisa Toro, Lynn Worobey, Michael L. Boninger, Rory Cooper, Jonathan Pearlman.

2009; Worobey et al., 2012; Worobey et al., 2014). Component failure has been reported as a cause of tips and falls (Kirby & Ackroyd-Stolarz, 1995), accidents (Hansen et al., 2004), and injury or threat of injury (Gaal et al., 1997). Wheelchair-related injuries have been reported on the rise (Kirby, Ackroyd-Stolarz, Brown, Kirkland, & MacLeod, 1994; Huiyun Xiang et al., 2006), with tips and falls reported as the leading cause. User's wheelchair satisfaction has been negatively correlated to number of wheelchair repairs needed (S. Fitzgerald et al., 2005).

Two main factors have been suggested to explain the high prevalence of repairs. First, in the U.S., laboratory testing has found that there are manual wheelchairs (MWCs) (Gebrosky et al., 2013; Wang et al., 2010) and power wheelchairs (PWCs) (Wang et al., 2010) being used by consumers that have not passed minimum durability standards when tested at independent laboratories. A decrease in wheelchair quality and repair services to reduce costs has been a concern since the roll out of the competitive bidding for durable medical equipment in 2011 by the Centers for Medicare and Medicaid Services (CMS) in the U.S. (Cramton, Ellermeyer, & Katzman, 2015; Martin Szmal, 2013). Second, wheelchair maintenance is not a common practice. Only 43% of wheelchair users self-report performing maintenance regularly (S. Fitzgerald et al., 2005). Furthermore, inspections of wheelchairs indicate that up to 99% of wheelchairs were in need of maintenance (Hansen et al., 2004; Young et al., 1985).

A shortcoming of previous wheelchair repair studies is they did not include details on that the types of repairs needed. Consequently, it was not possible to decipher what components were breaking down. There was also no information about where repairs were completed or who completed them. Additionally, we do not know whether simply asking about repairs completed, and not asking about repairs needed, underestimated the number of repairs (L. McClure et al., 2009) as some repairs might have been needed, but not completed. There is a need to further characterize and quantify wheelchair repairs that could provide more details to inform design, warranties, and user training. The objectives of this research were to investigate: 1) disparities between needed repairs and those that are completed and 2) prevalence of types of wheelchair repairs completed and location where the most significant repairs were completed for MWC and PWC users. A secondary objective was to explore how participant characteristics relate to the need for repairs or adverse consequences. Previous studies have reported that individuals were more likely to face an adverse consequence due to a wheelchair repair if they had Medicare/Medicaid as primary payer for the wheelchair (Worobey et al., 2012) or were in a racial minority group (Worobey et al., 2012).

2.2 METHODS

2.2.1 Participants

Participants were recruited between October 2012 and May 2015 at nine SCIMS sites: Midwest Regional SCI Care System, Spaulding Harvard SCI System, New England Regional SCI Center Network, Frazier Rehab and Neuroscience SCI Model System, Northern New Jersey SCI System, Regional SCI Center of the Delaware Valley, University of Pittsburgh Model Center on SCI, and National Rehabilitation Hospital and Northwest Regional SCI System. Participants were enrolled if they were over the age of 16 years, had neurological impairment due to a non-progressive SCI that occurred at least one year prior to the study, and used a wheelchair at least 40 hours per week. All centers obtained approval from their local Institutional Review Boards prior to the implementation of study procedures. After obtaining informed consent, participants were asked to complete a survey that was administered either during a face-to-face visit, over the phone, or sent through the mail. All data collected were self-reported by participants.

2.2.2 Survey

Demographic variables collected included gender, age, years post injury, ethnicity, race, occupation, funding source that paid for most of the wheelchair, and combined annual household income. In addition, questions from the mobility subdomain of Craig Handicap Assessment and Reporting Technique Short Form (CHART-SF) (Whiteneck et al., 1992) were asked. Wheelchair characteristics and repair information were: type of wheelchair used (MWC or PWC), type of power seat functions (only in PWCs), and number of working backup wheelchairs. All questions about wheelchairs were asked about the wheelchair used most often by participants and with respect to the past 6 months. Participants reported the total number of repairs needed followed by repairs completed in each of the categories presented in Table 1. Participants had the option to answer that repairs were needed/completed but they did not remember the exact number.

Table 1. Wheelchair repair categories and descriptions used in the self-reported survey.

Repair completed	Description
Wheels and casters	Tires, wheel axels, caster fork
Wheelchair frame	None
User interfaces	Brake locks, footrest, legrests, pushrims, headrests
Seating system	Back supports, seat pans
Peripheral items	Armrests, push handles, side guards, spoke guards, lateral supports, anti-tippers
Electrical system	Motors, batteries (PWCs only)
Power/control system	Joystick, controller, battery charger (PWCs only)

Those who reported needing repairs were asked to indicate whether the following adverse consequences occurred: no consequence, being stranded, being injured, missing work or school, and missing a medical appointment. Participants were asked to select where the most significant repair was completed: at home by the wheelchair user or family, at home by a vendor, at vendor's shop, and other (describe).

2.2.3 Data Reduction and Statistical Analysis

Race was coded as non-Hispanic White (White) or Minority. Occupation was grouped into working/student (included sheltered workshop, on-the job training) and at home (retired, unemployed, volunteer, disability or medical leave, homemaker). The funding source that provided the largest proportion of the payment for the wheelchair was categorized into: private insurance; Medicare/Medicaid; Worker's compensation; and other (county medical, self-pay, public health service, Veterans Administration). Those who answered "I don't know" to funding source were not included in this portion of the analysis. The number of adverse consequences, type of repairs completed, power seat functions and working backup wheelchairs were each dichotomized into none or ≥1. Participants reported annual household income in four ranges: <$25,000; $25,000-$49,999; $50,000 to $74,999; and ≥$75,000.

Descriptive statistics were performed on participant characteristics and wheelchair-related variables. Kruskal-Wallis test was used to evaluate differences in number of repairs needed among funding source and annual income. Mann-Whitney test was used to evaluate differences in number of repairs needed between participants' gender, race, and occupation as well as type of wheelchair, backup wheelchairs, and power seat functions in PWCs. It was also used to assess differences in participants' age and years post injury among those with and without adverse consequences. Spearman correlation was used to evaluate the relationship between number of repairs needed and participants' age, years post injury, and CHART-SF mobility sub-score. Chi-square analysis was used to assess associations between the dichotomized reports of consequences and the participant characteristics of gender, occupation, race, funding source, annual income, type of wheelchair, backup wheelchair, and location where the most significant repair was completed. Associations among type of wheelchair and dichotomized reports of type of repairs completed and location where repair was done were also investigated. Odds ratios and 95% confidence interval were calculated for 2x2 contingency tables (Rigby, 1999). For larger tables, cells where the observed value was greater than the expected value were described. The level of significance was set a priori at $\alpha=0.05$. All statistical analysis was performed using SPSS version 22.0.

2.3 RESULTS

2.3.1 Participants' characteristics

A total of 616 participants self-reported using a wheelchair over 40 hours per week. Table 2 contains the demographic characteristics by type of wheelchair used. Ninety percent (n=221) of the PWC users had at least one power seat function. Participants in the White group were twice as likely to have a working back up wheelchair than minorities ($X^2(1)=13.25$, CI 1.4,2.9, $p<0.001$). Significant associations between race and funding source ($X^2(3)=47.26$, $p<0.001$) and combined annual income ($X^2(3)=35.37$, $p<0.001$) were found. In particular, 67% of participants in the Minority group had Medicare/Medicaid as the primary funding source that paid for their wheelchair as compared to 35% of the White group. The majority of participants in the Minority group (62.3%) had a combined annual income <\$25,000 as compared to 32.7% in the White group. A significant association was found between funding source and having a working backup wheelchair ($X^2(1)=13.25$, $p=0.02$). Forty eight percent of the participants who did not have a backup wheelchair had Medicare/Medicaid.

Table 2. Characteristics of full time manual and power wheelchair users who completed the self-reported survey.

Characteristics	MWC (n=370)		PWC (n=246)	
	No. (%) of participants	No. of missing participants	No. (%) of participants	No. of missing participants
Gender		2		0
Male	308 (83.2)		183 (74.4)	
Female	60 (16.2)		63 (25.6)	
Race		16		10
White	260 (70.3)		180 (73.2)	
Minority	94 (25.4)		56 (22.8)	
Occupation		47		40
Working/student	123 (33.2)		46 (18.7)	
At home	200 (54.1)		160 (65.0)	
Funding source		18		11
Private	116 (31.4)		81 (32.9)	
Medicare/Medicaid	143 (38.6)		107 (43.5)	
Worker's comp	26 (7.0)		19 (7.7)	
Other	67 (18.1)		28 (11.4)	
Backup wheelchairs		2		3
Yes	203 (54.9)		163 (66.3)	
No	165 (44.6)		80 (32.5)	
Characteristics	Mean ± SD	No. of missing participants	Mean ± SD	No. of missing participants
Age	41.2±13.8	2	48.1±13.4	1
Years post injury	11.0±10.0	23	9.6±9.8	10

2.3.2 Wheelchair repairs needed and resulting adverse consequences

A total of 380 (62%) of the participants reported that their wheelchair needed at least one repair in the past 6 months (1.5±2.1 repairs). Table 3 contains the frequency counts of number of repairs needed in the past six months stratified by type of wheelchair. For those who could recall the number of repairs needed, no significant differences were found in numbers of repairs needed between MWC (1.48±2.36) and PWC (1.44±1.64) nor between PWC with (1.4±1.6) and without (1.3±2.4) power seat functions, $p>0.183$. No significant differences were found in number of repairs needed by occupation, race, gender, primary funding source, or income, $p>0.126$. No significant correlations were found between number of repairs needed and age or years post injury, $p>0.789$. For participants that remembered the exact number of repairs completed, CHART mobility sub-score and the number of repairs needed were significantly correlated $r_s=0.087$, $p=0.03$.

Table 3. Number of repairs needed stratified by manual and power wheelchair.

Type of wheelchair	No. of repairs					Missing
	0	1-3	4-6	7+	No. UK	
	No. of participants (%)					
MWC (n=370)	142 (23.0)	180 (29.2)	22 (3.6)	11(1.8)	10 (1.6)	5 (1.4)
PWC (n=246)	88 (14.3)	128 (20.8)	20 (3.2)	3 (0.5)	6 (1.0)	1 (0.4)
Total (n=616)	230 (37.3)	308 (50.0)	42 (6.8)	14 (2.3)	16 (2.6)	6 (0.9)

Abbreviation UK: unknown

Of the 380 participants who reported needing at least one repair, 104 (27.4%) reported experiencing at least one adverse consequence (Table 4). The odds of experiencing an adverse consequence were 2.2 higher for PWC than for MWC users ($X^2(1)=11.72$, CI 1.4,3.6, $p=0.001$) and 1.7 higher for participants in the Minority group than for the White group ($X^2(1)=4.49$, CI 1.03,2.9, $p=0.03$). A significant association was found between funding source and experiencing adverse consequences ($X^2(3)=10.31$, $p<0.04$). Fifty seven percent of those who experienced adverse consequences had Medicare/Medicaid. No significant associations were found between those who reported none and ≥1 adverse consequence and gender, occupation, having a backup wheelchair, or location where repair was completed. No significant differences were found in age and years post injury between none and ≥1 adverse consequence. For PWC users no significant association was found between none and ≥1 adverse consequences and presence of power seat functions. Only 7% (11/157) of participants who needed at least one repair did not have power seat functions.

Table 4. Frequencies of adverse consequences reported by those who needed at least one repair in the past 6 months for manual and power wheelchair users.

Type of wheelchair	Type of adverse consequence					
	None	Stranded	Injured	Missed work/school	Missed medical appointment	Missing
	No. of participants (%)+					
MWC (n=223)	159 (71.3)	31 (13.9)	9 (4.0)	12 (5.4)	17 (7.6)	17(7.6)
PWC (n=157)	86 (54.8)	38 (24.2)	9 (5.7)	12 (7.6)	18 (11.5)	14(8.9)
Total (n=380)	245 (64.5)	69 (18.2)	18 (4.8)	24 (6.4)	35 (9.3)	31(8.2)

+More than one type of adverse consequence can be reported per participant

2.3.3 Completed wheelchair repairs

Of those who reported needing at least one repair, 27 (7.1%) reported that no repairs were completed and 19 (5%, n=380) reported that repairs were completed but they could not remember the exact number. More participants that had a disparity between repairs needed and completed had Medicare/Medicaid as their funding source (n=15). In those who did not have repairs completed there were 20 MWC and seven PWC users and consequences experienced including being stranded, injured, and missed work/school. MWC users who completed repairs were 3.8 times more likely to complete at least one repair in the wheels and casters category ($X^2(1)$=42.8, CI 2.5,5.8,$p<0.001$) and 1.8 times more likely in the user interfaces category ($X^2(1)$=5.4, CI 1.1,3.0,$p=0.02$) than PWCs users. In contrast, PWCs were 1.9 times more likely than MWCs to complete at least one repair in the peripherals category (refer to Table 1 for definition) ($X^2(1)$=6.0, CI 1.2,3.2, $p=0.01$). No other significant associations were found between type of wheelchair and type of repairs. The most common repairs completed to PWCs were to the electrical and power and control system. Seventeen percent of participants reported completing more than one repair in the same category in the previous 6 months. The prevalence of types of repairs is presented by type of wheelchair in Figure 1.

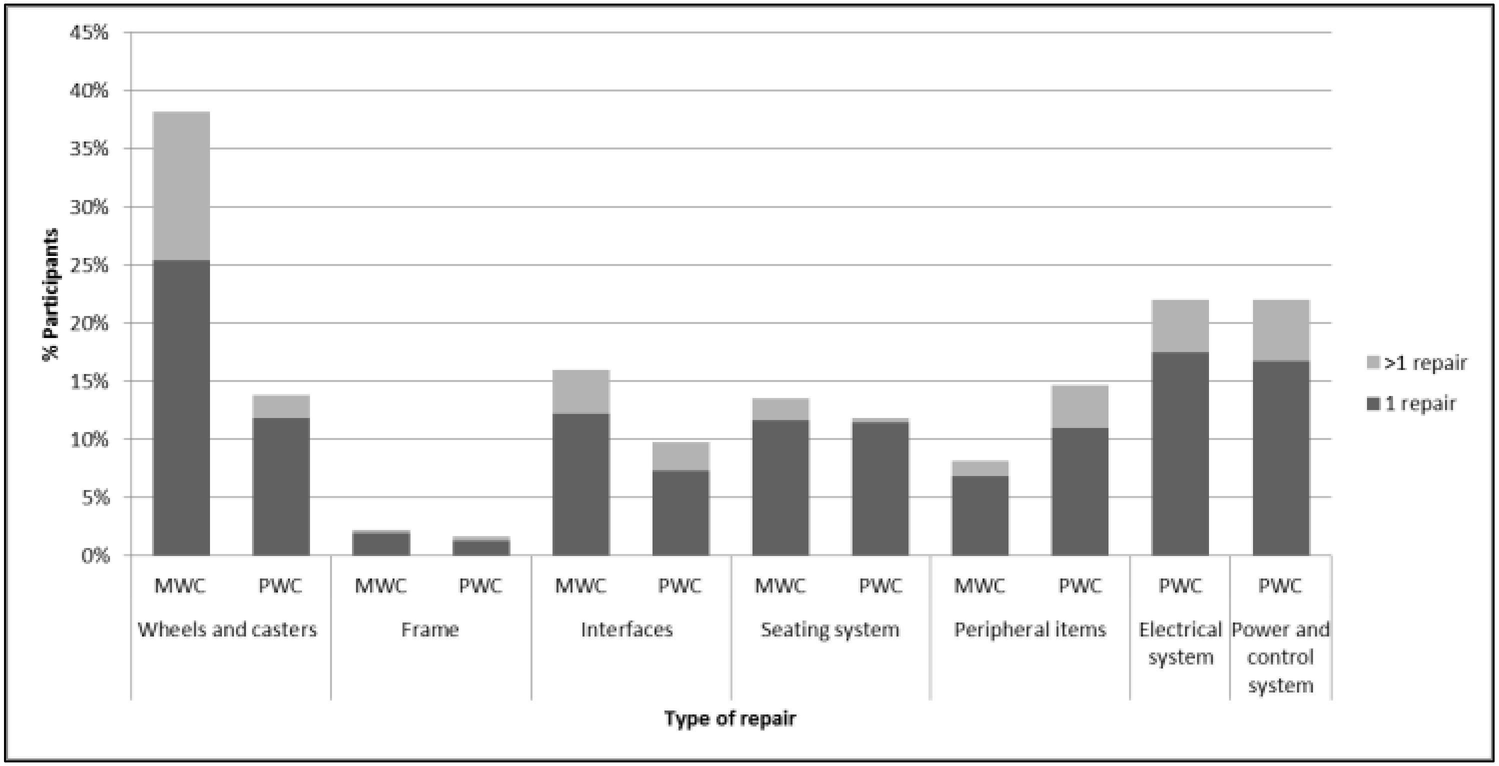

Figure 1. Proportion of manual and power wheelchair user participants reporting repairs completed per category of repair. More than one type of repair can be reported per participant.

For all participants who had at least one repair completed and reported location where most significant repair was completed, a significant association was found between location and wheelchair type (Table 5, $X^2(3)=34.1$, $p<0.001$). A greater proportion of MWC users completed the repair at home themselves as compared to PWC users.

Table 5. Proportion of manual and power wheelchair user participants reporting location where the most significant repair was completed.

Repair location	MWC	PWC	Total
No. participants (% of those who completed ≥1 repair)			
At home by me or family	81(39.9)	21(14)	102(28.9)
At home by vendor	41(20.2)	59(39.3)	100(28.3)
At vendor's shop	50(24.6)	46(30.7)	96(27.2)
Other +	15(7.4)	6(4)	21(5.9)
Missing	16(7.9)	18(12)	34(9.6)

+ Other including but not limited to bicycle store and rehab facility.

2.4 DISCUSSION

2.4.1 Wheelchair repairs needed and resulting adverse consequences

It is concerning that the overall percentage of participants requiring wheelchair repairs in the past six months was higher than previous studies (S. Fitzgerald et al., 2005; L. McClure et al., 2009; Worobey et al., 2012). Further, this study shows a disparity between the number of repairs needed and those completed, indicating that previous reports may have underestimated the number of repairs required. Frequently needing to repair the device may impact the individual's ability to participate and satisfaction with the device (Cooper et al., 1999; S. Fitzgerald et al., 2005; C Smith, McCreadie, Unsworth, Wickings, & Harrison, 1995). Our results found a small correlation between the number of repairs needed and CHART mobility sub-score. Further investigation to age and usage of the wheelchair and how it relates to the need for repairs is warranted.

The rate of adverse consequences and prevalence of being stranded were similar to previous studies (L. McClure et al., 2009; Worobey et al., 2012). Our results showed that 4.7% of the needed repairs caused an injury. This may indicate that many of the repairs reported were minor and not likely to result in injury (e.g. a flat tire). Gaal et al. reported component failure as the cause of incidents in 33% of the cases. Incidents were defined as “an event that interrupted normal wheelchair operation and either cause injury or posed the threat of injury in the rider’s judgment” (Gaal et al., 1997). In addition, reports to the Food and Drugs Administration in the U.S. reported that in 78% of the cases a breakdown of the engineering factors was involved during a wheelchair-related accident (Kirby & Ackroyd-Stolarz, 1995). However, the data was not categorized by type of wheelchair and scooters were about 53% of their sample. Caution is needed when comparing these results because our question did not ask for incidents when an injury “almost” occurred.

PWC users were found to face more adverse consequences than MWC users when their wheelchair needed repair (L. McClure et al., 2009; Worobey et al., 2012). Greater adverse consequences faced by PWC users might be explained by the fact that they have to wait for a vendor’s intervention. Fewer PWC users reported completing repairs themselves as compared to MWC users. We did not find that those with power seat functions faced more adverse consequences than those without; however, only 10% of total PWC users did not have power seat functions.

2.4.2 Completed wheelchair repairs

Our results support that asking wheelchair users only about completed repairs may underestimate the number of repairs, as we found that of those requiring repairs, 7.1% did not have repairs completed. Most participants who did not complete the repairs had Medicare/Medicaid. This could be explained by the fact that until November 2014 original medical necessity documentation was needed for a repair to be reimbursed (HME News, 2014). More data needs to be collected to explore if this new policy change reduces the number of participants needing repairs but not having them completed. It is also necessary to understand the reasons behind repairs not being completed (e.g. lack of insurance coverage or attempting to repair it but unsuccessful). The majority of those who did not complete a repair were MWC users, which suggests that educating them on how to perform maintenance may be successful in reducing the number of repairs left uncompleted.

Overall repairs to the wheels and casters were the most common followed by the user interfaces, while the least common repair needed was to the wheelchair frame. Specifically for MWCs wheel and caster repairs were the most common type of repair followed by interfaces, and seating system. This aligns with a previous study which reported tire problems more commonly occur in MWCs as compared to PWCs (S. Fitzgerald et al., 2005). While frame repairs in MWCs were not commonly reported, they are considered a critical failure and have been found in a subset of titanium and aluminum frames in laboratory testing (H. Liu et al., 2010; H. Y. Liu et al., 2008). The large prevalence of seating system repairs completed is concerning since long term consequences may occur such as developing pressure ulcers.

The types of repairs most common for PWCs were the electrical system and power and control system followed by wheels and casters. Further, other studies have found failure in the drive trail and controller (Gaal et al., 1997) and the motor (S. Fitzgerald et al., 2005) as the most common causes of incidents in PWCs. Fass et al. reported disconnected electrical connectors and joystick problems as the most common problems during durability standard testing (Megan V Fass et al., 2004).

Our results showed the involvement of a vendor in about 50% of the repairs done. Needing a vendor to complete the repair may indicate that the participant does not know how to complete the repair, or they lack the necessary supplies or level of function needed to complete the repair themselves. Inherent to the device complexity it is less likely that a user can fix a PWC at home, as was the case with thirty percent of the PWC users in our study (S. Fitzgerald et al., 2005). For instance, for PWC motors repairs usually require the wheelchair to be taken to the vendor's facility (Rentschler et al., 2004a). If the user does not have their wheelchair they have to use a wheelchair (loaner or backup) that may not have the same system, drive, etc. which could hinder their function. Even though repairing motors and electrical component by the users or caregivers might be unrealistic, learning how to identify problems when they start occurring and contacting a maintenance expert could reduce the likelihood of an adverse consequence. Therefore, there is a need to study how educating users on wheelchair maintenance impacts having an adverse consequences due to a wheelchair repair.

The prevalence of repairs completed at home (40% MWC and 14% PWC) reveals the willingness and ability of people to do it at home, and the fact that a training program could help them do it correctly. Maintenance training itself could help reduce the need for a repair. Even 'quick fixes' are important to address problems in a preventative manner as accidents can be caused by minor problems such as a loose foot support (Hansen et al., 2004). Kirby et al asked MWC users to report who would perform a repair if needed: 4.3% reported that no one was available to do the repair, 21.4% repaired it themselves, 40.3% by a friend or caregiver, and 34.1% by a dealer (Kirby et al., 1994). Our results have a lower percentage of MWC participants completing the repair themselves or family (40%) and larger by a vendor (45%). With our current data we cannot discern which type of repair was the most significant repair; therefore we cannot make inferences about how the location of the repair relates to the type of repair and severity. However, given the prevalent intervention of a vendor, it would be valuable to determine if educating MWC on basic maintenance, such as changing an inner tube, cleaning a caster, and adjusting the brakes reduces the need for a vendor's intervention. It is important to note that some MWC participants reported doing the repair at a bicycle store. Efforts to inform MWC users about alternative resources should be made.

One could argue that, as the primary means of mobility, wheelchairs are exposed to use and environments that lead to wear and therefore components need to be replaced. Components like wheels/tires are meant to wear and be replaced, making repairs unavoidable. But, the prevalent number of participants completing the same type of repair >1 in the past six months (Figure 1) suggests poor wheelchair reliability. Fass et al. define a wheelchair with high reliability as one that lasts a long time between incidences of problems (Megan V Fass et al., 2004). It is unsettling that the issues highlighted in previous studies that started data collection in 2004 are 10 years old are still present today. Advances in manufacturing techniques do not seem reflected in wheelchair durability (Gebrosky et al., 2013; Wang et al., 2010).

2.4.3 Participants' characteristics

Participants in the Minority group continue to be more likely to have an adverse consequence because of the need for a wheelchair repair, be of lower income, and have Medicaid/Medicare as reported by Worobey et al. (Worobey et al., 2012). It is troublesome that minorities in the SCIMS sites continue to appear to have more problems with wheelchairs (Hunt et al., 2004). Factors that may explain the disparities, such as providers' prejudice and equity of resources (Kemp & Parette, 2000), should be studied. Participants' demographics such as age, gender, and years post injury found in our study were comparable to those reported in previous studies (L. McClure et al., 2009; Worobey et al., 2012). The proportion of participants having at least one backup wheelchair (59.4%) has increased since the 2011 data set (34.4%) but is comparable to the 2006 data set (62.8%) (L. McClure et al., 2009; Worobey et al., 2012). Further investigation on characteristics of backup wheelchairs might be needed. Being stranded continues to be prevalent despite working backup wheelchairs being more available. This may be an indication that the problems are arising when the participant is away from home.

2.4.4 Study limitations

The reliability/validity of the survey is unknown; therefore, different interpretation by survey respondents of repair and type of repair categories may have occurred. Recall bias may be present. Even though our data provides more detail on type of repairs completed than previous studies, "repair" was not defined in our survey and we did not separate maintenance from repair. The categories of repairs were broad, and as such the conclusions that we can draw are limited. For participants who reported needing several types of repairs, it is unknown which repair was associated with what adverse consequence and which one was the most significant. Further, 'most significant repair' was not defined; therefore participants may have interpreted this question differently based on cost, risk of injury, adverse consequences, or complexity of the repair. The age and usage of the wheelchair were unknown, although other studies have not found significant differences based on age of the wheelchair for component failure incidence (Gaal et al., 1997) or number of repairs completed (S. Fitzgerald et al., 2005). Data was collected at centers of excellence for individuals with SCI where people may receive services that do not represent the general population of people with SCI who use wheelchairs nor other wheelchair users.

2.4.5 Future work

Further granularity could be useful to determine more specific repairs that are being completed such as replacing a pneumatic tube or a broken caster fork. For each type of repair additional detail is needed with respect to related adverse consequences, location where the repair was completed, and the time waited between needing and doing the repair. Capturing the time elapsed between identifying the need for a repair and the repair been completed could provide better insight into the impact of wheelchair repair services and its relation to adverse consequences. This could be paired with reports from vendors (Orzel, 2015) to explore the unmet need for repairs being completed.

It is important to differentiate between expected wear and tear due to use and component failure due to poor quality products. Understanding the severity of the repair needed will provide better information to propose effective solutions. A more objective manner to measure the current state of wheelchair disrepair could also aid in describing the state of wheelchair repairs. As wheelchairs are expected to wear due to regular use, wheelchair maintenance training must be implemented as part of the wheelchair service provision (World Health Organization, 2012) and its impact on wheelchair repairs should be studied. Finally, the relationship of wheelchair age (and product warranty) and usage information to repairs needed should be explored. This data could be relevant to policy makers with respect to the impact of the competitive bidding process that CMS is expected to be implemented nationwide in the U.S. in January, 2016.

2.5 CONCLUSION

The majority of wheelchair users reported needing at least one repair in the previous 6 months. The prevalence of repairs has continued to rise since the start of data collection on self-reported repairs in 2004. Not all the repairs that were needed were completed. Repairs to wheels and casters were the most common repair in MWCs, while repairs to the electronics and power system were most common for PWCs. More PWC users faced adverse consequences as compared to MWC users, in addition more Minority participants faced adverse consequences compared to White participants. There is an urgent need to reduce the number of repairs needed and to avoid having adverse consequences that impact health and participation of wheelchair users. Evidence suggests this could be accomplished through more routine maintenance (Wan-Yin Chen et al., 2011).

3.0 THE IMPACT OF THE WORLD HEALTH ORGANIZATION 8-STEPS IN WHEELCHAIR SERVICE PROVISION IN WHEELCHAIR MAINTENANCE STATE: A COHORT STUDY IN INDONESIA[3]

3.1 BACKGROUND

For many persons with disabilities, access to assistive technology (AT), such as wheelchairs, has been identified as a facilitator to full enjoyment of human rights (Johan Borg, Per-Olof Ostergren, et al., 2011; Skempes, Stucki, & Bickenbach, 2015; United Nations, 2006). Multiple studies in high-income countries have concluded that access to wheelchairs is a vital component of rehabilitation and a determining factor in successful participation in society and employment (Lenker & Paquet, 2003; Ripat & Woodgate, 2012; M. Scherer, Jutai, Fuhrer, Demers, & Deruyter, 2007; M. J. Scherer, Sax, Vanbiervliet, Cushman, & Scherer, 2005; World Health Organization & The International Spinal Cord Society, 2013). Approximately 15% of the world

[3] This Chapter's introduction and a portion of the methods, results, and discussion were submitted in the manuscript "The impact of the World Health Organization 8-steps in wheelchair service provision in wheelchair users in a less resourced setting: a cohort study in Indonesia" under review for publication in the journal BMC Health Services Research. By Maria Luisa Toro, Chika Eke, and Jonathan Pearlman.

has a disability and 10% of this section of the population requires a wheelchair because their ability to walk is limited (World Health Organization, 2008b; World Health Organization & World Bank, 2011). Unfortunately, only 5 to 15% of these individuals have access to an appropriate wheelchair (World Health Organization, 2008a). Therefore, lack of access to appropriate AT has been a “missing bridge” to human rights and development especially in less resources settings (Adya, Samant, Scherer, Killeen, & Morris, 2012; J. Borg, Larsson, & Östergren, 2011; World Health Organization & World Bank, 2011). Most users in less resourced settings rely on non-governmental organizations, charitable organizations, and other international organizations to access wheelchairs (Johan Borg & Östergren, 2015; Winter, 2006). In the early 2000’s large charitable organizations started mass-distributing wheelchairs (J Pearlman, Cooper, Zipfel, Cooper, & McCartney, 2006). Although this method of provision can reach many people in a relatively short period of time, the donations often do not meet criteria which ensure that each wheelchair will be more helpful to the user than harmful (Krizack, 2003; Mines, 2008). Many of the donations consist of hospital-style wheelchairs designed for temporary use in institutional settings which do not meet international durability standards, are not adjustable, are frequently provided without cushions, and typically do not meet the functional needs of users (Armstrong, Reisinger, & Smith, 2007; Johan Borg et al., 2012; Mukherjee & Samanta, 2005; J Pearlman et al., 2008; Toro, Garcia-Mendez, Dausey, & Pearlman, 2012). In addition, these wheelchairs are frequently provided without associated services such as fitting and user training in wheelchair mobility, maintenance, pressure ulcer prevention and proper transfer techniques (Johan Borg et al., 2012; Mukherjee & Samanta, 2005; J Pearlman et al., 2008; Toro, Garcia-Mendez, et al., 2012). High rates of wheelchair abandonment have been associated with poor device performance when devices do not meet or withstand the environmental demands or devices are selected without consideration of user opinion (Kim & Mulholland, 1999; Mukherjee & Samanta, 2005; B Phillips & H Zhao, 1993). Another criticism of this approach is that there is often no local capacity to repair the wheelchairs, including services, training and replacement parts; the user is left without a wheelchair once it is in state of disrepair (Eide & Oderud, 2009; Hotchkiss, 1987; Howitt, 2006; Mukherjee & Samanta, 2005; Oderud, 2006; Toro, Garcia, Ojeda, Dausey, & Pearlman, 2012b; Winter, 2006). To promote best practices in wheelchair provision world-wide, the World Health Organization (WHO) Guidelines for the Provision of Manual Wheelchairs in Less Resourced Settings (Guidelines) (World Health Organization, 2008a) and Wheelchair Service Training Packages (WHO WSTP) emphasize the eight critical steps for appropriate wheelchair services (throughout this chapter, this is referred as WHO 8-Steps): referral and appointment, assessment, prescription, funding and ordering, product preparation, fitting and adjusting, user training, follow-up, maintenance and repairs (World Heal, 2013; World Health Organization, 2012). The Guidelines and WHO WSTPs argue that in order to fully meet the needs of people with mobility impairments, wheelchairs must be adjustable to fit the user, suitable for the user's environment, available/reparable in the context where the user lives and accompanied by training in wheelchair use and maintenance (Constantine, Hingley, & Jowitt, 2006; Sheldon & Jacobs, 2006). Research is needed to investigate the impact of different models of wheelchair provision that will help guide national strategies to close the immense gap of access to appropriate wheelchairs in less resourced settings (Johan Borg, Lindstrom, & Larsson, 2009; Johan Borg, Lindstrom, & Larsson, 2011; Johan Borg, Per-Olof Ostergren, et al., 2011; Eide & Oderud, 2009; J Pearlman et al., 2008; J Pearlman et al., 2006; Sheldon & Jacobs, 2006; World Health Organization, 2008a) (Sheldon & Jacobs, 2006; Skempes et al., 2015). To the best of our knowledge, no objective evidence is available regarding the impact of wheelchairs provided through the WHO 8-Steps of wheelchair service delivery; the goal of this study was to gather objective data regarding the impact of these wheelchair services as it relates to wheelchair maintenance state at a 6 month follow up after receiving the new wheelchair.

3.1.1 Case-study of Indonesia

Around 20% of the total 240 million population has a disability limiting day-to-day functioning and social activities (Kusumastuti, Pradanasari, & Ratnawati, 2014). Approximately 10% of them, or 4.8 million people, require an appropriate wheelchair because their ability to walk is limited. Indonesia ratified the UNCRPD in 2011 which in-principle means the Indonesian government supports equal rights and opportunities for persons with disabilities (United Nations, 2006). Unfortunately, people with disabilities in Indonesia are at high risk for poverty and face social barriers leading to unproductivity and dependency (Kusumastuti et al., 2014). Youth with disabilities are more likely to live in low income households and less likely to be in school than their peers without disabilities (Filmer, 2008). The government provides health insurance to those who are poor but it does not include assistive technology (Kusumastuti et al., 2014). Limitations in appropriate provision of assistive devices include the lack of training in seating and mobility and the lack of coordination between providers to ensure the best possible outcome through technology (Carson, 1994). United Cerebral Palsy (UCP) Wheels for Humanity[4] is one of the organizations working towards addressing the need for adequate wheelchair provision in areas with limited rehabilitation services with funding support through the United States Agency for International Development (USAID). They have established an organization called UCP

[4] UCP Wheels for Humanity http://www.ucpwfh.org/

Roda Untuk Kemanusiaan (UCPRUK) in Indonesia. UCPRUK works with volunteer seating specialists to provide wheelchairs to people with limited mobility through the WHO 8-Steps (Wheels for Humanity Indonesia, 2014; World Health Organization, 2012). The purpose of this study was to investigate the impact of the UCPRUK's wheelchair provision services. Specifically, this chapter's goal was to investigate wheelchair maintenance state and self-reported repairs completed at a six month follow up after receiving the wheelchair.

3.2 METHODS

3.2.1 Ethical considerations

The Medical and Health Research Ethics Committee from the Faculty of Medicine at Gadjah Mada University (Yogyakarta, Indonesia) provided approval to conduct the study. Written informed consent from all participants was obtained before implementing study procedures. Data for this study was collected between April 2013 and April 2014, by members of the UCP team**.** No incentives for participation were offered. The University of Pittsburgh Institutional Review Board approval for de-identified data transfer was obtained prior to data analysis.

3.2.2 Study Procedures

UCPRUK provides services on a first-come, first-served basis and the demand for wheelchairs is always larger than what they can provide immediately. Participants are usually placed on a waiting list until wheelchairs and services are available. Depending on where the participant was on the waiting list, they were categorized as on the waiting list (Waitlist group) or intervention (Wheelchair group). Clients are assessed based on their needs and the most appropriate wheelchair out of four types is donated: roughrider, Kids, Harmony, and Specialized (Figure 2). The specialized wheelchair is not shown; it is a manual wheelchair with reclining back support. The wheelchair is then fitted and delivered to the client. During the delivery appointment, he/she is trained on how to handle it, how to transfer, basic maintenance, and how to contact the UCPRUK if problems arise. For the purpose of this Chapter, only participants who received a wheelchair were analyzed.

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Figure 2. Three types of manual wheelchairs available for provision at UCPRUK. A) Roughrider B) Kids C) Harmony.

Caregivers were enrolled as 'proxy' subjects for those who could not self-propel. Based on the inclusion criteria, people with mobility impairments coming to UCPRUK for a new wheelchair were invited to participate in the study. Data collection was done at baseline (when participants were assessed for a wheelchair) and approximately 6 months after the wheelchair was delivered. Demographic information such as date of birth, gender, nature of disability, and primary means of mobility were collected from each participant at baseline. Both baseline and follow up measures asked about employment/education status. At follow up the following measures were collected:

- Craig Handicap Assessment Recording Technique Short Form (CHART-SF) mobility subdomain questions (Hall, Dijkers, Whiteneck, Brooks, & Stuart Krause, 1998; Whiteneck et al., 1992).
- Wheelchair use: how many hours per day they used the wheelchair and the environment where the wheelchair was used (e.g. paved roads, curbs, urban/rural).
- Wheelchair Assessment Checklist (WAC): a screening procedure that consists of a checklist and scoring system for categorizing wheelchairs based on their physical and working conditions was used to assess wheelchairs at follow up (Karmarkar, Collins, & Cooksley, 2009). Items are scored 1, 2, or 3 (3 the item is in proper working condition). A total score was calculated based on the condition of all relevant components (Karmarkar, 2009). The checklist is available in Appendix A.
- Wheelchair repairs in the past 6 months in the categories presented below. Answers options to these questions were: None, repairs needed and completed (provide the number), repairs needed and completed but number unknown, and repairs needed but not completed.
    - Wheels and casters (includes tires, wheel axles, caster fork)
    - Wheelchair frame
    - Wheelchair-user interfaces (includes brake locks, footrests, legrests, pushrims, headrests)
    - Seating system (includes back supports, seat pans)
    - Peripheral items (includes armrests, push handles, side guards, spoke guards, lateral supports, anti-tippers)

- If a repair was needed then participants where asked whether an adverse consequence occurred due to the wheelchair needing repair and location where the most significant repair was completed were asked as described in Chapter 2.

All the questions were translated from English to Bahasa Indonesian and the translated back into English by a professional translator and reviewed for errors. Data collectors were trained on-site at UCPRUK in Yogyakarta in Java, Indonesia by 2 investigators from the University of Pittsburgh prior to participant recruitment and enrollment. One of the trainers was a Bahasa Indonesian native speaker. Following input from the training, the translated questionnaires were finalized. Paper-based questionnaires were used during data collection. After data collection was completed, all paper-based files were transcribed to a spreadsheet database by data collectors at UCPRUK. The de-identified database was sent to the investigators for analysis.

3.2.3 Data reduction and statistical analysis

3.2.3.1 Power calculation

This data was collected as part of a larger study that investigated the impact of receiving a wheelchair in a group of recipients as compared to a waitlist control group. For the purpose of the larger study, the CHART was selected as the main outcome for the power analysis calculation because it is a commonly used participation measure in rehabilitation research. For a power of 80%, alpha .05, and mean of paired differences of 25 points a priori analysis showed a requirement for 30 of each distinct type of participant (Adult, Adult+proxy, Child, and Child+proxy). To plan for attrition, the recruitment goal of 40 participants for each participant type (40x4) 160 participants.

3.2.3.2 Data analysis

Participants were stratified into: Adult, Adult+proxy, Child, and Child+proxy. Number of required self-reported repairs was dichotomized to not needing a repair or needing ≥1 repair in the past six months. Repairs completed were dichotomized to all repairs completed or ≥ 1 repair needed but not all completed. Descriptive statistics and frequency counts of demographics information, self-reported wheelchair repair questions, and WAC total score were calculated.

Chi-square or Fisher exact test were used to explore if there were associations between wheelchair type and: needing repairs, repairs completed, and living location. For continuous variables, Shapiro-Wilk tests revealed the data was not normally distributed. As such, Kruskal-Wallis was used to evaluate if there were differences in hours of daily wheelchair use and WAC score by type of wheelchair provided for each type of participant. Spearman correlation was used to assess relationship between WAC total score and CHART mobility subscore and average hours of daily wheelchair use. The level of significance was set a priori at $p=0.05$. To control for type I error, the post-hoc analysis p-value for the Kruskal-Wallis test was set at $p=0.008$ (Bonferroni correction).

Level of agreement between self-reported repairs needed (SR) but not completed and WAC item-by-item scores was explored through an item-by-item agreement analysis. A self-reported repair needed but not completed would be expected to agree with WAC score of 1 or 2 (problems found in the component) in one of the components that belong to the self-reported category. Table 6 presents how self-reported repair questions categories were grouped with corresponding WAC items. Three types of agreement (or lack thereof) were explored: 1) SR and WAC ≤2: participant self-reported needing but not completing a repair in the category and at least one WAC item scored 1 or 2, 2) Not SR and WAC ≤2: participant did not self-report needing but not completing a repair in the category and at least one corresponding WAC item scored 1 or 2, and 3) SR and WAC =3: participant self-report needing but not completing a repair in the category and all corresponding WAC items scored as in good working order. SPSS version 21 was used to perform all statistical analyses.

Table 6. Self-reported repair category and corresponding WAC items.

Component categories needing a repair in the past 6 months: answered as needed but not completed	WAC items that scored 1 or 2
Wheels and casters (Wh/Cs): includes tires, wheel axles, caster fork	Wheel axle, caster fork, caster wheel, drive wheel
Wheelchair frame (Fr)	Frame, cross brace, seat post
Wheelchair-user interfaces (Intf): includes brake locks, footrests, legrests, pushrims, headrests	Foot support, leg support, arm support position, arm support base, hand rim, wheel lock activation, head support
Seating system (SS): includes back supports, seat pans	Back support, cushion, seat base
Peripheral items (Ph): includes armrests, push handles, side guards, spoke guards, lateral supports, anti-tippers	Anti-tip, push handle, side guard

3.3 RESULTS

For the larger study a total of 344 participants were enrolled in the study. Of these, 29 passed away before the completion of the study and 6 were missing *Type of participant* information and were not included in the analysis. 167 participants were in the Waitlist group and 142 in the Wheelchair group. For the remaining of this Chapter, data will be presented only on the 142 participants who received a wheelchair and had follow up data. The average time between baseline and follow up was 193±27 days. Descriptive statistics of age, gender, and living environment stratified by type of participant are presented in Table 7 and for disability type in Table 8. In our sample 20% of participants had a wheelchair before receiving services at UCPRUK: 21 adults, two adult with proxy (two missing) and five children with proxy (one missing) had a wheelchair at baseline. Of the adults who did not have a wheelchair 26 crawled as their primary means of mobility, five ambulated, one used a wooden cane, and five a crutch. For children, 32 crawled and 27 were carried. A total of 18 participants had missing information related to primary means of mobility. Eighty-six percent reported living in a rural area and no significant associations were found between living place and participant type. Number of times per day that the user had to go over a curb was not significantly different across participant types and was the median 2 IQR 2. Approximately 80% of children were not enrolled in school and 60% of adults were not employed at both at baseline and follow up.

Table 7. Descriptive statistics for age, gender, and having a wheelchair at baseline based on type of participant.

Participant n=142	Age Mean±SD		Gender		Environment	
	Male	Female	Male	Female	Urban	Rural
A (n=55)	41.6±10.6	36.4±14.5	37, 67%	18, 33%	5, 9%	50, 91%
A+p (n=22)	23±10.1	40.2±21.8	11, 50%	11, 50%	3, 14%	19, 86%
C (n=6)	11.3±3.3	7.4	5, 83%	1, 17%	2, 33%	4, 67%
C+p (n=59)	10.3±3.7	10.4±6.4	34, 58%	25, 42%	10, 17%	49, 83%

A:Adult, A+p: Adult+proxy, C: Child, C+p:Child+proxy

Table 8. Disability type frequencies by type of participant.

P	CP	Polio	SCI	Stroke/Brain Injury	Intellectual	Amputee	MS, MD	Other	Missing
A	10	18	18	0	1	5	0	3	0
A+p	11	1	2	2	1	0	2	3	0
C	3	1	1	0	0	0	0	1	0
C+p	50	1	0	0	1	0	1	5	1

A:Adult, A+p: Adult+proxy, C: Child, C+p: child+proxy, SCI: spinal cord injury, MS: Muscular sclerosis, MD: muscular dystrophy

Overall 33.8% of participants reported needing ≥1 repair in the past 6 months and 70.8% of them reported at least one of these repairs was not completed. Average hours of daily wheelchair use, participants reporting ≥1 repairs needed, and ≥ 1 repairs not completed are listed in Table 9 by participant and wheelchair type. Four percent of those needing repairs had an adverse consequence; one adult who used a roughrider and one who used a harmony wheelchair reported being stranded.

Table 9. Average daily hours of wheelchair use, repairs needed and repairs not completed by type of participant and type of wheelchair.

P	Wheelchair type															
	Kids				Roughrider				Harmony				Specialized			
	n	use	%RN	%NC	n	use	%RN	%NC	n	use	%RN	%NC	n	use	%RN	%NC
A	0	-	-	-	37	4.7±3.6	32.4	58.3	17	6.4±3.8	47.1	75	1	0.5	0	0
A+p	6	2.5±1.4	33.3	100	4	1.5±.6	25	100	11	3.5±2.3	36.4	75	1	2	0	0.00
C	4	6.3±1.4	75	100	2	3.5±3.5	0	0	0	-	-	-	0	-	-	-
C+p	53	3.8±2.9	30.2	68.8	4	2.6 ±1.5	25	0	2	9±4.2	50	100	0	-	-	-
T	63	3.8±2.9	33.3	76.2	47	4.2±3.4	29.8	57.1	30	5.5±3.6	43.3	76.9	2	1.2±1.1	0	0

A:Adult, A+p: Adult+proxy, C: Child, C+p: child+proxy; %RN: needing repairs, %NC: repairs needed but not completed.

No significant association was found between type of wheelchair and needing ≥1repair or hours of wheelchair use. Overall WAC scores were significantly lower in Kids wheelchairs as compared to roughriders and harmony wheelchairs ($p<0.008$). No significant correlations were found between WAC scores and average hours of daily wheelchair use or between WAC and CHART mobility subscore (Median=51.5, IQR=27). No significant differences were found in CHART mobility subscore between those who did not need repair and those who needed ≥1 repair. Twenty three wheelchairs were identified with moderate debris in the WAC. Table 10 presents detailed information on number of participants' wheelchairs that: 1) had components scored with a problem (1 or 2), 2) had participants self-report completing and/or needed to be completed a repair in that category and not having that repair completed, 3) number of participants reporting location where the most significant repair was completed and 4) total WAC scores. Applying Fisher's exact test, the proportion of harmony wheelchairs needing a repair in the peripheral category was higher, ($p=0.03$).

Table 10. Frequency of self-reported and WAC measures by type of wheelchair and type of participant.

Measure	Roughrider	Kids	Harmony	Specialized
WAC Items scored = 1 or 2	2: Frame 1: cross brace 1: push handle 1: wheel axle 1: castor fork 10: drive wheel 1: cushion 10: handrim 3: wheel lock 2: seat base	1: frame 1: wheel axle 3: caster wheel 1: drive wheel 1: back support 2: cushion 14: handrim 1: cross brace 1: wheel lock 1: seat base 2: cloth guard	1: frame 2: foot support 1: legrest 1: cross brace 2: caster fork 3: caster wheel 1: drive wheel 1: cushion 2: back support 8: handrim 1: wheel lock 1: cloth guard	0
WAC+	61.2 (2.5)	59.7 (2.9)	61.9 (3.9)	55.7 (.)
Self reported	3: Wh/Cs completed 4: Wh/Cs needed 3: Fr completed 1: Fr needed 2: Intf needed 2: SS completed 1: SS needed 1: Ph needed	3: Wh/Cs completed 4:Wh/Cs needed 1: Fr completed 10: Intf needed 2: SS needed 1: Ph completed 4: Ph needed	2: Wh/Cs needed 3: Wh/Cs completed 1: Fr needed 1: Fr completed 1: Intf completed 4: Intf needed 1: SS completed 4: SS needed 2: Ph completed 4: Ph needed	0
Who?	8: myself/family 1: UCP/partner	5: myself/family	3: myself/family	0

+p=.002

To assess how self-reported measures of needing a repair and data collector measures corresponded, an item-by-item agreement analysis is presented in Table 11.

Table 11. Agreement (or lack thereof) between self-reported categories needing a repair and problems found in the WAC.

Component categories	Number of cases		
	SR & WAC ≤2	Not SR & WAC ≤2	SR & WAC =3
Wheels and casters	5	17	10
Wheelchair frame	0	6	2
Wheelchair-user interfaces	5	30	16
Seating system	1	7	7
Peripheral items	1	4	9

3.4 DISCUSSION

To our knowledge, this is the first cohort study that examined how wheelchair maintenance and self-reported wheelchair repairs present in a cohort of users who have received wheelchairs through WHO's 8-steps. Therefore, it contributes information that is needed related to the evaluation of different wheelchair delivery models (Greer, Brasure, & Wilt, 2012). Thirty percent of participants self-reported needing ≥1repair and almost 75% of them did not complete at least one of those repairs. Previous published work in the US, in addition to findings in Chapter 2, have reported that up to 62% of wheelchair users with spinal cord injury have needed a repair in the past 6 months (L. McClure et al., 2009; Toro, Pearlman, Oyster, & Boninger, 2014; Worobey et al., 2012). Findings in Chapter 2 indicated that 7% of repairs were not completed. Participants in Chapter 2 on average had ten years post injury, which presumably indicates that they were experienced wheelchair users. While for most of the participants in Indonesia this was their first wheelchair. This suggests that further emphasis should be made to educate new wheelchair users on what to do if repairs are needed. However, direct comparison between current study prevalence and US studies is not possible based on differences in location, providers, types of wheelchairs, wheelchair provision services, the age of the wheelchair (unknown in US studies vs six months in current study) type of disability (spinal cord injury in US studies vs varied in current study), terrain, and age as children were included in the current study. Further follow up could help elucidate the types of repairs required with increased wheelchair age inherent to the wheelchairs provided by UCPRUK.

Wheelchairs of participants in this study were only approximately 6 months old and both the kids and the adult roughrider wheelchairs are reported to be compliant with the International Organization for Standardization (ISO) 7176 standards (UCP Wheels For Humanity, 2014). Components failing at this stage should be covered through product warranty. The question of if the threshold of meeting ISO 7176 standard is enough to guarantee reliable wheelchairs in less-resourced settings, as argued in the WHO Consensus meeting, is yet to be answered (Sheldon & Jacobs, 2006).

Even though the WHO WSTP provided by UCPRUK includes training the user in wheelchair maintenance skills, only six basic tasks are taught and it was also done in conjunction to mobility skills and transfer in the same appointment (World Health Organization, 2012). Ninety six percent of the major repairs that were completed were done at home, suggesting that user training in maintenance may have had a positive effect. However, at the same time the current training may not be sufficient as a majority of repairs were not completed. Future supplemental wheelchair maintenance training may be beneficial in which wheelchair personnel are trained who could then train wheelchair users.

There are several potential factors that may explain the discrepancies between the WAC and self-reported repair data. First, repair was not defined to the users. The examples that were provided by the category were not exhaustive and therefore participants could have underreported repairs needed. In addition, most users answered needing/completing a repair but not remembering the exact number. Recall bias is granted, however its impact should be minimal as to most of them this was their first wheelchair and it was only six months old. Or, because it is so new they also might not have been aware of what to look for. Second, it is possible that self-reported data might not correlate to objective data and responses may be given to satisfy the interviewer, as encountered in a previous study (Johan Borg, Per-Olof Ostergren, et al., 2011).Further, only WAC total scores were computed. The calculation of a total composite scores are not encouraged (Streiner & Norman, 2008) and do not provide distinct scores between a broken and good working condition wheelchair so WAC scoring should be revised.

In terms of demographics, 49% (n=153) of our sample were children, which is a step towards an increased understanding of the impact of wheelchair provision on this population. Other studies that have included children have not had them exceed 20% of the total sample at most and have had small sample sizes (maximum of 60) (Glumac, Pennington, Sweeney, & Leavitt, 2009; Rispin & Wee, 2013; SL Shore, 2008; Susan Shore & Juillerat, 2012; Toro, Garcia-Mendez, et al., 2012). Eighty percent of the study participants did not have a wheelchair at baseline which is similar to baseline data from studies in India, Peru, Vietnam, and Chile with first time wheelchair users comprising more than 90% of their participants (SL Shore, 2008; Susan Shore & Juillerat, 2012). Average hours of wheelchair use was higher in this study compared to those reported in studies that have provided a single-size wheelchair to all of the users (Mukherjee & Samanta, 2005; SL Shore, 2008; Susan Shore & Juillerat, 2012). However, wheelchairs provided in this study were used on average for less than a third of the day. Wheelchairs are expected to wear as they are used; the low usage rate might also explain the few repairs needed. As school and employment status was not affected by access to a wheelchair it is likely that accessibility, public transportation, and attitudinal barriers need to be investigated further as barriers to participation to determine why usage time was low among participants. This also suggests that even with a wheelchair provided through the WHO 8-Steps, improvement in mobility is not guaranteed; more investigations into factors that continue to limit mobility are necessary. Fifty seven percent of participants were enrolled with a proxy, meaning that they were not independent propellers. It is likely that several of them could be independent with power mobility and alternative propulsion methods. This continues to highlight the fact that access to appropriate mobility is very limited in less resourced settings.

3.4.1 Study limitations

The results must be interpreted with caution; there was not agreement between the WAC and the self-reported measures and the reliability of these translated tools in unknown. The Child group had a very small sample size (n=6). Since participants were recruited as they came in for services on first-come first-served basis, additional efforts to recruit more for this group could not be made in the time allotted for the study. In addition, characteristics of wheelchair users in Indonesia are unknown; therefore we cannot explain whether most of the children who require a wheelchair are not independent for manual wheelchair mobility. Even though all questionnaires were translated to Bahasa Indonesian, back translated to English and re-revised during the data collectors training, the reliability and validity of the translated questionnaires is unknown. Another potential limitation is the protocol was long (2 hours) and entirely paper based and this may have led to disengagement of both the participant and the data-collector. An additional limitation to this data collection measure was that data was digitized only after all data was collected. It is likely that entry errors occurred; we could not control for that. This was a convenience sample, and thus not a randomly selected sample. Therefore, there is a risk for selection bias. Furthermore, this study was funded as part of UCP's grant to provide wheelchair services in Indonesia. The study was designed and the data was analyzed by an independent group of researchers, but the data was collected by a team from UCP, opening up a potential for bias.

3.4.2 Future work

Further study is warranted. There is a significant need for the development or implementation of a rigorous assistive technology or wheelchair outcome measure that is validated across cultures and languages (Bray, Noyes, Edwards, & Harris, 2014). Longterm follow-up on the condition, reliability and durability of wheelchairs and how they related to environment where they are used is suggested. This will inform manufacturers, users, UCPRUK, and ISO standards committee. The impact of providing further maintenance and repairs training to the wheelchair users should also be explored. A measure of distance travelled should also be collected, as this is an expected factor to influence component wear.

3.5 CONCLUSION

This study found that 33% users who received new manual wheelchairs provided according to the WHO 8-Step approach in Indonesia reported needing at least one repair in the past six months. There was a discrepancy of >70% between those who needed repairs and those that were completed. Training wheelchair users on maintenance and/or repairs beyond WHO's six maintenance steps could help address this issue. The majority of needed repairs did not result in an adverse consequence, however wheelchairs were less than 6-months old. Further and regular follow up to the performance of these wheelchairs is recommended.

4.0 DEVELOPMENT OF A WHEELCHAIR MAINTENANCE TRAINING PROGRAM AND QUESTIONNAIRE FOR CLINICIANS AND WHEELCHAIR USERS[5]

4.1 BACKGROUND

Approximately one percent of the world's population needs a wheelchair as their primary means of mobility (World Health Organization, 2008a). In the United States (US), approximately 3.6 million non-institutionalized people over the age of 15 use wheelchairs (Matthew W Brault, 2012). Access to an appropriate wheelchair and associated services is a vital step to accessing other human rights such as education, health, and employment (World Health Organization, 2008a). Hence, wheelchair-related problems may negatively affect users (S. Fitzgerald et al., 2005). Many wheelchair users experience wheelchair-related accidents each year which lead to injuries or even death (Calder & Kirby, 1990; W-Y Chen et al., 2011; Kirby & Ackroyd-Stolarz, 1995; Nelson et al., 2010; Ummat & Kirby, 1994; H Xiang et al., 2006). Unfortunately, wheelchair-related injuries are on the rise (Barnard, Nelson, Xiang, & McKenzie, 2010). Several factors have been explored for their influence on wheelchair-related injuries including tips and

[5]This chapter is under review for publication in the Journal of Rehabilitation Research and Development. By Maria Luisa Toro, Emily Krobot, Michelle Oyster, Lynn Worobey, Michael Lain, Samuel Bucior, Rory A. Cooper, and Jonathan Pearlman.

falls (Barnard et al., 2010; H Xiang et al., 2006), wheelchair and component failure (Kirby & Ackroyd-Stolarz, 1995; H Xiang et al., 2006; Young et al., 1985), and poor wheelchair maintenance (Calder & Kirby, 1990). Studies performed at several Spinal Cord Injury Model Systems sites in the US (including findings in Chapter 2) found that between 44.8 and 62% of wheelchair users needed at least one repair in the prior six months and this rate has increased over time (L. McClure et al., 2009; Toro et al., 2014; Worobey et al., 2012). As re-confirmed in Chapter 2, among the subset of users who reported needing repairs, between 19.7 and 30.5% indicated subsequent adverse events which included missing work, school or medical appointments, being stranded, or injured (L. McClure et al., 2009; Toro et al., 2014; Worobey et al., 2012). Several studies have provided evidence that manufacturers are producing wheelchairs that are not compliant with the American National Standards Institute/Rehabilitation Engineering and Assistive Technology Society of North America (ANSI/RESNA) minimum durability standards (American Association for Healthcare, 2013; Cooper et al., 1999; Cooper et al., 1997; Cooper et al., 1996; M.V. Fass et al., 2004; S. G. Fitzgerald et al., 2001; Kwarciak et al., 2005; H. Liu et al., 2010; H. Y. Liu et al., 2008; Rentschler et al., 2004b; Wang et al., 2010).

Improved wheelchair maintenance has been suggested as a strategy to keep users' wheelchairs in appropriate working condition (Arledge et al., 2011), increase reliability (World Health Organization, 2008a) and reduce wheelchair-related accidents and injury rates ("Chariots of fear: wheelchair-related accidents," 1992; Ray et al., 2005; Ray et al., 1997; Young et al., 1985). A study of 95 wheelchair users found that those who did not report having regular wheelchair maintenance completed were over ten times more likely to have a wheelchair-related accident in the prior three years than those who did (W-Y Chen et al., 2011). A randomized control trial (total N=216) that compared wheelchair-related accidents between a maintenance intervention (therapists determined if maintenance was needed) and a control group (self-requested maintenance) found that the intervention group had significantly fewer accidents compared to the control group (Hansen et al., 2004). While this research highlights the value of clinically-provided maintenance, this level of service is unrealistic in the US given that funding to support this type of technical assistance is constantly under attack to try to reduce health care costs (American Association for Healthcare, 2013). In addition, findings from Chapters 2 and 3 suggest that users and caregivers are willing and able to perform maintenance and repairs at home. Specifically, users and caregivers at home could potentially address manual and power wheelchair repairs needed in the categories of peripherals and interfaces. Power wheelchair users could learn to identify problems that are arising in the electrical components and power controllers, which were the most prevalent category power wheelchair users reported needing a repair. The fact that 7% of the users in Chapter 2 and 70% of the users in Chapter 3 left repairs uncompleted also suggests that learning what to do when a problem is present could help reduce uncompleted repairs.

Professional wheelchair maintenance services and training wheelchair users (and caregivers when applicable) in wheelchair maintenance are recognized as necessary steps during the provision of a new wheelchair (Arledge et al., 2011; Di Marco, Russell, & Masters, 2003; World Health Organization, 2008a). However, regular maintenance is reported as an uncommon practice (S. Fitzgerald et al., 2005; Hass, Fredén-Karlsson, & Persson, 1996; Nosek & Krouskop, 1995). One reason for this could be that it is common for wheelchairs to be provided without maintenance training (Best, Routhier, et al., 2014; Pedersen, Harmon, & Kirschner, 2014). Also, wheelchair maintenance is not a common topic in entry-to-practice occupational and physical therapy curriculums (Best, Miller, et al., 2014). Therefore, there is a need to increase the number of users, clinicians, family members, and caregivers receiving training in maintenance of wheelchairs (Arledge et al., 2011; Coolen et al., 2004; World Health Organization, 2008a).

Several resources are available that provide information supporting wheelchair maintenance including wheelchair manufacturers' user manuals, checklists found on the internet (Cooper, 2013; Denison, 2006; Lukersmith et al., 2013) and books (Cooper, 1998; Cooper et al., 2006). In addition, in wheelchair provision guidelines (World Health Organization, 2008a) and wheelchair service training (Khasnabis & Mines, 2012) developed by the World Health Organization (WHO), RESNA (Arledge et al., 2011), and Australian guidelines (Lukersmith et al., 2013). However, these resources alone are insufficient in the absence of training. The WHO module is the only one to include training on basic wheelchair maintenance for providers with an overview and practice of maintenance tasks (Khasnabis & Mines, 2012). It does not include structured training for wheelchair users or information on power wheelchairs. As findings in Chapter 3 suggest, there is a need for supplementary training to what WHO current offers that can educate users and caregivers on maintenance. To the best of our knowledge, no structured group training program exists to teach wheelchair users to maintain their manual or powered wheelchairs.

The purpose of this study was twofold: 1) to develop a Wheelchair Maintenance Training Program (WMTP) to teach clinicians how to train wheelchair users (and caregivers when applicable) in group settings to perform basic maintenance at home, and 2) to develop the Wheelchair Maintenance Training Questionnaires (WMT-Q) to measure the impact of the WMTP on clinicians and manual and power wheelchair users after they have participated in the training.

4.2 METHODS

The WMTP and WMT-Q were developed simultaneously through an iterative process. Figure 3 summarizes the development processes. The Methods and Results sections describe each phase in detail. For readability, the WMTP is described first followed by the WMT-Q.

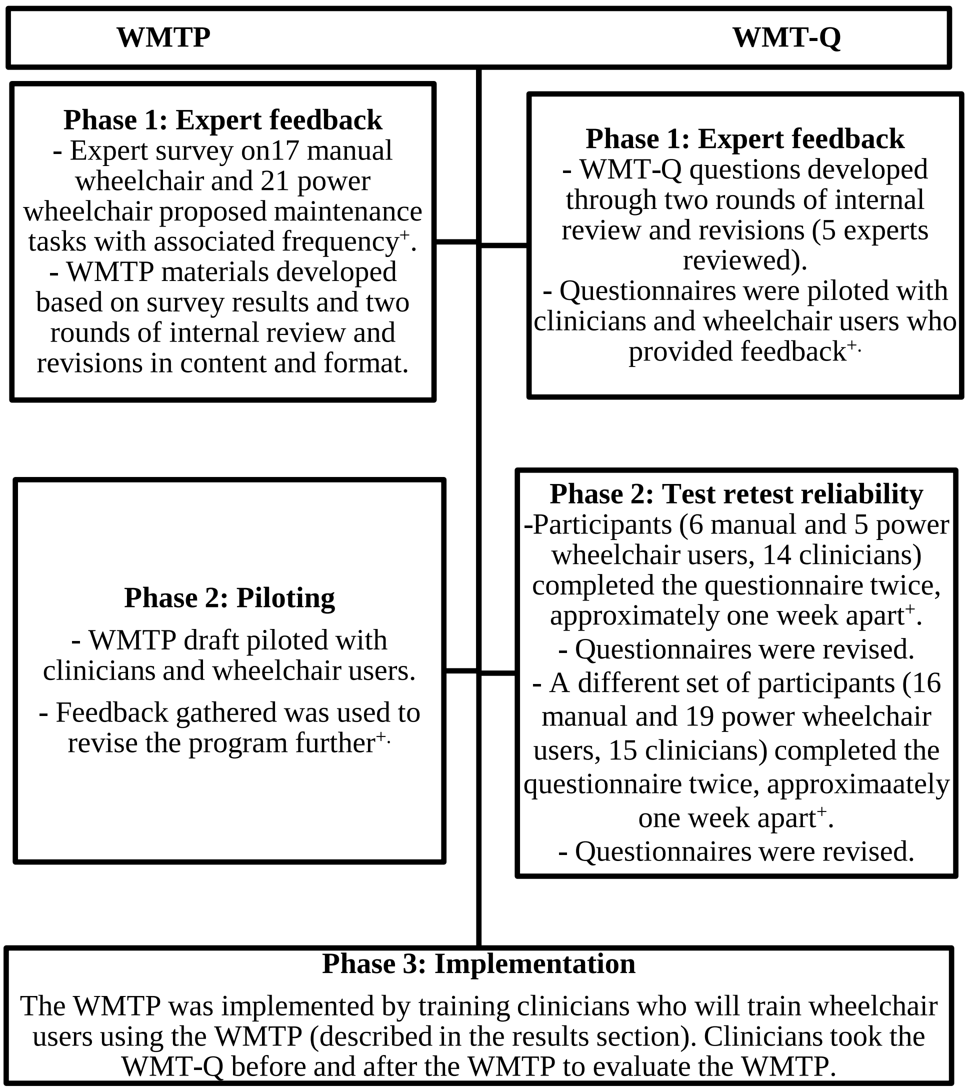

Figure 3. WMTP and WMT-Q three-phase iterative development process. [+]Indicates study approved by the Internal Review Board (Adapted from(Toro et al., 2015)).

4.2.1 Wheelchair Maintenance Training Program

Training materials (power point presentations, videos, and reference manual) were developed to teach clinicians on how to train wheelchair users (i.e. training of trainers) and for use by clinicians to educate wheelchair users (and caregivers when applicable).

4.2.1.1 Wheelchair Maintenance Training Program Phase 1

The WHO maintenance curricula (Khasnabis & Mines, 2012) and additional items from the literature cited above were used to generate a list for both manual and power wheelchair maintenance tasks. Tasks were grouped into check and action item categories. **Check items** were defined as *inspection* activities that the wheelchair user or caregiver could perform on the wheelchair. When problems are identified during a check, it was outlined when the user or caregiver should address the issue or an expert in wheelchair maintenance should be contacted. **Action items** were defined as *maintenance* activities that the wheelchair user or caregiver could perform on the wheelchair. An online survey was constructed with these check and action tasks followed by relevance and timing questions. The survey was sent to rehabilitation professionals, wheelchair users, and other identified experts who had at least one year of experience maintaining or repairing wheelchairs. They were asked to indicate which maintenance items they thought were important and whether the proposed frequency was appropriate. Maintenance tasks and the proposed frequency of completion items that had at least 80% agreement among experts were included (Lynn, 1986). The items that did not meet this cutoff were revised based on the comments. These results were used to develop the first draft of the training materials.

Following the development of the first draft, two internal review rounds by experts in wheelchair provision and maintenance were performed. For the first round of internal review, all materials were made available on a website for reviewers to download. An online form was sent with instructions on how to review the materials based on the schedule for each training session (i.e. clinicians and wheelchair users). Reviewers were asked to answer if each training session covered *enough, too little, or too much* information and also if the amount of time allocated was appropriate. Reviewers were given one week to review the materials and a meeting was held to discuss the comments as a group. Based on these results, a revised version of the WMTP was created and distributed to the same reviewers for a second round of review. The feedback was addressed and a revised WMTP draft was ready to be piloted.

4.2.1.2 Wheelchair Maintenance Training Program Phase 2

The WMTP was piloted by training clinicians and then these clinicians in turn trained wheelchair users on wheelchair maintenance using the materials developed. Clinicians were eligible to participate if they had at least one year of experience providing care to people and were able to attend all training sessions. Wheelchair users were able to participate if they were between 18 and 75 years old, used either a manual or power wheelchair for more than 50% of weekly mobility, lived in the community, and were able to attend the training with a caregiver if unable to perform maintenance independently.

Clinicians attended a 6-hour course in which they were exposed to various wheelchair maintenance techniques through presentations and hands-on maintenance activities. They were provided with materials that would enable them to teach others about wheelchair maintenance. Then, separate group sessions (two-hour sessions on two sequential days) were scheduled for the clinicians to teach manual and power wheelchair users maintenance skills using the training program.

Both clinicians and wheelchair users had the opportunity to provide written feedback after the training that captured parts of the course they found *difficult to understand*, *most useful*, and should be *added/emphasized* or *removed/reduced.* Three multiple-choice questions asked whether they thought the WMTP was useful and whether they would recommend it to colleagues/wheelchair users. Two focus groups were held after the training to discuss the usefulness of the program, suggestions for improvement, concerns, and ideas for reminding users about wheelchair maintenance. The focus group began with both the wheelchair users and clinicians, and then they separated into two groups. Wheelchair experts were present during the three trainings (5 sessions) as observers. Feedback gathered was used to revise the WMTP before its implementation.

4.2.2 Wheelchair Maintenance Training Questionnaire (WMT-Q)

Three versions (clinicians, manual wheelchair users, and power wheelchair users) of a knowledge-based WMT-Q were developed to evaluate whether the training impacted the knowledge and frequency of wheelchair maintenance self-reported performance among clinicians and wheelchair users.

4.2.2.1 WMT-Q Phase 1

Based on the literature mentioned above and the results of the expert survey conducted for the WMTP, a draft of the questionnaires was developed followed by two iterations of internal review by experts and revised based on this feedback. The resulting draft was piloted with rehabilitation professionals and wheelchair users. The questionnaires were uploaded in Wufoo[6] and the link to the questionnaire was distributed via email for participant recruitment. Each section was presented on a separate page and participants were not allowed to go to the previous page and change their answers.

4.2.2.2 WMT-Q Phase 2

The questionnaires were revised based on the results from the previous phase and uploaded and distributed in the same way described in phase 1. Participants were notified that they were going to be asked approximately one week later to complete the questionnaire again. The subscores for the each section of the questionnaire were converted to percentage scores for analysis. Test-retest reliability was calculated for the subscores using the two-way mixed consistency model intra-class correlation coefficient ICC(3,1). Based on the results of this test-rest reliability analysis, a revised version of the questionnaires was developed and its test-retest reliability was examined. A different set of participants were recruited in the same manner described above. ICC(3,1) and confidence intervals for ICC were calculated and reported (Kottner et al., 2011) for the subscores. The results of this round were used for a final refinement of the questionnaires to be used for the implementation of the WMTP.

Power analysis

Sample size for the test-retest reliability was calculated estimating that there was a correlation of 0.8, α=0.05, and power of 80%. A total of 60 participants were needed, 20 participants for each version of the questionnaire.

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[6] http://www.wufoo.com/

4.2.3 Phase 3: Implementation WMTP and WMT-Q

The WMTP and questionnaires were launched in the US in the summer of 2014 with clinician training at four different locations by the same investigators who trained clinicians in the pilot and who were involved in the development of the WMTP. As part of the WMTP evaluation, clinicians were asked to take the WMT-Q one week before the training and one week after the training and asked to fill out a course evaluation form at the end of the training. The Wilcoxon signed-rank test was used to explore if there were significant differences in the WMT-Q sub scores before and after the training.

4.3 RESULTS

4.3.1 Wheelchair Maintenance Training Program

4.3.1.1 Phase 1

A total of 19 experts answered the survey. They were on average 46.3 ± 10 years old and had 19.5 ± 11 years of experience in wheelchair maintenance (Table 12). Items and frequencies were revised based on comments and level of agreement between experts (Table 13). For instance, one item changed from “Check spokes weekly …if loose spokes are found, tighten them” to “If loose, contact a wheelchair maintenance expert”. As another example, the proposed cushion inspection frequency changed from monthly to at least weekly.

Table 12. Experts' demographic characteristics of the wheelchair maintenance item and frequency survey for phase 1.

Characteristic		# of participants
Gender	Male	15
	Female	4
Wheelchair related experience	Manual wheelchair user	3
	Wheelchair supplier	2
	Wheelchair supplier and ATP	5
	Physical therapist	3
	Occupational therapist	1
	Occupational therapist and ATP	2
	Rehabilitation engineer and ATP	1
	Rehabilitation engineer and manual wheelchair user	1
	Machinist	1

Abbreviation: ATP, Assistive Technology Professional certification by RESNA

Table 13. Frequency count of number of items that had at least 80% expert agreement in phase 1 for manual and power wheelchair maintenance items.

	Maintenance tasks	Frequency of maintenance tasks (among those that agreed upon the maintenance task)
Manual wheelchair maintenance	13/17	9/13
Power wheelchair maintenance	11/21	9/11

WHO's (Khasnabis & Mines, 2012) material format was followed with minor modifications to make the materials appropriate for wheelchair users. The first draft of materials included power point presentations, videos, posters, a clinician reference manual, and a wheelchair user workbook. Each specific maintenance item had instructions to answer what, how and when as well as a rationale for why since people tend to comply more with education and are more likely to adopt behavioral changes when they perceive the need to learn (May, Day, & Warren, 2006; Michie & Johnston, 2004). A tool-kit was added to the training package and was suggested as a take-home resource for wheelchair users when affordable by the training center. Proposed sessions included a 7-hour training session for clinicians and two 2-hour training sessions for wheelchair users. Experts for the first round of internal review included two physical medicine and rehabilitation doctors, one physical therapist, one occupational therapist, and a rehabilitation engineer. The main suggestions to improve the materials were:

- Include detailed pictures of different types of wheelchairs and components.
- Increase description of relevance and possible consequences for each maintenance item.
- Increase detail in the Clinician Reference Manual on how to deliver the training to wheelchair users.
- Include information on tool usage.

After the training materials were revised, a second round of expert internal review was performed. Three experts, two physical medicine and rehabilitation doctors and one with a doctorate degree in engineering who is also a manual wheelchair user, reviewed the materials. Suggestions included adding clarification to terms and improving consistency throughout the materials. The "action" and "check" items were reordered and redefined:

- Check items: inspection activities that the wheelchair user or caregiver performs on the wheelchair. When problems are identified, the check item is followed by an action item.
- Action items: maintenance activities that the wheelchair user or caregiver performs on the wheelchair.

All training materials, except the videos, were revised accordingly. A revised version of the videos were developed including this feedback and the comments that were received during the pilot that is described in the next section.

4.3.1.2 Phase 2

Two study investigators trained two clinicians using the WMTP. One of the clinicians trained four power wheelchair (and their caregivers) users and the other clinician trained one manual wheelchair user. Table 14 contains the agenda of the training sessions. All power wheelchair users participated with a caregiver during the training sessions. The training sessions were observed by three experts who took notes and also provided feedback after the training. Each participant was given a basic toolkit to take home that included hex, combination, and adjustable wrenches and a multi-bit screwdriver.

Table 14. Pilot training agenda for clinicians and wheelchair users.

Clinicians training	Wheelchair users training (the schedule was the same for manual and power wheelchair training)	
Day 1	Day 1	Day 2
-Registration and introduction -Wheelchair Maintenance - Training Questionnaire -Overview of Clinician's Reference Manual -Overview of Wheelchair User's Workbook -DVD demonstration of wheelchair maintenance -Hands-on manual wheelchair maintenance activity -Hands-on power wheelchair maintenance activity -Interactive question and answer session -Summary/discussion -Wheelchair Maintenance Training Questionnaire	-Introduction -Wheelchair Maintenance Training Questionnaire -Wheelchair maintenance overview -How to take care of a wheelchair at home DVD -Caring for a wheelchair at home -Hands-on wheelchair maintenance activity -Summary and homework	-Interactive question and answer session -Hands-on wheelchair maintenance activity -Summary and discussion -Wheelchair Maintenance Training Questionnaire

Clinicians reported that they found the training very useful to their practice and clients and would definitely recommend it to colleagues and wheelchair users. The Clinician Reference Manual, videos, and hands-on activity were found very useful, easy to learn, and well organized. Both clinicians reported that the ratio of trainers to participants may present a challenge. They suggested having volunteers available when caregivers are not present and to train with co-trainers.

Wheelchair users found the training useful and reported they probably would encourage their friends to participate in it. They found the training to be most useful for new wheelchair users. The most useful portions of the training were the toolkit, being informed of the statistics related to injury rates, the hands-on activity, and learning how to tighten components. The power point was found to be too repetitive and lacking pictures. The recommendations were to add more demonstrations while presenting and to improve the organization of the wheelchair users training. Caregivers that were present also found the training useful and beneficial. It was suggested that the training could be held at caregiving agencies and basic maintenance included as part of the "care plan" of the client. All wheelchair users reported that they addressed maintenance issues as they occur and all agreed that adopting preventive maintenance behavior may reduce the severity of the maintenance problems that could occur. The lessons learned from the pilot informed the subsequent revision of the WMTP. The power point presentations were revised based on the feedback and the format "sentence heading and visual evidence" was implemented as much as possible (Alley & Neeley, 2005).

4.3.2 Wheelchair Maintenance Training Questionnaires

4.3.2.1 Phase 1

The first version of the questionnaires was developed based on the content from first phase of the WMTP. Then, these drafts were presented to same group of experts that was described in the WMTP review above. They evaluated the tool and independently concluded that it appeared to measure the important aspects of wheelchair maintenance and provided recommendations to improve it. For instance, increase difficulty and reduce the length of the questionnaire; delete the nomenclature section; add multiple choice questions related to wheelchair maintenance, repairs, and replacement reimbursement policy in the US and best maintenance practices; and add as the first question an open ended question that asks what maintenance tasks and frequencies the respondent recommends. These recommendations were implemented and the revised questionnaires piloted online with 12 participants. Results showed that for the open ended question section, neither clinicians nor wheelchair users could tell the difference between what they should *look out for* and what they should *do on regular basis*. Therefore, this question was reworded for clarity.

4.3.2.2 Phase 2

A convenience sample of 25 participants was recruited. Participants answered the questionnaire at retest on average 10 days later after the first test. Based on these results a revised draft was developed. For the multiple choice questions the option "***I don't know***" was added to control for guessing. Several questions were answered correctly by all of the respondents and their wording was revised. The revised questionnaires had three sections each: open ended as described in Phase I; multiple choice questions on maintenance best practices, health insurance policy, and latest research evidence on wheelchair maintenance and repairs; and Capacity/Performance section that asks whether the respondent and/or caregiver know how to perform each maintenance task (Capacity) and if so how often do they perform it (Performance). A convenience sample of a different group of participants was enrolled for the second round of reliability. Sixty one participants answered the questionnaire at test and 50 at retest. The average time between test-retest was 11.7 days. Table 15 presents the test-retest reliability for each section of each version of the WMT-Q.

Table 15. WMT-Q test-retest reliability results for each subscore for the second round for clinicians, manual, and power wheelchair user versions.

WMT-Q version	**ICC(3,1), [CI]**		
	Open-ended	Multiple choice	Capacity/ Performance
Clinicians (n=15)	0.783^{*}, [0.468,0.922] 0.499^{+}, [0.003,0.798]	0.876^{*},[0.657,0.958]	0.856^{*}, [0.61,0.951]/ 0.886^{*}, [0.652,0.966]
Manual wheelchair users (n=16)	0.482, [-0.097,0.817]	0.579^{+},[0.038-0.857]	0.802^{*}, [0.448,0.939]/ 0.707^{+}, [0.253,0.906]
Power wheelchair users (n=19)	0.625^{+},[0.237,0.841]	0.770^{*},[0.484,0.907]	0.507^{+},[0.067,0.782]/ 0.596^{*}, [0.193,0.827]

$^{*}p<.001$; $^{+}p<.05$;

Based on these results, minor modifications were made and this revised draft was used as an evaluation tool during the implementation of the WMTP described above. The following changes were made to the three versions:

- Multiple choice questions: those that had 100% agreement in the correct answer were removed. In addition, those questions that had the option “None of the above” and “All of the above” were deleted.

- Capacity and Performance questions: For Capacity, the answer option “Unknown” was deleted since it was identified as ambiguous. All the Performance questions were revised by adding the specific maintenance task to the statement.
- The question “Do you have health insurance?” was added to the manual and power wheelchair versions to add further clarity to the health insurance questions.

The three versions of the WMT-Q can be found in Appendix B for clinicians, Appendix C for manual wheelchair users, and Appendix D for power wheelchair users.

4.3.3 Phase 3: Implementation of WMTP and WMT-Q

As of April 2015, a total of 15 clinicians have been trained. Table 16 describes the training materials used during the implementation phase.

Table 16. WMTP materials to train clinicians to train wheelchair users used for the implementation phase (Adapted from(Toro et al., 2015))

Material	Description	When is it used?
Clinician Training Power Point Presentation	Guide to train clinicians on how to train wheelchair users to perform maintenance	During clinicians’ training
Clinician reference manual	Includes detailed guidance on how to deliver the training to wheelchair users.	Clinicians use it to prepare for and during wheelchair users’ training
WMTP power point presentation (manual and power wheelchair versions)	Used by clinicians to train wheelchair users on how to perform maintenance on their wheelchair	During wheelchair users’ training
How to care for a wheelchair at home video (manual and power wheelchair versions)	5 minute video that demonstrates how to complete maintenance tasks	During wheelchair users’ and clinicians’ training
Wheelchair Maintenance Reminder Cards (manual and power wheelchair versions)	Given to the wheelchair users at the end of the training as reference material	During wheelchair users’ training

Overall the training was found to be useful, relevant, understandable, easy to tolerate, and enjoyable. Clinicians' suggestions were to emphasize the importance of the use of the appropriate tools while completing maintenance tasks as well as to include a checklist to guide the hands-on activity for wheelchair users. In addition, full body mirrors were added as a suggested resource to have available during wheelchair users training to facilitate observing wheelchair parts if they do not transfer out of the wheelchair. A revised version of the materials was distributed to all clinicians to be used during the training of the wheelchair users. The results of this WMT-Q suggest that clinicians receiving this training had a significant increase in maintenance knowledge (Table 17). The Performance score at pre-training was 11%, suggesting that training wheelchair users in wheelchair maintenance was not a common practice among the clinicians who participated in the implementation.

Table 17. WMT-Q pre-training and post-training subscores for clinicians.

WMT-Q	**Pre-training Mean (IQ)**	**Post-training Mean (IQ)**
Manual wheelchair open ended	26.8 (19.6) $^{\wedge}$	51.8 (25.0) $^{\wedge}$
Power wheelchair open ended	28.1 (21.9)	50.0 (43.0)
Multiple choice	56.8 (26.1) $^{\wedge}$	84.1 (28.4) $^{\wedge}$
Capacity	48.4(48.4) $^{\wedge}$	100 (0) $^{\wedge}$

Abbreviation: IQ, Interquartile range; $^{\wedge}p<0.007$

4.4 DISCUSSION

The WMTP is a structured training intervention that was developed through a rigorous iterative process. The WMTP was well received by clinicians that helped with the development, refinement, and were trained with it. Therefore, the WMTP curriculum could have implications for the education of rehabilitation clinicians and technicians that could translate later into education of wheelchair users. The developed in-person curriculum may be administered through formal curriculum and/or as a continuing education module (Best, Miller, et al., 2014). This training could be used as a complement to WHO's basic wheelchair service curriculum, which only includes training of the clinicians, but does not include detailed information to train wheelchair users and caregivers (Khasnabis & Mines, 2012). Training on wheelchair maintenance may be even more important where access to repair services is limited (Taylor et al., 2014). This training program is an adaptive program that will continue to be revised based on the training experiences.

The WMT-Q significantly improved throughout the iterations and has reached acceptable test-retest reliability. The significant increase in WMT-Q score after training suggests that clinicians had increased knowledge of wheelchair maintenance. The questionnaires also have the potential to be translated and validated for use in other countries and contexts.

4.4.1 Study Limitations

It is unknown whether the improvement in clinicians' knowledge as measured by the WMT-Q translates to improvements in clinician maintenance skills or problem-solving ability (May, Day, et al., 2006), or the transferability of these skills into wheelchair users' maintenance practice. Future work should evaluate clinicians at later follow-up time points to assess if they have retained the knowledge and if the frequency at which they are teaching or encouraging their clients to perform maintenance has increased. Acceptance by clinicians does not translate into program implementation; for the program to be implemented there needs to be buy-in at the level of managers and other decision-makers. A brief advocacy presentation could be developed to raise awareness about the importance of wheelchair maintenance to those that manage and fund wheelchair provision services.

For the WMT-Q reliability testing, the anonymity of the online responses minimizes our ability to ensure that respondents at each round were different. In addition, although we requested the respondents to be directly involved in wheelchair provision or be wheelchair users, there was no way to control for this (Best, Routhier, et al., 2014).

Scheduling may be more difficult for caregivers than for users themselves(Kirby et al., 2004), and so a single session training may be considered to increase the retention rate.

4.4.2 Future work

We will investigate whether the training of wheelchair users improved the knowledge of wheelchair maintenance as well as if it resulted in a reduction in wheelchair needing repairs and the related consequences, and study the impact of the training on social participation (Taylor et al., 2014). Based on the results of this phase, future studies could explore the impact of the training implemented by peer trainers. Studies have reported that wheelchair users perceive peer trainers with higher credibility than trainers who are not wheelchair users when teaching wheelchair-related skills (Standal & Jespersen, 2008). Other training alternatives may be also explored, especially for those who face barriers to transportation and commuting to rehabilitation facilities. For instance, home-monitored training via computer tablet may be another methodology to explore (Giesbrecht, Miller, Mitchell, & Woodgate, 2014).

Current clinicians' training is being adapted into an online training program. We are exploring ways of assessing trainees remotely when they participate in the online training version.

4.5 CONCLUSION

A wheelchair maintenance training program for clinicians and wheelchair users was practical and well received. Based on results from the questionnaires, it appears to be effective at improving clinicians' maintenance knowledge.

5.0 DEVELOPMENT AND PSYCHOMETRIC EVALUATION OF THE WHEELCHAIR MAINTENANCE ASSESSMENT TOOL[7]

5.1 BACKGROUND

Wheelchairs are a common assistive technology used to improve mobility, independence and participation in the community for people with mobility impairments (L. A. McClure et al., 2009; Officer & Posarac, 2011; World Health Organization, 2008b). Therefore, when a wheelchair breaks down, not only are the benefits lost, but the health and safety of the user may be endangered (W. Y. Chen et al., 2011; L. A. McClure et al., 2009; Ummat & Kirby, 1994). When a wheelchair does not perform well, satisfaction with the device is reduced(S. Fitzgerald et al., 2005) and it is more likely to be abandoned (B. Phillips & H. Zhao, 1993). It is concerning that many of the wheelchairs provided in the United States do not meet the minimum performance and durability standards(Cooper et al., 1999; Cooper et al., 1997; Cooper et al., 1996; M.V. Fass et al., 2004; S. G. Fitzgerald et al., 2001; Kwarciak et al., 2005; H. Liu et al., 2010; H. Y. Liu et al., 2008; Rentschler et al., 2004b) set by the American National Standards

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[7] This chapter has been under preparation for publication by: Maria Luisa Toro, Samuel Bucior, Michelle Oyster, Lynn Worobey, PhD, Emily Krobot, Michael L. Boninger, MD, Jonathan Pearlman, PhD

Institute (ANSI) and Rehabilitation Engineering and Assistive Technology Society of North America (RESNA). Engineering factors, such as defective wheelchairs and components, have been found as contributors to wheelchair-related accidents, injuries and fatalities(Kirby & Ackroyd-Stolarz, 1995; Huiyun Xiang et al., 2006). In addition, research has shown that between 44 and 57% of people with spinal cord injury have required at least one wheelchair repair in a six months period(L. McClure et al., 2009; Toro et al., 2014; Worobey et al., 2012). Between 22 and 30% of those who needed repairs also reported being stranded, missing appointments, school or work, or being injured due to this needed repair(L. McClure et al., 2009; Toro et al., 2014; Worobey et al., 2012). Many of these wheelchair problems are a relatively easy fix(Hansen et al., 2004; Toro, Garcia, et al., 2012b; Young et al., 1985).

In spite of this evidence, wheelchair maintenance is not a common practice. Between 77 and 99% of the wheelchairs have been found to need maintenance in both institutional(Young et al., 1985) and community settings(Hansen et al., 2004; Young et al., 1985). Even though users are concerned with the impact of poor maintenance(Caroline Smith, McCreadie, & Unsworth, 1995), less than half of them reported performing maintenance regularly(S. Fitzgerald et al., 2005). Lack of maintenance has been linked to a 10-fold increase in the likelihood of been injured(W. Y. Chen et al., 2011); which in addition to poor quality wheelchairs, makes attention to maintenance critical for the health and safety of wheelchair users(Wang et al., 2010). Evidence suggests that regular maintenance and care reduces the risk of being injured due to accidents(W. Y. Chen et al., 2011; Dudley, Cotter, & Mulley, 1992; Hansen et al., 2004; Kirby & Ackroyd-Stolarz, 1995), helps maintain function, and increases the wheelchair's useful lifespan(World Health Organization, 2008a). Even with clear instructions from RESNA's Wheelchair Service Provision (Arledge et al., 2011) and wheelchair manuals, maintenance does not occur consistently. One reason for this may be that there is no standardized approach to measuring maintenance status(Ray et al., 1997). If there were, it would allow people to alert the user and caregivers of the need for maintenance.

To our knowledge there are four checklists that can be used to assess the maintenance state of a manual wheelchair and to identify where problems are present: the Wheelchair Parts Questionnaire(Rispin, Goodwin, Wesley, & Wee, 2013), the checklist reported by Hansen et al.(Hansen et al., 2004), the World Health Organization Wheelchair Safe and Ready Checklist available in the Wheelchair Service Training Packages(World Health Organization, 2012, 2013), and the Wheelchair Assessment Checklist (Karmarkar et al., 2009) (WAC) for manual wheelchairs. The Wheelchair Parts Questionnaires provides a visual analog scale for the raters to answer the question: "Rate the current maintenance condition of the (part in question)". The raters in the Hansen et al. study selected whether the part had a problem or not and then specified the needed action. In the Wheelchair Safe and Ready checklist, the raters check a box to indicate whether the wheelchair component is safe and ready to use. In contrast, in the WAC, the individual wheelchair components are scored on a scale from 1 (poor condition) to 3 (good condition), weighted according to breakdown frequency and severity, and summed for a total score. Scores in a Spanish version of the WAC were found to be negatively correlated to the number of adverse events(Toro, Garcia, Ojeda, Dausey, & Pearlman, 2012a). We decided to build upon the WAC's previous work, which was done with input from a panel of experts, had preliminary reliability results and provided a description for each score. Descriptive scoring options for each item were chosen because it would give more informative results on the current wheelchair maintenance state. The purpose of this study was two-fold. First, to develop the Wheelchair Maintenance Assessment Tool for Manual Wheelchair (MW-MAT) based on the

WAC, and to add a Power Wheelchair version (PW-MAT). Second, to investigate the feasibility, face validity, and the intrarater and interrater reliability of both tools.

5.2 METHODS

5.2.1 Development

The W-MAT was designed to be used by a broad audience including clinicians, researchers, research assistants, vendors, and technicians to evaluate the maintenance state of a wheelchair and so that no level of experience with wheelchairs was necessary to use the tools. Items on the W-MAT were based on the WAC, books (Cooper, 1998), commercial wheelchair user manuals, wheelchair components described in standards(ANSI/RESNA, 2009; Waugh & Crane, 2013), and one-on-one discussions with three experienced power wheelchair users and three wheelchair professionals. The wheelchair professionals were: an occupational therapist and certified assistive technology professional with more than 10 years of experience as a wheelchair seating clinician; a mechanical engineer with over five years of experience testing wheelchair compliance with ANSI/RESNA standards, and a wheelchair technician with over 20 years of experience in wheelchair fitting, maintenance, and repairs. The results of this feedback were compiled into the MW-MAT and the PW-MAT. To establish face validity, a printed copy of each version of the W-MAT was distributed among the three wheelchair professionals for their review and then followed up by a one-on-one discussion. A consensus was reached among the wheelchair professionals on the wheelchair parts and scoring options for each item, which were integrated in the first revision before the pilot testing. The iterative process is illustrated in Figure

4. An accompanying “terms sheet” was also developed to describe terms and illustrate wheelchair parts on a drawing. The items in the first version (V1) of the MW-MAT were grouped into 3 sections. I) Frame and attachment: 6 items; II) Postural supports: 13 items; and III) Wheels and Casters: 7 items. The items in the first version of the PW-MAT were grouped into 4 sections. I) Frame and attachment: 7 items; II) Postural supports: 14 items; III) Wheels and Casters: 4 items; and IV) Interface and electronics: 12 items.

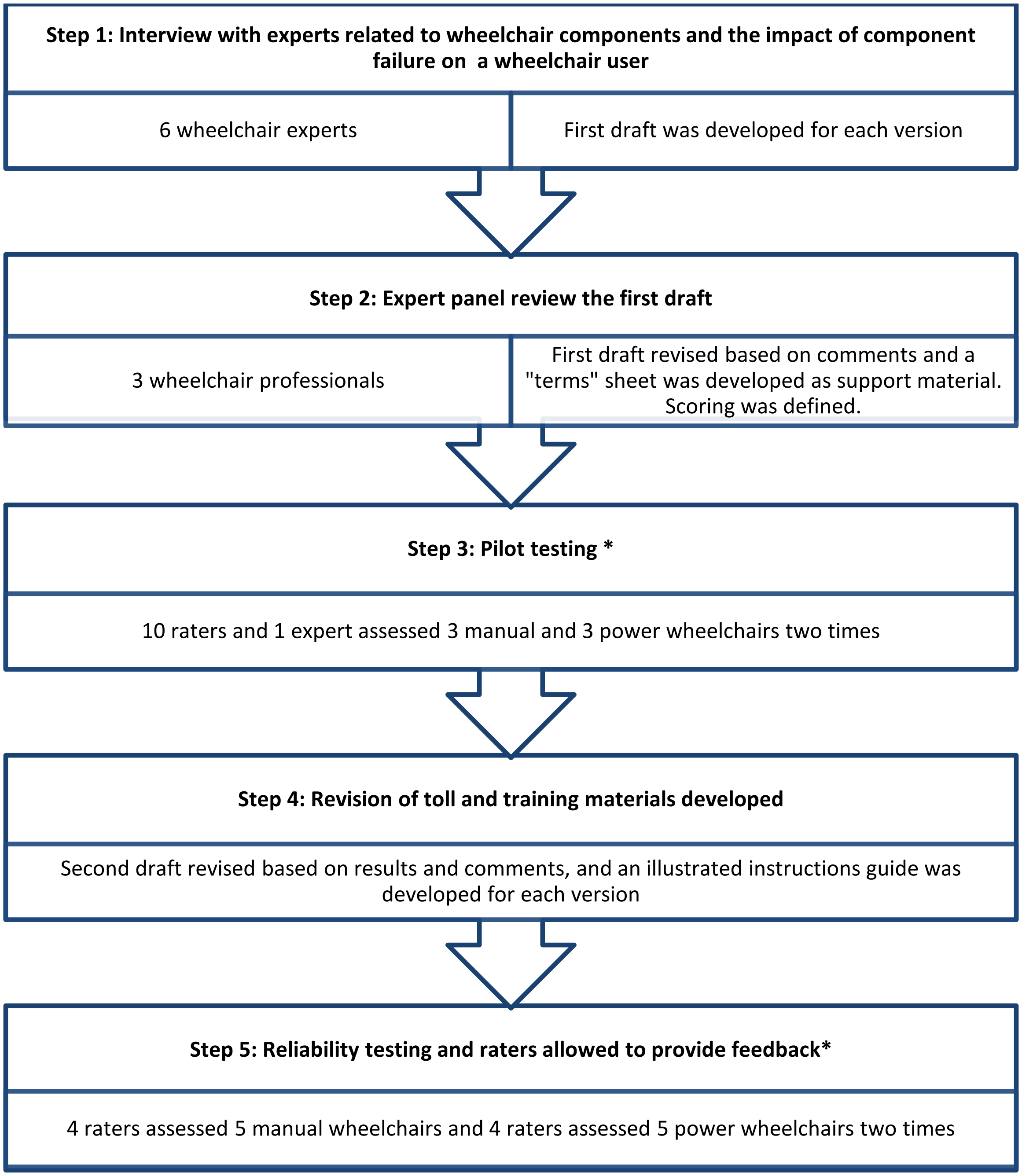

Figure 4. W-MAT development and reliability testing iterative process. *Steps that had institutional IRB approval.

5.2.2 Rater recruitment

One round of pilot and reliability testing of the MW-MAT and PW-MAT were performed at a university setting in the spring of 2014. A convenience sample of individuals that would represent those who would use the tool in research and clinical applications (clinicians, post-doctoral researchers, and research assistants) were approached in person or via email with the study flyer by study investigators and invited to participate. Those who were willing to participate were scheduled for two visits approximately one week apart. Raters signed an informed consent document approved by the University of Pittsburgh institutional review board. Each rater met the following inclusion criteria: at least 18 years old and able to attend both study visits. No specific qualifications were required for any of the pilot and reliability testing rounds, although one internal expert was asked to assess the wheelchairs in the pilot round.

5.2.3 Wheelchair selection

For both rounds of testing, investigators identified manual wheelchairs and power wheelchairs with varying features, characteristics, and working conditions. The wheelchairs were selected from a pool of used wheelchairs from local vendors, a wheelchair testing laboratory, and those used in research. Table 18 summarizes wheelchair make and model and provides examples of the wheelchairs conditions for each step of testing.

Table 18. Description of manual and power wheelchairs utilized during the pilot and the reliability testing.

Manual wheelchairs	Power wheelchairs
Pilot testing	
Breezy: broken frame and wheel lock, rough arms supports, sagging seat sling, handrim loose.	Quantum 6400: loose and worn foot, leg and trunk supports, loose control device mount and frayed cables.
Quickie T7A: broken back support folding mechanism, quick-release wheel mechanism, and foot support.	TDXSP: loose foot support, rough arm support, cushion with chipping foam, ripped back support cushion cover, loose back support uprights, batteries not holding charge.
Quickie GP: cushion wrongly placed, sagging sling back support, loose wheel axle and spokes, flat tires.	TDXSP: worn out tires, caster flutter, buttons in control panel not working, loose cables.
Reliability testing	
Rogue + Vicair cushion: rough surfaces in foot support, cushion wrongly placed, sagging seat sling, cracked frame and back support, anti-tippers not evenly spaced, back support folding mechanism missing hardware, broken quick- release wheel mechanism, rough surface on handrims, flat tires, brakes do not engage with tires.	Quantum 6400 + Flovair cushion: dirty, missing shrouds, worn foot and leg support, cushion wrongly placed, loose seat base, loose controller and missing joystick cap, motors with scrapping sounds, bad batteries, frayed cables and wires.
ADI + Jay basic: dented frame, caster float.	Permobil C500 + Roho cushion: dirty, one anti-tip and shrouds missing, rough arm supports, loose head support, deflated cushion, rust on back support hardware, back support cushion deteriorated, broken parking brake, drifts towards the left while driven,
Hospital + Roho cushion: missing Velcro in seat, deflated cushion, wheel interferes with clothing guard, wheel axle with play, loose spokes, cracked tires.	Permobil C300 + Invacare cushion: dirty, missing shroud's bolt, cracked seat base guide, missing left foot support, loose leg supports, loose and ripped upholstery in thigh and head supports, cracked arm support, cracked trunk support, cushion with bad odor, foam seat cushion with deterioration signs, rusted bolts in seat base, loose back support, worn out tires with cracks, recline power seat function with grinding noises.
Quickie GP + Jay active cushion: missing bolts in foot support, cushion foam deteriorated, debris in casters, flat tires.	Q6Edge+Synergy cushion: foot support flip-up mechanism broken, ripped and loose leg support, loose arm supports, frayed seat belt, missing Velcro in seat pan, gel cushion with leak, worn tires, broken parking brake and power elevating leg support, tilt mechanism and drive motor with grinding noises, batteries drain quickly.
All terrain Berta Osete + pindot cushion: dirty, loose foot supports, frayed calf strap, broken arm support, missing Velcro in seat, deteriorated foam cushion, sagging seat and back sling, cracked frame, loose spokes and handrim, flat tires.	Permobil C500 + Foam cushion: dirty, rust in anti-tip and postural supports bolts, missing shrouds, rust in suspension springs, worn head support cover, seat belt caught in back support.

5.2.4 W-MAT pilot testing

During the first visit, raters were asked to complete a demographics questionnaire, including years of experience working with wheelchairs. Then, without previous training, they were asked to assess the 6 selected wheelchairs using the W-MAT. A separate W-MAT was used for each wheelchair. During the second visit, which occurred approximately one week after the first visit, raters were asked to assess again the same wheelchairs in the same order using the W-MAT. Additional tools for the evaluation were gloves (suggested) and a 2”x 4” piece of lumber for the power wheelchair version. During both visits raters were directed to follow the instructions on the W-MAT and if they had questions to refer to the instructions and terms sheet. Investigators took notes on the questions that were asked. Raters were encouraged to write on the W-MAT and/or the terms sheet when they found something confusing, felt information was missing, or had any other comments. Assessment required interaction between the rater and the wheelchair, hence simultaneous scoring was not possible and each rater assessed each wheelchair independently. Investigators confirmed that each wheelchair was brought back to the initial (e.g. cushion or postural support position) condition to insure each rater assessed wheelchairs with identical conditions. The expert was a mechanical engineer with over five years of experience testing wheelchair compliance with ANSI/RESNA standards and evaluated the wheelchairs using the W-MAT one time and was asked to provide written feedback.

5.2.5 W-MAT revision and development of training

The feedback and psychometric properties results of the pilot testing were synthetized and the MW-MAT and PW-MAT were revised accordingly. Illustrated instruction guides for the MW-

MAT (Appendix F) and PW-MAT (Appendix H) were developed to better train raters on the use of each tool (manual and power wheelchair).

5.2.5.1 Reliability testing protocol

Compared to the pilot testing round, a broader range of wheelchair features and component conditions was included to better evaluate the W-MAT (Table 1). A new set of raters were recruited and asked to attend two study visits. Each rater was randomized into either manual or power wheelchairs, and only assessed that type of wheelchair. During the first visit, they were asked to complete a demographic questionnaire and to review the illustrated instruction guide on a laptop. Raters were instructed to follow the instructions on the W-MAT and if they had questions while using the tool to refer to the illustrated instruction guide. They were given the option of reviewing the illustrated instructions guide before starting the wheelchair evaluations or as they assessed the first wheelchair. During the second visit, which occurred approximately one week after the first visit, raters were asked to assess the same wheelchairs on blank W-MAT forms. Investigators did not answer questions while the raters were assessing the wheelchairs and raters did not see how other raters evaluated the wheelchairs. At the end of the second visit, raters were given an evaluation sheet to allow them to provide more comments on the tool and the instructions.

5.2.6 Data analysis

5.2.6.1 Power analysis

The sample size was calculated for the reliability round using the procedure for standard error of the reliability coefficient and sample size proposed by Streiner and Norman (Streiner & Norman, 2008). Based on the work by Karmarkar, an estimate of the likely Intra-class Correlation Coefficient (ICC) was set to 0.92 for both intra and interrater reliability and 0.6 was considered the minimum acceptable ICC (Karmarkar et al., 2009; Portney & Watkins, 2008). At least 4 raters were needed to assess 5 wheelchairs to be 95% certain that the reliability of the measure was above 0.6.

5.2.6.2 Data reduction

Descriptive statistics were computed for raters' demographic information to describe level of education and experience with wheelchairs. Interrater and intrarater reliability was determined by computing the ICC using model (2,1) and (3,1), respectively (Portney & Watkins, 2008). Interrater and intrarater reliability were calculated for each item, each section, and for the total score. This model assumes that all the raters rated all the wheelchairs. Therefore, only the items that did not have missing data were included (scored 0, 1, or 2). The items that scored not applicable or missing were not included in the statistical analysis but they were described. ICCs higher than 0.8 were considered strong, between 0.6 and 0.79 were acceptable, between 0.4 and 0.59 were moderate, and lower than 0.4 were weak (McClure, Boninger, Ozawa, & Koontz, 2011; Tsai, Rice, Hoelmer, Boninger, & Koontz, 2013). Spearman correlation was run to evaluate if there was a relationship between years of experience with wheelchairs and the intrarater reliability.

Investigators knew the "true score" of each wheelchair that was being assessed. These were compared to the total score results from the expert and raters. First, for the pilot testing and in the absence of a “gold standard”, as a measure of concurrent validity the overall sensitivity of the W-MAT was calculated with the total scores by the expert rater (Portney & Watkins, 2008). Sensitivity was defined by the true positive rate of wheelchairs which were deemed unsafe as measured by a total score = 0 (scoring described in the results section). The total score of 0 was decided “true presence of the trait” since we believe that for the W-MAT to be useful it should clearly detect an overall unsafe wheelchair. For both the pilot and reliability testing the sensitivity of the total score was also calculated for the total scores by the other raters. Statistical significance was set a priori to p=0.05. All data analysis was conducted using the statistical package IBM SPSS 22[a] and confidence intervals for the sensitivity analysis were calculated using an online clinical calculator[8].

5.3 RESULTS

5.3.1 Scoring

Each item was scored from 0-2, with 0 as a minimum score (state of disrepair) and 2 as a maximum score (good working order). The score was defined differently based on each item with a detailed description provided as part of the tool. These descriptions can be found in Appendix E for manual wheelchairs and Appendix G for power wheelchairs. There was also an option to indicate not applicable for the majority of the items.

From the feedback received from the experts and the type of wheelchair failures described in the standards (ANSI/RESNA, 2009) and durability studies (Megan V Fass et al.,

[8] Clinical calculator: http://vassarstats.net/clin1.html last visited on September 16, 2015.

2004; Gebrosky et al., 2013) the calculation of the total score was decided as follows and detailed in Figure 5 (item names can be found in Appendices E and G):

1. Total score 0: Unsafe to operate without immediate repairs.
2. Total score 1: repair and adjustment is needed which does not affect the operation and it is undetermined if the safety is affected.
3. Total score 2: Minor adjustments, no repair/replacement needed, and wheelchair in general good condition.

User's complaints were considered outside of the scope of the W-MAT. Since function depends on the unique interaction between their ability, health needs, and the condition of the wheelchair, to reduce the complexity of the tool, this was not included.

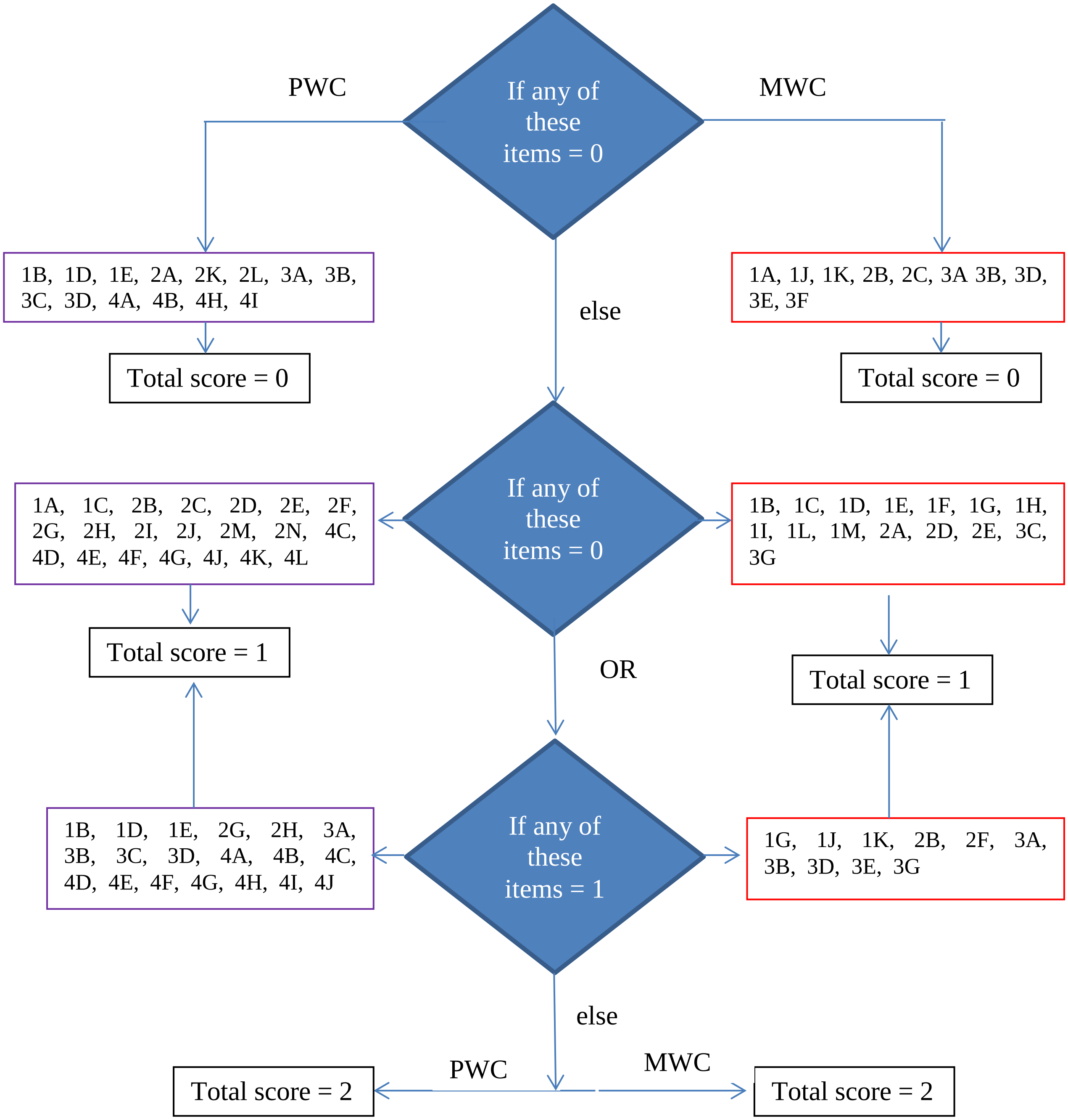

Figure 5. Total score category decision tree for the MW-MAT and PW-MAT V2.

5.3.2 W-MAT pilot testing

Ten raters with 1.98±2.4 (range 0 – 8) years of wheelchair experience attended both study visits. Seven were engineers who were graduate student researchers, two post-doctoral researchers (an engineer and a clinician), and 1 was a physical therapist. Time required to complete the W-MAT V1 ranged between minutes in MW-MAT 7-43 minutes and 7-61 in PW-MAT minutes. ICCs were not statistically significant for the intrarater reliability for the 10 raters in the MW-MAT and the PW-MAT. For several items, section scores, and total scores ICCs were not computed due to low variance. Therefore, we do not present these results in detail. Comprehensive training in the use of the tool is a strategy suggested to improve intrarater reliability (Portney & Watkins, 2008). Results yielded weak to strong item interrater reliability for manual (Table 19) and power wheelchairs (**Table 20**).

Missing data analysis indicated that participants were making mistakes in terms of the component identification. For the MW-MAT in session 1, raters 1, 2, 7, and 9 scored wheelchairs 2 and 3 as not having a folding mechanism when they had a folding back support. In session 2, raters 1 and 2 made the same mistake. We suspect the missing data from the item tires was by failing to read the item. We can also conclude that participants' confused push handles with back posts and clothing guards with lateral upper leg and pelvic support. To assess the folding mechanism the cushion needs to be removed. This item was located before the cushion placement assessment, which had weak reliability. We believe it is because the cushion was placed back by the rater and not necessarily in the same position each time. Therefore, the order of these items was changed. Back support base, cushion and cover were confusing to all participants. These items required further clarification and description.

Table 19. MW-MAT item-by-item, section, and total score interrater reliability for the pilot test round.

Item	Mean±SD	Session 1		Session 2	
		ICC(2,1), [CI]	M	ICC(2,1), [CI]	M
1A. Encrusted debris	1.72±0.58	0.77, [0.34,0.99]**	0	0.46,[-0.03,0.98]*	0
1B. Anti-tip devices	0.32±0.75	-	20	-	21
1C. Frame	1.05±0.99	0.91,[0.59,1] **	0	0.69,[0.29,0.99] **	0
1D. Fasteners	1.47±0.75	LV	2	0.01,[-0.14,0.86]	0
1E. Push handles	1.94±0.24	-	10	-	17
1F. Folding Mechanism	1.41±0.75	-	10	-	4
Frame and attachments	0.67±0.82	0.66,[0.28,0.99]**	-	0.42,[0.09,0.97]*	-
2A. Foot supports	0.92±0.90	0.97,[0.84,1]**	1	0.7,[0.32,0.99]**	0
2B. Lower leg supports	1.33±0.82	-	24	-	28
2C. Lateral upper leg supports	1.75±0.50	-	28	-	28
2D. Lateral pelvic support	1.67±0.71	-	25	-	27
2E. Arm support	0.90±0.90	0.93,[0.68,1] **	10	0.87,[0.44,1] *	10
2F. Head support	-	-	30	-	30
2G.Cushion placement	1.31±0.80	-0.26,[-0.29,0.79]	1	0.07,[-0.11,0.89]	0
2H. Seat cushion cover	1.23±0.56	0.64,[0.26,0.99]**	0	0.59,[0.18,0.98]**	0
2I. Seat base	1.62±0.61	-0.13,[-0.18,0.60]	0	0.0,[-0.18,0.88]	0
2J. Seat cushion	1.22±0.90	0.90,[0.68,1]**	0	0.92,[0.73,1]**	0
2K. Back support cover	0.68±0.83	0.42,[0.09,0.97]*	0	0.35,[-0.01,0.96]*	0
2L. Back support cushion	1.33±0.84	0.83,[0.09,1]	3	-	6
2M. Back support base	1.70±0.55	-	7	-	7
Postural supports	0.57±0.53	0.67,[0.28,0.99]**	-	0.66,[0.27,0.99]**	-
3A. Axles	1.36±0.89	0.00,[-0.31,1]	1	0.54,[0.12,0.98]*	0
3B. Spokes	1.93±0.32	LV	1	0.83,[0.09,1]	1
3C. Handrims	1.63±0.69	0.56,[0.14,0.98]*	0	0.89,[0.48,1]*	1
3D. Tires	1.35±0.87	-	2	-	3
3E. Caster assembly	0.88±0.87	0.19,[-0.04,0.93]	0	0.34,[-0.08,1]	1
3F. Alignment	1.27±0.69	0.52,[0.13,0.98]*	0	0.27,[0.03,0.94]*	0
3G. Brakes	1.38±0.70	0.67,[0.14,1]*	10	0.88,[0.53,1] **	10
Wheels and casters	0.42±0.59	0.04,[-0.07,0.84]	-	0.29,[0.03,0.95]*	-
Total score	0.08±0.28	LV		0.5,[-0.71,0.98]	

Abbreviation: LV unable to calculate because of low variance; M missing $^{*}p<0.05$; $^{**}p<0.001$

Table 20. PW-MAT item-by-item, section, and total score interrater reliability for the pilot test round.

Item	Mean±SD	Session 1		Session 2	
		ICC(2,1), [CI]	M	ICC(2,1), [CI]	M
1A. Encrusted debris	1.52±0.60	LV	0	LV	0
1B. Anti-tip devices	2.00±0.00	-	15	-	17
1C. Shrouds	1.85±0.52	-	3	-	2
1D. Frame/chassis	1.87±0.43	0.02,[-0.09,0.84]	0	LV	0
1E. Powerbase fasteners	1.90±0.40	LV	0	LV	0
1F. Link arms	1.97±0.18	LV	1	LV	0
1G. Suspension	1.37±0.71	0.34,[0.04,0.96]*	0	0.10,[-0.07,0.90]	0
Frame and attachments	1.20±0.71	0.26,[-0.003,0.95]	-	LV	-

Table 20 (continued)					
2A. Foot supports	1.47±0.77	0.19,[0,0.92] *	0	0.48,[0.13,0.98] **	0
2B. Lower leg supports (calf supports)	0.95±0.96	0.86,[0.49,1] **	9	0.91,[0.62,1] **	9
2C. Lateral upper leg supports (thigh guides)	1.11±0.99	-	20	-	21
2D. Lateral pelvic supports (hip guides)	1.56±0.81	-	23	-	21
2E. Arm supports	0.93±0.88	0.36,[-0.01,1] *	0	0.36,[-0.01,1] *	1
2F. Head support	1.62±0.80	-	19	-	20
2G. Seat belt	1.83±0.42	LV	0	LV	0
2H. Cushion placement	1.61±0.70	0.21,[-0.04,0.94]	0	LV	1
2I. Seat cushion cover	1.37±0.58	0.15,[-0.02,0.91]	0	0.13,[-0.03,0.9]	0
2J. Seat base	1.97±0.26	LV	0	LV	1
2K. Seat cushion	1.65±0.63	-0.11,[-0.12,0.17]	0	LV	0
2L. Back support cover	1.12±0.91	0.74,[0.35,0.99] **	0	0.76,[0.32,1] **	0
2M. Back support cushion	1.63±0.72	LV	0	0.51,[0.14,0.98] **	0
2N. Back support base	1.95±0.22	LV	0	LV	0
Postural supports	0.85±0.44	LV	-	LV	-
3A. Tires	1.98±0.13	LV	0	LV	0
3B. Front caster assemblies	1.93±0.25	LV	0	LV	0
3C. Rear caster assemblies	1.87±0.43	LV	0	LV	0
3D. Parking brake	1.86±0.40	-	2	-	2
Wheels and casters	1.73±0.55	LV	-	LV	-
4A. Control device (Joystick)	1.68±0.62	LV	0	LV	0
4B. Control Panel	1.63±0.61	0.82,[0.50,1] **	0	0.6,[0.22,0.98] **	0
4C. Seat elevation mechanism	1.82±0.50	-	19	-	19
4D. Recline mechanism	1.95±0.22	-	11	LV	10
4E. Leg support mechanism	1.89±0.40	-	11	-	13
4F. Tilt mechanism	1.87±0.34	-	11	LV	10
4G. Motors and gearboxes	1.41±0.77	0.50,[0.15,0.98] **	0	0.82,[0.39,1] **	1
4H. Alignment	1.90±0.35	0.02,[-0.07,0.81]	0	LV	0
4I. Running brake	1.71±0.49	0.04,[-0.02,0.99]	1	LV	0
4J. Batteries	1.00±0.97	-	21	-	19
4K. Cables	1.00±0.91	0.49,[0.1,1] **	1	0.58,[0.19,0.98] **	0
4L. Charging socket	1.73±0.45	LV	1	LV	0
Motor and controllers	0.63±0.78	0.23,[-0.01,0.94] *	-	-0.02,[-0.12,0.80]	-
Total score	0.28±0.52	0.36,[0.06,0.96] **		-0.03,[-0.11,0.76]	

Abbreviation: LV Unable to calculate because of low variance; M missing $^{*}p<0.05$; $^{**}p<0.001$

For power wheelchairs several raters made the mistake to assess the casters as the anti-tip wheels. In addition, some raters wrongly scored the shroud as not applicable when all chairs had shrouds. None of the power wheelchairs had hip guides nor lateral leg supports but several participants scored the clothing guard as a hip guide. Rater 9 incorrectly marked all parking brake as not applicable and was removed from this item. None of the wheelchairs had power seat elevator and some made the mistake to give this item a score. One rater wrongly scored recline, leg elevator, and tilt mechanisms as not applicable when they were in fact present.

Further comments from the expert helped us change the scoring options for the seat and back cushions. We had used “bottoms out” as the criteria by applying force to the cushion. It was changed to visually inspect the cushion condition, damage of the material and apparent compression of the material when not loaded. In addition, “loose” was added as one of the criteria for the lowest score for the rigid seat and back supports.

For PW-MAT it is important to note that when the controller box is loose, the alignment of the wheelchair would be difficult to assess because the joystick cannot be controlled steadily. The suspension item scoring description was suggested to be changed to match ISO standards specific wording for suspension.

Sensitivity of the total score of the MW-MAT and PW-MAT while used by an expert was 100% CI[30-100%] which suggests that the W-MAT is a valid tool to identify wheelchairs in an unsafe maintenance condition. The sensitivity of the total score of the tool when used by non-expert raters is presented in Table 21 for the pilot and reliability testing.

Table 21. MW-MAT and PW-MAT total score sensitivity analysis for the raters in the pilot test round.

Testing round	MW-MAT		PW-MAT	
	Session 1	Session 2	Session 1	Session 2
	Sensitivity% [CI%]			
Pilot (n=10)	93% [76-99%]	90% [67-98%]	77% [57-89%]	77% [67-98%]

5.3.3 W-MAT revision and development of training

The pilot testing round allowed us to gather feedback and identify challenges and inform the changes that needed to be implemented. The tools were revised in wording, order of the items, and description for clarity. Because the term sheet was not used often, raters suggested that more information was needed, and intrarater reliability is related to rater training, we developed an illustrated instruction guide, similar to the one developed for the Transfer Assessment Instrument (Tsai et al., 2013). This illustrated guide was created to provide raters more education on the decision-making process while assessing a wheelchair. The instructions guide included both text that describes how to assess each item and a picture of each item. The pictures have examples of items in different conditions and how they should be scored (Figure 6).

Figure 6. Example of an item description in the PW-MAT V2 illustrated guide used during the round of reliability testing.

5.3.4 Reliability testing

Eight raters were enrolled in the second round of reliability. Those who rated manual wheelchairs had 2.6±1.9 (range 0-4) years of wheelchair experience. Two were engineers and one a clinician who were graduate student researchers, and one has an undergraduate research assistant majoring in engineering. Those who rated power wheelchairs had 1.8±1.7 (range 0-4) years of wheelchair experience. One was an engineer who was a graduate student researcher, two were undergraduate research assistants majoring in engineering, and one clinician. No significant differences were found in demographics data between raters who assessed manual and power wheelchairs. Time required to complete the W-MAT V2 ranged between 12-32 minutes in MW-MAT V2 and in PW-MAT 18-37 minutes. Raters all commented that there was a learning curve to the tool. Table 22 shows interrater and intrarater reliability for the MW-MAT V2 and Table 23 for the PW-MAT V2.

Analysis of the missing data in MW-MAT V2 indicates that there was still confusion in the item lower leg support. One participant made one time the mistake of confusing a clothing guard for a lateral thigh support. The reordering and instructions seem to have positively affected the back support base and back support cover; however, the back support cushion had poor reliability but all participants marked not applicable appropriately. The folding mechanism item partially improved. Raters 11 and 17 scored as not applicable the rigid frame wheelchair even though they had a folding back support in both sessions. Interrater reliability for the other two raters alone ICC(2,1)=0.64,[-0.13,0.95],p=0.06 for session 1 and ICC(2,1)=0.8,[0.1,0.98],p=0.03 for session 2. Two participants had missing scoring for the brakes on the first wheelchair, which were disk brakes for the first session and one of them for the second session. ICC run without these raters did not improve for the first session but did for the second, ICC(2,1)=0.62,[0.03,0.97],p=0.03. Perhaps they were not familiar with this break and did not assess them.

Analysis of the missing data for the PW-MAT indicates that improvements were made and some confusion may still exist with the postural supports. Raters made mistakes with the trunk and the thigh supports.

No significant correlation was found between the intrarater reliability and the number of years of experience with wheelchairs ($p>0.05$). It was common that raters failed to use the "Comments" box to describe a problem that was found on a part. Sensitivity analysis showed promising positive results as showed in **Table 24** .

Table 22. MW-MT item-by-item, section, and total score intrarater and interrater reliability for round 2 of testing.

Item	Mean±SD	Intrarater reliability ICC(3,1), [CI]				Interrater reliability ICC(2,1), [CI]			
		Rater 11	Rater 14	Rater 17	Rater 18	Session 1	M	Session 2	M
1A. Foot supports	1.18±0.81	LV	0.54,[-0.48,0.95]	LV	0.88,[0.25,0.99] *	0.506,[0.04,0.92]*	0	0.17, [-0.21,0.8]	0
1B. Lower leg supports	1.07±0.92	LV	-	LV	-	-	14	-	12
1C. Lateral thigh supports	2.00±0.00	-	-	-	-	-	19	-	19
1D. Arm supports	1.00±0.89	LV	LV	LV	LV	0.81,[0.24,1] *	12	0.81, [0.24,1] *	12
1E. Trunk support	-	-	-	-	-	-	20	-	20
1F. Head support	-	-	-	-	-	-	20	-	20
1G.Cushion placement	1.10±0.81	0.87,[0.19,0.98] *	0.88,[0.25,0.99] *	0.8,[-0.03,0.98] *	0.53,[-0.49,0.94]	0.73, [0.32,0.96] **	0	0.67, [0.26,0.95] **	0
1H. Seat cushion cover	1.30±0.72	0.8,[-0.03,0.98]*	0.67,[-0.32,0.96]	0.7,[-0.26,0.96]	LV	0.32, [-0.05,0.856]	0	0.47, [0.01,0.91] *	0
1I. Seat cushion	1.28±0.78	-0.67,[-0.96,0.32]	LV	0.88,[0.25,0.99] *	LV	0.5, [0.10,0.91] *	0	0.26, [-0.09,0.83]	0
1J. Seat base	1.60±0.74	LV	LV	LV	LV	0.85, [0.52,0.98] **	0	0.85, [0.52,0.98] **	0
1K. Back support base	1.28±0.93	0.25,[-0.70,0.88]	0.91,[0.37,0.99] *	0.6,[-0.41,0.95]	0.91,[0.37,0.99] *	0.62, [0.21,0.94] *	0	0.96, [0.84,1] **	0
1L. Back support cover	1.47±0.64	-	LV	LV	LV	-	13	0.86, [0.31,1] *	12
1M. Back support cushion	1.31±0.87	0,[-1,1]	0.8,[-0.97,1]	LV	0.8,[-0.97,1]	0.33, [-0.21,1]	12	0.29, [-0.01,1]	12
PS	0.75±0.74	0.83,[0.07,0.98]	0.77,[-0.11,0.97]	0.83,[0.07,0.98] *	0.67,[-0.31,0.96]	0.56,[0.14.0.93] *	-	0.58,[0.15,0.93] *	-
2A. Encrusted debris	1.18±0.84	0.88,[0.22,0.99]*	0.64,[-0.35,0.96]	0.11,[-0.77,0.85]	-0.09,[-0.84,0.78]	0.41,[0.04, 0.88]*	0	0.22, [-0.06, 0.79]	0

Table 22 (continued)									
2B. Anti-tip devices	0.53±0.52	-	LV	LV	LV	-	13	LV	12
2C. Frame	1.13±0.82	0.17,[-0.75,0.86]	LV	LV	0.8,[-0.03,0.98] *	0.72,[0.34,0.96] **	0	0.79,[0.45,0.97] **	0
2D. Clothing guard	1.80±0.41	LV	-	LV	LV	-	13	0,[-0.31,1]	12
2E. Push handles	1.44±0.63	LV	LV	0.8,[-0.97,1]	LV	LV	12	0.86, [0.31,1] *	12
2F. Folding Mechanism	1.52±0.75	0.8,[-0.97,1]	LV	-	0.88,[0.22,0.99] *	-	7	LV	6
F&A	0.90±0.90	0.2,[-0.73,0.87]	LV	LV	0.70,[-0.26,0.96]	0.59,[0.16,0.93] **	-	0.83,[0.52,0.98] **	-
3A. Axles	1.47±0.83	0.8,[-0.03,0.98],0.03	0.88,[0.22,0.99] *	0.57,[-0.62,0.97]	LV	0.54, [0.06,0.95] *	0	0.94,[0.76,1] **	1
3B. Drive wheels	1.63±0.67	LV	0,[-0.81,0.81]	0.36,[-0.67,0.91]	0.36,[-0.64,0.91]	0.32,[-0.5,0.85]	0	0.27, [-0.10,0.84]	0
3C. Handrims	1.53±0.55	LV	LV	0.67,[-0.32,0.96]	0.54,[-0.48,0.94]	0.66, [0.23,0.95] *	0	0.88, [0.64,0.98] **	0
3D. Tires	1.00±0.93	LV	0.8,[-0.03,0.98] *	LV	0.9,[0.33,0.99] *	0.78, [0.44,0.97] **	0	0.75, [0.39,0.97] **	0
3E. Caster assembly	1.25±0.93	-0.17,[-0.86,0.75]	0,[-0.81,0.81]	0.4,[-0.61,0.92]	0.56,[-0.46,0.94]	0.15, [-0.09,0.74]	0	0.37, [-0.08,0.88]	0
3F. Brakes	0.85±0.92	-0.57,[-0.97,0.62]	LV	0,[-1,1] n=2	0.86,[-0.5,1]	0, [-0.382,1]	9	0.56, [-0.02,0.98] *	5
3G. Power drive system	1.47±0.83	-	-	-	-	-	20	-	0
W&C	0.55±0.85	0,[-0.81,0.81]	0.4,[-0.61,0.92]	0.43,[-0.59,0.92]	0.8,[-0.03,0.98] *	0.36,[-0.002,0.86] *	-	0.76,[0.36,0.97] **	-
TS	0.13±0.33	0,[-0.81,0.81]	-0.25,[-0.88,0.7]	LV	LV	0.33, [-0.06,0.86]	-	0.12, [-0.22,0.78]	-

Abbreviations: F&A: Frame and attachments; PS: Postural supports; W&C: Wheels and casters; TS: Total score; LV: Unable to calculate because of low variance; M missing *p<0.05; **p<0.001

Table 23. PW-MAT item-by-item, section, and total score intrarater and interrater reliability round 2.

Items	Mean±SD	Intrarater reliability ICC(3,1),[CI]				Interrater reliability ICC(2,1), [CI]			
		Rater 12	Rater 13	Rater 15	Rater 16	Session 1	M	Session 2	M
1A. Encrusted debris	1.30±0.69	LV	0.67,[-0.32,0.96]	0.2,[-0.73,0.87]	0.17,[-0.75,0.86]	0.23,[-0.14,0.82]	0	0.02, [-0.17,0.62]	0
1B. Anti-tip devices	1.12±0.89	LV	0.8,[-0.26,0.99]	-0.3,[-0.89,0.68]	0.57,[-0.62,0.97]	0.65[0.12,0.99]*	3	0.34, [-0.30, 0.97]	4
1C. Shrouds	0.68±0.86	0.2,[-0.73,00.87]	0.6,[-0.41,0.95]	0.36,[-0.64,0.91]	0.9,[0.33,0.99]*	0.94,[0.81,0.99]**	0	0.22, [-0.06,0.79]	0
1D. Frame/chassis/link arms:	1.55±0.55	0.4,[-0.609,0.915]	LV	LV	LV	0.11,[-0.18,0.75]	0	LV	0
1E. Suspension	1.73±0.55	0.6,[-0.412,0.949]	LV	0.38,[-0.62,0.91]	LV	-0.09,[-0.19,0.4]	0	LV	0
F&A	0.58±0.64	LV	0.71,[-0.23,0.97]	0.25,[-0.7,0.88]	0.47,[-0.56,0.93]	0.51,[0.11,0.91] **	-	0.26,[-0.11,0.84]	-
2A. Foot supports	0.85±0.80	0.91,[0.37,0.99]*	0.7,[-0.26,0.96]	0.17,[-0.75,0.86]	0.75,[-0.16,0.97] *	0.63,[0.21,0.94] *	0	0.53, [0.1,0.92] *	0
2B. Lower leg supports (calf supports)	1.20±0.91	0.67,[-0.32,0.96]	0,[-0.81,0.81]	-0.7,[-0.96,0.26]	0.67,[-0.32,0.96]	0.22,[-0.06,0.79]	0	0.12, [-0.25,0.77]	0
2C. Lateral thigh supports	0.80±0.96	LV	0.8,[-0.62,0.99]	N=1	0.5,[-0.86,0.98]	0.63,[0.11,0.99] *	7	-	8
2D. Arm supports	1.51±0.68	0.2,[-0.73,0.87]	-0.62,[-0.95,0.38]	0.54,[-0.48,0.94]	0.8,[-0.26,0.99]	-0.08,[-0.36, 0.75]	1	-0.02, [-0.23, 0.63]	0
2E. Trunk support	1.38±0.88	LV	0.8,[-0.26,0.99]	LV	N=1	0.92,[0.53,1] *	7	-	9
2F. Head support	1.23±0.67	0.29,[-0.68,0.89]	LV	0.44,[-0.57,0.92]	0.8,[-0.26,0.99]	0.64,[0.13, 0.97] *	1	0.16, [-0.17,0.78]	0
2G. Seat belt	1.41±0.87	0.64,[-0.55,0.97]	LV	-0.5,[-0.98,0.86]	LV	0.87,[0.55,0.99]**	4	0.33, [-0.34, 0.97]	4
2H. Cushion placement	1.45±0.71	LV	LV	-0.3,[-0.89,0.68]	LV	0.56,[0.14, 0.93] *	0	0.10, [-0.24, 0.77]	0
2I. Seat cushion cover	1.38±0.81	LV	0.6,[-0.43,0.95]	LV	-0.29,[-0.89,0.68]	-0.02,[-0.22, 0.61]	0	0,[-0.05,0.33]	0

Table 23 (continued)									
2J. Seat cushion	1.44±0.72	0.25,[-0.7,0.88]	0.67,[-0.32,0.96]	-0.57,[-0.97,0.62]	0.9,[0.33,0.99] *	0.3,[-0.16, 0.91]	1	-0.04, [-0.31, 0.67]	0
2K. Seat base	1.85±0.49	LV	LV	LV	LV	0, [-0.31,0.8]	1	LV	0
2L. Back support	1.80±0.56	LV	LV	-0.25,[-0.88,0.70]	LV	0.23, [-0.10,0.81]	0	LV	0
2M. Back support cover	1.53±0.68	0.17,[-0.75,0.86]	0.4,[-0.61,0.92]	-0.4,[-0.92,0.61]	0.17,[-0.75,0.86]	0.37, [-0.04, 0.87] *	0	0,[-0.25,0.68]	0
2N. Back support cushion	1.78±0.42	LV	0.4,[-0.61,0.92]	0,[-0.81,0.81]	LV	-0.12,[-0.27, 0.47]	0	LV	0
PS	0.90±0.78	0.67,[-0.32,0.96]	0.17,[-0.75,0.86]	-0.13,[-0.85,0.76]	0.67,[-0.32,0.96]	0.18,[-0.21,0.81]	-	0.29,[-0.15,0.85]	-
3A. Tires	1.98±0.16	0,[-0.81,0.81]	LV	LV	LV	LV	0	LV	0
3B. Front caster assemblies	1.75±0.59	LV	LV	LV	LV	-0.15, [0.-37,0.85]	6	LV	6
3C. Rear caster assemblies	1.67±0.60	0,[-0.95,0.95]	LV	-0.54,[-0.94,0.48]	LV	LV	3	LV	4
3D. Parking brake	1.49±0.80	LV	LV	0.5,[-0.86,0.98]	LV	0.46, [-0.08,0.98]	2	0.26, [-0.09,0.89]	1
W&C	0.78±0.58	LV	0.67,[-0.32,0.96]	-0.63,[-0.91,0.64]	0.4,[-0.61,0.92]	0.11,[-0.25,0.77]	-	-0.02,[-0.3,0.68]	-
4A. Control device (Joystick)	1.40±0.93	LV	LV	LV	LV	0.6, [0.19, 0.94] *	0	0.6,[0.19,0.94] *	0
4B. Control Panel	1.63±0.74	LV	LV	-0.91,[-0.99,-0.37]	-0.3,[-0.89,0.67]	-0.09, [-0.19,0.4]	0	-0.21, [-0.26, 0.06]	0
4C. Seat elevation mechanism	0.80±0.97	0.46,[-0.56,0.92]	LV	LV	0.88,[0.22,0.99]	0.14, [-0.1,0.74]	0	0.29, [-0.01, 0.83]	0
4D. Recline mechanism	1.55±0.75	0,[-0.81,0.81]	LV	0.06,[-0.79,0.83]	LV	LV	0	LV	0
4E. Leg support mechanism	1.18±0.87	0.88,[0.25,0.99] *	0.9,[0.33,0.99] **	-0.42,[-0.92,0.6]	0.6,[-0.41,0.95]	0.48,[0.08,0.91] *	0	0.21, [-0.20,0.83]	0
4F. Tilt mechanism	1.73±0.60	0.2,[-0.73,0.87]	0,[-0.81,0.81]	0.06,[-0.79,0.83]	LV	LV	0	LV	0
4G. Motors and gearboxes	1.56±0.64	0.87,[0.19,0.98] *	0,[-0.81,0.81]	0.0,[-0.88,0.88]	0,[-0.81,0.81]	LV	0	0.11, [-0.25, 0.84]	1
4H. Alignment	1.50±0.75	-0.36,[-0.91,0.64]	0,[-0.81,0.81]	-0.3,[-0.89,0.68]	LV	LV	0	LV	0

Table 23 continued									
4I. Running brake	1.80±0.41	0,[-0.81,0.81]	LV	-0.17,[-0.86,0.75]	LV	0.27, [-0.04, 0.82]	0	LV	0
4J. Batteries	1.25±0.98	LV	0.6,[-0.41,0.95]	-0.67,[-0.96,0.32]	LV	0.82, [0.50,0.98] **	0	0.2, [-0.21,0.82]	0
4K. Cables and connectors	1.20±0.91	0.53,[-0.49,0.94]	0.67,[-0.32,0.96]	-0.1,[-0.84,0.77]	LV	0.47, [0.08,0.9] *	0	0.36, [-0.08,0.88]	0
4L. Charging socket	1.36±0.49	LV	LV	-0.6,[-0.95,0.41]	LV	LV	1	LV	0
M&C	0.88±0.85	0.67,[-0.32,0.96]	-0.25,[-0.88,0.7]	LV	0.67,[-0.32,0.96]	0.47,[0.06,0.91] *	-	0.07,[-0.24,0.73]	-
TS	0.18±0.38	LV	LV	-0.25,[-0.88,0.70]	LV	LV	-	0.12,[-0.22,0.78]	-

F&A: Frame and attachments; PS: Postural supports; W&C: Wheels and Casters; M&C: Motor and controllers; TS: Total score; LV: Unable to calculate because of low variance; M missing $^{*}p<0.05$; $^{**}p<0.001$

Table 24. MW-MAT and PW-MAT total score sensitivity analysis for the raters in the reliability test round.

Testing round	MW-MAT		PW-MAT	
	Session 1	Session 2	Session 1	Session 2
	Sensitivity% [CI%]			
Reliability (n=4)	90% [72-97%]	85% [61-96%]	80% [56-93%]	85% [61-96%]

Raters provided constructive and positive feedback with suggestions towards improvement. Some examples are as follows:

- "For manual wheelchair assessment the thigh support and arm support are confusing, both can help support the leg".
- "The instructions guide can be improved by having two slides per item. One slide with the description and sample image and another with examples of possible damage with scoring options"
- "Clarify the description and instructions for assessing the parking brakes in power wheelchairs".
- "The scoring for the tool was straightforward".
- "Compile the items that have the same instructions in the illustrated instruction guide to make it shorter"

5.4 DISCUSSION

The purpose of the study was to develop and evaluate the reliability and validity of the MW-MAT and the PW-MAT. The tool can be completed in a reasonable time and uses equipment that is easy to acquire. Sensitivity analysis suggested that the W-MAT is a valid tool to identify unsafe maintenance conditions in both manual and power wheelchairs. Analysis showed improved reliability after items were revised and the illustrated instruction guide was added. The detailed illustrated instructions presentation offered better support for the raters as compared to the pilot testing round when no training was provided. However, the improvement in the MW-MAT was more satisfactory that in the PW-MAT. Negative values in the ICC are a limitation of the SPSS package used and indicate small between-subject variability as compared to large within-subject variability (i.e. poor reliability)[9]. Two reasons could explain the intrarater reliability results. A learning effect might have been present and/or boredom affected raters' ability. Raters assessed wheelchairs for about 2.5 hours during each session. To be able to rate consistently the scoring options needed to be read completely, and the illustrated instructions guide was not interactive. Even though the illustrated guide improved the reliability, a more interactive manner of combining the W-MAT with the illustrations should be explored.

A tool to objectively identify maintenance issues is currently needed for several reasons. First, wheelchairs needing repairs and these causing adverse consequences are a common problems (Worobey et al., 2012). In addition, not performing routine maintenance increases the chances of being injured (W. Y. Chen et al., 2011) and active maintenance checkups have shown reducing wheelchair-related accidents (Hansen et al., 2004). The strong sensitivity and moderate reliability results suggest that the W-MAT could be used as tool to help identify unsafe wheelchair conditions. It is valuable to have a tool with strong sensitivity and not ideal reliability when used in conjunction with expert's feedback in the absence of an outcome measure tool (Portney & Watkins, 2008).

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[9] King's College London Statistical Advisory Service www.kcl.ac.uk/ioppn/depts/biostatistics/SAS/faqs9.aspx#a9_5

One could argue that other approaches like a visual analog scale might be more reliable, especially if administered by experts (Rispin et al., 2013). But unless the anchors are related to a specific condition of a wheelchair part, it is unclear how a tool like this could provide insight on what are the specific problems of the components (e.g. fracture, rust, or wear). This could be compensated by a comments section where the problem is described. However, our findings showed that raters failed to use the “Comments” box to describe a problem that was found on a part. One advantage that the visual analog scale presents is that its administration may be faster than the current W-MAT scoring. Finally, requiring experts to use the tool as a condition for reliability limits the generalizability of the tool. This is especially important in less-resourced settings were maintenance and repair issues are potentially largest and the availability of wheelchair experts is very limited (World Health Organization, 2008a).

5.4.1 Future work

Based on the reliability results and the feedback from raters, both W-MAT versions and instructions guides will be revised. The instruction guide will be made more comprehensive with additional pictures of parts, components, and examples of scoring. The wording in both versions will be refined. An additional round of reliability testing is being completed to evaluate the revised version. An effort will be made to have every item appropriately powered. To stabilize rater’s performance, raters will be asked to participate in a first visit were instructions will be given, practice with one wheelchair and question/answers before the first visit for the reliability testing. After this is completed, it is our hope that the W-MAT can be used as an outcome tool to assess the impact of a wheelchair maintenance training program. In addition to being used as an intervention outcome measurement tool, the W-MAT has the potential to be used in a clinical setting. For instance, clinicians and/or vendors could use the W-MAT to assess a used wheelchair when a client is being assessed for a new wheelchair. The tool could help evaluate whether the maintenance and breakdown condition justify a new wheelchair. In addition, it could be used by wheelchair vendors and technicians when they service wheelchairs or when performing a yearly checkup and/or tuning. Finally, if the tool is used consistently by different stakeholders and the data is gathered in a repository, it has the potential to identify wheelchair maintenance issues and can provide guidance to designers and manufacturers on how to address them.

5.4.2 Study Limitations

Both manual and power wheelchairs exist in a wide range of components and characteristics. A condition to demonstrate reliability is the variability among subjects (wheelchair) scores. One weakness was the limited number of wheelchairs evaluated, all of which had a limited number of positive findings. Therefore, assessing a larger number of wheelchairs and their components would have enabled us to include wider variability and may have resulted in better reliability results. Since the assessment of a wheelchair was on average 20 minutes, the protocol was very time consuming and boredom likely affect rater's performance. However, the test was based on current wheelchair standards (ANSI/RESNA, 2009; Waugh & Crane, 2013) and expert input. For a thorough assessment of the wheelchair, the user has to transfer out of the wheelchair. This may pose a limitation in the use of the tool based on setting. The raters' education level represents a bias because they may be an interested group, and results might not be repeatable in a different population.

5.5 CONCLUSIONS

Results indicate that the MW-MAT and PW-MAT can be administered in a reasonable time. Future studies should evaluate the reliability of the revised version which includes more extensive training. There are no other instruments available to evaluate wheelchair maintenance state with detailed scoring and instructions guide. The maintenance state of a wheelchair is related to both safety and reliability of wheelchair use. After further reliability analysis, the W-MAT could give clinicians, technicians and researchers an objective measure to evaluate this critical aspect of wheelchair function.

6.0 THE IMPACT OF A WHEELCHAIR MAINTENANCE TRAINING PROGRAM IN POWER WHEELCHAIR USERS QUALITY OF LIFE AND WHEELCHAIR MAINTENANCE STATE: PRELIMINARY RESULTS OF A RANDOMIZED CONTROLLED TRIAL

6.1 BACKGROUND

Routine wheelchair maintenance performed or led by the wheelchair user is not a common practice (Nosek & Krouskop, 1995). Only 43% of wheelchair users self-reported performing maintenance regularly (S. Fitzgerald et al., 2005). Hence, it is not surprising that inspections of wheelchairs indicated that greater than 70% of wheelchairs are found in need of maintenance (Hansen et al., 2004; Young et al., 1985). The required maintenance was commonly basic interventions, such as cleaning and tightening parts, which could be learned by users to be completed at home (Nosek & Krouskop, 1995). Scarce user-performed maintenance may possibly be attributed to a lack of education on wheelchair maintenance that users receive. More than 50% of Veterans who received a wheelchair after a cerebral vascular accident reported not receiving written or verbal instructions on how to take care of the new wheelchair; and 45% did not know who to contact if a problem occurred (Garber et al., 2002). A study from rehabilitation centers in Canada found that only 12% of the centers always trained manual wheelchair users in maintenance and repairs, 46% sometimes, and 42% never (Best, Miller, et al., 2014). In contrast to 78% of these centers reported always training wheelchair users on transfers and 66% always training wheelchair users in basic mobility (Best, Miller, et al., 2014). A practice-based study in six inpatient rehabilitation centers in the US reported that 42% of patients received group training on manual wheelchair mobility skills 17 minutes/week on average of and 19% received 4.8 minutes/week on average of power wheelchair mobility (Zanca et al., 2011). There was no mention of group maintenance training, which presumably means it was non-existent; in-patient rehabilitation length of stay is short in the US. Lack of user training in wheelchair maintenance is concerning, especially since it is recognized by the WHO as one of the required wheelchair provision service steps (World Health Organization, 2008a). One possible explanation for users not receiving the wheelchair maintenance training they require is that those involved in the wheelchair delivery have no proper training in maintenance either. Globally there is a shortage of professionals knowledgeable in wheelchair provision including rehabilitation engineers and technicians (World Health Organization & United States Agency for International Development, 2011; World Health Organization & World Bank, 2011). And, even in high income settings, when wheelchair-related curriculum has been commonly found in entry-to-practice level programs, wheelchair maintenance was found only in 24% of the programs as compared to 76% and 90% that included mobility skills and transfers training respectively (Best, Miller, et al., 2014). Last, as seen in Chapter 3, even those who are provided wheelchairs following WHO's 8-step could also benefit from additional maintenance training. The goal of this chapter is to study the impact of the WMTP described in Chapter 4 on a group of power wheelchair users that attended the training as compared to a waitlist control group in: self-reported wheelchair components needing repairs and adverse consequences, W-MAT scores (Chapter 5), WMT-Q scores (Chapter 4), and quality of life.

6.2 METHODS

6.2.1 Participants

Community dwelling power wheelchair users who used their wheelchair >50% of weekly mobility with a diagnosis of non-progressive spinal cord injury, between 18 to 75 years old, were eligible to participate. Participants with a cognitive impairment that could interfere with learning (as measured by a score <23 in the mini-mental status test (Dick et al., 1984)), had a loaner wheelchair, or were unable to attend the two training sessions were excluded. A modified version of the mini-mental status was used because participants may not be able to complete some tasks due to physical disability. Participants were contacted and invited to participate via the Spinal Cord Injury Model Systems database, local rehabilitation facilities, outpatient facilities, and disability organizations in the US, specifically in Pittsburgh, PA and West Orange, NJ.

6.2.2 Randomization

Injury level and time post injury were used to complete stratification: Paraplegia, less than 1 year post injury; paraplegia, greater than 1 year post injury; tetraplegia, less than 1 year post injury; tetraplegia, greater than 1 year post injury. Stratification information was collected during the screening procedures. A permuted block randomization scheme with varying lengths was used. Blocks of length 2 and 4 were randomly chosen and the length of any given block was unknown to investigators. A randomization code list per site was generated prior to start of participant recruitment in the coordinating center (Pittsburgh).

6.2.3 Procedures

Potential participants were screened and if eligible and interested in participating the visit for baseline measures was scheduled. The investigator conducting the informed consent contacted the coordinating center by phone when the potential participant arrived for their baseline visit to obtain the group assignment. To blind participants from group assignment they were informed that they would be placed in the next available training group and a separate consent form was used for each group. A different investigator, blinded to group assignment, performed baseline and follow up measures.

After the training group was filled (n=6), participants received the training by trainers who were taught as described in Chapter 4. Participants were encouraged to attend the class with a caregiver. In addition to the maintenance training, participants in the training group received a toolkit, maintenance reminder cards, and asked to select up to two types of quarterly maintenance reminders (i.e. phone call, text message, email, or e-calendar event). At the end of the second training session participants were asked to evaluate the course similarly to the form used in a power wheelchair skill training program (Kirby et al., 2015). Specifically, the evaluation had a 5 point Likert-scale (strongly disagree to strongly agree) to rate if the workshop was: useful, relevant, easily tolerated, understandable, and enjoyable. Duration of the session was rated as either: too short, just right, or too long. And, a question asked whether they would recommend the training program to other wheelchair users. Participants had the opportunity to provide written feedback in terms of: what was difficult to understand; what was the most useful part of the training; what would you add/emphasize; what would you remove/reduce; and any other feedback towards improvement.

Approximately one month after the second maintenance class, participants in the training group completed a follow up either over the phone or online. Finally, six months after the second maintenance class participants in both groups completed a follow up over the phone or online and the W-MAT was administered in-person by investigators blinded to group assignment. The W-MAT was collected in person at participant's convenience either at the doctor's office, at a research lab, or at their home. Figure 7 shows the training and data collection timeline for all participants. Participants in the waitlist group did not receive training until after the 6 month follow up measure was collected. With the goal of reducing attrition, for the one-month follow-up, the window for collecting the data was three days prior to the one-month date and as late as 20 days after this date. All participants were contacted approximately three months after the completion of training to remind them that the six month follow-up data collection or pre-training data collection (waitlist group) was forthcoming in three months. The window for collecting this data was 14 days prior to the six-month date and as late as 20 days after this date.

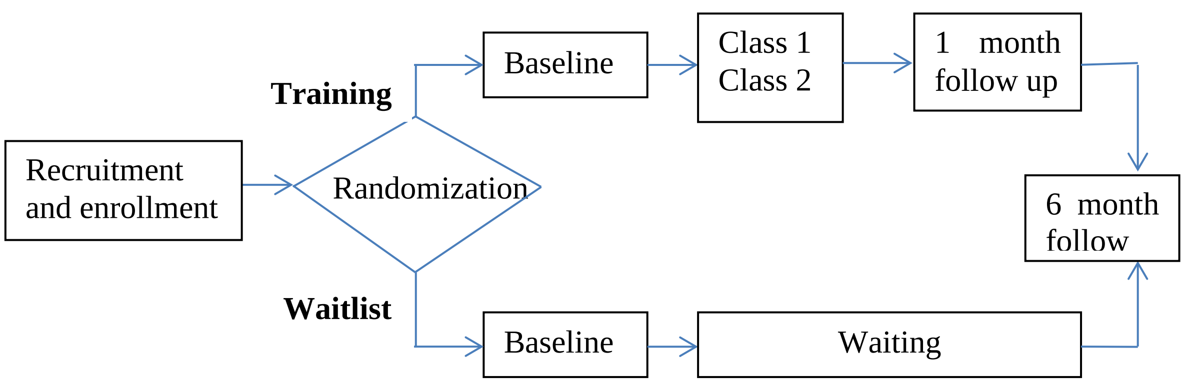

Figure 7. Power wheelchair users maintenance training study flow chart and data collection points timeline.

Questionnaires used and time points per group are presented on Table 25 and described below. Data was collected using forms created with Teleforms[10] software and the National Institutes of Health (NIH) Assessment Center[11]

Table 25. Measurements collected during each data collection point by training and waitlist group.

Measure	Training			Waitlist	
	BL	**1 m**	**6 m**	**BL**	**6 m**
Rapid Estimate of Adult Literacy in Medicine (REALM)	X			X	
Demographics	X			X	
Wheelchair type and repairs information	X		X	X	X
Quality of life	X	X	X	X	X
Wheelchair Maintenance Assessment Tool (chapter 4)	X		X	X	X
Wheelchair Maintenance Training Questionnaire (chapter3)	X	X+	X	X	X
Wheelchair change			X		X

Abbreviation: BL-baseline; m-month +Performance questions were not asked at 1 m.

- REALM: used to identify people who are at risk for poor health literacy skills (Bass, Wilson, & Griffith, 2003).
- Demographics: age, gender, level of SCI, race, years post injury, years of wheelchair use, and occupation.
- Wheelchair information: age, power seat functions, average indoor and outdoor use, exposure to snow/rain, and presence/absence of working back-up wheelchairs. Based on the limitations that the questions used in chapter 2 and 3, twelve types of repairs/components were included; detailed information on these questions can be found in Appendix I. The question related to "Worn out positioning support" was not properly written in Assessment Center; therefore it was not included in the analysis. In addition, each question had an accompanying image that provided clarification on what component the question referred to (Figure 8). The decision

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[10] Teleforms, available at www.cardiff-teleform.com/.
[11] Assessment Center^{SM} platform available at www.assessmentcenter.net.

tree for questions related to components needing repairs, consequences, and repair completion are illustrated in Figure 9.

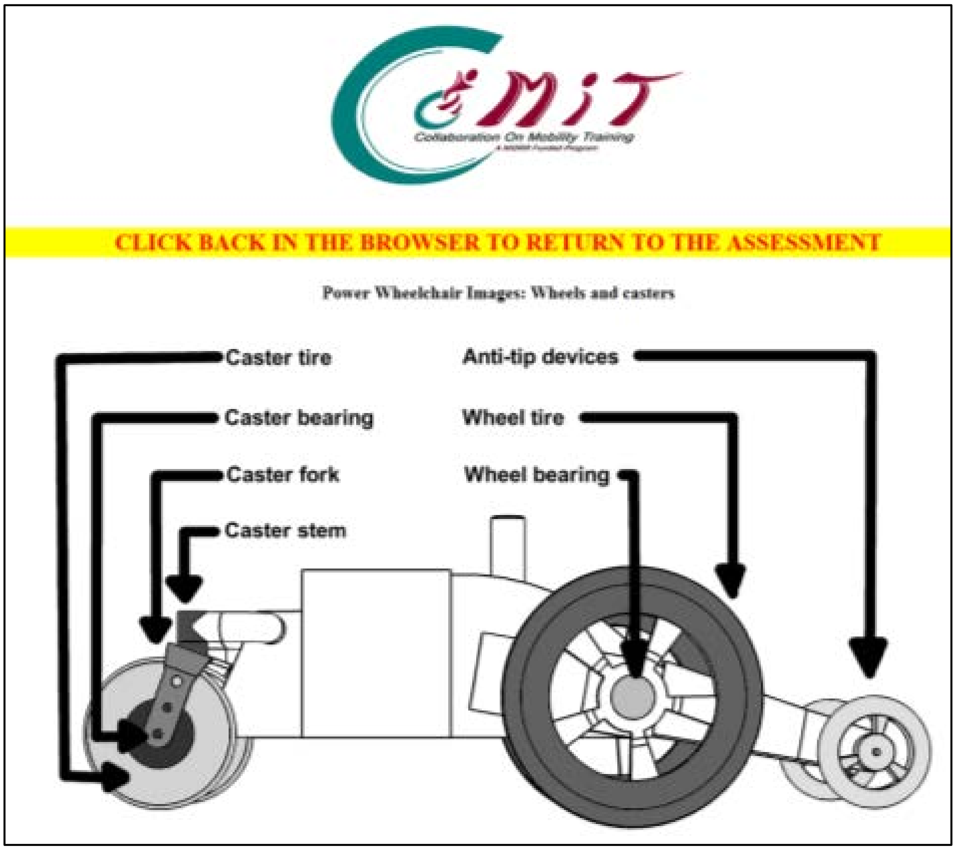

Figure 8. Example of illustration used to indicate wheelchair components mentioned in the self-reported repairs questionnaire.

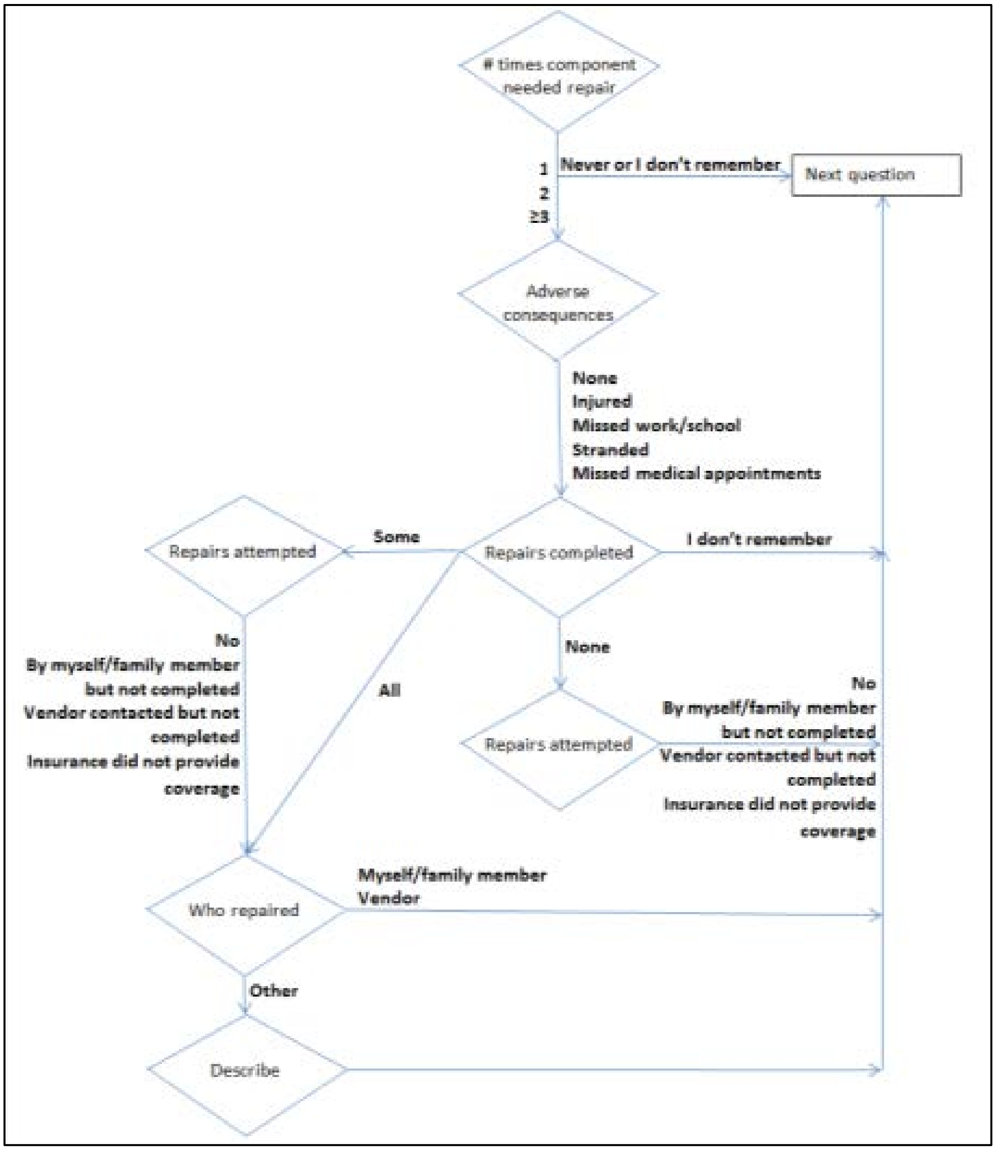

Figure 9. Power wheelchair component repair questions decision tree flow chart.

- Quality of life measures were collected in the social, physical, and mental health domains as described in Table 26.

In addition, the following two measures specific to population with spinal cord injury were collected:

- Wheelchair mobility: as measured by the Spinal Cord Injury Functional Index (SCI-FI) which contains distinct power wheelchair domains that assess a comprehensive range of activities, including mobility on different surfaces and activities such as weight shifting for pressure relief, reaching, and dressing (Jette et al., 2012).

- Independence: as measured by the Spinal Cord Injury Quality of Life (SCI-QOL) which assesses perceived control of activities, ability to live independently, and absence of dependence on others in the past 7 days (Tulsky et al., 2015).

Table 26. Instrument description for items used to measure quality of life from PROMIS.

Health domain	Instrument	PROMIS Item bank
Social Health Domain (Hahn et al., 2014; "PROMIS scoring manuals," 2015).	Ability to participate in social roles and activities: assesses the degree of involvement in one's usual social roles	v2.0
	Satisfaction with Social Roles and Activities: assesses satisfaction with performing one's usual social roles	
	Social isolation: assesses perceptions of being avoided, excluded, detached, disconnected from, or unknown by, others	
Physical ("PROMIS scoring manuals," 2015).	Pain interference: assesses the degree to which pain interferes with physical, mental and social activities in the past 7 days (Amtmann et al., 2010)	v1.1
Mental ("PROMIS scoring manuals," 2015).	Depression v1.0: assesses self-reported negative mood, views of self, social cognition, and decreased positive affect and engagement	v1.0

Assessment Center automatically provides a T-score (mean=50 and SD=10) per measure per participants. For pain, isolation, fatigue, and depression a higher T-score represents worse outcomes. In comparison for participation, satisfaction, mobility and independence a higher T-score represent better outcomes ("PROMIS scoring manuals," 2015). All scores are related to general US population, whereas Independence and Wheelchair mobility are related to US population with spinal cord injury. Social health measures are compared to a population with more people with chronic illnesses ("PROMIS scoring manuals," 2015).

- WMT-Q: subscores were calculated as follows:

$$Multiple\ choice = \frac{\sum Correct\ answers}{Total\ possible\ questions} x100$$

$$Capacity = \frac{\sum Questions\ answered\ Yes}{21 - \#\ skipped\ questions - not\ possible} x100$$

$$Performance = \frac{\sum Questions\ at\ least\ with\ the\ frequency\ in\ WMTP}{Capacity\ denominator} x100$$

6.2.4 Data reduction and analysis

6.2.4.1 Power analysis

Two-sided tests with a confidence level α = 0.05 were assumed for power analysis and sample size determination. Hansen et al. reported that the number of wheelchair accidents decreased by 100% after intervention while there was no decrease in number of accidents for control subjects (Hansen et al., 2004). By taking a conservative approach and assuming a 50% decrease, there will be 80% power to detect significant differences with a sample size of 35 on each group (training and waitlist).

6.2.4.2 Data reduction

Level of injury was dichotomized to tetraplegia [C8 and higher] and paraplegia [below C8]. Occupation was grouped into working/student (included sheltered workshop, on-the job training) and at home (retired, unemployed, volunteer, disability or medical leave, homemaker). The funding source that covered the largest portion of the purchase price wheelchair was categorized into: private insurance; Medicare/Medicaid; Worker's compensation; and other (county medical, self-pay, public health service, Veterans Administration). Those who answered "I don't know" to funding source were not included in this portion of the analysis. The variable Number of components needing at least one repair was calculated by adding the number of questions in Appendix I that had an answer ≥1 repair per participant. Similarly, number of components with repairs not completed were added per participant when "repairs completed" were answered as none or some (Figure 9). To further investigate the overall reasons behind repairs not being completed, all instances of repairs not completed and reasons were added by group and presented for baseline and follow up. To describe the prevalence of repairs needed, percentage of participants reporting at least one component needing ≥1 repair was calculated with respect to the entire group. To better understand the group of participants who required repairs, the percentage of participants having an adverse consequence and completing/not completing ≥1 repair were calculated with respect to those needing a repair. Percentage of reasons why repair was not completed was calculated with respect to those who reported completing none or some of the repairs. While percentage of those who completed a repair (i.e. vendor, myself/family, other) was calculated with respect to those who reported completing some or all repairs. Average daily hours of wheelchair use indoors and outdoors was calculated as follows and those whose calculation was 24 hours outdoor or 0 hours outdoors and indoors were not included in the analysis:

$$Indoor\ Use = \frac{(average\ week\ day\ indoor\ * 5 + average\ weekend\ day\ indoor\ * 2)}{7}$$

$$Outdoor\ Use = \frac{(average\ week\ day\ outdoor\ * 5 + average\ weekend\ day\ outdoor\ * 2)}{7}$$

6.2.4.3 Statistical analysis

Descriptive statistics of all variables per group per data collection time were calculated. Spearman rho was used to evaluate if there were significant correlations between the number of components needing repairs and hours of indoor use, hours of outdoor use, and wheelchair age.

Normal distribution assumption in continuous variables was explored using the Shapiro-Wilk test. To evaluate the effect of the random assignment, baseline measures were explored for differences between participants in the waitlist and training group as follows: Independent t-test for normally distributed continuous variables, Mann-Whitney for not normally distributed continuous variables, Chi-square (or Fisher's exact test when applicable) for categorical variables. Data was analyzed according to group membership regardless of study completion. Missing data patterns were studied and reasons for attrition and missing data are described.

Frequency counts for individual item-by-item for the W-MAT, WMT-Q, and self-reported repairs per time were calculated. Items in the WMT-Q capacity and performance score that had success rate ≤75% were described. This was based on the rationale proposed by Hosseini et al., which assumes that a difference in the 20-25% range would encourage clinicians to change their practices, such as wheelchair maintenance training (Hosseini, Oyster, Kirby, Harrington, & Boninger, 2012). Exploratory analysis was done to describe those who completed repairs (re-categorized to vendor and all others (myself, family, friend) and reasons for repairs not completed between group at each time.

Similarly to the agreement procedure described in Chapter 3, agreement between component self-reported needing but not completing a repair and corresponding W-MAT component was performed and items were grouped as shown in Table 27.

Table 27. Self-reported power wheelchair component needing but not completing a repair and corresponding W-MAT item.

Component categories needing a repair in the past 6 months: answered as needed but not completed	**W-MAT items scored 0 or 1**
Worn out wheel/caster; Broken caster assembly; Broken wheel or caster bearing	Anti-tip, tires, front caster assembly, rear caster assembly
Broken frame	Frame/chassis/link arms
Loose positioning support includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports	Foot support, lower leg support, lateral thigh support, arm support, trunk support, head support,
Worn out includes sagging seat and back upholstery, or worn out seat or back cushion); broken	Seat cushion cover, seat cushion, seat base, back support, back support cover, back support cushion
Broken suspension	Suspension
Broken controller box	Control panel, control device,
Battery did not hold charge	Batteries
Power seat function	Seat elevator, Recline, Leg elevator, Tilt

Mixed analysis of variance (ANOVA) was used to evaluate the effect of the WMTP intervention, time, and group*time interactions in the number of breakdowns and adverse events, WMT-Q, and PROMIS scores. In addition, a repeated measures ANOVA (or Friedman test when appropriate) was used to study the impact of the training in knowledge and its retention by evaluating if there were differences in WMT-Q multiple choice and capacity score scores at baseline, 1 month, and 6 month follow up in the training groups. Maulchly's test was used to test the sphericity assumption and if violated the Greenhouse-Geisser correction was used. Bonferroni correction was done for multiple testing (0.0167). Effect size for the repeated measures ANOVA was calculated $\eta^2 = SS_{effect}/SS_{Total}$ (Levine & Hullett, 2002).

Chi-square (or Fisher’s exact test) was used to explore if the proportion of participants facing an adverse consequence at follow up was different between groups as well as proportion of wheelchairs in each W-MAT total score per group at baseline and follow up.

6.3 RESULTS

Preliminary results include a total of 24 participants who were enrolled in the study in Pittsburgh, PA and West Orange, NJ. Figure 10 presents the study flow chart with number of participants contacted, consented, allocated, and analyzed. A total of six participants in the training group attended the sessions with a caregiver. Two participants missed the second session and a makeup session was arranged. For the second session, the ratio wheelchair user: assistant was 6:5 (2 trainers, 1 volunteer, and 2 caregivers) for Pittsburgh while West Orange was 4:4 (2 trainers and 2 caregivers). The maintenance reminders selected by participants in the training group were: text message and email (n=3), phone call (n=3), phone call and email (n=3), email (n=2), and phone call and text message (n=1).

6.3.1 Baseline and demographics information

Table 28 presents the demographic characteristics at baseline stratified by group. Independent t-test at baseline resulted in no significant differences between group years of wheelchair use, years post injury, wheelchair age, weight, quality of life measures (Table 29), WMT-Q scores (Table 30), and number of components needing repairs (Table 31), p>0.2. Mann-Whitney test at baseline resulted in no significant differences between groups for age, height, and hours of wheelchair indoor and outdoor use between groups, p>0.21. Fisher's exact test resulted in no significant associations between group and race, occupation, primary funding source that pay for the wheelchair, snow/rain exposure, level of injury, power seat functions, REALM score, and total W-MAT score (Table 33), p>0.13.

Average number of days between baseline and one month follow up after training was 83 days with a range of 56 to 153; while average days between baseline and six month follow up after the training was 224 days, range 184-283, and 225 days, range 185-266, for the training and the waitlist group respectively. Overall attrition rate was 20.8%; however, for the data collected via Assessment Center it was 29.2% and for the W-MAT 38% (Figure 10). Patterns in the follow up missing data were explored. An ordinal variable dropout was created (yes/no) for data collected through Assessment Center and W-MAT. First, no significant associations were found between group and not completing Assessment Center data and W-MAT data at follow up. Since there were no significant differences at baseline between groups, analysis of missing data was done within group to compare if there were significant differences between those who dropped out and those who did not. In the training group participants who dropped out were significantly younger (38.9±9) than those who returned for follow up (54.8±10.2), t(10)=2.5, p=0.03. No other significant differences within each group at baseline were found between those who did not have Assessment Center data out at six month follow up in number of components needing repairs, WMT-Q capacity and performance, and quality of life measures. For participants who had missing W-MAT at follow up, in the training group participants were more likely to not come in for follow up measure in person if they had paraplegia (none of the participants with paraplegia completed W-MAT), Fisher's exact p=0.018. At baseline, WMT-Q capacity and performance scores by level of injury (paraplegia and tetraplegia) were normally distributed and not significantly different, p>0.34. And WMT-Q performance score was not significantly correlated to the independence measure (SCI-QOL), p=0.342. Age was not significantly correlated to WMT-Q capacity and performance scores, p>0.74. Therefore, in this preliminary analysis, it appears that data is covariate-dependent Missing Completely at Random (CD-MCAR) since missing data is not related to the outcome of interest (Thabane et al., 2013); therefore, complete-case analysis is appropriate (Osborne, 2012; Wood, White, & Thompson, 2004).

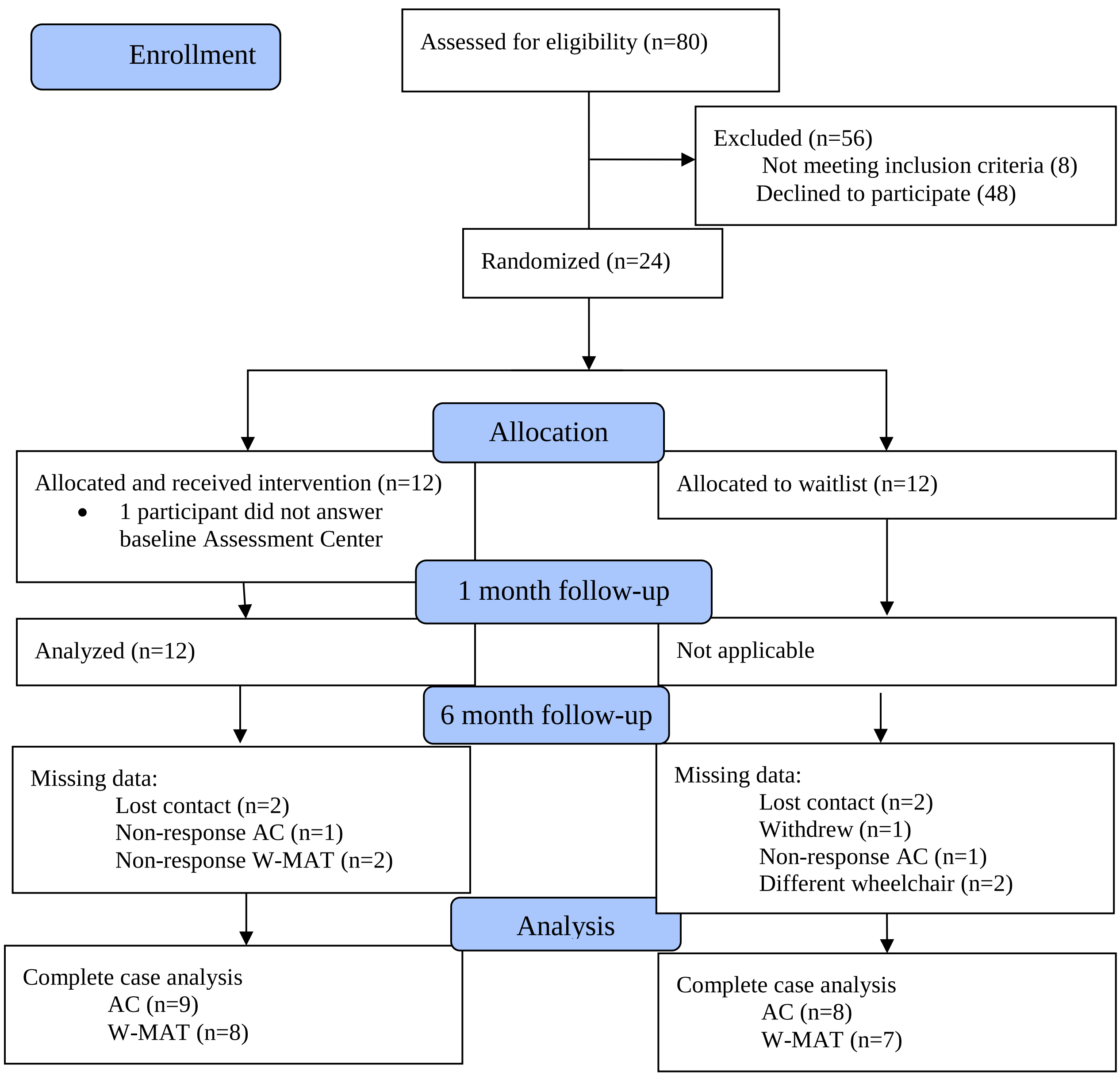

Figure 10. Power wheelchair users randomized controlled trial study recruitment and analysis numbers.

Table 28. Power wheelchair users demographic characteristics at baseline by waitlist and training group.

Participant's characteristics		Waitlist(n=11)	Training (n=12)
Age		49.1 ± 12.2	50.6 ±12.2
Years post spinal cord injury		13.9±12.5	17.0±13.0
Wheelchair age		3.4 ± 2.2	2.8 ± 1.4
Years of wheelchair use		14.5 ±12.9	16.2±12.4
Height		69.4±2.4 (n=11)	68.7 ± 5.6 (n=11)
Weight		163.2±39.6 (n=11)	203.2 ± 47.4 (n=10)
Daily average hours use	Indoor use	5.9±4.4	4.7±1.8
	Outdoor use	8.6±4.7	8.7±3.9
Snow/rain exposure	Never	0	1
	Occasionally	0	1
	Sometimes	5	6
	Often	6	4
Power seat functions	None	2	0
	Tilt	0	1
	Tilt and recline	2	0
	Tilt, recline, elev. Leg	4	4
	Recline, standing, elev. Leg	1	0
	Tilt, recline, seat, leg	2	6
	All	0	1
Gender	Male	7	7
	Female	4	5
	Missing	1	0
Race	non-Hispanic White	8	9
	Minority	3	3
	Missing	1	0
Funding WC	Private insurance	5	8
	Medicare/Medicaid	5	3
	Workers compensation	0	1
	Missing	2	0
Injury level	Paraplegia	2	3
	Tetraplegia	10	9
Occupation	Work/student	3	2
	At home	8	10
	Missing	1	0

6.3.2 Quality of life

All quality of life measures met the ANOVA assumptions except for Pain in the training group, and Satisfaction with Social Roles and Activities and Fatigue in the waitlist at 6 month follow up were not normally distributed. However, since ANOVA is robust for this violation, mixed effect ANOVA was still used. No significant effect of time, group or interaction group*time was found for the quality of life measures. For the training group no significant effect of time (baseline, 1 month, and 6 month follow up) was found for basic wheelchair mobility, independence, depression, ability to participate, satisfaction with social roles, social isolation, fatigue and pain, p>0.08. Table 29 presents average quality of life measures scores per group and time.

Table 29. Quality of life measures by waitlist and training group and baseline, one month and 6 month follow up.

Quality of life measure	Waitlist		Training		
	Baseline n=11	6 month n=8	Baseline n=11	1 month n=12	6 month n=9
SCI-FI wheelchair	49.6±7.4	49.8±7.5	45.6±8.7	45.11±8.8	46.0±9.9
Independence	49.0±6.7	49.0±5.4	47.7±8.5	45.4±7.6	46.4±7.9 n=8
Pain Interference	56.8±8.5	58.7±7.7	52.8±8.8	55.2±7.7	55.7±8.2
Depression	49.9±5.6	48.6±12.0	52.6±11.8	50.8±9.3	52.8±10.6
Ability to Participate	48.8±6.7	49.2±6.7	46.3±8.7	45.7±5.4	46.0±7.9
Satisfaction Social Roles	47.1±7.1	49.8±6.3	44.5±6.4	45.5±6.6	45.8±4.6
Social Isolation	46.4±8.3	44.5±9.9	50.4±7.9	48.4±8.7	48.8±9.1
Fatigue	50.7±9.8	51.1±10.1	50.2±8.4	51.1±7.5	53.0±5.7

6.3.3 WMT-Q

Table 30. presents total section scores by group and time and Appendix J presents the individual skills for WMT-Q capacity and performance. At baseline ≥75% of participants reported knowing how to perform only three (out of 21 total) maintenance tasks: clean the wheelchair and cushion, inspect that the cushion was in good condition, and how to contact a wheelchair maintenance expert. For the training group, at one month follow up after the training ≥75% of participants reported knowing how to perform 19 out of the 21 tasks in the questionnaire. Knowing how to check that the motor was working properly was positively answer by 53% and checking the tire pressure by 67%. These suggest that further effort could be made during the training to clarify how this is done. The capacity questions related seat-positioning strap and brakes were answered as “No Part” in several occasions at both baseline and follow up, even by participants in the training group. Further effort should be made during the training to use consistent vocabulary to decrease potential confusion. None of the maintenance tasks were self-reported to be performed at the frequency recommended during the training program by ≥75% of participants.

Table 30. Average WMT-Q subscores measures by waitlist and training group and baseline, one month and 6 month follow up..

	Waitlist		Training		
	BL (n=11)	6 month (n=8)	BL (n=11)	1 month (n=12)	6 month (n=9)
Multiple choice	38.1±11.8	45.5±12.7	28.7±14.2$^{+,\#}$	54.1±13.4^{+}	47.9±15.0$^{\#}$
Capacity	51.4±25.3	53.4±31.3	49.4±30.9$^{*,++}$	91.8±11.6*	85.6±19.3^{++}
Performance	35.4±20.7	31.8±27.8	35.5±34.9	NA	58.6±18.4

$^{+,\#}p<0.1$, $^{*,++}p<0.05$

Shapiro-Wilk test of WMT-Q multiple choice scores at one month and 6 month follow up showed that the multiple choice scores were normally distributed while the capacity scores were not. Multiple choice questions score met the sphericity assumption and a significant effect of time was found $F(2,14)=8.2$, $p=0.004$, $\eta^2=0.538$. Bonferroni correction was used (alpha=0.016) and post-hoc comparisons did not reveal significant differences in Multiple choice scores among times; but, there was a trend between baseline and 1 month follow up ($p=0.018$) and six month follow up ($p=0.09$). For capacity scores the sphericity assumption was violated, therefore the Greenhouse-Geisser correction was used (0.589). There was a significant effect of time $F(1.18,8.24)=21.7$, $p=0.001$, $\eta^2=0.756$. Post hoc analysis revealed there was a significant learning and knowledge retention; there was difference between baseline and one month follow up ($p=0.003$), baseline and six month follow up ($p=0.014$), and no difference between one month and six month follow up ($p=0.130$).

Mixed ANOVA results revealed that there was a significant interaction between time and group for capacity score $F(1,13)=5.8$, $p=0.03$, $\eta^2=0.165$ and performance scores $F(1,13)=5.2$, $p=0.04$, $\eta^2=0.238$ (Figure 11). Simple main effects analysis showed that there was a significant increase in capacity ($F(1,7)=16.6$, $p=0.005$, $\eta^2=0.703$) and performance scores ($F(1,7)=8.5$, $p=0.02$, $\eta^2=0.548$) for the training group only. No significant interaction between time and group for multiple choice and no significant effect of group were found.

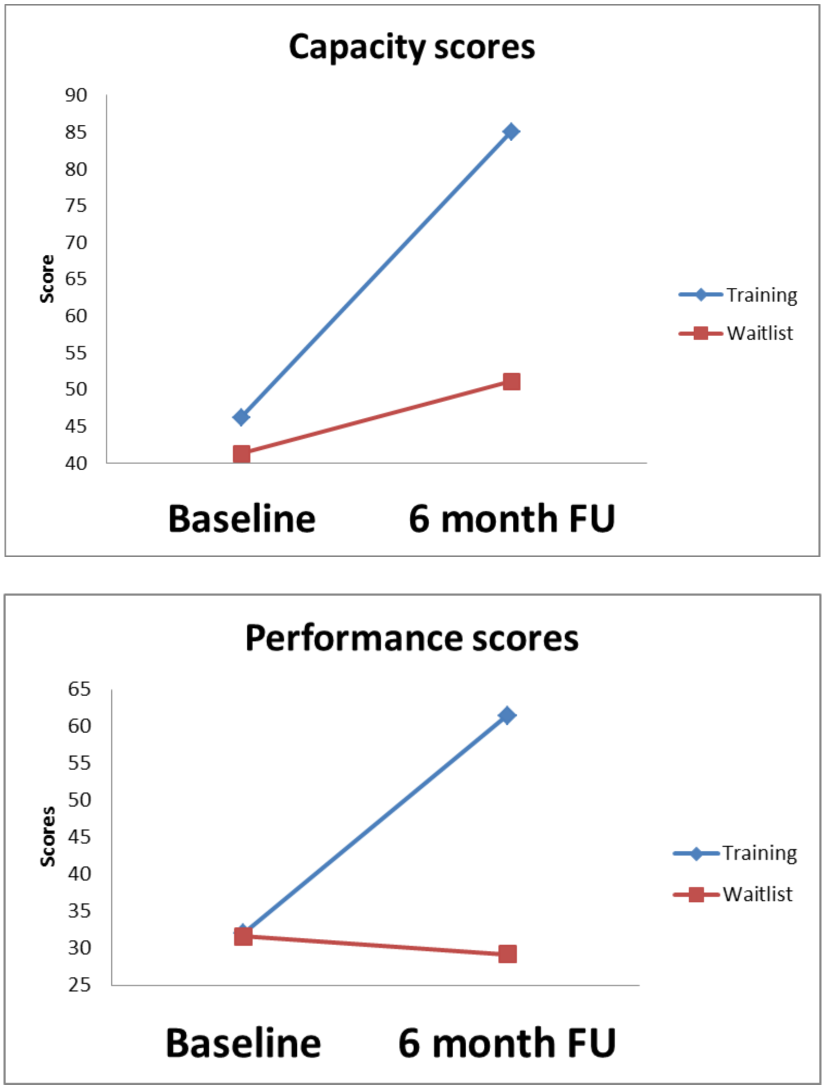

Figure 11. Interaction effect between time (baseline; 6 month follow up) and group (training in blue and waitlist in red) in WMT-Q capacity scores (top) and performance scores (bottom).

6.3.4 Self-reported repairs

At baseline participants in the waitlist group reported 2±1.8 ranging between none to 6 components needing at least one repair and in the training group 3.4±2.8 ranging from 0 to 8. No significant effect of time, group or interaction was found for number of components needing repairs per participant $F(1,15)=0.218$, $F(1,15)=0.988$, and $F(1,15)=0.064, p>0.05$ respectively. At baseline, no significant correlations were found for number of components needing a repair and wheelchair age, outdoor, and indoor use ($p>0.14$). Table 31 presents the overall results of participants needing repairs at baseline and follow up for both groups. Appendix K contains detailed results per component question.

Table 31. Prevalence of components needing repairs, adverse consequences, and repair completion for participants in the waitlist and training group at baseline and six month follow up.

Group	Waitlist		Training	
Time	BL	FU	BL	FU
Number of participants	n=12	n=8	n=12	n=9
Number of components needing repair	2 ± 1.8	1.9±1.4	3.4 ± 2.8	2.8±1.3
At least 1 component needed repair	83.3%	75.0%	75.0%	100.0%
At least one component needed ≥2 repairs	50.0%	62.5%	50.0%	33.3%
Those who needed repairs and ≥1 adverse consequence	20.0%	16.7%	33.3%	22.2%
At least one component w/repair not completed	40.0%	33.3%	88.9%	55.6%
Of those who had at least one component w/repair not completed +:	n=4	n=2	n=8	n=5
at least one component's repair not attempted	75.0%	33.3%	50.0%	40.0%
at least one component's repair attempted by them	25.0%	0.0%	37.5%	40.0%
at least one component's repair attempted via vendor	0.0%	66.7%	37.5%	60.0%
Of those who had at least one component repaired+	n=9	n=6	n=7	n=6
≥1 component repaired by them	50.0%	50.0%	55.6%	22.2%
≥1 component repaired by vendor	40.0%	66.7%	77.8%	77.8%
≥1 component repaired by them & vendor	10.0%	0.0%	0.0%	0.0%
≥1 component repaired by other	0.0%	0.0%	22.2%	0.0%

Abbreviation: BL baseline, FU 6 month follow up. +One participant could be in both categories.

All components were reported needing at least one repair by at least one participant both at baseline and follow up; except for a broken suspension that was never reported to need a repair at baseline by all participants. The most common repair needed was for loose positioning supports. No significant association was found between needing this type of repair (re-categorized to none and ≥1) and group at baseline and follow up. Overall, at baseline 78.3% of participants reported needing at least one repair in a loose positioning support and 41.1% at follow up. No significant association was found between having an adverse consequence and group at baseline and at follow up. The components needing a repair that caused an adverse consequence were: worn out wheel/caster was, broken wheel/caster bearing, worn out positioning support, controller box, broken frame, a battery not holding charge, and broken power seat function. Both at baseline and 6 month follow up participants in both groups had the repairs completed by a vendor except for: loose and worn out positioning supports, a battery, and a broken controller. The battery repair was reported completed at follow up by the participant in the waitlist himself as well as the broken controller box by the participant in the training group at baseline. No significant associations were found between who repaired the loose and the worn positioning support and group at baseline and follow up. Overall, the loose positioning supports were repaired by the participant/family/friend 62% of the times as baseline and 67% at follow up and by a vendor 38% at baseline and 33% at follow up. While 66.7% of worn positioning supports were repaired by vendors at baseline and 100% at follow up (only one repair needed in the waitlist group) and 38% by the participant/family/friend at baseline and 100% at follow up (only one repair needed in the training group). Repairs not being completed were prevalent and number of repairs not completed by participant were not significantly different between groups at baseline and follow up, $p>0.1$. To explore the reasons for this, all instances in which at least one repair was needed were added (Table 32). Overall the most common reason at baseline for not having a repair completed was not attempting to repair it. While at follow up it was contacting a vendor but him/her not completing the repair yet. At both times and groups there were no instances where participants reported that a repair was not completed because insurance did not pay for it.

Table 32. Total number of times when repairs were not completed and reasons for this for participants in the waitlist and training group at baseline and six month follow up.

Time	Group	Total components ≥1 repair	None or some repair(s) not completed	Reason for repair not been completed			
				Not attempted	Attempted by me/family	Vendor contacted	Missing
BL	WL	24	25%(6/24)	67%(4/6)	33%(2/6)	0	0
	T	41	44%(18/41)	50%(9/18)	22.2%(4/18)	17%(3/18)	2
FU	WL	15	20%(3/15)	0	0	100%(3/3)	0
	T	25	58.3%(14/24)	21%(3/14)	43%(6/14)	36%(5/14)	0

Abbreviation: WL waitlist, T training

6.3.5 W-MAT

No significant association was found in total W-MAT score and group assignment at baseline and follow up. The "comments" section was filled out by data collectors in 72.3% of all the instances (time and group combined) in which a score of 0 or 1 was given to an item. The most common problems described were related to wear and tear of the components. Table 33 presents the summary of the section and total scores per group and time. Appendix L presents detailed results for all items in the W-MAT. During the W-MAT collection at baseline 58% (7/12) of participants in the waitlist and 33% (4/12) in the training group transferred out of the wheelchair for the assessment. At follow up 50% (4/8) in the training group and 71% (5/7) in the waitlist group transferred.

Table 33. W-MAT section and total score per for participants in the waitlist and training group at baseline and six month follow up.

Section score	Time	Group (n)	% of participants Score 0	1	2
Frame and attachments	BL	W (12)	0.0%	16.7%	83.3%
		T (12)	0.0%	41.7%	58.3%
	FU	W (7)	14.3%	14.3%	71.4%
		T (8)	25.0%	50.0%	25.0%
Postural supports	BL	W (12)	25.0%	25.0%	50.0%
		T (12)	16.7%	25.0%	58.3%
	FU	W (7)	14.3%	14.3%	71.4%
		T (8)	0.0%	12.5%	87.5%
Wheels and casters	BL	W (12)	25.0%	25.0%	50.0%
		T (12)	16.7%	16.7%	66.7%
	FU	W (7)	28.6%	0.0%	71.4%
		T (8)	25.0%	12.5%	62.5%
Motor and controllers	BL	W (12)	0.0%	25.0%	75.0%
		T (12)	0.0%	16.7%	83.3%
	FU	W (7)	0.0%	42.9%	57.1%
		T (8)	12.5%	50.0%	37.5%
Total score	BL	W (12)	41.7%	16.7%	41.7%
		T (12)	25.0%	25.0%	50.0%
	FU	W (7)	42.9%	14.3%	42.9%
		T (8)	25.0%	50.0%	25.0%

Abbreviation: WL waitlist, T training, BL baseline, FU 6 month follow up

Table 34 presents the number of instances in which agreement (or lack thereof) between W-MAT item-by-item scores and self-reported repairs not completed. For the waitlist group in one instance the frame was reported as broken and not repairs but the participants was using a loaner wheelchair at follow up. Self-reported repair measures and W-MAT data collection at follow up were not conducted on the same day. In three instances data collectors wrote additional information in the comments box: one participant mentioned their air cushion would not hold air as it used to, even though during the W-MAT evaluation it seemed to be ho lding air fine; another case during the motor and tilt mechanism evaluation no noises were identified but participant mentioned both had been noisy lately.

Table 34. Overall agreement between items in the W-MAT and self-reported repairs not completed at baseline and six month follow up.

Component categories needing a repair in the past 6 months:	Baseline (number of cases)			6 month follow up (number of cases)		
	SR &W-MAT≤1	No SR and SR &W-MAT≤1	SR &W-MAT=2	SR &W-MAT≤1	No SR and SR &W-MAT≤1	SR &W-MAT=2
Worn out wheel/caster; Broken caster assembly; Broken wheel or caster bearing	2	5	2	1	2	0
Broken frame	0	0	1	0	0	1
Loose positioning support; Worn out positioning support	3	10	5	3	3	3
Worn out seating components; Broken seating components	1	0	3	2	0	4
Broken suspension	0	0	0	0	0	1
Broken controller box	1	0	6	0	1	1
Battery did not hold charge	0	0	2	0	0	0
Power seat function	0	1	1	1	0	1

Abbreviation: SR self-reported component needing a repair

6.3.6 Program evaluation

No significant association was found between course evaluation and site; therefore, data was combined and presented on Figure 12. Eight participants found the duration of the course to be just right, three too short, and one too long. All participants except one said they would definitely encourage other power wheelchair users to participant in the course, while one said probably would. Positive results were about trainers, maintenance skills, and resources. Positive comments included: “visuals and demos were great”; “instructors were very helpful and knowledgeable”; “excellent study subject, materials, and staff”.

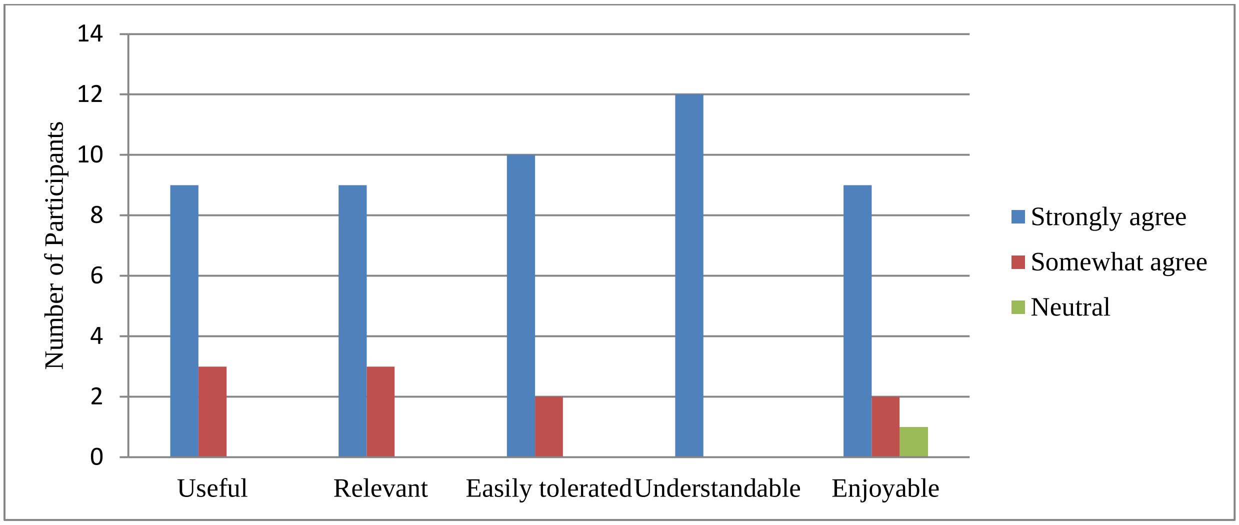

Figure 12. Power wheelchair user participants’ wheelchair maintenance training evaluation results.

The response about the most useful portion of the training varied among participants: toolkit provided (n=4), checklist/reminder cards that they could take home (n=4), learning where parts are located and how maintenance might be useful to prevent bigger problems (n=3), and hands-on portion (n=1).

Once participant found it difficult to remember how to check some features from session 1 to session 2. He found the first session redundant and suggested combining the lecture with the hands-on in one session. Considerations towards the improvement of the WMTP for power wheelchair users included: emphasizing on the need for maintenance since a new wheelchair is received; add more classes; class timing; have a knowledgeable peer trainer; and more information on how to get screws to stay. Finally, three participants suggested adding information on head and hip support.

Informal feedback from the instructors indicated that the order of the components in the maintenance checklist for the hands-on activity was found not practical. The order of the power point presentation and checklist for the hands-on practice were suggested to be changed to frequency in the same manner as the reminder cards that participants were given to take home.

6.4 DISCUSSION

This ongoing study is the first to examine the impact of wheelchair maintenance training in a group setting in power wheelchair users. Other power wheelchair-related trainings, such as wheelchair mobility, have been done one-on-one and none of them have focused on maintenance training (Kirby et al., 2015). The course evaluation was positive and may help to explain the 0% attrition at one month follow up for the training group. This is a preliminary analysis with a small sample size and some measures may be underpowered. Significant effect of the training on quality of life and adverse consequences due to a repair is yet to be determined with a larger sample size.

6.4.1 WMT-Q

Preliminary WMT-Q baseline scores support previous knowledge that state maintenance awareness and performance are not common (S. Fitzgerald et al., 2005). More than 75% of participants reported knowing how to contact a maintenance expert which is an improvement from a previous study in which <50% knew (Garber et al., 2002). Participant in the training group showed a significant improvement in maintenance knowledge and capacity at month after the training and retention at 6 month after the training. Adult learners have more difficulty remembering isolated facts (Phillips, 1999) which might explain the lower increase in multiple choice scores as compared to capacity scores. Both groups showed an improvement in knowledge and capacity with time. This suggests that there is a learning effect from the test. In addition, participants in the waitlist were present during the W-MAT administration and might have also learned from observing the data collector inspect the wheelchair. Having participant not present or blind folded during the W-MAT administration could be considered. The minimum-important-difference for the WMT-Q scores is unknown; the smallest difference in these subscores that wheelchair users perceive as beneficial is yet to be determined (Jaeschke, Singer, & Guyatt, 1989). The impact of the training is clearly seen on the performance scores interaction between time and group. Participants in the waitlist appear to have a reduction in performance as compared to an increased performance in the training group. However, the performance rate in those who received training was not compliant with the performance recommended in the training. This suggests that the maintenance cards and the quarterly reminders may not be enough to encourage wheelchair users to comply with the suggested maintenance frequency. Another explanation is that maintenance tasks may have been performed at the suggested frequency right after the training (e.g. motor disengage lever daily) and since problems were not found, the motivation to continue at this frequency was reduced. In industry, the effectiveness of the frequency of preventive maintenance programs is evaluated by measuring the effectiveness of the program in actually finding problems (Call, 2007). Even though the WMTP was developed based on experts' feedback, it is still unknown if the proposed performance frequency is appropriate. Further collection of "real-time" reports or logs of problems found while maintaining the wheelchair may help inform further refinement of the WMTP. Finally, even though participants had an increase in self-perceived capacity of doing maintenance tasks, their level of confidence is unknown. Future refinement of the WMT-Q could consider including measures of self-efficacy and then study how this related to performance (Bandura, 1977). A promising finding related to performance score is that it was not found correlated to the independence measure. This might indicate that the WMTP was successful in empowering wheelchair users as the director of their care, in this case maintaining their wheelchairs, when performing maintenance tasks that may have been independently not feasible (Hirsche, Williams, Jones, & Manns, 2011; Munce et al., 2014).

6.4.2 Self-reported repairs

Preliminary results showed no significant effect of the training in the number of components needing repairs or the likelihood of having an adverse consequence. However, the data collected provides further descriptive detail on the problem of repairs. First, overall the percentage of participants completing at least one repair appears to be larger than in previous reports (L. A. McClure et al., 2009; Worobey et al., 2012) and in Chapter 2. It also appears that this sample had a higher number of participants with components with repairs not completed than Chapter 2. For the training group at baseline it seemed it was even higher than those who did not complete repairs in Chapter 3 (70%). These preliminary results need to be interpreted with caution; it is a small convenience sample and the self-reported questions were not the same as used in the other studies. Participants may have decided to enroll in the current study because they had wheelchairs that were having worse maintenance issues than the general population of power wheelchair users with spinal cord injury. A suggested manner to explore if this is the case is to administer the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST); it has several items related to satisfaction with the durability and maintainability of the assistive technology device (Demers, Weiss-Lambrou, & Ska, 2002). An expected finding was that all the participants (100%) in the training group at 6 month follow up reported at least one component needed a repair. This might be an indication they were successful finding problems while performing the maintenance taught. For instance, training staff on detection of depression increased detection rates in the elderly (Eisses et al., 2005). It seems also that the number of components needing a repair in the past 6 months is higher than expected, especially since on average these wheelchairs were <5 years old and expected to have met ISO/ANSI durability standards. Type of components needing repairs appears to follow the same trend for the past 20 years, such as batteries, electrical components, and wheels and casters as the most common repairs as mentioned in Chapter 2 and found in other studies (Nosek & Krouskop, 1995).

The rate of adverse consequences was similar to previous reports (L. A. McClure et al., 2009; Worobey et al., 2012) and the results presented in Chapter 2. Being stranded due to a component needing a repair continues to be the most prevalent self-reported adverse consequence. The components needing repairs that were self-reported to cause the adverse consequences were not surprising. This information should be used to refine the WMTP to further emphasize on the importance routine maintenance may have on these items.

No significant correlations between number of components needing repairs and wheelchair age and outdoor or indoor hourly use concur with previous studies (S. Fitzgerald et al., 2005). Hours of wheelchair use and wheelchair age are not necessarily accurate proxies of miles travelled or roughness of the environment, which could be the largest contributors to wear and tear of the wheelchair. It is necessary to measure accurately how many miles or minute of operation the wheelchair has travelled or being used and in what context to be able to correlate these to repairs needed. This could better inform the frequency at which the wheelchair needs to be checked by an expert, expected time when tires need to be changed, etc. Much like how cars are expected to be maintained based on mileage or days of use.

The fact that the most common reason for not completing a repair was not even attempting it suggests that the potential negative consequences of the repairs are unknown to users and it stresses even more the importance of disseminating the WMTP. It is reassuring that not having components repaired because insurance did not pay for it was never the case in this study, which suggests an improvement from past trends (Nosek & Krouskop, 1995). However, not receiving immediate attention from vendor continues to be a problem (Nosek & Krouskop, 1995). Time between requesting and receiving a repair service may provide important information not only to the user but to the service providers (Orzel, 2015). Especially since vendors are the most common resource for repairs as found in this study, Chapter two and other studies (S. Fitzgerald et al., 2005; Nosek & Krouskop, 1995).

6.4.3 W-MAT

Preliminary results showed no significant association between W-MAT score and group at follow up. At this stage descriptive results also provide further insight on the current state of wheelchair maintenance and usability and validity of the W-MAT. Overall, 50% or more of the wheelchairs were found with at least one problem that would need to be addressed. Wear and tear were the most common problems found. The majority of the frames, motors and electrical components were found in good condition. However, in some cases data collectors wrote that the component was found in good condition according to the W-MAT description but the user mentioned it was not working reliably. This might suggest that the W-MAT alone might be insufficient detecting unreliability component operation. This could offer an explanation to the number of cases where a self-report component with a repair not completed disagreed with the W-MAT. While the cases in which the W-MAT reported a problem and it was not self-reported by a participant appears to reduce at the 6 moth follow up. This might suggest that there was an increased awareness of component inspection by participants. Based on the disagreement between self-reported repairs and W-MAT, the unknown reliability of the self-reported questions, and the moderate reliability of the W-MAT, it is clear that a tool that combines the strengths of both data collection measures is needed. Further insight to this matter is expected with a larger sample size. Several participants did not transfer out of their wheelchairs potentially making the W-MAT assessment less reliable.

6.4.4 Participant retention

For the purpose of this preliminary analysis, only complete-case results were presented. Excluding missing data may negatively impact power, but it is recommended as first step in data analysis before any imputation of missing data (Buchner & Findley, 1991). Upon completion of data collection, missing data and sensitivity analysis should be conducted to evaluate the robustness of the results (Thabane et al., 2013; Wood et al., 2004). Future explanations for attrition would be informative for future studies (P. Edwards et al., 2001).

Using creative ideas to increase study compliance and retention is a recommended practice in study design (Ferrucci et al., 2004). However, caution should be taken so that the enhanced participant retention strategies do not equal an intervention itself (G. Fitzgerald et al., 2015). Computer Assisted Testing (CAT) is suggested as a strategy to reduce participant's burden and increase study retention (Little et al., 2012). The majority of the outcome measures used in this study were CAT based, but overall data collection time was long which can explain the high attrition rate (Little et al., 2012). Another suggestion is to shorten the follow up period (Little et al., 2012). This was potentially evidenced with the 0% attrition rate at the one month follow up for the training group. Other low cost solutions that could be considered include: offering survey results, adding a statement in the follow up indicating that others have already responded, and using a picture in the body of the follow up email (Little et al., 2012).

6.4.5 Lessons for the WMTP and WMT-Q

Preliminary results support that wheelchair maintenance group training seems favorable and feasible; this is especially important since not having enough time to train wheelchair users has been identified by 63% of centers as a barrier towards training (Best, Routhier, et al., 2014). Caution should be made to avoid redundancy and also that the amount of information is overwhelming (May, May, Day, & Warren, 2006). Some participants mentioned that the information was repeated during the training – further improvement should be made.

Efforts were made to incorporate ISO standards language throughout the training and questionnaires. However, as item-by-item analysis of the WMT-Q suggests, this vocabulary may have hindered the learning process by not using a common language. A specific example is the question "do you know how to check the brakes" which appears to be confusing even for those who received training. All power wheelchairs have brakes, and this question was frequently answered as "no part". Revision of this item and/or consistency of terms used during the training are warranted. Future revisions should pay attention to this because participants have reported feeling alienated by the words and terminology used during the rehabilitation process (Standal & Jespersen, 2008). Current trainers could be asked to completed the Suitability Assessment of Materials as well (Doak, Doak, & Root, 1996).

In addition, there is a potential to collect further information on the trainings that are yet to be delivered. An observer and note-taker could attend the trainings and record the questions and interactions that happen between participants. Constant review and refinement based on feedback and lessons learned through delivering the training should be performed(May, May, et al., 2006).

Introducing the use of the Goal Attainment Scale (GAS) similarly to the one used in power wheelchair skills training before the training and revising it after the first session could help plan a more productive and tailored second training session (Kirby et al., 2015). Completing the GAS at the end of the second session would provide further detail in the effectiveness of the training program and will better inform the decision on how many training sessions are ideal. Few participants suggested that the training could be condensed in one session only. However, research suggests that behavior changes expected from an education program are predicted by contact time with the educator (Norris, Lau, Smith, Schmid, & Engelgau, 2002). The use of the GAS could also increase participants engagement since it will show that there is an individuality aspect to the training and their individual needs are taken into account (May, May, et al., 2006).

6.4.6 Study limitations

This is a convenience sample. Positive effects may be explained more by motivation than by the training itself. Efforts were made so data collectors were blinded to group assignment. However, in some cases participants will comment on either expecting to receive the class or how they liked the class. They might have biased the data collection of the W-MAT. A potential study limitation is the use of the W-MAT. As mentioned in Chapter 5 it has moderate reliability; but, it is the only maintenance assessment tool available with its level of detail. As suggested in the literature, even a test with moderate reliability can add sufficient information to justify its use, especially when used in conjunction with other test (Portney & Watkins, 2008). The self-reported questions' reliability is unknown, maintenance versus repair was not defined, and data collection time was long. Participants could have been bored and distracted and their answers may not represent their reality. Wheelchair vendor information per participant was not collected. Poor wheelchair reliability and repair/replacement could be associated to the vendor.

6.4.7 Future work

More data is being collected as this is as ongoing randomized trial. WMT-Q results are promising and results from the larger data set will provide more detail on the impact the WMTP had on adverse consequences, quality of life, and wheelchair maintenance state at follow up. Recommendations for the ongoing data collection and training include enhancing participant follow up strategies and formalizing more feedback collection during training are suggested to gather information that will inform future work. Specifically, add a collection sheet per class to record the number of attendees, caregivers, volunteers, and trainers. This information will help roll out the program during a future dissemination stage.

A combination of the self-reported repair questions with the W-MAT should be considered. It is evident that further detail is needed in terms of what repairs are required. Even so this type of detail may only be achieved graphically (i.e. taking pictures of the part in disrepair). Additional functional tests could be added The inclusion of people older than 75 and younger than 18 in addition to other types of disability should be considered in future studies.

6.5 CONCLUSIONS

The WMTP was well received by power wheelchair users. Participants showed a significant improvement in wheelchair maintenance-related knowledge as well as increase maintenance performance. Self-reported wheelchair components needing repairs are prevalent and vendors are the most common source of repairs completed. All participants in the training group at follow up self-reported at least one repair suggesting that the training might have increased the component problem detection rate.

7.0 WMTP DISSEMINATION: SPANISH TRANSLATION AND ONLINE IMPLEMENTATION OF THE MANUAL WHEELCHAIR MAINTENANCE TRAINING PROGRAM: A FEASIBILITY STUDY

7.1 BACKGROUND

Access to an appropriate wheelchair is a human right (United Nations, 2006). However, the majority of people with mobility impartments in developing countries who require a wheelchair do not have access to the appropriate devices and services (World Health Organization & World Bank, 2011). Barriers to access assistive technology include the shortage of professionals trained in the field, lack of user awareness on assistive technology, and lack of user training in proper utilization and maintenance of the assistive technology devices (Bausch & Ault, 2012; Clarkson University and Good Sheperd, 2004; Jans & Scherer, 2006; Rowley, Mitchell, & Weber, 1997; World Health Organization, 2014, 2015; World Health Organization & World Bank, 2011). Moreover, commonly users are left with an unsafe or unusable device when it needs a repair due to the lack of locally available and affordable repair and maintenance services (World Health Organization & World Bank, 2011).

In Mexico, according to the National Institute of Disabilities, approximately 5.1% (6.2 million) of their population live with a disability (Instituto Nacional de Estadística y Geografía México, 2010). With 23 sites, Teletón México is one of the largest nation-wide networks of pediatric outpatient rehabilitation centers in the world and provides services to up to 35,000 children with disabilities and their families every year (Teletón Fundación, 2015). Even though Mexico was one of the first countries to ratify the United Nations Convention on the Rights of Persons with Disabilities (United Nations, 2015a), federal policies fail to provide appropriate coverage for wheeled mobility devices and services. Some wheelchairs are donated via state programs to their poorest citizens[12], but the majority of their wheelchairs are donated by national[13] and international[14] non-governmental organizations. Studies conducted at one Teleton center found that wheelchairs are in need of maintenance and repairs (Toro, Garcia, et al., 2012b), do not meet durability standards (Toro, Garcia-Mendez, et al., 2012), and there is a need for on-site wheelchair maintenance and repairs services (Toro, Garcia, et al., 2012b). Poor state of maintenance may be related to a lack of knowledge on behalf of rehabilitation providers.

One strategy to build staff's capacity is through distance professional development programs, such as online training, that can be applied under a wide range of settings worldwide (Bausch & Ault, 2012; World Health Organization, 2014). Access to online training may aid in reducing the shortage of qualified professionals (Campbell, Gibson, Hall, Richards, & Callery, 2008) by bringing new and updated knowledge to those that may not otherwise have access to it (Abdel-Salam, Kauffmann, & Crossman, 2007; Bengiamin, Johnson, Zidon, Moen, & Ludlow, 1998; Hanover Research, 2011). Previous studies have not found significant differences in learning outcomes (knowledge acquisition) between online and traditional classroom students (Hanover Research, 2011). In some cases online learning has even been the preferred method of learning as it was deemed less time consuming than paper-learning (Cook, Dupras, Thompson, &

[12] http://sn.dif.gob.mx/dif-nacional-y-beneficencia-publica-entregaron-auxiliares-auditivos-y-sillas-de-ruedas/
[13] http://www.fundaciontelmex.org/salud/sillas-de-ruedas/ last visited September 17, 2015
[14] https://amwheelchair.org/wheelchairs-for-children-in-mexico/

Pankratz, 2005). Yet, there is resistance to implement online courses for areas that traditionally require hands-on activities like engineering laboratories (Abdel-Salam et al., 2007) or clinical skills (Austin & Rocchi Dean, 2006). Online education poses challenges in allowing participants to demonstrate whether they have learned and acquired the skills that are being taught (Chandler, Park, Levin, & Morse, 2013). One suggestion to assess skill acquisition is to photo-document hands-on activities done remotely (Reuter, 2009). Several studies have shown promising outcomes in acquiring skills beyond knowledge in different contexts such as pressure ulcer identification (Beeckman, Schoonhoven, Boucqué, Van Maele, & Defloor, 2008), hands-on fluid mechanics laboratory experiments (Abdel-Salam et al., 2007), and clinical skills in pharmacists (Austin & Rocchi Dean, 2006). Chandler et al. suggested that a greater difference in pre- to post-test results for online training predicted the likelihood of participant´s behavior in a hands-on assessment (Chandler et al., 2013).

Specifically for assistive technology, online education has been used with positive outcomes in this field (Goldberg, 2013; Sax, 2002). It has been suggested that distance learning methods must include the opportunity for students to personally interact with devices (Jans & Scherer, 2006). For instance, field trips to local settings that have assistive technology available could be a simulation strategy when in-person hands-on activities are not possible (Bausch & Ault, 2012). The goal of this chapter was three-fold: 1) translate into Spanish and adapt to an online platform the manual wheelchair component of the Wheelchair Maintenance Training Program, Questionnaires, and the Wheelchair Maintenance Assessment Tool; 2) train staff at rehabilitation centers in Mexico with this online program; and 3) assess the feasibility of this online training via program evaluation.

7.2 METHODS

7.2.1 Participants

Current Teletón efforts focus on building capacity at 11 centers that will implement new assistive technology services. This online maintenance project was proposed as part of their assistive technology training. We suggested that all staff (medical doctors, therapists, technicians, and administrators) who were participating in the new service be part of the training. This suggestion was made since assistive technology is a multi-disciplinary field (Jans & Scherer, 2006) and interprofessional practice is a recommended strategy for better patient care (World Health Organization, 2010).

7.2.2 WMTP translation and online adaptation

The manual wheelchair component of the Wheelchair Maintenance Training Program (WMTP) and Wheelchair Maintenance Training Questionnaire (WMT-Q) versions used for implementation described in Chapter 3, Wheelchair Maintenance Assessment Tool V2 (W-MAT) and illustrated instruction guide described in Chapter 4 were adapted and translated into Spanish. A wheelchair part and component vocabulary in Spanish was developed before the materials were translated. One investigator who was Spanish native speaker and bilingual in English selected the wheelchair component and parts translations (≥1 were available for many components) in Spanish from the WHO Guidelines in wheelchair provision (World Health Organization, 2008a) and wheelchair user manuals. Three professionals with experience in wheelchair provision native from Mexico and bilingual in English reviewed the options and selected the translation they thought most appropriate for each wheelchair part. Translations that had consensus at least between 2 reviewers were selected. If there was no consensus, the WHO translation was selected. Later, materials were translated by an investigator who was a native English speaker and bilingual in Spanish and reviewed independently by 2 investigators who were Spanish native speakers from Mexico and bilingual in English. Another investigator who was a Spanish native speaker and bilingual in English compiled the feedback and finalized the translation (

Figure 13). No back translation to English was performed due to resource limitations. The information and questions related to health insurance and power wheelchairs were not included in the WMTP or WMT-Q Spanish version.

The WMTP program and associated outcome measures were adapted to train staff at the rehabilitation centers to perform basic maintenance and repairs as well as train wheelchair users and caregivers to perform maintenance. The presentation for the training of the clinicians was adapted to an online session. Mainly, videos demonstrating how to perform each maintenance task were recorded. Videos from the "live" clinicians training discussed in Chapter 3 were included. Additional information was also added on basic repairs that were relevant to the setting such as changing wheel/caster bearings and aligning/tightening caster forks. Lastly, the presentation for manual wheelchair users, maintenance cards, manual wheelchair maintenance video, and clinician's reference manual were translated to Spanish through the process illustrated in Figure 13.

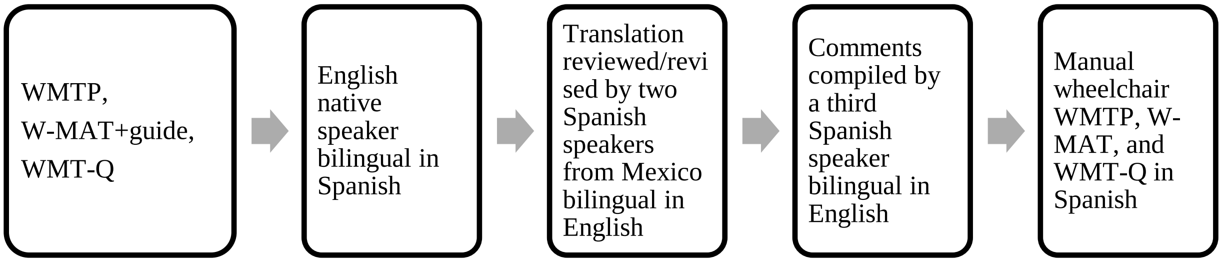

Figure 13. W-MAT, WMT-Q for manual wheelchair users and clinicians, and WMTP English-to-Spanish translation process.

7.2.3 WMTP online course

The WMTP online training was designed based on the methodology described by Goldberg (2013). Coursesites[15], an online free platform, was used to share the content (Figure 14). A discussion board was set up for participants to post questions.

[15] www.coursesites.com

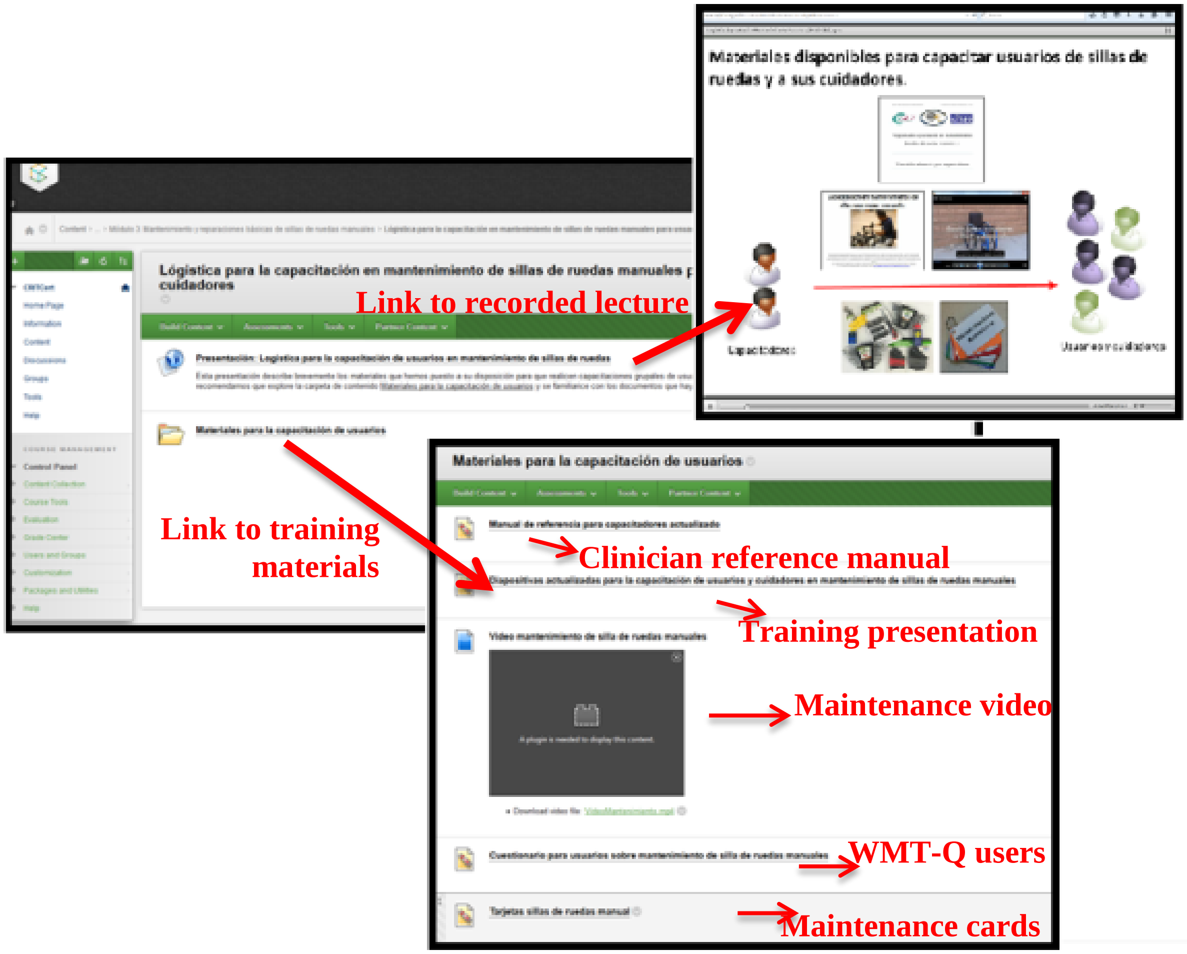

Figure 14. Example of Coursesites layout for the WMTP logistics portion of the course.

Figure 15 presents the schedule of the WMTP implementation. One week before the content was shared participants were asked to take the WMT-Q in Spanish for clinicians. Participants were notified when the content was uploaded and given two weeks to watch the lectures. Lectures were recorded using AdobeConnect[16] which created a unique URL for each recording with the exception of the first lecture: basic wheelchair maintenance. Since AdobeConnect does not support videos embedded in a power Point Presentation, the Power Point

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[16] http://www.adobe.com/products/adobeconnect.html

and presenter's voice were recorded using QuickTime for this session. This video was then compressed and uploaded in AdobeConnect. **Table 35** describes the lectures in detail.

Table 35. WMTP online Spanish lectures duration and description.

Lecture	Duration (min)	Description	Lecture link and related materials
Basic wheelchair maintenance	90	Importance of performing periodic maintenance with videos and pictures demonstrating how to perform each maintenance task.	Lecture link
Basic wheelchair repairs	30	Replacement of casters/ bearings, adjustment of fork structure, and adjustments to the axle.	Lecture link
W-MAT	15	Description and instruction of use of the W-MAT and illustrated guide.	Lecture link, W-MAT and Illustrated guide
Logistics to deliver the WMTP for wheelchair users and caregivers	28	Explanation of the training materials and suggested logistics for the group training for wheelchair users and caregivers.	Lecture link Maintenance cards, power point presentation, clinicians reference manual, maintenance video, and WMT-Q for manual wheelchair users.

A three-section practice activity was posted two weeks after the lectures were shared and participants were required to complete and submit it two weeks later. Participants were encouraged to complete the activity as a group. First, participants were asked to use the W-MAT on three different used wheelchairs available at their center and photo-document their findings with comments on the component problems found. In addition, they were asked to document questions and comments related to the usage of the W-MAT to be discussed in the online meeting. Second, participants investigated the warranty policy, ISO 7176 standards compliance, and replacement parts availability of the wheelchairs available in their region. Third, participants were tasked with identifying at least 10 locations where a wheelchair could be repaired in their region. The instructor then reviewed participant submissions and prepared a presentation based on common mistakes found in the usage of the W-MAT. As part of the program evaluation, an online group meeting was held two days after the submissions were submitted through a voice and text chat forum in which homework's feedback was provided (Goldberg, 2013). After the meeting the post-training WMT-Q was distributed and participants were allowed up to one week to complete it.

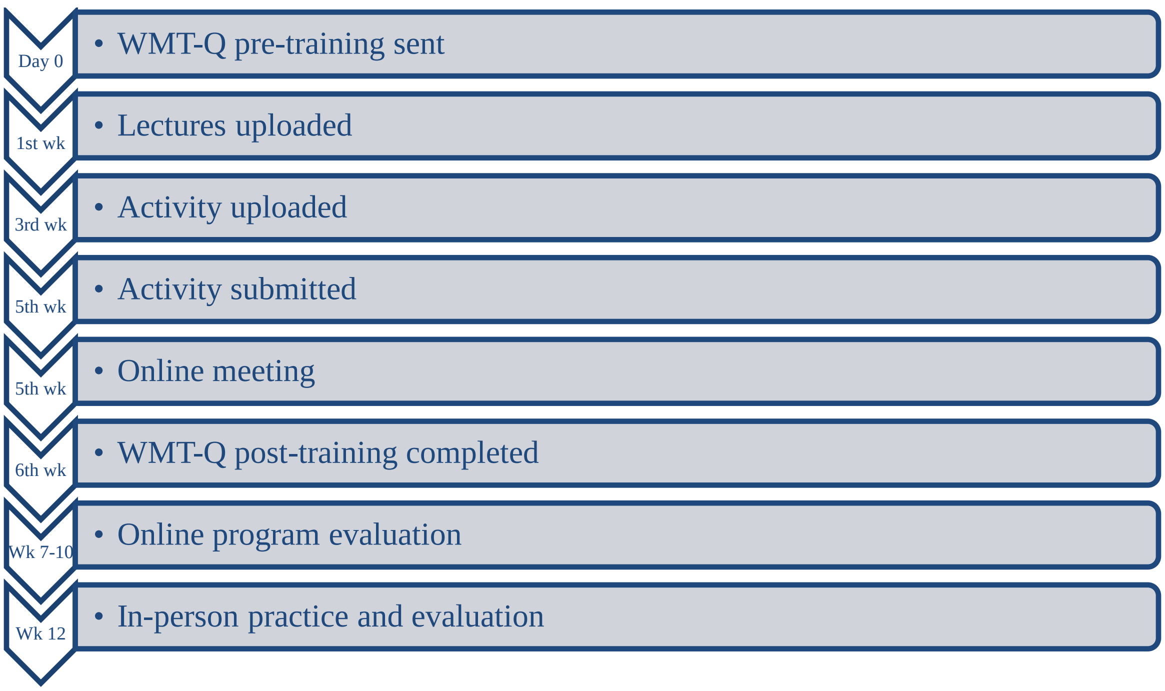

Figure 15. WMTP online course order and duration. Abbreviation wk: week.

7.2.4 Program evaluation

After the online training program was completed, an online evaluation survey was sent to participants to be completed individually in the following two weeks (Figure 15). The survey evaluated the general quality of the course, instructors' performance, the importance of different course components, modules, homework, course environment, and course logistics. The answers were based on a Likert scale: very low, low, medium, high very high. In addition, they were also asked to provide their general course perceptions by selecting their level of agreement with adjectives that described the course (strongly disagree, somewhat disagree, indecisive, somewhat agree, and strongly agree). Afterwards, the instructor held one online meeting with each center to discuss strengths, weaknesses, opportunities and threats (SWOT) on the maintenance services and training implementation. Further feedback was also solicited during the meeting to improve the online course.

7.2.5 In-person practice and evaluation

An on-site workshop took place at the University of Teleton in Estado de Mexico. Two participants from each site that participated in the online training attended. The agenda included a 20 minute presentation summarizing the evidence about the importance of wheelchair maintenance training for healthcare professionals, wheelchair users, and caregivers, and 30 minutes hands on activity. They followed the manual wheelchair maintenance checklist to inspect the wheelchair, noted problems identified, and how they could be addressed. For this activity participants also received a cleaning kit and tools. After the in-person workshop participants were asked to answer an evaluation for that portion of the program only.

7.2.5.1 Data analysis

Participants' background, wheelchairs available, common repairs found with the W-MAT, ISO standards, and local repair services are listed. WMT-Q section and total scores for pre- and post-training were calculated as described in Chapter 3. Wilcoxon signed-rank was used to assess if there were differences between pre- and post-training scores. Frequency counts for program evaluation answers, SWOT analysis summary, and feedback comments are presented.

7.3 RESULTS

A total of 40 employees (11 technicians, 18 therapists, 10 medical doctors, and one administrator) from 11 pediatric outpatient rehabilitation centers in Mexico participated. Between two to six participants per center underwent the online training. Figure 16 shows the location of the participating centers across Mexico.

Figure 16. Location of participating Teleton sites in Mexico (n=11).

7.3.1 Activity and online meeting

7.3.1.1 W-MAT

Common wheelchair problems included rusted parts (frame, screws), missing parts, sagged and ripped upholstery, and worn wheels and casters. Figure 17 presents examples of pictures that illustrated the problems found using the W-MAT.

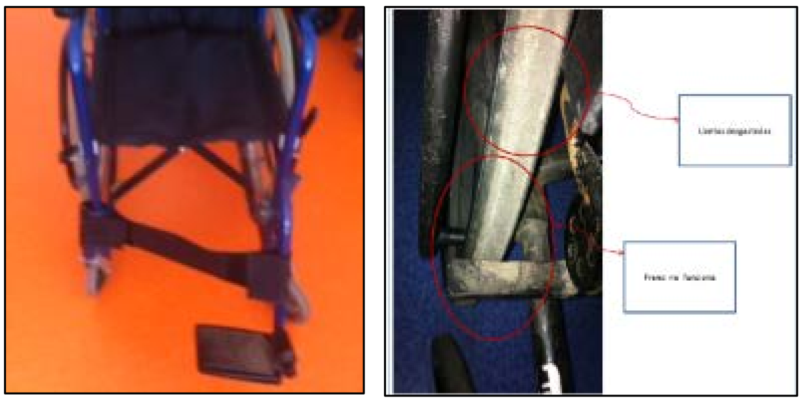

Figure 17. Example of pictures provided in the W-MAT. Left: missing foot support. Right: Worn tire and brake that does not engage the wheel.

7.3.1.2 Standards compliance, warranty, and replacement parts

Among the 11 centers a total of eight wheelchair suppliers were identified. Their product warranties ranged from six months to three years. Only one model of wheelchair from one vendor complied with European standards[17]. Four of the suppliers sold replacement parts and components.

[17] EC council directive 93/42 EWG I concerning medical devices

7.3.1.3 Local repair services

Participants reported 33 bicycle workshops, five welding shops, 17 orthopedic stores, four motor vehicle tire-changing shops, three wheelchair repair shops, and one mattress manufacturer. Some centers added that a tailor shop could also be a resource to repair the wheelchair upholstery.

7.3.1.4 Online meeting

The online meeting was recorded and then shared with the group for participants who could not attend **(link). Figure 18** shows the components of the online meeting environment. All the participants from each center were in the same physical location for the online meeting.

Overall participants found the W-MAT to be useful, practical, and thorough. Participants anticipated the W-MAT to be most useful during wheelchair follow up appointments. Suggestions to improve the W-MAT included adding tilt in space, custom-made foam seating system, and seatbelt items. A steep learning curve in the use of the W-MAT was acknowledged. Participants identified that the information gathered with the W-MAT could be shared with the wheelchair user/caregiver to discuss next steps and further follow ups. One center suggested using an adapted W-MAT for each different user depending on their type of wheelchair for them to use as home as a maintenance reference.

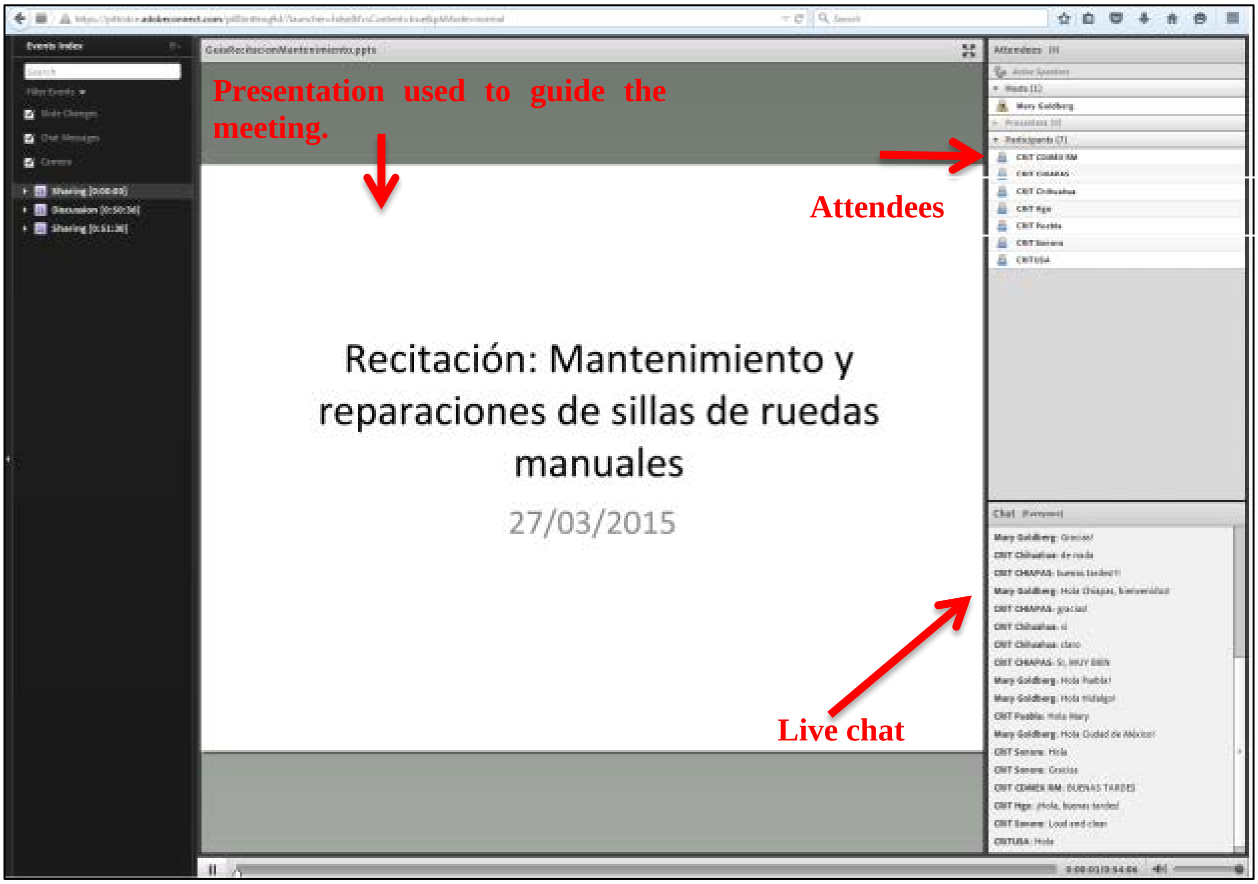

Figure 18. Online meeting environment in AdobeConnect.

Common errors using the W-MAT were selecting the wrong scoring description (Figure 19) and omitting description of the problem identified. These were discussed and clarified during the online meeting.

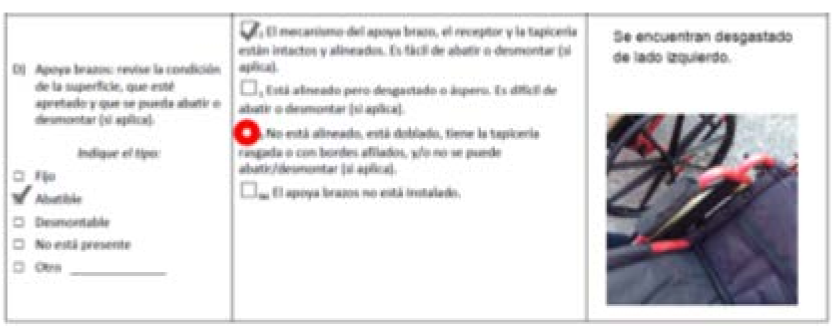

Figure 19. Example of an error in the W-MAT usage. The picture shows a worn arm support, the appropriate scoring is indicated with the red circle, while the black check was the option selected.

Feedback on the WMTP identified the need for more information about pediatric and power wheelchairs. Further, as several sites provided services to indigenous communities whose first language is not Spanish additional translation of the training program was suggested. More detail on repairs for more complex pediatric wheelchairs with postural supports was suggested. Finally, some participants suggested adding information on safe transfers for users who are able to perform maintenance independently. After the online meeting, information about tilt-in-space, seatbelt, and custom-made foam seating system components were added to W-MAT and WMTP and shared with participants. A proposed first step to include indigenous people was that personnel from that site translate only the maintenance cards that participants take home with them. The original file for the maintenance cards was shared with participants in an editable format with detailed instructions on how to edit them.

7.3.2 WMT-Q scores

A total of 31 participants answered the questionnaire pre- and 22 post-training. However, only 18 answered the WMT-Q before and after the training. Participants self-reported an average 2.2±2.9 years of experience with wheelchairs with a range of 0 to 10 years. There was a significant increase in maintenance-related knowledge and maintenance capacity before and after the training. Table 36 contains the score per section pre- and post-training for those who answered the questionnaire at both times. Median performance score before the training was 0%, which indicates that formal maintenance training to users was not a practice among these rehabilitation sites.

Table 36. Average scores for participants who answered the WMT-Q before and after the online training.

WMT-Q Spanish	WMT-Q Score Median (IQR)	
	Pre-training	Post-training
Manual wheelchair open ended	25(22)	28.6 (29.0)
Multiple choice	41.7 (16.7) ^	62.5 (52.1) ^
Capacity	40.48(82) ^	95.2(19)^

^p<0.008

Table 37. Proportion of participants' who self-identified as capable of doing maintenance tasks after the training.

% Participants	Maintenance tasks
70-79%	Inspect pneumatic tires pressure and cross-brace. Lubricate moving components.
80-89%	Inspect: caster flutter, back posts, plastic components, bearings, spokes, wheel locks, quick-release wheels. Contacting an expert for a yearly inspection.
90-99%	Inspect: movable components, wheels and casters, weld points.
100%	Clean frame and cushion. Inspect: cushion, upholstery, wheel alignment, handrims.

7.3.3 Program evaluation

7.3.3.1 Online evaluation survey

All participants answered the online survey (n=40). The majority (88%) found the course highly or very highly relevant to their work and that there was a cooperation environment during group activities. The components of the online course that were ranked as most useful were the recorded presentations and the videos. 39% found that the clarity of the homework and ease of having instructor's support for the homework was medium. More than 90% agreed that the platform (CourseSites and AdobeConnect), number of participants, and the order of the modules were appropriate; 22% felt that the length of the course was too short, 29% that it was passive, 20% slow, and 12% boring.

Examples of translated quotes of the written feedback received include:

"Currently wheelchair maintenance is done in a reactive manner. This training has made us aware of the importance that wheelchair maintenance has in the wheelchair user safety and wellbeing. We understood the importance of frequent inspection of the condition and function of the wheelchair and how a problem could even put the user at risk of an accident and injury. We are committed in educating our users and their families. In this way, there is a significant opportunity to implement the WMTP and educate our users to take care of their wheelchairs at home"

"We believe there is an opportunity to educate users and their families in appropriate maintenance techniques. We believe that if frequent preventive tasks are done, it is less likely that the device will fail".

7.3.3.2 Group online meeting

Participants were asked to discuss the feasibility, opportunities and barriers to implement the maintenance-training program at their centers. In general, almost all participants mentioned that it could be possible, and that it would be very convenient and useful for their patients. There was a consensus that there is a need for the families that they serve to learn this information. Additional homework was suggested to be added (i.e. perform more maintenance on more wheelchairs) and additional training on other types of wheelchair repairs. There was a consensus that live hands-on practice with an instructor would be beneficial. Below is the summary of the most common responses during the SWOT analysis:

Strengths

- Infrastructure and trained personnel to hold the trainings available (e.g. classrooms, etc).

- They self-identified as having the capacity to educate the rest of staff at their centers in the impact of a poorly maintained wheelchair. Therefore, if a problem is identified in a wheelchair, the staff would be aware to refer the wheelchair user to the appropriate maintenance person.
- They perceive the families they work with would be receptive to learn new knowledge that will benefit their child with a disability.

Weaknesses

- Lack of access to different types of wheelchairs for the classes.
- Difficulty to schedule wheelchair users/families and trainers for group training sessions.
- Not enough funding at the center to provide wheelchair users/families with tools needed.
- Unsure when they can roll out the training due to funding and logistics. They are concerned that as time passes, they may forget what was learned.
- Not having access to different types of wheelchairs (folding/rigid frame, postural supports, etc) for the training of the users.

Opportunities

- Raise awareness, reduce dependency, reduce costs – currently wheelchairs are replaced entirely instead of by failed component.
- Resources for assistive technology, its maintenance and repairs are very limited. Therefore, many families could be interested in learning how to do it themselves appropriately.
- For some centers the local availability of replacement parts was an opportunity to provide appropriate repair services at their center.
- For one center the lack of available replacement parts was perceived as an opportunity for them to become a supplier of components for their locality.

- Hold trainings off-site at communities where families can travel.
- Educate wheelchair donors on the importance of wheelchair maintenance and encourage them to donate the wheelchairs with tools.
- Encourage wheelchair suppliers to provide wheelchairs with tools.

Threats

- For some centers lack of locally available replacement parts was a threat to maintaining and repairing wheelchairs in a timely manner.
- Income level of the families they serve. Finding funding for replacement parts and tools to allow wheelchair users and caregivers perform maintenance at home may be difficult.
- Lack of accessible public transportation hinders families to travel with the wheelchair to a training site.

7.3.3.3 In-person workshop

Twenty two people participated in the in-person workshop. Feedback revealed that some participants they found it impractical that the checklist inspects the wheelchair component by side; instead, they suggested performing the inspection bilaterally. All agreed that having both the checklist and the problem reported table at their future wheelchair maintenance service would be useful to keep track of and document the wheelchair maintenance process. The majority of the participants found the workshop to be useful, relevant, easy to understand, tolerable, and enjoyable. More than half of the participants mentioned that the length of the workshop was too short. About 90% said that they would definitely encourage their colleagues to participate in the workshop. Finally, when asked to rate the utility of the workshop, 57% rated it to be extremely useful and 39% rated it very useful. Some of the most common comments about workshop improvements were: it was too short, it needed more practice in doing wheelchair repairs, it should involve not only identifying the problems but actually repairing them, and it should include power wheelchair basic maintenance.

7.4 DISCUSSION

An online Spanish version of the WMTP training for clinicians was piloted with 11 rehabilitation centers and 40 rehabilitation professionals in Mexico. The results suggest that online wheelchair maintenance training for clinicians/technicians is feasible. The training was well received, participants found it relevant to the work that they do, and perceived a benefit to training their clients. We attribute part of the success of the online program to the fact that participants were motivated because they were implementing new assistive technology services. Research has shown that learners' characteristics, such as motivation, contributes to the success of online learning programs in developing countries (Bhuasiri, Xaymoungkhoun, Zo, & Rho, 2012). These are similar to the outcomes of other assistive technology related online training that include increased awareness and immediate applicability to current job (Sax, 2002). Our methodology seems to have had satisfactory results. Homework was suggested to be completed by the group/center and the feedback on the homework was provided two days after it was submitted. Positive feedback on the online training program may be attributed to student-to-student interactions and instructor's timely and meaningful feedback (Eom, Wen, & Ashill, 2006; Williams, 2006). The suggested collaborative nature of the activities appeared to have been well received. Previous research have shown that collaborative online instruction had better outcomes than those in which students worked independently (Means, Toyama, Murphy, Bakia, & Jones, 2010). Our participants suggested that all the personnel at their center should take this course so they can identify problems and refer to appropriate repair/maintenance services before there is an adverse consequence. This suggestion emphasizes the importance that interprofessional courses for promoting interdisciplinary work and “sharing” the responsibility of making decisions as has been found in other studies (Sax, 2002).

The WMT-Q results suggest that participant’s perceived capacity of performing a task improved significantly after the training. Low performance scores before the training indicate that wheelchair users are not educated at these sites on how to maintain their own device. There is an opportunity to impact a large group of people, since anecdotal comments from participants indicate that about 70% of their clients are wheelchair users.

Some sites mentioned that they did not have access to a variety of wheelchairs suggested for the wheelchair users training. In addition, there was a consensus among sites that in-person instruction would have been beneficial. These results align with the findings of Jans and Scherer, lack of devices and the need for more hands-on training was also found as a barrier for assistive technology training (Jans & Scherer, 2006). Research suggests that “blended” or “hybrid” approaches might be the most effective delivery model (Casimiro, MacDonald, Thompson, & Stodel, 2009; Goldberg, 2013; Means et al., 2010).

The homework activities facilitated participants recognize the wheelchair maintenance and repairs resources that are locally available. The lack of available wheelchairs compliant to ISO durability standards was not surprising. Even in developed countries more than half of the wheelchairs are found non-compliant with international standards (Gebrosky et al., 2013; Wang et al., 2010). The fact that many of the wheelchair suppliers contacted were not aware of ISO 7176, indicates that there is an urgent need to educate all stakeholders (policy makers, suppliers, manufacturers, clinicians, wheelchair users, and caregivers) on the importance of utilizing devices that comply with durability standards. This network of pediatric services has leverage to impact suppliers' practices because they provide services to thousands of wheelchair users nationwide. In fact, two of the suppliers that were contacted during the activity followed-up with the personnel at the Human Engineering Research Labs inquiring about wheelchair testing. This shows the potential effect that consumers may have; however, to be able to have ISO-complaint wheelchairs in the country there also needs to be a change at the systems level (i.e. federal regulations).

W-MAT was found as a comprehensive tool to assess wheelchairs. The asynchronous method of assessing participants' use of the W-MAT seems favorable and could be explored further to assess maintenance skill acquisition.

7.4.1 Study limitations

The validity of the translations is unknown and further efforts to back translate the materials to English and compare to the English version should be made (Acquadro, Conway, Hareendran, & Aaronson, 2008). The reliability of the WMT-Q is unknown and the attrition of the questionnaire was more than 50%. This may have impacted the internal validity of these results. Even though we found a significant increase in self-reported knowledge, it is unknown how this knowledge relates to the ability to teach others as well as to perform the maintenance tasks. Participants had no option to choose between and online vs an in-person course. One limitation of the online audioconferencing and chat that were used for the homework discussion is that it may be difficult to retain participant's interest for a long period of time since there is no visual stimulation (Hanover Research, 2011).

We believe that participants were a highly motivated audience because their sites were in the process of implementing new assistive technology services. The positive perception of the course may not be generalizable to other audiences. Research suggest that those that self-select an online course do better in this setting than in an in-person because their self-efficacy, self-motivation, and dedication are higher (Reuter, 2009).

7.4.2 Future work

Additional adaptation and further development is required. Further effort should be made to solve technical difficulties mentioned, that is, audio and video quality. Poor interaction between the learner and the learning platform hinder the learning experience (Cook et al., 2005; Swan, 2003). The infrastructure and the quality of the system have also been identified as primary success factors of online programs by faculty (Bhuasiri et al., 2012). First, converting video recordings was a challenge both in Blackboard (Suk Hwang & Vrongistinos, 2012) and AdobeConnect. Additional software that functions better with videos such as AdobeCaptive or Youtube should be considered. Youtube presents an interesting option because it is free and its social media capabilities allow learners and instructors to asynchronously communicate (Manasco, Barone, & Brown, 2010). Since internet access is not ubiquitous, alternative formatting (e.g. interactive CD or flash drive) of the distance education program should also be explored (Jans & Scherer, 2006). Increasing mobile broadband penetration worldwide opens opportunities to consider mobile applications (International telecommunication Union, 2014). Second, the course could be revised to a more interactive manner in which participants can engage with the lesson more than passively watching the lecture such us quizzes, recording themselves performing maintenance, match photos and words, and scoring videos of someone else performing a maintenance activity (Karkou, Bakogianni, & Kavakli, 2008). This strategy might help to address individual learning styles, which has also been suggested as an appropriate strategy for online assistive technology-related training (Sax, 2002). Discussion board was found useful for peer-to-peer interaction in assistive technology education (Sax, 2002). Yet, in our course it was never used. Further effort to engage participants in the discussion board should be made. A different platform that could automatically allow participants access the course content only after the WMT-Q has been completed pre-training as well as providing the course completion certificate only after the WMT-Q post-training is completed.

A measure of actual ability to perform the maintenance tasks is still needed. One option is to do it similarly to how the W-MAT activity was carried-out. A directed hands-on practice in participants location with instructor's feedback could be explored (Mawn, Carrico, Charuk, Stote, & Lawrence, 2011). Participants could send pictures or videos and the instructor provides feedback asynchronously or via videoconferencing if he/she deems the learner needs extra feedback of live demonstration (Parrish, 2008). "How confident" one feels performing a maintenance task could provide further insight on the impact of the training program. Self-efficacy is considered a predictor of actually performing or engaging in a behavior (Bandura, 1977). Items related to several maintenance tasks are available in the work by Rushton et al. and could be considered to be added as an outcome measure of this training program (Rushton, Miller, Kirby, & Eng, 2013; Rushton, Miller, Lee Kirby, Eng, & Yip, 2011; Rushton, Smith, Miller, & Vaughan, 2015).

Finally, an additional module on repairs for wheelchair users and caregivers should be considered. In developing countries settings, and those who live in rural areas in the U.S., may not have readily access to a "maintenance expert". Empowering users and caregivers with more repair skills, may impact further the wheelchair use, adverse consequences due to a repair, and foster social participation.

This training program should be made available to the rest of the rehabilitation facilities in their network. A mentoring strategy could be explored to support the sites as they implement the group training for users and caregivers. Pioneer sites could then transition to becoming mentors of other sites that start AT-related services at a later stage. There are opportunities to further collaborate and study the impact of maintenance training in their users and the reliability of the wheelchairs that are provided at their sites. Last, further considerations to make this distance learning openly available is to comply with accessibility standards for people with hearing impairments as well as those who use screen-readers must be implemented.

7.5 CONCLUSION

The WMTP, WMT-Q, and W-MAT were translated to Spanish and the clinicians/technicians training adapted to an online course. Program evaluation results suggest that online manual wheelchair maintenance training for clinicians/technicians is feasible. Among all participants there was increased awareness on the importance of wheelchair maintenance and repairs and eagerness to educate their clients and other professionals. Further effort should be done to improve the quality and the hands-on practice, as well as the ability to assess maintenance skills acquisition.

8.0 CONCLUSIONS AND FUTURE WORK

This dissertation presented the development, implementation, and dissemination of a wheelchair maintenance program and associated outcome measures (WMT-Qs and W-MATs). The state of self-reported repairs continues to be highly prevalent. Self-reported wheelchair repairs were studied in a cohort of 616 wheelchair users with spinal cord injuries. Power wheelchair users were more likely to face adverse consequences due to their wheelchair needing a repair than manual wheelchair users. Results revealed that about 7% of those who needed a repair reported not completing them. A vendor completed the majority of power wheelchair repairs while users completed the majority of manual wheelchairs repairs. Specific components needing repairs, which ones caused the adverse consequences, and reasons for repairs not been completed remained unanswered with this study. Additionally, self-reported wheelchair repairs needed were studied in a cohort of 142 people (including children) who received new wheelchairs at UCPRUK, which provides wheelchairs following WHO 8-step in Indonesia. The majority of the participants lived in rural areas, this was their first wheelchair, and had the majority (>70%) of the repairs needed not completed. Results may indicate that additional user training to the proposed basic maintenance by the WHO 8-steps could benefit wheelchair users. Data from UCPRUK is a unique contribution to the literature in less-resourced settings. A rigorous body of literature is needed to support wheelchair provision programs in countries that have ratified the

UNCRPDs to inform stakeholders, including policy makers. This study also demonstrated the challenges of translating research tools to other languages and cultural contexts.

The Wheelchair Maintenance Training Program was developed iteratively. A 6-hour in-person workshop to train clinicians on how to perform maintenance and teach wheelchair users was implemented. The training of wheelchair users required two 2-hour sessions. The first session had interactive demonstrations and theory on why maintenance is important and how to perform it. The second session involved hands-on maintenance practice on their wheelchair. To assess the impact on knowledge and self-perceived capacity and performance of maintenance tasks the Wheelchair Maintenance Training Questionnaires were developed through an iterative 3 steps process that involved experts, pilot and test-retest reliability. Three versions, for clinicians, manual wheelchair users, and power wheelchair users, with acceptable test-retest reliability were developed. Finally, as an objective measure of wheelchair maintenance state, the Wheelchair Maintenance Assessment Tool was developed through an iterative process which included experts and pilot and reliability testing. A version for manual and for power with accompanying illustrated instruction guide per version were developed. The tools had items with acceptable intra- and interrater reliability and showed high sensitivity. The sensitivity for the total score of both versions was 100% when used by an expert. The W-MAT has the potential to fill a void in the assessment of a wheelchair to detect wheelchair maintenance issues and provide guidance on how to address them. To improve data collection questionnaires used in Chapters 2 and 3, further detail was added to the questions related to adverse consequence, place of repair, and repairs needed but not completed for component-related problem. The WMTP was used to train 15 clinicians in the US who showed a significant improvement in knowledge pre- and post-test and positive program evaluation. In addition, these clinicians trained several groups of power wheelchair users and their caregivers. Preliminary WMT-Q scores results from training and waitlist groups at baseline indicated that maintenance knowledge and performance were uncommon. In addition, WMT-Q of the training group showed that the WMTP has a significant effect on improving maintenance performance in addition to improvement in knowledge at pre and post-training as well as retention at a 6 month follow up. The WMTP was well received and positively evaluated by participants. These preliminary results suggest that the WMTP is a promising group-training program to increase the number of wheelchair users who are competent and committed to maintaining their wheelchairs. The impact of the WMTP on users' quality of life, reducing the likelihood of adverse consequences, and wheelchair maintenance state is yet to be determined with a larger sample size.

The manual wheelchair content of the WMTP, W-MAT, and WMT-Q was translated to Spanish and the clinicians training adapted to an online platform and the course's duration was one month. The W-MAT was perceived especially useful by technicians to be used during a yearly inspection by an expert. The positive course evaluation results suggest that this online training may be appropriate for this particular situation and context; that is, a group of motivated rehabilitation professional in the same site with reliable internet connection.

To sum up, the WMTP was well received and perceived as relevant and useful by clinicians in the US and Mexico and by power wheelchair users and their caregivers in the US. The Wheelchair Maintenance Training Program is a "live" program that will continue to evolve as we continue to disseminate it. The WMTP, W-MAT, and WMT-Q have the potential to fill the void in lack of wheelchair maintenance training and performance and wheelchair condition assessment in both in high and less resourced settings.

8.1 FUTURE WORK

8.1.1 Readiness to learn wheelchair maintenance

It is important to understand when is the best time to deliver the education program (Potter, Wolfe, Burkell, & Hayes, 2004). The goal of "patient education" is to empower consumers to assume maximum responsibility of their care (in this case wheelchair care) after discharge (Phillips, 1999). Specifically, users and their families did not perceive learning wheelchair maintenance as an important learning need during in-patient rehabilitation and 6 weeks after hospital discharge (McLennan, Anderson, & Pain, 1996). This suggests that if the training is delivered too early in the rehabilitation process, the content of the maintenance class may seem irrelevant to both users and caregivers (Wolfe, Potter, & Sequeira, 2004). A measure of "readiness" to attend a wheelchair maintenance training class could allow the delivery of most cost-effective education programs. The transtheoretical model of behavioral change indicates that proactively identifying those who are at the stage when they are ready to learn and implement the behavior changes results in better outcomes (Prochaska & Velicer, 1997).

8.1.2 Potential immediate dissemination

The more the WMTP is disseminated the greater the opportunity to conduct other types of study designs (i.e. Practice-based research) to measure the impact of the program (Horn, DeJong, & Deutscher, 2012). The WMTP, WMT-Q, and W-MAT could be further disseminated and evaluated in their current form in other settings. For instance, the European H-CARE[18] e-learning project recognizes that with the increasingly aging population, there needs more professionals trained in assistive technology (Ciobanu, Constantin, & Ciobanu, 2015) and created a vocational education training programs with different modules which is currently being deployed in 5 countries in Europe (Ciobanu, Harja, & Ciobanu, 2014). Second, rehabilitation and wheelchair mobility-related "boot camps" such as Motivation Romania[19], Wheels in Motion in Beitostølen health sport center Norway[20], and Vida Independiente in Mexico[21] could also be explored. These three boot camps are usually peer-led which could give the WMTP the opportunity to be assessed in that setting. Peer-led training with a non-peer co-trainer has been suggested to have a significantly large effect in groups of two wheelchair users learning wheelchair mobility skills (Best, Miller, Huston, Routhier, & Eng, 2015). In addition, the credibility of a peer-trainer has been perceived higher than of a non-peer trainer by wheelchair users in a wheelchair-related education program (Standal & Jespersen, 2008). Using the WMT-Q results to "mix" participants with different levels could also be a strategy to enhance the learning experience. Wheelchair skills and sports group training have highlighted the importance of learning from beginner, experienced fellow trainees in addition to an experienced peer trainer (Standal & Jespersen, 2008). Lastly, other platforms that can be used are international professional organizations and consortiums such as the recently launched International Society

[18] http://healthcaresales.eu/
[19] http://www.motivation.ro/en/home
[20] http://www.bhss.no/brukere.aspx
[21] http://vidaindependientemexico.com/?page_id=982

of Wheelchair Professionals[22] and/or the World Health Organization Global Alliance on Assistive Technologies (GATE)[23].

8.1.3 Further content development

The most effective number of training sessions has yet to be determined. Even though preliminary findings lean towards reducing the number of sessions to one, evidence suggests that behavioral change is predicted by number of contact hours with the educator. Second, additional content could be added the WMTP that includes power assist activated pushrims, items related to pediatric wheelchairs, and more information on alternative driving controllers (e.g. head array) for power wheelchairs. Furthermore, several inspection items are to identify noises in function/components; therefore, adding examples of sounds to the clinicians and wheelchair users training could be more informative and useful. Third, wheelchair users, trainers, and technicians should have the possibility to learn beyond basic maintenance if desired. The WMTP could be a modular by level program that includes: basic wheelchair maintenance (mandatory), repairs 1-level, and repairs 2-level. Enabling users and caregivers to learn basic repairs could reduce the likelihood that a repair is not completed on time because the vendor does not show up, or even worse, because there is no expert available which is a common case in less resourced settings. Wheelchair users can be their own technical support in their community. Lastly, refinement of the three versions of the WMT-Qs with self-efficacy questions, including the evaluation of their test-retest reliability properties is recommended.

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[22] www.wheelchairnet.org
[23] http://www.who.int/phi/implementation/assistive_technology/phi_gate/en/

8.1.4 Alternative training program format

Adults have different learning styles; availability of learning information in several formats should exist so the program becomes acceptable by the users (May, May, et al., 2006). Different formats include group training and internet-based programs (Lorig & Holman, 2003) and even a mobile application (app) with the ICT revolution (Dicianno et al., 2015). In addition, newly released United Nations sustainable development goals state: “The spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies, as does scientific and technological innovation across areas as diverse as medicine and energy” (United Nations, 2015b). In the US access to mobile phone is up to 80%, mobile broadband penetration is expected to reach almost 50% in 2015 (Dicianno et al., 2015; International Telecommunication Union, 2015). Specifically to the population with spinal cord injury, 97% of those individuals reporting use of the Internet or email at least monthly in the National Spinal Cord Injury Database. An online platform could be explored to support e-learning, continuously collect repairs data, and as data repository. Having an electronic version will allow for the capability of also uploading results that involve “sounds/noises” evaluation and images to accurately interpret the problem (by an expert for example). The use of pictures taken by the end-user to be reviewed by a provider were found usable in a teledermatology feasibility study (Berndt et al., 2012). One option could be to implement the W-MAT online with more visual and auditory cues than written descriptions. Using pictures to show examples of scoring will also make the tool easily translatable to other context and languages. W-MAT-like reminders could be displayed with instructions and examples of problems, how to log problems found, and what to do next. This could present a potential solution to the recall bias inherent to the self-reported repairs needed in the previous six months' questions. The social capabilities of the e-application could also be explored – as people sharing/competing has been suggested to incentivize engagement in the new behavior (Dicianno et al., 2015). Adding this wheelchair maintenance module to current existing mobile health applications that have been shown useful and effective, such as iMHere, could be explored (Parmanto et al., 2013). Standalone wheelchair app could also be explored. Apps to maintain and repairs cars, motorcycles, and bicycles exist while only one related to wheelchairs. For instance, aCar records information on repairs, maintenance, cost, mileage, and reminds the driver when the next maintenance check is due (Rebecca Linke, 2013). For bicycles, the BikeDoctor[24] and Bike Repair[25] apps give detailed troubleshooting instructions when there are problems by bike part. The Motorcyle Minder[26] allows for warranty dates tracking as well as repairs logs. Only one wheelchair maintenance app[27] was found and it only provides a checklist without images or interaction. Focus groups, including older adults, children, and wheelchair users living with different disabilities, should be conducted to understand if this is a feasible idea to users and caregivers. Several venues could be used to solicit feedback such as United Spinal Advocacy Alliance[28], user-based forums[29], United Spinal Tech Guide[30] and WheelchairMedic[31]. The online program (app or web-based) could have the option of self-selecting the route of the desired information to learn and could also propose a route based on the pre-training WMT-Q results (including confidence measures). Efforts should be made to insure the online materials are accessible.

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[24] http://bikedoctorapp.com/
[25] http://www.bikerepairapp.com/
[26] http://jgmapps.com/motorcycle-minder/
[27] https://www.youtube.com/watch?v=AsDAeWJ8uH4
[28] http://helpdesk.usersfirst.org/index.php?pg=kb.printer.friendly&id=41#p1565
[29] http://sci.rutgers.edu/
[30] http://www.usatechguide.org/
[31] http://www.wheelchairmedic.com/

It is important to also consider those potential beneficiaries who do not have access to a smartphone and/or preferred in-person training and practice. This is relevant in the US and in less resourced settings. The monthly wheelchair clinician approach at an independent living center showed promising results previously (Nosek & Krouskop, 1995). Independent living centers that provide peer-led group training classes quarterly or every six months could also be explored. Lastly, refresher courses should also be considered since they are suggested as a strategy to maintain behavioral changes (Hirsche et al., 2011). Regardless of training delivery methods, wheelchair users should have the means to retrieve information to refresh or confirm that a maintenance procedure is properly performed. If an emergency arises, it would be useful for the person to be able to have information readily available (May, May, et al., 2006). An app, an online portal with a community may aid enhance the information availability in a continuum.

8.1.5 Other outcomes measures

In relation to the Spanish translations, first the intra and inter-rater reliability of the W-MAT in Spanish and the WMT-Q test-retest reliability is yet to be determined. Second, follow up on the implementation of the WMTP for users and caregivers should be completed. Program evaluation information should be gathered, in addition to impact of the training on the life of the users; similarly to what was described in Chapter 6. There is a need to develop outcome measure tools in Spanish and relevant to children and/or proxies. PROMIS already has items related to quality of life in Spanish for children but the T-scores are relevant to the US population only. Investigation on how this robust research tool could be made available and contextually appropriate to other settings is warranted. The situation in each less resourced setting is different and may need to be investigated individually (Jefferds et al., 2010; Jon Pearlman, 2006).

Satisfaction with a wheelchair as it relates to its maintainability, durability and satisfaction with the service should be collected longitudinally and compared to the new available measures (WMT-Q and W-MAT) (Demers et al., 2002). There is a need for a data repository where uniform data can be aggregated and retrieved to inform all stakeholders.

While one can assume that an increased cost to the healthcare system is an important consequence of wheelchair breakdowns, little is published on the cost of maintenance and repairs to the system. The exact cost of these highly prevalent repairs needed it is unknown. Approximations from the University of Wisconsin suggest that the cost estimates of work absence due to the wheelchair needing a repair were $112 million in 2004 in the US[32]. It is necessary to measure the direct and indirect costs of repairs is needed, specifically as it relates to replacement part, technician labor (if applicable), number of work days lost to the wheelchair user, and cost of medical care if injured. Vendors already recognized the need to collect this information (Orzel, 2015). Collaboration with this initiative could be explored.

Measures of the cost effectiveness of the WMTP are needed. Whether participating in the program results in likely reduction in the systems cost and wage losses due to absenteeism because of a repair is needed and as yet undetermined. This will better inform the systems that would potentially have to allocate funding for the adoption of this type of training (Lorig & Holman, 2003).

[32] http://www.nasuad.org/sites/nasuad/files/hcbs/files/145/7226/AT_maintenance_repair_practices_WI.pdf

APPENDIX A. WHEELCHAIR ASSESSMENT CHECKLIST

Table 38. Wheelchair maintenance checklist used at 6 month follow up in Indonesia.

Mark Items not applicable	**I: Wheelchair frame and attachments (weight 1)**	**Right side**	**Left side**
☐0 Not applicable	Frame and tubes and Weld points **Comments**	☐ 3 No cracks, fractures and distortions ☐ 2 Cracks but no fractures or distortions ☐ 1 fractures and distortions	☐ 6 No cracks, fractures and distortions ☐ 5 Cracks but no fractures or distortions ☐ 4 fractures and distortions
☐0 Not applicable	Encrusted debris **Comments**	☐ 3 Free of encrusted debris ☐ 2 Encrusted debris to moderate extent ☐ 1 Encrusted debris to severe extent	☐ 6 Free of encrusted debris ☐ 5 Encrusted debris to moderate extent ☐ 4 Encrusted debris to severe extent
☐0 Not applicable	Footrests **Comments**	☐ 3 Move up/down smoothly and maintain position ☐ 2 Move with difficulty ☐ 1 Move with difficulty and cannot maintain position	☐ 6 Move up/down smoothly and maintain position ☐ 5 Move with difficulty ☐ 4 Move with difficulty and cannot maintain position
☐0 Not applicable	Legrest **Comments**	☐ 3 Swing away and latch easily; no visible bends ☐ 2 Swing away and latch with difficulty, no visible bends ☐ 1 Swing away and latch with difficulty, with visible bends	☐ 6 Swing away and latch easily; no visible bends ☐5 Swing away and latch with difficulty, no visible bends ☐ 4 Swing away and latch with difficulty, with visible bends
☐0 Not applicable	Armrests position and adjustment **Comments**	☐ 3 Remove and reposition easily ☐ 2 Remove and reposition with some difficulty ☐ 1 Remove and reposition with great difficulty	☐ 6 Remove and reposition easily ☐ 5 Remove and reposition with some difficulty ☐ 4 Remove and reposition with great difficulty
☐0 Not applicable	Armrest upholstery **Comments**	☐ 3 Intact ☐ 2 Minor damage ☐ 1 significant damage	☐ 6 Intact ☐ 5Minor damage ☐ 4 Significant damage

Table 38 (continued)			
☐0 Not applicable	Anti-tippers **Comments**	☐ 3 Present and evenly place ☐ 2 Present but not evenly placed ☐ 1 Present in inappropriate working conditions	☐ 6 Present and evenly place ☐5 Present but not evenly placed ☐ 4 Present in inappropriate working conditions
☐0 Not applicable	Fasteners **Comments**	☐ 3 No missing or lose fasteners ☐ 2 Moderate amount of missing or lose fasteners (<3) ☐ 1 Significant amount of missing or lose fasteners (>3)	☐6 No missing or lose fasteners ☐ 5 Moderate amount of missing or lose fasteners (<3) ☐ 4Significant amount of missing or lose fasteners (>3)
☐0 Not applicable	Push handles **Comments**	☐3 Intact no damage ☐ 2 Minor damage ☐ 1 Significant damage	☐ 6 Intact no damage ☐5 Minor damage ☐4 Significant damage
☐0 Not applicable	Scissor Comments	☐ 3 Closes smoothly ☐ 2 Closes with difficulty or partially ☐ 1 Does not close	☐ 6 Closes smoothly ☐ 5 Closes with difficulty or partially ☐4 Does not close
☐0 Not applicable	Frontal sliding post Comments	☐ 3 Slides up and down without difficulty ☐ 2 Slides up and down with difficulty ☐ 1 Does not slide	☐6 Slides up and down without difficulty ☐5 Slides up and down with difficulty ☐4 Does not slide
☐0 Not applicable	Seat guide Comments	☐3 In good conditions and slides easily up and down ☐ 2 In good conditions but slides with difficulty ☐ 1 In bad conditions and do not slide	☐ 6 In good conditions and slides easily up and down ☐5 In good conditions but slides with difficulty ☐4 In bad conditions and do not slide
Composite score = (Total score/valid items)*weight			
Mark Items not applicable	**II Wheels and caster (weight 2)**	**Right side**	**Left side**
☐0 Not applicable	Axle **Comments**	☐ 3 In good condition. If it has quick release it is in good condition and is fully adjustable ☐ 2 Minor damage. If it is quick release it is moderate adjustment (vertical/horizontal) ☐ 1 Significant damage. No adjustment	

Table 38 (continued)			
☐0 Not applicable	Caster forks **Comments**	☐ 3 Swivel freely stems are perpendicular to the floor ☐ 2 Swivel freely stems are not perpendicular to the floor ☐ 1 Does not swivel freely steems are not perpendicular to the floor	☐6 Swivel freely stems are perpendicular to the floor ☐5 Swivel freely stems are not perpendicular to the floor ☐4 Does not swivel freely steems are not perpendicular to the floor
☐0 Not applicable	Caster hubs **Comments**	☐ 3 Free of cracks tires have tread and are inflated it it is solid it is in good condition without cracks ☐ 2 Free of cracks tires do not have tread are not inflated ☐ 1 Have cracks tires do not have tread and are not inflated	☐ 6 Free of cracks tires have tread and are inflated it it is solid it is in good condition without cracks ☐5 Free of cracks tires do not have tread are not inflated ☐4 Have cracks tires do not have tread and are not inflated
☐0 Not applicable	Drive Wheel tires **Comments**	☐ 3 free of cuts or sidewall damage and are properly inflated ☐ 2 free of cuts or sidewall damage but are not properly inflated ☐ 1 free of cuts or sidewall damage but are not properly inflated	☐6 free of cuts or sidewall damage and are properly inflated ☐ 5 free of cuts or sidewall damage but are not properly inflated ☐4 free of cuts or sidewall damage but are not properly inflated
Composite score = (Total score/valid items)*weight			
Mark Items not applicable	**III Postural seating and support (weight 3)**	**Right side**	**Left side**
☐0 Not applicable	The frame tubes **Comments**	☐ 3 Do not impinge upon the body ☐ 2 Impinge upon the body ☐ 1Significantly impinge on body affecting seating posture	☐ 6 Do not impinge upon the body ☐5 Impinge upon the body ☐ 4Significantly impinge on body affecting seating posture
☐0 Not applicable	Seatback **Comments**	☐ 3 Intact and if removable has working release fittings ☐ 2 Intact and if removable does not has working release fittings ☐ 1 Not intact and if removable does not has working release fittings	

Table 38 (continued)			
☐0 Not applicable	WC cushion **Comments**	☐ 3 Correctly inflated (if applicable) and positioned appropriately ☐ 2 Correctly inflated (if applicable) but not positioned appropriately ☐ 1 Incorrectly inflated (if applicable) and not positioned appropriately	
Composite score = (Total score/valid items)*weight			
Mark Items not applicable	**IV Propulsion interface (weight 4)**	**Right side**	**Left side**
☐0 Not applicable	Hand rims conditions **Comments**	☐ 3 Smooth and do not pose any danger of acute injuries ☐ 2 Rough but do not pose any danger of acute injuries ☐ 1 Pose any danger of acute injuries	☐ 6 Smooth and do not pose any danger of acute injuries ☐ 5 Rough but do not pose any danger of acute injuries ☐4 Pose any danger of acute injuries
Composite score = (Total score/valid items)*weight			
Mark Items not applicable	**V Wheels locks (weight 6)**	**Right side**	**Left side**
☐0 Not applicable	Wheel locks position **Comments**	☐ 3Aligned and engage the wheel firmly (no movement) ☐ 2 Aligned and engage the wheel with back forth movement ☐ 1 Not aligned and does not engage the wheel firmly (back/forth; rotation)	☐ 6Aligned and engage the wheel firmly (no movement) ☐5 Aligned and engage the wheel with back forth movement ☐4 Not aligned and does not engage the wheel firmly (back/forth; rotation)
Composite score = (Total score/valid items)*weight			
Mark Items not applicable	**VI User Wheelchair Interface (weight 5)**	**Right side**	**Left side**
☐0 Not applicable	WC propulsion **Comments**	☐ 3 Straight without drag and no audible grinding sounds or clatter ☐ 2 Deviation with drag no audible grinding sounds or clatter ☐ 1 Deviation with drag audible grinding sounds or clatter	

Table 38 (continued)			
☐0 Not applicable	Legrests length and position **Comments**	☐ 3 Appropriate length and position ☐ 2 Moderately short/long in length and moderately close to/away from WC ☐ 1 Significantly short/long in length and significantly close to/away from WC	☐ 3 Appropriate length and position ☐ 2 Moderately short/long in length and moderately close to/away from WC ☐ 1 Significantly short/long in length and significantly close to/away from WC
☐0 Not applicable	WC Cushion Placement **Comments**	☐ 3Appropriately placed on wheelchair ☐ 2 Inappropriately oriented ☐ 1Cushion tuck in back or sliding in front	
☐0 Not applicable	Seat base **Comments**	☐ 3 Firm no sling upholstery and is appropriate length and width for resident ☐ 2 Sling upholstery but is appropriate length and width for resident ☐ 1 Sling upholstery and inappropriate in length and width for resident	
☐0 Not applicable	Headrest **Comments**	☐ 3 Aligned, tight and has intact upholstery ☐ 2 Aligned, tight but does not has intact upholstery ☐ 1 Not aligned, lose and does not has intact upholstery	
☐0 Not applicable	Lateral supports **Comments**	☐ 3 Aligned, and intact ☐ 2 Intact but not aligned ☐ 1 Not intact and not aligned	☐ 3 Aligned, and intact ☐ 2 Intact but not aligned ☐ 1 Not intact and not aligned
☐0 Not applicable	Hand rims position **Comments**	☐3 Present and attached properly (no excessive upper limb flexion/extension) ☐ 2 Present with minor problems ☐ 1 Present with improper attachment (excessive upper limb flexion/extension)	☐ 6 Present and attached properly (no excessive upper limb flexion/extension) ☐ 5 Present with minor problems ☐ 4 Present with improper attachment (excessive upper limb flexion/extension)

Table 38 (continued)			
☐0 Not applicable	Seat to floor height (feet propulsion) **Comments**	☐ 3 Appropriate ☐ 2 Low resulting in excessive knee flexion ☐ 1High resulting in sliding out of chair	
☐0 Not applicable	Wheel locks applications **Comments**	☐ 3 Can reach and use wheel locks independently and without any difficulty ☐ 2 Can reach and use his wheel locks independently with moderate difficulty ☐ 1 Cannot reach and use his wheel locks independently	☐ 3 Can reach and use wheel locks independently and without any difficulty ☐ 2 Can reach and use his wheel locks independently with moderate difficulty ☐ 1 Cannot reach and use his wheel locks independently
Composite score = (Total score/valid items)*weight			
Sum all composite scores			

APPENDIX B. WHEELCHAIR MAINTENANCE TRAINING QUESTIONNAIRE

CLINICIANS

1. Please enter your email: ________________________________
2. How many years of experience do you have in manual wheelchair provision? ____________years
3. How many years of experience do you have in power wheelchair provision? _____________ years

Please answer the following questions on wheelchair maintenance.

1. A manual wheelchair user comes to you with questions related to the regular maintenance of their wheelchair to keep it running well. The wheelchair user wants to know what items they should 'check' on a regular basis, and also what maintenance activities they should 'perform' on a regular basis.

On the lines below, please provide a list of 5 to 10 items that you would tell the wheelchair user to check and activities they should perform on a regular basis. Be sure to be specific and comprehensive, and include the frequency of each item (e.g. daily, weekly, monthly, yearly).

Think of a check as an inspection and the activities that you perform as an intervention.
As an example related to someone's house, it is important to 'check' (or 'inspect') the batteries in a smoke detector every six months, and also important to 'change' the filter on the furnace every 6 months.

2. A power wheelchair user comes to you with questions related to the regular maintenance of their wheelchair to keep it running well. The wheelchair user wants to know what items they should 'check' on a regular basis, and also what maintenance activities they should 'perform' on a regular basis.

On the lines below, please provide a list of 5 to 10 items that you would tell the wheelchair user to check and activities they should perform on a regular basis. Be sure to be specific and comprehensive, and include the frequency of each item (e.g. daily, weekly, monthly, yearly).
As an example related to someone's house, it is important to 'check' the batteries in a smoke detector every six months, and also important to 'change' the filter on the furnace every 6 months.

Please answer the following multiple choice questions.
Importance of wheelchair maintenance

1. How many times more likely is a wheelchair user to sustain an injury if he/she does not maintain the wheelchair?

☐$_1$ No increased likelihood to sustain injuries

☐$_2$ Two times more likely

☐ $_3$ Five times more likely

☒$_4$ Ten times more likely

☐$_6$ I do not know

2. Approximately, what percentage of wheelchair users in the community experience wheelchair-related injuries each year?

☐$_1$ Less than 1%

☒$_2$ 5% to 18%

☐$_3$ 30% to 52%

☐$_4$ 62% to 70%

☐$_6$ I do not know

3. The majority of commercial wheelchairs tested by independent wheelchair testing laboratories meet the minimum durability standards set forth by ANSI/RESNA Wheelchair Standards.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

4. The number of wheelchair breakdowns in the United States has been decreasing over time.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

5. Approximately, what percentage of wheelchair users with spinal cord injury have reported at least one wheelchair breakdown in the past 6 months?

☐$_1$ 20-30%

☒$_2$ 50-60%

☐$_3$ 70-80%

☐$_6$ I do not know

6. Which of the following can be a consequence of a wheelchair breakdown? (select all that apply)

☒ $_1$ Being stranded at home and missing work and appointments

☒ $_2$ Being injured

☐$_3$ More likely to get a shoulder overuse injury

☐$_6$ I do not know

7. Power wheelchairs have more frequent breakdowns than manual wheelchairs.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

8. Injuries due to a wheelchair breakdown occur more frequently among power wheelchair users if they have powered seat functions compared to no power seat functions.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

Health insurance policies

9. A consequence of frequent wheelchair breakdowns is the increased cost to the health care system.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

If 9 is true, then answer:

10. In the United States, wheelchair repairs and replacement costs account for approximately what annual percentage of the direct wheelchair expenditures by a large-scale provider for wheelchairs (such as the Department of Veterans Affairs or Medicare)?

☐$_1$ 5%

☐$_2$ 10%

☒$_3$ 30%

☐$_4$ 50%

☐$_6$ I do not know

In the United States, many health insurance policies follow Medicare's coverage. The following questions are related to Medicare's policies, which may or may not apply to all of your clients' health insurance.

11. It is Medicare's policy to replace a wheelchair every five years, regardless of the wear and tear on the wheelchair.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

12. Medicare's policy is to replace a wheelchair cushion every two years.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

13. Medicare's policy reimburses wheelchair providers for an annual preventive maintenance checkup for manual or power wheelchairs.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

14. Medicare's policy is to reimburse for the repair of wheelchair parts when they are in state of disrepair. For example, a new battery will be reimbursed when the current battery is not holding charge during an average day.

☒ $_1$ True ☐$_0$ False ☐$_6$ I do not know

Maintenance Practice

15. Lubricating moving parts is considered a good practice; therefore, it is recommended to lubricate sealed bearings.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

16. All pneumatic tires should be inflated to 150lb to reduce rolling resistance.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

17. Tightening the wheel spokes at home with a spoke wrench is recommended when loose spokes are identified.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

18. Tires should be inflated after you adjust the wheel-locks to improve braking performance.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

19. To maximize the lifespan of the wheelchair batteries, they need to be run down completely before recharging them.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

20. Power wheelchair or scooter batteries need to be charged only with the charger that is provided with the wheelchair.

☒ $_1$ True ☐$_0$ False ☐$_6$ I do not know

21. Well-maintained power wheelchair or scooter batteries are expected to last 5 years.

☐ $_1$ True ☒ $_0$ False ☐$_6$ I do not know

22. Tightening loose bolts with all your force will guarantee that they will not become loose again.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

Maintenance Skills

Please answer questions about maintenance activities that a wheelchair user might perform on their own wheelchair. For each activity, you will answer **if you can do the activity** and whether you currently train the users on how to do it.

1.a Do you know how to wipe down a wheelchair and cushion?

☐$_1$Yes ☐$_0$No

1.b Do you currently train wheelchair users and/or caregivers on how to wipe down a wheelchair and cushion?

☐$_1$Yes ☐$_0$No

2.a Do you know how to remove dirt and lint from the caster axles?

☐$_1$Yes ☐$_0$No

2.b Do you currently train wheelchair users and/or caregivers on how to remove dirt and lint from the caster axles?

☐$_1$Yes ☐$_0$No

3.a Do you know how to check the pressure in the tires, and inflate them if they are low?

☐$_1$Yes ☐$_0$No

3.b Do you currently train wheelchair users and/or caregivers on how to check the pressure in the tires, and inflate them if they are low?

☐$_1$Yes ☐$_0$No

4.a Do you know how to check whether the spokes of the manual wheelchair wheels are adjusted correctly?

☐$_1$Yes ☐$_0$No

4.b Do you currently train wheelchair users and/or caregivers on how to check whether the spokes of the manual wheelchair wheels are adjusted correctly?

☐$_1$Yes ☐$_0$No

5.a Do you know how to check whether the manual wheelchair wheel locks (brakes) are working properly, and adjust them if necessary?

☐$_1$Yes ☐$_0$No

5.b Do you currently train wheelchair users and/or caregivers on how to check whether the manual wheelchair wheel locks (brakes) are working properly, and adjust them if necessary?

☐$_1$Yes ☐$_0$No

6.a Do you know how to lubricate manual wheelchair moving parts, such as the folding mechanism, front casters, and exposed hinges?

☐$_1$Yes ☐$_0$No

6.b Do you currently train wheelchair users and/or caregivers on how to lubricate moving parts?

☐$_1$Yes ☐$_0$No

7.a Do you know how to clean a manual wheelchair quick-release wheel axle and axle housing?

☐$_1$Yes ☐$_0$No

7.b Do you currently train wheelchair users and/or caregivers on how to clean the quick-release wheel axle and axle housing?

☐$_1$Yes ☐$_0$No

8.a Do you know how to check all nuts and bolts, and how to tighten the loose ones?

☐$_1$Yes ☐$_0$No

8.b Do you currently train wheelchair users and/or caregivers on how to check all nuts and bolts, and how to tighten the loose ones?

☐$_1$Yes ☐$_0$No

9.a Do you know how to check whether the parts in a manual wheelchair that are originally designed to be released, such as leg supports, foot supports, arm supports, back supports, and tilt mechanisms, are working and adjusted properly?

☐$_1$Yes ☐$_0$No

9.b Do you currently train wheelchair users and/or caregivers on how to check whether the parts in a manual wheelchair that are originally designed to be released, such as leg supports, foot supports, arm supports, back supports, and tilt mechanisms, are working and adjusted properly?

☐$_1$Yes ☐$_0$No

10.a Do you know how to contact a wheelchair maintenance expert to have a wheelchair professionally serviced?

☐$_1$Yes ☐$_0$No

10.b Do you currently recommend wheelchair users and/or caregivers get the wheelchair thoroughly serviced by a wheelchair maintenance expert?

☐$_1$Yes ☐$_0$No

11.a Do you know how to check whether the wheel and caster bearings are working properly and do not need adjustment or maintenance?

☐$_1$Yes ☐$_0$No

11.b Do you currently train wheelchair users and/or caregivers on how to check whether the wheel and caster bearings are working properly and do not need adjustment or maintenance?

☐$_1$Yes ☐$_0$No

12.a Do you know how to check whether the tires, casters, and anti-tip wheels are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

12.b Do you currently train wheelchair users and/or caregivers on how to check whether the tires, casters, and anti-tip wheels are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

13.a Do you know how to check whether the cushion and cover are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

13.b Do you currently train wheelchair users and/or caregivers on how to check whether the cushion and cover in need of repair or replacement?

☐$_1$Yes ☐$_0$No

14.a Do you know how to check whether the upholstery is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

14.b Do you currently train wheelchair users and/or caregivers on how to check whether the upholstery is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

15.a Do you know how to check the wheel alignment?

☐$_1$Yes ☐$_0$No

15.b Do you currently train wheelchair users and/or caregivers on how to check that the wheels are aligned?

☐$_1$Yes ☐$_0$No

16.a Do you know how to check whether the manual wheelchair cross brace folding mechanism is working properly or in need of repair or replacement?

☐$_1$Yes ☐$_0$No

16.b Do you currently train wheelchair users and/or caregivers on how to check whether the manual wheelchair cross brace folding mechanism is working properly or in need of repair or replacement?

☐$_1$Yes ☐$_0$No

17.a Do you know how to check whether the plastic parts, such as the side or clothing guard or shrouds, are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

17.b Do you currently train wheelchair users and/or caregivers on how to check whether the plastic parts, such as the side or clothing guard or shrouds, are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

18.a Do you know how to check whether the weld points are intact and free of cracks?

☐$_1$Yes ☐$_0$No

18.b Do you currently train wheelchair users and/or caregivers on how to check the weld points?

☐$_1$Yes ☐$_0$No

19.a Do you know how to check whether the manual wheelchair handrims are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

19.b Do you currently train wheelchair users and/or caregivers on how to check whether the manual wheelchair handrims are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

20.a Do you know how to check whether the backrest canes or posts are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

20.b Do you currently train wheelchair users and/or caregivers on how to check whether the backrest canes or posts are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

21.a Do you know the process to clean the power wheelchair seat function mechanisms and tracks (tilt, recline, leg support elevator, and seat elevator)?

☐$_1$Yes ☐$_0$No

21.b Do you currently train wheelchair users and/or caregivers on how to clean the power wheelchair seat function mechanisms and tracks (tilt, recline, leg support elevator, and seat elevator)?

☐$_1$Yes ☐$_0$No

22.a Do you know how to check that the power wheelchair electrical connections are firmly in place?

☐$_1$Yes ☐$_0$No

22.b Do you currently train wheelchair users and/or caregivers on how to check that the power wheelchair electrical connections are firmly in place?

☐$_1$Yes ☐$_0$No

23.a Do you know how to check that all the power wheelchair wiring is safe by checking the rubber wire housing is in need of repair or replacement and all wires are properly secured with no chance of being caught between moving parts?

☐$_1$Yes ☐$_0$No

23.b Do you currently train wheelchair users and/or caregivers on how to check that all the power wheelchair wiring is safe by checking the rubber wire housing is in need of repair or replacement and all wires are properly secured with no chance of being caught between moving parts?

☐$_1$Yes ☐$_0$No

24.a Do you know how to check the casters for flutter?

☐$_1$Yes ☐$_0$No

24.b Do you currently train wheelchair users and/or caregivers on how to check the casters for flutter?

☐$_1$Yes ☐$_0$No

25.a Do you know how to check whether the power wheelchair joystick and rubber boot are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

25.b Do you currently train wheelchair users and/or caregivers on how to check whether the joystick and rubber boot are in need of repair or replacement?

☐$_1$Yes ☐$_0$No

26.a Do you know how to check whether the seatbelt is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

26.b Do you currently train wheelchair users and/or caregivers on how to check whether the seatbelt is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

27.a Do you know how to check whether the power wheelchair battery charger cable is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

27.b Do you currently train wheelchair users and/or caregivers on how to check whether the power wheelchair battery charger cable is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

28.a Do you know how to check whether the brakes in a power wheelchair are working properly?

☐$_1$Yes ☐$_0$No

28.b Do you currently train wheelchair users and/or caregivers on how to check whether the brakes in a power wheelchair are working properly?

☐$_1$Yes ☐$_0$No

29.a Do you know how to check whether the power wheelchair motor is working properly or is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

29.b Do you currently train wheelchair users and/or caregivers on how to check whether the power wheelchair motor is working properly or is in need of repair or replacement?

☐$_1$Yes ☐$_0$No

30.a Do you know how to check whether the power wheelchair controller is working properly, including power seat functions, indicators (battery, speed, etc), and horn?

☐$_1$Yes ☐$_0$No

30.b Do you currently train wheelchair users and/or caregivers on how to check whether the power wheelchair controller is working properly, includes power seat functions, indicators, and horn?

☐$_1$Yes ☐$_0$No

31.a Do you know how to check if the lever that disengages the motor or brakes on a power wheelchair is working properly?

☐$_1$Yes ☐$_0$No

31.b Do you currently train wheelchair users and/or caregivers on how to check that the lever that disengages the motor or brakes on a power wheelchair is working properly?

☐$_1$Yes ☐$_0$No

APPENDIX C. WHEELCHAIR MAINTENANCE TRAINING QUESTIONNAIRE

MANUAL WHEELCHAIR

Please answer the following questions on wheelchair maintenance.

1. Who performs (or will perform) your wheelchair maintenance?

   ☐1 You

   ☐2 You and your caregiver

   ☐3 Your caregiver

Note: If your caregiver plays a role in the maintenance of your wheelchair, please answer this questionnaire with him or her.

2. We want to know what you think about the regular maintenance of your **manual wheelchair** to keep it running well. What items should you 'check' on a regular basis, and what maintenance activities should be 'performed' on a regular basis?

On the lines below, please provide a list of the items that you should check and activities you should perform on a regular basis. Be sure to be specific and comprehensive, and include the frequency of each item (e.g. daily, weekly, monthly, etc).

Think of a check as an inspection and the activities that you perform as an intervention.
As an example related to someone's house, it is important to 'check' (or 'inspect') the batteries in a smoke detector every six months, and also important to 'change' the filter on the furnace every 6 months.

Importance of wheelchair maintenance

3. Wheelchair maintenance has significant potential to reduce wheelchair repairs and replacement costs and to reduce the risk of their users being injured due to a wheelchair breakdown.

☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

4. How many times more likely is a wheelchair user to sustain an injury if he/she does not maintain the wheelchair?

☐$_1$ No increased likelihood to sustain injuries

☐$_2$ Two times more likely

☐$_3$ Five times more likely

☐$_4$ Ten times more likely

☐$_6$ I do not know

5. Approximately what percentage of wheelchair users in the community experience wheelchair-related injuries each year?

☐$_1$ Less than 1%

☐$_2$ 5% to 18%

☐$_3$ 30% to 50%

☐$_4$ 62% to 70%

☐$_5$ 80% to 90%

☐$_6$ I do not know

6. Which of the following can be a consequence of a wheelchair breakdown? (select all that apply)

☐$_1$ Being stranded at home and missing work and appointments

☐$_2$ Being injured

☐$_3$ More likely to get shoulder overuse injury

☐$_6$ I do not know

7. Regular wheelchair maintenance tasks are listed in the user manual.

   ☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

Health insurance policies

8. Do you have Medicare or Medicaid as your health care insurance?

   ☐$_2$ Yes, I have Medicare/Medicaid as my health insurance

   ☐$_1$ No, I have other health insurance

   ☐$_0$ No, I do not have health insurance

   ☐$_6$ I do not know

9. It is Medicare/Medicaid's policy to replace a wheelchair every five years, regardless the wear and tear of the wheelchair.

   ☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

10. Medicare/Medicaid's policy is to replace a wheelchair cushion every two years.

    ☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

11. Medicare/Medicaid's policy is to reimburse wheelchair providers for an annual preventive maintenance check-up for manual and power wheelchairs.

    ☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

12. Medicare/Medicaid's policy is to reimburse for the repair of wheelchair parts when they are in state of disrepair.

    ☐ $_1$ True ☐$_0$ False ☐$_6$ I do not know

Maintenance Practice

13. Wheelchair cushions last as long as the wheelchair itself.

    ☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

14. Lubricating moving parts is considered a good practice; therefore, it is recommended to lubricate sealed bearings.

☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

15. All pneumatic tires should be inflated to 150psi to reduce rolling resistance.

☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

16. Tightening the wheel spokes at home with a spoke wrench is recommended when loose spokes are identified.

☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

17. Tires should be inflated after you adjust the wheel-locks to improve braking performance.

☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

18. Tightening loose bolts with all your force will guarantee that they will not become loose again.

☐$_1$ True ☐$_0$ False ☐$_6$ I do not know

Maintenance Skills

Please answer the following questions about maintenance activities that you might perform on your wheelchair.

If you have more than one wheelchair, please remember that it is your primary manual wheelchair that you will be answering about.

For each activity, please answer **if you or your caregiver can do the activity**. You will also answer how often you or your caregiver **perform the activity**. If the question does not apply to your wheelchair because it does not have the part, please select “Not Possible”.

The answer options for the performance questions mean:

Daily: Generally, at least once a day.

Weekly: Generally, at least once a week.

Monthly: Generally, at least once a month.

Quarterly: Generally, at least 4 times in a year.

Yearly: Generally, at least once a year.

Never: Generally, less often than once a year or never.

1.a Do you know how to wipe down your wheelchair and cushion?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

1.b How often have you or your caregiver wiped down your wheelchair and cushion?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

2.a Do you or your caregiver know remove dirt and lint from the caster axles?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

2.b How often have you or your caregiver removed dirt and lint from the caster axles?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

3.a Do you or your caregiver know how to check the pressure in your tires, and inflate them if they are low?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

3.b How often have you or your caregiver checked the pressure in your tires?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

4.a Do you or your caregiver know how to check whether the spokes of your wheels are adjusted correctly?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

4.b How often have you or your caregiver checked whether the spokes of your wheels are adjusted correctly?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

5.a Do you or your caregiver know how to check whether your wheel locks (brakes) are working properly, and adjust them if necessary?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

5.b How often have you or your caregiver checked whether the wheel locks (brakes) are working properly?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

6.a Do you or your caregiver know how to lubricate your manual wheelchair moving parts, such as the folding mechanism, front casters, and exposed hinges?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

6.b How often have you or your caregiver lubricated manual wheelchair moving parts?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

7.a Do you or your caregiver know how to clean your manual wheelchair quick-release wheel axle and axle housing?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

7.b How often have you or your caregiver cleaned the manual wheelchair quick-release wheel axle and axle housing?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

8.a Do you or your caregiver know how to check nuts and bolts, and how to tighten the loose ones?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

8.b How often have you or your caregiver checked nuts and bolts?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

9.a Do you or your caregiver know how to check whether the parts in a manual wheelchair that are originally designed to be released, such as leg supports, foot supports, arm supports, back supports, and tilt mechanisms, are working and adjusted properly?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

9.b How often have you or your caregiver checked the parts that are originally designed to be released, such as leg supports, foot supports, arm supports, back supports, and tilt mechanisms, are working and adjusted properly?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

10.a Do you or your caregiver know how to contact a wheelchair maintenance expert to have a wheelchair professionally serviced?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

10.b How often have you or your caregiver contacted a wheelchair maintenance expert to have your wheelchair professionally serviced?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

11.a Do you or your caregiver know how to check whether the wheel and caster bearings are working properly and do not need adjustment or maintenance?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

11.b How often have you or your caregiver checked whether the wheel and caster bearing are working properly?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

12.a Do you or your caregiver know how check whether the tires, casters, and anti-tip wheels are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

12.b How often have you or your caregiver checked whether the tires, casters, and anti-tip wheels are in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

13.a Do you or your caregiver know how check whether the cushion and cover are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

13.b How often have you or your caregiver checked whether the cushion and cover are in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

14.a Do you or your caregiver know how to check whether the upholstery is in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

14.b How often have you or your caregiver checked whether the upholstery is in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

15.a Do you or your caregiver know how to check the wheel alignment?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

15.b How often have you or your caregiver checked wheel alignment?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

16.a Do you or your caregiver know how to check whether the cross brace folding mechanism is working properly or in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

16.b How often have you or your caregiver checked whether the cross brace folding mechanism is working properly or in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

17.a Do you or your caregiver know how to check whether the plastic parts, such as the clothing guard, is in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

17.b How often have you or your caregiver check whether the clothing guard is in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

18.a Do you or your caregiver know how to check whether the weld points are intact and free of cracks?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

18.b How often have you or your caregiver checked whether the weld points are intact and free of cracks?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

19.a Do you or your caregiver know how to check whether the manual wheelchair handrims are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

19.b How often have you or your caregiver checked whether the handrims are in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

20.a Do you or your caregiver know how to check whether the backrest canes or posts are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

20.b How often have you or your caregiver check whether the backrest posts are in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

APPENDIX D. WHEELCHAIR MAINTENANCE TRAINING QUESTIONNAIRE

POWER WHEELCHAIR

Please answer the following questions on wheelchair maintenance.

1. Who performs (or will perform) your wheelchair maintenance?

☐1 You

☐2 You and your caregiver

☐3Your caregiver

<u>Note: If your caregiver plays a role in the maintenance of your wheelchair, please answer this questionnaire with him or her.</u>

Maintenance tasks

2. We want to know what you think about the regular maintenance of your **power wheelchair** to keep it running well. What items you should 'check' on a regular basis, and also what maintenance activities should be 'performed' on a regular basis.

On the lines below, please provide a list of the items that you would check and activities you should perform on a regular basis. Be sure to be specific and comprehensive, and include the frequency of each item (e.g. daily, weekly, monthly, etc).

As an example related to someone's house, it is important to 'check' the batteries in a smoke detector every six months, and also important to 'change' the filter on the furnace every 6 months.

Wheelchair maintenance importance

3. Wheelchair maintenance has significant potential to reduce wheelchair repairs and replacement costs and to reduce the risk of their users to get injured due to a wheelchair breakdown.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

4. How many times more likely are you to sustain an injury if you do not maintain your wheelchair?

☐$_1$ No increased likelihood to sustain injuries

☐$_2$ Two times more likely

☐$_3$ Five times more likely

☒$_4$ Ten times more likely

☐$_6$ I do not know

5. Approximately what percentage of wheelchair users in the community experience wheelchair-related injuries each year?

☐$_1$ Less than 1%

☒$_2$ 5% to 18%

☐$_3$ 30% to 50%

☐$_4$ 62% to 70%

☐$_5$ 80% to 90%

☐$_6$ I do not know

6. Which of the following can be a consequence of a wheelchair breakdown? (select all that apply)

☒$_1$ a. Being stranded at home and missing work and appointments

☒$_2$ b. Being injured

☐$_3$ c. More likely to get shoulder overuse injury

☐$_6$ I do not know

7. Power wheelchairs have been reported to have more frequent breakdowns than manual wheelchairs.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

8. Users of power wheelchair with seat functions reported being injured in greater number than those who did not have seat functions

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

9. Regular wheelchair maintenance tasks are listed in the user manual.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

Health insurance policies

10. Do you have Medicare or Medicaid as your health care insurance?

☐$_2$ Yes, I have Medicare/Medicaid as my health insurance

☐$_1$ No, I have other health insurance

☐$_0$ No, I do not have health insurance

☐$_6$ I do not know

11. It is Medicare/Medicaid's policy to replace a wheelchair every five years, regardless the wear and tear of the wheelchair.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

12. Medicare/Medicaid's policy is to replace a wheelchair cushion every two years.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

13. Medicare/Medicaid's policy is to reimburse wheelchair providers for an annual preventive maintenance check-up for manual and power wheelchairs.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

14. Medicare/Medicaid's policy is to reimburse for the repair of wheelchair parts when they are in state of disrepair.

☒ $_1$ True ☐$_0$ False ☐$_6$ I do not know

Maintenance Practice

15. Wheelchair cushions last as long as the wheelchair itself.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

16. Lubricating moving parts is considered a good practice; therefore, it is recommended to lubricate sealed bearings.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

17. All pneumatic tires should be inflated to 150psi to reduce rolling resistance.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

18. To maximize the lifespan of the batteries they need to be run down completely before recharging them.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

19. Well-maintained power wheelchair or scooter batteries are expected to last 5 years.

☐$_1$ True ☒$_0$ False ☐$_6$ I do not know

20. Power wheelchair or Scooter batteries need to be charged only with the charger that is provided with the wheelchair.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

21. Tightening loose bolts all your force will guarantee that they would not loosen again.

☒$_1$ True ☐$_0$ False ☐$_6$ I do not know

Maintenance tasks and timeline power wheelchair

Please answer the following questions about maintenance activities that you might perform on your wheelchair.

If you have more than one wheelchair, please remember that it is your primary manual wheelchair that you will be answering about.

For each activity, please answer **if you or your caregiver can do the activity**. You will also answer how often you or your caregiver **perform the activity**. If the question does not apply to your wheelchair because it does not have the part, please select "Not Possible".

The answer options for the performance questions mean:

Daily: Generally, at least once a day.

Weekly: Generally, at least once a week.

Monthly: Generally, at least once a month.

Quarterly: Generally, at least 4 times in a year.

Yearly: Generally, at least once a year.

Never: Generally, less often than once a year or never.

1.a Do you or your caregiver know how to wipe down the wheelchair and cushion? ☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

1.b How often have you or your caregiver wiped down your wheelchair and cushion?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

2.a Do you or your caregiver know how to check the pressure in your tires and how to inflate them if they are low?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

2.b How often have you or your caregiver checked the pressure in your tires?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

3.a Do you or your caregiver know how to check whether the head support, arm supports, and foot supports are are working properly and do not need adjustment or maintenance?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

3.b How often have you or your caregiver checked whether the head, arm, and foot support are working properly?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

4.a Do you or your caregiver know how to remove dirt and lint from the caster axles?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

4.b How often have you or your caregiver removed hear and lint from the caster axles?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

5.a Do you or your caregiver know the process to clean the power seat function mechanisms and tracks (tilt, recline, leg support elevator, and seat elevator)?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

5.b How often have you or your caregiver cleaned the power seat function tracks?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

6.a Do you or your caregiver know how to check that the electrical connections are firmly in place?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

6.b How often have you or your caregiver checked that the electrical connections are firmly in place?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

7.a Do you or your caregiver know how to check that all the wiring is safe and has no chance of being caught between moving parts?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

7.b How often have you or your caregiver checked whether the wiring is safely placed?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

8.a Do you or your caregiver know how to contact a wheelchair maintenance expert to have the wheelchair professionally serviced?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

8.b How often have you or your caregiver contacted a wheelchair maintenance expert to have your wheelchair professionally serviced?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

9.a Do you or your caregiver know how to check whether the tires, casters, and anti-tip wheels are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

9.b How often have you or your caregiver checked whether the tires, casters, and anti-tip wheels are in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

If yes answer:

10.a Do you or your caregiver know how to check the casters for flutter?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

10.b How often have you or your caregiver checked the casters for flutter?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

11.a Do you or your caregiver know how to check whether the cushion and cover are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

11.b How often have you or your caregiver check whether the cushion and cover are in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

12.a Do you or your caregiver know how to check whether the upholstery is in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

12.b How often have you or your caregiver checked whether the upholstery is in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

13.a Do you or your caregiver know how to check whether the joystick and rubber boot are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

13.b How often have you or your caregiver done checked whether the joystick and rubber boot are in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

14.a Do you or your caregiver know how to check whether the seat-positioning strap is in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

14.b How often have you or your caregiver checked whether the seat-positioning strap is in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

15.a Do you or your caregiver know how to check whether the battery charger cable in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

15.b How often have you or your caregiver checked that the battery charger is in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

16.a Do you or your caregiver know how to check whether the brakes are working properly or in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

16.b How often have you or your caregiver checked whether the brakes are working properly or in need of repair or replacement?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

17.a Do you or your caregiver know how to check whether the plastic shrouds are in need of repair or replacement?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

17.b How often have you or your caregiver checked whether the plastic shrouds are in need of repair or replacement t?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

18.a Do you or your caregiver know how to check whether the motor is working properly?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

18.b How often have you or your caregiver checked whether the motor is working properly?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

19.a Do you or your caregiver know how to check whether the controller is working properly, including power seat functions, indicators (battery, speed, etc), and horn?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

19.b How often have you or your caregiver checked whether the controller is working properly, including power seat functions, indicators (battery, speed, etc), and horn?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

20.a Do you or your caregiver know how to check the nuts and bolts, and how to tighten the loose ones?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

20.b How often have you or your caregiver checked nuts and bolts?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

21.a Do you or your caregiver know how to check whether the lever that disengages the motor is working properly?

☐$_1$Yes ☐$_0$No ☐$_2$ Not possible

If yes answer:

21.P How often have you or your caregiver checked whether the lever that disengages the motor is working properly?

☐$_5$ Daily ☐$_4$ Weekly ☐$_3$ Monthly ☐$_2$ Quarterly ☐$_1$ Yearly ☐$_0$ Never

APPENDIX E. WHEELCHAIR MAINTENANCE ASSESSMENT TOOL MANUAL WHEELCHAIRS

Instructions:

- The use of gloves is recommended.
- Score all items in each section.
    - Indicate the specific type of part according to the checkboxes when applicable.
    - Select ONE description that represents most closely the current state of the wheelchair part.
    - If an item is present on both the left and right side of the wheelchair, evaluate each side separately and report **the side(s) that present a problem.**
        - For example, if the push handle on the right side is intact and has a smooth grip but the left side is dented, report the description of the left side push handle.
        - Left and right are based on a wheelchair occupant's perspective.
    - In the **Describe problem if applicable** field of each item, provide specific details of the problems assessed.
        - **<u>It is crucial that you fill out this section when a problem is identified.</u>**

NOTE: If an item has a significant problem, suggest that the user contact a wheelchair maintenance expert immediately unless that item is marked with an *.

Transfer Instructions

- Ask the participant if they are comfortable transferring out of the wheelchair for you to perform the remaining portion of the assessment.

- If the participant agrees to transfer out of the wheelchair, while the participant is in the wheelchair, assess the following item:
  - 3.0 Power drive system (page 12 on printed version)

- Please mark whether or not the participant transferred out of the wheelchair.
  - ☐ Participant transferred out of the wheelchair.
  - ☐ Participant did not transfer out of the wheelchair.

- **DO NOT SIT ON THE PARTICIPANT'S WHEELCHAIR AT ANY TIME.**

- If the participant does not transfer out of the wheelchair, the following items may be challenging to assess. Therefore, if you do not identify any problem visually, write in the **Describe problem if applicable** box: "complete assessment was not possible".

  - 1.G Cushion placement (page 5)
  - 1.H Seat cushion cover(page 6)
  - 1.I Seat cushion (page 6)
  - 1.J Seat base (page 7)
  - 1.K Back support (page 7)
  - 1.L Back support cover (page 8)
  - 1.M Back support cushion (page 8)

1. Postural Supports	Score	Describe problem if applicable
1.A) Foot supports: Inspect surface, tightness, and movement. *Indicate type:* ☐$_1$ Rigid ☐$_2$ Flip-up, one piece ☐$_3$ Flip-up, two pieces ☐$_9$ Other ____________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact surface. Easy to flip-up (if applicable. ☐$_1$ Aligned, tight, but worn or rough. Difficult to flip-up (if applicable). ☐$_0$ Not aligned, loose, has sharp edges or unable to flip-up or missing. ☐$_{NA}$ Foot supports are not installed.	
1.B) Lower leg (calf) support assembly: Inspect surface, tightness, and movement. Includes lower leg frame (LLF), lower leg support (LLS), and mounting/attachment hardware. *Indicate type:* ☐$_1$ Rigid LLF w/calf strap ☐$_2$ Swing away LLF w/ LLS ☐$_3$ Swing away LLF w/o LLS ☐$_9$ Other ____________ ☐$_{10}$ Not present	☐$_2$ Lower leg support (LLS) is aligned, tight, and has intact upholstery/fabric (if applicable). Lower leg frame (LLF) is tight and easy to swing away (if applicable). ☐$_1$ LLS is aligned, tight, but worn or rough. LLF is difficult to move or swing away. ☐$_0$ LLS is not aligned, loose, ripped upholstery/fabric, has sharp edges, or LLF is unable to swing away/remove or is missing. ☐$_{NA}$ Neither LLS nor LLF are installed.	

1. Postural Supports	**Score**	**Describe problem if applicable**
1.C) Lateral thigh supports: Inspect surface, tightness, and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Removable ☐$_9$ Other ________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact upholstery. Easy to remove (if applicable). ☐$_1$ Aligned, tight, but worn or rough. Difficult to remove. ☐$_0$ Not aligned, loose, ripped upholstery, has sharp edges or unable to remove. ☐$_{NA}$ Lateral upper leg supports are not installed.	

1.D) Arm supports: Inspect surface, tightness, and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Flip-up ☐$_3$ Removable ☐$_9$ Other ______________ ☐$_{10}$ Not present	☐$_2$ Arm support mechanism, receiver, and upholstery are aligned and intact. Easy to swing away/remove (if applicable). ☐$_1$ Aligned, but worn or rough. Difficult to remove or swing away. ☐$_0$ Not aligned, bent, ripped upholstery, has sharp edges or unable to swing away/remove. ☐$_{NA}$ Arm supports are not installed.	
1.E) Trunk support: Inspect surface, tightness, and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Swing-away ☐$_3$ Removable ☐$_9$ Other ______________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact upholstery. Easy to correctly swing-away/remove (if applicable). ☐$_1$ Aligned, tight but worn or rough. Difficult to swing-away/remove (if applicable). ☐$_0$ Not aligned, loose, ripped upholstery, has sharp edges, unable to swing-away/remove (if applicable) or has missing or loose bolts. ☐$_{NA}$ Trunk support is not installed.	
1. Postural Supports	**Score**	**Describe problem if applicable**

1.F) Head support: Inspect surface, tightness, and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Removable ☐$_3$ Flip-down ☐$_9$ Other __________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact upholstery. Easy to remove/flip-down (if applicable). ☐$_1$ Aligned, tight, but worn or rough. Difficult to remove/flip-down. ☐$_0$ Not aligned, loose, ripped upholstery, has sharp edges or unable to remove/flip-down (if applicable). ☐$_{NA}$ Head support is not installed.	
1.G) *Cushion placement: Inspect visually. Look for a “Front”/”Back” label, handle, zipper, the placement and check velcro for security.	☐$_2$ Appropriately placed and secured. ☐$_1$ Appropriately placed but inappropriately secured. ☐$_0$ Inappropriately placed. ☐$_{NA}$ Cushion is not removable or not present.	

1. Postural Supports	**Score**	**Describe problem if applicable**
1.H) Seat cushion cover: Inspect visually. Remove cover if possible. Holes with a diameter greater than the diameter of a typical pen (approximately 8mm or 5/16”) are considered large. *Indicate type:* ☐$_1$ Removable ☐$_2$ Fixed ☐$_{10}$ Not present	*If removable cushion cover* ☐$_2$ Fits tightly, clean, with no holes or worn spots. ☐$_1$ Fits tightly, easy to align. Has worn spots, small holes, dirt or zips with great difficulty. ☐$_0$ Fits loosely, very dirty, has bad odor, larger holes, is difficult to align or does not zip or cover not present or otherwise damaged or inappropriately placed. ☐$_{NA}$ Cushion is not present. *If fixed cushion cover* ☐$_2$ Clean with no cracks, holes or worn spots. ☐$_1$ Worn spots, dirt or small holes, but no cracks. ☐$_0$ Very dirty or has a bad odor, larger holes or cracks,. ☐$_{NA}$ Cushion is not present.	

1.I) Seat cushion: Inspect the cushion materials after opening the cushion cover. *Indicate type:* ☐$_1$ Foam ☐$_2$ Foam + Gel ☐$_3$ Foam + air ☐$_4$ Gel ☐$_5$ Air ☐$_6$ Air-filled packets ☐$_7$ Honeycomb ☐$_9$ Other ________ ☐$_{10}$ Not present	☐$_2$ Cushion is intact, gel can be kneaded easily, holds air, or foam is in good condition (if applicable). ☐$_1$ Cushion present fair signs of deterioration, some rigidity in the gel or foam starting to de-color or chip ☐$_0$ Cushion materials are punctured, deflated, cracked, rigid or otherwise damaged, or unable to remove the cushion cover due to damage. ☐$_{NA}$ Cushion not present.	
1. Postural Supports	**Score**	**Describe problem if applicable**
1.J) Seat base: Inspect visually after removing the cushion (if applicable and possible). *Indicate type:* ☐$_1$ Rigid ☐$_2$ Sling	*If rigid seat base support* ☐$_2$ Base is tight with no cracks, distortions or sharp edges. May have aesthetic scratches that do not break through paint/outer coating. ☐$_1$ Tight and has scratches that break through paint/outer coating. ☐$_0$ Loose or has larger cracks, distortions or sharp edges. *If sling seat base* ☐$_2$ Upholstery is tight and has no rips or tears. ☐$_1$ Upholstery sags, but has no rips or tears.	

	☐$_0$ Upholstery has rips or tears.	
1.K) Back support: Inspect visually after removing the cushion (if applicable and possible). *Indicate type:* ☐$_1$ Rigid base ☐$_2$ Sling (after answering this item move on to item **2.A) Encrusted debris**)	*If rigid base back support* ☐$_2$ Base is tight with no cracks, distortions or sharp edges. May have aesthetic scratches that do not break through paint/outer coating. ☐$_1$ Tight and has scratches that break through paint/outer coating. ☐$_0$ Loose or has larger cracks, distortions or sharp edges. *If sling back support* ☐$_2$ Upholstery is tight and has no rips or tearing. ☐$_1$ Upholstery sags but has no rips or tearing. ☐$_0$ Upholstery has rips or tearing.	
1. Postural Supports	**Score**	**Describe problem if applicable**

1.L) **Back support cover:** Inspect visually. **Remove cover if possible.** Holes with a diameter greater than 8mm (about the diameter of a typical pen) are considered large. *Indicate type:* ☐$_{1}$ Removable ☐$_{2}$ Fixed ☐$_{10}$ Not present	*If removable back support cover* ☐$_{2}$ Tight, clean, with no holes or worn spots. ☐$_{1}$ Tight, easy to align. Has worn spots, small holes or dirt. ☐$_{0}$ Loose, very dirty, has bad odor or large holes or is difficult to align. ☐$_{NA}$ Back support cover is not installed or back support is sling. *If fixed back support cover* ☐$_{2}$ Clean with no cracks, holes or worn spots. ☐$_{1}$ Worn spots, dirt, or small holes but no cracks. ☐$_{0}$ Very dirty or has a bad odor, large holes or cracks. ☐$_{NA}$ Back support cover is not installed or back support is sling.	
1.M) **Back support cushion:** Inspect the cushion materials after opening the cushion cover. *Indicate type:* ☐$_{1}$ Foam ☐$_{2}$ Air ☐$_{9}$ Other __________ ☐$_{10}$ Not present	☐$_{2}$ Cushion is intact, gel can be knead easily, holds air, foam is in good condition (if applicable). ☐$_{1}$ Cushion presents fair signs of deterioration, some rigidity in the gel or foam starting to de-color or chip ☐$_{0}$ Cushion materials are punctured, cracked, rigid or otherwise damaged. ☐$_{NA}$ Back support cushion is not installed or back support is sling.	

2. Frame and Attachments	**Score**	**Describe problem if applicable**
2.A) *Encrusted debris (dirt, mud or other grime): Inspect visually, paying particular attention to casters and folding mechanisms.	☐$_2$ Free of encrusted debris. ☐$_1$ Encrusted debris to moderate extent with no debris caught in moving parts. ☐$_0$ Encrusted debris to significant extent, debris caught in moving parts, or has a bad odor.	
2.B) Anti-tip devices: Inspect visually and test if wheels rotate.	☐$_2$ Tight and evenly spaced; wheels turn. ☐$_1$ Not evenly spaced with respect to the ground or properly fastened. Wheels turn. ☐$_0$ Cracks, distortions or other wear; wheels do not turn; or only one anti-tip device is present. ☐$_{NA}$ Anti-tip devices are not installed.	

2.C) Frame: Inspect visually, paying particular attention to weld points.	☐$_2$ Free of rust, cracks, distortions or sharp edges. May have minor scratches that do not break through the outer coating or paint. ☐$_1$ Scratches break through outer coating or paint. ☐$_0$ Rust, cracks, distortions or sharp edges.	
2.D) Clothing guard: Inspect visually. *Indicate type:* ☐$_1$ Removable ☐$_2$ Foldable ☐$_{10}$ Not present	☐$_2$ Intact, tight, and smooth. ☐$_1$ Intact but loose or rough. Does not interfere with wheel movement. ☐$_0$ Sharp edges, cracks, distortions or interferes with wheel movement. ☐$_{NA}$ Cloth guard is not installed.	
2. Frame and Attachments	**Score**	**Describe problem if applicable**
2.E) *Push handles: Inspect visually. Does not include the back posts.	☐$_2$ Intact and smooth surface. ☐$_1$ Dented or rough surface. ☐$_0$ Significant distortions, cracks or sharp edges on surface. ☐$_{NA}$ Push handles are not installed.	

2.F) Folding Mechanism: Open and close fully several times if possible. *Indicate type:* ☐$_1$ Cross brace (seat folds in) ☐$_2$ Folding back	☐$_2$ Closes fully and smoothly. Seat and/or back are firmly in place when fully open. ☐$_1$ Closes partially or with difficulty. ☐$_0$ Does not fold or does not stay secure. ☐$_{NA}$ Frame is not designed to fold.	

3. Wheels and Casters	Code	Describe problem if applicable
3.A) Axles: Test for play. *Indicate type:* ☐$_1$ Quick Release: Remove and reattach wheels. Check that axle latches correctly. ☐$_2$ Fixed	☐$_2$ Quick release functions smoothly or if fixed axle has no play. ☐$_1$ Minor damage, quick release functions with difficulty. ☐$_0$ Significant damage, quick release does not function or latch, or axle has excessive play.	
3. Wheels and Casters	**Code**	**Describe problem if applicable**
3.B) Drive wheels	*If spoke wheels* ☐$_2$ All spokes are appropriately and uniformly tight. Wheel appears	

Indicate type: ☐$_1$ **Spoke wheels:** Test tension of **ALL** spokes and wheel trueness. ☐$_2$ **Mag wheels** (thick molded plastic): Inspect material and test wheel trueness.	true when spun. ☐$_1$ One or two loose or damaged spokes. ☐$_0$ Three or more loose ordamaged, or at least one missing spoke, or wheel is visibly not true. *If mag wheels* ☐$_2$ Material is free from cracks and appears true. May have aesthetic scratches. ☐$_1$ Material has deep scratches. ☐$_0$ Material has cracks, distortions, sharp edges or wheel is visibly not true.	
3.C) Handrims: Inspect visually, and then test for play and surface roughness.	☐$_2$ Smooth surface and tightly attached. ☐$_1$ Rough surface, but no sharp edges. ☐$_0$ Loose or sharp edges. ☐$_{NA}$ Handrims are not installed.	
3.D) Tires *Indicate type:* ☐$_1$ **Pneumatic:** When depressed by a thumb, the tire should deflect no more than 5mm (about the height of three stacked pennies). ☐$_2$ **Solid:** Inspect visually.	*If pneumatic tires* ☐$_2$ Tires are properly inflated and have sufficient tread. ☐$_1$ Tires are inappropriately inflated or tread is insufficient or uneven (if applicable). ☐$_0$ Tires are flat, tread is bald/cracked or tire is damaged. *If solid tires* ☐$_2$ Tires are free of cracks and have sufficient tread (if applicable). ☐$_1$ Insufficient or uneven tread (if applicable). ☐$_0$ Cracks, flat spots, bulges, bald tread, or tire is damaged.	

3. Wheels and Casters	Code	Describe problem if applicable
3.E) Caster assembly: Raise each caster and spin both the caster assembly and the caster wheel. Check for caster play, float, and flutter.	☐$_2$ Casters swivel with resistance and wheels spin freely. Stems have no play.and are perpendicular to the floor. ☐$_1$ Casters swivel freely, wheels spin freely with clicking, or stems have some play. ☐$_0$ Casters do not swivel or spin freely, float, flutter, or have excessive play or stem is not perpendicular to the floor.	
3.F) Brakes: Test by pushing the wheelchair with the brakes engaged.	☐$_2$ Aligned and engage the wheels firmly. When pushed, the wheelchair skids and the wheels do not turn. ☐$_1$ Aligned and engage the wheels. Wheels may turn slightly when first pushed, but do not rotate afterward. ☐$_0$ Not aligned, do not engage the wheel firmly, wheels rotate with the wheelchair when pushed, or break or attachment assembly interferes with the wheel while not engage. ☐$_{NA}$ Brakes are not installed.	

3.G) Power drive system: Assists or provides propulsion. Ask user about the batteries and test by asking the user to move and turn the chair. *Indicate type:* ☐$_1$ Handrim-activated power-assist drive ☐$_2$ Power add-on unit	☐$_2$ Batteries hold adequate charge for a normal day. Motors run smoothly and quietly. Joystick and control panel work correctly (if applicable). ☐$_1$ Batteries require minimal recharging during a normal day, motors run with some noise but without scrapes or grinding, or joystick is loose or misaligned. ☐$_0$ Batteries require significant recharging during a normal day, motors run with scrapes or grinding, or joystick or controls are damaged. ☐$_{NA}$ No power drive system is installed.	

APPENDIX F. MANUAL WHEELCHAIR W-MAT ILLUSTRATED INSTRUCTIONS GUIDE

Wheelchair Maintenance Assessment Tool for Manual Wheelchairs: **W-MAT**

Draft 10/06/2014

This training material was supported by the U.S. Department of Health and Human Services, National Institute on Disability Independent Living and Rehabilitation Research (H133A120004). The contents of this manual are solely the responsibility of the authors and do not necessarily represent the official views of the U.S. Department Health and Human Services.

1

Acronyms/abbreviations

- W-MAT: wheelchair maintenance assessment tool
- MWC: Manual Wheelchair
- WC: Wheelchair
- LLF: Lower leg frame
- LLS: Lower leg support
- w.r.t.: with respect to

2

W-MAT for MWCs

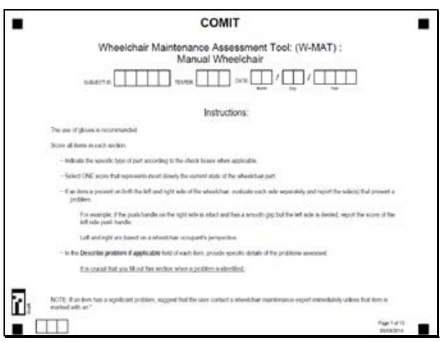
- Designed to objectively measure MWC condition.
- The condition as measured by this tool is not affected by what parts are or are not installed or whether the WC is an appropriate fit.
- Read the first two pages on the W-MAT before reviewing this power point training.

3

Be Aware!

- The use of gloves is recommended.
- Whenever possible, evaluate the WC with the user out of the WC.
  - Mark whether or not the user transfers from the wheelchair in the first page of the W-MAT.
- Always inspect visually for sharp edges or other potential points of injury before using your hands.
- **DO NOT SIT ON THE PARTICIPANT'S WHEELCHAIR.**

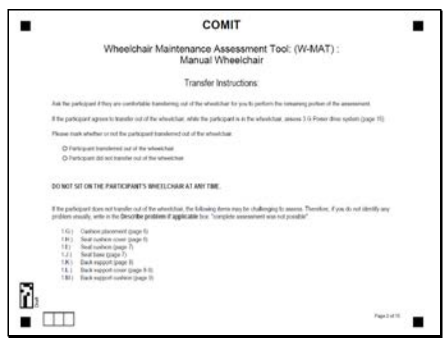
4



COMIT

Wheelchair Maintenance Assessment Tool: (W-MAT) : Manual Wheelchair

Instructions:



COMIT

Wheelchair Maintenance Assessment Tool: (W-MAT) : Manual Wheelchair

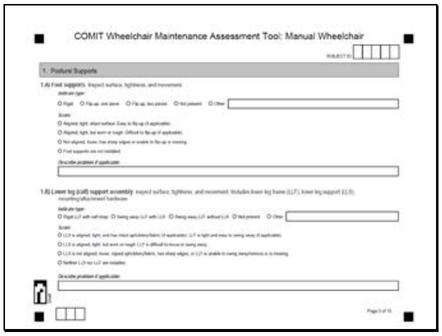
Transfer Instructions

DO NOT SIT ON THE PARTICIPANT'S WHEELCHAIR AT ANY TIME.

General instructions

- Each component is evaluated individually.
- If an item is present on both the left and right side of the wheelchair, evaluate each side separately and report the side(s) that present a problem.
- Any problems should be reported in the field
  - *Describe problem if applicable*.
- If an item has a significant problem, suggest that the user contact a wheelchair maintenance expert immediately unless that item is marked with an *.

7



General instructions (cont.)

Advise the user to contact a wheelchair maintenance expert w.r.t the foot support.

9

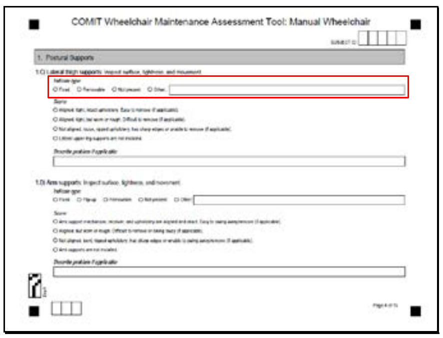
General instructions (cont.)

- "Removable" components can be removed without any tools.
- Moving components should be evaluated for correct movement by to moving it through its range of motion 3 times.
- If a part or nut/bolt falls off:
  - Put it back on and tighten with your hand.
  - Report it in the comment box that corresponds to that part on the W-MAT.
  - Suggest that the user contact a wheelchair maintenance expert immediately unless that item is marked with an *.
- **Do not perform maintenance on the WC.**

Fixed

Removable

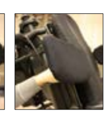
10



Section 1: Postural supports

- This section contains many different postural support components which come in many different types.
- Most WC's will have some items marked "Not present" or "Not applicable" in this section.
- "Removable" components can be removed without any tools.
- Any component that is moved should be returned to its original position after testing.
- Do not readjust components that are adjustable.
- **Do not** tighten any loose components!
- Read pages 3 to 9 in the W-MAT while reviewing this section.

Example: swing-away trunk support assessed and returned to original position



1A) Foot supports: Intended to contact and support the foot.

- Different types of foot supports.

Flip-up, one piece

Rigid

Two-piece flip-up foot

13

1A) Foot supports: evaluation examples.

- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness/wear by hand.
- Wiggle the foot support and check whether it moves w.r.t. the frame/lower leg support assembly.

Select: Aligned tight, intact surface. Easy to flip-up.

Select: Aligned, tight, but worn or rough. Difficult to flip-up (if applicable)

Describe problem if applicable: Right difficult to flip-up.

Select: Not aligned, loose, has sharp edges or unable to flip-up or missing
Describe problem if applicable:
Cracked bend with sharp edges (left); Loose, left side missing bolt (right).

14

1B) Lower leg (calf) support assembly: Intended to contact and support the lower leg.

- Different types of lower leg supports.

Rigid LLF with calf strap

Swing away LLF without LLS

Swing away LLF with LLS

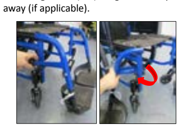
Not present

15

1B) Lower leg (calf) support assembly: evaluation examples

- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness by hand.
- Wiggle the calf support and check whether it moves w.r.t. the frame/lower leg support assembly.
- Check the tightness of the LLF w.r.t. the WC frame
- Check the tightness of the LLS w.r.t. the LLF.

Select: Lower leg support (LLS) is aligned, tight, and has intact upholstery/fabric (if applicable). Lower leg frame (LLF) is tight and easy to swing away (if applicable).



Select: LLS is aligned, tight, but worn or rough. LLF is difficult to move or swing away. ***Describe problem if applicable:*** Left LLS is rough.

16

1C) Lateral thigh supports: Intended to contact and provide lateral support to the thighs.

Fixed lateral thigh support

Clothing guards are NOT thigh supports.
Select: Not present

17

1C) Lateral thigh supports: evaluation examples.

- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness /wear by hand.
- Wiggle the thigh support and check whether it moves w.r.t. the frame.

Select: Aligned, tight, intact upholstery. Easy to remove (if applicable).

18

1D) Arm supports: different types of arm supports.

Fixed

Flip-up

Removable

Not present

19

1D) Arm supports: Intended to contact and support the lower arm.

- Visually inspect surfaces for damage or sharp edges before touching and check surface roughness by hand.
- Wiggle the arm support and check whether the arm support moves w.r.t. the frame.
- Check the arm support mechanisms and/or receivers, if applicable.

Select: Arm support mechanism, receiver, and upholstery are aligned and intact. Easy to swing away/remove.

Select: Aligned, but worn or rough. Difficult to remove or swing away.

Describe problem if applicable : right arm support difficult to swing away.

Select: right arm support receiver is bent, ripped upholstery, has sharp edges or unable to swing away/remove.

Describe problem if applicable : right arm support weld cracked and has sharp edges.

Describe problem if applicable : right arm support receiver is bent.

20

1E) Trunk support: Intended to contact and support the trunk.

- Observe the bracket that attaches the support to the back support to see whether it is swing-away, removable, or fixed.
- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness/wear by hand.
- Wiggle the trunk support and check whether it moves w.r.t. the frame.

Swing-away trunk support to check it is aligned, tight, and easy to swing-away

Fixed trunk support

1F) Head supports: Intended to contact and support the head.

- Observe the bracket that attaches the support to the back support to see whether it is flip-down, removable, or fixed.
- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness/wear by hand.
- Wiggle the head support and check whether it moves w.r.t. the back support.
- Any movement under hand pressure counts as loose.

Fixed head support

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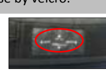
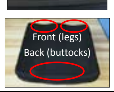
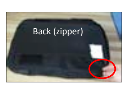
1G) Cushion placement: Seat and back cushions should be oriented and placed appropriately.

- Without moving the cushion, look for a "Front/Back" label.
- Cushions often have a contour towards the back for the buttocks and two leg contours near the front.
- Zippers are also typically towards the rear and handles on the front.
- After checking placement:
- Remove the cushion and check that the cushion is secured to the seat base by velcro.





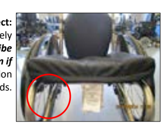


1G) Cushion placement (securing): evaluation examples

Select: Appropriately placed and secured.

Select: Appropriately placed but inappropriately secured. ***Describe problem if applicable:*** velcro not present on seat.

Select: Inappropriately placed. ***Describe problem if applicable:*** cushion is backwards.



1.H) Cushion cover: Protective cover for the seat cushion.

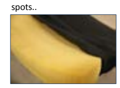
- Inspect the outside of the cover.
- Remove the cover (if applicable).
  - **Stop** if the cover is damaged or material begins to fall out.
  - Put the cover back **properly.**
- Check for holes, worn spots, dirt, odor, and zipper problems.
- If in doubt about whether a hole is small or large, assume that it is large.

Removable cover | Fixed cover | Cover not present

25

1.H) Cushion cover: scoring examples.

Select: Fits tightly, clean, with no holes or worn spots..



Select: Worn spots, dirt, or small holes, but no cracks. ***Describe problem if applicable:*** dirt (top); small hole (bottom).

Select: Very dirty or has a bad odor, larger holes, or cracks. ***Describe problem if applicable:*** deteriorating cover (top); large holes (center and bottom).

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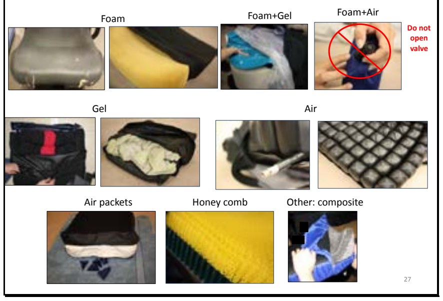
1.I) Seat cushion: types of cushions



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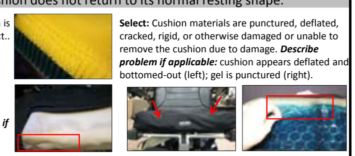
1.I) Seat cushion: scoring examples.

- Inspect visually
- Remove cover if possible
- Inspect that the material is intact, the foam does not chip, the gel allows you to move it, it holds air, and it does not appear "bottomed-out".
  - Cushion is fully compressed when the user sat on it.
  - Or cushion does not return to its normal resting shape.

Select: Cushion is intact..

Select: Cushion presents fair signs of deterioration.. ***Describe problem if applicable:*** foam deterioration.

Select: Cushion materials are punctured, deflated, cracked, rigid, or otherwise damaged or unable to remove the cushion due to damage. ***Describe problem if applicable:*** cushion appears deflated and bottomed-out (left); gel is punctured (right).



1J) Seat base: different types of seat base.

Sling

Rigid

29

1J) Seat base: Surface of the seat that is covered with a cushion.

- Inspect visually for cracks and sharp edges before touching.
- If rigid, look for scratches that break through paint/coating.
- If sling, looks for sagging, rips, or tearing in the upholstery.

Select: Upholstery is tight and has no rips or tears.

Select: Upholstery sags, but has no r rips or tears. ***Describe problem if applicable:*** Sagging upholstery.

Select: Upholstery has rips or tears. ***Describe problem if applicable:*** upholstery as missing rivets and is ripped.

Select: Tight and has scratches that break through paint. ***Describe problem if applicable:*** scratches

30

1K) Back support: different types of back supports.

Sling

Rigid

31

1K) Back support: Rigid or sling surface that supports the user's back.

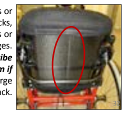
- Inspect visually for cracks and sharp edges before touching.
- If rigid, also look for scratches that break through paint/coating.
- If sling, looks for sagging, rips, or tearing in the upholstery.

Select: Base is tight with no cracks, distortions or sharp edges.

Select: Upholstery sags but has no rips or tearing. ***Describe problem if applicable:*** sags on top.

Select: Upholstery has rips or tearing. ***Describe problem is applicable:*** upholstery is ripped.

Select: Loos or has larger cracks, distortions or sharp edges. ***Describe problem if applicable:*** large crack.

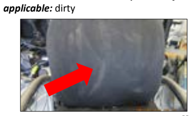


1L) Back support cover: Covers back support cushion.

- This item is only applicable for WCs with **rigid** back supports.
- Inspect the outside of the cover.
- **Remove the cover**.
  - Stop if the cover is damaged or material begins to fall out.
- Check for holes, worn spots, dirt, odor, and zipper problems.
- Compare the holes to a typical pen. If in doubt about whether a hole is smaller or larger, assume that it is larger.

Select: Tight, clean, with no holes or worn spots.

Select: Tight, easy to align. Has worn spots, small holes, or dirt. ***Describe problem if applicable:*** dirty



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1M) Back support cushion: Contacts and supports the posterior surface of trunk and is placed on the back support base

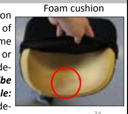
- This item is only applicable for WCs with **rigid** back supports.
- Inspect visually.
- Remove cover if possible.
- Inspect that the material is intact.
  - Foam should not chip.
  - Gel should be able to move around.
  - Air cushions should hold air and have intact valves.
- Cushions should not appear "bottomed-out".

Select: Cushion is intact, gel can be kneaded easily, holds air, foam is in good condition.

Air cushion

Select: Cushion presents fair signs of deterioration, some rigidity in the gel or foam starting to de-color or chip. ***Describe problem if applicable:*** foam starting to de-color.

Foam cushion



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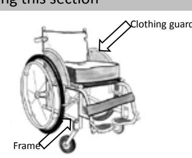
Section 2: Frame and attachments

- This section focuses on the frame and frame-related attachments.
- Avoid performing any maintenance, including simple cleaning, removing debris, or tightening bolts.
- Read items and scoring on pages 9 and 10 in the WeMAT while reviewing this section



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2A) Encrusted Debris: Foreign matter (e.g. dirt, hair) caught on or in the wheelchair.

- Free of encrusted debris: some dust/dirt acceptable
- Moderate encrusted debris: enough dirt for reasonably clear drawing
- Debris to a significant extent: enough to completely cover original color, e.g. mud
- Check if debris is caught in moving parts such as the casters or folding mechanisms. If found, score 0.

Select: Free of encrusted debris.

Select Encrusted debris to moderate extent with no debris caught in moving parts. ***Describe problem if applicable:*** dusty frame

Select: Encrusted debris to significant extent, debris caught in moving parts or has bad odor. ***Describe problem if applicable:*** very dirty and bad odor (left); debris on caster axle.

2B) Anti-tip devices: Devices that limit the extent that the wheelchair can tip.

- Inspect visually: the anti-tippers should be evenly spaced and free of cracks, distortions, or other wear.
- Check if they are tight by wiggling.
- The wheels should turn, though they do not need to turn freely.
- If anti-tip receivers are present but not the anti-tip devices.
  - Answer NA and add in the comments that hardware was present but not the anti-tip.

Select: Tight and evenly spaced, wheels turn.

Select: Not evenly spaced with respect to the ground or properly fastened. ***Describe problem if applicable:*** not evenly spaced.

Select: Cracks, distortions or other wear, wheels do not turn; or only one anti-tip device is present. ***Describe problem if applicable:*** Right anti-tip missing.

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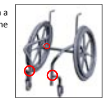
2C) Frame: The underlying structure of the wheelchair. Check welds as well.

- Inspect the frame visually for rust, cracks, distortions, sharp edges, or scratches that break through the paint/coating.
- Cracks often occur at or near weld points.
- Inspect the weld points on fixed drive wheel axles.

Common weld points on a rigid frame



Select: Rust, cracks, distortions or sharp edges. ***Describe problem if applicable:*** crack on wheel axle (top); crack on caster weld (bottom).

Select: Scratches break through outer coating or paint. ***Select problem if applicable:*** scratches on paint on LLF.

2D) Clothing guard: Provides a barrier between the occupant and the wheel.

- Inspect the guard visually for cracks, distortions, or sharp edges.
- Wiggle the guards to determine if tight or if they can interfere with the rear wheels.
- Feel surface for roughness.
- Inspect that the clothing guard does not interfere with the wheel movement.

Select: Intact, tight, and smooth.

Select: Intact but loose or rough. Does not interfere with wheel movement. ***Describe problem if applicable:*** Right side is somewhat loose.

Select: Sharp edges, cracks, distortion or interferes with wheel movement. ***Describe problem if applicable:*** left side is cracked.

39

2E) Push handles: Handles above the back support that allow an assistant to maneuver the wheelchair.

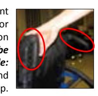
- Inspect the handles visually for cracks, distortions, or sharp edges.
- Wiggle the handles to determine if tight.
- Feel surface for roughness.

Back posts are not included in the push handle evaluation

Select: Dented or rough surface. ***Describe problem if applicable:*** some roughness left side.

Select: Intact and smooth surface.

Select: Significant distortion, cracks or sharp edges on surface. ***Describe problem if applicable:*** left side is stuck and does not flip-up.



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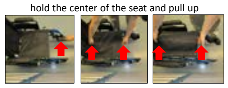
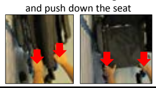
2F) Folding Mechanism (Cross brace): Components under the seat that allow the wheelchair to fold inward.

- WCs with a cross brace mechanism fold inward to a reduced width.
- Fold/unfold three times before scoring.
- Check that the seat guides hold the seat in place when locked and are in good condition.

To fold the WC, flip-up the foot supports, then hold the center of the seat and pull up



To unfold the WC, hold the edges of the seat and push down the seat



If seat guide is not intact, the folding mechanism will not stay secure when opened

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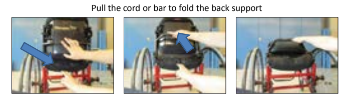
2F) Folding Mechanism (Folding back): Components that allow the back of the wheelchair to fold in.

- Most rigid frame WCs have a folding back support.
- Fold/unfold three times before scoring.
- Check that the back is tight when upright.

Pull the cord or bar to fold the back support



Zoom of working mechanism; it must stay secured when latched.

42

2F) Folding Mechanism: scoring examples.

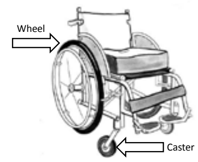
Select: Closes fully and smoothly. Seat and/or back are firmly in place when fully open.

Select: Does not fold or does not stay secure. ***Describe problem if applicable:*** missing bolt on folding back bracket right side (top); cracked right folding back bracket (bottom).

Select: Closes partially or with difficulty. ***Describe problem if applicable:*** folding back support is difficult to fold because the securement pin on left side is bent

Section 3: Wheels and casters

- Avoid performing any maintenance, including inflating tires or adjusting brakes.
- Read items and scoring on pages 11 to 13 in the W-MAT while reviewing this section.



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3A) Axles: Components about which the wheels rotate

- Test for play by wiggling the wheel in multiple directions.
- For quick release axles, attach and remove each wheel three times.

Select: Quick release functions smoothly or if fixed axle has no play.

Select: Significant damage, quick release does not function or latch, or axle has excessive play. ***Describe problem if applicable:*** left wheel does not latch (top), rusted and stuck right axle (bottom).

Select: Minor damage, quick release functions with difficulty. ***Describe problem if applicable:*** right wheel difficult to release.

To remove a quick release axle, press the button and pull out. Put back the axle and without pressing the button pull out.

3B) Drive wheels: types of spokes wheels.

MAG wheels: Wheels in which the hub and rim are connected by molded plastic

Spoke wheels: Wheels in which the hub and rim are connected with metal spokes.

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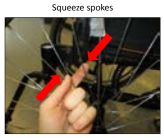
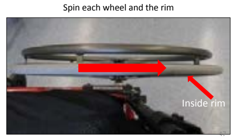
3B) Drive wheels (spoke wheels): Wheels in which the hub and rim are connected with metal spokes.

- Test tension by squeezing every two adjacent (or parallel, if applicable) spokes. Test every spoke in each wheel.
- Check material for scratches, cracks, and other wear.
- Test trueness by spinning each wheel.
- Observe if the wheel inside rim is wobbling - note if the rim (**not** the tire) deviates by 1.5mm or 1/16in, about width of a single penny.

Squeeze spokes

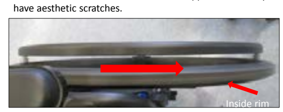


Spin each wheel and the rim



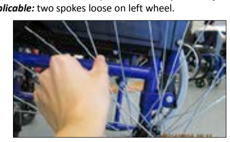
3B) Drive wheels: scoring examples.

Select: Material is free from cracks and appears true. May have aesthetic scratches.



Select: Three or more loose, damaged, or at least one missing spoke, or wheel is visibly not true. ***Describe problem if applicable:*** damaged spokes on left wheel

Select: One or two loose spokes. ***Describe problem if applicable:*** two spokes loose on left wheel.



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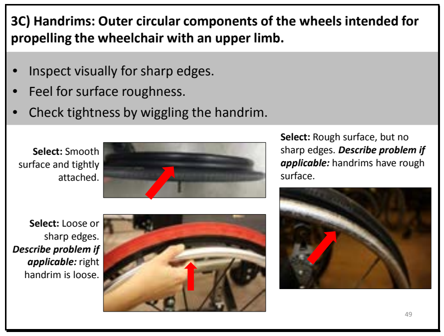
3C) Handrims: Outer circular components of the wheels intended for propelling the wheelchair with an upper limb.
• Inspect visually for sharp edges.
• Feel for surface roughness.
• Check tightness by wiggling the handrim.
Select: Smooth surface and tightly attached.
Select: Rough surface, but no sharp edges. Describe problem if applicable: handrims have rough surface.
Select: Loose or sharp edges. Describe problem if applicable: right handrim is loose.
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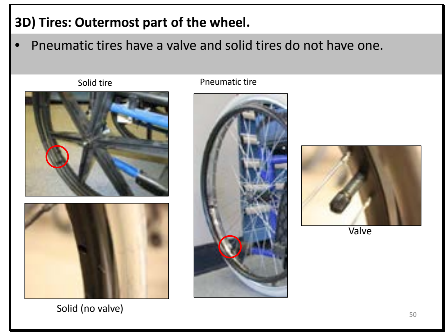
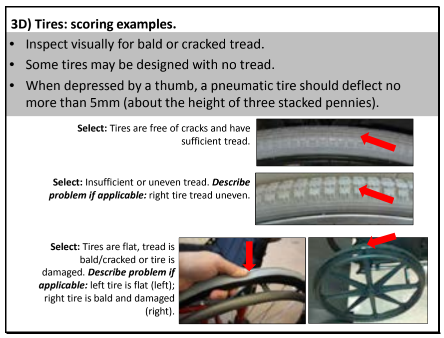
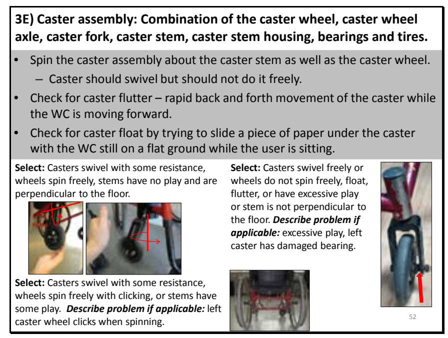

3D) Tires: Outermost part of the wheel.
• Pneumatic tires have a valve and solid tires do not have one.
Solid tire
Pneumatic tire
Valve
Solid (no valve)
50


3D) Tires: scoring examples.
• Inspect visually for bald or cracked tread.
• Some tires may be designed with no tread.
• When depressed by a thumb, a pneumatic tire should deflect no more than 5mm (about the height of three stacked pennies).
Select: Tires are free of cracks and have sufficient tread.
Select: Insufficient or uneven tread. Describe problem if applicable: right tire tread uneven.
Select: Tires are flat, tread is bald/cracked or tire is damaged. Describe problem if applicable: left tire is flat (left); right tire is bald and damaged (right).


3E) Caster assembly: Combination of the caster wheel, caster wheel axle, caster fork, caster stem, caster stem housing, bearings and tires.
• Spin the caster assembly about the caster stem as well as the caster wheel.
– Caster should swivel but should not do it freely.
• Check for caster flutter – rapid back and forth movement of the caster while the WC is moving forward.
• Check for caster float by trying to slide a piece of paper under the caster with the WC still on a flat ground while the user is sitting.
Select: Casters swivel with some resistance, wheels spin freely, stems have no play and are perpendicular to the floor.
Select: Casters swivel freely or wheels do not spin freely, float, flutter, or have excessive play or stem is not perpendicular to the floor. Describe problem if applicable: excessive play, left caster has damaged bearing.
Select: Casters swivel with some resistance, wheels spin freely with clicking, or stems have some play. Describe problem if applicable: left caster wheel clicks when spinning.
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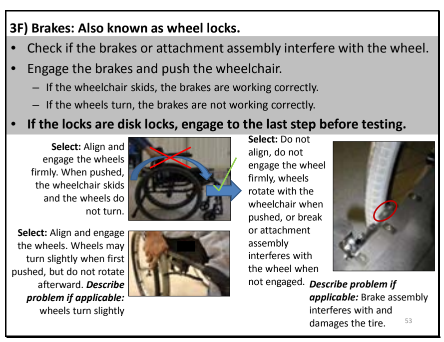
3F) Brakes: Also known as wheel locks.
• Check if the brakes or attachment assembly interfere with the wheel.
• Engage the brakes and push the wheelchair.
– If the wheelchair skids, the brakes are working correctly.
– If the wheels turn, the brakes are not working correctly.
• If the locks are disk locks, engage to the last step before testing.
Select: Align and engage the wheels firmly. When pushed, the wheelchair skids and the wheels do not turn.
Select: Do not align, do not engage the wheel firmly, wheels rotate with the wheelchair when pushed, or break or attachment assembly interferes with the wheel when not engaged. Describe problem if applicable: Brake assembly interferes with and damages the tire.
Select: Align and engage the wheels. Wheels may turn slightly when first pushed, but do not rotate afterward. Describe problem if applicable: wheels turn slightly
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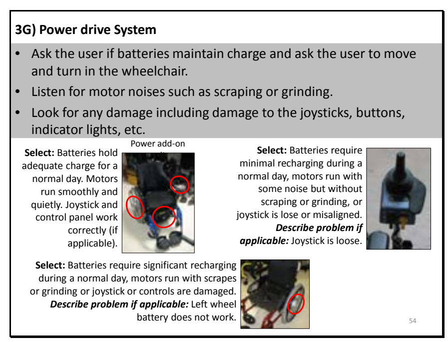
3G) Power drive System
• Ask the user if batteries maintain charge and ask the user to move and turn in the wheelchair.
• Listen for motor noises such as scraping or grinding.
• Look for any damage including damage to the joysticks, buttons, indicator lights, etc.
Power add-on
Select: Batteries hold adequate charge for a normal day. Motors run smoothly and quietly. Joystick and control panel work correctly (if applicable).
Select: Batteries require minimal recharging during a normal day, motors run with some noise but without scraping or grinding, or joystick is lose or misaligned. Describe problem if applicable: Joystick is loose.
Select: Batteries require significant recharging during a normal day, motors run with scrapes or grinding or joystick or controls are damaged. Describe problem if applicable: Left wheel battery does not work.
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APPENDIX G. WHEELCHAIR MAINTENANCE ASSESSMENT TOOL POWER WHEELCHAIR

Instructions:

- The use of gloves is recommended.
- Score all items in each section.
  - Indicate the specific type of part according to the checkboxes when applicable.
  - Select ONE description that represents most closely the current state of the wheelchair part.
  - If an item is present on both the left and right side of the wheelchair, evaluate each side separately and report **the side(s) that present a problem.**
    - For example, if the trunk support on the right side swing-away works properly but the left side does not, report the description of the left side trunk support.
    - Left and right are based on a wheelchair occupant's perspective.
  - In the **Describe problem if applicable** field of each item, provide specific details of the problems assessed.
    - **<u>It is crucial that you fill out this section when a problem is identified.</u>**

NOTE: If an item has a significant problem, suggest that the user contact a wheelchair maintenance expert immediately unless that item is marked with an *.

Record battery level here:_________________

Tools:

- Piece of lumber with 50mm or 2in nominal width (e.g. 2x4) or 1 1/2" high speed bump.

Transfer Instructions

- Ask the participant if they are comfortable transferring out of the wheelchair for you to perform the assessment.

- If the participant agrees to transfer out of the wheelchair, while the participant is in the wheelchair, assess the following item(s):
  - 1.0 Suspension (page 4)
  - 4.H) Alignment (page 12)
  - Ask the participant to transfer out of the wheelchair.

- Please mark whether or not the participant transferred out of the wheelchair.
  - ☐ Participant transferred out of the wheelchair.
  - ☐ Participant did not transfer out of the wheelchair.

- **DO NOT SIT ON THE PARTICIPANT'S WHEELCHAIR AT ANY TIME.**

- If the participant does not transfer out of the wheelchair, the following items may be challenging to assess. Therefore, write in the **Describe problem if applicable** box: "complete assessment was not possible".
  - 2.H) Cushion placement (page 7)
  - 2.I) Seat cushion cover(page 7)
  - 2.J) Seat cushion (page 8)
  - 2.K) Seat base (page 8)
  - 2.L) Back support (page 9)
  - 2.M) Back support cover (page 9)
  - 2.N) Back support cushion (page 10)

1. Frame and Attachments	Score	Describe problem if applicable
1.A) * Encrusted debris (dirt, mud or other grime): Pay particular attention to casters and drive wheels.	☐$_2$ Free of encrusted debris ☐$_1$ Encrusted debris to moderate extent, but debris is not caught in moving parts. ☐$_0$ Encrusted debris to severe extent or debris is caught in moving parts or debris has bad odor.	
1.B) Anti-tip devices: Inspect visually and test if wheels rotate.	☐$_2$ Present and evenly spaced. Wheels turn. If applicable, wheels have sufficient tread/rubber. If spring loaded, springs are in good condition. ☐$_1$ Present with wheels that can turn but not evenly spaced with respect to the ground or properly fastened. If applicable, wheels lack tread/rubber. ☐$_0$ Have bends, cracks, rust or other wear, have wheels that do not turn, missing on one side, or have damaged springs. ☐$_{NA}$ Anti-tip devices are not installed.	
1.C) *Shrouds: Inspect visually.	☐$_2$ Present with no scratches, cracks, or distortions. ☐$_1$ Present with scratches or loose. ☐$_0$ Present with distortions or cracks or missing.	
1.D) Frame/chassis/link arms: Inspect visually, paying particular attention to weld points.	☐$_2$ Free of rust, cracks, distortions, or sharp edges. May have minor scratches that do not break through the outer coating or paint. ☐$_1$ Scratches break through outer coating or paint on the frame or suspension springs. Link arms misaligned or lose. ☐$_0$ Rust, cracks, distortions, or sharp edges. Link arms bent or dented or oil comes out of the spring or damper.	

1.E) Suspension: Test by asking the user to drive the wheelchair over obstacles and note any wheels that lose contact with the ground and listening for squeaking sounds.	☐$_2$ At least three wheels remain on the test plane at all times. ☐$_1$ Less than three wheels remain on the test plane at any point during the test and then drop back onto the test plane, whether or not any anti-tip devices contact the test plane. ☐$_0$ The wheelchair anti-tip device(s) (if applicable) contacts the test plane and the wheelchair remains stuck on the anti-tip device(s) (if applicable) or the wheelchair tips. The wheelchair squeaks during the test.	

2. Postural Supports	**Score**	**Describe problem if applicable**
2.A) Foot supports: Inspect surface, tightness, and movement. *Indicate type:* ☐$_1$ Flip-up, one piece ☐$_2$ Flip-up, two pieces ☐$_9$ Other____________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact surface. Easy to correctly flip-up (if applicable). ☐$_1$ Aligned, tight, but worn or rough. Difficult to flip-up (if applicable). ☐$_0$ Not aligned, loose, has sharp edges, unable to flip-up (if applicable), missing or has missing or rusted parts (e.g. bolts). ☐$_{NA}$ Foot supports are not installed.	

2.B) Lower leg supports (calf supports): Inspect surface, tightness, and movement. Includes lower leg frame (LLF), lower leg support (LLS), and mounting/attachment hardware. *Indicate type:* ☐$_1$ Center mount LLF w/ LLS ☐$_2$ Center mount LLF w/o LLS ☐$_3$ Swing away LLF w/ LLS ☐$_4$ Swing away LLF w/o LLS ☐$_9$ Other_______________ ☐$_{10}$ Not present	☐$_2$ Lower leg support (LLS) is aligned, tight, and has intact upholstery/fabric (if applicable). Lower leg frame (LLF) is tight and easy to swing away (if applicable). ☐$_1$ LLS is aligned, tight, but worn or rough. LLF is difficult to move or swing away (if applicable). ☐$_0$ LLS is not aligned, loose, ripped upholstery, has sharp edges, or LLF is unable to swing away/remove or missing or has missing or rusted parts (e.g. bolts). ☐$_{NA}$ Neither LLS nor LLF are installed.	
2. Postural Supports	**Score**	**Describe problem if applicable**

2.C) Lateral thigh supports: Inspect surface, tightness and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Removable ☐$_9$ Other_______________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact upholstery. Easy to remove (if applicable). ☐$_1$ Aligned, tight but worn or rough. Difficult to remove. ☐$_0$ Not aligned, loose, ripped upholstery, has sharp edges, unable to remove, missing, or has missing or rusted parts (e.g. bolts). ☐$_{NA}$ Lateral thigh supports are not installed.	
2.D) Arm supports: Inspect surface, tightness and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Flip-up ☐$_3$ Removable ☐$_9$ Other______ ☐$_{10}$ Not present	☐$_2$ Arm support mechanism, receiver, and upholstery are aligned and intact. Easy to flip-up/remove (if applicable). ☐$_1$ Aligned, but worn or rough. Difficult to remove/flip-up (if applicable). ☐$_0$ Not aligned, bent, ripped upholstery, has sharp edges, unable to flip-up/remove (if applicable), or has missing or rusted parts (e.g. bolts). ☐$_{NA}$ Arm supports are not installed.	
2.E) Trunk supports: Inspect surface, tightness and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Swing-away ☐$_3$ Removable ☐$_9$ Other_____________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact upholstery. Easy to correctly swing-away/remove (if applicable). ☐$_1$ Aligned, tight but worn or rough. Difficult to swing-away/remove (if applicable). ☐$_0$ Not aligned, loose, ripped upholstery, has sharp edges, unable to swing-away/remove (if applicable), or has missing or rusted parts (e.g. bolts). ☐$_{NA}$ Trunk supports are not installed.	

2. Postural Supports	**Score**	**Describe problem if applicable**
2.F) Head support: Inspect surface, tightness and movement. *Indicate type:* ☐$_1$ Fixed ☐$_2$ Flip-down ☐$_3$ Removable ☐$_9$ Other___________ ☐$_{10}$ Not present	☐$_2$ Aligned, tight, intact upholstery. Easy to correctly flip-down/remove (if applicable). ☐$_1$ Aligned, tight but worn or rough. Difficult to flip-down/remove (if applicable). ☐$_0$ Not aligned, loose, ripped upholstery, has sharp edges, unable to flip-down/remove (if applicable), or has missing or rusted parts (e.g. bolts). ☐$_{NA}$ Head support is not installed.	
2.G) Seat belt: Test if the belt can be adjusted and buckled and note any damage.	☐$_2$ Belt buckles and releases easily, length is easily adjusted. ☐$_1$ Difficult to adjust length or buckle belt. ☐$_0$ Belt is damaged, cannot be adjusted or buckled. ☐$_{NA}$ Seat belt is not installed.	
2.H) *Cushion placement: Inspect visually.	☐$_2$ Appropriately placed and secured. ☐$_1$ Appropriately placed but inappropriately secured. ☐$_0$ Inappropriately placed. ☐$_{NA}$ Cushion is not removable or not present.	

2. Postural Supports	**Code**	**Describe problem if applicable**
2.I) Seat cushion cover: Inspect visually. Remove cover if possible. Holes with a diameter greater than the diameter of a typical pen (approximately 8mm or 5/16”) are considered large. *Indicate type:* ☐$_{1}$ Removable ☐$_{2}$ Fixed ☐$_{10}$ Not present	*If removable cushion cover* ☐$_{2}$ Fits tightly, clean, with no holes or worn spots. Easy to position on seat base. ☐$_{1}$ Fits tightly, easy to align. Has worn spots, small holes (up to 5 mm diameter) or dirt. ☐$_{0}$ Fits loosely, very dirty, has bad odor, larger holes or is difficult to align or cover not present or inappropriately placed. ☐$_{NA}$ No cushion present *If fixed cushion cover* ☐$_{2}$ Clean with no cracks, holes, or worn spots. ☐$_{1}$ Worn spots, dirt, or small holes (up to 5 mm diameter), but no cracks. ☐$_{0}$ Very dirty or has a bad odor, larger holes, or cracks. ☐ $_{NA}$ No cushion present.	

2.J) Seat cushion: Inspect the cushion materials after opening the cushion cover. *Indicate type:* ☐$_1$ Foam ☐$_2$ Foam + Gel ☐$_3$ Foam + air ☐$_4$ Gel ☐$_5$ Air ☐$_6$ Air-filled packets ☐$_7$ Honeycomb ☐$_9$ Other______________ ☐$_{10}$ Not present	☐$_2$ Cushion is intact, gel can be kneaded easily, holds air, or foam is in good condition (if applicable). ☐$_1$ Cushion presents fair signs of deterioration, some rigidity in the gel or foam starting to de-color or chip. ☐$_0$ Cushion materials are punctured, deflated, cracked, rigid, or otherwise damaged or unable to remove the cushion cover due to damage. ☐$_{NA}$ Cushion not present.	
2. Postural Supports	**Code**	**Describe problem if applicable**

2.K) Seat base: Inspect visually after removing the cushion (if applicable and possible). *Indicate type:* ☐$_1$ Rigid ☐$_2$ Captain style	*If rigid seat base* ☐$_2$ Base is tight with no cracks, distortions or sharp edges. May have aesthetic scratches that do not break through paint/outer coating. ☐$_1$ Tight and has scratches that break through paint/outer coating. ☐$_0$ Loose or has larger cracks, rust, distortions or sharp edges. ☐$_{NA}$ Captain style	
2. Postural Supports	**Code**	**Describe problem if applicable**

2.L) Back support: Inspect visually after removing the cushion (if applicable and possible). *Indicate type:* ☐$_1$ Rigid base ☐$_2$ Sling: After answering this item, move on to item **3.A) Tires**. ☐$_3$ Captain style	*If sling back support base* ☐$_2$ Upholstery is tight and has no rips or tearing. ☐$_1$ Upholstery sags but has no rips or tearing. ☐$_0$ Upholstery has rips or tearing. *If rigid base or captain style back support* ☐$_2$ Base is tight with no cracks, distortions or sharp edges. May have aesthetic scratches that do not break through paint/outer coating. ☐$_1$ Tight and has scratches that break through paint/outer coating. ☐$_0$ Loose or has larger cracks, rust, distortions or sharp edges.	
2.M) Back support cover: Inspect visually. **Remove cover if possible.** Holes with a diameter greater than the diameter of a typical pen (approximately 8mm or 5/16”) are considered large. *Indicate type:* ☐$_1$ Removable ☐$_2$ Fixed ☐$_{10}$ Not present	*If removable back support cover* ☐$_2$ Tight, clean, with no holes or worn spots. ☐$_1$ Tight, easy to align. Has worn spots, small holes or dirt. ☐$_0$ Loose, very dirty, has bad odor or large holes or is difficult to align. ☐$_{NA}$ Back support cover is not installed or back support is sling. *If fixed back support cover* ☐$_2$ Clean with no cracks, holes or worn spots. ☐$_1$ Worn spots, dirt, or small holes but no cracks. ☐$_0$ Very dirty or has a bad odor, large holes or cracks. ☐$_{NA}$ Back support cover is not installed or back support is sling.	

2. Postural Supports	Code	Describe problem if applicable
2.N) Back support cushion: Inspect the cushion materials after opening the cushion cover. *Indicate type:* ☐$_1$ Foam ☐$_2$ Air ☐$_3$ Captain style ☐$_9$ Other______________ ☐$_{10}$ Not present	☐$_2$ Cushion is intact, gel can be knead easily, holds air, foam is in good condition (if applicable). ☐$_1$ Cushion presents fair signs of deterioration, some rigidity in the gel or foam starting to de-color or chip. ☐$_0$ Cushion materials are punctured, cracked, rigid or otherwise damaged. ☐$_{NA}$ Back support cushion is not installed or back support is sling.	

3. Wheels and Casters	Score	Describe problem if applicable
3.A) Tires *Indicate type:* ☐$_1$ Pneumatic: When depressed by a thumb, the tire should deflect no more than 5mm (about the height of three stacked pennies). ☐$_2$ Solid: Inspect visually.	*If pneumatic tires* ☐$_2$ Wheels are properly inflated and have sufficient tread. ☐$_1$ Wheels are inappropriately inflated or tread is insufficient or uneven. ☐$_0$ Wheels do not hold pressure or tread is bald, cracked, or has bulges. *If solid tires* ☐$_2$ Wheels are free of cracks and have sufficient tread. ☐$_1$ Insufficient or uneven tread. ☐$_0$ Cracks, flattening or bald tread or has bulges.	
3.B) Front caster assemblies: Test by moving and turning chair. <u>Do not consider interference between the caster and the footrest as a problem.</u>	☐$_2$ Swivel with stems perpendicular to the floor. Have tightly sealed caps. Wheels spin freely. ☐$_1$ Loose caps or wheels spin freely with clicking or Insufficient or uneven tread. ☐$_0$ No caps, do not swivel, or stems not perpendicular to floor. Wheels do not spin freely or caster flutter is present or has cracks, flattening or bald tread or has bulges. ☐$_{NA}$ Front-wheel drive power wheelchair.	
3. Wheels and Casters	**Score**	**Describe problem if applicable**

3.C) Rear caster assemblies: Test by moving and turning chair.	☐$_2$ Swivel with stems perpendicular to the floor. Have tightly sealed caps. Wheels spin freely. ☐$_1$ Loose caps or wheels spin freely with clicking or Insufficient or uneven tread. ☐$_0$ No caps, do not swivel, or stems not perpendicular to floor. Wheels do not spin freely or caster flutter is present. or has cracks, flattening or bald tread or has bulges. ☐$_{NA}$ Rear-wheel drive power wheelchair.	
3.D) Parking brake: Related to the motor disengage lever. When disengaged, the chair should be able to be manually pushed. When engaged, the wheels should not turn when manually pushed, even if the chair skids.	☐$_2$ Lever stays in place firmly and functions correctly. ☐$_1$ Lever does not stay firmly in place and may be activated unintentionally. ☐$_0$ Lever does not function correctly.	

4. Interface and Electronics	Score	Describe problem if applicable
4.A) Control device (e.g. joystick): Test the joystick while the wheelchair is powered off.	☐$_2$ Joystick is well sealed and moves easily. Tight and aligned to wheelchair correctly. ☐$_1$ Joystick is somewhat loose or misaligned. ☐$_0$ Joystick is insufficiently sealed or plastic cap missing, does not move easily or is extremely loose.	
4.B) Control Panel: Test all inputs (e.g. buttons, knobs) and outputs (e.g. indicators lights, LED/LCD display) and note any issues.	☐$_2$ All inputs and outputs function properly. ☐$_1$ Inputs do not always activate. ☐$_0$ Inputs and outputs do not always activate.	
4.C) Seat elevation mechanism: Test seat functions throughout the whole range by listening for noise during operation and looking for jerky movement.	☐$_2$ Functions smoothly. ☐$_1$ Functions unevenly or with grinding noises. ☐$_0$ Does not function due to mechanical problems. ☐$_{NA}$ Seat elevation mechanism is not present.	

4. Interface and Electronics	Score	Describe problem if applicable
4.D) Recline mechanism: Test seat functions throughout the whole range by listening for noise during operation and looking for jerky movement.	☐$_2$ Functions smoothly. ☐$_1$ Functions unevenly or with grinding noises. ☐$_0$ Does not function due to mechanical problems. ☐$_{NA}$ Recline mechanism is not present.	
4.E) Elevating leg support mechanism: Test seat functions throughout the whole	☐$_2$ Functions smoothly. ☐$_1$ Functions unevenly or with grinding noises.	

range by listening for noise during operation and looking for jerky movement.	☐$_0$ Does not function due to mechanical problems. ☐$_{NA}$ Elevating leg support mechanism is not present.	
4.F) Tilt mechanism: Test seat functions throughout the whole range by listening for noise during operation and looking for jerky movement.	☐$_2$ Functions smoothly. ☐$_1$ Functions unevenly or with grinding noises. ☐$_0$ Does not function due to mechanical problems. ☐$_{NA}$ Tilt mechanism is not present.	
4.G) Motors and gearboxes: Listen for noises while the wheelchair is moving.	☐$_2$ Runs smoothly and quietly. ☐$_1$ Runs with some noise but without scrapes or grinding. ☐$_0$ Runs with scrapes or grinding.	
4.H) Alignment: The control device should point exactly straight for testing.	☐$_2$ The wheelchair travels straight when the control device is pointed straight. ☐$_1$ Drifts slightly to one side while the control device is pointed straight, able to correct with minimal joystick movement. ☐$_0$ Drifts significantly to one side while the control device is pointed straight.	
4.I) Running brake: Test by starting and stopping at different speeds	☐$_2$ Stops evenly and smoothly. ☐$_1$ Turns or is noisy when stopping. ☐$_0$ Does not stop completely.	
4. Interface and Electronics	**Score**	**Describe problem if applicable**
4.J) Batteries: Ask the user if the wheelchair lasts for a normal day.	☐$_2$ The batteries hold adequate charge for a normal day. ☐$_1$ Batteries require one recharging during a normal day. ☐$_0$ Batteries require significant recharging during a normal day; user has to carry the charger all the time.	

4.K) Cables and connectors: Cables should be well secured and out of the way. All layers of insulation should be intact. Connectors should be always tightly connected.	☐$_2$ Insulation undamaged, cables are secured to chair and out of the way. ☐$_1$ Outer insulation has cracks, cables secured to chair. ☐$_0$ Inner insulation is cracked or cut or cables are not secured. Connectors are loose.	
4.L) Charging socket: Inspect visually.	☐$_2$ Functional, free of debris and has cap if exposed. ☐$_1$ Functional, but has some debris or lacks cap if exposed. ☐$_0$ Nonfunctional or has significant debris or corrosion.	

APPENDIX H. POWER WHEELCHAIR W-MAT ILLUSTRATED INSTRUCTIONS GUIDE

Wheelchair Maintenance Assessment Tool for Power Wheelchairs: **W-MAT**

Draft 09/18/2014

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1

Acronyms/abbreviations

- LLF – Lower leg frame
- LLS – Lower leg support
- PWC – Power Wheelchair
- WC – Wheelchair
- w.r.t. – with respect to

2

W-MAT for PWCs

- Designed to objectively measure PWC condition.
- The condition as measured by this tool is not affected by what parts are or are not installed or whether the WC is an appropriate fit.
- Read the first two pages of the W-MAT before reviewing this power point training.

3

Be Aware!

- The use of gloves is recommended.
- Whenever possible, evaluate the WC with the user out of the WC.
  - Mark whether or not the user transfers from the wheelchair in the first page of the W-MAT.
- Always inspect visually for sharp edges or other potential points of injury before using your hands.
- **DO NOT SIT ON THE PARTICIPANT'S WHEELCHAIR.**

4

COMIT

Wheelchair Maintenance Assessment Tool: (W-MAT) :
Power Wheelchair

Instructions:

The use of gloves is recommended.

Score all items in each section.

Record battery level here:

Page 1 of 17

COMIT

Wheelchair Maintenance Assessment Tool: (W-MAT) :
Power Wheelchair

Transfer Instructions:

DO NOT SIT ON THE PARTICIPANT'S WHEELCHAIR AT ANY TIME.

General instructions

- Each component is evaluated and scored individually.
- If an item is present on both the left and right side of the wheelchair, evaluate each side separately and report the side(s) that present a problem.
- Any problems should be reported in the field:

  Describe problem if applicable:
- If an item has a significant problem, suggest that the user contact a wheelchair maintenance expert immediately unless that item is marked with an *.

7

COMIT Wheelchair Maintenance Assessment Tool: Power Wheelchair

1. Frame & Attachments

1.A) *Encrusted debris (dirt, mud, or other grime):

Describe problem if applicable:

1.B) Anti-tip devices: Inspect visually and test if wheels rotate.

Describe problem if applicable:

1.C) *Shrouds: Inspect visually

Describe problem if applicable:

General instructions (cont.)

1.B) Anti-tip devices: Inspect visually and test if wheels rotate.

Score:

Describe problem if applicable:

Left side anti-tip is missing

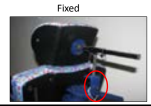
Advise the user to contact a wheelchair maintenance expert w.r.t the anti-tip device.

9

General instructions (cont.)

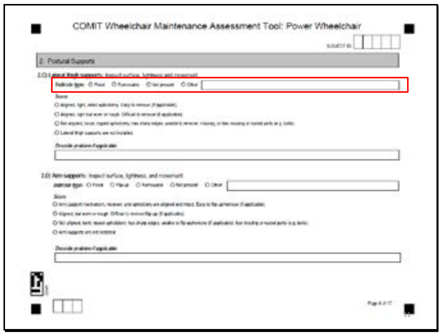
- "Removable" components can be removed without any tools.
- Moving components should be tested for correct movement by to moving it through its range of motion 3 times.
- If a part or nut/bolt falls off:
  - Put it back on and tighten with your hand.
  - Suggest that the user contact a wheelchair maintenance expert immediately unless that item is marked with an *.
  - Report it in the comment box that corresponds to that part on the W-MAT.
- **Do not perform maintenance on the WC.**

Fixed



Removable

10



COMIT Wheelchair Maintenance Assessment Tool: Power Wheelchair

2. Postural Supports

2.D) Arm supports: Inspect surface, tightness, and movement

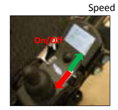
Describe problem if applicable

11

Familiarize yourself with how the PWC operates

- Identify how the PWC turns on/off
- Identify how the speed is regulated
- Identify how to toggle between power seat functions and speed modes (if applicable)
- **If in doubt, ask the user, he/she is the expert!**
- Record on page 1 the battery charge indicator level

Speed knobs



Speed buttons

12

Troubleshooting

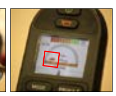
If the PWC is not responding as expected, for instance:

- Too slow
- Not moving

1) Check if the controller displays an error:
   - Read what it says and act accordingly
   - If you do not understand the error
     - Cycle the power on/off

2) If the error persists:
   - Make sure that the motor disengage lever(s) is engaged
   - Put the seating system back (or close to) neutral sitting
   - Ask the user





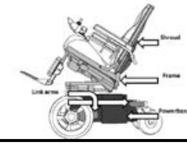

13

1. Frame and attachments

This section focuses on the frame and frame-related attachments.

Avoid performing any maintenance, including simple cleaning, removing debris, or tightening bolts.

Read items and their scoring on pages 3 and 4 in the W-MAT while reviewing this section.

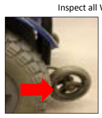


14

1.A) Encrusted debris: Foreign matter (e.g. dirt, hair, grime, mud) caught on or in the wheelchair.

- Free of encrusted debris : some dust/dirt acceptable
- Moderate encrusted debris: enough dirt for reasonably clear drawing
- Debris to a significant extent: enough to completely cover original color, e.g. mud
- Check if debris is caught in moving parts such as the casters or folding mechanisms

Inspect all WC surfaces for debris




15

1.A) Encrusted debris: scoring examples.

Select: Free of encrusted debris.

Select: Encrusted debris to moderate extent, but debris not caught in moving parts**.**
Describe problem if applicable: dirt on the battery shrouds (top); dirt on metal parts of the frame (bottom).

Select: Encrusted debris to severe extent or debris caught in moving parts or debris has bad odor.
Describe problem if applicable*:* Mud throughout the base and supports and has a muddy smell.

16

1.B) Anti-tip devices: Devices that limit the extent that the wheelchair can tip.

Anti-tip devices can be present in rear-wheel drive and front-wheel drive PWCs.

Anti-tip on a rear-wheel drive base

Anti-tip on a front-wheel drive base

Anti-tip devices **not** present: Mid-wheel drive base

17

1.B) Anti-tip devices: scoring examples.

- Inspect visually: the anti-tippers should be evenly spaced with respect to the ground and free of cracks, distortions, or other wear.
- Check if they are tight by wiggling.
- The wheels should turn, though they do not need to turn freely.

Select: Present and evenly spaced. Wheels turn. If applicable, wheels have sufficient tread/rubber. If spring loaded, springs are in good condition.

Select: Have bends, cracks, rust, or other wear, have wheels that do not run, missing on one side, or have damaged springs. ***Describe problem if applicable:*** Left anti-tip is missing (top). Rusted bolt on left anti-tip (bottom).

Select: Present with wheels that can run but not evenly spaced with respect to the ground or properly fastened. If applicable, wheels lack tread/rubber. ***Describe problem if applicable:*** wear and do not turn.

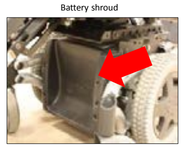
18

1.C) Shrouds: Protective plastic covers often on the powerbase and/or back of seat.

Wheel and battery shrouds are necessary to protect from dirt and moisture.

Wheel shroud

Battery shroud



19

1.C) Shrouds: scoring examples.

Inspect visually for shroud integrity: scratches, cracks, distortions, tightness.

Select: Present with no scratches, cracks, or distortions.

Select: Present with distortions or cracks or missing. ***Describe problem if applicable:*** missing wheel shroud (top picture).

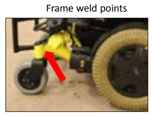
Select: Present with scratches or loose. ***Describe problem if applicable***: loose shroud on back.

Missing battery shroud (bottom picture)

20

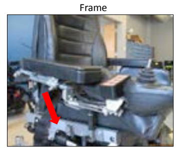
1.D) Frame/chassis/link arms: The underlying structure of the wheelchair.

Frame weld points



Link arm

Frame



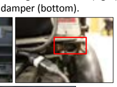
21

1.D) Frame/chassis/link arms: scoring examples.

- Inspect the welds, the painting, and identify rusted parts/bolts/nuts and cracks. Cracks often occur at or near weld points or holes.
- Activate the suspension by pushing down on different parts of the chair.
- Step back and look at the chair on a level surface to see if it looks uneven. This may indicate frame or suspension damage or misalignment. Do this without a user in the chair if possible.

Select: Scratches break through outer coating or paint on the frame or suspension springs. Link arms misaligned or lose. ***Describe problem if applicable:*** Right rear link arm has scratches that break through he paint.

Select: Rust, cracks, distortions, or sharp edges. Link arms bent or dented or oil comes out of the spring or damper. ***Describe problem if applicable:*** crack on left rear seat frame (Left); rusted bolt on right rear frame (right); rusted bolt and rust on damper (bottom).

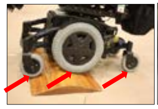


22

1.E) Suspension: Used to force link arms to ground.

- To evaluate suspension, the user needs to be on the PWC and drive it straight forward over a speed bump at comfortable speed.
- Inspect visually that oil does not come out of the springs/dampers.
- Identify squeaking sounds during the test. This may indicate lack of lubrication in the suspension.
- Listen for any clunks or other noises which may indicate component failures or damage.

Drive forward and check all wheels/casters



Suspension damper

Suspension springs

23

1.E) Suspension: scoring examples.

Select: At least three wheels remain on the test plane at all times.

24

Section 2: Postural supports

- This section contains many different postural support components which come in many different types.
- Most WC's will have some items marked "Not present" or "Not applicable" in this section.
- "Removable" components can be removed without any tools.
- Any component that is moved should be returned to its original position after testing.
- Do not readjust components that are adjustable.
- **Do not** tighten any loose components!
- Read items and scoring on pages 5 to 11 in the W-MAT while reviewing this section.

Example: swing-away trunk support assessed and returned to original position

2.A) Foot supports: Intended to contact and support the foot.

Flip-up two pieces

Flip-up one piece

26

2.A) Foot supports: scoring examples.

- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness/wear by hand.
- Wiggle the foot support and check whether it support moves w.r.t. the frame/lower leg support assembly.
- Inspect if fasteners (bolts, nuts, or rivets) have rust or are missing.

Select: Aligned, tight, intact surface. Easy to correctly flip-up (if applicable).

Select: Not aligned, loose, has sharp edges, unable to flip-up (if applicable), missing or has missing or rusted parts. ***Describe problem if applicable:*** Left foot support is missing.

Select: Aligned, tight, but worn or rough. Difficult to flip-up (if applicable. ***Describe problem if applicable:*** right foot support coating wore.

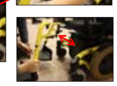
27

2.B) Lower leg (calf) supports : Intended to contact and support the lower leg.

Center mount w/LLS

Center mount w/o LLS

Swing away w/o LLS



Swing away LLF with LLS

28

2.B) Lower leg (calf) supports: scoring examples.

- Lower leg frames (LLFs) may or may not have a support (LLS) attached.
- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness/wear by hand.
- Wiggle the calf support and check whether it support moves w.r.t. the frame/lower leg support assembly.
- Check the tightness of the LLF w.r.t. the WC frame.
- Check the tightness of the and the LLS w.r.t. the LLF.
  - Movement on the direction of leg rest elevation is acceptable.
- Inspect if fasteners (bolts, nuts, or rivets) have rust or are missing.

Select: LSS is aligned, tight, and has intact upholstery/fabric (if applicable). LLF is tight and easy to swing away (if applicable).

Select: LLS is not aligned, loose, ripped upholstery, has sharp edges or LLF is unable swing-away/remove or missing or has missing or rusted parts

Describe problem if applicable:
Left LLS not aligned and lose.

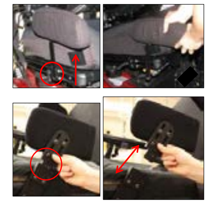
Select: LLS is aligned, tight, but worn or rough. LLF is difficult to flip-up (if applicable).
Describe problem if applicable:
Right LSS is worn.

29

2.C) Lateral thigh supports: Intended to contact and provide lateral support to the thighs.

Fixed lateral thigh supports

Removable supports



30

2.C) Lateral thigh supports: scoring examples.

- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness/wear by hand.
- Wiggle the thigh support and check whether the foot support moves.
- Inspect if fasteners (bolts, nuts, or rivets) have rust or missing.

Select: Aligned, tight, intact upholstery. Easy to remove (if applicable).

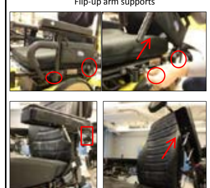
Select: Aligned, tight, but worn or rough. Difficult to remove if applicable. ***Describe problem if applicable:*** some roughness on right thigh support tube.

Select: Not aligned, loose, ripped upholstery, has sharp edges, unable to remove, missing, or has missing or rusted parts. ***Describe problem if applicable:*** rusted bolt and bracket (left); missing bolt (center); ripped upholstery (right).

31

2.D) Arm support: : Intended to contact and support the lower arm.

Flip-up arm supports



Removable arm support

32

2.D) Arm support: scoring examples.

- Visually inspect surfaces for damage or sharp edges before touching and check surface roughness by hand.
- Wiggle the arm support and check whether the arm support moves w.r.t. the frame.
- Check the arm support mechanisms and/or receivers, if applicable.
- Inspect if fasteners (bolts, nuts, or rivets) have rust or are missing.

Select: Arm support mechanism, receiver, and upholstery are aligned and intact. Easy to flip-up/remove (if applicable).

Select: Not aligned, bent, ripped upholstery, has sharp edges, unable to flip-up/remove (if applicable), has missing or rusted parts. ***Describe problem if applicable:*** on the left side ripped upholstery.

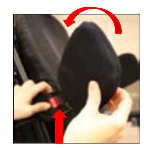
Select: Aligned, but worn or rough. Difficult to remove/flip-up (if applicable). ***Describe problem if applicable:*** on the left side rough upholstery l(top) and rough surface (bottom).

33

2. E) Trunk support: Postural device intended to contact the lateral side of the trunk.

Fixed trunk supports

Swing-away trunk support



34

2. E) Trunk support: scoring examples.

- Observe the bracket that attaches the support to the frame to see whether it is swing-away, removable, or fixed.
- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness by hand.
- Wiggle the trunk support and check whether it moves w.r.t. the frame.
- Inspect if fasteners (bolts, nuts, or rivets) have rust or are missing.

Select: Aligned, tight, intact upholstery. Easy to correctly swing-away/remove.

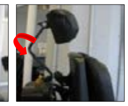
Select: Aligned, tight but worn or rough. Difficult to swing-away/remove. ***Describe problem if applicable:*** left difficult to swing away.

Select: Not aligned, loose, ripped upholstery, has sharp edges, unable to swing-away/remove, or has missing or rusted parts. ***Describe problem if applicable:*** left trunk support is not aligned and has missing bolt.

35

2.F) Head support: Intended to contact and support the head.

Flip-down head support



Fixed

Removable head support

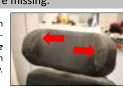
36

2.F) Head support: Intended to contact and support the head.

- Observe the bracket that attaches the support to the back support to see whether it is flip-down, removable, or fixed.
- Visually inspect surfaces for damage or sharp edges before touching.
- Check surface roughness by hand.
- Wiggle the trunk support and check whether it moves w.r.t. the frame.
- Inspect if fasteners (bolts, nuts, or rivets) have rust or are missing.

Select: Aligned, tight, intact upholstery. Easy to correctly flip-down/remove.

Select: Aligned, tight, but worn or rough. Difficult to flip-down/remove. ***Describe problem if applicable:*** worn upholstery.



Select: Not aligned, bent, ripped upholstery, has sharp edges, unable to flip-down/remove (if applicable), has missing or rusted parts. ***Describe problem if applicable:*** ripped upholstery and covered with tape.

2. G) Seat belt: Adjustable belt or strap intended to position or support the occupant.

- Inspect that buckle is working.
- Inspect that hardware is tightly attached to the frame.
- Inspect that the belt is not frayed.

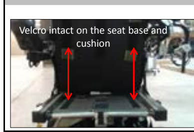
Select: Belt buckles and releases easily, length is easily adjusted.

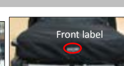
Select: Difficult to adjust length or buckle belt. ***Describe problem if applicable:*** difficult to slide belt through buckle.

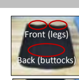
Select: Belt is damaged, cannot bet adjusted or buckled. ***Describe problem if applicable:*** belt is loose.

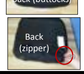
2.H) Cushion placement: Seat cushion should be oriented, placed, and secured appropriately.

- Without moving the cushion, look for a "Front/Back" label.
- Cushions often have a contour towards the back for the buttocks and two leg contours near the front.
- Zippers are also typically towards the rear.
- Cushions may have a handle on the front.
- Remove the cushion.
- The cushion should be secured in place by velcro or similar fasteners.
- Put it back PROPERLY



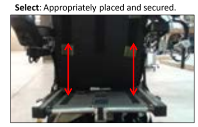






2.H) Cushion placement: scoring examples.

Select: Appropriately placed and secured.



Select: Inappropriately placed. ***Describe problem if applicable:*** the front of the cushion is to the side.

Select: Appropriately placed but inappropriately secured. ***Describe problem if applicable:*** the velcro in the cushion does not attach to the velcro on the seat.

40

2.I) Cushion cover: Protective cover for the seat cushion.

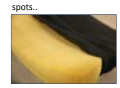
- Inspect the outside of the cover.
- Remove the cover (if applicable).
  - **Stop** if the cover is damaged or material begins to fall out.
  - Put the cover back **properly.**
- Check for holes, worn spots, dirt, odor, and zipper problems.
- If in doubt about whether a hole is small or large, assume that it is large.

Removable cover | Fixed cover | Cover not present

41

2.I) Cushion cover: scoring examples.

Select: Fits tightly, clean, with no holes or worn spots..



Select: Worn spots, dirt, or small holes, but no cracks. ***Describe problem if applicable:*** dirt (top); small hole (bottom).

Select: Very dirty or has a bad odor, larger holes, or cracks. ***Describe problem if applicable:*** deteriorating cover (top); large holes (center and bottom).

42

2.J) Seat cushion: types of cushions

43

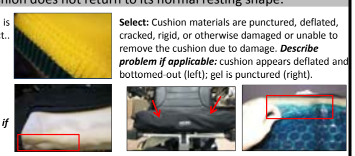
2.J) Seat cushion: scoring examples.

- Inspect visually
- Remove cover if possible
- Inspect that the material is intact, the foam does not chip, the gel allows you to move it, it holds air, and it does not appear "bottomed-out".
  - Cushion is fully compressed when the user sat on it.
  - Or cushion does not return to its normal resting shape.

Select: Cushion is intact..

Select: Cushion presents fair signs of deterioration.. ***Describe problem if applicable:*** foam deterioration.

Select: Cushion materials are punctured, deflated, cracked, rigid, or otherwise damaged or unable to remove the cushion due to damage. ***Describe problem if applicable:*** cushion appears deflated and bottomed-out (left); gel is punctured (right).

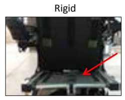


2.K) Seat base: Surface of the seat that is covered with a cushion.

- Inspect visually that there are no sharp edges/cracks.
- Wiggle to check the seat base is tightly secured
- Inspect for rust, cracks, and distortions.

Captain style

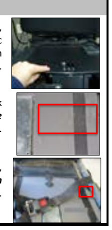
Rigid



Select: Base is tight with no cracks, distortions or sharp edge. May have aesthetic scratches that do not break through paint/outer coating.

Select: tight and has scratches that break through paint/out coating.. ***Describe problem if present:*** paint scratches.

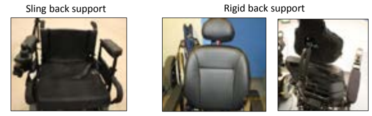
Select: Loose, has larger cracks, distortions rust.. ***Describe problem if present:*** rusted bolt.



2.L) Back support: Rigid or sling surface that supports the user's back.

- Inspect both the back support base and the back support attachment hardware.
- Inspect visually for cracks and sharp edges before touching.
- If rigid, also look for scratches that break through paint/coating.
  - Remove cushion if possible.
- If sling, look for sagging, rips, or tearing in the upholstery.
- Wiggle and check that it is not loose.

Sling back support | Rigid back support



46

2.L) Back support: scoring examples.

Select: Base is tight with no cracks, distortions or sharp edges. May have aesthetic scratches that do not break through pain.

Select: Upholstery sags but has no rips or tearing. ***Describe problem if applicable:*** sagging in top part.

Select: Loose or has larger cracks, distortions or sharp edges.
Describe problem if applicable: Loose, missing nut on bolt.

47

2.M) Back support cover: Covers back support cushion.

- Only applicable to rigid back support. If sling, score NA.
- Inspect the outside of the cover.
- Remove the cover (if applicable).
  - **Stop** if the cover is damaged or material begins to fall out.
  - Put the cover back **properly.**
- Check for holes, worn spots, dirt, odor, and zipper problems.
- If in doubt about whether a hole is small or large, assume that it is large.

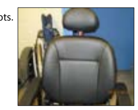
Removable cover (velcro left, zipper right)

Fixed

48

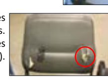
2.M) Back support cover: scoring examples.

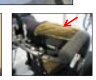
Select: Tight, clean, with no holes or worn spots.



Select: Tight, easy to align, Has worn spots, small holes or dirt.
Describe problems if applicable: dirt in the bottom of cover.

Select: Very dirty or has bad odor, large holes or cracks.
Describe problem if applicable: large holes (left); foam in cover cracked (right).

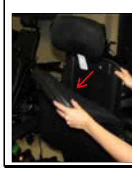




2.N) Back support cushion: Contacts and supports the posterior surface of trunk and its placed on the back support base

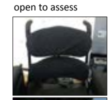
- This item is only applicable for WCs with **rigid** back supports.
- Inspect visually.
- Remove cover if possible
- Inspect that the material is intact, the foam does not chip, the gel allows you to move it, it holds air, and it does not appear "bottomed-out".

Remove cushion to assess when applicable



Air back cushion – open to assess

Foam back cushion – open to assess

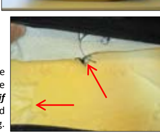


2.N) Back support cushion: scoring examples.

Select: Cushion is intact, gel can be kneaded easily, holds air, foam is in good condition (if applicable).

Select: Cushion presents fair signs of deterioration, some rigidity in the gel or foam starting to de-color or chip. ***Describe problems if applicable:*** foam started to de-color and has some rigidity.

Select: Cushion materials are punctured, cracked, rigid or otherwise damaged. ***Describe problems if applicable:*** cushion is cracked and foam layer is chipping.



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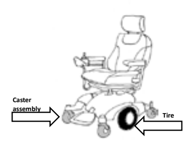
3. Wheels and Casters

- Avoid performing any maintenance, including inflating tires.
- Read items and scoring on pages 12 and 13 in the W-MAT while reviewing this section.



52

3.A) Tires: Outermost part of the wheel.

- Identify is solid of pneumatic- if pneumatic check inflation by pressing your thumb against the tire. It should deflect no more than 5mm (about the height of three stacked pennies).
- Inspect visually for wear, bulges, cracks.

Pneumatic tire

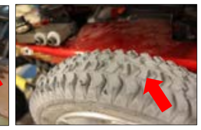
Solid tire

53

3.A) Tires: scoring examples.

Select: Wheels are properly inflated and have sufficient tread.

Select: insufficient or uneven tread. ***Describe problems if applicable:*** insufficient tread (left); uneven tread (right).



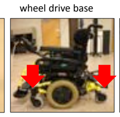
54

3.B) Front caster assemblies and 3.C) Rear caster assemblies: Caster wheel, axle, fork, stem, stem housing, bearings, and tires.

- Check the caster stem is perpendicular to the floor,
- Listen that there is no clicking sound when the wheelchair moves (bearing problem)
- Check the caster for wear
- Check caster stem cap
- Ask the user to drive and check for caster flutter (rapid back and forth movement).

Front casters on rear-wheel drive base

Front and rear casters on mid-wheel drive base



Rear casters on front-wheel drive base

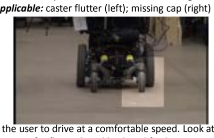
55

3.B) Front caster assemblies and 3.C) Rear caster assemblies are scored using the same rubric: scoring examples

Select: Swivel with stems perpendicular to the floor. Have tightly sealed caps. Wheels spin freely.

Select: Loose caps or wheels spin freely with clicking or insufficient or uneven tread. ***Describe problems if applicable:*** uneven tread.

Select: No caps, do not swivel, or stems not perpendicular to floor. Wheels do not spin freely or caster flutter is present or has cracks, flattening, or bald tread or has bulges. ***Describe problems if applicable:*** caster flutter (left); missing cap (right)



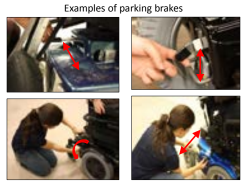
Ask the user to drive at a comfortable speed. Look at the casters for flutter (rapid back and forth movement).

56

3.D) Parking brake: When disengaged, the wheelchair should be able to be moved by pushing it. When engaged, the wheels should not turn when pushed, even if the wheelchair skids.

- There are many different types of parking brakes.
- Check if there are two or one lever. If two, disengage/engage both for testing.

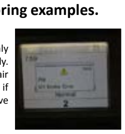
Examples of parking brakes



57

3.D) Parking brake: scoring examples.

Select: Lever stays in place firmly and functions correctly. When disengaged, the wheelchair controller should display an error if attempted to drive



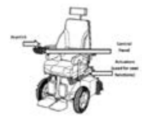
Select: Lever does not stay firmly in place and may be activated unintentionally. ***Describe problems if applicable:*** right lever does not stay firmly in place.

Select: Lever does not function correctly. ***Describe problems if applicable:*** the left lever pulls out but does not disengage the motor. The chair does not move if manually pushed when the lever is out.

58

4. Interface and Electronics

- Evaluate the functionality of the wheelchair controller system
- **Do not** perform any maintenance on the wheelchair if problems are found.
- Read items and scoring on pages 14 and 17 in the W-MAT while reviewing this section.



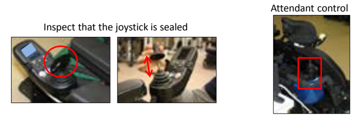
59

4.A) Control device: any device that controls movement of the wheelchair (e.g joystick).

- **DO NOT** tighten nuts/bolts if found lose.
- Apply the same to an attendant control joystick if present.

Inspect that the joystick is sealed

Attendant control



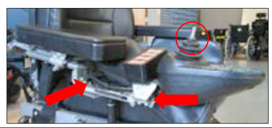
Inspect that the controller is not lose, there are no missing bolts, and can be retracted if applicable

4.A) Control device: scoring examples.

Select: Joystick is well sealed and moves easily. Tight and aligned to wheelchair correctly.

Select: Joystick is somewhat loose or misaligned. ***Describe problems if applicable:*** joystick loose.

Select: Joystick is insufficiently sealed or plastic cap missing, does not move easily or is extremely loose. ***Describe problems if applicable:*** joystick is not sealed and all the control device is very loose.



4.B) Control panel: Buttons and indicators used to convey information and operate the wheelchair.

- Test that all buttons/knob are working repeatedly.
- If unsure of the function of a buttons ask the user!

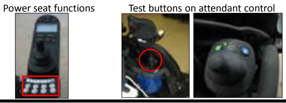
On/off button and horn button

Speed knob

Proportional joystick

Power seat functions

Test buttons on attendant control



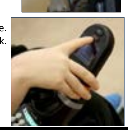
These are for demonstration purpose and may vary depending on the wheelchair!

4.B) Control panel: scoring examples.

Select: All inputs and outputs function properly.

Select: Inputs do not always activate. ***Describe problems if applicable:*** need to push hard the "mode" button several times for it to cycle through options.

Select: Inputs and outputs do not always activate. ***Describe problems if applicable:*** horn does not work.

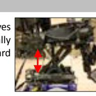


63

Power seat functions change the position of the seat and include:4.C) Seat elevation mechanism, 4.D) Recline, 4.E) Elevating leg support, 4.F) Tilt.

- Test full range evaluate whether the system gets stuck, jerks or makes unexpected noises (grinding, squeaking, clanking).
- Put the wheelchair back in the neutral position after testing the seat functions.
- If unsure if the wheelchair has the power seat function, ask the users.
- Be careful with items that might poke the frame or interfere with movement (e.g. backpacks).

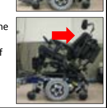
4.C) Seat elevation: moves the seat vertically upward/downward



4.D) Recline: changes angle between the bottom and back of seat.

4.E) Elevating leg support: Changes angle of leg supports relative to the seat

4.F) Tilt: Changes the angle between the bottom and back of the seat.

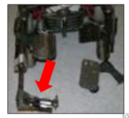


Power seat function scoring examples:

For recline select: Functions smoothly.

For seat elevation select: functions unevenly or with grinding noises. ***Describe problems if applicable:*** grinding noise when highest elevation is reached.

Select: Does not function due to mechanical problems. ***Describe problems if applicable:*** only right leg support elevates.



65

4.G) Motor and gear boxes: Provide propulsion for the wheelchair.

- Do not confuse with the motor of the power seat functions!
- Ask the user to drive at a moderate speed.
- Listen to the motor.
- Note grinding or scraping noises.
- If unsure ask the user if the noise you identify has always been present.

Listen carefully

66

4.H) Alignment: The control device should point exactly straight for testing.

- Ask the user to drive in a straight line at a moderate indoor speed.
- View from the back.
- Note veering to the side.
- If veering is noted, ask the user for permission to drive the PWC.
- Stand by the controller's side and drive in a straight line at a moderate indoor speed.
- Note veering to the side.

67

4.I) Running brakes: Means of slowing/stopping the wheelchair.

- Ask the user to drive straight at a moderate speed and ask them to release the joystick.
- Note if there are jerky movements.
- Note if the brakes make noises:
  - When the joystick is released there should be only one "click" sound.
  - Note if the brakes make additional noises.
- Note if the chair takes a very long time to come to a complete stop, which could pose a safety risk for the user.

68

4.J) Batteries: Power the wheelchair.

- Ask the user if the wheelchair is holding charge as when it was new. If the answer is yes, **select: :** The batteries hold adequate charge for a normal day.
- Ask if the battery lasts throughout the entire day without charging. if the answer is no ask how many times it needs to be charged during the day.
  - **If the answer is one time select:** Batteries require on recharging during a normal day.
  - **If the answer is more than one time select:** Batteries require significant recharging during a normal day; user has to carry the charger all the time.
- Refer to the first page on the W-MAT where the battery level was recorded.
  - Note if during testing the battery charge indicator reduced. If so, **Select:** Batteries require significant recharging during a normal day; user has to carry the charger all the time. ***Describe problem if applicable:*** battery charge significantly reduced during testing.

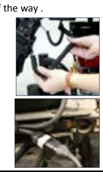
Battery level indicators

69

4.K) Cables and connectors: power wheelchairs often have cables running near the control device, seating system, and powerbase.

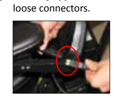
- Check that cables are well secured and out of the way of moving parts.
- Check that all layers of insulation are intact.
- Check that all connectors are tight.

Select: Insulation undamaged, cables are secured to chair and out of the way .



Select: Outer insulation has cracks, cables secured to chair. ***Describe problems if applicable:*** outer insulation not intact.

Select: Inner insulation is cracked or cut or cables are not secured. Connectors are loose. ***Describe problems if applicable:*** loose connectors.



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4.L) Charging socket: This socket allows a charger to connect to the wheelchair.

- Charging sockets may be in the controller box and/or the base.
- Check it is appearance and cleanliness.

Select: Functional, free of debris..

Select: Functional, but has some debris. ***Describe problems if applicable:*** some debris

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APPENDIX I. WHEELCHAIR REPAIRS AND ADVERSE CONSEQUENCES QUESTIONS

The next section will ask about any repairs in the past 6 months on the wheelchair you use most often: ***<u>This includes anything that you or someone else needed to fix for your wheelchair to work properly, such as pumping up a flat tire, tightening a bolt or screw, having the frame repaired, or replacing a worn-out part such as a cushion.</u>***

5. In the past 6 months, how many times did you have a worn out tire or tube on any wheel (*wheels or casters*) on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what wheels and casters are, pictures can be found here:
For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/wheels.html
For power wheelchairs: **http://www.upmc-sci.pitt.edu/comit-pwc/wheels.html**

If answer to 5 ≥1 ask 5.1 and 5.2:

5.1 Did you experience any of the following consequences as a result of the worn out tires or tubes (wheels or casters)? **(Select all that apply)**

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

5.2 Was the repair(s) of the worn out tires or tubes of any wheel (*wheels or casters*) completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 5.2 is 0 or 1 ask 5.3:

5.3 Were any repairs of the tires or tubes of any wheel (*wheels or casters*) attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 5.2 is 1 or 2 ask 5.4:

5.4 Who completed the repair(s) of the *worn out tires or tubes of any wheel (wheels or casters)*? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

8. In the past 6 months, how many times did you have a broken caster assembly (*includes caster fork or stem*) on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what caster assembly is, pictures can be found here: **http://www.upmc-sci.pitt.edu/comit-pwc/wheels.html**

If answer to 8 ≥1 ask 8.1 AND 8.2:

8.1 Did you experience any of the following consequences as a result of the broken caster assembly *(includes caster fork and stem)*? **(Select all that apply)**

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

8.2 Was the repair(s) of the *broken caster assembly* (*includes caster fork or stem*) completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 8.2 is 0 or 1 ask 8.3:

5.3 Were any repairs of the *broken caster assembly* (*includes caster fork or stem*) attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 8.2 is 1 or 2 ask 8.4:

8.4 Who completed the repair(s) of the *broken caster assembly* (*includes caster fork or stem*)? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

9. In the past 6 months, how many times did you have a broken wheel or caster bearings on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what wheel or caster bearings are, pictures can be found here:

For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/wheels.html

For power wheelchairs: http://www.upmc-sci.pitt.edu/comit-pwc/wheels.html

If answer to 9 ≥1 ask 9.1 and 9.2:

9.1 Did you experience any of the following consequences as a result of the *broken wheel and/or caster bearings*?

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

9.2 Was the repair(s) of the *broken wheel and/or caster bearings* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 9.2 is 0 or 1 ask 9.3:

9.3 Were any repairs of the *broken wheel and/or caster bearings* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 9.2 is 1 or 2 ask 9.4:

9.4 Who completed the repair(s) of the *broken wheel and/or caster bearing(s)*?

(Select all that apply)

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

10. In the past 6 months, how many times did you have a broken wheelchair frame on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what the frame is, pictures can be found here**:**

For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/frame.html

For power wheelchairs: http://www.upmc-sci.pitt.edu/comit-pwc/frame.html

If answer to 10 ≥1 ask 10.1 AND 10.2:

10.1 Did you experience any of the following consequences as a result of the *broken wheelchair frame*?

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

10.2 Was the repair(s) of the *broken wheelchair frame* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 10.2 is 0 or 1 ask 10.3:

10.3 Were any repairs of the *broken wheelchair frame* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 10.2 is 1 or 2 ask 10.4:

10.4 Who completed the repair(s) of the *broken wheelchair frame*? (Select all that apply)

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

11. In the past 6 months, how many times did you have a loose positioning support(s) (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)* on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what positioning supports are, pictures can be found here:

For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/positioning.html

For power wheelchairs: **http://www.upmc-sci.pitt.edu/comit-pwc/positioning.html**

If answer 11 ≥1 ask 11.1 AND 11.2:

11.1 Did you experience any of the following consequences as a result of the l*oose positioning support(s)* (*includes foot supports*, *leg supports*, *arm supports*, *head supports*, *lateral supports*, *and/or trunk supports)*?.

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

11.2 Was the repair(s) of the l*oose positioning support(s)* (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 11.2 is 0 or 1 ask 11.3:

11.3 Were any repairs of the l*oose positioning support(s)* (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 11.2 is 1 or 2 ask 11.4:

11.4 Wh0 completed the repair(s) of the l*oose positioning support(s)* (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)*?

(Select all that apply)

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ________________________

12. In the past 6 months, how many times did you have a worn out positioning support(s) (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)* on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what positioning supports are, pictures can be found here:

For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/positioning.html

For power wheelchairs: **http://www.upmc-sci.pitt.edu/comit-pwc/positioning.html**

If answer to 12≥1 ask 12.1 AND 12.2:

12.1 Did you experience any of the following consequences as a result of the *worn out positioning support(s)* (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)*?

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

12.2 Was the repair(s) of the *worn out positioning support(s)* (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 12.2 is 0 or 1 ask 12.3:

12.3 Were any repairs of the *worn out positioning support(s)* (*includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 12.2 is 1 or 2 ask 12.4:

12.4 Who completed the repair(s) of the *worn out positioning support(s) (includes foot supports, leg supports, arm supports, head supports, lateral supports, and/or trunk supports)*? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

13. In the past 6 months, how many times did you have worn out seating components (*includes sagging seat and back upholstery, or worn out seat or back cushion*) on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what seating components are, pictures can be found here:

For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/seating.html

For power wheelchairs: **http://www.upmc-sci.pitt.edu/comit-pwc/seating.html**

If answer 13≥1 ask 13.1 AND 13.2:

13.1 Did you experience any of the following consequences as a result of these *worn out seating components (includes sagging seat and back upholstery, or worn out seat or back cushion)*?

(Select all that apply)

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

13.2 Was the repair(s) of the *worn out seating components (includes sagging seat and back upholstery, or worn out seat or back cushion)* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 13.2 is 0 or 1 ask 13.3:

13.3 Were any repairs of the *worn out seating components (includes sagging seat and back upholstery, or worn out seat or back cushion)* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 13.2 is 1 or 2 ask 13.4:

13.4 Who completed the repairs(s) of the *worn out seating components (includes sagging seat and back upholstery, or worn out seat or back cushion)*?

(Select all that apply)

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

14. In the past 6 months, how many times did you have a broken seating components (*includes a crack in the seat base or back support or hardware or punctured air cushion*) on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what seating components are, pictures can be found here:

For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/seating.html

For power wheelchairs: **http://www.upmc-sci.pitt.edu/comit-pwc/seating.html**

If answer to 14 ≥1 ask 14.1 AND 14.2:

14.1 Did you experience any of the following consequences as a result of the *broken seating components (includes a crack in the seat base or back support or hardware or punctured air cushion)*?.

(Select all that apply)

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

14.2 Was the repair(s) of the *broken seating components (includes a crack in the seat base or back support or hardware or punctured air cushion)* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 14.2 is 0 or 1 ask 14.3:

14.3 Were any repairs of the *broken seating components (includes a crack in the seat base or back support or hardware or punctured air cushion)* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 14.2 is 1 or 2 ask 14.4:

14.4 Who completed the repair(s) of the *broken seating components (includes a crack in the seat base or back support or hardware or punctured air cushion)*? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

15. In the past 6 months, how many times did you have a broken suspension elements (*includes dampers and springs)* on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what suspension elements are, pictures can be found here:

For manual wheelchairs: http://www.upmc-sci.pitt.edu/comit-mwc/suspension.html

For power wheelchairs: http://www.upmc-sci.pitt.edu/comit-pwc/suspension.html

If answer to 15 ≥1 ask 15.1 AND 15.2:

15.1 Did you experience any of the following consequences as a result of the *broken suspension elements (includes dampers and springs)*? **(Select all that apply)**

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

15.2 Was the repair(s) of the *broken suspension elements (includes dampers and springs)* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 15.2 is 0 or 1 ask 15.3:

15.3 Were any repairs of the *broken suspension elements (includes dampers and springs)* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 15.2 is 1 or 2 ask 15.4:

15.4 Who completed the *broken suspension elements (includes dampers and springs)* completed?

(Select all that apply)

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

QUESTIONS 16 to 19 ONLY APPLY FOR POWER WHEELCHAIR USERS

16 In the past 6 months, how many times did you have a broken controller box on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what controller box is, pictures can be found here:

http://www.upmc-sci.pitt.edu/comit-pwc/controller.html

If answer 16 ≥1 ask 16.1 and 16.2:

16.1 Did you experience any of the following consequences as a result of the *broken controller box* ?.

(Select all that apply)

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

16.2 Was the repair(s) of *broken controller box* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 16.2 is 0 or 1 ask 16.3:

16.3 Were any repairs of the *broken controlle)* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 16.2 is 1 or 2 ask 16.4:

16.4 Who completed the *broken controller box* completed? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

17. In the past 6 months, how many times did you have a loose controller box on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what controller box is, pictures can be found here: **http://www.upmc-sci.pitt.edu/comit-pwc/controller.html**

If answer to 17≥1 ask 17.1:

17.1 Did you experience any of the following consequences as a result of the l*oose controller box* ?.

(Select all that apply)

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

17.2 Was the repair(s) of the l*oose controller box* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 17.2 is 0 or 1 ask 17.3:

17.3 Were any repairs of the l*oose controller box* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 17.2 is 1 or 2 ask 17.4:

17.4 Who completed the l*oose controller box* completed? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ________________________

18. In the past 6 months, how many times did you have a battery that would not hold a charge on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If answer 18≥1 ask 18.1 and 18.2:

18.1 Did you experience any of the following consequences as a result of the *battery not holding a charge*?

(Select all that apply)

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

18.2 Was the repair(s) of the *batteries would not hold a charge* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 18.2 is 0 or 1 ask 18.3:

18.3 Were any repairs of the *battery that would not hold a charge* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 18.2 is 1 or 2 ask 18.4:

18.4 Who completed the *battery that would not hold a charge* completed? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

19. In the past 6 months, how many times did you have a broken power seat function(s) (*includes seat elevation, elevating leg rest, tilt, recline, and standing)* on your wheelchair that needed to be repaired?

☐ Never ☐ 1 time ☐ 2 times ☐ 3 or more times ☐ I do not remember

If you are not familiar with what power seat functions, pictures can be found here: **http://www.upmc-sci.pitt.edu/comit-pwc/powerseat.html**

If answer 19 ≥1 ask 19.1 and 19.2:

19.1 Did you experience any of the following consequences as a result of the *broken power seat function(s) (includes seat elevation, elevating legrests, tilt, recline, and standing)*?

(Select all that apply).

☐ 0 No consequences occurred due to this breakdown.

☐ 1 I have been stranded (either at home or away from home) because of this wheelchair breakdown.

☐ 2 I have been injured because of this wheelchair breakdown.

☐ 3 I have missed work or school because of this wheelchair breakdown.

☐ 4 I have missed medical appointments because of this wheelchair breakdown.

19.2 Was the repair(s) of the *broken power seat function(s) (includes seat elevation, elevating legrests, tilt, recline, and standing)* completed?

☐ 0 No repair completed

☐ 1 Some but not all of the repairs were completed

☐ 2 All the repairs were completed

☐ 3 I do not remember

If answer to 19.2 is 0 or 1 ask 19.3:

19.3 Were any repairs of the *broken power seat function(s) (includes seat elevation, elevating legrests, tilt, recline, and standing)* attempted but unsuccessful?

☐ No, repair was not attempted.

☐ Yes, the vendor was contacted but did not complete the repair.

☐ Yes, myself or my family member attempted repair but could not complete it.

☐ Yes, but insurance would not provide coverage for repair

If answer to 19.2 is 1 or 2, answer 19.4:

19.4 Who completed the repair(s) of the *broken power seat function(s) (includes seat elevation, elevating legrests, tilt, recline, and standing)* completed? **(Select all that apply)**

☐ 1 Repairs were completed by myself or a family member.

☐ 2 Repairs were completed by a wheelchair vendor.

☐ 3 Other ______________________

APPENDIX J. WMT-Q ITEM-BY-ITEM PER GROUP BY TIME

Table 39. WMT-Q capacity and performance item-by-item results at baseline and follow up for participants in the training and waitlist group.

Do you know how to...	Group	Time (n)	Capacity (yes)	% who performed the maintenance task						
				Daily	Weekly	Monthly	Quarterly	Yearly	Never	Miss.
Wipe down the wheelchair and cushion	W	BL (11)	90.9%	9.1%	63.6%	18.2%	0.0%	0.0%	0.0%	0.0%
		6 mo FU (8)	87.5%	25.0%	12.5%	37.5%	0.0%	0.0%	12.5%	0.0%
	T	BL (11)	90.9%	27.3%	27.3%	18.2%	18.2%	0.0%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	100.0%	44.4%	33.3%	11.1%	11.1%	0.0%	0.0%	0.0%
Check the pressure in your tires and inflate them	W	BL (6)	16.7%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		6 mo FU (2)	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%
	T	BL (3)	33.3%	0.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%
		1 mo FU (3)	66.7%							
		6 mo FU (2)	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Check postural supports are working properly and do not need adjustment or maintenance	W	BL (11)	72.7%	9.1%	27.3%	27.3%	0.0%	0.0%	9.1%	0.0%
		6 mo FU (7)	57.1%	14.3%	14.3%	14.3%	0.0%	0.0%	14.3%	0.0%
	T	BL (11)	72.7%	18.2%	9.1%	36.4%	0.0%	9.1%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	100.0%	66.7%	22.2%	11.1%	0.0%	0.0%	0.0%	0.0%

Table 39 (continued)

Remove dirt and lint from the caster axles	W	BL (11)	27.3%	0.0%	9.1%	0.0%	0.0%	0.0%	18.2%	0.0%
		6 mo FU (8)	62.5%	0.0%	12.5%	12.5%	0.0%	0.0%	37.5%	0.0%
	T	BL (8)	25.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%
		1 mo FU (12)	91.7%							
		6 mo FU (7)	85.7%	0.0%	0.0%	28.6%	42.9%	14.3%	0.0%	0.0%
Clean the power seat function mechanisms and tracks	W	BL (10)	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%
		6 mo FU (6)	33.3%	0.0%	0.0%	16.7%	0.0%	0.0%	16.7%	0.0%
	T	BL (10)	30.0%	10.0%	10.0%	10.0%	0.0%	0.0%	0.0%	0.0%
		1 mo FU (12)	83.3%							
		6 mo FU (9)	66.7%	11.1%	11.1%	11.1%	22.2%	11.1%	0.0%	0.0%
Check that the electrical connections are firmly in place	W	BL (11)	27.3%	0.0%	0.0%	0.0%	9.1%	0.0%	18.2%	0.0%
		6 mo FU (7)	57.1%	14.3%	0.0%	14.3%	14.3%	0.0%	14.3%	0.0%
	T	BL (11)	45.5%	40.0%	0.0%	0.0%	40.0%	20.0%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	77.8%	33.3%	22.2%	11.1%	11.1%	0.0%	0.0%	0.0%
Check that all the wiring is safe and not caught	W	BL (11)	27.3%	0.0%	9.1%	9.1%	0.0%	0.0%	9.1%	0.0%
		6 mo FU (7)	57.1%	28.6%	0.0%	14.3%	0.0%	0.0%	14.3%	0.0%
	T	BL (11)	54.5%	18.2%	0.0%	0.0%	0.0%	27.3%	9.1%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	100.0%	33.3%	11.1%	22.2%	33.3%	0.0%	0.0%	0.0%

Table 39 (continued)

Contact a wheelchair maintenance expert	W	BL (11)	90.9%	0.0%	0.0%	0.0%	36.4%	54.5%	0.0%	0.0%
		6 mo FU (8)	87.5%	0.0%	0.0%	0.0%	50.0%	25.0%	12.5%	0.0%
	T	BL (11)	90.9%	0.0%	9.1%	9.1%	27.3%	36.4%	9.1%	0.0%
		1 mo FU (12)	91.7%							
		6 mo FU (9)	100.0%	0.0%	0.0%	0.0%	44.4%	55.6%	0.0%	0.0%
Check if the tires, casters, and anti-tip wheels are in need of repair or replacement	W	BL (11)	63.6%	0.0%	9.1%	27.3%	18.2%	0.0%	9.1%	0.0%
		6 mo FU (7)	57.1%	0.0%	28.6%	14.3%	0.0%	0.0%	14.3%	0.0%
	T	BL (11)	45.5%	18.2%	9.1%	0.0%	9.1%	9.1%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	77.8%	22.2%	11.1%	22.2%	11.1%	11.1%	0.0%	0.0%
Check the casters for flutter	W	BL (11)	36.4%	9.1%	9.1%	0.0%	9.1%	0.0%	9.1%	0.0%
		6 mo FU (8)	37.5%	0.0%	0.0%	25.0%	0.0%	0.0%	12.5%	0.0%
	T	BL (8)	25.0%	12.5%	0.0%	0.0%	0.0%	0.0%	12.5%	0.0%
		1 mo FU (12)	83.3%							
		6 mo FU (9)	77.8%	22.2%	0.0%	22.2%	11.1%	11.1%	11.1%	0.0%
Check if cushion and cover are in need of repair/replacement	W	BL (11)	90.9%	18.2%	27.3%	27.3%	18.2%	0.0%	0.0%	0.0%
		6 mo FU (8)	75.0%	12.5%	25.0%	25.0%	0.0%	12.5%	0.0%	0.0%
	T	BL (11)	63.6%	36.4%	18.2%	0.0%	9.1%	0.0%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	100.0%	33.3%	11.1%	11.1%	11.1%	11.1%	0.0%	0.0%

Table 39 (continued)

Check if the upholstery is in need of repair/replacement	W	BL (11)	72.7%	9.1%	0.0%	36.4%	18.2%	0.0%	0.0%	0.0%
		6 mo FU (8)	50.0%	12.5%	12.5%	25.0%	0.0%	0.0%	0.0%	0.0%
	T	BL (11)	54.5%	27.3%	9.1%	9.1%	9.1%	0.0%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	88.9%	33.3%	33.3%	11.1%	11.1%	0.0%	0.0%	0.0%
Check if the joystick and rubber boot are in need of repair/replacement	W	BL (11)	72.7%	45.5%	0.0%	18.2%	0.0%	0.0%	9.1%	0.0%
		6 mo FU (8)	50.0%	12.5%	0.0%	12.5%	0.0%	0.0%	25.0%	0.0%
	T	BL (11)	36.4%	27.3%	0.0%	9.1%	0.0%	0.0%	0.0%	0.0%
		1 mo FU (12)	91.7%							
		6 mo FU (9)	88.9%	66.7%	0.0%	0.0%	22.2%	0.0%	0.0%	0.0%
Check if the seat-positioning strap is in need of repair/replacement	W	BL (10)	50.0%	20.0%	10.0%	10.0%	10.0%	0.0%	0.0%	0.0%
		6 mo FU (8)	25.0%	0.0%	0.0%	12.5%	0.0%	0.0%	12.5%	0.0%
	T	BL (10)	60.0%	30.0%	0.0%	0.0%	10.0%	0.0%	10.0%	10.0%
		1 mo FU (11)	90.9%							
		6 mo FU (8)	75.0%	25.0%	25.0%	0.0%	25.0%	0.0%	0.0%	0.0%
Check if the battery charger cable in need of repair/replacement	W	BL (11)	45.5%	27.3%	0.0%	18.2%	0.0%	0.0%	0.0%	0.0%
		6 mo FU (6)	33.3%	16.7%	0.0%	12.5%	0.0%	0.0%	0.0%	0.0%
	T	BL (11)	72.7%	36.4%	18.2%	9.1%	0.0%	0.0%	9.1%	0.0%
		1 mo FU (12)	91.7%							
		6 mo FU (9)	77.8%	55.6%	22.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Check if the brakes are working properly or in need of repair/replacement	W	BL (10)	20.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		6 mo FU (7)	71.4%	42.9%	0.0%	14.3%	0.0%	0.0%	14.3%	0.0%
	T	BL (5)	50.0%	37.5%	0.0%	0.0%	12.5%	0.0%	0.0%	0.0%
		1 mo FU (9)	75.0%							
		6 mo FU (5)	83.3%	66.7%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 39 (continued)

Check if the plastic shrouds are in need of repair/replacement	W	BL (11)	45.5%	9.1%	9.1%	27.3%	0.0%	0.0%	0.0%	0.0%
		6 mo FU (7)	42.9%	0.0%	14.3%	14.3%	100.0%	0.0%	0.0%	0.0%
	T	BL (8)	37.5%	25.0%	0.0%	0.0%	12.5%	0.0%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (8)	87.5%	37.5%	0.0%	25.0%	25.0%	0.0%	0.0%	0.0%
Check if the motor is working properly	W	BL (11)	36.4%	27.3%	0.0%	0.0%	0.0%	9.1%	0.0%	0.0%
		6 mo FU (8)	12.5%	0.0%	0.0%	12.5%	0.0%	0.0%	0.0%	0.0%
	T	BL (11)	22.2%	22.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		1 mo FU (12)	58.3%							
		6 mo FU (9)	88.9%	55.6%	0.0%	11.1%	11.1%	0.0%	11.1%	0.0%
Check if the controller is working properly	W	BL (11)	45.5%	36.4%	0.0%	9.1%	0.0%	0.0%	0.0%	0.0%
		6 mo FU (8)	50.0%	12.5%	25.0%	12.5%	0.0%	0.0%	0.0%	0.0%
	T	BL (11)	45.5%	36.4%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%
		1 mo FU (12)	91.7%							
		6 mo FU (9)	100.0%	55.6%	0.0%	11.1%	11.1%	0.0%	11.1%	11.1%
Check the nuts and bolts and tighten the loose ones	W	BL (11)	54.5%	0.0%	9.1%	27.3%	9.1%	9.1%	0.0%	0.0%
		6 mo FU (8)	62.5%	0.0%	12.5%	0.0%	0.0%	12.5%	37.5%	0.0%
	T	BL (11)	36.4%	9.1%	0.0%	18.2%	0.0%	9.1%	0.0%	0.0%
		1 mo FU (12)	100.0%							
		6 mo FU (9)	88.9%	22.2%	11.1%	11.1%	33.3%	11.1%	0.0%	0.0%
Check if the lever that disengages the motor is working properly	W	BL (11)	36.4%	9.1%	9.1%	9.1%	0.0%	0.0%	9.1%	0.0%
		6 mo FU (8)	62.5%	12.5%	0.0%	0.0%	0.0%	12.5%	60.0%	0.0%
	T	BL (11)	36.4%	9.1%	0.0%	18.2%	0.0%	9.1%	0.0%	0.0%
		1 mo FU (12)	91.7%							
		6 mo FU (9)	55.6%	0.0%	0.0%	11.1%	22.2%	22.2%	0.0%	0.0%

APPENDIX K. SELF-REPORTED COMPONENT NEEDING REPAIRS

Table 40. Self-reported repairs needed, completed, and adverse consequences at baseline and 6 month follow up for participants in the waitlist and control group.

In the past 6 months did you need a repair in…	Grp.	Time (n)	Needed repair	M	Of those who needed repairs				Of those who **did not** complete all or some repairs		Of those who **did** complete some or all repairs		
					Adv. Conse	M	Completed repair	M	Repair attem. & unsucess ful	M	Repair complet ed by	M	Oth er
Worn out tire/tube/ wheel		BL (12)	67%: never 25%: 1 time	8%	33%: none 33%: stranded 33%: missed W/S & Dr.	0	33%: none 67%: all	0	100%: not attem.	0	100%: vendor	0	na
	W	FU (8)	62.5%: never 12.5%: 1 time 12.5%: 2 times 12.5%: don't recall	0	100%: none	0	100%: all	0	na	0	100%: vendor	0	na

Table 40 (continued)

Worn out tire/tube/ wheel		BL (12)	50%: never 42%:1 time	8%	100%: None	0	80%: all	20%	na	0%	100%: vendor	0%	na
	T	FU (9)	56%: never 33%: 1 time 11%:≥3 times	0	75%: none 25%: stranded & missed Dr.	0	100%: all	0	100%: all succs.	0	100%: vendor	0	Na
Broken caster assembly (caster fork/stem)		BL (12)	92%: never	8%	na	na	na	na	na	na	na	na	na
	W	FU (8)	100%: never	0	na	na	na	na	na	na	na	na	na
		BL (12)	75%: never 8.3%:1 time 8.3%:2 times	8.3%	100%: none	0	100%: all	0	na	0	100%: vendor	0	na
	T	FU (9)	77.8%: never 11.1%: 2 times	11.1 %	100%: none	0	100%: all	0	na	0	100%: vendor	0	na
Broken wheel or caster bearing		BL (12)	83.3%: never 8.3%: 1 time	8.3%	100%: missed W/S & Dr.	0	100%: all	0	na	0	100%: vendor	0	na
	W	FU (8)	88%: never 12%: 2 times	0	100%: none	0	100%: none	0	100%: vendor contacte d	0	na	na	na
		BL (12)	83%: never 17%: 2 times	0	100%: none	0	50%: all	50%	na	0%	100%: vendor	0%	na
	T	FU (9)	78%: never 11%: 2 times 11%: don't recall	0	100%: none	0	100%: all	0	na	0	100%: vendor	0	Na

Table 40 (continued)

Broken frame	W	BL (12)	92%: never	8%	na	na	na	na	na	na	na	na	na
Broken frame	W	FU (8)	88%: never 12%: 1 time	0	100%: stranded	0	100%: none	0	100%: vendor cntd.	0	na	na	na
Broken frame	T	BL (12)	92%: never 8%: 1 time	0	100%: none	0	100%: none	0	100%: not attem.	0	na	na	na
Broken frame	T	FU (9)	78%: never 11%: 1 time 11%:2 times	0	50%: none 50%: injured	0	50%: some 50%: all	0	100%:vendor cntd.	0	100%: vendor	na	na
Loose positioning support	W	BL (12)	8.3%: never 33%: 1 time 8.3%: 2 times 42%: ≥3 times	8.30 %	100%: none	0	10%: none 90%: all	0	100%: attem. m/f	1	56%: m/f 33%: vendor 11%: m/f & vendor	0	na
Loose positioning support	W	FU (8)	50%: never 12.5%: 1 time 12.5%: 2 times 25%: 3≥ times	0	100%: none	0	100%: all	0	100%: all succs.	0	50%: m/f 50%: vendor	0	Na

Table 40 (continued)

Loose positioning support		BL (12)	33%: never 25%: 1 time 25%: 2 times 17%: 3≥ times	0	100%: none	0	12%: none 38%: some 50%: all	0	50%: attem. m/f	50 %	57.1%: m/f 28.6%: vendor 14.2%: other	0	Friend
	T	FU (9)	67%: never 11%: 1 time 11%: 2 times 11%: 3≥ times	0	100%: none	0	33%: none 67%: some	0	33%: vendor cntd. 67%: attem. m/f	0	100%: m/f	0	na
Worn out positioning support		BL (12)	50%: never 33.3%: 1 time 8.3%: ≥3 times	8%	80%: none 20%: missed W/S	0	20%: none 80%: all	0	100%: not attem.	0	25%: m/f 75%: vendor	0	
	W	FU (8)	88%: never 12%: ≥3 times	0	100%: none	0	100%: all	0	na	0	100%: myself	0	na
		BL (12)	50%:never 33%: 1 time 17%: 2 times	0	83%: none 17%: injured	0	33%: none 17%: some 50%: all	0	67%: not attem. 33%: vendor cntd	0	25%: myself 50%: vendor 25%: other	0	Friend
	T	FU (9)	56%: never 33%: 1 time 11%: ≥3 times	0	100%: none	0	75%: none 25%: all	0	67%: not attem. 33%: attem. m/f	0	100%: vendor	0	na

Table 40 (continued)

Worn seating components (includes cushions)	W	BL (12)	83.3%: never 8.3%: ≥3 times	8%	100%: none	0	100%: none	0	100%: attem. m/f	0	na	na	na
	W	FU (8)	75%: never 25%: 1 time	0	100%: none	0	50%: none 50%: all	0	100%: vendor cntd	0	100%: vendor	0	na
	T	BL (12)	75%: never 17%: 1 time 8%: 2 times	0	100%: none	0	33%: none 67%: all	0	100%: not attem	0	100%: vendor	0	na
	T	FU (9)	56%: never 33%: 1 time 11%: ≥3 times	0	100%: none	0	75%: none 25%: all	0	33.3%: not attem. 33.3%: vendor cntd 33.3%: attem. m/f	0	100%: vendor	0	na
Broken seating components	W	BL (12)	83.3%: never 8.3%: 1 time	8%	100%: none	0	100%: none	0	100%: not attem.	0	na	na	na
	W	FU (8)	8: never	0	na	na	na	na	na	na	na	na	na
	T	BL (12)	75%: never 25%: 1 time	0	100%: none	0	67%: none 33%: some	0	100%: not attem.	0	100%: vendor	na	na
	T	FU (9)	89%: never 11%: ≥3 times	0	100%: none	0	100%: none	0	100%: attem. m/f	0	na	na	na

Table 40 (continued)

Broken suspension	W	BL (12)	92%: never	8%	na	na	na	na	na	na	na	na	na
		FU (8)	100%: never	0	na	na	na	na	na	na	na	na	na
	T	BL (12)	100%: never	0	na	na	na	na	na	na	na	na	na
		FU (9)	89%: never 11%: ≥3 times	0	100%: none	0	100%: none	0	100%: attem. m/f	0	na	na	na
Broken controller box	W	BL (12)	75%: never 17%:1 time	8%	50%: none 50%: missed W/S	0	50%: none 50%: all	0	100%: not attem.	0	100%: vendor	0	na
		FU (8)	62%: Never 38%: 1 time	0	67%: none 33%: stranded	0	100%: all	0	na	0	100% vendor	0	na
	T	BL (12)	67%: never 17%: 1 time 8%: 2 times 8%: ≥3 times	0	50%: none 50%: stranded	0	25%: none 50%: some 25%: all	0	33%: vendor cntd 67%: attem. m/f	0	33%: m/f 67%: vendor	0	na
		FU (9)	67%: never 22%: 1 time	11%	100%: none	0	50%: none 50%: all	0	100%: vendor cntd	0	100%: vendor	0	na
Battery did not hold charge	W	BL (12)	92%: never	8%	na	na	na	na	na	na	na	na	na
		FU (8)	88%: never 12%: 1 time	0	100%: none	0	100%: all	0	na	0	100%: m/f	0	na

Table 40 (continued)

Battery did not hold charge		BL (12)	75%: never 25%: 1 time	0	67%: none 33%: stranded	0	67%: none 33%: all	0	50%: not attem. 50%: vendor cntd	0	100% vendor	0	na
	T	FU (9)	89%: never	11%	na	na	na	na	na	na	na	na	na
Power seat function		BL (12)	83.3%: never 8.3%: 1 time	8%	100%: none	0	100%: all	0	na	0	100%: vendor	0	na
	W	FU (8)	100%: never	0	na	na	na	na	na	na	na	na	na
		BL (12)	67%: never 25%: 1 time 8%: 2 times	0	50%: none 50%: stranded	0	25%: none 75%: all	0	100%: not attem.	0	100%: vendor	0	na
	T	FU (9)	67%: never 11%: 1 time 11%: 2 times	11%	50%: none 50%: injured	0	50%: all 50%: some	0	100%: vendor cntd.	0	100%: vendor	0	na

APPENDIX L. W-MAT ITEM-BY-TEM RESULTS

Table 41. W-MAT item-by-item scores and comments at baseline and 6 month follow up for participants in the waitlist and training group.

Item	Time	Group (n)	Number of participants				Comments
			Score			Miss.	
			0	1	2		
1A Encrusted debris	BL	W (12)	0.0%	33.3%	66.7%	0	Mud and dirt present; Dirt and lime on some of the bolts
		T (12)	0.0%	33.3%	66.7%	0	*Empty*
	FU	W (7)	0.0%	71.4%	28.6%	0	Superficial debris; all dirt is superficial; some dirt and chipping of paint; some dirt in the lower part, hair in the recline activator; Some dirt
		T (8)	0.0%	50.0%	50.0%	0	Some dirt but nothing substantial; some dirt in the lower base
1B Anti-tip devices	BL	W (12)	0.0%	0.0%	41.7%	7 np	*Empty*
		T (12)	0.0%	16.7%	41.7%	5 np	Anti-tip is bent inwards; wheels resist spin, but do spin
	FU	W (7)	0.0%	0.0%	28.6%	5 np	*Empty*
		T (8)	12.5%	0.0%	12.5%	6 np	Bent but wheels move freely
1C Shrouds	BL	W (12)	0.0%	33.3%	66.7%	0	Scratches; scratches
		T (12)	0.0%	33.3%	66.7%	0	Scratches; scratches
	FU	W (7)	0.0%	28.6%	71.4%	0	Superficial scratches
		T (8)	0.0%	50.0%	50.0%	0	Superficial scratches no significant damage; a few scratches
1D Frame/chassis/link arms:	BL	W (12)	0.0%	16.7%	83.3%	0	Scratches; scratches
		T (12)	0.0%	25.0%	75.0%	0	Scratches only; scratches; scratches
	FU	W (7)	14.3%	14.3%	71.4%	0	Scratches break through out coating no other issues; some rust in the right back spring attachment
		T (8)	0.0%	25.0%	75.0%	0	Mild rust; scratches

Table 41 (continued)

1E Suspension	BL	W (12)	0.0%	0.0%	91.7%	1	*Empty*
		T (12)	0.0%	0.0%	91.7%	1	*Empty*
	FU	W (7)	0.0%	0.0%	71.4%	2 miss	*Empty*
		T (8)	0.0%	0.0%	100.0%	0	*Empty*
2A Foot supports	BL	W (12)	25.0%	16.7%	58.3%	0	Left foot support does not lock in place; not moving standing chair; padding is worn/torn; rough surface
		T (12)	0.0%	41.7%	58.3%	0	Duck taped padding to foot rest; left one is a little difficult to flip up; a bit worn; difficult to flip up on left side
	FU	W (7)	14.3%	28.6%	57.1%	0	Coating somewhat worn, bolts underneath are rusted; surface was worn and rough
		T (8)	0.0%	12.5%	87.5%	0	Scratches
2B Lower leg supports	BL	W (12)	0.0%	0.0%	75.0%	1 np 2 miss	*Empty*
		T (12)	8.3%	0.0%	66.7%	1 np 2 miss	Is loose
	FU	W (7)	14.3%	0.0%	57.1%	2 np	bolts are rusted, but otherwise in good condition
		T (8)	0.0%	12.5%	87.5%	0	*Empty*
2C Lateral thigh supports	BL	W (12)	25.0%	0.0%	16.7%	3 np 4 miss	Ripped upholstery; loose; right support is missing; left support is in good condiiton
		T (12)	8.3%	8.3%	58.3%	1 np 2 miss	Left side is loose, right side has broken belt
	FU	W (7)	0.0%	14.3%	28.6%	4 np	Upholstery is torn and edges are exposed
		T (8)	0.0%	12.5%	62.5%	2 np	Not aligned but intact
2D Arm supports	BL	W (12)	16.7%	33.3%	50.0%	0	Right difficult to flip up; right support has frayed upholstery edges; ripped uphostery, loose; small crack and hole in upholstery
		T (12)	0.0%	33.3%	66.7%	0	Worn around edges, no tears; left upholstery is worn, rough; worn around edges/scratches

Table 41 (continued)

2D Arm supports		W (7)	14.3%	14.3%	71.4%	0	Right pad lose and worn; left loose; plastic edge was worn out
	FU	T (8)	12.5%	37.5%	50.0%	0	Worn down padding; left cover is ripped; worn around edges
2E Trunk support	BL	W (12)	0.0%	0.0%	50.0%	3 np 3 miss	*Empty*
		T (12)	8.3%	16.7%	41.7%	4 np	Loose, only present on right side; ripped upholstery, sharp edges; right side difficult to remove
	FU	W (7)	0.0%	0.0%	28.6%	4 np	*Empty*
		T (8)	0.0%	0.0%	62.5%	2 np 1 miss	*Empty*
2F Head support	BL	W (12)	8.3%	0.0%	41.7%	3 np 3 miss	Ripped upholstery
		T (12)	8.3%	16.7%	33.3%	2 np 3 miss	Difficult to remove. small holes in upholstery on one side; loose, not aligned
	FU	W (7)	0.0%	14.3%	28.6%	3 np 1 miss	Cover somewhat worn and little loose
		T (8)	0.0%	12.5%	37.5%	4 np	Small holes in upholstery on right side
2G Seat belt	BL	W (12)	8.3%	8.3%	75.0%	1 np	Seat belt is only partially installed
		T (12)	0.0%	8.3%	91.7%	0	Difficult to adjust; not used, located behind seat.
	FU	W (7)	0.0%	0.0%	85.7%	1 np	*Empty*
		T (8)	0.0%	0.0%	100.0%	0	*Empty*
2H Cushion placement	BL	W (12)	0.0%	0.0%	100.0%	0	*Empty*
		T (12)	0.0%	0.0%	91.7%	1 miss	*Empty*
	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	0.0%	87.5%	1 miss	*Empty*
2I Seat cushion cover	BL	W (12)	0.0%	16.7%	75.0%	0	Small tear frayed; slightly worn along front edge
		T (12)	0.0%	8.3%	58.3%	4 miss	*Empty*

Table 41 (continued)

2I Seat cushion cover	FU	W (7)	14.3%	28.6%	57.1%	0	Ripped; large, rear tip that has been repaired by user
		T (8)	0.0%	0.0%	87.5%	1 miss	*Empty*
2J Seat cushion	BL	W (12)	0.0%	8.3%	91.7%	0	Complete access not possible
		T (12)	0.0%	0.0%	66.7%	4 miss	*Empty*
	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	0.0%	87.5%	1 miss	*Empty*
2K Seat base	BL	W (12)	0.0%	0.0%	83.3%	2 miss	*Empty*
		T (12)	8.3%	0.0%	58.3%	4 miss	Scratches, a bit of rust
	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	12.5%	75.0%	1 miss	*Empty*
2L Back support	BL	W (12)	0.0%	0.0%	100.0%	0	*Empty*
		T (12)	8.3%	0.0%	66.7%	3 miss	*Empty*
	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	0.0%	87.5%	1 miss	*Empty*
2M Back support cover	BL	W (12)	0.0%	8.3%	75.0%	2 miss	Small holes
		T (12)	0.0%	16.7%	50.0%	4 miss	Dirt, small holes
	FU	W (7)	0.0%	14.3%	85.7%	0	Dome dirt between cushion and back flap
		T (8)	0.0%	12.5%	75.0%	1 miss	Worn spots on the side
2N Back support cushion	BL	W (12)	0.0%	0.0%	83.3%	2 miss	*Empty*
		T (12)	0.0%	0.0%	66.7%	4 miss	*Empty*
	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	0.0%	87.5%	1 miss	*Empty*
3A Tires	BL	W (12)	8.3%	16.7%	75.0%	0	Tread on left tire
		T (12)	8.3%	0.0%	91.7%	0	*Empty*

Table 41 (continued)

3A Tires		W (7)	14.3%	0.0%	85.7%	0	Have cracks and worn out
	FU	T (8)	12.5%	0.0%	87.5%	0	Balding in center
3B Front caster assemblies		W (12)	8.3%	16.7%	58.3%	2 front wheel	No cap on left side, bald tires; insufficient tread; chunks of tread missing on 2 casters; otherwise in good condition
	BL	T (12)	8.3%	0.0%	33.3%	7 front wheel	Insufficient tread on both sides; right side is worse, right side caster flutter
		W (7)	0.0%	0.0%	57.1%	3 front wheel	*Empty*
	FU	T (8)	12.5%	0.0%	50.0%	3 front wheel	No cap on left side
3C Rear caster assemblies		W (12)	16.7%	8.3%	66.7%	1 rear	Bald tires; right caster has no cap; otherwise in good condition; small chunck from l caster tire; otherwise in good condition
	BL	T (12)	8.3%	16.7%	75.0%	0	Uneven tread; chunks out of tread; no cap on right caster; insufficient tread and chunks of tread missing
		W (7)	14.3%	0.0%	85.7%	0	Caps were not there.
	FU	T (8)	12.5%	25.0%	62.5%	0	Loose caps cracking in wheels; tread has chunks of tread missing in multiple places; no caps on both sides
3D Parking brake		W (12)	0.0%	0.0%	100.0%	0	*Empty*
	BL	T (12)	0.0%	0.0%	100.0%	0	*Empty*
		W (7)	0.0%	0.0%	100.0%	0	*Empty*
	FU	T (8)	0.0%	0.0%	100.0%	0	*Empty*
4A Control device (Joystick)		W (12)	0.0%	0.0%	100.0%	0	*Empty*
	BL	T (12)	0.0%	8.3%	91.7%	0	*Empty*
		W (7)	0.0%	14.3%	85.7%	0	One bolt is loose
	FU	T (8)	0.0%	0.0%	87.5%	1 miss	*Empty*
4B Control Panel		W (12)	0.0%	0.0%	100.0%	0	*Empty*
	BL	T (12)	0.0%	8.3%	91.7%	0	Indicator lights do not work; missing button cover on panel

Table 41 (continued)

4B Control Panel		W (7)	0.0%	0.0%	100.0%	0	*Empty*
	FU	T (8)	0.0%	12.5%	87.5%	0	Broken panel controls less responsive
4C Seat elevation	BL	W (12)	0.0%	0.0%	41.7%	7 np	*Empty*
		T (12)	0.0%	0.0%	58.3%	5 np	*Empty*
	FU	W (7)	0.0%	14.3%	28.6%	4 np	Some grinding
		T (8)	0.0%	0.0%	50.0%	4 np	*Empty*
4D Recline	BL	W (12)	0.0%	8.3%	75.0%	2 np	*Empty*
		T (12)	0.0%	0.0%	91.7%	1 np	*Empty*
	FU	W (7)	0.0%	14.3%	57.1%	2 np	Some grinding
		T (8)	0.0%	12.5%	62.5%	2 np	*Empty*
4E Leg support	BL	W (12)	0.0%	0.0%	66.7%	4 np	*Empty*
		T (12)	0.0%	8.3%	83.3%	1 np	Slight grinding noise
	FU	W (7)	0.0%	14.3%	42.9%	3 np	Gets stuck in the end
		T (8)	0.0%	12.5%	75.0%	1 np	Uneven operation; squeaks and noisy
4F Tilt	BL	W (12)	0.0%	0.0%	75.0%	3 np	*Empty*
		T (12)	0.0%	0.0%	91.7%	1 np	*Empty*
	FU	W (7)	0.0%	14.3%	57.1%	2 np	Some grinding at the end
		T (8)	0.0%	12.5%	87.5%	0	Some grinding when it came back
4G Motors and gearboxes	BL	W (12)	0.0%	25.0%	75.0%	0	Squeaking noise when turning
		T (12)	0.0%	0.0%	100.0%	0	*Empty*
	FU	W (7)	0.0%	14.3%	85.7%	0	Left side locks up where the right wheel will keep moving
		T (8)	0.0%	0.0%	100.0%	0	*Empty*
4H Alignment	BL	W (12)	0.0%	0.0%	100.0%	0	*Empty*
		T (12)	0.0%	0.0%	100.0%	0	*Empty*

Table 41 (continued)

4H Alignment	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	12.5%	87.5%	0	Drifts to the right
4I Running brake	BL	W (12)	0.0%	8.3%	91.7%	0	*Empty*
		T (12)	0.0%	0.0%	100.0%	0	*Empty*
	FU	W (7)	0.0%	14.3%	100.0%	0	Can stop sharply
		T (8)	0.0%	0.0%	100.0%	0	*Empty*
4J Batteries	BL	W (12)	0.0%	0.0%	100.0%	0	*Empty*
		T (12)	0.0%	0.0%	100.0%	0	*Empty*
	FU	W (7)	14.3%	14.3%	71.4%	0	Battery is losing charge capacity- replacement is pending
		T (8)	0.0%	0.0%	100.0%	0	*Empty*
4K Cables and connectors	BL	W (12)	0.0%	25.0%	75.0%	0	Some exposed wiring to control panel; exposed wiring to control panel; loose cable at controller
		T (12)	0.0%	16.7%	83.3%	0	slight chips in wire covers; some cables are loose and not secured to chair
	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	0.0%	100.0%	0	*Empty*
4L Charging socket	BL	W (12)	0.0%	0.0%	100.0%	0	*Empty*
		T (12)	0.0%	0.0%	100.0%	0	*Empty*
	FU	W (7)	0.0%	0.0%	100.0%	0	*Empty*
		T (8)	0.0%	0.0%	100.0%	0	*Empty*

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