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Wheelchairs

## REVIEW & ANALYSIS

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# Powered Mobility for Middle-Aged and Older Adults

## Systematic Review of Outcomes and Appraisal of Published Evidence

### ABSTRACT

Auger C, Demers L, Gélinas I, Jutai J, Fuhrer MJ, DeRuyter F: Powered mobility for middle-aged and older adults: systematic review of outcomes and appraisal of published evidence. *Am J Phys Med Rehabil* 2008;87:666–680.

**Objective:** To identify the outcomes of power mobility devices for middle-aged and older adult users, and to critically appraise the research evidence.

**Design:** Systematic review of primary source studies involving adults aged 50 and over using power mobility devices (1996–2007). Articles were (i) mapped to the Taxonomy of Assistive Technology Device Outcomes, which describes categories of impact of assistive devices from the vantages of effectiveness, social significance, and subjective well-being; and (ii) appraised using the Grading of Recommendations, Assessment, Development, and Evaluation criteria.

**Results:** This review retained 19 studies and identified 52 different categories of impacts of power mobility devices spanning the three vantages of the taxonomy. The coverage of outcome dimensions was not as extensive for adults age 50 and over as it was for mixed-age groups. Most of the research designs were assigned very low evidence grades. Three studies were low to moderate in quality of evidence, among which one was a randomized trial.

**Conclusions:** A vast array of potential impacts of powered mobility devices have been described in the last decade. The level of quality of this evidence is improving, but most of these studies were not designed to verify causal relationships, and this is largely responsible for the absence of unequivocal evidence for directly attributing benefits to devices themselves and for quantifying relationships between power mobility device intervention and outcome. To raise the level of evidence about power mobility device interventions in older adults, studies are needed that use prospective designs, better-defined user groups, and well-grounded conceptual frameworks for measuring interventions and outcomes.

**Key Words:** Wheelchairs, Self-Help Devices, Systematic Review, Aged, Middle-Aged, Disabled Persons, Rehabilitation, Outcome Assessment, Health Care

**M**obility outside the home is essential for social inclusion and is associated with various positive health indicators.<sup>1,2</sup> For example, the frequency of outings has been identified as a protective factor against depression<sup>3</sup> and functional decline.<sup>4</sup> On the other hand, home confinement is associated with a reduction of leisure and social activities, lower quality of life, higher use of health services, and poor nutrition.<sup>5</sup> Some 6.8 million Americans use assistive technology devices to assist with mobility.<sup>6</sup> The demand for power mobility devices (PMD), which include electric wheelchairs and, more recently, scooters, has increased substantially since the late 1990s in Western countries.<sup>6–9</sup> For example, increases in provincial subsidies in Canada range from 40% (1998–2003)<sup>10</sup> to 340% (1995–2001).<sup>11</sup> In the United States, PMDs are used by more than 291,000 people<sup>6</sup> and account for 66% of Medicare expenses<sup>12</sup> for mobility-related devices.

Motorized devices are especially relevant for middle-aged and older adults, because the proportion of PMD use increases considerably with age. For instance, older American adults are 3.5 times more likely to use a PMD than are working-age adults.<sup>6</sup> PMD use involves lifestyle changes,<sup>13</sup> and the nature of these changes may vary across the lifespan. Compelling evidence is needed for the putative benefits of PMDs for defined user groups. Absent that evidence, economic imperatives are likely to result in eligibility guidelines that deprive potential users of that technology. Reliable evidence on the outcomes of PMD use is also needed for the adaptation of interventions to the increasing needs of the aging population.

The search for evidence on the outcomes of PMD use in middle-aged and older adults was the starting point of the present study. In the field of assistive technology, outcomes have been broadly defined as “any changes in users’ lives or their environment that are causally attributable to the use of a device.”<sup>14</sup> A prerequisite to any outcomes research is an understanding of the

fundamental values that are important to capture. The Taxonomy of Assistive Technology Device Outcomes<sup>15</sup> identifies generic classes of outcomes from the published literature as the most pertinent for advancing research and the conceptual modeling of assistive technology device intervention–outcome relationships. The taxonomy operationalizes the outcomes from three vantages, consisting of effectiveness, social significance, and subjective well-being, as shown in Table 1. Effectiveness includes the effects of assistive technologies on four dimensions. The first three are the effects on the user’s body function (e.g., skin condition), activity, and participation (e.g., independence in domestic activities), as well as on environmental factors (e.g., attitudes of family and community members) as defined by the International Classification of Functioning, Disability and Health.<sup>16</sup> The fourth dimension refers to effects on the user’s longevity. Social significance covers the impacts of assistive technologies on society, such as caregiving, costs, residential care placement, service use, and device use. Finally, subjective well-being refers to outcomes at the levels of subjective psychological functioning (e.g., self-esteem), quality of life (e.g., perceived participation), and satisfaction (e.g., satisfaction with the assistive device).

The question, *What are the outcomes and quality of evidence regarding PMD use in middle-aged and older adults?* is challenging to answer because theoretical and empirical research was largely nonexistent in the field of assistive technology outcomes research until the late 1990s.<sup>17–19</sup> Reviews published in recent years have addressed specific diagnostic groups such as stroke,<sup>20</sup> but they have lacked a systematic methodology<sup>21</sup> or have not distinguished outcomes for powered and manual wheelchairs.<sup>18</sup> The existing reviews, therefore, have not specifically addressed the outcomes of PMD use in middle-aged and older adults.

The primary objective of this review was to identify the PMD outcomes that have been studied

**TABLE 1** Domains from the three vantages of the Taxonomy of Assistive Technology Devices Outcome

Effectiveness	Social Significance	Subjective Well-Being
ICF body functions	Caregiving	Psychological functioning (subjective)
ICF activity and participation	Cost	Quality of life
ICF environmental factors	Residential care placement	Satisfaction
User longevity	Service use	
	Device use	

ICF, International Classification of Functioning, Disability and Health.

Adapted from: Jutai J, Fuhrer M, Demers L, et al. Toward a taxonomy of assistive technology device outcomes. *Am J Phys Med Rehabil* 2005;84:294–302.<sup>15</sup>

in middle-aged and older adult users, using the Taxonomy of Assistive Technology Device Outcomes. An additional objective was to critically appraise the levels of evidence that characterize the available research. The review covers two categories of PMDs: (1) electric wheelchairs that have four or six wheels and that are usually controlled by using a joystick or an alternative access mode such as head control or a sip-and-puff switch, and (2) three- and four-wheeled scooters that consist of a seat attached to a platform and that are guided by a tiller, typically using two hands.

## METHODS

### Inclusion Criteria

The present review considered studies with a variety of research designs, ranging from randomized control trials to case studies, without any restriction for measurement methods. Inclusion criteria were (i) primary source studies, (ii) at least one adult age 50 and over who used a PMD, and (iii) a separate description of outcome results for PMD users. Studies that covered multiple device types were retained if outcomes were separately described. Studies that focused on experimental PMD prototypes or employing dummies were excluded.

### Search Methods for Identifying Studies

The literature search was performed as described in Figure 1 by two reviewers with master-level research training in the field of rehabilitation, and guided by a librarian experienced in systematic reviews. Using three Web data bases (Embase, PsycINFO, and Medline), the search was limited to articles published in French or English between 1996 and June 2007. The search strategy relied on iterative strategies because no specific key words were available for PMDs throughout the period covered. For each database, a core set key words were identified on the basis of a few eligible articles. For example, Medline key words were: *\*self-help devices/or wheelchairs/or dependent ambulation or mobility limitation*. Because there is no specific key word for electric wheelchairs or scooters in this database, these results were combined with *electric power supplies/or electricity*. To capture any references to PMDs, titles and abstracts were also searched with the natural terms *power\$ wheelchair\$ or power\$ mobility or motor\$ wheelchair\$ or (electric and wheelchair\$) or (scooter\$ and (electric\$ or motor\$ or power\$))*. The search strategy located 445 references, which were exported to Endnote 9 with their abstracts. Duplicates were then eliminated electronically and manually, and 307 different references remained.

One reviewer discarded publications deemed irrelevant on the basis of title and/or abstract. After this screening, 50 full articles were obtained and read independently by two reviewers to finalize the selection process. The two reviewers discussed their results and came to a consensus to determine which studies to keep for analysis (Appendix).

### Appraisal of the Evidence

Selected studies were evaluated and graded according to the methods set out by the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) working group.<sup>22</sup> This grading system was elaborated through international collaborations to establish consensus across the full spectrum of medical specialties and clinical care. GRADE criteria first classify the quality of evidence into four levels (*high* = randomized trial, *moderate* = quasi-randomized trial, *low* = observational study, and *very low* = any other evidence). Then, the GRADE system takes into account the methodological limitations of the study. The rating is downgraded by one or two levels if the evidence is compromised by serious methodological flaws, such as lack of allocation concealment or blinding, or large loss to follow-up. On the other hand, some study designs may obtain a lower quality level initially and be upgraded by up to two levels if, for example, the magnitude of the effect is very large.

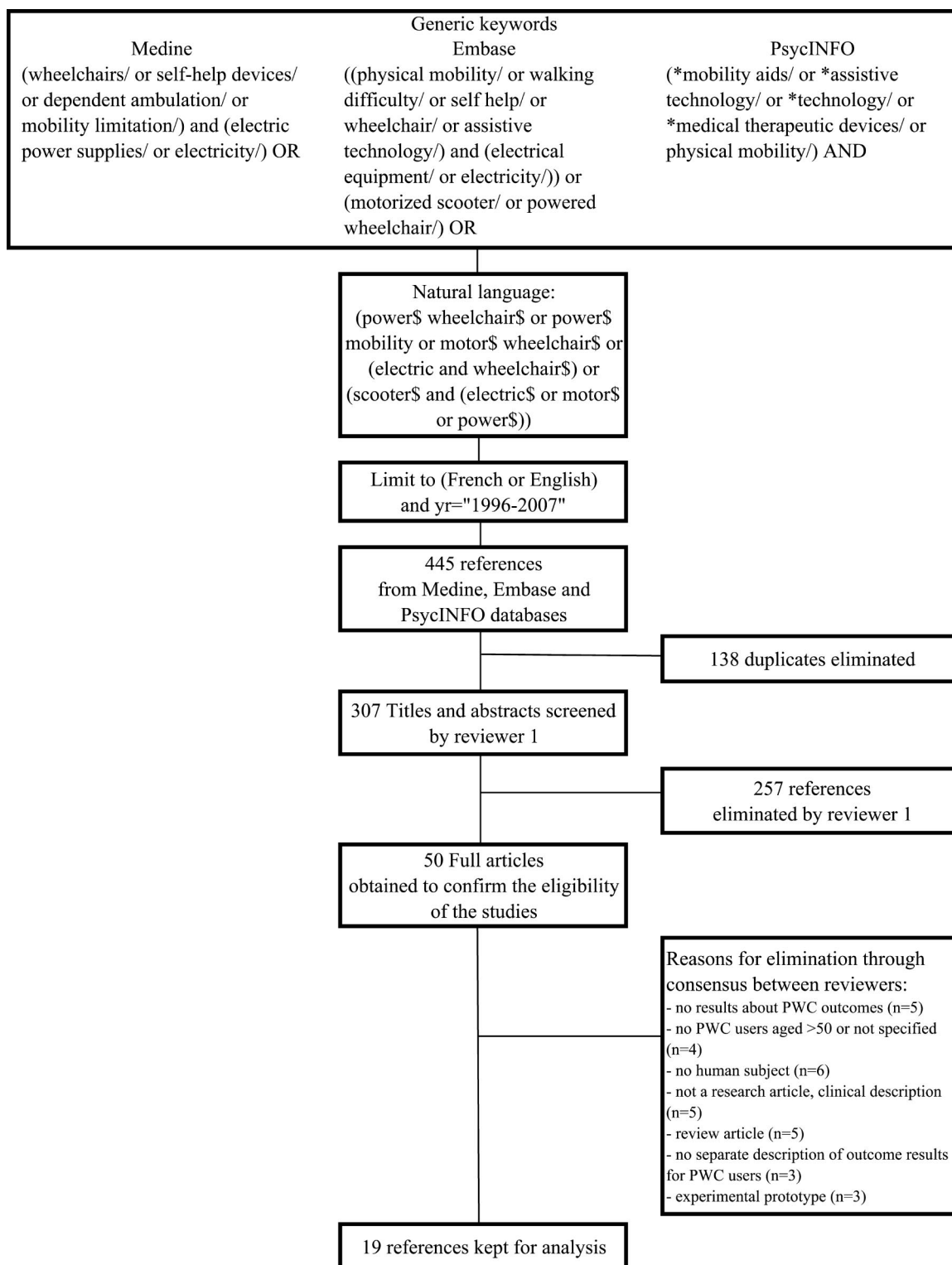
Data were extracted using a standard form (available on request from the authors). The appraisal of the quality of the evidence was performed by one reviewer for multiple case studies and cross-sectional descriptive studies. Both reviewers assessed studies that involved group comparison across time (e.g., using a pre/post design) or with controls (e.g., a randomized trial). For studies reporting more than one primary outcome, the outcome with the highest level of evidence was considered, as suggested by the GRADE group.<sup>22</sup> Discrepant judgments between the two reviewers were discussed and resolved.

## RESULTS

A total of 19 studies involving qualitative, mixed methods, and quantitative approaches were kept for analysis. The following sections provide a description of these studies, outline the domains of outcomes they cover from the vantages of effectiveness, social significance, and subjective well-being, and appraise the levels of evidence.

### Description of Studies Characteristics of Samples

Of the 19 studies retained, 3 comprised all ages,<sup>9,23,24</sup> 11 included a mixed population of



**FIGURE 1** Search methods. / = searches key word as a subject heading; \* = focuses the subject heading as the main topic; \$ = truncation symbol.

adults and older users,<sup>25–35</sup> and 5 focused exclusively on senior users<sup>11,36–39</sup> (Table 2). Men represented up to 100% of some samples and at least a majority in most publications. The populations studied came from Western countries, and the diagnostic categories were generally heterogeneous.

Seven studies were restricted to specific conditions, including arthritis,<sup>34</sup> stroke,<sup>23,33,38</sup> multiple sclerosis,<sup>30,32</sup> and amyotrophic lateral sclerosis.<sup>29</sup> Users were predominantly community dwellers, but three samples were drawn from long-term care facilities,<sup>11,30,35</sup> and one was from an acute care



**TABLE 2** Description of the reviewed studies (*n* = 19)

Authors. Study Title. Year.	<i>n</i>	Age Range in Years (Mean)	Female:Male Ratio	Geographic Area	Living Arrangement	Type of Power Mobility Devices	Type of Diagnosis
Miles-Tapping C. Power wheelchairs and independent life styles. 1997. <sup>27</sup>	15	35–72	8:7	Canada	Community	EWC or scooters	Not reported
Evans R. The effect of electrically powered indoor/outdoor wheelchairs on occupation: a study of user's views. 2000. <sup>26</sup>	8	39–76	4:4	UK	—	Indoor/outdoor EWC	Stroke, multiple sclerosis, cerebral palsy, poliomyelitis, motor neuron disease
Frank A, Ward J, Orwell N, et al. Introduction of a new NHS electric-powered indoor/outdoor chair (EPIOC) service: benefits, risks and implications for prescribers. 2000. <sup>9</sup>	113	6–89 (43–48)	72:52	UK	Community	Indoor/outdoor EWC	Multiple sclerosis, muscular dystrophy, cerebral palsy, rheumatoid arthritis, poliomyelitis, spinal cord injury, cardiovascular disease, spina bifida, other neurological and musculoskeletal conditions
Buning M, Angelo J, Schmeler M. Occupational performance and the transition to powered mobility: a pilot study. 2001. <sup>28</sup>	8	27–52	4:4	USA	—	EWC	Spinal cord injury, muscular dystrophy, multiple sclerosis, cardiopulmonary insufficiency, traumatic brain injury
Trail M, Nelson N, Van J, et al. Wheelchair use by patients with amyotrophic lateral sclerosis: a survey of user characteristics and selection preferences. 2001. <sup>29</sup>	42	32–75 (53.9)	5:17	USA	—	Motorized wheelchairs (type: —)	Amyotrophic lateral sclerosis
Cooper RA, Thorman T, Cooper R, et al. Driving characteristics of electric-powered wheelchair users: how far, fast, and often do people drive? 2002. <sup>25</sup>	17	(46.9)	7:11	USA	Community	EWC	Spinal cord injury, cerebral palsy, multiple sclerosis, spina bifida, poliomyelitis, traumatic brain injury, muscular dystrophy, lower motoneuron disease
Davies A, De Souza L, Frank A. Changes in the quality of life in severely disabled people following provision of powered indoor/outdoor chairs. 2003. <sup>23</sup>	51	14–83 (52)	23:28	UK	Community	Indoor/outdoor EWC	Multiple sclerosis, muscular dystrophy, cerebral palsy, spinal cord injury, stroke, rheumatoid arthritis, poliomyelitis, other neurological and musculoskeletal conditions
Dawson J, Thornton H. Can patients with unilateral neglect following stroke drive electrically powered wheelchairs? 2003. <sup>37</sup>	2	67–70	0:2	UK	Hospital	EWC (one specific model)	Stroke with evidence of unilateral neglect
Devitt R, Chau B, Jutai J. The effect of wheelchair use on the quality of life of persons with multiple sclerosis. 2003. <sup>30</sup>	16	41–70 (53.4)	—	Canada	Complex continuing care hospital	Power wheelchairs (type: —)	Multiple sclerosis

TABLE 2 Continued

Authors. Study Title. Year.	<i>n</i>	Age Range in Years (Mean)	Female:Male Ratio	Geographic Area	Living Arrangement	Type of Power Mobility Devices	Type of Diagnosis
Belcher M, Frank A. Survey of the use of electric indoor/outdoor powered wheelchair service. 2004. <sup>24</sup>	203	Max 86 (43)	—	UK	—	Indoor/outdoor EWC	—
Brandt A, Iwarsson S, Stahle A. Older people's use of powered wheelchairs for activity and participation. 2004. <sup>36</sup>	111	65–92 (77)	55:56	Denmark	Community	EWC and four-wheel scooters	—
Wressle E, Samuelsson K. User satisfaction with mobility assistive devices. 2004. <sup>31</sup>	34	27–80 (62)	17:13	Sweden	—	Powered chair (type: —)	—
Hall K, Partnoy J, Tenenbaum S, et al. Power mobility driving training for seniors: a pilot study. 2005. <sup>11</sup>	12	73–97	5:7	Canada	Long-term care facility	EWC and scooters	Stroke, chronic obstructive pulmonary disorder, multiple sclerosis, musculoskeletal diagnosis (e.g., arthritis)
Mortenson W, Miller W, Boily J, et al. Perceptions of power mobility use and safety within residential facilities. 2005. <sup>35</sup>	9	42–90	5:4	Canada	Long-term care facilities	Powered chair (type: —)	Progressive and nonprogressive conditions
Barker D, Reid D, et al. The experience of senior stroke survivors: factors in community participation among wheelchair users. 2006. <sup>38</sup>	10	70–80 (75.5)	—	Canada	Community	EWC and scooter	Stroke
Boss T, Finlayson M. Responses to the acquisition and use of power mobility by individuals who have multiple sclerosis and their families. 2006. <sup>32</sup>	7	31–72 (58)	5:2	USA	Living with at least one family member	EWC and scooters	Multiple sclerosis
Pettersson I, Tornquist K, Ahlstrom G. The effect of an outdoor powered wheelchair on activity and participation in users with stroke. 2006. <sup>33</sup>	32	43–85 (67)	10:22	Sweden	—	EWC with a joystick and three-wheeled scooters	Stroke
Evans S, Frank A, Neophytou C, et al. Older adults' use of, and satisfaction with, electric powered indoor/outdoor wheelchairs. 2007. <sup>39</sup>	17	60–80 (69)	8:9	UK	Community	Indoor/outdoor EWC	Spinal cord injury, multiple sclerosis, cerebrovascular disease, rheumatoid arthritis, poliomyelitis, comorbid disabilities
Hoening H, Pieper C, Branch LG, et al. Effect of motorized scooters on physical performance and mobility: a randomized clinical trial. 2007. <sup>34</sup>	43	(63)	9:34	USA	Community	Scooter (one specific model)	Osteoarthritis of the knee (40), rheumatoid arthritis (3)

EWC, electric wheelchair.

\*Number of power mobility device users within a larger sample.

**TABLE 3** Study designs, quality of evidence, and conceptual frameworks

First Author	<i>n</i>	Study Design	Quality	Duration of Power Mobility Device Use	Conceptual Framework
Qualitative paradigm					
Miles-Tapping <sup>27</sup>	15	Multiple case studies	VL	—	Symbolic interactionism
Evans R <sup>26</sup>	8	Multiple case studies	VL	1–2 yrs	Human occupation
Mortenson <sup>35</sup>	9*/19	Multiple case studies	VL	6 mos to 20 yrs	Client-centered occupational therapy
Barker <sup>38</sup>	2*/10	Multiple case studies	VL	>1 yr	ICF and continuity theory
Boss <sup>32</sup>	7	Multiple case studies	VL	3–20 yrs (except one waiting)	Grounded theory approach and Canadian Model of Occupational Performance
Evans S <sup>39</sup>	17	Multiple case studies	VL	9–19 mos; mean 14 mos	Qualitative framework approach
Mixed methods					
Buning <sup>28</sup>	8	Posttest <sup>§</sup>	VL	6–24 mos; median 13.5 mos	Person–environment interaction model
Quantitative paradigm					
Frank <sup>9</sup>	113	Posttest	VL	1–10 mos; mean 3.9 ± 1.4 mos	—
Trail <sup>29</sup>	22*/42	Cross-sectional	VL	2 wks to 2.1 yrs; mean 6.2 mos	—
Cooper <sup>25</sup>	17	Cross-sectional	VL	14.4 ± 11.5 yrs	—
Davies <sup>23</sup>	51	Pre/post (R)	L	0 and 97 ± 16 days	—
Dawson <sup>37</sup>	2	ABA single subject (R)	VL	10 days	Right-hemisphere-activation approach
Devitt <sup>30</sup>	7*/16	Cross-sectional	VL	2 wks to 10 yrs	Theoretical framework of the Psychosocial Impact of Assistive Device Scale
Belcher <sup>24</sup>	203	Cross-sectional	VL	—	—
Brandt <sup>36</sup>	111	Cross-sectional	VL	1–22 yrs; mean 4.5 yrs	Human activity assistive technology
Wressle <sup>31</sup>	34	Cross-sectional	VL	14–26 mos	Matching person with technology
Hall <sup>11</sup>	12	Posttest	VL	—	Person–environment–occupation model
Pettersson <sup>33</sup>	32	Pre/post (R)	L	0 and 3–5 mos; mean 4 mos	ICF
Hoening <sup>34</sup>	22*/43	Randomized controlled trial (R, C)	M	0–3 mos	—

\* Number of power mobility device users within a larger sample; § pre- and posttest measures assessed during the same interview. ICF, International Classification of Functioning, Disability and Health; R, repeated measures; C, control or comparison group; quality of evidence: VL, very low; L, low; M, moderate; H, high as defined by the Grading of Recommendations, Assessment, Development, and Evaluation group.

hospital.<sup>37</sup> The types of PMDs varied across studies. Nine studies were restricted to one type of PMD, such as electric wheelchairs<sup>9,23–26,28,37,39</sup> or four-wheeled scooters.<sup>34</sup> The others either did not specify the type<sup>27,30,31,35</sup> or included a mix of PMD types.<sup>11,32,33,36,38</sup>

### Conceptual Foundations

The conceptual frameworks used by the authors as a foundation for delineating outcomes were heterogeneous. Several of the quantitative studies failed to identify one (Table 3). Concepts were mostly drawn from generic frameworks related to the social and

health sciences, from person–environment models, and from occupational therapy. Three studies were based on assistive technology–specific frameworks.<sup>30,31,36</sup> Only one referred to concepts from gerontology, and it proposed a new model.<sup>38</sup>

### Research Designs

The research designs involved qualitative (*n* = 6), mixed methods (*n* = 1), and quantitative (*n* = 12) approaches (Table 3). The duration of PMD use was not controlled in most studies and varied from no experience to more than 20 yrs within a single sample.

Each of the six qualitative studies used a multiple-case-study design involving 2–17 PMD users assessed once during an individual interview. One study used mixed methods with a concurrent triangulation strategy in which the quantitative results of eight participants were complemented with qualitative interviews.<sup>28</sup>

Quantitative studies were the most common. They were predominantly cross-sectional/descriptive designs ( $n = 6$ ) and posttest designs without a comparison group ( $n = 2$ ). Samples varied from 7 to 203 PMD users. One repeated-measures ABA design was replicated with two participants.<sup>38</sup> Three studies used pre/post measurements based on a standardized time interval of 4 mos or less.<sup>23,33,34</sup> One of the latter studies was a randomized control trial and was the only one that involved a comparison group.<sup>34</sup>

### Domains of Outcomes Covered

The outcomes measured by the 19 studies were mapped onto the three vantages of the Taxonomy of Assistive Technology Device Outcomes.<sup>17</sup> The results for each vantage are presented separately for PMD users age 50 and over and for studies that cover mixed-age groups in Tables 4–6.

### Effectiveness

Twelve studies covered three dimensions from the effectiveness vantage. Included were the body functions, activity and participation, and environmental dimensions (Table 4). No study reported impacts on users' longevity, the fourth dimension of the effectiveness vantage. A total of 12 categories of outcomes were reported.

Seven of the 12 categories of outcomes were addressing PMD users age 50 and over. Effects on activity and participation included impacts on moving around in natural environments<sup>11,36</sup> and standardized settings,<sup>37</sup> as well as on using transportation.<sup>36</sup> Other effects on activity and participation were considered in terms of community, social, and civic life.<sup>36</sup> The effects of PMD use on environmental factors were mostly considered in terms of obstacles such as the attitudes of strangers and experiences of stigmatization.<sup>38,39</sup> Most of the categories of outcomes reported for the samples ages 50 and over were also seen in mixed-age groups. However, three outcomes were exclusively reported for the samples ages 50 and over. They were effects on body function through reports of injuries,<sup>39</sup> and the impact on frequency of shopping.<sup>36</sup> One study reported PMD use as an environmental facilitator—namely, on the attitudes of strangers.<sup>38</sup>

Five additional effectiveness outcomes were exclusively reported in samples of mixed-age groups. Pettersson et al.<sup>33</sup> covered four of those

outcomes related to learning and communicating, self-care, interpersonal relationships, and participation in work and education. The last, as reported by Pettersson et al.<sup>33</sup> and Davies et al.,<sup>23</sup> addressed the effect of PMDs on the users' overall functioning.

### Social Significance

Eight studies covered four of the five domains related to social significance—namely, caregiving, cost, service use, and device use (Table 5). No study reported impacts on residential care placement, the fifth domain of the social significance vantage. A total of 10 outcome categories were reported.

Only two studies addressed users ages 50 and over. Reported outcomes included service use and device use through the frequency of accidents and mechanical failures,<sup>39</sup> and the frequency of device use indoors and outdoors depending on the season.<sup>36</sup> Samples of mixed-age groups covered more categories. In addition to those covered for older adults, they referred to effects on caregivers,<sup>9,27,32</sup> costs related to damage of property,<sup>32,35</sup> and other measures of device use, such as rate of use,<sup>31</sup> activity level, speed, and distance traveled.<sup>25</sup>

### Subjective Well-Being

All the domains of the subjective well-being vantage were addressed by the studies under review (Table 6). A total of 17 of them presented 30 categories of outcomes.

Psychological functioning was addressed by three studies in users ages 50 and over. Feelings of freedom,<sup>36</sup> independence,<sup>38,39</sup> and sense of purpose and self-worth<sup>38</sup> were frequent themes. Safety was a concern,<sup>39</sup> as were issues of privacy in the process of acquiring the PMD.<sup>39</sup> Studies including mixed-age groups explored more categories from the psychological functioning dimension—namely, confidence and self-esteem,<sup>26–28,30,31</sup> experience of self,<sup>26,27</sup> and issues of adaptability after PMD use.<sup>27,28,30,32</sup>

Satisfaction was addressed by eight studies, two of which included only users ages 50 and over. Satisfaction with PMDs was examined in older adults through the reported satisfaction<sup>36,39</sup> and importance<sup>36</sup> of the PMD, and satisfaction with PMD-related services.<sup>39</sup> Evans et al.<sup>39</sup> also have reported the level of satisfaction with environmental factors such as the natural and built environments, as well as the human environment. Comfort was an additional aspect covered in mixed-age samples.<sup>9,23,29</sup>

Domains pertaining to quality of life are similar to the effectiveness vantage, but they are addressed from the user's subjective standpoint. Three studies considered this domain for PMD users ages 50 and over. Impacts on quality of life were



**TABLE 4** Power mobility device (PMD) studies reporting effectiveness outcomes

Outcome Domain	Study (First Author)	
	PMD Users >50 yrs Old	Mixed-Age Groups
ICF body functions		
Injuries	Evans S	
ICF activity and participation		
Learning and communicating		Pettersson
Walking and moving around using equipment	Brandt, Dawson, Hall	Cooper, Frank, Hoenig, Pettersson
Moving around using transportation	Brandt	Belcher
Self-care		Pettersson
Acquisition of necessities	Brandt	
Interpersonal interactions and relationships		Pettersson
Major life areas (education, work, economic life)		Pettersson
Community, social, and civic life	Brandt	Pettersson
Overall functioning		Davies, Pettersson
ICF environmental factors		
Facilitators	Barker	
Obstacles	Barker, Evans S	Belcher, Boss, Miles-Taping, Mortenson

ICF, International Classification of Functioning, Disability and Health.

participation in mobility activities,<sup>36</sup> carrying prioritized or valued activities,<sup>36,38,39</sup> return to previous occupations,<sup>40</sup> and access to new locations and activities.<sup>40</sup> Studies in mixed-age groups reported 11 additional categories of outcomes pertaining to quality of life. Included were subjective effects on body function such as raised energy level,<sup>9,27</sup> pain relief,<sup>23</sup> and health stability.<sup>23</sup> A variety of other activity and participation areas were studied for this age group, as detailed in Table 6.

### Quality of Evidence

The quality of evidence was very low for the majority of studies ( $n = 16$ ), followed by low ( $n =$

2) and moderate ( $n = 1$ ) ratings, according to the GRADE criteria (Table 3). None ranked at the high level. One study's<sup>34</sup> quality score was downgraded from high to moderate, but none of the studies were upgraded. The main results of the three studies with low to moderate ratings are presented because they constitute the highest level of evidence available.

The best quality of evidence was obtained by a randomized control trial (RCT) classified with a *moderate* rating.<sup>34</sup> Its primary goal was to determine the effect of PMD use by 22 persons with arthritis on subsequent deconditioning at 1 and 3 mos after scooter allocation.<sup>34</sup> The RCT design entailed highly

**TABLE 5** Power mobility device (PMD) studies reporting social significance outcomes

Outcome Domain	Study (First Author)	
	PMD Users >50 yrs Old	Mixed-Age Groups
Caregiving		
Level of assistance by care providers		Frank, Miles-Tapping
Freedom for caregivers		Boss
Cost		
Damage of property		Boss, Mortenson
Service use		
Accidents and mechanical failures of PMD	Evans S	Belcher, Frank
Device use		
Rate of use		Wressle
Frequency of use outdoors	Brandt	Wressle
Frequency of use indoors	Brandt	Wressle
Frequency of use depending on season	Brandt	Wressle
Speed and distance traveled		Cooper
Peak activity level during a day		Cooper

**TABLE 6** Power mobility device (PMD) studies reporting subjective well-being outcomes

Outcome Domain	Study (First Author)	
	PMD Users >50 yrs Old	Mixed-Age Groups
Psychological functioning (subjective)		
Feeling of freedom, control	Brandt	Boss, Evans R
Independence, competence	Barker, Evans S	Buning, Davies, Devitt, Evans R, Miles-Tapping, Mortenson, Wressle
Privacy	Evans S	Miles-Tapping
Safety (feeling)	Evans S	Belcher, Boss, Miles-Tapping, Wressle
Sense of purpose, self-worth	Barker	Evans R
Adaptability/learning to adjust		Boss, Buning, Devitt, Miles-Tapping
Confidence, assertiveness, self-esteem		Buning, Evans R, Devitt, Miles-Tapping, Wressle
Experience of self		Evans R, Miles-Tapping
Satisfaction		
Comfort of PMD		Davies, Frank, Trail
Satisfaction with PMD	Brandt, Evans S	Hoening, Trail, Wressle
Importance of PMD	Brandt	
Satisfaction with service for PMD	Evans S	Boss, Wressle
Satisfaction regarding environmental obstacles	Evans S	
Quality of life: subjective body function, activity, and participation		
Energy and drive functions: energy level		Frank, Miles-Tapping
Pain		Davies
Perceived health state		Davies
Walking and moving around using equipment	Brandt	Boss, Cooper, Davies, Frank, Miles-Tapping, Wressle
Moving around using transportation		Buning, Hoening
Self-care		Pettersson
Acquisition of necessities	Brandt, Evans S	Buning, Evans R, Frank, Pettersson
Caring for household objects and animals, and assisting others		Pettersson
Interpersonal interactions and relationships		Buning
Major life areas (education, work, economic life)		Buning, Evans R, Frank, Miles-Tapping, Pettersson
Community, social and civic life	Brandt, Evans S	Davies, Evans R, Frank, Miles-Tapping, Pettersson, Wressle
Perception of occupational performance		Buning
Carry prioritized/valued activities	Barker, Brandt	
Quality of life		Buning, Davies, Mortenson
Going to new locations, new activities, expanded roles	Barker	Boss, Buning, Evans R, Hoening, Miles-Tapping, Pettersson, Trail
Return to previous occupations	Barker	Evans R
Possibility to be active		Wressle

restrictive criteria, such as having a valid driver's license and owning a car, to ensure group homogeneity. Random allocation to PMD use was ethically feasible because this study recruited "elective" PMD users—that is, only adults with knee osteoarthritis or rheumatoid arthritis who were able to walk independently for at least 15 m. No statistically significant changes on the 6-min walk distance test were observed, and scooters were used intermittently. The walking ability of the PMD users remained stable

during the first 3 mos when compared with 21 similar controls, indicating that PMD use did not induce significant short-term deconditioning. Questionnaire data also suggested that the PMDs afforded users a broader selection within their usual spectrum of activities.

The two other studies were classified with *low* ratings because they were observational studies using pre/post measures without control groups. One study included 32 poststroke participants<sup>33</sup>

and examined activity and participation before and after 3–5 mos in first-time PMD users. The context for the intervention was prescription by three Swedish centers for assistive technologies. The delay between the stroke and PMD prescription, as well as comorbidities, were not reported. A statistically significant small effect size (ES) on overall functioning after PMD use was reported for the modified World Health Organization Disability Assessment Schedule II total score (ES: 0.26) as well as for the subscale *Getting around* (ES: 0.41). A large ES was reported for the subscale *Self-care* (ES: 0.84). With the Individual Prioritized Problem Assessment, a large ES was observed—namely, for domestic life (ES: 1.6), interpersonal interactions (ES 1.4), and for community, social, and civic life (ES: 2.4). Moreover, ES values above 0.8 were estimated for 97% of individual participants.

The third study measured pre/post changes in health-related quality of life. The study involved 51 severely disabled people age 14 and more than 4 mos after the provision of a subsidized powered indoor/outdoor chair.<sup>23</sup> The study population was recruited consecutively during a fixed period, without any exclusion criteria. Independent interviewers evaluated a highly heterogeneous sample of 11 diagnostic categories, spanning from adolescence to old age, for which no information is available on functional levels, comorbidities, and services associated with receiving the PMDs. Some were previous PMD users. No significant effect of PMD use was found on health-related quality of life according to the descriptive version of the EQ-5D, but significant results were obtained with the visual analog scale version for mobility ( $P = 0.001$ ), pain/discomfort ( $P = 0.001$ ), and overall quality of life ( $P = 0.02$ ).

## DISCUSSION AND CONCLUSION

The objectives of the present review were to identify PMD outcomes that have been studied in middle-aged and older adult users, and to critically appraise the level of evidence of that research. As a first step, we kept all the research designs, to maximize the mapping of the outcomes of interest in that field. As a second step, we weighted that evidence and presented the papers with the best levels of evidence.

Although relatively few studies have been published on PMD outcomes, those published have addressed most of the domains of the Taxonomy of Assistive Technology Device Outcomes, covering a total of 52 categories. All the taxonomy domains were covered by at least one reference, except for user longevity and residential care placement. Many authors considered both the objective and subjective outcomes of PMDs,<sup>9,23–25,33,34,36,38</sup> an

approach that has been supported in recent years.<sup>41,42</sup> Subjective well-being was the vantage most commonly measured, thus emphasizing the importance of a client-centered approach to outcome measurement in this field. Social significance outcomes were the least frequently examined, especially in studies involving older participants. No publication addressed economic evaluation issues per se.

The categories of outcomes reported for older adults were less varied than for mixed-age groups. This result needs to be qualified by considering that fewer publications are available for the older group. In addition, outcomes such as work and education are not as relevant for this population, thereby reducing the number of categories applicable to them. Other possible explanations could be related to diagnostic differences associated with age, because stroke was the leading condition of PMD users ages 50 and over in this review, whereas multiple sclerosis and spinal cord injury tended to be predominantly represented in mixed-age samples. This trend is in agreement with the clinical and demographic characteristics of PMD users.<sup>6</sup> Only one study in the present review analyzed associations between age and various PMD outcomes.<sup>36</sup> This issue deserves further investigation. For instance, Verbrugge and Shang<sup>43</sup> show that the prevalence of disability is higher for older adults but that the duration of disability is shorter in the group aged 75 and over. Future studies should take into account the double challenge faced by older PMD users who must adjust to a new disability as well as to a new assistive technology.

The analysis highlighted numerous limits of the research pertaining to PMD outcomes. The evidence is scarce, mostly descriptive, and based on eclectic conceptual frameworks. The findings from study to study are not necessarily comparable, because types of PMDs, duration of PMD use, living arrangements, and diagnosis frequently differ. Although the literature acknowledges that outcomes can vary as a function of user experience with an assistive technology device,<sup>14,44</sup> none of the studies we reviewed controlled for duration of use by adults ages 50 and over. Moreover, no study used pre/post measures or comparison groups for this population. A recent review identified similar levels of evidence of PMD interventions for the pediatric population.<sup>45</sup>

On the positive side, recent publications on mixed-age groups present a higher level of evidence when compared with the review by Reid et al.<sup>18</sup> that covered publications until 1999. At the time, only the lowest level of evidence according to Sackett's criteria<sup>46</sup> was available. Since then, three descriptive studies have interviewed more

than 100 PMD users, contributing to our capacity to compare populations from different countries. Moreover, three recent studies have used a repeated-measures design or comparisons with controls and have, thus, achieved a higher level of evidence. It is interesting to note that these studies addressed potential adverse effects of PMDs, such as deconditioning, as well as positive outcomes of PMDs, namely, on objective functioning (activity and participation) and subjective quality of life.

The results of the present review must be interpreted with caution. The research designs that have been implemented until now have enriched our understanding of the range of beneficial and adverse outcomes that PMDs may have. The findings definitely suggest that PMDs have impacts that go far beyond moving from point A to point B within the home. However, most of these studies were not designed to verify causal relationships, and this is largely responsible for the absence of firm evidence. In the absence of substantiated evidence about the outcomes of PMD use in older adults, decision makers may be tempted to restrain this age group's access to these devices. This would be an erroneous application of the present findings. All of the statistically significant findings that were reviewed related to positive outcomes. Consequently, PMDs should be presumed to be potentially helpful to candidate users until the evidence points to the contrary.

Well-designed studies are needed to address a number of issues that arise from the findings reviewed. At present, we cannot judge the cost-benefit yields of PMD-related interventions. The cost side of the equation seems to drive decision making because the benefit side has not been substantiated. Priority should be assigned to efforts to identify the profiles of PMD users who gain the most from this assistive technology. Frequency of use should not be the only outcome of interest, because this benchmark disadvantages older adults whose frequency of outings diminishes with aging.<sup>47,48</sup> We should also question whether impairment-based eligibility criteria are the most appropriate way to govern access to subsidy programs. That is inconsistent with descriptive evidence suggesting that individuals with moderate limitations exhibit the most positive impacts of PMD use in terms of participation in meaningful activities.<sup>36</sup> Studies are also needed that provide better information about the PMD intervention itself (e.g., including user training and follow-up services) and about other interventions (e.g., architectural modifications of the home and adapted transportation) that are occurring concurrently with it. Finally, the PMD impacts that are studied need to be better balanced with respect to the advantages comprising

the Taxonomy of Assistive Technology Device Outcomes.<sup>15</sup> The focus of the reviewed studies on users' subjective well-being needs to be complemented by an emphasis on a normative perspective involving the advantages of effectiveness and social significance.

There were limitations to the review. Only five studies were available that focused exclusively on older adults. Consequently, our search strategy used permissive inclusion criteria to locate any article that included middle-aged and older adults. This led to the inclusion of articles with variable proportions of older adults. The applicability of results of mixed-age groups to the population aged 50 or older is unknown. Moreover, data extraction was not blinded with respect to authors' names or research designs, though the evidence on quality-assessment bias supports this approach.<sup>49</sup> Finally, this review addressed any changes in users' lives or their environment that seemed causally attributable to the use of a PMD under typical conditions. This led to the elimination of articles that focused on experimental wheelchairs<sup>50,51</sup> or new components of PMDs such as experimental joysticks.<sup>52</sup> The impacts of these new technologies are very promising, and functions such as stair climbing and obstacle detection could open up participation possibilities for future PMD users. The conservative scope of our findings must be kept in mind.

In conclusion, this review has revealed that the range of PMD outcome dimensions was less extensively covered in studies of older adults than in studies of mixed-age groups. Three publications with low to moderate levels of evidence suggest beneficial effects of the PMD use for mixed-age groups as well as an absence of adverse effects. The remaining studies provide little support for causal inferences regarding PMD effects. To raise the level of evidence about PMD interventions in older adults, studies are needed that use prospective designs, better-defined user groups, and well-grounded conceptual frameworks for quantifying relationships between PMD interventions and outcomes.

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## APPENDIX Rejected articles classified by main reason for elimination\* (n = 31)

### No Results About Power Mobility Device Outcomes (n = 5)

- Simpson RC, Hedman G: Ideas to help break down barriers. *IEEE Eng Med Biol Mag* 1999;18:59–63
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### No Power Mobility Device Users Aged >50, or Age Range Not Specified (n = 4)

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- Beaumont-White S, Ham RO: Powered wheelchairs: are we enabling or disabling? *Prosthet Orthot Int* 1997;21:62–73
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### No Human Participant (n = 6)

- Simpson RC, Hedman G: Opening doors with assistive technology. *IEEE Eng Med Biol Mag* 2002;21:45
- Kreutz D, Maurer C: Wading through the possibilities. *Rehab Manag* 2002;15:18
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### No Research Question/Design, Comment (n = 5)

- Cooper RA, Cooper R, Schmeler M, Boninger ML: Push for power. *Rehab Manag* 2004;17:32–6
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- Eng JJ: Getting up goals. *Rehab Manag* 2004;17:34–7

### Review Article (n = 5)

- Cooper RA, Cooper R, Tolerico M, Guo S, Ding D, Pearlman J: Advances in electric-powered wheelchairs. *Top Spinal Cord Inj Rehabil* 2006;11:15
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## APPENDIX Continued

### No Separate Description of Outcome Results for Power Mobility Device Users (n = 3)

- Brochard S, Pedelucq JP, Cormerais A, Thiebaut M, Remy-Neris O: Satisfaction with technological equipment in individuals with tetraplegia following spinal cord injury [in French]. *Ann Readapt Med Phys* 2007;50:78–84
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### Experimental Prototype (n = 3)

- Dicianno BE, Spaeth DM, Cooper RA, Fitzgerald SG, Boninger ML: Advancements in power wheelchair joystick technology: effects of isometric joysticks and signal conditioning on driving performance. *Am J Phys Med Rehabil* 2006;85:631
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\* Reasons for elimination through consensus between reviewers, on the basis of the full article.