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REVIEW ARTICLE

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Wheelchair service provision education for healthcare professional students, healthcare personnel and educators across low- to high-resourced settings: a scoping review

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ABSTRACT

Purpose: This review aimed to collate and summarize available research literature about wheelchair service provision education available to healthcare professional students, healthcare personnel and educators across low- to high-resourced settings.

Methods: The Joanna Briggs Institute methodological steps for scoping reviews were followed. Included studies were mainly sourced from Medline, Embase, CINAHL, Scopus, Academic Search Complete and ProQuest. Independent title, abstract and full-text screening with defined inclusion and exclusion criteria was performed. All screening and extraction were performed independently by two authors. A thematic approach was used to synthesize results. Data extracted from included studies were charted according to a template that we created. The study quality was also appraised.

Results: A total of 25 articles were included (11, 36% from high-income settings) with 12 (48%) observational studies and 13 (52%) experimental studies. The literature addressed three main topics: (1) assessing wheelchair service provision knowledge, (2) implementing training interventions using in-person, online and/or hybrid learning approaches and (3) describing current wheelchair service provision education globally. The most frequently reported training programs used were the Wheelchair Skills Program and the World Health Organization Wheelchair Service Training Package – Basic Level.

Conclusion: Limited information has been published about the integration of wheelchair content into the curricula of professional rehabilitation programs. Efforts to build international partnerships, improve the quality and currency of training programs and build resources that can assist educators in the integration of wheelchair-related content into professional rehabilitation programs should be prioritized.

➤ IMPLICATIONS FOR REHABILITATION

- This is the first review that examined and synthesized the current state of wheelchair service provision education for rehabilitation students and personnel across low- to high-income countries.
- Findings from this review indicate that there is limited information about the integration of wheelchair-related content into professional rehabilitation programs.
- Efforts to build international partnerships, standardize wheelchair service provision content and evaluation and integrate training into professional rehabilitation programs worldwide should be prioritized.

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Supplemental data for this article can be accessed here

Introduction

Access to assistive products, such as wheelchairs, can reduce inequalities experienced by people with disabilities by enabling them to participate in society and enjoy fundamental freedoms [1]. A wheelchair has been defined as an extrinsic and intrinsic enabler that allows people with posture and mobility impairments to actively participate in their daily living across their life spans [2]. An appropriate wheelchair, defined by the World Health Organization (WHO) as "*a wheelchair that meets the user's needs and environmental conditions; provides proper fit and postural support; is safe and durable; is available in the country; and can be obtained and maintained and services sustained in the country at the most economical and affordable price*" [3] can promote well-being, function and independence to people with disabilities [4,5]. Conversely, an inappropriate wheelchair can result in poorer health outcomes [6]; decreased functional abilities and quality of life [7,8]; social isolation and even death [9]. The WHO has published global guidelines that highlight eight sequential steps involved in wheelchair service provision (i.e., referral and appointment, assessment, prescription, funding and ordering, product preparation, fitting, user training, and follow-up, maintenance and repairs) [3] and a series of open-source Wheelchair Service Training Packages in multiple languages to support appropriate wheelchair service delivery worldwide [10–14]. Yet, providing an appropriate wheelchair and its associated services remains a challenge worldwide. There is an increasing volume of evidence revealing the need to build a competent workforce of rehabilitation professionals and strengthen the wheelchair service provision curricula in professional rehabilitation programs [15–19].

Evidence has emerged demonstrating limited competency in wheelchair service provision among entry-to-practice students [15,16,19,20] and clinicians [21–23] who are primarily responsible for wheelchair service delivery (i.e., those in physical therapy [PT], occupational therapy [OT], and prosthetics and orthotics [P&O] programs). A survey completed by 72 representatives from PT, OT and P&O university programs from low- to high-income countries reported that ∼21% of programs do not include wheelchair-related education in their curricula [18]. Among those institutions that do, on an average, wheelchair-related content was taught for 20 h or less instead of the 35 to 40 h recommended by the WHO [24]. In addition, these institutions varied in their curriculum, teaching methods, and evaluation approaches to teach and assess wheelchair service provision competency. [18]. Recently, Kirby et al. surveyed 110 OTs in Nova Scotia, Canada on their wheelchair-skills-training practices and views. Few professionals reported providing wheelchair-skills training to their clients and only about one-third considered themselves adequately prepared for the trainer role [25]. A similar survey was completed by 309 wheelchair service providers from 35 countries [26]. Although a higher proportion of respondents provided training, the amount of training was minimal with a median total of training time for clients and caregivers of 45 and 30 min [26]. Moreover, in their scoping review of wheelchair service provision education and training in low and lower middle income countries (LLMIC), McSweeney and Gowran found that wheelchair-related education and training is particularly limited in less-resourced settings and not integrated into university programs; instead, education is mainly provided by non-governmental organizations [19]. The review recommended the integration of wheelchair-related content into existing curricula in universities to guarantee a sustainable and competent workforce to undertake wheelchair service provision globally [19]. Although the situation may be more problematic in LLMICs, the lack of wheelchair service delivery competency among rehabilitation professionals and the limited integration of wheelchair content into professional rehabilitation programs is a global concern, not just limited to less-resourced settings [20].

Despite the availability of open-source, evidence-based wheelchair service provision training materials [10,11,27,28] and the development of effective novel training methods to teach wheelchair content [22,23,29–31], there is a lack of integration of such content into professional rehabilitation programs resulting in limited competencies among rehabilitation professionals that limits the pace of workforce training and therefore appropriate wheelchair service provision. Fung et al. uncovered barriers to the integration of wheelchair service provision content into rehabilitation programs curricula related to difficulties in the integration process, limited human and physical resources, limited funding and time constraints [17]. Other studies have reported lack of awareness among educators in rehabilitation programs of existing open-source resources for wheelchair service provision education as additional barriers [18,19].

The need to build a competent workforce has been prioritized in the 2018 Wheelchair Stakeholders' Meeting as an action item to meet the sector goal: "*By 2030, 10 countries have new or strengthened evidence-based, adequately resourced, integrated wheelchair services supported by policies, competent personnel, and a range of appropriate wheelchairs*" [32]. More recently, a group of stakeholders published a position paper that identified several global challenges to accessing appropriate wheelchairs, including the need for a competent workforce of wheelchair service providers. These authors posit that "*building capacity and delivering adequate education and training for all*" is a key component to the development of sustainable wheelchair provision systems [4].

The shortage of competent wheelchair service providers and the lack or limited integration of wheelchair-related content into professional rehabilitation programs have been recognized; however, it is unclear what information is available about wheelchair service provision education for healthcare students and personnel and who is offering that education. A review is needed to systematically synthesize the evidence, map the key concepts and provide suggestions for future research priorities. We selected a scoping review method because (1) wheelchair service *education* is an emerging topic in rehabilitation and we were interested in synthesizing evidence from a variety of sources [33–35]; (2) we were seeking to identify and describe the key characteristics and factors in wheelchair service provision education that can assist in bridging the research gaps [33,35]; (3) we formulated exploratory questions and were not interested solely in comparing the effectiveness of educational interventions as a systematic review might do [33]; and (4) we recognized that much of the current evidence is low-level with a variety of study designs [34,35]. The results from such a review will inform the development of the International Society of Wheelchair Professionals (ISWP) Wheelchair Educators' Package (WEP), an online toolkit that will assist educators of rehabilitation professionals globally to overcome barriers in the integration of wheelchair content into their curricula.

Materials and methods

Our review follows the methodological steps outlined by the Joanna Briggs Institute [36] and the reporting guidelines for the conduct of scoping reviews, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [37]. A brief overview of our process is outlined below including deviations from the initial protocol; the details of the methods are published in a previous protocol paper

[38]. The protocol was registered at Open Science Framework (Registration doi: 10.17605/OSF.IO/C5P3T).

Stage 1: Identifying research questions

The overarching research question for the scoping review was: "What is known about wheelchair service provision education for healthcare professional students, healthcare personnel and educators as offered by universities, organizations, and industries?". To delineate exploration of the overarching question, three sub-questions were identified: (1) "How are wheelchair service provision education curricula developed, integrated and delivered"; (2) "What are the expected skills and competencies after wheelchair service provision education and how are these evaluated?"; and (3) "What is the evidence for educational effectiveness and clinical impact, and how are these measured?"

Stage 2: Identifying relevant articles

A comprehensive search strategy was developed with specific concepts and key terms. The primary search strategy was then implemented using the following electronic databases: Medline, Embase, EBM Reviews, CINAHL, SCOPUS and Academic Search Complete. Additionally, a grey literature search was conducted using ProQuest (ERIC, PAIS Index, Dissertations & Theses Global, Canadian Research Index and Dissertations & Theses @ Université de Montréal). The search strategy, adapted for each indexed database, is presented in Supplementary File 1.

Following full-text screening of indexed articles, the grey literature was subsequently searched using OpenGrey, Campbell Collaboration, Health Systems Evidence, WHO Library and key websites involved in or related to wheelchair service provision. The reference lists of the included studies were searched to identify additional articles. In addition, a selection of four journals pertinent to the field (i.e., Disability and Rehabilitation: Assistive Technology; Archives of Physical Medicine and Rehabilitation; PLOS ONE; and Advances in Health Sciences Education) were hand searched to ensure that no relevant and recently non-indexed articles, published between January to August 2020, were missed.

The literature search was designed to retrieve both peer-reviewed and non peer-reviewed publications pertaining to wheelchair service provision education offered to healthcare profession personnel, students and educators (including rehabilitation engineers and technicians as well as community-based rehabilitation workers) and by universities, organizations and industries from low-to-high income countries. The inclusion period was from January 1993 onwards in accordance with the publication of the Standard Rules on the Equalization of Opportunities for Persons with Disabilities. Languages considered for inclusion were English and French, as translation support was available. The exclusion criteria are detailed in the protocol paper [38].

Additional articles were identified by the research team and accepted as eligible studies after Stage 2 was completed (Figure 1). These articles underwent the same process for the remaining Stages as the initially screened articles.

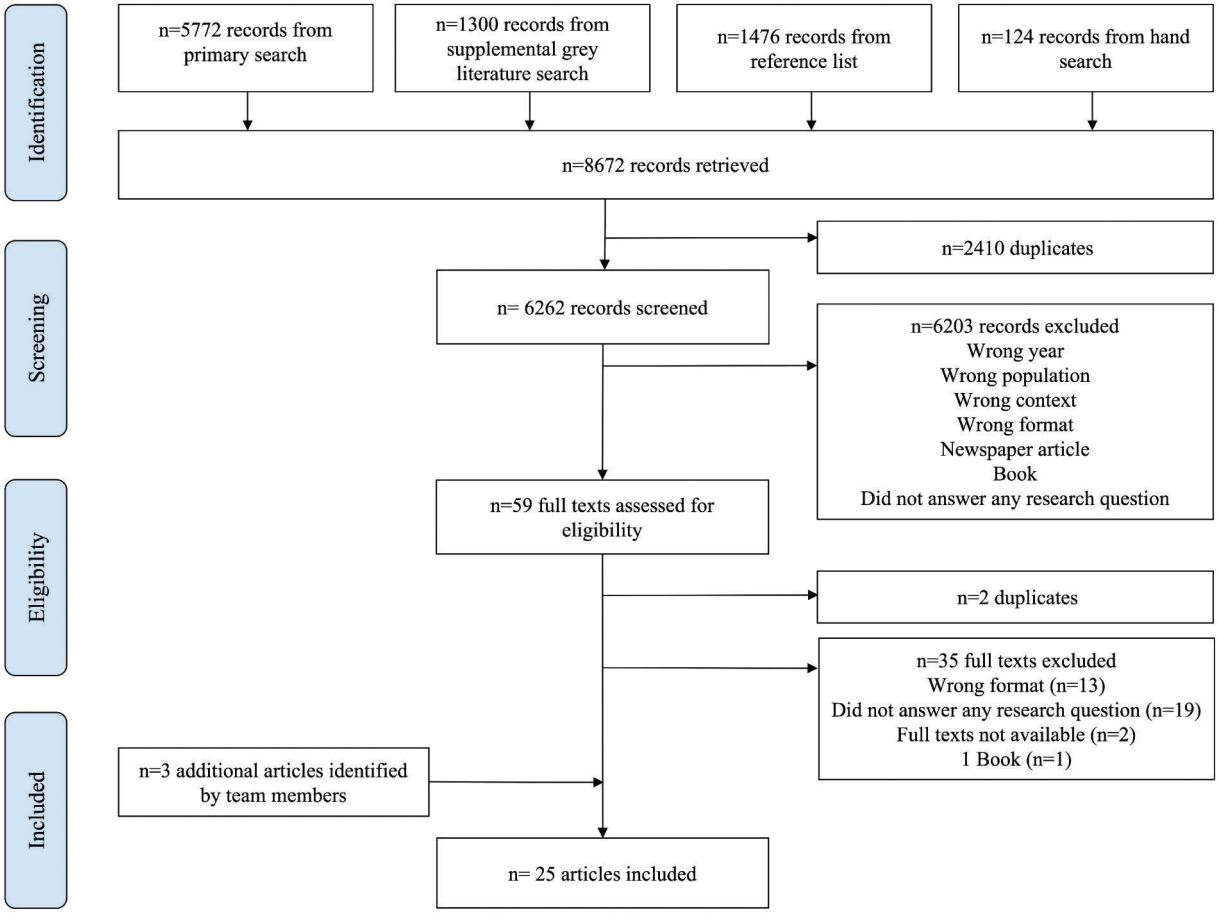

Figure 1. PRISMA-ScR flowchart.

Stage 3: Article selection

Two reviewers (S. A. B. and M. N. – acknowledgement section) independently screened the titles and abstracts of identified studies and the full-text records were obtained for articles deemed eligible. The results of the independent screening were compared and there was 98.9% agreement during title and abstract screening and 91.8% agreement during full-text screening. Discrepancies between reviewers were resolved by discussion.

Covidence® software was used for screening titles and abstracts. The software was also used to manage citations throughout the selection process.

Stage 4: Charting the data

Data were extracted using a piloted and refined data template which was developed for the purpose of this review (Supplementary File 2). The following information was extracted: author(s), year of publication, location or country of origin, aims, study population and sample size (if applicable) as well as content related to the review questions (wheelchair service provision education and training development, integration and delivery; skills and competencies for safe and effective wheelchair service provision; skills and competencies evaluation; effectiveness and clinical impact of wheelchair service provision education and training). This process involved independent data extraction by two reviewers (Y. B. M. and S. K.), a minor deviation from the four reviewers originally proposed in the protocol. Each reviewer independently reviewed half of the included articles and subsequently engaged in a meeting to review and discuss the data extraction with a third team member (P. W. R.) to ensure consistency and accuracy of data extraction. One of the independent reviewers (Y. B. M.) was lead author for three included studies [22,23,29] and thus was not involved in the data extraction for these studies.

Two independent reviewers (S. A. B. and Y. B. M.) appraised the quality of the included articles using the Mixed Methods Appraisal Tool (MMAT) version 2018, an established and validated assessment tool for quantitative, qualitative and mixed-methods studies [39,40]. The reviewers held discussions until consensus was reached. As the MMAT is not appropriate for review papers and reports, three included articles [19,41,42] were not assessed.

Stage 5: Collating, summarizing and reporting the results

The data were narratively synthesized using a thematic-analysis approach. Direct text quotations from the included articles were extracted and used for the narrative synthesis. As a first step, the direct text quotations were populated in the data-extraction form and then condensed into content-related categories. Second, the three sub-questions of the review were considered as the primary themes and, for each primary theme, sub-themes were identified and extracted data were collated and summarized into a table (content-related categories). This table was formatted to report the synthesized results with specific details relating directly to the three key sub-questions of the scoping review. Descriptive statistics (e.g., frequency, percentages) were used to summarize the amount and range of the related literature, including publication type, year and country.

Results

Eligible studies

Figure 1 provides the PRISMA-ScR flowchart of this review. Of 6262 records initially screened, 59 underwent a full-text review and 22 were selected to be included in the study. Three additional studies [43–45] were identified and selected post-study-selection stage, resulting in the inclusion of a total of 25 articles. Table 1 presents the analyzed articles in reverse chronological order by type of study, study design, study purpose, location and setting, and target population. Among the 25 articles, 12 (48%) were observational studies and 13 (52%) were experimental studies. Twenty-two articles (88%) represented studies conducted across 30 countries; some articles included more than one setting: three (10%) low income; eight (26.7%) lower-middle income; eight (26.7%) upper-middle income; and 11 (36.7%) high-income. The remaining three articles [19,41,42] did not represent studies in a specific country but met the inclusion criteria and provided information from >70 countries across low to high-income. The majority of articles, $n = 19$ (76%), were published within the last five years (2017–2021) and were focussed on (1) assessing wheelchair service provision knowledge in specific settings [15,16], (2) implementing training interventions to teach wheelchair service provision knowledge and/or skills [22,23,29,31,42–50] and (3) enhancing understanding on current wheelchair service provision education globally [17–19,41]. The most frequent target population were students, clinicians or professors from OT, followed by PT and P&O. After identifying the main topics, the articles were organized in tables to provide structure to answer this study's research questions and present the data in an efficient way. Sub-question #1, "How are wheelchair service provision education curricula developed, integrated and delivered", is addressed in Table 2. Sub-question #2, "What are the expected skills and competencies after wheelchair service provision education and how are these evaluated?", and sub-question #3, "What is the evidence for educational effectiveness and clinical impact, and how are these measured?" are addressed in Table 3. Three articles [18,19,41] that were not included in Tables 2 and 3 are described in the section "*Current state of integration of wheelchair-content into curricula globally*" below.

Wheelchair service provision education curricula

Course development

A total of four studies [44,47,50,51] reported information about course development of wheelchair-related content (Table 2: A. Development, integration and delivery of a novel course). Only two articles [47,50] indicated the resource used (i.e., the WHO training materials [10], the Rehabilitation Engineering and Assistive Technology (RESNA) [52] and Australian guidelines [53]) to develop their courses. The learning activities implemented included lectures, videos and hands-on practice. Three articles reported the integration of the course in the curricula in university programs but did not include details about the integration process [44,50,51]. In these programs, one course was mandatory for fourth year medical students [44] and the other two were optional courses for OT students [50] and PT, OT, and Biomedical Engineering students or clinicians [51]. The course that was not integrated into a university program curricula was developed to train clinicians and wheelchair users on basic wheelchair maintenance activities [47]. In the four articles, the duration of the courses varied from 2 to 20 h. Overall, the articles contained limited information about course topics, distribution of the time allocated for

Table 1. Purpose, design, location, and target population of included studies.

Study title (author, year)	Study purpose	Location and setting	Study design	Target population (*n*)
Descriptive studies				
Final Year Students' Knowledge on Basic Manual Wheelchair Provision: The State of Occupational Therapy Programs in Colombia. (Toro-Hernandez et al., 2020) [15]	To assess the current wheelchair provision knowledge of final year occupational therapy students through ISWP Basic Wheelchair Service Knowledge Test.	Colombia [UM] Academic	Cross-sectional e-mail survey.	OT students ($n = 83$)
Undergraduate physiotherapy students' basic wheelchair provision knowledge: a pilot study in two universities in Colombia. (Toro-Hernandez et al., 2019) [16]	To evaluate basic manual wheelchair provision knowledge in final-year physiotherapy undergraduate students in two programs in Colombia.	Colombia [UM] Academic	Cross-sectional Study.	PT students ($n = 116$)
Integration of wheelchair service provision education: current situation, facilitators and barriers for academic rehabilitation programs worldwide. (Fung et al., 2019) [17]	To develop an in-depth global portrait of the wheelchair service provision education offered in academic rehabilitation programs, the process of its integration and the associated facilitators and barriers.	11 countries [H = 4, UM = 2, LM = 3, L = 2] Academic	Semi-structured qualitative interviews.	Faculty members in OT, PT, and P&O ($n = 14$)
Wheelchair Service Provision Course – Evaluation Report. 2018 [42]	To provide a comprehensive theoretical understanding of Wheelchair Service Delivery and to develop an understanding of the theoretical principles, skills and knowledge underlying the management skills and knowledge in the management of wheelchair service delivery.	148 countries: [H, UM, LM, L] Organization	Program evaluation.	PT clinicians, students, assistants and healthcare professionals ($n = 5559$)
Enabling appropriate personnel skill-mix for progressive realization of equitable access to assistive technology. (Smith et al., 2018) [41]	To review the current capacity of human resources in enabling access to AT as well as the systems and processes within which they function.	Global	Review paper.	Workforce for provision of AT services
Wheelchair service provision education and training in low and lower middle income countries: a scoping review. (McSweeney et al., 2017) [19]	To review wheelchair provision education and training for personnel in the field of in LLMIC and identify where gaps exist.	LLMIC[a] [UM = 6, LM = 49, L = 29]	Scoping review.	Not applicable
Development and evaluation of a wheelchair service provision training of trainers programme. (Munera et al., 2017) [46]	To understand if the WSTPt is an effective mechanism to train aspiring wheelchair service provision trainers.	South Africa and Thailand [UM], Kenya [LM] Community	Action research; mixed-methods surveys & focus groups.	Trainees who passed ISWP Basic training ($n = 22$)
Wheelchair service provision education in academia. (Fung et al., 2017) [18]	To develop an enhanced understanding of the current wheelchair service provision education provided in professional rehabilitation programmes worldwide.	21 countries [H = 8, UM = 7, LM = 5, L = 1] Academic	Cross-sectional online survey.	Educational institutions worldwide ($n = 72$)
Development of a wheelchair maintenance training programme and questionnaire for clinicians and wheelchair users. (Toro-Hernandez et al., 2017) [47]	To develop a WMTP as a tool for clinicians to teach wheelchair users (and caregivers) in a group setting to perform basic maintenance at home in the USA and to develop a WMT-Questionnaire.	USA [H] Academic, Research Laboratory and Clinic	Mixed methods: cross-sectional online survey and formative research.	Clinicians and Wheelchair Users, Content Development Experts and Graduate medical and PT students ($n = 17$)
A description of manual wheelchair skills training curriculum in entry-to-practice occupational and physical therapy programs in Canada. (Best et al., 2015) [59]	To describe the current entry-to practice MWC skills training curriculum in OT and PT programs.	Canada [H] Academic	Cross-sectional online survey.	Directors of academic (OT/PT) programs ($n = 28$)

(*continued*)

Table 1. Continued.

Study title (author, year)	Study purpose	Location and setting	Study design	Target population (*n*)
Impact of training for wheelchair service specialists. (White et al., 2003) [51]	To describe the development of a university-validated course, designed to enhance the knowledge, clinical skills and academic ability of both therapists and engineers who now work in wheelchair services.	England and Northern Ireland [H] Clinic	Cross-sectional postal survey.	OT, PT and bio-medical engineers ($n = 24$)
Assessment for the Prescription of Wheelchairs: What Training is Available to Therapists? (Silcox et al., 1995) [60]	To discover the amount of time spent on and some of the content of the training presently available to therapists, both in college and from the wheelchair service.	UK [H] Academic and Clinic	Cross-sectional postal survey.	Academicians and practitioners ($n = 95$)
Experimental studies				
Efficacy of a Remote Train-the-Trainer Model for Wheelchair Skills Training Administered by Clinicians: A Cohort Study with Pre- vs. Post-Training Comparisons. (Worobey et al., 2021) [45]	To test the hypotheses that remote training improves trainer confidence and, when these trainers train others, the capacity and confidence of the trainees improves.	USA [H] Academic	[Quasi-experimental design] Cohort study with pre- versus post-training comparisons.	Clinician trainers ($n = 7$) and able-bodies trainees ($n = 19$)
Effect of an interventional educational wheelchair program on medical students' understanding of manual wheelchair use. (Gilbert et al., 2021) [44]	To identify the effect of an educational interactive wheelchair program on medical students' understanding of wheelchair use.	USA [H] Academic	[Quasi-Experimental Design] Repeated-measures survey study with postintervention comparison.	Medical students ($n = 123$)
Improvement and retention of wheelchair training skills for students in entry-level occupational therapy education. (Giesbrecht et al., 2021) [43]	To assess the effectiveness of a boot camp on capacity and self-efficacy in wheelchair skills and self-efficacy in clinical practice, retention of improvements, and effective boot camp attributes.	Canada [H] Academic	Mixed-methods: Cohort design using blinded repeated measures quantitative evaluation and qualitative questionnaire.	OT students ($n = 42$)
Using remote learning to teach clinicians manual wheelchair skills: a cohort study with pre- vs post-training comparisons. (Worobey et al., 2020) [48]	To test the hypothesis that remote learning to teach clinicians manual wheelchair skills is effective.	USA [H] Clinic	[Quasi-Experimental Design] Cohort study with pre- vs post-training comparisons.	Physiotherapists and Occupational therapists ($n = 41$)
A condensed wheelchair skills training 'boot camp' improves students' self-efficacy for assessing, training, spotting, and documenting manual and power wheelchair skills. (Smith et al., 2019) [49]	To test the hypothesis that the WSTP, added to the standard curriculum, would result in significantly greater overall improvements in wheelchair skills than a standard undergraduate OT curriculum alone.	Canada [H] Academic	[Quasi-experimental design] Pre-post study.	OT students ($n = 44$)
Wheelchair skills training for occupational therapy students: comparison of university-course versus "boot camp" approaches. (Rushton et al., 2019) [31]	To test the hypothesis that occupational therapy students who receive wheelchair skills training education using a distributed-practice university-course approach versus a condensed-practice boot camp approach results in greater improvements post-intervention in relevant outcomes.	Canada [H] Academic	Quasi-experimental design.	OT students and OT graduates ($n = 55$)
Comparing the effectiveness of a hybrid and in-person courses of wheelchair service provision knowledge: a controlled quasi-experimental study in India and Mexico. (Burrola-Mendez et al., 2019) [22]	To compare the effectiveness of a Hybrid Course and In-person Course in English and Spanish in increasing knowledge in basic level wheelchair service provision.	Mexico [UM] India [LM] Clinic	Quasi-experimental design.	Rehabilitation sciences students or professionals who have not taken the ISWP Basic Test ($n = 81$)

(*continued*)

Table 1. Continued.

Study title (author, year)	Study purpose	Location and setting	Study design	Target population (*n*)
Implementation of the hybrid course on basic wheelchair service provision for Colombian wheelchair service providers. (Burrola-Mendez et al., 2018) [23]	To evaluate the influence of the Spanish Hybrid Course on Basic Wheelchair Service Provision, a training based on the WHO WSTP-Basic level.	Colombia [UM] Community	[Quasi-experimental design] Pre–post repeated measures.	Wheelchair service providers ($n = 15$)
Development of a Hybrid Course on Wheelchair Service Provision for clinicians in international contexts. (Burrola-Mendez et al., 2018) [29]	To develop and evaluate a blended learning approach for the WHO WSTP-Basic level.	USA [H] Academic	Quasi-experimental design.	Students, staff and professors from OT, PT, RST, P&O programs ($n = 6$)
Developing wheelchair training program for rehabilitation and occupational therapy students. (Sarsak et al., 2018) [50]	To develop the minimum skills and knowledge required by personnel involved in wheelchair service delivery, and to integrate the WTP into the regular rehabilitation curricula and training programs.	Jordan [UM] Academic	Quasi-experimental design.	OT students ($n = 40$)
Preliminary Evidence to Support a "Boot Camp" Approach to wheelchair Skills Training for Clinicians and Learning Effects of Self-Learning Tool. (Giesbrecht et al., 2015) [30]	To evaluate the impact of providing intensive large-group training on wheelchair-specific self-efficacy and skill capacity among occupational therapy students.	Canada [H] Academic	[Quasi-Experimental Design] Repeated-measures without a control group.	OT students ($n = 65$)
A Wheelchair Workshop for Medical Students Improves Knowledge and Skills A Randomized Controlled Trial. (Kirby et al., 2011) [55]	To test the hypothesis that a multicomponent workshop about wheelchairs, tailored for undergraduate medical students, is effective in improving medical students' wheelchair-related knowledge, skills, and attitudes.	Canada [H] Academic	Randomized controlled trial.	Medical students ($n = 26$)
Wheelchair Skills Training Program for Clinicians: A Randomized Controlled Trial With Occupational Therapy Students. (Coolen et al., 2004) [56]	To test the hypothesis that the WSTP, added to the standard curriculum, would result in significantly greater overall improvements in wheelchair skills than a standard undergraduate OT curriculum alone.	Canada [H] Academic	Randomized controlled trial.	OT students ($n = 40$)

AT: assistive technology; H: high-income countries; ISWP: International Society of Wheelchair Professionals; L: low-income countries; LM: lower middle-income countries; LLMIC: low and lower middle-income countries; MWC: manual wheelchairs; OT: occupational therapy; PT: physical therapy; UM: upper middle-income countries; WHO: World Health Organization; WMTP: wheelchair maintenance training programme; WHO WSTP: World Health Organization Wheelchair Service Training Package; WSTP: wheelchair skills training program; WSTPt: Wheelchair Service Training of Trainers Programme; WTP: wheelchair training program.
[a]The study used the 2018 World Bank classification. The classification has changed since then.
[b]The information inside the brackets ([ ]) was inferred based on what the authors reported in the manuscripts.

teaching wheelchair content, and process implemented to develop the course.

Course adaptation and delivery

About half of the articles, $n = 13$ (52%), described the adaptation of existing wheelchair-related training materials using different learning environments (Table 2: B. Adaptation and integration of existing training courses). Authors of eight articles (62%) reported using the Wheelchair Skills Program (WSP) [54] as the training resource adapted and/or tested in a different learning environment. The WHO WSTP-Basic level [10] was the second most used training package, $n = 4$ (31%). The learning environments used were in-person, $n = 5$ (39%), a hybrid combination of online and in-person, $n = 4$ (31%) and exclusively online training, $n = 3$ (23%).

The articles that employed an in-person learning approach adapted the WSP using a condensed-practice training format (e.g., boot camp, workshop) [30,49,55,56] and a distributed-practice university course approach [31] to teach wheelchair skills at Canadian universities. The course duration varied from 1 day of 2 to 8 h [30,31,55,56] to 2 days of 6.5 h each [49] and 5 days of three hours each [31]. These courses, or components of courses, were exclusively focussed on wheelchair skills, relating to step 7: User training of the WHO 8-steps for wheelchair service provision [57].

The articles that followed a hybrid learning approach ($n = 4$) [22,23,29,43] used a combination of online and in-person environments as the teaching strategy. Most studies, $n = 3$ (75%) [22,23,29] adapted the WHO WSTP-Basic level 40-h in-person course into a hybrid approach in English and Spanish, detailing the content, teaching and learning strategies, evaluation processes, material and procedures implemented in the online and in-person sections. The course adaptation strategies for the online portion included creating videos, discussion forums, interactive online modules, short quizzes and interactive activities that were

Table 2. Development, integration and delivery of wheelchair service provision education.

In-text citation	Course development	Learning environment Teaching activities/resources	Integrated into University Program	Delivery	
				Course (format, level, duration)	Who delivered the course
(A) Development, integration and delivery of a novel course					
Gilbert et al., 2021 [44]	Resources Not Reported **Content** Lecture: Epidemiology; wheelchair etiquette; recommendations for communication with persons with a disability. Video: Appropriate prescriptions; types and components including cushions; wheelchair-related shoulder pain, pressure injuries, and medical complications associated with wheelchair mechanical malfunction; personal wheelchair-related experience; clips of advanced wheelchair skills and adaptive recreational activities. **Process** Not reported **Developers** Experienced clinicians.	**[In-person]** Lecture, video and interactive wheelchair experience [synchronous]	Yes	**Format** Mandatory Component of Clerkship [condensed] **Level** Undergraduate: 4th year **Duration** 2 h.	Not reported
Sarsak et al., 2018 [50]	**Resources** WHO WSPT-Basic level and intermediate and unspecified educational resources **Content** Seating biomechanics; postural supports; manual and power wheelchairs; seat functions; wheelchair functional outcomes; clinical implications and special cases; occupational therapist role in wheelchair provision process; accessibility issues; wheelchair skills training; wheelchair adjustments **Process** 3 phases: pre-test phase, WTP phase, and post-test phase. **Developers** Researchers in the Department of Occupational Therapy at the University of Jordan.	**[In-person]** Interactive lecture, handouts, group work and exercises [synchronous]	Yes	**Format** Training program [optional] **Level** Undergraduate **Duration** 4 × 5-h sessions. 1 session/ week over 4 consecutive weeks.	Not reported
Toro-Hernandez et al., 2017 [47]	**Resources** Wheelchair provision guidelines and wheelchair service training developed by the WHO, RESNA and Australian guidelines **Content** Inspection and maintenance activities **Process** Phase 1. An online survey sent to experts with at least one year of experience maintaining, repairing or providing wheelchairs. Phase 2. First draft of the program using the WHO material format. Phase 3. Two review rounds of the first draft by experts in wheelchair provision, maintenance and wheelchair user-related training. **Developers** University-based team (undergraduate and graduate students, research scientist, clinical coordinator, rehabilitation	**[In-person]** Lecture, video, handouts and practice [synchronous]	No	**Format** [Training program] **Level** Continuing education **Duration** 6-h course + 2 training sessions (2-h sessions on 2 sequential days).	Not reported

(*continued*)

Table 2. Continued.

In-text citation	Course development	Learning environment Teaching activities/resources	Integrated into University Program	Delivery	
				Course (format, level, duration)	Who delivered the course
	science professor, communications specialist).				
White et al., 2003 [51]	**Resources** Not reported **Content** Topic areas such as pressure management, postural management and equipment knowledge. **Process** A postal survey was undertaken by 165 wheelchair service therapists and 160 wheelchair service managers. **Developers** Not Reported	**Not reported** Lecture, practice, work-based tasks (resource file, informative visit, case studies, reflective diary) [synchronous]	Yes	**Format** [Optional course] Core module of generalist knowledge and additional specialist courses. With credit recognition **Level** Continuing education **Duration** Not reported.	Range of professionals and service users.
(B) Adaptation and integration of existing training courses					
Worobey et al., 2021 [45]	**Resources** Wheelchair skills program **Teaching activities/resources** Videos [asynchronous self-study] **Process** Not reported **Team** Not reported	**Online**	No	**Format** Training of trainers program **Level** Continuing education **Duration** Not reported.	Not reported
Giesbrecht et al., 2021 [43]	**Resources** Wheelchair skills program **Teaching activities/resources** Boot camp: Online tutorial [asynchronous self-study], demonstration and verbal instruction, practice with strategic feedback [synchronous role play] **Process** Not reported **Team** Not reported	**[Online and In-person]**	Yes	**Format** Compulsory advanced clinical skills course **Level** Graduate **Duration** 4 h.	Expert instructor
Worobey et al., 2020 [48]	**Resources** Wheelchair skills program **Teaching activities/resources** Instructional video-recordings and handouts [asynchronous self-study], dyad practice with self-selected frequency and duration of sessions and remote asynchronous feedback **Process** Not reported **Team** Not reported	**Online**	No	**Format** [Optional condensed education: boot camp] **Level** Undergraduate and continuing education **Duration** Variable. Average of 3 sessions. Session durations [15–120] min. Total time for practice and spotting combined [40–330] min.	Content expert + experienced trainer-of-trainers with experience in wheelchair training and provision.
Smith et al., 2019 [49]	**Resources** Wheelchair skills program **Teaching activities/resources** Lecture, demonstration, and hands-on training [synchronous] **Process** Not reported **Team** Not reported	**[In-person]**	No	**Format** [Optional condensed education] Bootcamp **Level** Graduate **Duration** 2 days. 6.5 h dedicated to both manual or power wheelchair skills.	5 individuals with extensive training in the wheelchair skills program.
Burrola-Mendez et al., 2019 [22]	**Resources** WHO WSPT Basic level **Teaching activities/resources** Online: Discussion forums, case studies, short quizzes, videos and interactive activities [asynchronous], mandatory synchronous meetings, in-person training In-person: Theoretical and	**Hybrid** **Online and In-person**	No	**Format** [Training program] **Level** Undergraduate, graduate and continuing education **Duration** Online: Online section: 2 weeks, 9 modules: 12 h, meetings: 4 h. In-person section: 3 consecutive days, 8 h per day.	Online: Online section: ISWP Hybrid Course developer and staff In-person section: Trained Occupational Therapist, Medical Doctor, Biomedical Engineer and Physical Therapist In-person only: Trained Occupational Therapist,

(*continued*)

Table 2. Continued.

In-text citation	Course development	Learning environment Teaching activities/resources	Integrated into University Program	Delivery	
				Course (format, level, duration)	Who delivered the course
	practical sessions occurred simultaneously [synchronous] **Process** Not reported **Team** Not reported			In-person only: 5 consecutive days, 8 h per day.	Medical Doctor and Biomedical Engineer.
Rushton et al., 2019 [31]	**Resources** WHO-8 steps wheelchair service provision, Wheelchair Skills Program **Teaching activities/resources** University course: Lecture, case studies, demonstration and practice [synchronous] Boot camp: Lecture, demonstration and practice [synchronous] **Process** Not reported **Team** Not reported	**[In-person]**	Yes	**Format** Optional credited course and [Optional Condensed Education] Boot camp **Level** Graduate and continuing education **Duration** University course: 15 weeks, 24 h Boot camp: 8 h.	University instructors]
[42]	**Resources** Guidelines on the provision of manual wheelchairs in less-resourced settings developed by the WHO **Teaching activities/resources** Lecture, quiz, videos, case studies, discussion forums [asynchronous] **Process** HI completed the French translation of the programme of courses. **Team** Physiopedia, the International Committee of the Red Cross and Humanity & Inclusion.	**Online**	No	**Format** [MOOC] 4-Course Program + 1 Optional Course **Level** Undergraduate and continuing education **Duration** 17 h over 4 weeks. [4–6] h each course.	Not reported
Burrola-Mendez et al., 2018 [23]	**Resources** WHO WSPT-Basic level **Teaching activities/resources** [Discussion forums and videos [asynchronous], mandatory synchronous meetings, in-person training][a] **Process** Not reported **Team** Not reported	**Hybrid**	No	**Format** [Training program] **Level** Continuing education **Duration** Online section: 2 weeks, synchronous meetings of 90 min each. In-person section: 3½ days, 8 h per day.	Online section: ISWP staff and ISWP Hybrid Course developer In-Person section: Trained Physical Therapist, Medical Doctor, and Biomedical Engineer.
Burrola-Mendez et al., 2018 [29]	**Resources** WHO WSPT-Basic level **Teaching** Activities/resources Discussion forums and videos [asynchronous], mandatory synchronous meetings, in-person training **Process** 2 rounds of internal and external revisions. First round: A module prototype was developed and distributed to the HSC members to collect feedback about the visual design of the course, the modules' sections and the layouts. Second round: All modules and their respective content were created and distributed *via* the online platform. For this round,	**Hybrid**	No	**Format** [Training program] **Level** Undergraduate and Graduate **Duration** Online section: 8 modules (average of 10 h), 3 synchronous meetings of 90 min each. In-person section: 3 days of in-person training, 8-9 h per day.	2 Trained physical therapists; 1 occupational therapist.

(*continued*)

Table 2. Continued.

In-text citation	Course development	Learning environment Teaching activities/resources	Integrated into University Program	Delivery	
				Course (format, level, duration)	Who delivered the course
	feedback was solicited on curriculum content and platform access. Learning objectives were developed according to the WHO WSTP-Basic level. **Team** Online section: Multidisciplinary members from high-, middle- and low-income countries with experience in delivering wheelchair training and developing educational programs for high- and low-resource settings.				
Munera et al., 2017 [46]	**Resources** WHO Wheelchair Service Training of Trainers Programme (WSTPt) **Teaching activities/resources** Didactic training and practice [synchronous] **Process** Not reported **Team** Not reported	**Not reported**	No	**Format** Training of trainers program **Level** Continuing education **Duration** 5 days.	Advanced-level wheelchair service providers and experienced WHO WSTP trainers.
Giesbrecht et al., 2015 [30]	**Resources** Wheelchair skills program **Teaching activities/resources** Lecture, instruction, demonstration and practice [synchronous] **Process** Not reported **Team** Not reported	**[In-person]**	No	**Format** [Optional condensed education] Boot camp **Level** Graduate **Duration** 4.5-h: 1-h overview of the WSTP + 3.5 h of hands-on training.	Two experienced occupational therapists, with WSTP training and *>* 5 years of clinical experience.
Kirby et al., 2011 [55]	**Resources** Wheelchair skills program **Teaching activities/resources** Lecture, practice, community experience and reflective exercise [synchronous], self-study [asynchronous] **Process** Not reported **Team** Focus group of a senior medical student, a family physician, a community-based wheelchair user, a community-based caregiver, a physiatrist, and an occupational therapist.	**[In-person]**	No	**Format** [Training program] workshop **Level** Undergraduate **Duration** Approximately 4 h: 45-min didactic presentation + 2-hour practical experience (3 × 40-min stations) + approximately 60-min community experience + approximately 15-min reflective exercise.	Experienced occupational therapist, rehabilitation engineer, and physiatrist.
Coolen et al., 2004 [56]	**Resources** Wheelchair skills program **Teaching activities/resources** WSTP: Instructional video and practice with feedback [synchronous] Standard curriculum: Lecture and practice [synchronous], community experience [asynchronous] **Process** Not reported **Team** Not reported	**[In-person]**	Yes	**Format** Component of a course **Level** Undergraduate **Duration** WSTP: 2–3 h Standard curriculum: 1st year: 2 × 3-h sessions + 4 h of community experience over a 2-week period, 3d year: 3 × 2-h, 4th year: 2 × 3-h.	Not reported
(C) Wheelchair service provision education: State of integration					
Fung et al., 2019 [17]	**Resources** WHO package, motivation packages from motivation Charitable Trust, United Kingdom,	**Not applicable**	Yes	**Format** Mostly components of a course. Optional wheelchair-specific course	[Educators across academic rehabilitation programs and resource settings].

(*continued*)

Table 2. Continued.

In-text citation	Course development	Learning environment Teaching activities/resources	Integrated into University Program	Delivery	
				Course (format, level, duration)	Who delivered the course
	WHO Community-Based Rehabilitation Learning Community, Wheelchair Skills Program, Pittsburgh Maintenance Package **Teaching activities/resources** Lecture, case studies, videos, patient models and practice.			**Level** Undergraduate and continuing education **Duration** Variable. [3–40] h.	
Best et al., 2015 [59]	**Teaching activities/resources** Lecture, instruction, demonstration, practice, and extra-curricular activity (exposure during clinical placements, spending a day in a wheelchair) [synchronous].	**Not applicable**	Yes	**Format** Mandatory course and component of a course **Level** Undergraduate **Duration** Variable. [<1,>6] h: 8 institutions delivered >6 h training; 8 institutions delivered <5 h training; 5 institutions offered no training.	Not reported
Silcox et al., 1995 [60]	**Teaching activities/resources** Not reported	**[In-person]**	Yes	**Format** Not reported **Level** Undergraduate and continuing education **Duration** Variable. 17.73 h (mean) in OT and PT Colleges. 8.52 h (mean) in Wheelchair Service Centres.	[Trainers in OT and PT Colleges and Wheelchair Service Centres].

Sub-question #1. "How are wheelchair service provision education curricula developed, integrated and delivered".
AT: assistive technology; HI: humanity & inclusion; ICRC: International Committee of the Red Cross; MOOC: Massive Open Online Courses; OT: occupational therapy; PT: physical therapy; RESNA: Rehabilitation Engineering and Assistive Technology Society of North America; SCI: spinal cord injury; WHO WSTP: World Health Organization Wheelchair Service Training Package; WSTP: Wheelchair Skills Training Program; WTP: Wheelchair Training Program.
The information inside the brackets ([ ]) was inferred based on what the authors reported in the manuscripts.
[a]Referenced in "Development of a Hybrid Course on Wheelchair Service Provision for clinicians in international contexts."

completed asynchronously. The in-person sessions followed the strategies recommended by WHO WSTP-Basic level [24]. The duration of the online portion ranged from 14 to 16 h (35–40% of the course) and was followed by 3 to 3.5 days of 8 to 9 h per day in-person training [22,23,29] for international rehabilitation professionals and/or students (i.e., OT, PT, P&O and Biomedical Engineers). The other article that implemented a hybrid learning approach [43] adapted the WSP into a 4-h boot camp with one online module to teach wheelchair skills to OT students at a Canadian university. No details were included about the adaptation strategies and duration of the online component of the course.

The articles that reported using an online learning approach ($n = 3$) [42,45,48], provided limited information about the procedures used to adapt the course online. Two studies adapted the WSP to teach manual wheelchair skills to clinicians (i.e., PT, OT, physician and therapy assistant) located in the USA [45,48]. These studies reported use of instructional video recordings, handouts, case studies, guided skills practice sessions, asynchronous feedback, discussion forums and quizzes as teaching and learning resources. One article reported a wheelchair skills practicing time among participants that ranged from 40 to 330 min [48]. The other study adapted the WHO WSTP-Basic level into a Massive Open Online Course (MOOC) in English and French with a course duration of 16 to 24 h over 4 weeks [42]. This study reported a registration of 5559 participants from 148 countries in a course running from September to October of 2018 [42]. The report does not include information about dropouts and course completion rates.

Only three studies (23.1%) [31,43,56] reported integration of courses into university program curricula; all of them were Canadian OT programs and related to wheelchair skills. All courses (or course components) were optional: one used exclusively a boot camp approach (4 h) [43], another used a wheelchair skills workshop (2 to 3 h) [56] and the third compared a boot camp approach (5 h) with a distributed-practice (14 h) university course [31]. This last study provided the content of the university course reflecting the integration of the WHO 8-steps [31].

Course competencies and effectiveness

No articles explicitly stated the expected skills and competencies after wheelchair service provision education. However, targeted competencies among the studies that tested the effectiveness of a specific course or a specific competency among rehabilitation professionals ($n = 17$, Table 3) included knowledge ($n = 11$) [15,16,22,23,29,44,47,50,51,55,56] and the combination of wheelchair skills and self-efficacy ($n = 6$) [30,31,43,45,49,55].

The most frequent evaluation of knowledge was on *basic* manual wheelchair service provision knowledge, defined as the knowledge and skills to provide wheelchair service to people with mobility impairment who can sit upright without additional postural support [24]. These articles ($n = 5$) [15,16,22,23,29] used the ISWP Basic Test [58] as the outcome measure. Other studies tested wheelchair skills knowledge [55,56], basic maintenance skills [47] and general wheelchair service provision knowledge (unspecified content) [44,50,51]. Regardless of the selected outcome to measure knowledge, most studies used a quasi-

Table 3. Wheelchair service provision education: course effectiveness and competencies.

In-text citation Sample size	Targeted competencies	Outcome measure	Outcome measure characteristics (type, construct measure, response scale, administration time)	Educational effectiveness
Testing effectiveness				
Worobey et al., 2021 [45] $N = 7$ clinicians and 19 trainees	Skill self-efficacy	1. WST-Q 4.3 version 2. SEATS-M 3. Video-recordings of the trainees	1: [subjective], capacity and confidence, [3-point Likert scale] (2 = yes, 1 = yes with difficulty, 0 = no) and (0 = not at all confident,1 = somewhat confident,2 = confident). 2: [subjective], self-report measure of clinicians' self-efficacy to assess, train and spot each WST skill, 4-point [Likert] scale from 0 to 4 (not at all confident, somewhat confident, neutral, fairly confident, completely confident) 3: [subjective], trainees' performance upon skill acquisition (WST capacity scores of 1 or 2) evaluated by researchers.	**Skill** 1. Trainee 4-item median [IQR] WST-Q scores significantly increased with training for capacity (13% [6,31] to 88% [75,88], $p < 0.001$) and confidence (13% [0,31] to 88% [81,100], $p < 0.001$). **Self-Efficacy** 2. The median [IQR] pre-training 32-item SEATS scores for assessment, training and spotting were 62% [53, 86], 57% [57, 84], and 96% [77, 97]. Trainer confidence increased for assessment ($p = 0.003$) and training ($p = 0.002$), but not spotting ($p = 0.056$).
Gilbert et al., 2021 [44] $N = 123$	Knowledge	Pre and post surveys	[subjective], understanding of (1) impact of manual wheelchair use, (2) challenges of manual wheelchair use, (3) manual wheelchair skills, and (4) wheelchair etiquette, 14 items scored on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) and open-ended questions.	The mean ± SD pre-and post-survey section scores for the main outcome measures were as follows: 3.9 ± 0.7 and 4.4 ± 0.6 for the impact of manual wheelchair use, 3.1 ± 1.0 and 4.4 ± 0.6 for challenges of manual wheelchair use, 2.4 ± 0.9 and 4.4 ± 0.7 for manual wheelchair skills, and 2.5 ± 1.0 and 4.0 ± 0.8 for wheelchair etiquette, respectively. Two-tailed sign tests demonstrated improvement from pre- to post-survey for all four outcome measure summary scores ($p < 0.001$). These score improvements remained significant after data were stratified for gender, prior wheelchair experience, and prior PM&R rotation experience.
Giesbrecht et al., 2021 [43] $N = 42$	Skill Self-efficacy	1. WST-Q 2.Wheelcon-M 3. SEATS	1: [objective], wheelchair skill capacity, 3-point Likert scale (2 = yes; 1 = yes, with difficulty, 0 = no) 2: subjective, self-report, manual wheelchair confidence,11-point Likert scale (0 = not confident; 10 = completely confident). 3: [subjective], self-efficacy for assessing, training, spotting, and documentation,5-point Likert scale (1 = not at all confident, 5 = completely confident).	**Skill** Post-hoc analyses revealed a significant increase from T1(prior to boot camp) to T2(following boot camp) for all measures and subscales At follow-up WST-Q had decreased significantly ($p < 0.001$) **Self-efficacy** Post-hoc analyses revealed a significant increase from T1 to T2 for all measures and subscales 2. WheelCon Total and Self-management subscale showed a statistically significant increase, indicating scores had been maintained and improved further by T3. 3. The remaining measures did not demonstrate significant change, indicating they were also maintained at follow-up.
Smith et al., 2020 [49] $N = 44$	Skill Self-efficacy	1. SEATS-M 2. SEATS-P 3. WST-Q for manual and power wheelchair users	1 and 2: [subjective], self-efficacy for assessing, training, spotting, and documentation,5-point Likert	**Skill** WST-Q capacity scores increased by 47.17% for manual wheelchair skills and by 37.08% for power

(*continued*)

Table 3. Continued.

In-text citation Sample size	Targeted competencies	Outcome measure	Outcome measure characteristics (type, construct measure, response scale, administration time)	Educational effectiveness
			scale (1 = not at all confident, 5 = completely confident). 3: [subjective], self-reported wheelchair skills capacity;32 items for manual wheelchair users and 29 items power wheelchair users.	wheelchair skills (p= <0.001) **Self-efficacy** Students' scores improved between 28.39% and 35.28% (p= <0.001) for all domains of the SEATS (assessing, training, spotting, and documentation).
Burrola-Mendez et al., 2019 [22] $N = 81$	Knowledge	ISWP Basic Test	[objective], basic wheelchair service provision knowledge, multiple-choice, approximately one hour to complete.	The sensitivity analysis did not show changes in the significance of the differences of differences between the Hybrid and In-person groups in the total knowledge score nor in the subgroup analyses. However, both study groups experienced statistically significant improvements in the primary outcome when comparing post- and pre-test scores ($p < 0.0001$).
Rushton et al., 2019 [31] $N = 55$	Skill Self-efficacy	1. WST-Q 2. WheelCon-M 3. SEATS	1: subjective, self-reported capacity, confidence, and performance in wheelchair skills, 2: subjective, self-reported measure of wheelchair confidence,11-point Likert scale (0 = not confident; 10 = completely confident). 3: [subjective], self-report measure of a clinicians' self-efficacy to assess, train, spot and document wheelchair skills, 5-point Likert scale (1 = not at all confident, 5 = completely confident).	**Skill** There were no significant differences in change scores (T2–T1) between the experimental and control groups on the WST-Q capacity (log transformation, F 1,53 = 0.47, $p = 0.497$, eta squared = 0.01), WST-Q confidence (F1,54 = 0.14, $p = 0.707$, eta squared = 0.00), WheelCon ($F = 4.0$, $p = 0.051$, eta squared = 0.07), **Self-efficacy** SEATS assessment (log transformation, $F = 0.00$, $p = 0.969$, eta squared = 0.00), SEATS training (F1,53 1,55 = 0.46, $p = .502$, eta squared = 0.01), SEATS spotting ($F = 0.57$, $p = 0.453$, eta squared = 0.01) and SEATS documentation (F 1,53 1,4 8 = 2.8, $p = 0.099$, eta squared = 0.06).
Burrola-Mendez et al., 2018 [23] $N = 15$	Knowledge	ISWP Basic Test	[objective], basic wheelchair service provision knowledge, multiple-choice, approximately one hour to complete.	Mean post assessment -scores were significantly higher (Mean (M) = 56.13, Standard deviation (SD) = 7.8), than pre-assessment scores ($M = 50.07$, $SD = 8.38$, $t(14) = 4.923$, $p = <0.0001$). All domains, except for Fitting presented an increase in mean scores between pre-test and post-test. Assessment reported a significant difference in the pre-test scores ($M = 13.93$, $SD = 2.19$) and post-test scores ($M = 16.33$, $SD = 2.06$), $t(14) = 5.041$, $p = <0.0001$.
Burrola-Mendez et al., 2018 [29] $N = 6$	Knowledge	ISWP Basic Test	[objective], basic wheelchair service provision knowledge, multiple-choice.	Post-assessments scores were significantly higher ($M = 64.17$, $SD = 5.41$) than pre-assessments scores ($M = 53.33$, $SD = 1.66$), t(5) = 4.897, $p = 0.004$; Cohen's $d = 1.99$.
Sarsak et al., 2018 [50] $N = 40$	Knowledge	Paper-based test: WTP Test	Knowledge improvement, multiple-choice, approximately 30 min.	At pre-test, the mean pre-WTP test score was 2.92 with the minimum average score of 1/10 and the

(*continued*)

Table 3. Continued.

In-text citation Sample size	Targeted competencies	Outcome measure	Outcome measure characteristics (type, construct measure, response scale, administration time)	Educational effectiveness
				maximum average score of 4/10; however, at post-test, the mean post-WTP test score was 7.32 with the minimum average score of 4/10, and the maximum average score of 10/10. Wilcoxon signed ranks test showed that there was a significant difference between pre-test and post-test WTP results for all students ($p < 0.001$).
Munera et al., 2017 [46] $N = 22$	Self-Efficacy	1. Trainee satisfaction surveys 2. Focus groups 3. Training Competency assessment tool	1: [subjective test], includes self-assessment question on confidence in delivering the WHO WSTP. 2: Not reported. 3: Not reported.	There was an increase in confidence to deliver the training after the WHO WSTPt. Participants reported an average of 80.6% confidence to deliver the WHO WSTPt after the training.
Toro-Hernandez et al., 2016 [47] $N = 17$	Knowledge	WMT-Q	[objective and subjective], wheelchair maintenance knowledge, multiple-choice and open-ended questions.	Mean difference in knowledge between pre and post-training a. Manual wheelchair open-ended − 25 ($p < 0.007$) b. Powered wheelchair − 21.9 (not statistically significant) c. Multiple choice − 27.3 ($p < 0.007$). d. Capacity − 51.6 ($p < 0.007$).
Giesbrecht et al., 2015 [30] $N = 65$	Skill Self-efficacy	1. WST-Q version 4.2 2. WheelCon-M short form version	1: [subjective], self-reported capacity to perform wheelchair skills, [3-point Likert scale] (2 = yes, 1 = yes with difficulty, 0 = no), with a total possible score of 64 points. 2: [subjective], self-reported in [test-taker] ability to safely perform different wheelchair-related activities, 11-point Likert scale (0 = not confident, 10 = completely confident).	**Skill** At post intervention, the WST-Q score mean increased by 24.7 (95% confidence interval, 22.1–27.3; p=.000), reflecting a 38.6% improvement (Cohen $d = 2.8$). **Self-efficacy** The WheelCon-M mean score improved by 3.0 (95% confidence interval, 2.5–3.3; $p = 0.000$).
Kirby et al., 2011 [55] $N = 26$	Knowledge Skill Self-efficacy	1. Written knowledge test, 2. Practical examination 3. The Scale of Attitudes Towards Disabled Persons 4. Survey	1: [objective], knowledge about the prevalence of wheelchairs in the community, safety, the method by which wheelchairs are provided and modified to fit the individual needs of users, the WSP (Wheelchair Skills Program), and the principles of motor skills learning, true/false, multiple-choice, and short-answer type of questions, approximately 30 min to complete. 2: [objective], wheelchair skills, approximately 30 min for each participant to complete this examination. 3: [subjective], attitudes towards persons with disability, 6-point Likert scale (from I disagree very much" to "I agree very much." 4: [subjective], Student's perception of overall workshop experience, free-response comments. 5-point Likert-type scale (1="very poor", 5= "very good").	**Knowledge** The difference in the means ± SD was 23.9% ± 7.5% (95% confidence interval, 17.6–30.3%; $p < 0.0001$). **Skill** 2. The difference in the means ± SD was 34.4% ± 9.6% (95% confidence interval, 26.3–42.5%; $p < 0.0001$). 3. The difference in the means was 1.6% ($p = 0.93$). **Self-efficacy** The perceptions of the students who took the workshop were highly positive.

(*continued*)

Table 3. Continued.

In-text citation Sample size	Targeted competencies	Outcome measure	Outcome measure characteristics (type, construct measure, response scale, administration time)	Educational effectiveness
Coolen et al., 2004 [56] $N = 40$	Knowledge Skill	1. WST 2. WST-K	1: objective, wheelchair skills, 2: [knowledge test on how to perform wheelchair skills].	**Knowledge** For the WSTP group, the total percentage WST-K scores were greater than the WST scores by mean differences of 13.4% before training ($p<.0001$) and 16.7% after training (P_.0001). For the second-year control group, the mean differences were 13.6% before training ($p<.0001$) and 9.1% after training ($p<.0001$). **Skill** Students in the second-year control group increased their mean percentage WST scores by 9.7% ($p<.015$), whereas those in the WSTP group increased by 25.0% ($p<.001$). The WSTP group improved to a greater extent ($p<.005$). The mean WST 2 and 3 scores did not differ significantly ($p<.29$). The mean WST score of the fourth-year control group was significantly lower than the WST 2 score of the second-year WSTP group ($p<.0001$) but not the second-year control group ($p<.58$).
White et al., 2003 [51] $N = 24$	Knowledge	Survey	[subjective], benefits and support required for future participants in a university-based course.	Increase in Knowledge (71%) – use of the information to train others (92%), engaging in further personal research activities (88%) – these aspects were rated good by the participants.
Testing competency				
Toro-Hernandez et al., 2020 [15] $N = 83$	Knowledge	ISWP Basic Test	[objective test], manual basic wheelchair service provision knowledge, [multiple-choice].	Average Total Domain pass scores per university Assessment – 57.6%; prescription – 51.3%; process – 51.0%; production – 48.5%; fitting – 23.7%; user training – 44.9%; follow-up – 49.2% **Total score – 48%** None of the participants passed the test.
Toro-Hernandez et al., 2019 [16] $N = 116$	Knowledge	ISWP Basic Test	[objective test], manual basic wheelchair service provision knowledge, [multiple-choice], <105 min.	Median and inter quartile ranges for each Domain Assessment–Median = 68.4 IQR [57.9–73.7]; prescription–median = 50.0 IQR [41.7–58.3]; process–median = 70.0 IQR [50.0–80.0]; production–median = 40.0 IQR [20.0–60.0]; fitting–median = 30.0 IQR [20.0–40.0]; user training–median = 46.7 IQR [36.0–60.0]; follow-up–median = 50.0 IQR [25.0–75.0] None of the participants passed the test.

Sub-question #2."What are the expected skills and competencies after wheelchair service provision education and how are these evaluated?."
Sub-question #3. "What is the evidence for educational effectiveness and clinical impact, and how are these measured?"
SEATS: self-efficacy in assessing, training, and spotting; SEATS-M: self-efficacy in assessing, training, and spotting manual wheelchair skills; SEATS-P: self-efficacy in assessing, training, and spotting power wheelchair skills; Wheelcon-M: Wheelchair Use Confidence Scale for Manual Wheelchair Users; WMT-Q: Wheelchair Maintenance Training Questionnaire; WST: wheelchair skills test; WST-K: wheelchair skills test – knowledge; WST-Q: wheelchair skills test questionnaire; WTP: wheelchair training program.
The information inside the brackets ([ ]) was inferred based on what the authors reported in the manuscripts.

experimental pre-post design to evaluate knowledge change after educational interventions [22,23,29,44,47,50,51].

A total of six articles [30,31,43,45,49,55] evaluated WSP [27] impact on wheelchair skills and self-efficacy in wheelchair use or provision of wheelchair skills training. The outcome measures most frequently used, in their different versions, were the Wheelchair Skills Test – Questionnaire (WST-Q) [30,31,43,45,49] to measure self-report wheelchair skills capacity, confidence and/or performance; the Self Efficacy for Assessment, Treatment and Spotting (SEATS) [31,43,45,49] to measure self-efficacy in clinical application of wheelchair skills training and documentation; and the Wheelchair Use Confidence scale (WheelCon) [30,31,43] to measure self-efficacy for wheelchair mobility and self-management. Similar to the studies that tested knowledge, the most frequent study design to evaluate wheelchair skills and self-efficacy was the quasi-experimental pre-post design.

Current state of integration of wheelchair-content into curricula globally

Three articles described practices in the integration of wheelchair-related content into professional rehabilitation programs (Table 2: Wheelchair service provision education: State of integration) [17,59,60]. One study reported wheelchair-related content integration practices in 11 low- to high-income countries with a course duration that ranged from 2 to 45 h of teaching in mandatory or optional courses in academic rehabilitation programs [17]. This study described barriers that educators experience integrating content into curricula (e.g., time constraints, limited human resources) and proposed strategies to overcome those difficulties (e.g., use of open-source online modules, guest lectures) [17]. The two other studies described practices in high-income countries. In one Canadian survey [59], OT and PT programs integrated wheelchair skills content in the format of a mandatory course or course component at the undergraduate level, with a course duration that ranged from <1 to >6 h. Almost a quarter, $n = 5$ (24%), of the surveyed institutions offered no training. In a UK survey, OT and PT programs at the undergraduate level reported a mean of 17.73 h of teaching wheelchair-related content with no details of the courses' format [60].

The three articles reported exclusively in Table 1 provide an overview of wheelchair service provision education globally and current capacity of personnel in enabling access to assistive technology [18,19,41]. McSweeney and Gowran reported limited competency among wheelchair service providers and a lack of integration of wheelchair service provision education in university programs in low and low- to middle-income countries (LMICs). They emphasized the need to integrate wheelchair content into university programs, endorse accreditation, and promote standardization of minimum competencies in wheelchair service provision to guarantee the development of a sustainable training strategy [19]. Fung et al. investigated the global situation of wheelchair service provision education which evidenced a lack of standardization in wheelchair content among professional rehabilitation programs and variability in course duration, with most courses allocating less time than recommended by the WHO. The authors encouraged the development of tools for educators that assist them in the integration of wheelchair content [18].

Methodological quality assessment

Overall, the articles had high methodological quality. The MMAT reported a total of 88% of questions fulfilling the methodological criteria. In the majority articles grouped as "quantitative non-randomized," the question *"Are the confounders accounted for in the design and analysis?"* could not be addressed by the information reported in the paper. Similarly, all articles that used a mixed methods design did not report information that may help reviewers to assess the question *"Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?."*

Discussion

Summary of eligible studies

Up to August 2021, a total of 25 publications were identified with the majority being published in the last 5 years reflecting an emergent interest in the field and the necessity to better understand the current state of wheelchair service education globally. This growth in research aligns with the agenda of the 2018 Wheelchair Stakeholders Meeting [32], the 2017 Global Priority Research Agenda and ultimately [61], the Members States commitment to fulfilling the promise of the United Nations (UN) Convention of the Rights of People with Disabilities [62] and the UN Sustainable Development Goals [63].

As expected, we found low-level evidence with a similar representation of descriptive (48%) and experimental studies (52%) using a variety of study designs. Among experimental studies, the quasi-experimental design using pre–post measures was the most common with sample sizes that range from 6 to 123 participants and only one article reporting a sample size bigger than 100 participants [44]. Quasi-experimental designs have become widely used in education research since 2009 as some topics in education are not amenable for randomized controlled trials (RCTs) as they present ethical challenges and/or may be too expensive [64]. Our scoping review yielded only two RCTs, one published in 2004 [56] and the second one in 2011 [55] and 10 quasi-experimental designs published between 2015 and 2021. In terms of study location, the results provided information from more than 30 countries; however, only three articles (10%) were conducted in low-income countries while most of the evidence came from high-income countries, $n = 11$ (36%).

Despite the broad population of this scoping review inclusion criteria, the majority of studies focussed on target populations for a limited number of professional groups (i.e., student and clinicians; overwhelmingly OT and PT) and has the potential to be biased from this professional/educational perspective. Additional assistive technology profession educators are encouraged to be more active in the development of the evidence base in this area so that educational, and ultimately, patient outcomes can benefit from multiple, collaborative professional perspectives.

Wheelchair service provision education globally: programs used and delivery methods

The WSP was the most frequently reported training package used to teach wheelchair-related content in high-income settings. The WSP is a set of assessments, tools and training protocols related to wheelchair skills exclusively [27]. This program was used in eight (62%) of the experimental studies that adapted and delivered training materials using different learning environments such as condensed-practice training formats (i.e., workshops and boot

camps) delivered in-person to OT students and clinicians and self-paced training formats delivered online to clinicians. Both learning environments and training formats have been effective in increasing wheelchair skills. Although the frequency in use of the WSP may indicate that the WSP has been widely distributed and incorporated in wheelchair-related education, it is important to note that all the studies were implemented in English-speaking, high-income countries (i.e., Canada and USA) using mostly in-person and online learning approaches (only one study used a hybrid approach). No evidence has been published about the adaptation and use of the WSP in less-resourced environments except for one article that explored the potential applicability of the WSP to the Indian context [65]. Many factors can limit the use of the WSP in LMICs; for instance, the WSP is available exclusively in English and French-Canadian, this is a fundamental barrier for researchers and educators whose mother tongue is not English or French [66]. Some groups have translated parts of the materials, but official translations are limited to the aforementioned languages. Even for those educators who may be proficient in the language, translating and adapting the content into their curricula will represent a burden on their already busy schedules. Another potential barrier to the use of the WSP is limited physical resources (e.g., limited wheelchairs and equipment) and human resources (e.g., trained instructors) [17] encountered in many LMICs. Moreover, the WSP's Manual of over 300 pages, may represent an obstacle for health care providers with limited literacy. In many LMICs, community health workers also known as village health workers, lay health workers, or *promotores*, play a critical role in healthcare delivery [67], including rehabilitation services [68,69]. These workers, who may not have received professional rehabilitation education might find the format and length of the WSP manual challenging.

It is important to note that the WSP's scope is focussed on wheelchair skills and it does not cover all the WH0-8 steps in comprehensive wheelchair service delivery. Therefore, resolving the challenges listed here for the WSP do not address the training gap.

The WHO WSTP-Basic level was the second most frequently reported training package used to adapt and deliver training. The package was used in four (31%) of the experimental studies that adapted and delivered training materials to teach wheelchair-related content. One article adapted the WHO WSTP-Basic level into a continuing education course using a hybrid format [29]; subsequently, two studies implemented the course among rehabilitation professionals from LMICs (i.e., Colombia, India and Mexico) [22,23]. The hybrid methodology combines online and in-person learning environments and has been widely used in health education among LMICs to overcome barriers to knowledge dissemination [70,71]. In order to be considered a hybrid course, 30 to 80% of the content needs to be delivered online [72]. None of the articles provided the percentage of content delivered online; however, we could infer from the articles' tables that describe the courses' content, that this criterion was fulfilled [22,23,29]. One article used an online self-paced tutorial prior to a 4-h boot camp on wheelchair skills to train OT students at a Canadian university [43]. It is unknown if the extent of the online module ranged between 30% and 80% of the total content course to be considered as a hybrid.

As opposed to high-income countries, training programs that targeted LMICs exclusively used the WHO WSTP-Basic level, a 40-h comprehensive course that covers the WHO-8 steps of wheelchair service provision. The availability of the WHO WSTP-Basic level in multiple languages, access to training materials for trainees (e.g., working book, reference manual) and trainers (e.g., PowerPoint presentations, trainer's manual, videos, posters) and the fact the content covers all steps of wheelchair service provision, may increase its dissemination and usage. Nevertheless, some research teams have identified limited content and training time for various wheelchair service provision steps. For instance, the WSP includes 32 mobility skills for manual wheelchair users as opposed to the seven skills encompassed in the WHO WSTP-Basic level [10,27]. Another training package, the Wheelchair Maintenance Training Program (WMTP) considered a more extensive list of maintenance activities to be taught to wheelchair users and caregivers than the ones included in the WHO WSTP-Basic level [28,47]. The WHO WSTP-Basic level is a high-profile and globally impactful training that was developed through a consensus rather than evidence-based process and is not frequently updated like typical curriculum is. The WSP and the WMTP are examples of evidence-based packages that serve to both highlight the gaps in the WHO-WSTP and provide examples of how they can be supplemented and expanded.

Integration of wheelchair-related content into curricula: the need for further support

Limited information is known about the integration of wheelchair content into the curricula of professional rehabilitation programs. Three articles reported on the development and integration of wheelchair related courses; one for medical students in the USA (high-income country) [44], another for OT students in Jordan (upper-middle-income country) [50], and a third for PT, OT and Rehabilitation Engineers in the UK (high-income country) [51]. These articles provided minimal to no information about the process involved in the course development and the methods used to integrate the content. From the articles that adapted a pre-existing training course (i.e., WSP) using an alternative learning methodology, three articles [31,43,56] integrated the courses (or components of the courses) into the curricula in OT programs in Canada (high-income country), the majority of them as optional. Among these articles, only one [31] provided details about the distribution of content, practical activities, and evaluation resources that may benefit other programs in a similar context to integrate wheelchair-related content into their curriculum. In addition, it was the only article that has reported the WHO 8-steps content integrated into the curriculum [31].

The integration of wheelchair-related content into professional rehabilitation programs is limited but emerging primarily in high-income countries. This review yielded no articles reporting the integration of wheelchair content into rehabilitation programs at academic institutions in low-income countries. The educational initiatives to build a competent workforce in wheelchair service provision in LMICs are still offered as continuing education programs by non-governmental organizations [22,23]. This finding aligns with the results from the scoping review of wheelchair service provision education and training in LLMIC [19] and reinforces the need to standardize and integrate training into university programs.

Recently, Fung et al. reported that time constraints and difficulties in the integration process (e.g., lack of teaching materials) have been identified by a sample of educators from low-to high-income settings as principal barriers to the integration of wheelchair content [17]. These barriers are not exclusive to the rehabilitation field. Heavy workloads and time constraints to manage academic activities (e.g., teaching, conducting research) are inherent problems of the academic system. Ziker et al. reported faculty

members at a University in the USA worked ~61 h per week [73]. Similarly, a survey conducted in Spain reported that, on an average, faculty work 49 h per week (11.5 h more than stipulated by law) with 20% of faculty members reporting they worked more than 60 h/week [74]. The coronavirus pandemic extenuated an already unbalanced workload by increasing stress, burnout, poor mental health and career uncertainty among academics [75]. Conducting teaching online can triplicate the preparation time [75] leaving educators less time to update their courses and conduct other activities. Educators worldwide need support and resources to facilitate the integration of content into their courses and curricula.

Since July of 2020, ISWP and an international group of 32 wheelchair educator experts from 21 low- to high-income countries have been working on the development of the Wheelchair Educators' Package, an online toolkit that attempts to address barriers in the integration of wheelchair content into curricula. This toolkit is to be launched in 2022 and will be a resource that may assist educators in improving wheelchair-related content in professional rehabilitation programs worldwide.

Limitations

A limitation of this study is its potential language bias; only English and French publications were included, which may not reflect a global view on wheelchair service provision education. Also, the time frame considered may have excluded some relevant evidence which has prevented us from drawing further conclusions; nevertheless, this is unlikely considering that most evidence has been published in the last 5 years.

Call-to-action

Build international partnerships for wheelchair sector professional education and research: "leave no one behind"

The underrepresentation of wheelchair service provision education in LMICs limits the scope of analysis and threatens that the recommendations that arise from this review could be biased towards what is known in middle- and high-income settings. Many of the papers included in this study refer to health professionals, including OT and PT, who have received more comprehensive training. It is less likely that wheelchair service delivery is provided by these professionals in LMICs [19]. Researchers in LMICs struggle with multiple barriers to conducting research and this may be attenuated by establishing collaborative partnerships with research teams at academic institutions in high-income countries. Such partnerships would reduce disparities in education and research [76,77] and contribute to more accessible education for all wheelchair service provision personnel. Sponsoring micro-credentials towards professional qualifications and post-graduate are specific examples worth pursuing. This type of collaboration could lessen the gap across income level countries and enhance understanding of wheelchair service education globally to better identify the key characteristics and factors that may assist in "*building capacity and delivering adequate education and training for all,*" a crucial component to address the global challenge of developing sustainable wheelchair provision systems [4].

Integrate wheelchair content into university programs worldwide

This scoping review found limited reporting of wheelchair-related content integration or evidence of guidelines to support educators in the integration process. Moreover, there is little detail pertaining to the specific learning outcomes used to measure knowledge, skills and attitudes nor how to best assess the transfer of acquired competencies into clinical practice. We call for a wheelchair sector education task force that includes professional societies, academic institutions, practitioners, providers and industry representatives to take action with the mission to establish guidelines for developing, integrating and updating content. If we are to achieve the promising goals to *support competency development and stimulate collaboration* by 2023 [32] *good health and well-being*, *promote quality education* and *reduce inequalities among countries*, *leaving no one behind* [63] these actions are paramount.

Conclusions

An appropriate wheelchair is essential for many people with a physical disability to meet personal posture and mobility needs, supporting health, well-being and inclusion. Wheelchair sector education and training are critical to promoting best practice. This is the first scoping review to provide a comprehensive synthesis of the current state of wheelchair service provision education for rehabilitation students and personnel across low- to high-income countries. The results from this synthesis indicate that there is limited information about the integration of wheelchair-related content into professional rehabilitation programs. Efforts to build international partnerships, standardize wheelchair service provision content and evaluation forms and integrate training into professional rehabilitation programs worldwide should be prioritized.

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