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Review Article

Manual Handling in Aged Care: Impact of Environment-related Interventions on Mobility

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ABSTRACT

The manual handling of people (MHP) is known to be associated with high incidence of musculoskeletal disorders for aged care staff. Environment-related MHP interventions, such as appropriate seated heights to aid sit-to-stand transfers, can reduce staff injury while improving the patient's mobility. Promoting patient mobility within the manual handling interaction is an endorsed MHP risk control intervention strategy. This article provides a narrative review of the types of MHP environmental controls that can improve mobility, as well as the extent to which these environmental controls are considered in MHP risk management and assessment tools. Although a range of possible environmental interventions exist, current tools only consider these in a limited manner. Development of an assessment tool that more comprehensively covers environmental strategies in MHP risk management could help reduce staff injury and improve resident mobility through auditing existing practices and guiding the design of new and refurbished aged care facilities.

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1. Introduction

Health-care workers continue to have one of the highest rates of musculoskeletal disorders (MSDs) internationally [1,2]. The manual handling of people (MHP), including assisting patients to ambulate, transfer to/from furniture, and perform daily hygiene activities, has long been identified as a principal contributing factor to the high MSD incidence among nurses [3]. As a result of the rapid increase in the number of older adults globally [4] and the growing need for aged care services, MSD injury risk exposure for residential aged care workers is likely to further increase.

Encouraging participation in the manual handling interaction is an endorsed MHP risk control intervention that could promote the resident's mobility and reduce the extent of assistance required from care staff [5,6]. This MHP strategy may require changes in how the care worker performs the task, for example, through a training intervention to improve care staff understanding of the importance of encouraging the older person to move themselves [7] and/or through changes within the environment. The efficacy of

environment-related MHP interventions, such as appropriate seated heights to aid sit-to-stand (STS) transfers, is well supported by evidence from diverse fields, including gerontology, nursing, and physiotherapy. Optimizing resident mobility, where possible, is also clearly articulated within the legislative and funding framework of residential aged care service provision in Australia [8,9]. However, in the delivery of care, these relatively simple and cost-effective environment-related MHP interventions that address quality of care outcomes for the resident and represent best practice in MHP risk management for the care worker do not appear to have been systematically applied. As illustrated in Fig. 1, this article explores the interdependent priorities of promoting mobility and reducing injury, with a particular focus on the importance of environment-related MHP interventions that can influence both at the same time. Through a narrative review process, this article reviews the impact of key environmental factors on mobility of the older person and the extent to which these environmental factors are assessed and considered in research investigations of MHP injury risk exposure for care workers and/or in MHP practice. The article then

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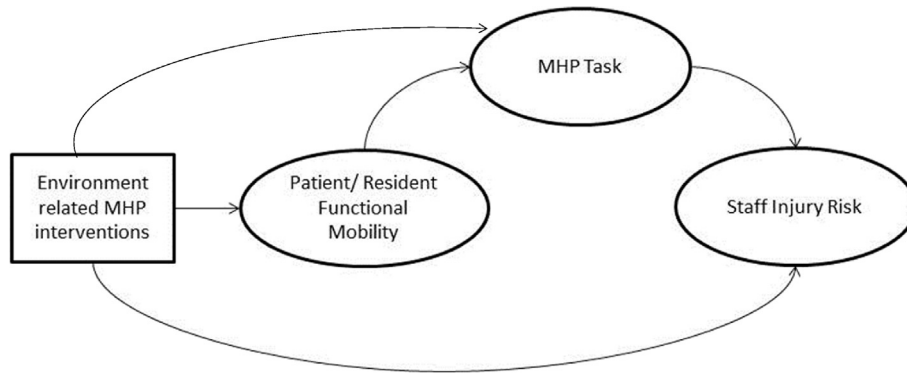


Fig. 1. Conceptual model of the dual relationship of environment-related MHP risk control interventions for staff injury risk exposure and patient/resident functional mobility.

considers how potential benefits of optimizing environmental factors to improve mobility of older adults can be applied in MHP risk management within residential aged care.

2. Methods

This investigation was undertaken through an extensive review of the literature based on searches of the following electronic databases: MEDLINE, CINAHL, PsychINFO, Embase, PEDro, Ergonomics Abstracts, Ovid, ScienceDirect, Scopus, Australian Digital Theses Program, and ProQuest Dissertations and Theses. In addition to reviewing contents of these searches, we performed searches of citations with Web of Science and manually searched reference lists, individual journals that were predominant in the search results, and relevant grey literature including government and industry publications and conference proceedings. MHP experts associated with the development and/or application of patient/person handling assessment tools were contacted for the purpose of locating other sources of grey literature. Publications reviewed were limited to English language. Quantitative, qualitative, and mixed methods research investigations were included.

Search terms used to identify relevant publications are detailed in the Appendix. Combined searches of “patient handling” and “mobility” and “aged” found publications describing mobility outcomes for the patient associated with patient handling/MHP interventions to be limited. Accordingly, separate search strategies were applied, focusing on “patient handling and staff injury MHP outcomes” or “mobility and the older person”. As a result of the importance of STS transfer performance for the older person, an extensive review of studies with STS outcome measures was undertaken. Inclusion criteria were therefore MHP interventions and staff injury risk exposure outcomes; MHP interventions and patient mobility outcomes; older adult mobility ability; and older person’s ability to transfer sit-to-stand and/or stand-to-sit. Exclusion criteria were publications associated with specific diseases/disorders (e.g., Parkinson’s disease). These searches yielded 328 references.

Research publications were grouped and analyzed for methodological quality and relevance against predetermined criteria (i.e., author/s; year of publication; study type/design; setting/measurements; sample size; subjects; results/comments), and findings were summarized in a table format. Summary tables included hazardous patient handling tasks; biomechanical evidence for lower back stress associated with patient handling; mobility and older adults; STS transfers and older adults; and assistive technology (AT) and older adults. In addition, summary tables from review of patient handling/MHP risk management literature included summary of methodologies and key findings of

systematic literature reviews evaluating MHP risk control interventions and summary of analysis of specific patient/person handling assessment tools that have been applied within MHP practice and research. Electronic database search alerts (for example: “patient handling” AND “injury”; “sit-to-stand”; and “older person OR aged”) and repeat searches using key terms enabled regular updating of the review. After further analysis, 99 citations published between 1982 and 2017 were included as references in this narrative review.

3. Results

3.1. Environmental factors that may benefit both resident and care worker in aged care

Capabilities and limitations associated with aging are complex phenomena and have a major influence on the risk of increased dependency and residential aged care placement [10,11]. Age-related changes in physiological capacity, including muscle strength and power and joint range of motion, influence the older person’s ability in ambulation, bed mobility, and bed and chair transfers [12–14]. However, capability with mobility task performance may be improved through exercise and rehabilitation [15,16], whereas mobility task demands can be reduced through assistance from a care worker (i.e., manual handling), the provision of equipment, and environmental changes [17,18]. Encouraging the patient to move independently, where possible, is an endorsed MHP intervention based on individualized assessment of the patient’s health status, environment, and mobility tasks to be performed [6,7,19,20].

Within the health and community service sectors, risk management principles have been applied in assessing the risks for care staff associated with MHP tasks and in implementing risk control strategies. Selecting appropriate risk control measures introduces the fundamental concept of the “Hierarchy of Risk Controls” whereby strategies are ranked from the highest level of effectiveness and reliability to the lowest [21]. The most reliable risk control measures involve eliminating the hazard and are sometimes known as “higher order” risk controls. If the hazard cannot be eliminated, the next measures that should be considered are substitution, isolation, and engineering controls. MHP risk control strategies at these levels include selection of appropriate AT and furniture such as electrically operated and adjustable beds. The least effective risk control strategies involve administrative strategies such as manual handling training. Despite being the most frequently used control, research has consistently demonstrated that manual handling training has failed to reduce injury incidence

[22–24]. For example, an evaluation of an MHP training intervention in a Swedish hospital 3 years after implementation demonstrated no reduction in MSD incidence [22]. This was consistent with later findings from a prospective controlled study by Hartvigsen et al [23] evaluating lower back pain incidence following intensive MHP education and provision of low technology MHP equipment such as slide sheets. Similarly, evaluation of training strategies that promoted patient participation and mobility in the handling interaction reported improvements in the nurse's task performance but did not provide evidence of reduced injury incidence [25,26].

By contrast, environment-related MHP interventions are higher order risk control strategies (i.e., substitution and/or engineering) that may potentially benefit care worker and patient/resident. Providing an aged care resident with a “toilet surround with seat” to promote independent transference from sitting to standing, for example, is an effective strategy for reducing staff exposure to MHP risks (e.g., heavy lifting, awkward, and/or sustained postures) that is not reliant on MHP technique training. Accordingly, this article outlines the evidence for environment-related MHP interventions that may promote patient/resident mobility, including seated heights, AT, and clear space and considers the extent to which these controls have been measured within MHP research and practice (e.g., MHP assessment tools).

3.1.1. Seated heights

Assisting with STS transfers is a frequently performed MHP task that is known to expose care staff to adverse loading of spinal structures, including intervertebral disc compression loading exceeding the recommended 3.4 KN proposed by the National Institute for Occupational Safety and Health [27,28]. Individualized seated heights are principal environment-related MHP interventions that may promote mobility of the older person and reduce the extent of staff assistance required. STS performance is dependent on muscle strength [29,30] and may also be influenced by a range of other factors, including sensation, speed, balance and psychological status [31], foot position [32], and age [29]. The older person may be required to perform the STS transfer under a range of different conditions related to the individual (e.g., posture) and the environment (e.g., seat type, height, and angulation). Physical characteristics of the chair and their influence on the individual's ability to rise from the seated position have been considered in extensive evaluation of the determinants of STS performance, including seat height [33,34], armrests [33], and chair type [35]. Seat height has been identified as the principal chair-related determinant influencing STS performance [34,36]. Higher chairs facilitate STS transfers, whereas lower seat heights increase the demands of the task as they require increased lower limb muscle strength [34,37]. STS research evidence involving older adults in laboratory settings has supported seated height ranges between 100% and 120% of measured lower leg length (i.e., seated knee height) for optimal STS transference [12,33].

An understanding of environmental factors that may aid STS performance for the older person and reduce the extent of assistance required from care workers is of particular relevance to this discussion [38]. This includes chair-related factors (e.g., chair type, armrests, height), bed height and type, toilet height, low technology-assistive devices to aid mobility such as bedpoles/sticks and grab rails, and clear space including adequate chair foot clearance. Investigations of movement patterns associated with rising from the bed have identified age-related differences indicative of increasing physical challenges with task performance for the older person [12,14]. Individualized seated height assessment to meet an older person's mobility needs, within the context of MHP risk management, should inform the provision and/or height

adjustment of chairs, beds, and toilet AT. These MHP risk control strategies are also supported by evidence from related falls research [39–41]. Promoting independent transfers through bed/seat height adjustment has also been considered in relation to falls risk associated with hospital bed side-rail use [39]. Bilateral bed side rails have been extensively used as a falls prevention strategy in health and aged care facilities despite evidence that frequency of falls is not reduced [39,40,42]. Investigation of strategies to reduce restrictive bed side-rail use and bed-related falls has recommended individualized nursing care interventions including bed and toilet height adjustment based on lower leg length to promote functional independence of the older person in transfers [43]. Capezuti et al [39] found that optimizing seated heights to assist STS transference for an aged care resident reduced potential environmental hazards that may influence falls risk.

Adjustable height beds enable staff to adopt more optimum postures for performance of MHP tasks at the bed side [44,45] and should also benefit the patient through optimal height adjustment for STS transfers. Additional benefits from electrically operated and adjustable beds, also referred to as “electric profiling beds” or EPBs, have been identified including reduced frequency of MHP task performance and postural load for the care worker and the potential to reduce risk of pressure sores and promote patient independence [46,47]. Oxley et al's [47] investigation of EPB use in residential aged care facilities (RACFs) in the UK suggested reduced exposure to physical MSD risk factors (e.g., awkward postures) for the carer associated with electric adjustment of bed height and raising the backrest. Benefits for residents, including the potential for independent back rest operation and bed height adjustment to assist with STS transfers, were suggested although not quantified.

Optimizing mobility of all aged care residents is an accreditation requirement in Australia, under Aged Care Standard Two “Outcome 2.14: Mobility, Dexterity and Rehabilitation”. RACFs must ensure that “optimum levels of mobility and dexterity are achieved for all residents” [8]. Variable height furniture is an evidence-based strategy that can assist the facility in meeting these mobility requirements for the resident, while also reducing injury risk for care staff [5,6]. However, despite these dual benefits, evidence of optimizing seated heights to aid STS transference for residents within the context of MHP risk management in aged care has been found to be lacking [38].

3.1.2. Assistive technology to aid mobility

AT to aid mobility is another important environment-related MHP risk control intervention that can facilitate transfers, promote independent mobility of the older person, and reduce staff exposure to manual handling risk factors [48]. Pope and Tarlov [49] defined ATs as “devices and techniques that can eliminate, ameliorate, or compensate for functional limitations” (p. 225). ATs such as bed sticks/poles, overhead trapeze, bed ladders, standing frames, grab rails, and toilet seat raisers can assist the older person to perform functional tasks and interact with their social and physical environment [49]. Alexander et al [12] suggested that bed mobility task performance by older adults may be improved through an increased focus on upper limb strength and function and/or the influence of bed design modifications such as additional handholds. Bed attachments, such as bed sticks/poles, can provide the older person with handholds to assist in bed mobility tasks and STS transfers from the bed. When moving from supine lying to sitting, additional handholds can assist the older person with turning and elevating the trunk.

Use of low technology bed AT have been advocated as an MHP intervention, with benefits for residents and staff [6,48], although MHP research related to bed attachments to aid mobility have been found to be limited [50]. Recent findings of the South Australian

Coroner in relation to the death of an aged care resident by “head and neck entrapment” associated with the *KA524 bedpole apparatus* [51] highlighted patient safety issues and further supported the need to prioritize research regarding the benefits and limitations of this equipment.

Mechanical *manual handling equipment* is advocated for transfers and repositioning of dependent patients who are unable to assist with transfers (i.e., nonweight bearing/partial weight bearing/noncooperative) [52–54] and may also aid improvements in mobility. Findings from investigations of the use of mechanical manual handling equipment, including ceiling-mounted patient hoists [55,56] and lateral transfer devices [57], have included patient subjective experiences. Owen et al’s [58] investigation of an MHP intervention identified a high level of patient comfort and security with all assistive devices used as opposed to manual methods. Similar findings have been reported by Pellino et al [57] in relation to the use of mechanical equipment for lateral transfers as compared with manual methods such as a drawsheet or slide board. In a study by Alamgir et al [56], ceiling-mounted hoist systems were reported by the patient to be more comfortable than mobile hoists [56].

Findings from related research evaluating MHP equipment use to assist with STS transfers during physiotherapy treatment activities indicated potential benefits within a rehabilitation rather than residential context [59,60]. Extending the understanding of the impact of mechanical manual handling equipment on MHP intervention outcomes could inform clinical benefits including improving and/or maintaining mobility.

3.1.3. Clear space

Clear space for care staff, patient, and equipment, including bed space, room dimensions, and fixed architectural features, is an environmental factor that may also impact manual handling outcomes for staff and patients [61–63]. Engkvist’s [61] investigation of factors involved in overexertion back injuries among nurses in a group of Australian hospitals demonstrated that environmental risks, most often inadequate space and/or lack of availability of lifting equipment, resulted in care tasks being performed in awkward postures.

Guidance for provision of space within health and aged care facilities is provided in national and international publications [64–66]. However, empirical data to inform these recommendations have been found to be limited [62,67].

Villeneuve [65] described a participatory ergonomic methodology for the design of a new hospital in Canada with the involvement of a wide range of staff and medical representatives. Architectural plans were reviewed and discussed, life size work area simulations were trialed and analyzed, and reference sites were visited. Recommended bed spaces of 14 m² provided for clear space of 1,800 mm on the “primary” side of the bed (i.e., primary work space), 1,200 mm on the secondary side, and 1,200 mm at the foot of the bed to enable wheelchair circulation. A similar collaborative human factors design approach for a new hospital in the United States described by Reiling et al [64], which included mock ups of patient rooms, a trade display, and “Failure Modes and Effects Analysis” (i.e., FMEA), recommended a standardized hospital room with a bed space area of 17.86 m².

A series of studies in the UK highlighted a lack of evidence supporting National Health Service (NHS) recommendations for health-care design [62,68]. Hignett and Evan’s [68] evaluation of transfers from wheelchair to toilet in two room layouts (4.15 m² and 4.08 m², respectively) using mobile and ceiling hoists demonstrated that the mobile hoist required more space than that provided (1,088 mm bedroom width for layout 1 and 1,005 mm for

layout 2) and significantly more than that for the ceiling hoist. In addition, more time was required, and more demanding postures (i.e., Rapid Entire Body Assessment (REBA) scores) were observed, with use of the mobile hoist. Hignett and Lu’s [62] investigation of bed space provision extended previous research through the development of task envelopes (TEs) which represent the spatial requirements for a range of “activities, participants, and interfaces” in a work space (p. 29).

In Australia, a range of publications have provided design guidance for residential aged care facilities including “*Design Guidelines for Queensland Residential Aged Care Facilities*” [69], “*Guide to the Safe Design of Aged Care Facilities*” [70], and “*Residential Aged Care Built Environment Audit Tool*” [71]. The importance of functional capacity of the older person and the associated manual handling needs, when designing acute health and aged care facilities, were considered in the development of the WorkSafe Victoria “*Guide to designing workplaces for safer handling of people (3rd Ed)*” [66]. Of note, this pivotal manual handling guidance publication highlighted problems associated with compliance with the “Building Code of Australia”. The Building Code of Australia, with reference to relevant Australian Standards including AS 1428-*Design for Access and Mobility*, provides minimum requirements for space and support aids for a person who can transfer independently but does not consider the additional needs of the person who requires personal assistance [66]. As a result, the space provided in health and aged care facilities built with reference to this standard may not be adequate for staff and/or handling equipment required when assisting dependent patients/residents. The WorkSafe Victoria [66] guide seeks to address this through generic spatial requirements for safe handling in bedrooms, bathrooms, corridors, storage areas, and lounge/dining rooms; area-specific design considerations (e.g., bathrooms); and an audit checklist to aid in identification of patient handling risks. Spatial dimensions provided are based on requirements for manual handling tasks where furniture and equipment within the manual handling zone are easily moveable. Accordingly, MHP risk assessment should consider optimum arrangement of furniture and fittings for safe performance of MHP tasks and mobility of the resident. The lack of empirical evidence, supporting the development and application of these spatial recommendations, could be informed by an MHP assessment instrument, for use in residential aged care, which provides systematic evaluation of an aged care resident’s bedroom and bathroom environment, with reference to the resident’s mobility/manual handling needs. This could be considered within the regular assessment of MHP practices that is undertaken in RACFs as part of ongoing risk assessment and management and improvements to quality of care.

3.2. MHP risk management: extent of consideration of environment-related MHP interventions that may influence mobility of the older person

Given that environment-related MHP interventions are important for increasing the mobility of residents and may have consequent positive effects on likelihood of staff injury, this section examines the extent to which these controls are systematically documented and assessed in the context of MHP in aged care. This necessitated a review of methods that have been used within MHP research studies and professional guidance for identifying MHP hazards, assessing risks, and evaluating interventions. More recently, this has included a range of patient/person handling assessment tools that have been applied in different countries and environments and for different purposes. This review sought to identify gaps regarding the assessment and evaluation of

environment-related MHP interventions that may influence patient mobility outcomes and to determine if an existing assessment tool could be applied to further investigate this aspect of MHP risk management. Assessment methods have been grouped by their main level of focus, based on similar categories described by Fray [72], namely, those that focus on the patient/resident; the work environment; the nurse/care worker; and the organization.

3.2.1. MHP assessment methods: patient/resident level of focus

At the level of focus of the *patient/care worker* interaction, safe manual handling task performance for care staff is informed by the patient's health status, care needs, and work environment. Information from the individual manual handling risk assessment and the manual handling plan is generally recorded and communicated to care staff. The risk assessment process may also involve using a numerical rating system to determine the level of risk associated with care of the particular patient, such as the patient handling assessment tool developed by Radovanovic and Alexandre [73]. This instrument provides evaluation of an individual patient's manual handling needs within a hospital context based on a scoring matrix. The tool considers the patient's needs and abilities, as well as specific environment-related "special risks", but does not include quantification of environmental factors and/or MHP interventions such as individualized chair or bed height adjustment.

Other methods for assessing patient handling risks at the individual patient level are included in health and safety guidance publications. The WorkSafe Victoria "*Transferring People Safely*" guide for the manual handling of people [6] and the Queensland Health [74] *Patient Handling Facility Unit Risk Assessment Tool (FURAT)* include tables detailing methods for safe performance of common patient handling tasks (e.g., repositioning in bed). Similar safe systems for manual handling task performance have been developed for application in other countries, including New Zealand [75], the USA [76], Canada [77], and the UK [5]. Of relevance to this article, these MHP guides provide a broad-based approach to management of major MHP related risks and include limited reference to assessment of MHP strategies for encouraging patient-independent mobility such as seated height adjustment and/or provision of bed attachments to aid mobility (e.g., overhead bars, bed sticks). However, although possibly limited, strategies to encourage independent mobility are a basic principle that underpins the approach described in these international guidance documents. These publications advocate an ergonomics/human factors systems approach, of which maintaining and encouraging patient mobility are fundamental.

3.2.2. MHP assessment methods: work environment level of focus

Several MHP assessment instruments have been developed primarily for the evaluation of risk for the care worker within a particular *work environment* (i.e., *work unit*). These methods and instruments include

- Assessment of systems for managing MHP risks within a facility/work unit: *Accident Compensation Corporation (ACC) (MHP Risk Assessment Audits)* [75]; *FURAT tool* [74].
- Environment assessment checklists [66].
- Evaluation of manual handling risk exposure for staff in a facility/work unit: *MAPO Index (Movement and Assistance of Hospital Patients)* [78]; *Care Thermometer* [79].
- Assessment of manual handling equipment needs for a particular work environment [79].

Assessment of MHP risks within a work environment can provide a summary of identified hazards and risk controls to inform risk

control strategies. Examples include the Queensland Health [74] *FURAT* instrument and the *MHP Risk Management Audit Forms* provided in the New Zealand (ACC) *MHP Guide* [75]. Systematic evaluation of risk management at the facility/unit level with the *FURAT* tool considers a range of risk factors including patient profiles, environmental risks, equipment provision and condition, staffing, and MHP tasks performed. Analysis of identified risk factors and existing and proposed risk control strategies informs MHP risk management. The New Zealand [75] "*Risk Assessment Audit Form*" and "*Moving and Handling Audit Form*" assess MHP risk management against a range of criteria and provide a numerical rating of compliance to aid identification of issues and prioritization of interventions. By contrast, audit checklists included in the WorkSafe Victoria *Design Guide for Safer Handling of People* (2007) are designed specifically for identification of MHP risks that may be related to the design of an existing work unit or planned workplace.

Limited assessment of factors that may enable the patient to use their residual physical capacity were included in the *MAPO Index* [78,80] and *Care Thermometer* [79], which are methods for evaluation of residual risk for health-care staff within a particular work environment. Specifically, the *Care Thermometer* tool provides an indication of quality of care and risk of the patient becoming inactive through unnecessary use of patient handling equipment but does not extend to individualized evaluation of patient environments such as seated heights. MHP risk factors assessed with the *MAPO index* include the degree of "disability" of the patients in the work unit, patient handling workload, some aspects of the environment (such as clear space and bed type), type and availability of equipment, and aspects of staff training and education. Quantitative physical environment data include assessment of clear space and seating heights. Armchair and toilet heights of less than 50 cm are recorded as "inadequate" as this may reduce the patient's ability to transfer STS although seating requirements for individual patients are not included [78,80].

3.2.3. MHP assessment methods: nurse/care worker level of focus

At the level of focus of the individual *nurse/care worker*, observational assessment methods have been used extensively for the identification and evaluation of care staff exposure to physical MSD risk factors. Study methods have included biomechanical, postural, physiological, and subjective measures [45,52,53,81], as well as specific patient/person handling assessment tools, for evaluation of nurse manual handling exposure, compliance, and competence [82,83]. Patient-related risk factors and risk control strategies have been considered including levels of patient dependency; cooperation and involvement of the patients in the patient handling interaction; and posture at completion of the task [26,84,85].

Patient participation and mobility during the manual handling interaction have been considered in several patient/person handling assessment tools developed for systematic evaluation of an individual nurse/care worker's compliance and/or competence with recommended patient handling methods [26,83–85]. These instruments consider ways of optimizing patient mobility but only through the lens of nurse task performance. This is evidenced with the *Direct Nurse Observation Tool* (DiNO) evaluation of the extent of patient participation during the performance phase of the task, described as "*according to his/her ability to perform voluntary movements*" (Johnsson et al 2004 p593). Patient-related outcome measures in the DiNO tool included whether the patient experienced pain and felt fear or uncertainty and their posture on completion of the transfer. The *Structure of the Observed Patient Movement Assistance Skills (SOPMAS)* patient/person handling assessment tool [85] also focuses on evaluation of nurse competence with patient handling tasks. The instrument is based on the

Structure of Observed Learning Outcome learning taxonomy [86] and uses a scoring matrix method for the assessment of the nurse's level of competence with four task items: the interaction between the patient and nurse, the patient's movements, the nurse's posture and movements, and the use of environment/auxiliary devices (Tamminen-Peter and Haintikainen 2004). Assessment of environment-related MHP interventions that may influence mobility with SOPMAS was only indexed by observations of the nurse's MHP technique, such as whether the nurse adjusted the bed to a safe working height for MHP task performance. Similarly, Warming et al [26] evaluated bed height adjustment with consideration of nurse, transfer, and patient ability, with measures such as "bed adjusted for patient's ability when transferring from bed to chair" (Warming et al 2004:612).

Measures of the resident's mobility, within the context of nurse MHP task performance, were included in Taylor et al's [87] recent investigation of the feasibility of a nurse training intervention in "person-centered mobility care". Mobility outcomes of aged care residents were measured using the validated "Physical Mobility Scale" [88] and an instrument developed by the researchers (i.e., Taylor et al 2015) for evaluation of residents' autonomy during, and experience of, mobility care entitled: the "Transfer Observation Instrument". However, Taylor et al's [87] focus on nurse/care worker training does not extend to evaluation of environment-related MHP interventions that may influence mobility.

3.2.4. MHP assessment methods: organizational level of focus

Evaluating MHP risk management systems at an *organizational* level can describe essential aspects of system effectiveness including management commitment and effective processes to support MSD prevention. In this regard, the *FURAT* tool [74], discussed previously, focuses on both patient handling risks for care staff in a work unit and organizational review. Management personnel of a health-care unit/facility are required to undertake a mandatory annual *FURAT* assessment of the patient handling risk management system in accordance with legislative occupational health and safety management system requirements in that state. In the UK, instruments developed for evaluation of organizational performance in relation to patient handling include the "Manual Handling Risk Controls in Hospitals" Scoring System [89] and the "Patient Handling Organizational Question Set" [90].

3.2.5. Assessment methods with multiple levels of focus: "tool for risks outstanding in patient handling interventions or TROPHI"

The *TROPHI* patient handling assessment tool [72,91] provides evaluation of multiple MHP intervention outcomes, including several patient outcomes (i.e., patient condition, patient perceptions, patient injuries, and quality of care). The instrument has been designed for application in a ward or unit and incorporates data from the 12 most preferred patient handling intervention outcomes identified through research with expert focus groups in four EU countries. Data derived provide a score for each outcome and a total score that indicates the level of effectiveness of the MHP risk management system [91]. Specific evaluation of environment-related interventions was not within the scope of this instrument.

In summary, review of existing MHP assessment methods according to the level of focus indicated that promoting mobility of the older person within the manual handling interaction was principally included in tools that evaluate individual nurse/care worker task performance. Within this MHP risk management context, assessment of environment-related MHP interventions that may influence mobility is mainly restricted to observations of the nurse's MHP technique (e.g., optimal use of space, furniture, and equipment). MHP assessment of care staff risk within a

particular environment/work unit included some measures relevant to patient/resident mobility although this was limited with regard to the nature and extent of environment-related interventions and their impact on patient outcomes.

4. Discussion

As the population ages, the need for provision of community and residential aged care services will continue to grow [92], resulting in increased exposure of care workers to MHP risks. Delivery of cost-effective care for the older person, which meets the person's need to maintain independence and autonomy and does not increase the injury burden for workers, should be a priority. Ensuring an older person's environment meets their mobility and manual handling needs is a strategy that can potentially provide these dual benefits. As outlined previously, environmental strategies are preferable as interventions than the more commonly used and often less effective controls such as staff training [23,93].

Age-related impairments may influence an older person's capabilities and limitations in performance of functional mobility tasks and may necessitate personal assistance from a care worker (i.e., MHP task) and residential aged care services. An older person's ability to perform functional mobility tasks may be improved through rehabilitation and exercise and/or through reducing the physical demands of the task. Evidence reviewed in this article supports the importance of environment-related MHP risk control strategies for reducing mobility task demands for the older person, such as optimum seated heights to aid STS transfers, clear space for resident, staff, and equipment, and provision of appropriate AT. In particular, the importance of seat height as the principal chair-related factor influencing STS performance for patients/residents was well evidenced [34,36].

The potential dual benefits of environment-related MHP strategies, in terms of promoting patient/resident mobility and reducing care staff exposure to MHP risk, warrant investigation of how these controls were assessed and applied in provision of care. Methods for the assessment of MHP risks and/or effectiveness of MHP interventions include some measures of environmental factors although assessment was limited with regard to the nature and extent of environment-related MHP interventions, such as seating provision and height adjustment that may influence outcomes for the older person. Assessment and/or evaluation methods at the patient/resident level were found to include reference to encouraging independent mobility and use of AT [73,75] but did not extend to assessment of functional mobility outcomes. Consideration of patient outcomes at the environmental level was found with several assessment methods, including the potential impact of seated heights [78] and MHP equipment [79], although evaluation of individual environment-related requirements for the patient/resident was not identified. While at the level of focus of the care worker, patient-related risk factors have been assessed to a limited extent with several specific patient/person handling assessment tools developed for the evaluation of care worker/nurse performance, including patient participation in the transfer and patient comfort and security [84,85]. However, the extent of assessment of environment-related MHP interventions was limited to observations of nurse technique, such as use of equipment and clear space. Overall, these observations mean that the tools that are used to facilitate MHP risk assessment do not comprehensively cover the environment-related conditions that have been shown to facilitate mobility of the older person, in particular, factors that reduce the task demands such as seated heights and STS transfers [13]. These existing MHP assessment instruments have been designed for specific purposes, thereby limiting appropriation for different

purposes (such as comprehensive reviews of environment-related risk controls).

4.1. Implications for future research and practice: development of an MHP assessment tool

Further investigation of specific environment-related MHP interventions, particularly associated with transferring on and off beds, chairs, and toilets, could assist with improvement of MHP risk management practices. The authors acknowledge that a range of MHP assessment tools already exist and that the development and validation of reliable and valid tools are lengthy processes that can require extensive resources. However, as an instrument for targeted evaluation of the nature and extent of environment-related MHP interventions that may influence mobility is not currently available, development of a patient/person handling assessment tool for this specific purpose is clearly indicated. Such a tool should be based on existing MHP assessment tools, research evidence, and MHP guidance publications to enable systematic assessment and analysis of associations between an older person's levels of performance with common mobility tasks and relevant environmental factors that may influence mobility within the context of MHP risk management. The focus of this assessment would be the quantification of environmental factors that may reduce mobility task demands for the older person, with reference to existing functional mobility information such as physiotherapy assessments (e.g., *Physical Mobility Scale* [88]), rather than indexing functional mobility per se. Information derived could aid identification of appropriate MHP interventions and support individualization of the older person's environment.

For an RACF, systematic evaluation of environment-related interventions within and between facilities should highlight inconsistencies and/or variations in MHP practices and support benchmarking of quality of care indicators. Information derived may also be used to demonstrate compliance with the aged care accreditation standards detailed within the *Aged Care Act 1997* [94]. In particular, a tool that quantifies the extent to which the environment addresses individual resident mobility/manual handling requirements would assist an aged care accreditation assessor in determining if resident mobility is being optimized, which may be constrained by existing documentation and limited time on site. These data could also be used to modify existing risk controls and guide design of new and refurbished facilities.

4.2. Limitations

Limitations of this general narrative review of the literature, as compared with systematic reviews of the MHP evidence base [95–97], are acknowledged. The academic approach adopted in publications such as the study by Amick et al [95] places randomized control trials (RCTs) at the highest level of evidence, followed by good quality individual trials, and is of particular value within areas such as the pharmaco-medical domain [98]. However, as argued by Forbes and Griffiths [98], the focus on experimental outcomes-based research has limitations in complex health-care systems because not all questions are quantifiable. In an RACF, for example, it would be difficult to prevent factors such as psychosocial MSD risk factors (e.g., work stress associated with managing challenging and changing resident behaviors) from confounding research data. In addition, from an ethical and/or legal perspective, it may not be possible to provide “interventions” such as AT to aid mobility to some of the residents and not make them available to others in a control group [72]. Evaluating evidence on these traditional bases is therefore difficult.

As this article aimed to evaluate what underpins MHP risk management in relation to environment-related interventions that

may influence patient mobility, it was of importance to focus on what is considered with existing instruments that are used within the MHP. Actual auditing of MHP practices, including the extent of application of those tools, was outside of that purpose. Similarly, although related falls research was considered, falls risk and prevention were beyond the scope of this paper, although related falls research was considered. For example, evidence from falls research has also supported the importance of individualized seated height assessment to meet an older person's mobility needs [39–41]. Investigation of strategies to reduce restrictive bed side-rail use and bed-related falls has recommended individualized nursing care interventions including bed height adjustment based on lower leg length to promote functional independence of the older person in transfers [43]. Environment-related MHP interventions should be informed by falls research and be consistent with falls prevention strategies.

4.3. Conclusions

This article's contribution to the MHP evidence base comes through identifying a set of MHP interventions with dual benefits for patient and staff which have been mostly ignored in how we assess MHP. Given the dual priorities of keeping older people more mobile and independent, while protecting staff from injury in MHP tasks, the development of a patient/person handling tool for assessment of environment-related MHP interventions could be of assistance in improving MHP risk management. Existing evidence-based MHP assessment tools could provide the basis of this instrument which should be subjected to wide consultation and content validation to ensure the tool is fit for purpose. Assessment with the tool could be used to audit existing practices, improve safety for all stakeholders, and contribute to better design of aged care facilities in the future. Of importance, evaluation could potentially address the nexus between work health and safety and care of the older person.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.shaw.2018.02.003>.

Appendix. Key search terms

Key words/terms used in searches included
 “patient” (truncated) AND “handling” (truncated).
 “manual” (truncated) AND “handling” (truncated).
 “no lift”.
 “zero lift”.
 lifting (truncated).
 nurse (truncated).
 “back” AND “injuries”.
 “musculoskeletal” AND “injury” (truncated) or “disorder”.
 “risk” AND “assessment”.
 aged (truncated).
 “long term care” OR “nursing homes” OR “homes for the aged”.
 “hospital” AND “beds”.
 Toilet (truncated).
 Bath (truncated).
 transfers (truncated).
 hoist (truncated).
 ADL.

IADL.
 mobility (truncated).
 ambulate (truncated) OR “walk” (truncated).
 “sit-to-stand”.
 rising.
 “bed” AND “mobility” (truncated).
 “assistive technology” OR “self-help devices”.

References

- [1] Safe Work Australia. Australian workers compensation statistics 2014–15. Revised July 2017. [Internet]. 28/07/2017. Available from: <https://www.safeworkaustralia.gov.au/doc/australian-workers-compensation-statistics-2014-15>.
- [2] US Department of Labor, Bureau of Labor Statistics. News release: nonfatal occupational injuries and illnesses requiring days away from work; 2015 [Internet]. 10/11/2016. Available from: <https://www.bls.gov/news.release/pdf/osh2.pdf>.
- [3] Hignett S. Work-related back pain in nurses. *JAN* 1996;23:1238–46.
- [4] United Nations Department of Economic and Social Affairs, Population Division. World population prospects: the 2017 revision, key findings and advance tables. Working Paper No. ESA/P/WP/248. [Internet]; 2017. Available from: https://esa.un.org/unpd/wpp/Publications/Files/WPP2017_KeyFindings.pdf.
- [5] (HOP6). In: Smith J, editor. The guide to the handling of people: a systems approach. 6th ed. Teddington, Middlesex: BackCare; 2011.
- [6] [Internet] WorkSafe Victoria. Transferring people safely. 3rd ed.; 2009. Available from: http://www.worksafe.vic.gov.au/_data/assets/pdf_file/0011/12224/Transferring_People_Safely_-_Web.pdf.
- [7] Kindblom-Rising K, Wahlstrom R, Nilsson-Wikmar L, Buer N. Nursing staff's movement awareness, attitudes and reported behaviour in patient transfer before and after an educational intervention. *Appl Ergon* 2011;42:455–63.
- [8] Australian Aged Care Quality Agency (AACQA). Aged care standards [Internet]; 2012. Available from: <http://www.accreditation.org.au/accreditation/accreditationstandards/>.
- [9] Australian Institute of Health & Welfare (AIHW). Australia's welfare [Internet]; 2011. Available from: <http://www.aihw.gov.au/publication-detail/?id=10737420537>.
- [10] Guralnik J, Ferrucci L, Pieper CF, Leveille SG, Markides KS, Ostir GV, Studenski S, Berkman LF, Wallace RB. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol A Biol Sci Med Sci* 2000;55A:M221–31.
- [11] Tinetti ME, Allore H, Araujo KLB, Seeman T. Modifiable impairments predict progressive disability among older persons. *J Aging Health* 2005;17:239–56.
- [12] Alexander NB, Grunawalt JA, Carlos S, Augustine J. Bed mobility task performance in older adults. *J Rehabil Res Dev* 2000;37:633–8.
- [13] Alexander NB, Galecki AT, Grenier M, Nyquist L, Hofmeyer M, Grunawalt J, Medell J, Fry-Welch D. Task-specific resistance training to improve the ability of activities of daily living-impaired older adults to rise from a bed and from a chair. *J Am Geriatr Soc* 2001;49:1418–27.
- [14] Mount J, Kresge L, Klaus G, Mann L, Palomba C. Movement patterns used by the elderly when getting out of bed. *Phys Occup Ther Geriatr* 2006;24:27–43.
- [15] Forster A, Lambley R, Hardy J, Young J, Smith J, Green J, Burns E. Rehabilitation for older people in residential care. *Cochrane Database Syst Rev* 2009;1.
- [16] Rydwick E, Frandrin K, Akner G. Effects of physical training on physical performance in institutionalised elderly patients (70+) with multiple diagnoses. *Age Ageing* 2004;33:13–23.
- [17] Clarke P, Chan P, Santaguida P, Colantonio A. The use of mobility devices among institutionalized older adults. *J Aging Health* 2009;21:611–26.
- [18] Liu S, Lapane K. Residential modifications and decline in physical function among community dwelling older adults. *Gerontologist* 2009;49:344–54.
- [19] Brown Wilson C. Safer handling practice for nurses: a review of the literature. *Br J Nurs* 2001;10:108–14.
- [20] Rockefeller K. Using technology to promote safe patient handling and rehabilitation. *Rehabil Nurs* 2008;33:3–9.
- [21] CDC. The National Institute for Occupational Safety and Health (NIOSH). Hierarchy of controls [Internet]; 2016. Available from: <https://www.cdc.gov/niosh/topics/hierarchy/>.
- [22] Lagerstrom M, Josephson M, Pingel B, Tjernstrom G, Hagberg M. Evaluation of the implementation of an education and training programme for nursing personnel at a hospital in Sweden. *Int J Ind Ergon* 1998;21:79–90.
- [23] Hartvigsen J, Lauritzen S, Lings S, Lauritzen T. Intensive education combined with low tech ergonomic intervention does not prevent low back pain in nurses. *Int J Occup Environ Med* 2005;62:13–7.
- [24] Kay K, Glass N. Debunking the manual handling myth: an investigation of manual handling knowledge and practices in the Australian private health sector. *Int J Nurs Pract* 2011;17:231–7.
- [25] Kindblom-Rising K, Stenstrom CH, Wahlstrom R. Effects of staff training in natural mobility: a long-term follow-up. *Adv Physiother* 2002;4:136–44.
- [26] Warming S, Juul-Kristensen B, Ebbehøj NE, Schibye B. An observation instrument for the description and evaluation of patient transfer technique. *Appl Ergon* 2004;35:603–14.
- [27] Marras W, Davis KG, Kirking BC. A comprehensive analysis of low-back disorder risk and spinal loading during the transferring and repositioning of patients using different techniques. *Ergonomics* 1999;42:904–26.
- [28] Yip Y. A study of work stress, person handling activities and the risk of low back pain among nurses in Hong Kong. *JAN* 2001;36:794–804.
- [29] Gross MM, Stevenson P, Charette SL, Pyka G, Marcus R. Effect of muscle strength and movement speed on the biomechanics of rising from a chair in healthy elderly and young women. *Gait Posture* 1998;8:175–85.
- [30] O'Meara DM, Smith RM. Differences between grab rail position and orientation during the assisted sit-to-stand for able-bodied older adults. *J Appl Biomech* 2005;21:57–71.
- [31] Lord SR, Murray SM, Chapman K, Munro B, Tiedemann A. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. *J Gerontol A Biol Sci Med Sci* 2002;57:M539–43.
- [32] Khemlani MM, Carr JH, Crosbie J. Muscle synergies and joint linkages in sit-to-stand under two initial foot positions. *Clin Biomech* 1999;14:236–46.
- [33] Schenkman M, Riley P, Peiper C. Sit to stand from progressively lower seat heights - alterations in angular velocity. *Clin Biomech* 1996;11:153–8.
- [34] Mazza C, Benvenuti F, Bimbi C, Stanhope SJ. Association between subject functional status, seat height, and movement strategy in sit-to-stand performance. *J Am Geriatr Soc* 2004;52:1750–4.
- [35] Munro BJ, Steele JR, Bashford G, Ryan M, Britten N. A kinematic and kinetic analysis of the sit-to-stand transfer using an ejection chair: implications for elderly rheumatoid arthritic patients. *J Biomech* 1998;31:263–71.
- [36] Janssen WGM, Bussmann HBJ, Stam HJ. Determinants of the sit-to-stand movement: a review. *Phys Ther* 2002;82:866–79.
- [37] Schurr K, Sherrington C, Wallbank G, Pamphlett P, Olivetti L. The minimum sit-to-stand height test: reliability, responsiveness and relationship to leg muscle strength. *Clin Rehabil* 2012;26:656–63.
- [38] Taylor J, Sims J, Haines TP. The impact of manual handling on nursing home resident mobility during transfers on and off furniture. *J Gerontol Nurs* 2011;37:48–56.
- [39] Capezuti E, Mailsin G, Strumpff N, Evans L. Side rail use and bed-related fall outcomes among nursing home residents. *J Am Geriatr Soc* 2002;50:90–6.
- [40] Hignett S, Masud T. A review of environmental hazards associated with in-patient falls. *Ergonomics* 2006;49:605–16.
- [41] Cameron ID, Murray GR, Gillespie LD, Robertson MC, Hill KD, Cumming RG, Kerse N. Interventions for preventing falls in older people in nursing care facilities and hospitals. *Cochrane Database Syst Rev* 2010 Jan 20;1.
- [42] US Food & Drug Administration (FDA). Clinical guidance for the assessment and implementation of bed rails in hospitals, long term care facilities, and home care settings. (Hospital Bed Safety Workgroup.) [Internet]; 2003. Available from: http://www.ecri.org/Documents/Patient_Safety_Center/BedSafetyClinicalGuidance.pdf.
- [43] Capezuti E, Wagner L, Brush B, Boltz M, Renz S, Talerico K. Consequences of an intervention to reduce restrictive side rail use in nursing homes. *J Am Geriatr Soc* 2007;55:334–41.
- [44] Botha WE, Bridger R. Anthropometric variability, equipment usability and musculoskeletal pain in a group of nurses in the Western Cape. *Appl Ergon* 1998;29:481–90.
- [45] Caboor D, Verlinden M, Zinzen E, Van Roy P, Van Reil MP, Pieter Clarys J. Implications of an adjustable bed height during standard nursing tasks on spinal motion, perceived exertion and muscular activity. *Ergonomics* 2000;43:1771–80.
- [46] Murphy D, Charles S, Monnington S. An evaluation of electric profiling beds in the acute hospital setting: benefits to manual handling and patient care [Internet]. Bro Morgannwg Trust & HSE. 2004. Available from: <http://www.hse.gov.uk/healthservices/epb-acute-hospital.pdf>.
- [47] Oxley L, Fox D, Jones A, Smith M, Yeomans L. Electric profiling beds in residential and nursing homes [Internet] In Manual handling and service user benefits. RR764; 2010. Available from: <http://www.hse.gov.uk/research/rp/pdf/rr764.pdf>.
- [48] Fragala G, Fragala M. Sustaining mobility through enhanced bed egress. *Ann Long Term Care* 2014;22:11–20.
- [49] Institute of Medicine. Disability in America. Towards a national agenda for prevention [Internet]. Washington (DC): The National Academies Press. 1991. Available from: <https://www.nap.edu/catalog/1579/disability-in-america-toward-a-national-agenda-for-prevention>.
- [50] Occupational Therapy Australia Ltd. Position statement: provision of bed sticks and poles. *Aust Occup Ther J* 2015;62:465–7.
- [51] South Australian Coroners Court. Coronial inquest [Internet]; 2010. Available from: http://www.courts.sa.gov.au/courts/coroner/findings/findings_2010/Hutton_Arthur_John.pdf.
- [52] Garg A, Owen B, Beller D, Banaag J. A biomechanical and ergonomics evaluation of patient transferring task; bed to wheelchair and wheelchair to bed. *Ergonomics* 1991;34:289–312.
- [53] Zhuang Z, Stobbe TJ, Hsaio H, Collins JW, Hobbs GR. Biomechanical evaluation of assistive devices for transferring residents. *Appl Ergon* 1999;30:285–94.
- [54] Zhuang Z, Stobbe TJ, Hsaio H, Collins JW, Hobbs GR. Psychophysical assessment of assistive devices for transferring patients/residents. *Appl Ergon* 2000;31:35–44.
- [55] Mughal W, Duke K, Harrison D, Worksafe BC. Implementation and evaluation of a “Safety Culture” in residential care through involvement of front-line workers [Internet]. Richmond (British Columbia): WorkSafeBC. 2007.

- Available from: http://www.worksafebc.net/contact_us/research/funding_decisions/assets/pdf/2006/RS2006_IG10.pdf.
- [56] Alamgir H, Li OW, Gorman E, Fast C, Yu S, Kidd C. Professional practice evaluation of ceiling lifts in health care settings: patient outcome and perceptions. *AAOHN J* 2009;57:374–80.
- [57] Pellino T, Owen B, Knapp L, Noack J. The evaluation of mechanical devices for lateral transfers on perceived exertion and patient comfort. *Orthop Nurs* 2006;25:4–12.
- [58] Owen BD, Keene K, Olsen S. An ergonomic approach to reducing back/shoulder stress in hospital nursing personnel: a five year follow up. *Int J Nurs Stud* 2002;39:295–302.
- [59] Ruszala S, Musa I. An evaluation of equipment to assist patient sit-to-stand activities in physiotherapy. *Physiotherapy* 2005;91:35–41.
- [60] Burnfield JM, McCrory B, Shu Y, Buster TW, Taylor AP, Goldman AJ. Comparative kinematic and electromyographic assessment of clinician and device-assisted sit-to-stand transfers in patients with stroke. *Phys Ther* 2013;93:1331–41.
- [61] Engkvist IL. The accident process preceding back injuries among Australian nurses. *Saf Sci* 2004;42:221–35.
- [62] Hignett S, Lu J. Ensuring bed space right first time. *HEJ* 2008;62:29–31.
- [63] Holman G, Ellison K, Maghsoodloo S, Thomas R. Nurses perceptions of how job environment and culture influence patient handling. *Int J Orthop Trauma Nurs* 2010;14:18–29.
- [64] Reiling J, Breckbill C, Murphy M, McCullough S, Chernos S. Facility designing around patient safety and its effect on nursing. *Nurs Econ* 2003;21:143.
- [65] Villeneuve J. Participatory ergonomic design in health care facilities. In: Charney W, Hudson A, editors. *Back injury among healthcare workers*. Boca Raton, FL: Lewis Publishers; 2004. p. 161–78.
- [66] WorkSafe Victoria. A guide to designing workplaces for safer handling of people [Internet]; 2007. Available from: <http://www.worksafe.vic.gov.au/forms-and-publications/forms-and-publications/designing-workplaces-for-safer-handling-of-people>.
- [67] Capodaglio EM. Hospital bathroom ergonomics: safety, usability and accessibility issues. *Clin Nurs Stud* 2014;2:1–11.
- [68] Hignett S, Evans D. Spatial requirements in hospital shower and toilet rooms. *Nurs Stand* 2006;21:43–6.
- [69] Queensland Health. Design guidelines for Queensland residential aged care facilities [Internet]; 1999. Available from: https://www.health.qld.gov.au/_data/assets/pdf_file/0025/151099/qh-gdl-374-8.pdf.
- [70] SafeWork SA (2010). Guide to the safe design of aged care facilities [Internet]; 2010. Available from: http://www.safework.sa.gov.au/uploaded_files/ac_sd.pdf.
- [71] Victoria Department of Health. Residential aged care services built environment tool [Internet]; 2012. Available from: <https://www2.health.vic.gov.au/about/publications/policiesandguidelines/resi-aged-care-built-env-audit-tool>.
- [72] Fray M. A comprehensive evaluation of outcomes from patient handling interventions. PhD Thesis. [Internet]. Loughborough University. 2010. Available from: <https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/6322/1/Thesis-2010-Fray.pdf>.
- [73] Radovanovic C, Alexandre N. Validation of an instrument for patient handling assessment. *Appl Ergon* 2004;35:321–8.
- [74] Queensland Health. Patient handling facility unit risk assessment tool (FURAT). Occupational Health and Workplace Safety Unit, Department of Health, Queensland Government; 2012.
- [75] Accident Compensation Corporation (ACC). Moving and handling of people. The New Zealand Guidelines 2012 [Internet]; 2012. Available from: <http://www.acc.co.nz/preventing-injuries/at-work/industry-specific-safety/moving-and-handling-people-nz-guidelines/index.htm>.
- [76] Nelson A, Matz M, Chen F, Siddharthan K, Lloyd J, Fragala G. Development and evaluation of multifaceted ergonomics program to prevent injuries associated with patient handling tasks. *Int J Nurs Stud* 2006;43:717–33.
- [77] Worksafe British Columbia (BC). Handle with care: patient handling and the application of ergonomics (MSI) requirements [Internet]; 2006. Available from: <https://www.worksafebc.com/en/resources/health-safety/books-guides/handle-with-care-patient-handling-and-the-application-of-ergonomics-msi-requirements?lang=en>.
- [78] Battevi A, Menoni O. Screening of risk from patient manual handling with MAPO method. *Work* 2012;41:1920–7.
- [79] ArjoHuntleigh. Care thermometer [Internet]; 2017. Available from: <http://www.arjohuntleigh.com.au/services/assessment-services/care-thermometer/>.
- [80] Battevi N, Menoni O, Grazia Ricci M, Cairoli S. MAPO index for risk assessment of patient manual handling in hospital wards: a validation study. *Ergonomics* 2006;49:671–87.
- [81] Schibye B, Hansen AF, Hye-Knudsen CT, Essendrop M, Bocher M, Skotte J. Biomechanical analysis of the effect of changing patient-handling technique. *Appl Ergon* 2003;34:115–23.
- [82] Knibbe JJ, Friele RD. Prevalence of back pain and characteristics of the physical workload of community nurses. *Ergonomics* 1996;39:186–98.
- [83] Kjellberg K, Johnsson C, Proper K, Olssen E, Hagberg M. An observation instrument for assessment of work technique in patient transfer tasks in patient transfer tasks. *Appl Ergon* 2000;31:139–50.
- [84] Johnsson C, Kjellberg K, Kjellberg A, Lagerstrom M. A direct observation instrument for assessment of nurses' patient transfer technique (DiNO). *Appl Ergon* 2004;35:591–601.
- [85] Tamminen-Peter L, Hantikainen V. SOPMAS (Structure of the observed patient movement assessment skill). Helsinki, Finland: University of Turku; 2004.
- [86] Biggs JB, Collis KF. Evaluating the quality of learning – the SOLO taxonomy. New York: Academic Press; 1982.
- [87] Taylor J, Barker A, Hill H, Haines TP. Improving person-centred mobility care in nursing homes: a feasibility study. *Geriatr Nurs* 2015;36:98–105.
- [88] Nitz JC, Hourigan SR. Measuring mobility in frail older people: reliability and validity of the physical mobility scale. *Australas J Ageing* 2006;25. 31e35.
- [89] Smedley J, Poole J, Waclawski E, Harrison J, Stevens A, Buckle P, Coggon D. Manual handling risk controls in hospitals (MARCH): a cross-sectional survey of UK hospitals. *HSMR* 2004;17:121.
- [90] Hignett S, Crumpton E. Development of a patient handling assessment tool. *Int J Ther Rehabil* 2005;12:178–81.
- [91] Fray M, Hignett S. TROPHI: development of a tool to measure complex, multifactorial patient handling interventions. *Ergonomics* 2013;56:1280–94.
- [92] Australian Institute of Health and Welfare (AIHW). Australia's Health 2014. Cat. No. AUS 178. [Internet] In Australia's health series no. 14. Canberra: AIHW. 2014. Available from: <http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=60129548150>.
- [93] Martimo K, Verbeek J, Karppinen J, Furlan AD, Takala E-P, Kuijper P, Jauhiainen M, Viikari-Juntura E. Effect of training and lifting equipment for preventing back pain in lifting and handling: systematic review. *BMJ* 2008;336:429–31.
- [94] Australian Government Department of Health and Ageing (DoHA). Aged care act 1997 [Internet]; 2012. Available from: <http://www.health.gov.au/internet/main/publishing.nsf/Content/ageing-legislat-aca1997-prindex.htm>.
- [95] Amick B, Tullar J, Brewer S, Irvin E, Mahood Q, Pompeii L, Wang A, Van Eerd D, Gameno D, Evanoff B. Interventions in health-care settings to protect musculoskeletal health: a systematic review [Internet]; 2006. Available from: http://www.google.com.au/search?client=safari&rls=en&q=Interventions+in+health-care+settings+to+protect+musculoskeletal+health:+a+systematic+review.&ie=UTF-8&oe=UTF-8&gfe_rd=cr&ei=PyZnVOiMBqqN8QePsoGwDA.
- [96] Bos EH, Krol B, van Der Star A, Groothoff JW. The effects of occupational interventions on reduction of musculoskeletal symptoms in the nursing profession. *Ergonomics* 2006;49:706–23.
- [97] Dawson AP, McLennan SN, Schiller SD, Jull G, Hodges P, Stewart S. Interventions to prevent back pain and back injury in nurses: a systematic review. *Occup Environ Med* 2007;64:642–50.
- [98] Forbes A, Griffiths P. Methodological strategies for the identification and synthesis of 'evidence' to support decision-making in relation to complex healthcare systems and practices. *Nurs Inq* 2002;9:141–55.