European Geriatric Medicine 6 (2015) 598–603

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Technology applied to geriatric medicine

Geriatric bathroom design to minimize risk of falling for older adults–a systematic review

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ARTICLE INFO

Article history:
Received 6 April 2015
Accepted 11 May 2015
Available online 10 June 2015

Keywords:
Older adults
Risk of falls
Geriatric
Bathroom

ABSTRACT

Purpose: Falls among older adults are a growing concern in today's society, and poor design of the home environment is likely to have a detrimental effect on the risk of falling. The aim of the study is to identify bathroom design alternatives that affect the risk of falling for older adults.
Methods: Literature sources such as Medline, PubMed, CINAHL, Abstract in Social Gerontology, Google Scholar, The Cochrane Library are searched up to August 2014, and papers that meet inclusive criteria of participants 65 years and over, randomized controlled trial (RCT), quasi-experimental, and non-experimental descriptive studies are included. Nine papers are found to meet these inclusive criteria.
Results: Most studies are found to have been carried out in the USA, Canada, and Australia. Studies are classified based on the major design components of bathrooms: toilet, bathtub, lighting, and flooring.
Conclusions: To the authors' knowledge this is the first systematic review on this topic. An inter-disciplinary framework for the concept of geriatric design is identified and implemented on the bathroom design. Results show the possibility of generating various evidence-based design scenarios that are associated with less risk of falling for older adults.

1. Introduction

With the baby-boomer cohort aging, projection studies have estimated that the Canadian population of older adults, aged 65 years and over, will increase by over 20% of the total Canadian population in the next 20 years, reaching 10.4 million older adults by 2036 [1]. Statistically, one out of three older adults is subject to experience a home fall in a yearly basis [2–6]. Given that 50% of falls that occur in the home environment result in hospitalization [6], a safe and secure living environment for older adults is of vital importance. Inter-disciplinary collaboration between gerontological and architectural researchers must be generated to create an applicable methodology to reduce the risk of falls for older adults. This collaboration should map out an approach to geriatric design that ensures older adults can live comfortably and safely with the minimum associated risk of falls. This inter-disciplinary research should provide best practice to reduce the risk of falls for older adults through evidence-based architectural design specifications, which can be achieved through the conceptual approach of geriatric design, such as geriatric bathroom design.

Home bathrooms have been found to be one of the most common fall areas for older adults [7,8]. Studies have reported difficulty in performing Activities of Daily Living (ADL) in the home bathroom area as a person ages, such as sitting to standing from the toilet, and entering and exiting the bathtub [9–12]. Preceding studies have investigated bathroom design adjustments as part of home design assessment in order to reduce the possibility of falls for older adults [13–20]. Other studies have closely identified the required bathroom design alterations that might reduce the risk of falling [11,12,21–23]. For instance, Capezuti et al. (2008) have investigated the optimal toilet height in relation to an individual's lower leg length that is associated with the minimum risk of falling for older adults. Additionally, Sveistrup et al. (2006) have identified the optimal grab-bar configurations for entering and/or exiting the bathtub. This paper addresses best practices for improving home bathroom to support geriatric design and facilitate collaboration between gerontological and architectural data. This research synergizes the findings from multiple evidence-based studies in order to devise a structured framework for the optimal bathroom design alternatives for reducing the risk of falling for older adults.

2. Materials and method

For the purpose of this study, older adults are defined as those aged 65 years and over. Controlled trial studies are included if

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[1] This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

http://dx.doi.org/10.1016/j.eurger.2015.05.004
1878-7649/

Table 1
Number of papers for each category of evidence.

Evidence category	No of papers	Reference
RCT studies	1	[15]
Quasi-experimental	1	[23]
Non-experimental descriptive	7	[11,12,21,22,24–26]
Systematic review	0	–

specified for older adult groups or if older adults are considered as a recognized part of a broader age range. To ensure inclusive literature in the specified area, non-experimental descriptive studies are included if results have been clearly described. Table 1 illustrates the number of papers falling into each category of evidence. Studies are categorized according to the bathroom design components or space design features that have been evidenced to have an effect on the risk of falling for older adults: toilet, bathtub, lighting and flooring [11,12,15,21–26]. Common assistive devices that are used in close relationship to any bathroom component that have been evidenced to have an effect on the risk of falling for older adults are also included. For instance, bathmats, bath seats, and bath grab-bars are considered as attached features to the bathtub component [22,27–29]. Only studies that directly assess or investigate optimal design for bathroom components are considered. All studies have been conducted within the span, 1988 to 2014.

The scope of this research is defined by the age of the selected group, type of space design (bathroom), and type of studies in relation to falls. Medline, PubMed, CINAHL, Abstract in Social Gerontology, Google Scholar, and The Cochrane Library are the databases searched up to August 2014. Selected research include randomized control trials, quasi-experimental, and non-experimental descriptive studies that directly relate to bathroom design specifications evidenced to have an effect on the risk of falling for older adults. The following keywords are used systematically in various arrangements: older adult, senior, age, aging, elderly, older people, fall, bath, toilet, wash, bathroom, washroom, toilet, bathtub, floor, and light. Basic criteria are developed such as peer reviewed studies, and specific age groups.

3. Results and discussion

The search results in a total of 35,014 studies, which are reduced to 454 studies meeting inclusive criteria, illustrated in Fig. 1. Additionally, 12 papers from lists of references or manual searches in journal databases are included for the subject matter. Those studies are closely examined and abstracts are reviewed for each. Inclusively, nine studies are found to meet the research criteria: four studies on toilet [11,23–25], four on bathtub [12,21,22,24], one on lighting [26], and one on flooring design [15]. Details of the evidence-based studies reviewed are illustrated in Table 2. Most of the evidence-based studies identified that address a detailed design specification for bathroom components are non-experimental descriptive studies. Randomized control trials are limited in this kind of research, as a detailed specification for the bathroom environmental design can be achieved through a non-experimental descriptive study. However, a randomized control trial study by Stevens et al. (2001) has been included in fall prevention strategies for older adults to address the floor design specifications.

3.1. Component 1: toilet design

Sit-to-Stand (STS) transfer is a locomotor activity that involves a shift in the centre of mass and might increase the risk of falling for older adults [7,30,31]. For older adults aged 85 years and over,

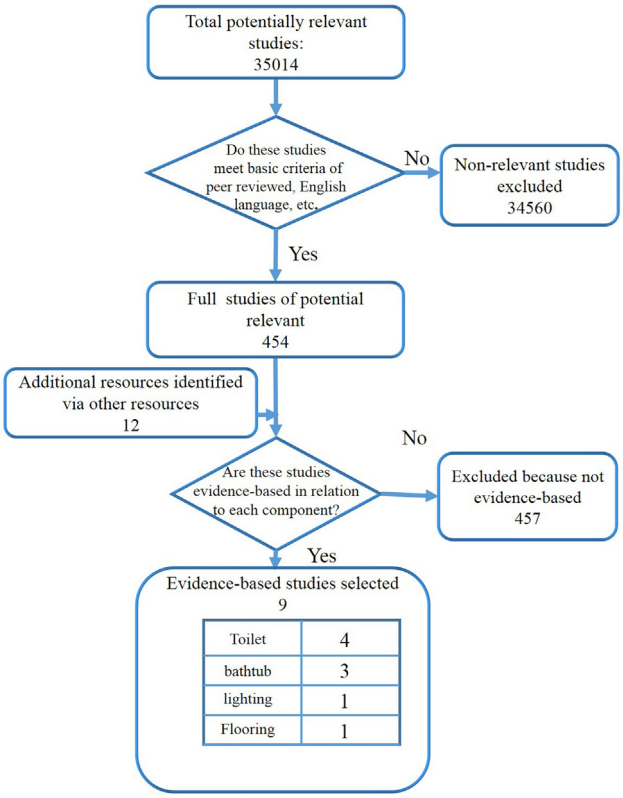

Fig. 1. Flowchart of the systematic review algorithm.

50% have been found to lack the ability to perform a sit-to-stand transfer from the toilet [32]. Toilet height needs to be adjusted in relation to the individual's Lower Leg Length (LLL) in order to facilitate the toilet sit-to-stand motion [23]. Capezuti (2008) has found that the toilet height required for independent toilet sit-to-stand transfer should be 100% to 120% of the individual's LLL. Optimal design for toilet height is illustrated in Table 3. This toilet height is usually achieved by adding a toilet seat as an assistive device [27]. Another assistive device that is commonly used to assist older adults performing toilet sit-to-stand transfers is a toilet grab-bar [11,33]. Sanford et al. (1995) have found that the optimal combination for independent and safe toilet sit-to-stand transfer is the following specifications, as illustrated in Fig. 2: (a) diagonal grab-bar: 1220 mm length, 45° angle, and 500 mm distance from the end of the toilet; and (b) horizontal grab-bar: 500 mm length, and 300 mm distance from the end of the toilet. Kinoshita et al. (2012) have investigated the optimal grab-bar height that reduces the torque on the lower limbs, and found 900 mm to 1100 mm to be the optimal height for the toilet grab-bar, as illustrated in Table 3. A grab-bar surface texture that is too smooth or too rough might lead to a fall, as the grasping hand movement under the body weight may result in losing balance and consequently falling [24,34,35]. Additionally, in order to facilitate the toilet grab-bar graspability, a circular handrail cross-section with a circumference between 100 mm and 160 mm (32 mm to 51 mm diameter) is recommended [24].

3.2. Component 2: bathtub design

According to the evidence-based studies reviewed, entering or exiting bathtub and sitting in or getting up from the bathtub are identified as difficult tasks for older adults [12,36]. Sveistrup et al. (2006) have investigated different grab-bar configurations that facilitate older adults getting into and out of the bathtub, and