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Pedestrian falls: A review of the literature and future research directions

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ABSTRACT

Introduction: Pedestrian falls (PFs) – falls in public spaces without collisions with other road users – are a significant cause of serious transport-related injuries, amounting to three-quarters of all pedestrians admitted to hospital. *Methods:* This scoping review examined peer-reviewed research on PFs published between 1995 and 2015. Electronic databases (Scopus, SafetyLit, and PubMed) were used to find studies identifying PFs or outdoor falls (the latter also including falls in gardens). *Results:* We identified only 28 studies reporting relevant information on PFs (i.e., 15 prospective, 10 retrospective, and 3 intervention studies). The results show that more walking is related to a lower risk of PFs. Older people, especially older women, have a higher risk of (injurious) PFs. Outdoor fall victims have equally good or better health characteristics and scores on balance tests compared to those who have not experienced such falls. Road factors such as uneven surfaces, busy junctions, stairs, and slippery surfaces seem to play an important role in PFs, but much of the research on these factors is of a qualitative nature. *Practical applications:* As PF victims are generally in good health (apart from normal age-related problems) but at risk due to road factors, we recommend to adopt a human factors approach. The road system should be adapted to human capabilities and limitations including those of pedestrians. Measures such as preventing uneven surfaces and good winter maintenance seem to be effective. However, we advise more quantitative research on road factors to inform design guidelines and standards for public space authorities given the qualitative nature of current research on road factors.

1. Introduction

Every year approximately 10% of people aged 65 and over experience pedestrian falls (PFs),[1] (Decullier et al., 2010; Duckham et al., 2013; Kelsey, Procter-Gray, Hannan, & Li, 2012; WHO, 2007), defined by Methorst et al. (2017) as falls in outdoor public spaces without colliding with other road users. Public spaces include roads and sidewalks but also public parks, squares, and stairs if these are part of public spaces. These falls are a significant cause of serious transport-related injuries (Elvik, Høye, Vaa, & Sørensen, 2009; Larsson & Björketun, 2007; Mulder, Bloemhoff, Harris, Van Kampen, & Schoots, 1995; Vaa, 1993). Fig. 1 shows that the great majority of non-fatal pedestrian injuries in traffic are due to PFs. Using data from the Netherlands, Switzerland, and Austria, Methorst et al. (2017) concluded that 4–9 times as many pedestrians are injured in falls than in pedestrian–vehicle collisions. They expect that aging of the population will contribute to an increase of the number of injuries due to PFs. A Dutch estimate indicated that the total costs due to PFs would be around 17% of the total costs of traffic crashes in 2003–2007 (including the costs of PFs; excluding the costs of Property Damage Only crashes; Methorst, Van Essen, Ormel, & Schepers, 2010). If anxiety about falling due to a previous fall or a poorly designed, non-inclusive environment leads seniors to restrict outdoor walking (Ward Thompson, Curl, Aspinall, Alves, & Zuin, 2012; Wijlhuizen, De Jong, & Hopman-Rock, 2007), this could prevent them from taking part in activities and enjoying the major health benefits of related physical exercise (Kelly et al., 2014). PFs are therefore an important public health issue.

Most research on pedestrian injuries has focused on collisions (see e.g. Elvik et al., 2009; Langham & Moberly, 2003; Rosen, Stigson, & Sander, 2011; Schwebel et al., 2014), which is understandable because, in contrast to PFs, these collisions are included in the definition of traffic crashes (the involvement of a vehicle is required to define an accident as a traffic crash; Eurostat, 2009). It is likely that PFs are less known among road safety researchers and practitioners because of their exclusion from the definition and, consequently, from official statistics (Methorst et al., 2017). There are many studies on falls in general (Gillespie et al., 2012), but most of these combine outdoor and indoor falls into one category. Outdoor falls are closely related to PFs but also include falls in gardens because these occur outside buildings. Outdoor falls have been called a neglected, hidden, and under-researched public health problem (Feypell, Methorst, & Hughes, 2010; Gyllencreutz,

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[1] Each year, 29–35% of people over 65 years sustain falls (WHO, 2007); 30–45% of falls among elderly are PFs (Decullier et al., 2010; Duckham et al., 2013; Kelsey et al., 2012).

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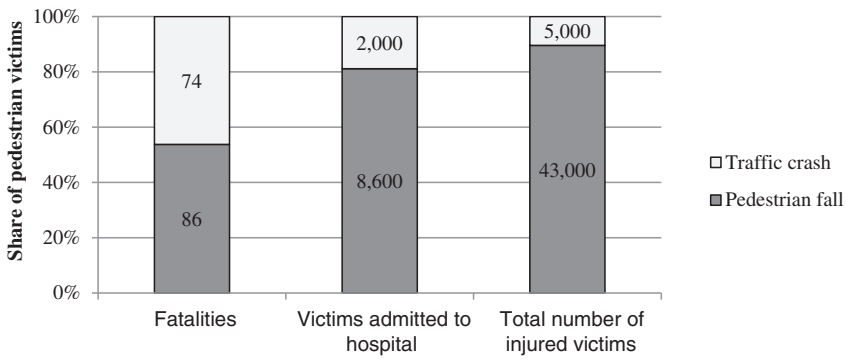

Fig. 1. Pedestrian injuries in the Netherlands in 2011 (Den Hertog et al., 2013; Methorst et al., 2017).

Björnstig, Rolfsman, & Saveman, 2014; Li et al., 2006). Only recently has research interest accelerated due to valuable research initiatives such as the prospective "MOBILIZE Boston cohort study" focusing on fall risks in the elderly (e.g., Li et al., 2014) and studies on risks associated with icy roads in Nordic countries (e.g., Berggård & Johansson, 2010; Gyllencreutz et al., 2014). Previously published review papers focus on falls and fall prevention (Gillespie et al., 2012; Karlsson, Vonschewelov, Karlsson, Cöster, & Rosengen, 2013; Stalenhoef, Crebolder, Knottnerus, & Van Der Horst, 1997), but do not address PFs, even though the related health burden is substantial. As the risk factors and the environment associated with outdoor and indoor falls differ (Kelsey et al., 2010), specific research may be needed to inform public space authorities about adequate preventive strategies and measures for PFs. Directions for recommendations depend on whether the primary contributing factors are related to individual health, behavior, and wearing of suitable footwear or to responsibilities of public space authorities. This review aims to summarize and discuss research on factors contributing to PFs published between 1995 and 2015. It is considered that this period is long enough to allow for the meaningful examination of the extent, range, and nature of research on PFs. In doing so, recommendations for public space authorities are explored and key research areas for future investigations are identified.

The remainder of this paper is organized as follows: Section 2 outlines the methods of this scoping review such as search terms and study inclusion criteria. Section 3 summarizes the characteristics of the included studies and discusses their results. Section 4 discusses the outcomes and directions for future research. Finally, Section 5 shortly lists the main conclusions of this review.

2. Methods

2.1. Literature search

This scoping review (Dijkers, 2015) discusses literature on PFs. Peer-reviewed empirical studies in English language scientific journals published between 1995 and 2015 were identified from electronic databases (Scopus, SafetyLit, and PubMed). The following search terms were utilized: 'outdoor fall,' 'outside fall,' 'pedestrian fall,' 'single-pedestrian,' 'non-motor pedestrian,' and 'pedestrian-only.' The search resulted in a total of 698 (partly overlapping) hits as follows: Scopus: 544, SafetyLit: 26, and PubMed: 128.

2.2. Inclusion criteria and selection process

Based on the article titles, abstracts, and keywords the identified reports were initially evaluated using the following inclusion criteria:

a) The study had to be an observational or intervention study published in a peer-reviewed scientific journal.
b) The study had to distinguish PFs or outdoor falls (i.e., not be restricted to a single 'fall category' combining both outdoor and indoor falls). Studies combining trips and slips (without landing on the ground) with falls into one category were also excluded.
c) The study had to include risk factors related to PFs and was not to be restricted to injury consequences only.

Altogether 29 papers comprising 28 empirical studies were included (one study was described in two papers) and retrieved in full text for detailed evaluation (further referred to as 'the sample'). The studies were divided into prospective observational studies, retrospective studies and intervention studies. Besides the 28 studies on which the main conclusions are based, additional literature is used to provide context, for instance to explain hypotheses tested by researchers.

3. Results

This section discusses the identified 28 studies that included a material relevant to PFs. Section 3.1 describes the design and the quality characteristics of these studies. As road safety is often described in terms of exposure and the risk factors of road users, infrastructure, and vehicles (Elvik et al., 2009; Schepers, Hagenzieker, Methorst, Van Wee, & Wegman, 2014), Section 3.2 deals with the relationship between the amount of walking and PFs while the subsequent Sections 3.3, 3.4, and 3.5 describe the contributions of human characteristics and behavior, road factors, and footwear. This approach is used to structure contributing factors and distinguish between factors related to individual characteristics and behavior and environmental conditions possibly linked to responsibilities of public space authorities.

3.1. Study characteristics and quality

Table 1 presents an overview of prospective observational studies (see Section 3.1.1), retrospective studies (see Section 3.1.2), and intervention studies (see Section 3.1.3).

3.1.1. Prospective observational studies

In the 15 prospective observational studies (see Table 1), participants, most over 70 years, recorded daily fall occurrences on a calendar that they mailed back to the study staff monthly or quarterly. Participants reporting a fall were interviewed. A strength of prospective designs is the reduction of recall bias, a problem caused by the possibility of participants forgetting falls (Cummings, Nevitt, & Kidd, 1988). Another advantage of following a cohort is that there are participants with and without falls who can be compared. The design of the research, therefore, allows for quantitative assessment of the contribution of risk factors.

An important quality criterion for internal validity is providing statistical control for potentially confounding variables (Elvik, 2011).

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