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Determinants of safety outcomes and performance: A systematic literature review of research in four high-risk industries

Pieter A. Cornelissen, * Joris J. Van Hoof, Menno D.T. De Jong

Department of Communication Science, University of Twente, The Netherlands

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ABSTRACT

Introduction: The incidence of pedestrian death over the period 2010 to 2014 per 1000,000 in North Cyprus is about 2.5 times that of the EU, with 10.5 times more pedestrian road injuries than deaths. With the prospect of North Cyprus entering the EU, many investments need to be undertaken to improve road safety in order to reach EU benchmarks. *Method:* We conducted a stated choice experiment to identify the preferences and tradeoffs of pedestrians in North Cyprus for improved walking times, pedestrian costs, and safety. The choice of route was examined using mixed logit models to obtain the marginal utilities associated with each attribute of the routes that consumers chose. These were used to estimate the individuals' willingness to pay (WTP) to save walking time and to avoid pedestrian fatalities and injuries. We then used the results to obtain community-wide estimates of the value of a statistical life (VSL) saved, the value of an injury (VI) prevented, and the value per hour of walking time saved. *Results:* The estimate of the VSL was €699,434 and the estimate of VI was €20,077. These values are consistent, after adjusting for differences in incomes, with the median results of similar studies done for EU countries. The estimated value of time to pedestrians is €7.20 per person hour. *Conclusions:* The ratio of deaths to injuries is much higher for pedestrians than for road accidents, and this is completely consistent with the higher estimated WTP to avoid a pedestrian accident than to avoid a car accident. The value of time of €7.20 is quite high relative to the wages earned. *Practical applications:* Findings provide a set of information on the VRR for fatalities and injuries and the value of pedestrian time that is critical for conducing ex ante appraisals of investments to improve pedestrian safety.

1. Introduction

The number of occupational accidents exceeds 313 million annually worldwide (International Labour Organization [ILO], 2015), underscoring the relevance of occupational health and safety for organizations. According to ILO (1998) occupational accidents include work-related events that are unexpected or unplanned and result in one or more workers suffering a personal injury, disease, or death. These regrettable events have serious physical and emotional consequences for the employees involved, have severe impacts on co-workers, first responders, and families, and result in costs estimated at 4% of the global gross domestic product (ILO, 2015). The origin of occupational safety as a topic of interest for organizations can be traced back to the 19th century, when rapid industrialization was characterized by economic, technical, and social changes on an unprecedented scale (Swuste, van Gulijk, & Zwaard, 2010). However, improving safety proved much more complicated than expected, causing a division between the scientific and the corporate worlds (Swuste, van Gulijk, Zwaard, & Oostendorp, 2014). Whereas science tried to understand accidents as processes of causes and effects, organizations adhered to their trusted theory of accident proneness: the idea that some people are predisposed to be more susceptible to accidents (Arbous & Kerrich, 1951). In this study we aim to provide an overview of the most prevalent safety factors studied over the past 35 years, provide an overview of the determinants of safety outcomes, and ultimately bridge the gap between the scientific and the corporate worlds. Whereas previous research provided overviews of the literature from a historical perspective (e.g., Swuste et al., 2010, 2014), or focused on a specific topic (e.g., Clarke, 2013; Wagstaff & Lie, 2011), or a specific domain (e.g., Abdul-Aziz & Hussin, 2003; Mearns & Yule, 2009), our study delivers a comprehensive overview of the occupational safety literature over the last 35 years, covering a broad range of topics in four different domains (construction, (offshore) petro chemistry, warehouses, and manufacturing). Before we describe our methodology and results, we will provide a short overview of the main variables in occupational safety research literature. Finally, we will critically review our findings and discuss implications for both practice and research, as well as directions for future research.

* Corresponding author at: Faculty of Behavioural, Management and Social Sciences, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands.
E-mail address: p.a.cornelissen@utwente.nl (P.A. Cornelissen).

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1.1. Safety outcomes and performance

The ultimate end goal in occupational safety is the reduction or – preferably – elimination of negative safety outcomes. These negative safety outcomes come in different forms like near misses, accidents, and injuries. These events are often distinguished from each other based on Heinrich's pyramid (for more information see Heinrich, 1931), which classifies unwanted safety-related events based on their outcomes. We will use a similar, although compressed, classification. We classify negative outcomes that have the potential to inflict harm as *incidents*, such as near misses and employee errors. We classify incidents that result in property or financial damage as *accidents*, and we classify accidents that result in mental or physical damage as *injuries*, including those accidents that resulted in fatalities.

The leading line of thought is that good or better performance leads to the decrease or absence of negative safety outcomes (Christian, Bradley, Wallace, & Burke, 2009). As such, improved performance can be viewed as both a precursor of negative safety outcomes and as a goal in itself. Safety performance has been defined as those 'actions or behaviors that individuals exhibit in almost all jobs to promote the health and safety of workers, clients, the public, and the environment' (Burke, Sarpy, Tesluk, & Smith-Crowe, 2002) and is considered to consist of two components: safety compliance and safety participation (e.g., Neal & Griffin, 2002; Neal, Griffin, & Hart, 2000). Safety compliance refers to 'following safety procedures and carrying out work in a safe manner,' whereas safety participation refers to 'helping coworkers, promoting the safety program within the workplace, demonstrating initiative, and putting effort into improving safety in the workplace' (Neal et al., 2000).

1.2. Determinants

A wide variety of possible precursors and determinants of safety have been studied. Examining the work environment, Bjerkan (2010) distinguishes between the physical work environment and the mental work environment. Whereas the physical work environment refers to tangible elements like machinery, the mental work environment refers to elements like job demands and working hours. Related elements that have attracted considerable attention from researchers are culture (e.g., Guldenmund, 2000) and climate (e.g., Zohar, 2010).

Another topic of interest is the influence of (other) employees. Elements such as manager attitudes (e.g., Mullen, 2004), leadership styles (e.g., Kelloway, Mullen, & Francis, 2006), and pressure exerted by colleagues (Choudhry, 2012) are all considered important influencers of behavior. However, characteristics of individual employee such as age and experience, are considered important as well (e.g., Basha & Maiti, 2013).

Finally, there are several external elements that might influence occupational safety. What are the effects of stakeholders, legislation, and external control bodies (e.g., Ko, Medeloff, & Gray, 2010)?

2. Method

To examine the foci of research to date, we conducted a systematic search in the occupational safety literature from 1980 to 2015. A systematic review of the literature is typically based on a 'detailed and comprehensive plan and search strategy derived a priori' in order to reduce bias (Uman, 2011). In contrast to a meta-analysis we do not strive to come to a 'single quantitative estimate or summary effect size' using statistical techniques (Uman, 2011). Instead, we aim to present an overview of topics addressed in both quantitative and qualitative research on occupational safety, and their general direction. This approach is similar to approaches in previous systematic reviews (e.g., Ahonen, Benavides, & Benach, 2007; Kringos, Boerma, Hutchinson, Van der Zee, & Groenewegen, 2010). Below, we will elaborate on our systematic selection process and analysis.

2.1. Literature search

Our aim was to capture as much of the available literature on occupational safety as possible. We therefore chose a literature search using broad search terms as a starting point, as opposed to citation networks that may result in overlooking new and less frequently cited literature. Our literature search was conducted using the following bibliographic databases: Scopus, Web of Science, PsycInfo, and Business Source Elite. We used combinations of keywords that emerged from the literature as key indicators of occupational safety: *safety performance*; *safety participation*; *safety compliance*; *occupatio**; and *employ**. This resulted in a total of 27,527 records published between 1979 and 2015.

2.2. Article selection

The further selection of articles was performed in steps, as depicted in Fig. 1. Based on the available information in Endnote we removed duplicates, articles written in languages other than English, and – as a quality assurance – non-peer reviewed articles ($n = 16{,}302$). This step reduced the selection to 11,225 articles. Not all non-peer reviewed articles could be excluded based on the information available in Endnote. This resulted in the removal of articles matching this criterion during multiple phases of the selection process. Then, three consecutive steps were completed. First, the first author evaluated the titles and marked articles that did not meet the following inclusion criteria: (a) describe safety in an occupational setting; (b) focus on interventions, determinants, or measurement of occupational safety; (c) conducted in the construction, warehouse, manufacturing, offshore, or petrochemical sector; (d) published in a peer-reviewed journal; and (e) be written in English. The four domains of construction, (offshore) petro chemistry, warehouses, and manufacturing were included based on a combination of elements. First, the construction and manufacturing sector combined accounted for more than a fifth of all fatal accidents that occurred in 2013 in the EU-28 (Eurostat, 2016). Second, the Dutch Inspectorate SZW mentions that the construction and chemistry are among those sectors where employees are subject to high health and safety risks (Inspectorate SZW, 2016), furthermore, the chemical sector has proven to be a domain where accidents can have a big environmental impact (e.g., Deepwater Horizon in 2010). Third, the domain of warehouses was included as employees here are subject to a high number of (mechanical) risks, such as forklifts and conveyors. Fourth, these four domains share a number of similarities that makes them relatively comparable: they represent highly technical environments with a number of occupational risks and are staffed with mostly blue-collar workers. Lastly, other well-studied areas are excluded as they represent highly specific risks (e.g., underground mining), require employees to be highly educated and trained (e.g., aviation), or mainly have a focus on the safety of others (e.g., hospitals). A random sample of 10% of the articles was assessed for eligibility by the second author, which resulted in a substantial Cohen's kappa for inter-coder reliability (.73). Based on the screening of titles, 6,558 articles were excluded and 4,667 articles remained. When there was any doubt or disagreement during this step, the article was retained for the next round of analysis. We repeated this process by reading the abstracts of the remaining articles. The Cohen's kappa over the sample of abstracts ($n = 474$) was again substantial (.68). After exclusion of 2,600 articles based on abstract content, a sample of 2,067 articles remained. As the initial search was conducted during October 2014, we repeated our search during October 2015 so as to include all relevant articles published in the last months of 2014. This returned 24 additional articles, which underwent the same process of selection. From these 2,091 records we excluded any remaining gray and white literature ($n = 324$) and articles that were not published online ($n = 614$). The majority of the remaining articles were directly available for download. To retrieve the 222 articles that were published online but were unavailable to us through the subscriptions of University XX [Removed for review purposes], we used a combination of

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