A FACTORIAL ANALYSIS OF SAFETY PERFORMANCE MEASURES: A STUDY AMONG CONSTRUCTION WORKERS IN GAUTENG, SOUTH AFRICA

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Abstract
The health and safety (H&S) of construction workers has been a subject of much deliberation for decades. However, there is scant literature focusing on aspects of workers' safety performance (SP) relating to their unhealthy and unsafe eating behavior. The paper presents findings on an exploratory factor analysis of H&S performance measures. A 10-item questionnaire which was developed after an extensive literature review was used to collect empirical data on SP of construction workers in the Gauteng Province of South Africa. Results showed that SP could be reasonably measured by two constructs. The two constructs were clearly defined as trailing and prevailing. The emerged trailing measures were named lagging indicators while the prevailing ones were designated as leading indicators. The results lend support to extant literature which advocates the use of both leading and lagging safety performance indicators for effectively assessing construction workers' safety performance. The study provides evidence which could be beneficial in psychometric evaluation of construction workers' safety performance and behaviours on construction sites.

Keywords: Construction workers, Exploratory Factor Analysis, Gauteng, Safety performance

1 Introduction

The construction industry is fraught with accidents and deaths on an unacceptable level. This is in spite of its recognized contribution to socio-economic development with regard to contribution to Gross Domestic Product (GDP) and improvement in the quality of lives of an economy's citizens through job provision (Khan, 2008; Ofori, 2012). Although a decline in the number of fatal injuries in recent years has been indicated, statistics still report unacceptably high rates of accidents, injuries and fatalities (Musonda, 2012; Health and Safety Executive (HSE), 2014). The number and cost of injuries and deaths in the construction industry are deplorable and many of them are preventable (Janackovic et al., 2013). It is necessary to improve the H&S system continually in order to reduce the costs and increase companies' competitiveness and efficiency (Janackovic et al., ibid.).

Furthermore, attention to construction workers' H&S is crucial since they are at the centre of construction activities and as such are indispensable. Individual workers and their supervisors must make daily decisions about safety at work because it influences or competes with other performance facets of the job. These can be related to the task itself (e.g., safety vs. on-time delivery or productivity), or to the worker performing the task (e.g., safety vs. personal discomfort or extra effort) (Huang et al., 2013). Poor safety at work could result from workers' unhealthy eating behaviours, among other things (Melia & Becerril, 2009; Lingard & Turner, 2015). In addition, the nature of construction work predisposes construction workers to hazards which pose a threat to their H&S. Such hazardous conditions may include extreme heights, machinery failure, welding emissions, unguarded machinery, which may lead to falls, being struck by heavy construction equipment, electrocutions, silica dust, asbestos, lead, accidents, structure collapses, and so on (ElSafty et al., 2012). Continuous attention to and integrated management of safety and health increases operational excellence and profitability in the sense that the occurrence of injuries and deaths is reduced, avoidable expenditure on on-site exigencies is reduced, productivity is increased, and in fact, morale and motivation among employees as well as implications of H&S are realised (Janackovic et al., 2013).

Much research has been conducted on H&S measurement and management (Lin et al., 2009) and in the construction industry specifically (Hinze et al., 2013; Lingard et al., 2013). However, most literature focused on the work environment, managerial and organizational aspects of H&S. Few studies have been devoted to safety performance measures related to the lifestyle behaviours of the workers which have been suggested to be unhealthy (Melia & Becerril, 2009). The present study identifies safety performance measures which could be related to workers' unhealthy eating behaviours and explores underlying structures of the measures. The objective of the current paper is to analyse the structure of the safety performance measures used in the study. The study could be useful to researchers and employers in the construction industry in assessing safety behaviours and performance of the workers.

2 Measuring Health and Safety Performance

According to Dingsdag et al. (2008), one of the most practical guiding principles of the measurability of safety performance is given in the Australian/ New Zealand Standard, *AS/NZS 4804: 2001 Occupational health and safety management systems—General guidelines on principles, systems and supporting techniques* (AS/NZS 4804) which defines safety performance as "the measurable results of the occupational health and safety management system related to the organisation's control of health and safety risks, based on its OHS policy, objectives and targets" and measuring performance includes measurement of OHS management activities and results. This section discusses measures of assessing workers' safety activities and results.

It has been generally acknowledged that the traditional metric used to measure H&S performance is a record of accidents, injury and ill-health statistics (Musonda, 2012). However, some researchers argue that measuring H&S performance by the frequency of accidents and injuries is sometimes inappropriate, unreliable and deceptive as gross under-reporting could occur (Musonda, ibid.). In addition, injury rates often do not reflect the potential severity of an event, merely the consequence; they reflect outcomes, not causes (Hinze et al., 2013).

In addition to injury and accident statistics, other measures reveal the state of safety performance of workers in an industry. ElSafty et al. (2012) opined that an Occupational Safety and Health Administration (OSHA) recordable injury is an occupational injury or illness that requires medical treatment more than simple first aid. First aid involves a particular level of treatment (such as cleaning and covering of wounds, use of non-prescription medication, etc; whereas medical treatment occurs when an injury or disease requires a higher degree of care and management to ensure a full recovery, for instance, treatment of fractures, suturing of wounds and prescribing and providing drugs to manage symptoms (Biggs et al., 2009; International Council on Mining and Metals (ICMM), 2014).

Other recordable criteria include death, restricted work, days away from work, significant injuries or illnesses diagnosed by physician and lost work day incidents (ElSafty et al., ibid.). Days away from work, restricted duty and transferred duties are related to injuries which are severe enough that workers are away from work, placed on restricted duty or assigned a lighter job because of the injury. Supporting this view, the ILO stated that loss of working capacity or inability to perform normal or routine work functions on the next calendar day after an injury reflects poor worker safety performance (ILO, 2003). Statistics on the days away from work or on restricted duty due to an injury are useful when analyzing how much loss is incurred from injuries (ElSafty et al., 2012). Lost work day or lost time injuries are also useful in interpreting solutions to lowering the number of injuries and fatalities per year (Dingsdag, 2008; ElSafty et al., 2012). Absence from work due to an injury, for more than three consecutive working days is considered serious and compensable (ILO, 2003; Cameron & Duff, 2007).

According to Farooqui et al. (2008), the use of personal protective equipment (PPE) is one of the basic practices required for safety on construction sites. It is a performance issue which belongs to self-protection category and can be used to indicate safety performance levels of firms (Farooqui et al., ibid.; Biggs et al., 2009; Construction Industry Institute (CII), 2014). Workers face bodily harm when they do not wear (correctly) PPE. For instance, falls from heights could occur with weak scaffolding and lack of safety belts; cement burns could be sustained without protective gloves and boots while cementing; injuries could be sustained on fingers, eyes, head, or feet due to absence of PPE, and so on (Farooqui et al., 2008).

Another performance issue which is critical is the assessment of risks involved in a given task before embarking on it. The identification of the tasks, hazards and the risks of a job prior to work enables implementation of protective measures to ensure that work is done safely (Campbell Institute, 2014).

Furthermore, near-misses or close calls were shown to be indicators of safety performance ((Biggs et al., 2009; Hinze et al., 2013; CII, 2014). Reporting of the near-misses and/or accidents is also crucial in reflecting workers' attitude and commitment to safety at the workplace. However, according to Masood et al. (2014), the workers may be uncertain about reporting accidents or near-misses because sometimes there is no mechanism for compensation for injuries, and/or they may blame their luck which made them victims of the accident.

The above-mentioned indicators relate to construction workers, prior to or after an incident, and were therefore adopted as the indicators of worker safety performance, in the current study. This implies that some indicators may be trailing (also called lagging indicators), providing data about incidents after the fact (Hinze et al., 2013), whereas others may be prevailing (called leading indicators), potentially leading to an injury or incident (Biggs et al., 2009). Both leading and lagging indicators reflect safety performance (Hinze et al., 2013; Lingard et al., 2013). According to Atkins (2011), the use of a set of safety performance indicators provides a greater indication of safety performance than concentrating on one measure in isolation (or indeed a small number of random measures). Good safety performance indicators should be quantifiable and permit statistical inferential procedures and should be valid and representative of what is to be measured (Roelen and Klompstra, 2012). The interpretations should relate to the system and its operational context (Herrera, 2012).

3 Research Methodology

To achieve the objective of the study, a review of literature related to safety performance of workers in general and construction workers in particular was conducted. Various sources including academic and professional journals, books, government reports, newspapers, magazines, theses and dissertations were consulted. A 5-point likert-scale questionnaire was thereafter developed to elicit information workers' safety performance on construction sites. The identified items related specifically to those measures which could be associated with unhealthy eating, since this was the purpose of the main study. The questionnaire, which consisted of 10 items, was pilot-tested, reviewed and revised by experts (consisting of the researcher's supervisors and a statistician). The final questionnaire had response categories were assigned 1, 2, 3, 4 and 5, for "on every project", "more than two times", "two times", "once before" and "never", respectively. Therefore, higher scores were meant to represent higher safety performance.

The questionnaire was self-administered to construction workers on building and civil engineering construction sites in Midrand, Samrand, Johannesburg and Centurion. The participants, selected through heterogeneity and convenience sampling, included workers who were actively engaged in the physical construction activities as opposed to the site managers and supervisors. This group was chosen as they were the most susceptible to poor safety performance on construction sites. A cover letter accompanied the questionnaire to explain the purpose of the study and obtain informed consent. The respondents participated voluntarily and anonymously. Out of a total of 220 questionnaires, 183 were completed and used for the empirical analysis.

The raw data were analysed using Statistical Package for Social Sciences (SPSS) version 22. The Cronbach's alpha and mean inter-item correlations were used to assess the internal consistency reliability of the scale. Factor analysis using principal axis factoring and oblimin rotation was then conducted to examine underlying structures of the theorized variables. However, prior to the factor analysis, preliminary considerations for the factorability of data were assessed. The sample size requirement of 150+ was met (Pallant, 2013). The Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests were also used to assess factorability. Missing data were excluded using listwise deletion. The data were however skewed, concentrating on the "never" category. Outliers were identified and removed before analysis The Kaiser's criterion (retaining eigenvalues above 1), scree test (retaining factors above the "breaking point") were used to determine the emerging components or empirical constructs.

3.1 Validity and Reliability

Various measures were taken to ensure that the variables developed from extant literature (termed theoretical constructs in the current study) and those realised after the factorial analysis (termed empirical constructs) were valid and reliable. Through an extensive and thorough literature review and synthesis, expert reviews and validation as well as pilot-testing, construct validity of the theoretical variables was achieved (Olson, 2010). The Cronbach's alpha internal consistency reliability test was used to statistically assess the internal consistency of the ten theoretical variables as well as the two empirical constructs including lagging indicators (comprising absence from work for more than three days due to an injury, medical treatment beyond first aid, restricted work, near-misses, injury and sickness at work, and reporting of accidents) and leading indicators (consisting of risk assessment prior to performing a task, accepting any kind of work regardless of risks involved, and failure to wear PPE).

The resulting values, presented in table 1, indicated good internal consistency of the constructs. Before factor analysis, the scale was considered to be reliable and representative of what is to be measured, with a good alpha index of 0.83 (Roelen and Klompstra, 2012; Pallant, 2013). After analysis, the internal consistency reliability of the constructs, tested using both the Cronbach's alpha and mean inter-item indices, was equally good. Cronbach's alpha values of above 0.7 indicate acceptable internal consistency reliability and mean inter-item coefficients ranging from 0.2 to 0.4 indicate good internal consistency (Pallant, 2013).

Table 1. Internal consistency reliability of empirical constructs

	Cronbach's alpha	Mean inter-item correlations	Number of items
Lagging measures	0.885	0.530	7
Leading measures	0.763	0.521	3

4 Findings and Discussion

Prior to performing the factor analysis, suitability of the data for factor analysis was tested. The KMO value was 0.832, exceeding the recommended value of 0.6 and the Bartlett's test of sphericity reached statistical significance at p = .000 (< .05), supporting the factorability of the data. The correlation matrix which showed the presence of many coefficients of 0.3 and above also supported the suitability of data for factor analysis.

Factor analysis of the ten items revealed that only two components had eigenvalues above 1 (4.511 and 1.885) as shown in Table 2, and the results of the scree test (Figure 1) also supported that only the first two components accounted for approximately 64% of the variance. The two components were thereafter rotated to reveal their item-loadings (Table 3). Seven of the factors strongly loaded on the first component, while the remaining three loaded on the second. The two components were then adopted as the empirical constructs.

Table 2. Percentage variance explained by the safety performance measures

Factor		**Total**	**% of Variance**	**Cumulative %**
1	been away from work for more than three days due to an injury	4.511	45.106	45.106
2	been treated medically for injuries (more than simple first aid) on site	1.885	18.851	63.958
3	been asked to do limited work after an injury	.815	8.148	72.106
4	been involved in incidents or near-misses	.710	7.097	79.202
5	been injured at work	.594	5.938	85.141
6	been sick at work	.451	4.506	89.647
7	failed to report an accident or incident	.330	3.297	92.944
8	failed to consider the possible risks in a particular task	.296	2.959	95.903
9	accepted any kind of work, not minding the danger/risk involved	.235	2.353	98.256
10	failed to wear personal protective equipment (PPE)	.174	1.744	100.000

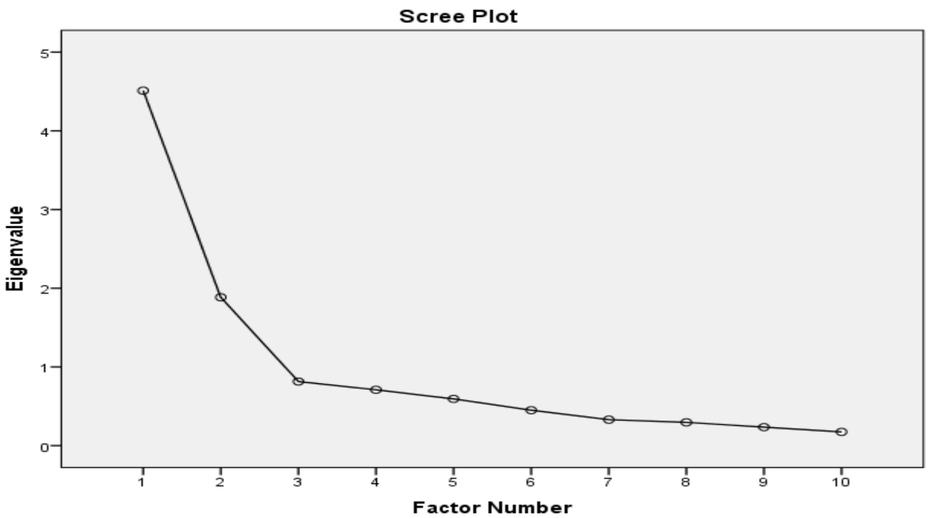

Figure 1. Scree plot showing constructs above the breaking point

Table 3. Loading matrix of the safety performance measures

	Measures	**Component**	
		1	**2**
1	been away from work for more than three days due to an injury	.946	-.119
2	been treated medically for injuries (more than simple first aid) on site	.872	-.009
3	been asked to do limited work after an injury	.813	-.177
4	been involved in incidents or near-misses	.670	.011
5	been injured at work	.651	.289
6	been sick at work	.613	.049
7	failed to report an accident or incident	.465	.258
8	failed to consider the possible risks in a particular task	-.073	.850
9	accepted any kind of work, not minding the danger/risk involved	-.036	.704
10	failed to wear personal protective equipment (PPE)	.124	.564

The interpretation of the two components showed that positive measures clumped together and negative measures did the same, consistent with positive and negative schedule scales used in extant literature (Pallant, 2013). Hence, the first component with negative items was named *lagging indicators*, while the second component with positive items was named *leading indicators* (ICMM, 2014).

In relation to construction safety performance, prevailing performance measures are leading indicators which provide information that prompt actions to achieve desired outcomes and/or avoid unwanted outcomes whereas trailing performance measures are lagging indicators that provide safety results, for instance, the extent of worker injuries (Hinze et al., 2013). Differentiating and using both indicators provide a more reliable and/or accurate measurement of safety performance (Lingard et al., 2013). Leading metrics can be useful in predicting future levels of safety performance, thereby providing information which could guide implementation of interventions to improve and impact positively on the safety process, before any negative (trailing) incidences occur (Hinze et al., ibid.).

The study provides support to extant literature which advocates the use of both leading and lagging indicators to measure safety performance in the construction industry. Traditional measures of safety, which are after-the-fact measures that assess safety after injuries occur, has a shortcoming in the sense that it bases measurement on failure of the system (Dingsdag et al., 2008; Farooqui et al., 2012). Pre-emptive actions need to be taken before accidents occur. Leading indicators can help to predict safety levels to engender the necessary pro-active measures before the occurrence of accidents. Therefore, leading indicators should ideally be included in assessing of worker safety performance levels. This is even more important for assessing construction worker safety performance in order to reduce the risks associated with working in an inherently unsafe environment. In addition, the attitude and behaviour of construction workers with respect to safety is influenced by their trepidations of risk, safety, rules, procedures and management (Masood et al., 2014). Although leading indicators may be cumbersome to collect and measure, may not directly reflect actual success in preventing injury and/or disease, and may be subject to random variation (Dingsdag et al., 2008), they are increasingly becoming adopted (Lingard et al., 2013; Hinze et al., 2013). Equal consideration should be given to leading measures. A combination of both classifications to support behavioural changes can lead to sustainable worker safety levels in the long run. The use and adoption of both should be encouraged to drive H&S continuous improvement (Construction Owners Association of Alberta (COAA), 2011).

5 Conclusion and Further Research

The study sought to explore the underlying structure of safety performance measures. Safety performance was found to be measured by two components. The components had positive and negative safety performance measures, respectively. They were therefore named leading and lagging measures, accordingly. Lagging and leading measures should therefore be used to evaluate and effectively manage safety performance of construction workers.

The study provides evidence which could be useful in psychometric evaluation of construction workers' safety performance and behaviours on construction sites. By highlighting safety performance/behaviours of the workers, construction stakeholders could be enabled to make informed decisions regarding improving H&S performance of the workers, and thus improve the productivity, profits and competitiveness in their establishments. The limitations of the current study warrant mention. Firstly, the study was conducted in only one province in South Africa and may not be generalized to workers in the entire country or other countries. Secondly, the method of data collection was quantitative. More in-depth information could have been elicited with a follow up qualitative technique such as interviews, especially to shed more light on the "never" category responses. Future studies could therefore attempt the study using a different approach to extract more information or determine if dissimilar results would be obtained.

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