Relationship between Nutrition and Construction Safety Performance: Experimental work

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***Abstract* --** It is known that nutrition is linked with worker health and safety (H&S) performance. However, this relationship has not been evaluated empirically. The present paper evaluates the relationship between nutrition and safety performance on construction sites. Empirical data were collected through a field questionnaire survey conducted on site construction workers in South Africa. Principal components analysis and Spearman's correlation analysis were used to analyze the data. Findings revealed that increased consumption of certain foods termed "alternatives" in the current study, including dairy products, eggs, nuts, fish and cereals, was associated with improved safety performance. No significant correlation was found between nutritional choice and negative performance measures. By providing evidence of which foods may be correlated with safety performance of construction workers on construction sites, the design of explicit nutrition interventions for construction workers, particularly including planning for these significant foods, will be allowed. The study will also result in nutrition being given more attention in H&S considerations on construction sites.

***Index Terms:*--**Construction workers, nutrition, safety performance, South Africa

I. Introduction

Workers' H&S performance continues to be a huge concern for the construction industry [24]. The construction sector is notorious for being one of the most dangerous industries along with transportation, mining and agricultural sectors. It accounts for 30 – 40% percent of the world's fatal injuries [19]. This is in spite of its importance in economic development through employment provision and infrastructure development [8]. The construction sector accounts for 7% of global employment and contributes 10% to global Gross Domestic Product (GDP) [31].

The notoriety of the construction industry in terms of its poor H&S performance underscores the need for increased focus on ways to improve H&S performance. One of such ways is through addressing construction workers' unhealthy behavior including inter alia, unhealthy eating [18]. Adequate nourishment, through consumption of a variety of foods from different food groups including proteins, carbohydrates, vitamins and minerals [1] can raise national productivity by 20% [33]. In this regard, it is economically important to focus on the nutrition of construction workers who engage in mentally and physically-demanding tasks on a daily basis [20] and who have pivotal roles in construction processes.

Research has shown that construction workers have poor nutrition [11], [13], [21] and [27] and this leads to poor health [13], reduced acuity, increased risks and rates of incidents, accidents and injuries, reduced efficiency and productivity, increased costs incurred in treating avoidable illnesses and diseases, lost working days, losses in profits, and ultimately reduced Gross Domestic Product [23]. This execrable situation not only affects construction workers, but also their families, passers-by and the economy as a whole. Research on the subject of nutrition is therefore warranted.

The relationship between nutrition and health is known. Literature abounds on the importance of proper nutrition on health [3], [30] and [32] and in safety performance improvements [28]. However, it appears that there is a dearth of empirical studies focusing on the relationship between nutrition and safety performance in the construction industry. Previous studies which dealt with the aspect of safety performance [17] and [28] did not use statistical analyses to demonstrate the relationship. The objective of the present paper is to evaluate the relationship between nutrition and safety performance. Knowledge of the foods which could improve safety performance is necessary if the status quo regarding H&S performance in the construction industry is to be improved.

II. Nutrition And H&S Performance

Nutrition is the intake of food, considered in relation to the body's dietary needs [32]. Research has shown that construction workers' unhealthy eating affects their safety performance on construction sites [18]. [27] found that construction workers in India were bread-winners to large families and were poorly paid and this lead to regular, but sometimes inadequate consumption of staple foods including rice, beans and potatoes. Meat consumption was rare amongst these workers because they could not afford meat.

Similar studies, [12] and [17], found that construction workers, especially men, had poor nutritional intake. According to the authors, the poor nutritional intake was evidenced by regular consumption of unhealthy foods such as fatty foods [17] sugar sweetened beverages and fizzy drinks [25], and in general, foods of questionable nutritional quality and safety [28]. Poor nutritional intake leads to increased risk of obesity which leads to the development of chronic and non-communicable diseases [25] and [26] and which in turn leads to deterioration of health and invariably, to poor performance of workers in terms safety performance and productivity.

According to [10], unhealthy eating results in weakened immune system, increased susceptibility to diseases and infections, depression (which adversely affects concentration)

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and mental illness. Nutrient deficiencies also impair physical working capacity of individuals [10] and [33]. Fatigue and drowsiness, from hypoglycaemia, can occur when a meal is skipped, and this could lead to mistakes or errors which result in accidents, injuries and sometimes deaths [28] and [29]. Workers in the construction industry, which is a high risk sector involving a lot of hazardous work, cannot perform their duties while fatigued or suffering from ill-health as these can result in death or permanent disability [2].

A. Measuring nutritional intake

Different methods such as 24-hr dietary recalls, food frequency questionnaires, anthropometric measures and measurement with bio-markers have been used to determine nutritional intake. However which method one decides to use depends on the questions to be probed, the settings, the participants and the outcomes required [15]. [1] and [12] designed and validated a food frequency questionnaire (FFQ) to obtain quantitative information about the usual food consumption patterns with the aim of assessing the frequency with which certain food items or groups (including meat, fish, eggs, fat-rich foods, dairy products, fruits, vegetables, etc.) were consumed during a period of seven days (a week). The authors concurred that consumption of food from all the food groups including carbohydrates, proteins, vitamins and minerals, increased the probability of nutrient adequacy.

B. Measuring H&S performance

Health and safety performance of workers can be measured with accident statistics [14]. However it has been indicated that accident and injury statistics alone cannot adequately measure H&S performance since they usually do not reveal the causes, only the outcomes. Hence, other advocated indicators for H&S performance measurement [4], [7] and [14]. Therefore, in addition to injury and ill-health statistics, safety performance indicators include medically treated injuries (beyond first aid), return to work rates, non-injury incidents or near-misses, absence from work for more than three consecutive working days, reporting of incidents or close-calls, and wearing correct personal protective equipment (PPE) [4], [7] and [14].

III. METHODS

In order to achieve the current study's objective, certain techniques were adopted. An extensive literature review was conducted to identify relevant concepts and a likert-scale questionnaire was developed therefrom. The questionnaire consisted of 14-item questions relating to the frequency of consumption of a list of food items in a working week (adapted from [1]) as well as 10–item questions relating to safety performance on sites. The questionnaire was pilot-tested, reviewed and revised by experts before being self-administered to construction workers on construction sites. 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. Out of a total of 220 questionnaires distributed, 183 were returned and used for the empirical analysis.

Using Statistical Package for Social Sciences (SPSS) version 22, raw data were subjected to principal components analysis (PCA) using principal axis factoring and oblimin rotation. PCA was conducted in order to examine underlying structures of the theorized variables and to reduce the large number of related variables prior to using them in other analysis. Preliminary considerations for PCA were assessed. The sample size requirement of 150+ was met [22]. Suitability of data for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests. Missing data were excluded using listwise deletion. Outliers were also identified and removed before analysis. Outputs from the PCA (principal components), which contributed to the variance in the data sets were then adopted, retained, interpreted and used for correlation analysis. Decisions on which factors to retain were made using the Kaiser's criterion (retaining eigenvalues above 1), scree test (retaining factors above the "breaking point") and MonteCarlo parallel analysis (retaining factors whose initial eigenvalues were larger than the criterion values from parallel analysis). Spearman's correlation analysis was subsequently conducted. Spearman's correlation was thought to be suitable because the distribution of data for safety performance was slightly non-normal being positively skewed.

Cronbach's alpha *a* test and inter-item correlations were used to assess internal consistency reliability before and after PCA. Before PCA, the alpha indices for the nutritional intake and safety performance sub-scales were $a = 0.76$ and 0.83, respectively, indicating good internal consistency. The alpha values after PCA ranged from "0.43 to 0.89". Alpha values of > 0.4 are fairly acceptable [6]. Where *a* values are low, it is more appropriate to report mean inter-item correlations [22]. Mean inter-item correlation values ranging from "0.2 to 0.4" indicate good internal consistency [22]. The nutritional uptake sub-scale with $a = 0.43$ had a mean inter-item correlation of 0.27, indicating good internal consistency.

IV. FINDINGS AND DISCUSSION

A. Results from PCA

The suitability of the data for factor analysis was first assessed. With regard to the measures of nutritional intake, the KMO value for the measure of sampling adequacy was 0.735, exceeding the recommended value of 0.6 and the Bartlett's test of sphericity reached statistical significance at $p = .000$ (< .05), indicating suitability of data for factor analysis [22].

Four components, accounting for 61.45% of the total variance, with eigenvalues 3.685, 2.162, 1.535 and 1.222, explaining 26.32%, 15.44%, 10.96% and 8.73% of the variance, respectively, were extracted and retained based on the Kaiser's criterion, the scree test and parallel analysis. Factors with eigenvalues above 1, factors above the breaking point on the scree line and factors whose initial eigenvalues were larger than the criterion values from parallel analysis (as shown in Table I) were retained for rotation.

Interpretation of the four retained factors revealed strong item-loadings on the first two components and weak loadings on the 3rd and 4th components (shown in Table II). Components 3 and 4 were still retained because they had good and fairly acceptable Cronbach's alpha values, respectively. In addition, the fourth component contained important, universal and core

foods [5] usually consumed together. The four components were named alternatives, traditional core, secondary core and core foods, respectively, based on their nature, importance and universality amongst the study participants [5].

With regard to the safety performance variables, the KMO value was 0.832 and the Bartlett's test of sphericity reached statistical significance at p = .000 (< .05), supporting the factorability of the data. PCA of the ten items revealed that only two components had eigenvalues above 1 (4.511 and 1.885). The results of the scree test also suggested that only the first two components, which accounted for approximately 64% of the variance, could be retained. These two factors were therefore retained for further analysis.

Table III presents the item-loadings on the two components. The items clearly loaded as negative and positive items, consistent with positive and negative schedule scales used in extant literature [22]. Hence, the first component with negative items was named *lagging indicators*, while the second component with positive items was named *leading indicators* [16].

TABLE I
COMPARISON OF INITIAL EIGENVALUES AND CRITERION VALUES

Component	Initial eigenvalue from PCA	Criterion value (random eigenvalue) from parallel analysis	Decision
1	3.685	1.4014	**accept**
2	2.162	1.2653	**accept**
3	1.535	1.2081	**accept**
4	1.222	1.1082	**accept**
5	0.850	1.0396	reject
6	0.819	0.9110	reject

TABLE II
LOADING MATRIX OF NUTRITION COMPONENTS

Item	Component			
	1	2	3	4
dairy products	**.702**	-.137	.029	.042
eggs	**.683**	-.099	.014	.471
nuts	**.680**	.105	.088	-.105
fish	**.590**	.136	-.005	-.034
cereals	**.405**	.353	.183	-.231
extra salt	-.026	**.725**	-.281	.071
a lot of sugary foods	.014	**.666**	-.036	.167
a lot of fried foods	-.172	**.609**	.248	-.009
pasta	.268	**.466**	.206	-.141
grains like rice	.127	**.420**	-.018	-.036
vegetables	-.002	-.083	**.795**	.166
fruits	.120	-.018	**.793**	.052
meat	.078	.010	.044	**.597**
corn meal	-.049	.085	.075	**.336**

TABLE III
LOADING MATRIX OF SAFETY PERFORMANCE COMPONENTS

Item	Component	
	1	2
Absence from work for more than three days due to an injury	***.946***	-.119
Medical treatment beyond first aid on site	***.872***	-.009
Restricted activity after an injury	***.813***	-.177
Incidents or near-misses	***.670***	.011
Injuries at work	***.651***	.289
Sickness at work	***.613***	.049
Failure to report accidents or incidents	***.465***	.258
Failure to conduct risk assessment before undertaking tasks	-.073	***.850***
Accepting any kind of work, regardless of the danger/risk involved	-.036	***.704***
Failure to wear correct PPE	.124	***.564***

B. Results from Correlation Analysis

A correlation matrix was constructed in order to discover important relationships between nutrition variables and safety performance variables, using Spearman's *rho*. Table 4 presents the results of the analysis. A statistically significant positive correlation was found between alternative foods and leading positive indicators (*rho* = 0.22, *N* = 174, *p* < .01), with higher rates of consumption of dairy foods, eggs, nuts, fish and cereals associated with higher incidence of positive performance measures including consideration of risks, accepting any kind of work mindless of risks/dangers involved, and wearing personal protective equipment (PPE). This seemed to suggest that consumption of the "alternative" foods is associated with increased focus and careful consideration or contemplation of risks and hazards before undertaking tasks on construction sites. This finding aligns with findings from [9] which indicated associations between nutrient adequacy and cognitive processes including reasoning, planning, problem-solving, multi-tasking and strategic thinking.

No significant relationship was found between consumption of alternative core foods and safety performance lagging indicators. Likewise, no statistically significant relationships were shown between traditional core foods and safety performance, secondary core foods and safety performance, and core foods and safety performance. These findings are inconsistent with findings from studies by [17], [28] and [29] which suggested that consumption of healthy and varied foods was associated with occurrence or non-occurrence of accidents, injuries and incidents on construction sites.

A possible explanation for the inconsistency could be the nature of the data used in the present study which had most of the responses for safety performance measures concentrated on the "never" category. Respondents may have responded the way they did because they were afraid to respond truthfully for fear of getting into trouble or they really did not experience the stated safety performance issues.

Furthermore, the inconsistent findings could be explained by a possible indirect relationship between nutrition and safety performance. It could be that nutrition has a direct relationship with health and only an indirect relationship with safety performance. For instance, consumption of foods high in fat (included in traditional core foods) could result in obesity which in turn leads to exceeded weight limits for safety gear

[29] and thus failure to wear correct PPE. Also, low blood sugar (hypoglycaemia) results in sleepiness, confusion and blurry vision [29] which could invariably result in accidents and injuries.

TABLE IV
SPEARMAN'S CORRELATIONS

		Lagging indicators	Leading indicators
Alternative foods	Correlation Coefficient	-.045	.218
	Sig. (2-tailed)	.554	.004
	N	173	174
Traditional core foods	Correlation Coefficient	-.043	.120
	Sig. (2-tailed)	.578	.113
	N	173	175
Secondary core foods	Correlation Coefficient	.010	.060
	Sig. (2-tailed)	.891	.434
	N	172	175
Core foods	Correlation Coefficient	-.010	-.123
	Sig. (2-tailed)	.893	.106
	N	173	174

V. CONCLUSION AND RECOMMENDATIONS

The study set out to evaluate the relationship between nutrition and safety performance. A significant relationship was found between "alternative foods" (including dairy foods, eggs, nuts, fish and cereals, in the current study) and positive indicators of safety performance, albeit a weak relationship. The finding could be used to design nutrition intervention programmes targeted at construction workers aimed at improving their nutrition and thus H&S performance. In a bid to encourage healthy eating, nutrition education programmes should incorporate the importance of consuming these identified food items. In addition, supplementary feeding programmes at construction sites should include these foods. Construction employers and managers can also commit to healthy eating through environmental or organizational changes such as increasing the availability of these significant foods at worksites and arranging with food vendors to sell at reduced prices. These interventions will encourage construction workers to eat such food items and improve their overall nutrition. By improving construction workers nutrition, H&S performance will be invariably improved.

There is limited research focusing on construction workers' nutrition as it influences their H&S performance on sites. Based on the findings of the present study, future research could focus on exploring the indirect relationship between nutrition and safety performance. Other research methods, for instance, participant observations, could be used to explore relationship between the times of consumption of specific foods and occurrence of accidents, injuries or near-misses. Future research could also adopt a longitudinal approach to examine changes in effect over time (i. e., before and after nutrition intervention). The extent to which safety performance is influenced by nutrition could also be investigated in future. Furthermore, since the current study was conducted in South Africa, and amongst 183 construction workers, future studies could use a different and/or larger sample.

In conclusion, the study provided useful evidence to develop measures that will go a long way in improving the nutrition of construction workers. In turn, their physical and mental health, especially cognitive thinking, would be sustained and safety performance records will invariably improve. Improving the H&S status quo will benefit construction workers and their families, construction employers and stakeholders as well as the economy as a whole since avoidable costs will be reduced, productivity will be increased and Gross Domestic Product will ultimately increase.

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