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Exploring Multifaceted Dimensions of Health and Safety Risk Perceptions: A Factor Analysis Approach Among Masonry Workers in Informal Construction Sites, Dar es Salaam, Tanzania

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Abstract Informal construction (IC) refers to construction activities carried out by individuals who are neither licensed nor regulated, making them vulnerable to health and safety risks (HSR). This paper uses factor analysis to discern patterns in masonry workers' HSR perceptions in IC in Dar es Salaam. By combining these perceptions into components, the study aims to provide a comprehensive understanding of the challenges workers face in IC settings. This approach enables targeted solutions to enhance workplace health and safety (HS), aligning with Sustainable Development Goals (SDGs) 3, 8, and 11, which promote health, inclusivity, safety, and sustainability in communities. An interpretivist epistemological approach was used to thoroughly review literature on workers' HSR perceptions in construction. A survey collected data from IC workers in Dar es Salaam, Tanzania, based on 19 identified perceptions. Multivariate techniques, particularly factor analysis, was then employed to condense variables into manageable perceptions. Using factor analysis, the study grouped 19 perceptions on HSR among IC workers into four main factors: general workplace hazards, environmental injuries, health and ergonomic issues, and workplace hygiene concerns. This research enhances our understanding of the issue within a previously unexplored context. The study, conducted empirically in Tanzania, utilizes factor analysis to customize, contextualize, and consolidate various aspects of workers' perceptions regarding HS risks in IC into distinct components.

Keywords Multifaceted Dimensions, Health & Safety Risks Perception, Risk Management, Labor Act, WHO OHS Standards, ILO OHS Regulations, Factor Analysis, Masonry Workers, Informal Construction Sites, Tanzania

1. Introduction

Across different regions and societies, the construction industry has consistently been essential to a nation's economy. It is pivotal in laying the groundwork for a thriving society by creating infrastructure, housing, and commercial spaces that drive economic growth and improve people's quality of life [1] and [2]. It is also crucial, making a significant contribution to the economy's Gross Domestic Product (GDP) and employment levels [3]. Worldwide, the construction sector represents approximately 6% of the global GDP, with projections indicating that this figure could reach around 14.7% by 2030 [4] and [5]. For instance, in mainland Tanzania, the construction sector's growth rate was about 15.1% in 2017, up from 12.9% in 2015. This growth corresponded to a contribution of 12.2% to the national GDP in 2017, slightly higher than the 11.1% contribution observed in 2015 [6].

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The construction industry encompasses both formal and informal subsectors. The informal sector encompasses unlicensed and unregulated individuals involved in various construction activities, including supplying both unskilled and skilled labour for tasks like earthworks, walling, and concrete works [7] and [8]. It refers to any construction work undertaken by individuals, regardless of their professional training or certification, and conducted outside of formal agreements.

While IC occurs in both developed and developing nations, it's particularly prevalent in developing countries grappling with low per capita income [9] and [10]. In Beijing's historic inner-city areas, a significant portion of the building inventory consists of informal constructions that local residents have gradually erected over time [11]. [10] argue that no single framework can encompass all the diverse informal practices that have occurred, are occurring, and will occur within European integration over time. Studies on informal construction, such as those by [12], [13] and [14], highlight the higher prevalence of this activity in Sub-Saharan Africa compared to other regions. These studies explore the various aspects of informal construction, including its nature, scale, management, and social welfare implications for workers.

There is presence of IC practices within formal construction projects in Tanzania. This suggests the potential for overlap between formal and informal sectors, with formal projects incorporating informal methods and formal land being used for informal construction [15]. This potential overlap highlights the significant contribution of the IC sector to the overall construction industry and, consequently, the wider economy. Notably, construction work can account for up to 80% of all employment opportunities in developing countries [16].

Both formal and informal construction sectors are vulnerable to HS risks due to their operations [17].

Effective risk management plays a vital role in minimizing these hazards [7]. Essential aspects include defining comprehensive safety procedures and policies, appointing safety personnel, conducting frequent safety training sessions, ensuring sufficient availability of personal protective equipment (PPE), developing emergency response plans, maintaining detailed records of workplace accidents, establishing efficient communication systems, and providing fair compensation to workers who sustain injuries [7]. International bodies like the World Health Organization (WHO) and the International Labour Organization (ILO) have introduced fundamental standards and guidelines for occupational health and safety in the construction industry, focusing on risk evaluation, hazard mitigation, workforce training, and creating a secure and healthy work environment [87] and [88]. Unfortunately, such measures are often absent in the informal construction sector, resulting in higher rates of accidents and injuries [56]. Contributing factors include limited awareness of safety protocols, lack of safety officers, inadequate training programs, insufficient PPE, absence of emergency and risk management plans, lack of accident documentation, partial or no compensation for injury-related losses, ineffective communication systems, weak governmental oversight, and the absence of strict penalties for worker exploitation and non-compliance with regulatory standards [87].

The nature of the work and environment in the construction industry exposes employees to various HS risks and occupational accidents, making it the most dangerous industry globally [18]. Construction workers are at risk of developing work-related health disorders due to exposure to occupational risks [19]. HS issues on construction sites are not limited to formal construction but are also relevant and worse to the IC sector. The effectiveness of HS measures on construction sites is influenced by the way construction site stakeholders perceive risks [7]. In IC, workers are consistently held responsible for unsafe practices and perceived lack of awareness, leading to a rise in construction site accidents [20].

Within the realm of construction site health and safety, a critical factor is worker risk perception (RP). This concept encompasses a worker's ability to effectively identify and evaluate the level of severity associated with on-site hazards [21]. It transcends mere awareness of danger and delves into an informed understanding of potential outcomes. It involves recognizing the potential of a hazard to cause harm and assessing the probability of that harm happening. [22] highlights a critical issue in the construction industry: a prevalent underestimation of occupational health risks among construction workers. This manifests in their perception of health and safety protocols as less important and their overall lack of enthusiasm for taking preventative measures. The aim of this paper is to use factor analysis to discern patterns in masonry workers' HSR perceptions in IC in Dar es Salaam. Combining perceptions into components aimed to yield a comprehensive understanding of challenges encountered by workers in IC settings.

A substantial body of research, including works by [23], [21] and [24], has investigated worker risk perception within formal construction environments. However, these studies have largely neglected to delve into the risk perceptions of workers operating in informal construction settings. This gap in knowledge represents a critical limitation, as understanding how informal construction workers perceive risks is paramount to safeguarding their safety and well-being. In their investigation of health and safety risk perceptions among Tanzanian masonry workers within informal construction settings, [7] identified and ranked approximately 19 distinct concerns. This relatively high number of factors presents a potential challenge in developing and implementing effective management strategies. Naturally, it is simpler to address a small set of combined issues than to manage a lengthy list of problem factors. [25] presents the notion of "bounded rationality," proposing that decision-makers are constrained by cognitive limitations that hinder their ability to fully consider all pertinent information and choices. Consequently, they may concentrate on a subset of issues perceived as the most urgent or significant. When confronted with a big number of interconnected challenges, policymakers and practitioners face a crucial strategic decision. They must choose whether to address each factor individually or prioritize a manageable subset of highly interlinked issues for their interventions [26] and [27]. In the context of IC in Dar es Salaam, factor analysis emerges as a vital tool to comprehensively understand the patterns underlying masonry workers' perceptions of health and safety risks. By systematically combining these perceptions into distinct components, this approach can reveal crucial insights. Such insights are instrumental in developing targeted interventions that directly address the specific challenges faced by IC workers. This focused approach supports the goals set out in SDGs 3, 8, and 11 of the 2030 Agenda, specifically ensuring health and well-being for everyone, advancing decent work and economic growth, and encouraging sustainable cities and communities.

2. Literature Review

2.1. Informal Construction Sector Dynamics in Tanzania

The concept of the informal economy (IE) is believed to have led to the emergence of the IC industry [28]. IC sector is well described as being made up of independent workers and small businesses that don't have formal licenses or registrations. These groups continue to be significant in the construction industry by providing labor and various services [29]. Most residential buildings in the informal construction sector are built without following current bylaws, health insurance requirements, levies, or other legal obligations [30]. [31] used the relationship between building permits and cement usage to demonstrate the significant amount of unplanned construction in Kenyan cities during the 1990s. Despite being challenging to quantify and not well understood, the informal construction sector is growing in both developed and developing countries [32]. [33] highlighted that a considerable portion of global construction output is generated within the informal sector. In underdeveloped nations, informal construction activities account for up to 80% of employment (ibid). The formal construction sector relies on the IC sector for labor, which in turn provides employment and income opportunities [12]. The Tanzanian government's construction industry policy acknowledges and supports the IC sector as a vigorous part of the construction industry [34]. Due to their informal status, both clients and artisans often neglect health and safety considerations [35].

2.2. Workers' Perception on Health and Safety Risks in Construction Sites

On general construction sites, workers' perceptions on health and safety risks are shaped by several factors, including the conditions of the site, the practices of management, and the awareness of the individuals involved. It shows that construction workers frequently encounter high-risk environments because their work often involves using heavy machinery, working at heights, and handling hazardous materials [36]. Even with the presence of regulations and safety protocols, many workers still view risks as unavoidable elements of their job, which can result in a certain level of complacency. [37] contend that for HS risk management to be effective, it is essential not only to comply with regulatory frameworks but also to develop a safety culture that promotes proactive identification and mitigation of risks. Furthermore, workers' personal experiences and the visible commitment of management to safety can greatly impact their perceptions and attitudes toward HS on construction sites [38]. Therefore, enhancing workers' perception of HS risks requires a comprehensive strategy that encompasses training, enforcement, and cultural changes within the industry.

Table 1. A synopsis of supporting research on HSRs in construction. Adapted from Mwemezi et al. (2024)

HSRs		Supporting literature
HSR1	Injury or death due to falling from height (Slip and trips)	[39]; [40]
HSR2	Injury or death due to falling objects	[41]; [42]; [43]
HSR3	Muscular disorder due to manual handling of materials and tools/equipment	[44]; [39]
HSR4	Injury due to unintended collapse (collapsing trenches)	[45]; [46
HSR5	Injury or death due to collapsing walls (for demolition works and/or poorly constructed walls)	[47]; [44]
HSR6	Diseases caused by exposure to airborne fibers and toxic materials	[48]; [49.
HSR7	Injury or death due to exposure to sharp and/or protruding objects	[39]
HSR8	Respiratory diseases due to inhalation of dust	[44]; [50]
HSR9	Muscular disorder due to bending and twisting	[46]; [50]
HSR10	Hand and vibration syndrome (Vibratory tools)	[51]
HSR11	Diseases due to exposure to hazards such as excessive noise, heat and humidity	[50]
HSR12	Injury or death due to exposure to crushing risks from moving objects	[52]; [19]
HSR13	Sickness due to poor drinking water or poor toilet facilities	[53]; [54]; [55]
HSR14	Injury or death due to usage of equipment	[46]
HSR15	Skin sanitizers, irritants (Bitumen, acids, alkalis, cement)	[52]; [56]
HSR16	Fatigue	[57]
HSR17	Bullying and stress	[44]; [50]
HSR18	Injury caused by the environment with limited lighting	[58]
HSR19	Injury due to existence of wild animals e.g., snakes that might cause injury	[47]

Table 2. One-sample t-test results for the perception of HSRs. Adapted from [7]

HSRs	Mean score	SD	Rank	Test value (μ = 3.5) *t*	*df*	Sig 2-tailed	Mean difference	95% Confidence interval of the difference		Significant (*p* <0.05)
								Lower	Upper	
HSR 15	4.15	0.916	1	12.332	303	**0.000**	0.648	0.54	0.75	Yes
HSR 13	4.07	0.838	2	11.775	303	**0.000**	0.566	0.47	0.66	Yes
HSR 1	3.98	0.908	3	9.221	303	**0.000**	0.480	0.38	0.58	Yes
HSR 3	3.78	0.816	4	6.046	303	**0.000**	0.283	0.19	0.37	Yes
HSR 9	3.72	0.884	5	4.412	303	**0.000**	0.224	0.12	0.32	Yes
HSR 2	3.70	0.874	6	4.069	303	**0.000**	0.204	0.11	0.30	Yes
HSR 7	3.67	0.839	7	3.556	303	**0.000**	0.171	0.08	0.27	Yes
HSR 8	3.52	0.944	8	0.304	303	0.761	0.016	-0.09	0.12	No
HSR 16	3.47	1.065	9	-0.431	303	0.667	-0.026	-0.15	0.09	No
HSR 19	3.43	1.501	10	-0.802	303	0.423	-0.069	-0.24	0.10	No
HSR 14	3.32	1.049	11	-3.061	303	**0.002**	-0.184	-0.30	-0.07	Yes
HSR 4	3.16	1.080	12	-5.472	303	**0.000**	-0.339	-0.46	-0.22	Yes
HSR 18	3.07	1.196	13	-6.281	303	**0.000**	-0.431	-0.57	-0.30	Yes
HSR 12	3.04	1.072	14	-7.434	303	**0.000**	-0.457	-0.58	-0.34	Yes
HSR 5	3.04	1.137	15	-7.064	303	**0.000**	-0.461	-0.59	-0.33	Yes
HSR 11	3.00	1.149	16	-7.587	303	**0.000**	-0.500	-0.63	-0.37	Yes
HSR 17	2.96	1.424	17	-6.564	303	**0.000**	-0.536	-0.70	-0.38	Yes
HSR 6	2.88	1.296	18	-8.275	303	**0.000**	-0.615	-0.76	-0.47	Yes
HSR 10	2.59	1.207	19	-13.115	303	**0.000**	-0.908	-1.04	-0.77	Yes

In the IC sector, the perception of HS risks is often markedly different due to the lack of formal regulations and oversight. [35] notes that both clients and artisans frequently neglect health and safety considerations due to the informal nature of their work. This sector, which is prevalent in many developing countries, operates outside the purview of official health and safety regulations, leading to higher exposure to unsafe working conditions [30]. Workers in informal construction sites often lack formal training and awareness about potential risks, further exacerbating the issue. [33], reported that as much as 80% of employment in developing countries is derived from IC activities, highlighting the sector's scale and importance. [12] highlight that the formal construction sector relies on the informal sector for labor, yet this relationship does not translate into improved safety standards. Addressing HS in IC sites requires targeted interventions that include education, community engagement, and the establishment of basic safety protocols tailored to the informal context. Table 1 now presents the list of HSRs on construction sites, compiled from various studies.

3. Research Methodology

This study builds upon the established perceptions about HS risks among informal workers in the informal construction sector, as delineated and prioritized in Table 2. In this study, factor analysis is employed to extract a smaller set of factors from a larger array of interconnected variables. This is an extraction of maximum common variance from all variables and put them into a common score for making the dataset more manageable.

3.1. Reliability and Validity of the Instrument

The structured questionnaire was designed to gather primary data. The data were collected from masonry workers at informal construction sites across the districts of Dar es Salaam. Before distributing the questionnaire, a pilot study involving seven professionals selected from the construction industry was conducted. Professional feedback from the survey's pilot test was incorporated to enhance the questionnaire before collecting primary data [59]. The questionnaire comprised inquiries and assertions pertaining to variables concerning informal workers' perceptions of HS risks in informal construction. These were formulated based on a review of literature. Each statement was evaluated on a five-point Likert scale from 1 to 5, with a rating of 5 indicating frequent agreement with the statement. A total of 384 questionnaires were distributed to informal construction workers, yet only 304 respondents provided their insights on health and safety risks, yielding a response rate of 79.17%, surpassing the recommended 70% threshold for impressiveness [60]. All statistical analyses were conducted using IBM SPSS version 27.

3.1.1. Cronbach's Alpha

The questionnaire's reliability was evaluated by employing Cronbach's alpha via IBM SPSS software (version 27), aiming to gauge the scale's reliability and internal consistency.

This approach is applied based on the premise that several items are measuring a shared underlying construct. For instance, in the survey on informal workers' perceptions of health and safety risks, there are several questions addressing distinct aspects. However, when aggregated, they can be considered as collectively measuring the overall perception. Cronbach's alpha varies between 0 and 1, with a value exceeding 0.7 generally deemed acceptable. A higher alpha value indicates a strong correlation among the variables in the test [61].

3.1.2. Average Variance Extracted (AVE) and Composite Reliability (CR)

In this study, evaluating the quality of a measure of variance was crucial. This was achieved by examining convergent validity and composite reliability through the average variance extracted (AVE) and composite reliability (CR) coefficients. AVE quantifies the extent to which a construct's variance relates to the variance attributed to measurement error [62]; [63]. To be precise, AVE serves as a metric for assessing convergent validity.

Convergent validity was utilized to assess the degree of correlation among multiple indicators of the same construct that exhibit agreement. To ascertain convergent validity, calculations of factor loading of items, composite reliability, and average variance extracted (AVE) are required [64]. AVE and CR values range from 0 to 1, with higher values reflecting greater reliability. An AVE of 0.5 or higher confirms convergent validity. The average variance extracted is calculated by summing the squared loadings and dividing by the number of items [64].

Composite reliability is a measure used to assess the internal consistency of items within a scale [65]. As noted by [62], composite reliability represents the shared variance among observed variables that represent a latent construct. Acceptable values generally range from 0.6 to 0.7, with higher values above 0.7 being preferred in more advanced stages of analysis. Additionally, [62] propose that if the average variance extracted (AVE) is below 0.5 but the composite reliability is above 0.6, the construct's convergent validity is still considered adequate.

3.2. Factor Analysis

In this study, exploratory factor analysis (EFA) was used to examine the dataset, with the goal of revealing complex relationships among items and grouping items that contribute to unified concepts. Due to its exploratory nature, factor analysis does not differentiate between independent and dependent variables. Instead, it clusters similar variables into factors to reveal underlying constructs, relying only on the data's correlation matrix [66]. In this study, factor analysis using principal components extraction was applied to determine if the statements reveal distinct factors related to informal workers' perceptions of HS risks in IC. Principal component analysis (PCA) is a statistical method used to capture variation by calculating principal data components to reveal significant patterns within the dataset [67].

Factor analysis generally involves three main stages: a) assessing the suitability of the data, b) extracting factors, and c) rotating and interpreting factors. These steps can be described as follows:

3.2.1. Evaluation of the Appropriateness of the Data

To determine if the dataset is suitable for factor analysis, both the sample size and the extent of correlation among the variables must be considered [68]; [69]. Generally, it is recommended to have a larger sample size for factor analysis, ideally about ten cases per item. Even with a smaller sample size, adequacy can still be achieved if the solutions show several marker variables with high loadings, typically below 0.80 [70]. Evaluating the strength of relationships among the items requires ensuring that the correlation coefficient in the correlation matrix is greater than 0.3. Multicollinearity, a form of disturbance characterized by significant inter-correlations among independent variables, can distort analysis outcomes. It renders some variables statistically insignificant, undermining the reliability of statistical inferences drawn from the data [71]; [68]. Therefore, the presence of multicollinearity among the variables is assessed using the determinant score.

a) Determinant Score

The determinant value serves as a crucial indicator for multicollinearity or singularity. A determinant score exceeding 0.00001 in the correlation matrix indicates the absence of multicollinearity. If the determinant value falls below 0.00001, it becomes necessary to identify pairs of variables exhibiting correlation coefficients (r) greater than 0.8 and contemplate removing them from the analysis. A lower score may indicate that clusters of three or more questions/ statements display significant inter-correlations, thus prompting a reduction in the threshold for item elimination until this condition is met. If correlation is singular, the determinant $|R|$ equals 0 [72]; [70].

b) Factorability of the Data

Two statistical measures are employed for evaluating the factorability of data in factor analysis: the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett’s test of Sphericity [70]. In order to assess the suitability of the data regarding the perceptions of health and safety risks among informal construction workers in the Tanzanian informal construction sector for subsequent analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (MSA) and Bartlett test of sphericity (BTS) were performed.

These two tests establish the minimum criteria that the data must meet to be deemed suitable for further analysis. The Kaiser-Meyer-Olkin (KMO) value ranges from 0 to 1, with a minimum threshold of 0.50 recommended [73]; [74]. The Bartlett test assesses whether the correlation matrix significantly differs from the identity matrix, where all diagonal elements are 1 and all other elements are 0. The Bartlett test evaluates the magnitude of relationships among variables, and its significance level is necessary for the data to be deemed appropriate for analysis [73].

3.2.2. Factor Extraction

Factor extraction involves identifying the minimum number of factors necessary to effectively capture the relationships among the variables. Various methods exist for determining the appropriate number of underlying factors. Principal component analysis (PCA) and common factor analysis are commonly employed for obtaining factor solutions [70]. In this study, PCA was utilized since the aim was to analyze the data to derive the smallest number of factors needed to represent the dataset effectively.

Determining the Optimal Number of Factors for Extraction

This study employs two methods to aid in determining the appropriate number of factors to retain: Kaiser's Criterion and the Scree Test. Both Kaiser's Criterion (also known as the Eigenvalue Criterion) and the Scree Test help establish the number of initial unrotated factors to extract. The eigenvalue represents the ratio of shared variance to unique variance explained by a particular extracted factor [69].

a) Kaiser’s (Eigenvalue) Criterion

The eigenvalue of a factor signifies the proportion of total variance accounted for by that factor. In factor analysis, factors with eigenvalues exceeding one are retained. This rule is founded on sound reasoning: an eigenvalue surpassing one is deemed significant, indicating that the factor explains more shared variance than unique variance [75]. Measure and composite variables belong to distinct categories. Factors are latent constructs formed by combining measured variables and thus should comprise more than just one measured variable. However, eigenvalues, like all sample statistics, are subject to sampling error [76].

Therefore, it is crucial for the researcher to exercise discretion when employing this approach to decide on the number of factors to extract or retain [77].

b) Scree Test

A visual method for determining the number of factors, using a scree plot, was introduced by Cattell in 1996. This plot displays the magnitudes of eigenvalues on the vertical axis against the corresponding factor numbers on the horizontal axis [78]. Within the graph, the eigenvalues are represented as dots, connected by a line. Factor extraction is recommended to cease at the point where a distinct 'elbow' or leveling occurs in the plot [73]. This test aids in identifying the optimal number of factors that can be extracted before the unique variance starts to outweigh the shared variance structure [79].

3.2.3. Factor Rotation and Interpretation

Interpreting factors derived during the initial extraction phase can be challenging due to substantial cross-loadings, where multiple factors exhibit correlations with numerous variables. Factor rotation can be approached in two main ways: orthogonal (uncorrelated) or oblique (correlated) factor solutions [73]. In this research, orthogonal factor rotation was employed due to its tendency to yield solutions that are simpler to interpret and present. The varimax, quartimax, and equimax methods are associated with orthogonal rotation. Additionally, the Varimax technique was used in this study as introduced by [80], aims to reduce the number of variables with high loadings on each factor. Varimax primarily emphasizes maximizing differences among the squared pattern structure coefficients on a factor, focusing on a column perspective. The goal of rotation is to maximize the spread in loadings, enhancing high loadings after extraction and further lowering low loadings. If the rotated component matrix reveals numerous significant cross-loading values, it is advisable to conduct another factor analysis iteration. This iteration aims to ensure that each item is loaded onto only one component by eliminating all variables with cross-loadings [77].

4. Results and Discussion

This section presents the results obtained using the statistical software IBM SPSS version 27. The study included 304 informal construction workers from the Dar es Salaam region. The majority of workers (46%) fell into the age group of 18 to 35 years, followed by 33% aged between 36 to 45 years. Workers had a minimum of six years of work experience, indicating that most respondents possessed the necessary maturity and experience to participate in the survey. The vast majority, 95.4%, were male, highlighting the limited involvement of females in informal construction work.

This study has adhered to three primary stages in conducting factor analysis: a) evaluating the appropriateness of the data, b) extracting factors, and c) rotating and interpreting the factors.

4.1. Stage 1: Evaluation of the Appropriateness of the Data

In evaluating the dataset's suitability for factor analysis in this study, considerations such as sample size and the strength of relationships among the items were considered. Additionally, the Kaiser-Meyer-Olkin measure was utilized to gauge the data's adequacy for factor analysis. Similarly, Bartlett’s test of Sphericity, correlation matrix, and determinant score were calculated to assess the dataset's suitability for effective factor analysis [81].

Factor analysis necessitates relatively sizable samples, with certain recommendations specifying minimum sample sizes ranging from n=100 to n=500 [73]. [69] indicates that several textbooks provide guidance on recommended sample sizes for factor analysis: 100 is deemed poor, 200 fair, 300 good, 500 very good, and 1000 or more excellent. The sample size for the study was 304 informal construction workers which is good for factor analysis.

Table 3. Correlation matrix[a] and determinant score. Authors own work

	HSR1	HSR2	HSR3	HSR4	HSR5	HSR6	HSR7	HSR8	HSR9	HSR10	HSR11	HSR12	HSR13	HSR14	HSR15	HSR16	HSR17	HSR18	HSR19
HSR1	1																		
HSR2	.745**	1																	
HSR3	.132*	-0.007	1																
HSR4	.461**	.523**	.242**	1															
HSR5	.452**	.533**	.191**	.780**	1														
HSR6	.245**	.305**	.242**	.655**	.644**	1													
HSR7	.299**	.331**	.373**	.401**	.464**	.457**	1												
HSR8	.166**	.210**	.330**	.449**	.412**	.613**	.395**	1											
HSR9	.129*	0.039	.479**	.154**	.192**	.272**	.344**	.338**	1										
HSR10	.237**	.283**	.258**	.694**	.661**	.761**	.350**	.536**	.281**	1									
HSR11	.386**	.431**	.169**	.636**	.667**	.678**	.408**	.496**	.234**	.735**	1								
HSR12	.445**	.524**	.150**	.718**	.751**	.678**	.496**	.490**	.194**	.679**	.683**	1							
HSR13	.132*	0.103	.166**	0.101	.139*	-0.002	.162**	0.040	.363**	0.014	.168**	0.092	1						
HSR14	.363**	.444**	0.103	.575**	.601**	.466**	.328**	.328**	.169**	.462**	.531**	.621**	.307**	1					
HSR15	.591**	.508**	0.105	0.109	.134*	-.130*	.171**	-0.051	0.104	-0.112	0.056	.128*	.116*	.212**	1				
HSR16	0.098	0.084	.126*	.172**	.115*	.200**	.168**	.183**	0.020	.125*	.162**	.193**	-0.002	0.102	.154**	1			
HSR17	-0.100	-.125*	.360**	.315**	.307**	.548**	.382**	.468**	.503**	.512**	.389**	.336**	.334**	.240**	-.310**	.116*	1		
HSR18	.354**	.440**	0.086	.712**	.721**	.761**	.312**	.512**	0.081	.753**	.711**	.700**	-0.080	.501**	-0.015	.135*	.333**	1	
HSR19	.411**	.473**	-0.061	.397**	.450**	.178**	0.095	0.059	0.075	.232**	.410**	.399**	.489**	.557**	.328**	0.006	-0.014	.277**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
N=304
[a]. Determinant Score = 0.044
HSR- Health and Safety Risk

Table 3 indicates that the correlation matrix exhibits enough correlations, supporting the use of factor analysis. The matrix reveals that only a small number of items have inter-correlations exceeding 0.3 among the variables, suggesting that the proposed factor model is appropriate. The determinant value serves as a significant indicator for multicollinearity. With a determinant score of 0.044, which exceeds 0.00001, it suggests the absence of multicollinearity [71]; [68].

Table 4 illustrates that the KMO value for the dataset in this study was 0.900, surpassing the threshold of 0.50, while the BTS value was found to be significant at p=0.000. The KMO value of 0.900 exceeds the recommended threshold of 0.6 [82]; [83], and Bartlett's Test of Sphericity [84] yielded statistical significance, affirming the factorability of the dataset.

Table 4. KMO and Bartlett's test for perceptions of workers on HSRs in IC. Authors own work

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.900
Bartlett's Test of Sphericity	Approx. Chi-Square	3812.987
	df	171
	Sig.	0.000

4.2. Stage 2: Factor Extraction

Kaiser's criterion and the Screen test were employed to ascertain the number of initial unrotated factors for extraction. The eigenvalues linked with each factor indicate the variance explained by those particular linear components. Any coefficient value below 0.5 is disregarded, leading to the exclusion of factor loadings below 0.5 [82].

Table 5 illustrates the eigenvalues and the total variance explained. Principal component analysis was employed as the factor extraction method in this study. Prior to extraction, nineteen linear components were identified within the dataset. Following extraction and rotation, four distinct linear components remained within the dataset, each with eigenvalues exceeding 1. These four factors collectively account for 70.4% of the total variance. It is recommended that the retained factors explain at least 50% of the total variance [81]; [69]. The result indicates that four factors can account for 70.4% of the common variance among the nineteen variables. This aligns with the KMO value of 0.900, indicating a favourable suitability for factor analysis with these variables. This preliminary outcome implies that the ultimate solution will likely yield no more than four factors. The first component has accounted for 33.7% of the total variance, corresponding to an eigenvalue of 7.53. The second component explains 14.4% of the variance, with an eigenvalue of 2.62. Similarly, the third component accounts for 13.25% of the variance, with an eigenvalue of 1.87, while the fourth component explains 9.07% of the variance, with an eigenvalue of 1.37.

Table 5. Eigenvalues (EV) and Total Variance Explained. Authors own work

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.534	39.651	39.651	7.534	39.651	39.651	6.395	33.659	33.659
2	2.615	13.765	53.416	2.615	13.765	53.416	2.744	14.440	48.099
3	1.865	9.818	63.235	1.865	9.818	63.235	2.518	13.254	61.353
4	1.366	7.190	70.425	1.366	7.190	70.425	1.724	9.072	70.425
5	0.942	4.957	75.382						
6	0.644	3.388	78.770						
7	0.591	3.112	81.882						
8	0.513	2.698	84.580						
9	0.452	2.380	86.959						
10	0.385	2.024	88.984						
11	0.335	1.762	90.746						
12	0.293	1.540	92.285						
13	0.260	1.366	93.651						
14	0.246	1.295	94.946						
15	0.224	1.177	96.123						
16	0.212	1.118	97.241						
17	0.191	1.004	98.245						
18	0.171	0.897	99.142						
19	0.163	0.858	100.000						
Extraction Method: Principal Component Analysis.									

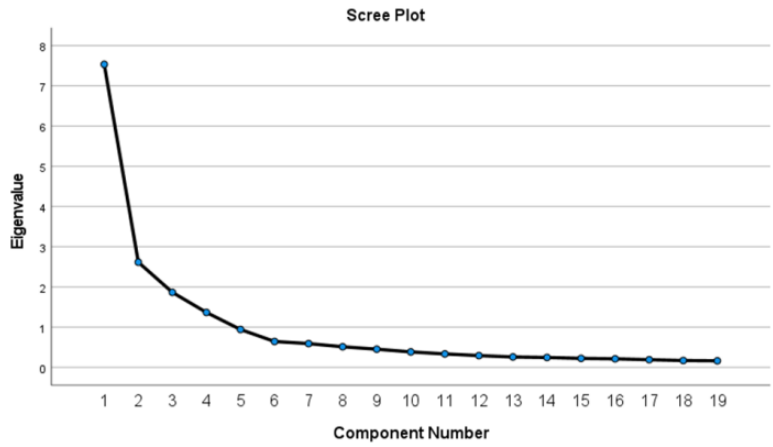

Figure 1. The scree plot showing extracted factors on 19 identified perceptions of workers on HSRs in IC. Authors own work

Table 6. Rotated component matrix[a] for the perceptions of workers on HSRs in IC. Authors own work

Perceptions	Component			
	1	2	3	4
Perceived General Workplace Hazards and Safety Risks				
Injury caused by the environment with limited lighting	0.902			
Hand and vibration syndrome (Vibratory tools)	0.858			
Diseases caused by exposure to airborne fibers and toxic materials	0.852			
Injury or death due to exposure to crushing risks from moving objects	0.820			
Injury due to unintended collapse (collapsing trenches)	0.809			
Injury or death due to collapsing walls (for demolition works and/or poor constructed walls)	0.808			
Diseases due to exposure to hazards such as excessive noise, heat and humidity	0.804			
Injury or death due to usage of equipment	0.607			
Respiratory diseases due to inhalation of dust	0.584			
Perceived Occupational Injuries from Environmental Factors				
Skin sanitizers, irritants (Bitumen, acids, alkalis, cement)		0.866		
Injury or death due to falling from height (Slip and trips)		0.803		
Injury or death due to falling objects		0.753		
Injury or death due to exposure to sharp and/or protruding objects		0.565		
Perceived Occupational Health and Ergonomic Issues				
Muscular disorder due to manual handling of materials and tools/equipment			0.784	
Muscular disorder due to bending and twisting			0.772	
Bullying and stress			0.604	
Fatigue			0.679	
Perceived Workplace Health and Hygiene Concerns				
Sickness due to poor drinking water or poor toilet facilities				0.841
Injury due to existence of wild animals e.g., snakes that might cause injury				0.708

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Table 7. Reliability, Average Variance Extracted (AVE) and Composite Reliability (CR). Authors own work

Factor	Factor interpretation	Cronbach α (reliability)	AVE	CR
1	Perceived General Workplace Hazards and Safety Risks	0.937	0.62	0.94
2	Perceived Occupational Injuries from Environmental Factors	0.763	0.57	0.84
3	Perceived Occupational Health and Ergonomic Issues	0.705	0.51	0.80
4	Perceived Workplace Health and Hygiene Concerns	0.721	0.60	0.75

Figure 1 illustrates the Scree test, where a graph presents eigenvalues on the y-axis against the component numbers in their order of extraction on the x-axis. Initially, larger factors with higher eigenvalues are extracted, followed by smaller ones. The scree plot aids in identifying the number of factors to retain. In this instance, the plot indicates four factors with eigenvalues exceeding one, which collectively explain a significant portion of the total variability in the data. Conversely, the remaining factors contribute minimally to the variability and are deemed less important [73].

4.3. Stage 3: Factor Rotation and Interpretation

The current research employed principal component analysis for extraction and varimax orthogonal rotation with Kaiser normalization. Table 6 displays factor loading post-extraction. Factor loading values depict the association of each variable with the underlying factors. Variables with substantial loading values exceeding 0.50 signify their representativeness of the factor [77].

Component 1 is denoted as 'perceived general workplace hazards and safety risks' and encompasses nine items: injury resulting from poor lighting conditions in the environment, hand and vibration syndrome (associated with vibratory tools), diseases stemming from exposure to airborne fibers and toxic substances, risks of injury or fatality due to being crushed by moving objects, injuries resulting from unintended trench collapses, risks of injury or fatality due to collapsing walls (in demolition or poorly constructed settings), diseases resulting from exposure to excessive noise, heat, and humidity, risks of injury or fatality due to equipment use, and respiratory diseases caused by inhaling dust. The correlation coefficients between these items in component 1 are 0.902, 0.858, 0.852, 0.820, 0.809, 0.808, 0.804, 0.607, and 0.584, respectively. Component 1, representing perceived general workplace hazards and safety risks, accounts for 34% of the total variance, with an eigenvalue of 7.53. The structure of the component illustrates its broad associations with workplace dangers and safety concerns. This is supported by the inclusion and discussion of various elements within the component as a general health and safety hazards in the workplace as discussed by the existing literature [44], [50] and [46]. Studies have indicated that the items within the component represent perceived general health and safety risks in the workplace, as emphasized by [58], [51], [19], [48] and [45]. Hence, this component may be renamed as a “'perceived general workplace hazards and safety risks.”

The second component entitled as ‘perceived occupational injuries from environmental factors’ explained 14.4% variance with eigenvalue 2.62. This component contained four variables such as skin sanitizers, irritants (Bitumen, acids, alkalis, cement), injury or death due to falling from height (Slip and trips), injury or death due to falling objects and injury or death due to exposure to sharp and/or protruding objects with the correlation of 0.866, 0.803, 0.753, and 0.565 with component 2 respectively. Studies such as [56], [43], [42], [52], [85] and [40] corroborate the significance of the items in this component, as they are closely related to environmental factors in the workplace that can lead to occupational injuries. Hence, this component may be renamed as a “perceived occupational injuries from environmental factors.”

The component 3 is marked as ‘perceived occupational health and ergonomic issues’. It contains four items namely muscular disorder due to manual handling of materials and tools/equipment, muscular disorder due to bending and twisting, bullying and stress and fatigue which have a correlation of 0.784, 0.772, 0.604, and 0.679 with component 3 respectively. The third component explained 13.25% variance with eigenvalue 1.87. The four items of the third component tend to agree according to their combination as shown in various studies such as [57], [49] and [39]. Hence, this component may be renamed as a “perceived occupational health and ergonomic issues.”

Component 4 is designated as ‘perceived workplace health and hygiene concerns’. It contains two items namely sickness due to poor drinking water or poor toilet facilities and injury due to existence of wild animals e.g., snakes that might cause injury which have a correlation of 0.841 and 0.708 with component 4 respectively. The fourth component explained 9.07% variance with eigenvalue 1.37. The two grouped items of the fourth component seemed to match with the respective component as they are corroborated with the existing literature such as [47], [53], [54] and [55]. Hence, this component may be renamed as a “perceived workplace health and hygiene concerns.”

4.4. Reliability and Validity Test Results

To validate internal consistency, Cronbach’s alpha is computed to assess the accuracy and reliability of the instrument. A Cronbach’s alpha value above 0.7 is considered satisfactory as a threshold for adequacy [61]. The hFigh Cronbach's alpha values (0.94, 0.76, 0.71, and 0.72) for the four components in Table 7 which are perceived general workplace hazards and safety risks, perceived occupational injuries from environmental factors, perceived occupational health and ergonomic issues, and perceived workplace health and hygiene concerns demonstrate the reliability of the survey instrument. With a Cronbach’s alpha coefficient of 0.90, surpassing the threshold of 0.7 for total scale reliability, it is evident that the variables demonstrate a correlation with their respective component groupings, indicating internal consistency. Convergent validity is confirmed when the average variance extracted equals or exceeds 0.5 [64]. The AVE values for the components concerning perceived general workplace hazards and safety risks, perceived occupational injuries from environmental factors, perceived occupational health and ergonomic issues, and perceived workplace health and hygiene concerns are 0.62, 0.57, 0.51, and 0.60 respectively. In accordance with Shrestha (2021) criteria, an AVE value of $\geqslant$ 0.5 signifies convergent validity. It is evident from Table 7 that all AVE values meet or exceed this threshold. Moreover, as shown in Table 7, the composite reliability values for components 1, 2, 3, and 4 are 0.94, 0.84, 0.80, and 0.75 respectively. This indicates the internal consistency among the scale items [62].

5. Conclusions

This study extracted few factors components from the large number of perceptions of health and safety risks among masonry workers in the informal construction sector of Dar es Salaam, Tanzania so as to be more manageable. Through the application of factor analysis, distinct patterns emerged, leading to the identification of four key perceived components. These are general workplace hazards and safety risks, injuries from environmental factors, occupational health and ergonomic issues, and workplace health and hygiene concerns. By consolidating these perceptions into comprehensive components, a nuanced understanding of the challenges faced by workers in informal construction settings has been achieved. This approach facilitates the development of targeted interventions aimed at promoting workplace health and safety, aligning with SDGs related to health, economic growth, and resilient urban environments. By addressing the combined health and safety risks identified in this study, stakeholders can effectively prioritize measures to enhance the well-being of masonry workers and contribute to broader sustainable development objectives.

5.1. Significant Contributions and Implications

The study makes three significant contributions. Firstly, it identifies components of perceived occupational health and safety risks, crucial for enhancing worker welfare in Tanzania's informal construction sector. Secondly, it fills knowledge gaps, aligning with [86] acknowledgment of such contributions. Additionally, it sheds light on health and safety risk perceptions among informal construction workers in Tanzania, an under-researched area. Moreover, it extends efforts to understand perceptions across developing economies, particularly within Sub-Saharan Africa, where health and safety standards in informal construction are still evolving.

5.2. Practical Implications

The study's findings carry practical and policy implications, especially for masonry workers in informal construction and regulatory institutions addressing health and safety concerns in Tanzania's construction sector. This study's insights can empower authorities like OSHA to better manage HSR in IC. By pinpointing key concerns, it can inform policymakers in revising relevant policies. Factor analysis provided a clear picture, allowing decision-makers to focus on actionable workers' HSR perceptions in IC instead of overwhelming details. This knowledge can significantly improve health and safety practices in IC.

5.3. Research limitations and Recommendation for Further Research

The following limitations are noted. Geographic and Economic Contexts: The study collected data from the informal construction sector (ICS) in Dar es Salaam, Tanzania. However, due to variations in geographic and economic conditions, the study's findings cannot be generalized to other regions within Tanzania or beyond. Trade-Specific Focus: The study specifically examined masonry workers (MW) within the ICS. Future research should explore the perceptions of health and safety risks (HSR) from other trades (such as painters, welders, carpenters, joiners, etc.) in the Tanzanian ICS, as different trades may have varying perspectives on HSR. Comparative Analysis: Future studies could compare the ICS industry with other informal industries in terms of business size and related factors. In summary, these limitations highlight areas for further investigation and potential avenues for enhancing our understanding of health and safety in the construction sector.

Disclosure Statement

No potential conflicts of interest were disclosed by the authors.

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