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Holistic View on Multi-Stakeholders' Influence on Health and Safety Risk Management in Construction Projects in Tanzania

Sarah Phoya and Krystyna Pietrzyk

Abstract

Construction projects constitute complex and dynamic systems, which pose high health and safety risks to the practitioners. As a result, many researchers have underscored the importance of risk management that requires inputs from all stakeholders across different stages of the construction project from the design up to the construction phase. However, there is a limited knowledge about stakeholders' influence on health and safety risk management in building construction projects in Tanzania. To fill this gap, a case study approach was employed to analyse three large ongoing construction projects in Dar es Salaam in Tanzania. Data were collected through questionnaire survey and in-depth interview with a range of stakeholders: clients, consultants, contractors, workers and regulatory agencies. From the findings and with reference to literature, the systems thinking approach was used to develop a model showing the stakeholders' influence on health and safety risk management. The pattern of relationships between different stakeholders and the capacity of the system to offer health and safety control was traced using the results of the case studies of the three projects. The study confirms that there is a link chain relationship when stakeholders influence the health and safety risk management at the following stages of the construction projects in Tanzania.

Keywords: health and safety, risk management, stakeholders, building construction projects, system

1. Introduction

Generally, literature on risk management ascertain that all key project stakeholders (clients, designers, sub-contractors, contractors, and statutory authorities) should be involved in considering safety systematically, stage by stage at the outset of the project [1]. In fact, many health and safety risks arise due to lack of risk management from initiation of project to the completion of construction projects [2, 3]. This underscores the fact that, health and safety risk in construction project originates upstream from the building process itself and is connected to processes such as planning, scheduling, design, tendering and construction.

In view of the redistributive impact of poor safety performance, all stakeholders involved in different stages of construction project should be accountable for safety

risk management [4]. In a similar vein, Charles et al. [5] and Zhang et al. [6] also emphasised the importance of developing communication networks throughout the construction process and well-articulated responsibilities for the stakeholders involved in the project. Furthermore, in its 1992 code of practice, on 'Safety and Health in Construction', the International Labour Organisation (ILO) outlined the responsibilities of health and safety among different groups in construction project. The ILO [7] advised that national laws of different countries should include responsibilities of health and safety risk to clients and designers (engineers, architects and quantity surveyor) in construction projects.

Several studies have been conducted on project stakeholders' influence on health and safety risk management. Some of the authors have focused on safety responsibility among designers during the design phase [8–11] while others focused on the role of clients on health and safety management [12–16]. They maintain that clients have a major role in project implementation, and therefore, they should push for the safety requirements. Furthermore, Well and Hawkins [17] have focused on safety in the procurement phase. They argue that addressing the issue of construction safety in the design and procurement phase could have a substantial impact on reducing injuries and costs associated with safety-related delays in projects.

Notably, all these studies have focused on individual stakeholder and their roles with emphasis on their individual viewpoints on risk management. Consequently, there has not been much study focused on the mechanisms on how these stakeholders can co-operate as a team to influence health and safety risk management in a systems thinking model. It is not known how project stakeholders would interact, communicate, deal with risk information, let alone on their roles, liabilities and responsibilities which influence health and safety risk management. This study therefore explores the influence of multi-stakeholders such as clients, design teams and contractors on health and safety risk management in construction projects in Tanzania using systems thinking model. The aim is to develop holistic understanding of multi-stakeholders' influence on health and safety risk management.

2. Theoretical framework

2.1 The concept of stakeholders

A stakeholder is a relatively recent term coined originally for the corporate sector. Freeman [18] defined a stakeholder as a person or an entity that can affect or is affected by the accomplishment of an organisational or project purpose. Mitchell et al. [19] classified stakeholders into definitive stakeholders, expectant stakeholders and latent stakeholders based on their power, legitimacy and the urgency of their claim on the organization. Clarkson [20] classified stakeholders into primary stakeholders, on whom a corporation depends for its survival, and secondary stakeholders, as those who are not essential but have influence on or are influenced by the corporation. Both Leung and Olomolaiye [21] and Olander and Landin [22] categorise stakeholders as either internal (clients, consultants or contractors) or external (external public or external private parties) to a project. Internal stakeholders are those involved in the decision-making process, whereas external stakeholders are most often affected by the potential outcome of the project, either directly or indirectly as stakeholders. Here, stakeholders are considered as those whose performances play an important role in determining a project's success. These stakeholders include project clients, project management consultants (architects, engineers and quantity surveyors) and project contractors, sub-contractors, workers and regulators and legislators in the legal system. The strong cooperation

of stakeholders is necessary for project success, since a project can be considered a temporary organisation of stakeholders pursuing an aim together.

2.2 Health and safety risk management

Risk is regarded as the measure of probability (likelihood) and consequences of not achieving the defined goal [23]. Therefore, risk event has two primary components, that is a probability/likelihood of occurrence of an event and impact of the event—amount at stake. In that regard, risk is considered as a function of likelihood and impact [24]. Risk in this research means the possibility of suffering harm or loss, a factor, a cause of element involved in certain danger and its severity in individual or enterprises in informal construction sector. The sources (hazards) of health and safety risks on construction sites are identified as: nature and physical layout of the work space, location and weather, equipment and hazardous materials, human behaviour and attitude, leadership, and safety culture of the organisation.

Risk management is defined as 'a systematic way of looking at areas of risk and consciously determining how each should be treated. It is a management tool that aims at identifying sources of risk and uncertainty, determining their impact and developing appropriate management responses' [23]. The overall goal of risk management is to maximise the opportunities and minimise the negative consequences of risk threats in a project [25]. Therefore, as a process, RM should be cyclic and dynamic in nature and is important to be established early in a project and continually addressed throughout the project lifecycle, and it should be proactive rather than reactive, involving all stakeholders in the project. Generally, risk management involves process in risk identification, risk analysis and risk response [23, 24].

2.3 The concept of systems thinking

Senge [26] describes a system as a perceived whole, whose elements belong together because they affect each other over time and operate towards a common purpose. It focuses on holistic perspective emphasising the interplay between the systems and their elements in determining their respective functions. The interaction between the system's elements can be complex with simultaneous mutual influences rather than the linear cause and effect chain relationship [27]. The elements in the system may be tightly and strongly linked and change in response to each other, therefore, indicating strong interdependence of the system's components.

Construction projects are complex systems involving multiple and mutual components. Thus, construction projects consist of many interacting stakeholders such as clients, contactors, consultants and workers with different management objectives and functions that contribute to the whole. Thus, each stakeholder in a project has specific roles to play to achieve a collective project goal. However, the roles of the stakeholders are quite interrelated and insufficient performance of one of them directly affects the project's goal achievement no matter how well other stakeholders perform their roles. To understand this type of relationship, a systems thinking approach needs to be employed. Reed [28] opines that the systems thinking model gives leaders a deeper understanding of the roles or behaviour of the parts that make up a system. Therefore, in dealing with a complex and dynamic social system, systems thinking becomes crucial to synthesise a problem by seeing things in terms of patterns and relationships. Therefore, the evolution of a systems model for this study is an approach to develop a holistic understanding of multi-stakeholders' influence on health and safety risk management in building construction projects.

A system is the concept where one level can be appropriately regarded as nested within another level. The levels are characterised by emergent properties that are

irreducible and represent constraints on the degree of freedom of components at the level below. Hierarchies, under the system theory, are characterised by control and communication processes operating at the interfaces between levels [29]. This concept literally creates an environment in which all the system, subsystems and super system are linked together to achieve the overall project goal. Construction projects are manifestations of the hierarchy's concept of a system in terms of the arrangement of subsystems, systems and super systems [30]. A construction project operates in a large/super system such as construction industry in Tanzania. The construction project also comprises different stages or levels in its project lifecycle with highly diverse stakeholders from inception to completion and then to project commission. These levels or stages include briefing, design, procurement, construction and commissioning whereby each system acts as a sub-system. The adopted hierarchy concept of system illuminates how different stages of construction projects are interrelated in terms of stakeholders' participation in risk management.

Additionally, a system can be either closed or open. Closed systems are those that do not interact with their environment. On the other hand, open systems dynamically exchange information with their environment in the form of feedback loop [31]. Construction projects have been regarded as an open system. This open system is affected by and exchanges information with the environment. Moreover, project stakeholders are guided and regulated by different regulatory bodies, professional societies, policies and regulations, political systems economic and market forces in the briefing, designing, procurement and construction processes.

Therefore, the evolution of the system model for this study is an approach to develop a holistic understanding of multi-stakeholder's influence on health and safety risk management in building construction projects. The system model becomes crucial to synthesise a problem by seeing things in terms of patterns and complexity of interrelationships of stakeholders, their roles and responsibilities, communication and how they influence health and safety risk management.

3. Methodology

The main issues were to assess first the factors of the influence of the stakeholder's participation on health and safety risk management and then using case study approach to test those factors in the real projects. The study adopted mixed method whereby both the quantitative and qualitative research approaches were used.

The first part of the study was quantitative method based on questionnaire survey for clients, architects, engineers, quantity surveyors, contractors and site workers. Questionnaires were administered by research assistants. Out of 100 questionnaires distributed, 84 (84%) were fairly filled and returned. Respondents were randomly selected. Ten factors were identified from the literature and respondents were required to rank the way they influence them by using a five-point Likert scale. In a Likert scale, they were asked to respond to each of the factors. The ratings used were: 1—Very poor, 2—Poor, 3—Moderate, 4—Good, and 5—Very good. Inferential statistics were used for the analysis of the data, for the initial stage of the data analysis as indicated in **Table 1**. The hypothesized value is the middle of the used Likert scale which is equal to 2.5. The factors which have mean score above 2.5 were considered to be relevant and were validated in the case study.

The second part of the study was qualitative method whereby case study was adopted. The main purpose of this phase was to develop a clear understanding of how project stakeholders can influence health and safety risk management in construction project based on the factors from survey. Three large building construction projects were selected, and the unit of analysis was stakeholders involved

S/N	Factors	N	Mean score	Rank
1	Role performed by stakeholders	80	4.3	1
2	Individual knowledge and experience	80	4.1	2
3	Stakeholders' power attributes	80	4.1	2
4	Condition of contract	80	4.0	4
5	Nature of health and safety risk	80	4.0	4
6	Communication mode	80	3.9	6
7	Individual perception	80	3.8	7
8	Health and safety regulations	80	3.8	7
9	Professional by-laws	80	3.8	7
10	Procurement regulations	80	3.8	7
Average mean			3.96	
Cronbach's alpha: 0.97 (moderate reliability)				
Average inter-item correlation: 0.53				

Table 1.
The ranking of mean scores (MSs) on the factor influences stakeholders on health and safety risk management.

in these projects. These stakeholders are clients, project managers, architects, engineers, quantity surveyors, site managers, health and safety committee and construction workers. Interview and observations were used for data collection within the case studies. Case studies were selected based on the size of the project (large project, number of employees more than 20 on the sites and falling under design-bid-build procurement method (thus, project with clear separation of project phases, briefing, design, procurement (bidding) and construction). The following projects were chosen:

Project A—The construction of a two-storey warehouse. The scope of the work included demolition of the existing building and construction of the double-storey building which comprised stores and office accommodation. The contract value of the project is Tsh 3,350,200,000 = \$ 1,298,527.13 USD as per June 2017 exchange rate with contract period of 18 months. The project was procured using design-bid-build method whereby the client was private sector. The project had a safety department well equipped with safety equipment and first-aid facilities with full-time safety officer. The client had safety policy and was involved in planning of the various safety features in the project.

Project B—The construction of five-storey maternity ward in one of the hospitals. The project had a contract period of 30 month with contract value of Tsh 7,412,470,000 = \$4,547,527 USD. The client was a government institution and design-bid-build procurement method was used. The site had safety department and four safety officers with one safety coordinator. The client, consultant team and contractor had safety policies. The client and consultant team selected contractor based on safety merits.

Project C—The construction of a 26-storey building comprising residential apartments, offices and car park accommodation located in Dar es Salaam. The contract value of project was Tsh 132,254,917,029 ≈ \$80,889,856 USD as per June 2017 exchange rate with a contract period of 162 weeks. The project was procured using the design-bid-build contract with client being the government institution. The client employ project manager and clerk of the work who stayed at the site full time. One of the responsibilities was to ensure that the contractor has adhered to the health and safety issues. The consultant team and contractor had safety policies.

4. Data presentation and discussion

Table 1 indicates that all factors that influence stakeholders’ participation on health and safety risk management have mean score above the midpoint of 2.5, with an average mean of 3.96. The leading factor was the role performed by stakeholders in the project. Thus, indicating that health and safety risk management is embedded in the role performed by stakeholders, individual knowledge and experience and power attributes were ranked second. Other factors include nature of health and safety risk, mode of communication, individual perception, health and safety regulations, professional by-laws and procurement regulations. This implies that all factors are relevant for stakeholder to influence health and safety risk management performance in construction projects. Based on this finding, the factors were tested in the three construction projects through systems thinking approach.

5. Systematic view of stakeholders’ influence on health and safety risk management

To understand the influence of stakeholders on health and safety risk management, one should look at the roles performed by each stakeholder in each project stage (briefing, design, procurement and construction) and how their role influences health and safety management. The stakeholders considered are those whose performances play an important role in determining project success. These stakeholders include the project client, project management consultants (project managers, architects, engineers and quantity surveyors) and project contractors, sub-contractors and workers as well as regulators and legislators in the legal system. Stakeholders’ participation in health and safety risk management during the different stages is analysed and presented in **Figures 1–4**. Blue shadow indicates the most active stakeholder at the stage considered. The grey shadow indicates the stakeholders whose decisions at the previous stages have consequences during the actual stage.

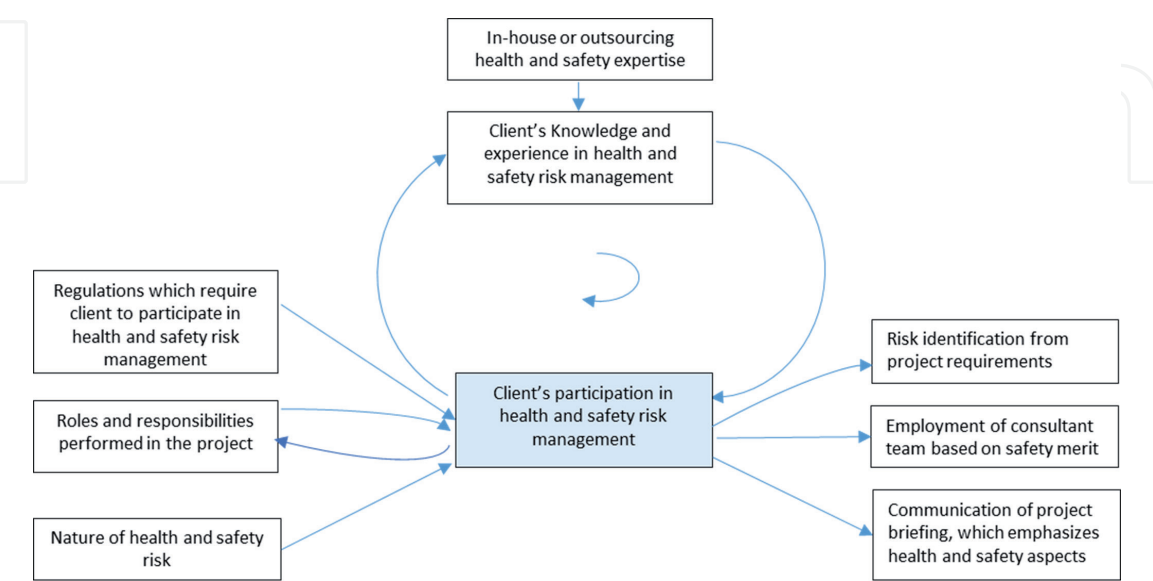


Figure 1. Stakeholders’ participation in health and safety risk management during the briefing stage, according to the cases analysed.

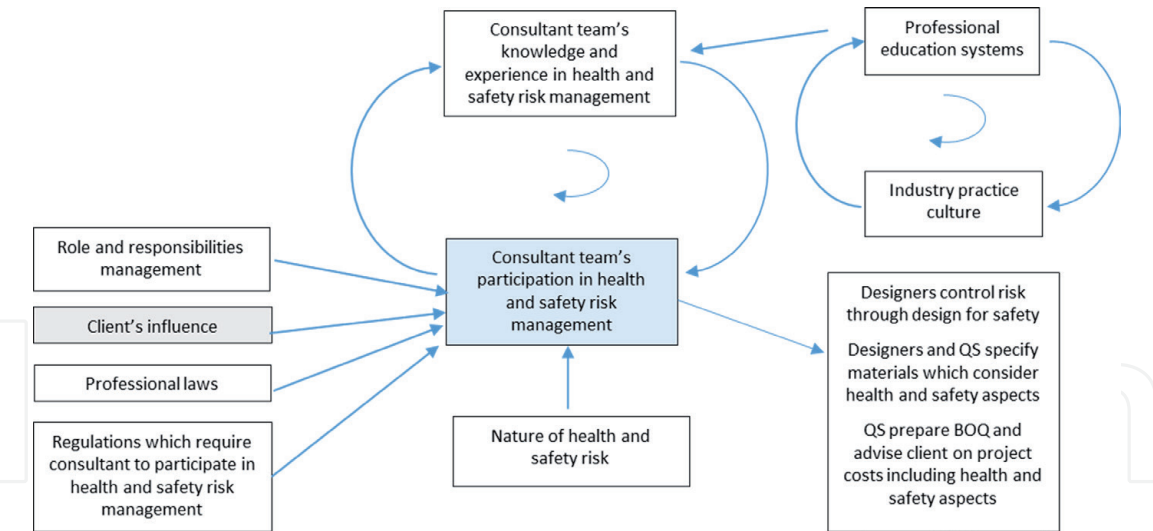


Figure 2.
Stakeholders' influence on health and safety risk management during the design stage, according to the cases analysed.

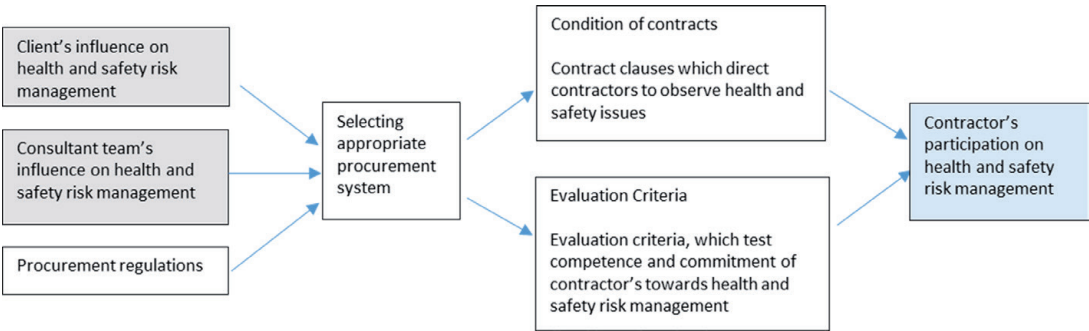


Figure 3.
Stakeholders' influence on health and safety risk management during procurement stage, according to the cases analysed.

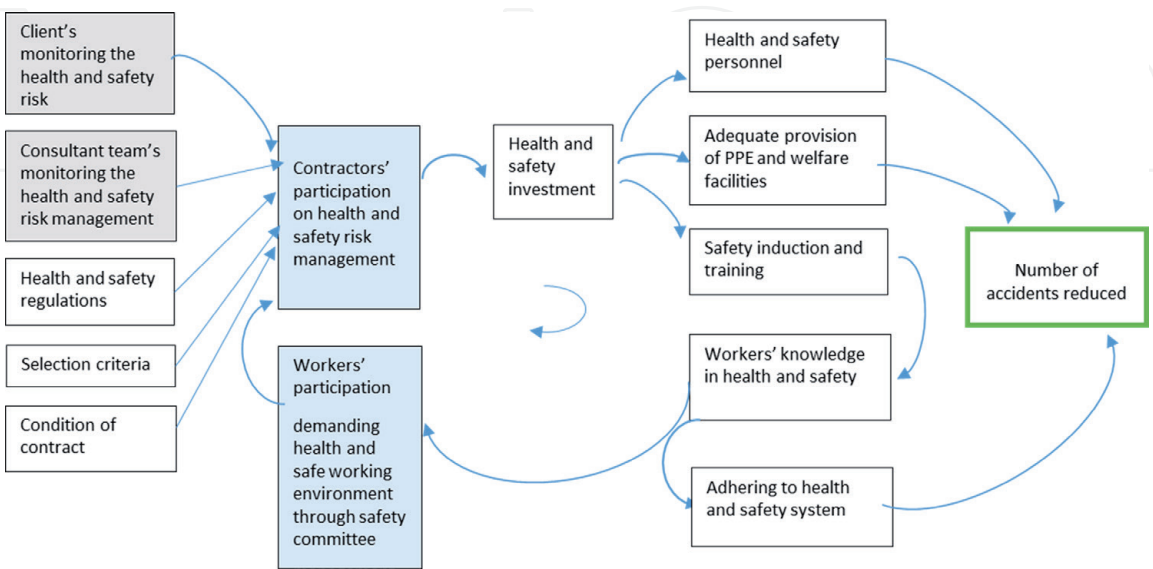


Figure 4.
Stakeholder's influence on health and safety risk management during the construction stage, according to the cases analysed.

5.1 Briefing/inception stage

During the briefing stage of projects, the clients are observed as the main actors in all decisions concerning project initiation and implementation. Thus, clients were directly involved in initiating projects, setting up project requirements, employment of the consultant teams and communicating project requirements to the consultant teams. During the inception stage of the project, the study further reveals that all the clients of three projects were involved in the identification of hazards during project requirement set-up. In the two projects (A and B), they identified hazards such as noise and dust whereas in Project C, the nature of the site was confined and, therefore, hazards issues were also considered at this stage. Moreover, clients employed consultant teams based on their competency; in Project A, the consultants were employed based on previous experience with client and health and safety merit, whereas in Projects B and C, the consultant teams were employed based on Public Procurement Act (PPA) regulations of 2005, primarily because these were public projects. The implication of this orientation is that in Project A, the client was free to make a better choice of the consultant because he/she was free to use any appointment method. This was particularly instrumental because he/she had documented the practical experience of the shortlisted consultants. Of course, one cannot rule out bias or decision made on the basis of vested interest, particularly because in private projects, clients are not bound by the PPA provisions. At the same time, where the consultants were appointed based on general competences, they did not necessarily focus on the aspect of health and safety risk management. Thus, there could be a danger that health and safety issues would be played down. Fortunately, this was not the case in projects B and C.

Furthermore, during the inception stage, the clients had to communicate project requirements to the consultant teams. Multi-channel approaches were used to communicate health and safety information among the consultant teams. Likewise, the clients and the consultant teams collaborated in the identification of hazards and the establishment of control measures in the early stages of the projects. This was observed in all the three projects during the briefing meetings. For example, the client and the consultant team in Project A agreed to change the building outline to bypass the underground electrical cable. In Project C, permission to close one of the free access roads to the site was requested from the authorities. In other words, the project inception stage is very crucial in determining health and safety risk management issues because it is the stage where a client jointly works with consultant teams in a real situation (at the site) where they are actively involved, consult each other, inform and collaborate in identification of hazards, assessment of risks and possible control. Moreover, it is the crucial stage where clients are active in decision-making, therefore quite instrumental in health and safety concern. Moreover, it was noted that clients had experts (in-house or outsourcing) with experience and knowledge in health and safety risk management. The presence of these experts had an impact on client knowledge and consciousness in risk management. This contention underscores the fact that the initiator/client of a project does not necessarily need to have health and safety knowledge before he/she can build. However, he/she needs to have experts (in-house or outsourcing) to provide guidance on risk management in the briefing stage. This observation is also supported by [15].

Figure 1 illustrates that, regulations, role performed by clients and the nature of health and safety risks are guiding client to influence health and safety risk management. This indicates that regulations should assign client responsibilities for health and safety risk management and specify the role the client should play.

It further revealed that to achieve health and safety risk management, knowledge and experience must exist among individuals/groups at a particular point.

While clients participate in health and safety risk management, they acquire more experience and knowledge, hence forming the feedback loop of acquisition of knowledge and experiences.

5.2 Design stage

This study has established that the consultant team, to some extent, has influenced health and safety risk management. It occurs predominantly in the control of risk during design, consideration of health and safety items in the BOQ, and the provision of the budget for health and safety matters. For example, in Project A, the designers were involved in risk control through the design for safety, while it was not the case in projects B and C. In Project A, design for safety was required by the client. In many instances, design decisions can be regarded as the 'source' of health and safety risks in the construction industry; therefore, they ought to be checked and addressed at design stage. However, the design for safety was a major challenge across the projects analysed. For example, in Project A, design for safety was only implemented on the concept outline, rather than being fully integrated in detailed design and material specifications, while in Projects B and C, it was not implemented at all.

Consultant teams in all three projects acknowledged to have limited knowledge on designing for safety. This was also supported by the findings from the review of curricular of higher education of architects and engineers where there were no modules covering health and safety aspects. The other reasons for not considering health and safety during design were associated with conventional opinion among professionals that safety is contractors' responsibility and with lack of regulations supporting designers (architects and engineers) to apply design for safety. Nonetheless, in Project C, there was at least a provision for special professional indemnity insurance that covered accidents that may arise because of faults in the design. The presence of professional indemnity insurance indicates that the designers were committed to legal liabilities for health and safety risks. On the other hand, quantity surveyors participated actively in the preparation of BOQs and cost estimate in all the three projects. It was noted that financial provision for health and safety risk management was made in the preliminary items in BOQ and contingency. At this stage, the consultant teams largely provide advice, leaving key decisions to the clients.

Figure 2 provides summary of the relationship of components that influence health and safety risk management during the design stage.

Figure 2 shows that the opportunities provided by the roles played by the team, client engagement, professionals' by-laws and regulations, the nature of health and safety risk are necessary for consultant the team to influence health and safety risk management during the design stage. It is further revealed that in order to influence health and safety risk management, relevant knowledge and experience are required. Knowledge and experience can be tapped from industry practice culture and higher learning institutions. Therefore, it can be noted that the more the consultant team participate in health and safety risk management, the more knowledgeable and experience they will be, hence they will participate more on health and safety risk management. This indicates the feedback loop. On the other hand, furthermore, the more the professional education system includes health and safety knowledge, the more the industry will tap this knowledge through practice.

5.3 Procurement stage

During the procurement stage, the main emphasis of the study was to evaluate the contractors' capabilities and commitment towards risk management. Whereas

in Project A, the contractor was employed through the shortlisting method, in Projects B and C, the contractors were employed based on the competitive bidding method in accordance with the criteria stipulated in the Public Procurement Regulations of 2005. In this regard, in Projects B and C, the clients had to adhere to the stipulated procedure and guidelines. Major criteria for selecting consultants and contractors were based on the general competences; therefore, as already noted, knowledge on health and safety was not an issue. As a consequence, it was possible to select a contractor with unproven or unsafe track record or practice within health and safety risk control.

Apart from established regulations, however, it was observed that the additional criteria beyond those established in the regulations were used in Project B. The client and the consultant team set criteria such as site safety management, provision of Personal Protective Equipment (PPE) to the workers and provision of first-aid facilities. The criteria were derived from the site visits of the client and the consultant team and introduced to the bidders for ongoing construction projects. This approach offered a way to test information on the ground to ensure correct decisions were made. It is particularly so, if such visits are made in advance, without knowing the prospective contractors (before the contractors are selected).

The study established the link between the procurement process and contractors' competence and commitment to health and safety risk management. The study has further established that procurement process is influenced by the client, the consultant team and existing regulation as indicated in **Figure 3**.

Figure 3 illustrates in which way the employment of a competent and safety-conscious contractor depends on the client's and the consultant team's participation as well as the procurement regulations. Indeed, if the client's and consultant team's level of participation in risk management increases, the number of pre-qualified criteria involved for selecting an appropriate contractor will also increase. On the other hand, conditions of contracts with specific clauses which address health and safety risk management will also increase the contractor's commitment towards enhancing effective health and safety management practice.

5.4 Construction stage

During the construction stage, contractors had many health and safety responsibilities as they were involved in actual activities at the sites. They employed health and safety personnel, provided PPE and other welfare facilities to the workers. They also had to assess, communicate and control risks on-sites. It was noted that one safety officer was employed in Project A, whereas four and six officers were employed in Projects B and C respectively. Project A had only one safety officer possibly because of the nature of the project in terms of size, location, site configuration and number of employees. The Project A site had a total of 40 employees and the project comprised two floors. In Projects B and C, projects were more complex with 5 and 26 floors and employed approximately 400 and 500 workers respectively. What is critical here, however, is that the presence of safety officers is an indication that the contractors were committed to risk management. Safety officers play a critical role; they work on behalf of site managers to identify risk, communicate risk to workers and control risk.

During the construction stage, the contractors provided safety induction training to workers in all the three projects. In Project A, the client collaborated with the contractor to provide safety induction training, whereas in Projects B and C, clients required the contractors to provide health and safety training to the workers and submit training reports to them. The conclusion is that clients can play specific role in ensuring that workers are well informed about health and safety risks and

overall risk management efforts at building sites. This finding is consistent with that of study done by [32] that multiplicity of communication channels, methods and different stakeholders play out simultaneously in the communication of risk information within construction sites.

In all the three projects, the clients and consultant teams participated in regular inspections during the construction stage. Most importantly, the inspections were done randomly, without prior notification; issues observed during site inspection included the contractors' compliance in health and safety matters on-sites. During inspection, in all three projects, compliance certificates were issued and shortfall notices or fines were imposed on those who did not comply. Accordingly, the consultant team issued warning letters to Project B where defaults were noted. Sometimes, photographs were taken as evidence and site inspection reports were presented in the site monthly meetings. Such steps helped to boost safety risk management.

Furthermore, it was observed that in the three projects, all stakeholders were closely linked together through regular site meetings which were held monthly. Health and safety on-site were among the main agenda of these meetings. This implies that these meetings are monitoring tools for health and safety risk management performance where some of the stakeholders were informed, consulted, advised and involved in decision-making. This finding is consistent with that of study [33] that different stakeholders have different sources of power such as technical expertise; legitimate, political position; resources information; reward and coerce power which influence risk management in construction sites.

It was also noted that Projects B and C had safety committee meetings. Safety committee meetings involved the workers' representatives, the contractors' safety team and the client's representatives. The workers' representatives were elected by workers themselves from each trade. The elections of safety representatives exemplified political power among the workers. It was observed that these meetings were partly interactive, especially when the workers' representatives raise their concern towards health and safety issues on-site.

One can say that contractors still bear relatively high responsibilities of health and safety risk management. However, contractor fulfilment of these responsibilities depends on: how he/she was procured, the consultant management and supervision, client's demands and the existing regulations as indicated in **Figure 4**.

Figure 4 indicates that contractor's participation in health and safety risk management in construction projects requires client's monitoring system, consultant's communication and monitoring system, health and safety regulations which assign specific responsibilities to contractors, conditions of contract which direct the contractor to observe health and safety aspects and the evaluation criteria which test the competencies in health and safety issues.

It also further illustrates that, there is a causal relationship between contractor's participation in health and safety risk management and workers' participation. Thus, if the contractor is committed to health and safety risk management, he/she can employ health and safety personnel, provide proper PPE to the workers and provide safety induction to the workers. The presence of safety personnel such as safety managers and safety officers on-site is essential for communicating safety information to the workers. Therefore, if the number of safety personnel increases, the amount of safety induction and refresher training would also increase. These would, in turn, boost the workers' knowledge and, hence, they would adhere to safety practices such as wearing PPE all the time and proper housekeeping. Workers' adhering to safety risk management would eventually reduce the number of accidents on construction sites. On the other hand, the workers' knowledge would influence them to demand for better working environment through safety committee meetings which would, in turn, influence the contractor's investments in risk management.

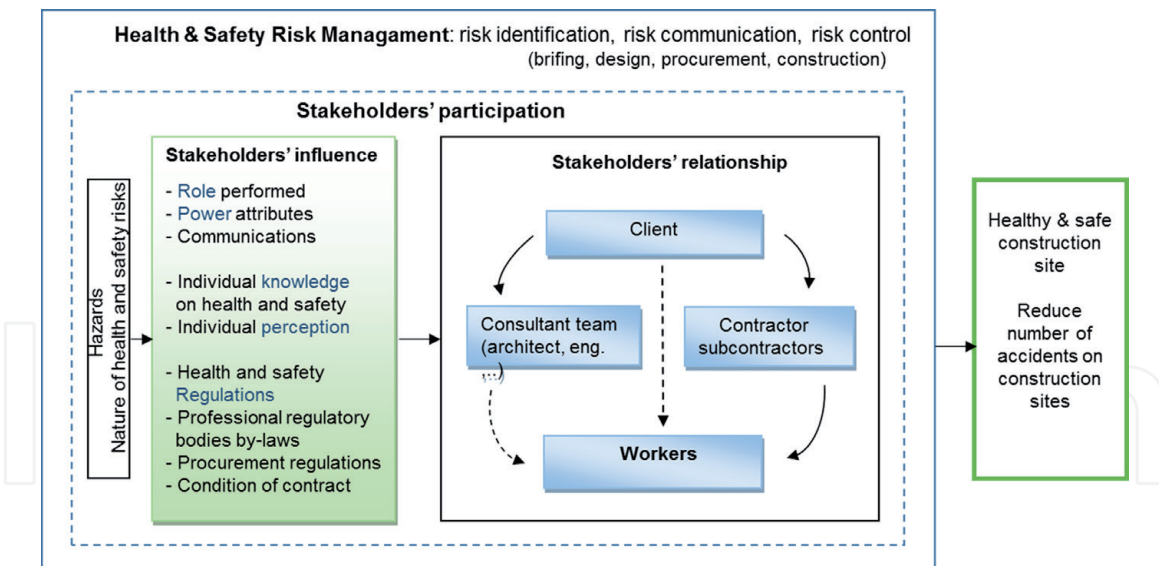


Figure 5.

Framework for stakeholders' participation in health and safety risk management in construction projects in Tanzania.

5.5 Development of final framework

The final framework was developed by considering the findings from survey and validated in multiple case studies with the aim of enhancing clarity and effectiveness. The framework consists of the following features: factors influencing stakeholders' participation and stakeholders' relationships in the health and safety risk management (hazard-risk identification, risk communication and risk control). The output of the framework is to reduce the number of accidents on construction sites.

Figure 5 indicates that when stakeholders participate in health and safety risk management, they are influenced by their roles and responsibilities in the project, the communication process in place, the stakeholders' power attributes and individual knowledge on health and safety issues as well as by health and safety regulations and professional bodies' by-laws. Therefore, to ensure a smooth risk management process and effective stakeholders' influence on risk management, the balance of those factors must be considered. **Figure 5** further indicates that when stakeholders participate, they create a link chain relationship. This 'link chain' participation relationship is in conformity with the concept of interconnectedness of system thinking. Thus, each stakeholder's involvement in a system has a critical role in influencing and making the system work. Non-performing of one stakeholder can break the chain, hence making the system fails to work. The goal of risk management is to reduce the number of accidents in construction sites. A mechanism to ensure each stakeholder's influence one another is paramount.

6. Conclusions

This research has investigated multi-stakeholders' influence on health and safety risk management in three large construction projects in Tanzania. There is an empirical evidence showing that different project's stakeholders such as clients, architects, engineers, quantity surveyors, contractors and workers are able to participate in health and safety risk management at different phases/stages of the project and in different ways. However, the holistic view over their relationships

and actions is needed to make the risk control process effective. This study has demonstrated a 'link chain' relationship reflecting the stakeholders' influence on health and safety risk management. While this chain relationship is evident, still there can be some gaps or vulnerabilities making the system not work effectively. Therefore, this study proposes the framework showing important factors and links to improve stakeholders' influence on health and safety risk management.

The graphs given in **Figures 1–5** concerning the following stages of the construction projects show the changing responsibilities of the main stakeholders concerning health and safety and the importance to secure the continuity of the health and safety risk management process through all the stages because the risks on construction sites depend on the decisions made earlier. It is noted that the role and responsibilities performed by stakeholders give potential opportunity for them to influence health and safety risk management. Thus, the health and safety risk are embedded in their role and responsibilities performed in the project. A clear understanding of the role and responsibilities of each stakeholder in the project is important. Also, knowledge and skills of health and safety risk management are very important and a pre-requisite for clients, designers, QS, contractors and workers' participation process. This knowledge and experience are obtained from the construction industry practice and training institutions. Therefore, health and safety modules should be emphasised in curricula of training institutions that produce professionals such as architects, engineers and quantity surveyors. The existing health and safety regulations and by-laws from professional registration bodies, procurement regulations and condition of contracts play an important role to influence stakeholders to participate in health and safety risk management. Thus, if the regulations are strong and supported by strong enforcement, the industry practice culture will also change in a positive way. The existing health and safety policies and regulations need to be reviewed to influence stakeholders to participate in health and safety risk management much more effectively and substantively.

The pattern of relationships between different stakeholders and the capacity of certain control actions/tools were analysed using the results of case studies for all three projects. For the individual project, the system dynamics approach could be applied on the more detailed level tracing the specific pattern relevant for the actual stakeholders' participation successes and failures to build up effective and robust system for healthy and safe construction site.

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