



## **THEORETICAL FRAMEWORK FOR FACTORS CONTRIBUTING TO UNSAFE WORKPLACES AND IMPLEMENTING WORK SAFETY REQUIREMENTS**

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### **Abstract**

Unsafe acts are types of work that involve risks. They have accounted for more than 70% of all accidents, especially in the field of construction, for more than a decade. Several attempts have been made to reduce the causes of unsafe acts; however, the intended unsafe act, which is the foremost type, has received scant attention in previous studies. Most published research on this issue has shown that taking a shortcut is a direct cause of shortcut-based accidents and 24% of these accidents can be explained by the habit of the actor. Approximately, 76% of these accidents can be explained by different underlying causes rather than habits. This paper is to demonstrate the application of proposed conceptual models to study the factors contributing to the generation of shortcut-based accidents. The scope of this paper is to illustrate the main foundation of proposed structure models based on the analysis of qualitative data and is limited to the identification of the underlying structure models.

**Keywords:** Shortcuts; Construction sector; Stress; Tension; safety training; risk perception



## **1. Introduction**

The literature provides a useful account of how the rate of accidents resulting from unsafe acts has remained unchanged for more than a decade. In that period, a number of researchers sought to determine the severity of unsafe acts by focusing on human errors. They have reported that human errors cause approximately 70% to 90% of accident-related work injuries [1,2]. In complex systems (for example, aviation, construction, and nuclear power), approximately 80% to 88% of the total accidents were reported as caused by human errors [3-8]. A shortcut is an intended act that is either a routine violation or an expected violation by the performer. The former constitutes a larger proportion of all unsafe acts, contributing to 62.66% of total industrial accidents [9], whereas the latter is rare [1]. Minimizing motivational agents of taking shortcuts requires an understanding of the different factors associated with both the activity and mental processes [8,10].

Despite the importance of minimizing the motivational problems to take shortcuts, there remains a paucity of evidence on the effects of different factors related to these issues. Most existing studies on shortcuts have focused on worker habits, making it difficult to conduct satisfactory research. In recent years, it has been found that 24% of total shortcuts result from workers' habits [11]. This implies that workers make errors and are aware of them. Hence, this indicates that 76% of the total causes of shortcuts are still unexplained, and thus constitutes the major proportion of accidents resulting from unsafe acts as previously highlighted.

The main purpose of this paper is to conduct an analysis of qualitative data in the past related publications to study all possible factors associated with the motivational problems to take shortcuts. The objective is limited to develop the conceptual models for those associations based on the collected qualitative data.



### *1.1 Safety Training and Risk Perception*

The debate about the perception has gained fresh prominence, with many arguing that both understanding and acknowledgment are subject to the level of the perception [12,13]. The strength of the risk perception can minimize the unsafe acts and can be reachable if effective safety training has been delivered [14]. The effective safety training shows the lives of the workers and the reality of their jobs while exposed to risks [15] and will increase their knowledge about such risks [16,17]. Moreover, it enhances hazard recognition or risk perception that can improve workers' decisions [18-20]. Hence, the strength of the risk perception was highlighted by four sequential levels, namely, understanding after feeling about the received stimulus and then acknowledgment after thinking to perform an action. In this paper, the first two levels have been constituted in one indicator called the feeling-based risk and the other two levels have been embedded to a single indicator called thinking-based risk. Those two indicators were considered to infer the routine perception-based error as endogenous, which can be predicted by the safety training effectiveness as exogenous.

### *1.2 Safety Training and Motivational Problems to Take Shortcuts*

In the literature, the safety training was associated with unsafe acts minimization in the construction field as reported in [4,11] and improved safety compliances as highlighted by [6]. When the workers received a sufficient amount of safety training, they can complete the assigned work safely as indicated in [21,22] with a minimum of errors as stated in [23,24]. Poor training was highlighted as one significant aspect causing accidents at construction sites [4,25], mostly if new employees have not been trained in safe practices [26]. This paper considers that safety training effectiveness acts as an exogenous factor to predict the motivational problems to take shortcuts as endogenous factors.

### *1.3 Stress-Based Tension and Motivational Problems to Take Shortcuts*



Effective safety communication can improve safety perception and minimize unsafe acts as reported in [27,28]. The perception of role clarity, career commitment, and job performance were affected by the safety leadership communication on job sites [29,30]. Safe behavior was defined as the function of the perception of safety management in recent research [27] and as a function of the workers' needs and the work environment [3,32]. Hence, safety communication affects the way of feeling and thinking about risks and safety. The work environment increases the possibility of misunderstanding the safety perception as reported in [26]. Recent work noted the same issue in the available controls within safe work instruction [33]. The safe work instruction is a source of risk if it is not properly developed to mitigate the effects of the physical work environment. The workload and extra rules in safe work instruction were affected by safety perception [34-36]. Attention was paid in a recent study to mediate the relationship between safe behavior and the combination of attitude, personal norms, and control perception [15]. Therefore, the aforementioned findings show that stress-based tension as an exogenous factor can be predicted by different issues, such as, safety communication, work environment and margin of personal-life time. The effect of those issues can also have impact on both feeling and thinking about risks and safety requirements.

Routine violation is the most common type of human error and minimizing it requires the understanding of different factors associated with activity processes and mental processes as highlighted by [8]. Safe behavior can be significantly changed by communicating safe work instruction [37]. The effect of emotional speech on changing workers' behavior was also highlighted [28]. Effective safe work instruction can reduce 67% of accidents at construction sites [6]. Establishing safe work instruction can minimize the likelihood of human errors [14]. The normal working conditions found were significantly associated with safety compliance [37]. The workload and extra rules in safe work instruction affected safety compliance [34]. The effect of workers' commitment to safety-related issues was subject to the available time for serving their needs. Tight



schedules and timetables to accomplish certain tasks were reported as reasons for time pressures [27]. Unnecessary rules were also reported as time pressures [38]. The above evidences support the existence of an association between stress-based tension as an exogenous factor and motivational problems to use shortcuts as an endogenous factor.

#### 1.4 Research Objective

Falling from a height is the foremost type of accident globally and there is no evidence of an association between this type of accident and unsafe acts [11,17]. In Saudi Arabia, regulations have been developed to minimize work-related accidents but the trend analysis of construction accidents, as shown in figure 1, does not show a sign of improvement in the number of accidents related to falling from a height as found on the updated data by General Organization of Social Insurance known as GOSI [39]. This paper assesses the associations of different underlying factors with the sequential mediators, namely, routine perception-based errors and motivational problems to take shortcuts, which in turn cause falling from a height.

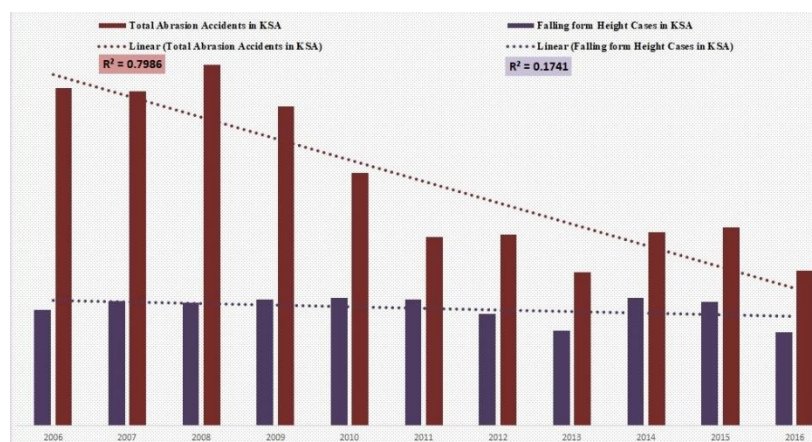


Figure (1): foremost type of accident in Saudi Arabia (GOSI, 2017).



## **2. Material and Method**

The work was to conduct the analysis of the qualitative data on the related literature over the past two decades. The main scope was to investigate the relationships between different variables and their contributions to unsafe workplaces at a construction site through the concurrent effects of both routine perception-based errors and motivational problems of taking shortcuts. Different search engines were employed in search process, such as, Safety Science, Reliability of Engineering and System Safety, Accident Analysis and Prevention, Safety and Health at Work, Human Factors and Ergonomics Society, International Journal of Environmental Research and Public Health, Procedia Engineering, etc. Moreover, there are different search terms were used for initial selection process, such as, unsafe acts in construction site, intention unsafe acts management, effective safety training to take shortcuts, risk perception, risk management, etc. Moreover, Mendeley desktop was also adopted to suggest other similar publications.

Based on initial selection process, 368 publications were found (322 articles, 8 thesis, 4 conferences, 7 books, and 28 post-notes). The post-notes were published on a professional safety website. The final selection process was subjected to different filters used as criteria for filtering irrelative data. The first filter was used based on the contents in the abstract that meet with the aforementioned objective in this paper and the main focus was on the written purpose of each publication. The outcomes of the first filter end with 204 publications (182 articles, 3 theses, 2 conferences, 4 books, and 13 post-notes). The second filter was done after reviewing the entire abstract and 172 articles, 1 thesis, 2 books, 2 conferences, and 6 post-notes were maintained. From the collection of qualitative data from the main body of each publication, the final number of references was fixed as listed in the related section. The findings were analyzed to configure the main foundation for constructing the conceptual models.

## **3. Proposed Conceptual Models of Associations**



The probability of falling from a height is the main endogenous factor as previously mentioned that can generally be expressed as a function of safety training effectiveness, stress-based tension, routine perception-based errors, and motivational problems to take shortcuts as shown in figure 2. Safety training effectiveness is an exogenous factor that can be inferred by different indicators associated with it (frequency, coverage, reaction, learning, and behavior). Stress-based tension is another exogenous factor that is detected by communication, the physical work environment, and the margin of personal life as measured indicators. Routine perception-based error is an endogenous factor that inferred by both feeling-based risks and thinking-based risks concerning the received stimuli and then taking action accordingly. That action could be saving time, reducing effort, or gaining value through shortcuts. These issues are motivational problems to take shortcuts, which are other endogenous factors that can be inferred by such issues. The literature has been used as a foundation for constructing the conceptual models in this paper. The specifications of each model are explained in the following sub-subsections.

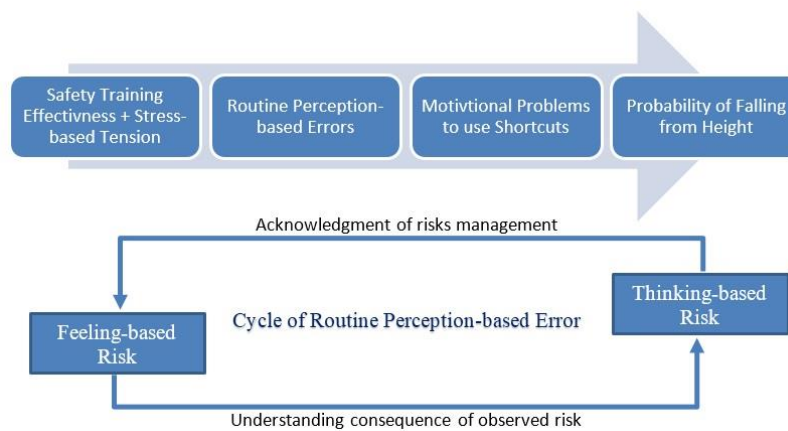


Figure (2): overview of idea in the proposed model

### 3.1 Two Exogenous and Two Mediators in Series to Main Endogenous

The aforementioned exogenous factors (safety training effectiveness and stress-based tension) have independent effects on two endogenous factors acting as



mediators in a series (routine perception-based errors and motivational problems to take shortcuts, respectively). The former mediator has been suggested as a consequence of effects that can be loaded from feeling to reach understanding and thinking to reach acknowledgment. It then causes the latter mediator. Hence, the proposed conceptual model can be illustrated as shown in figure 3.

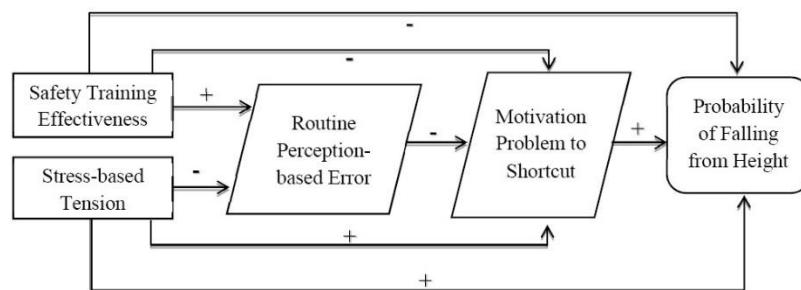


Figure (3): proposal of first conceptual model with two exogenous and two mediators

### 3.2 Specifications of Proposed Model with Two Mediators in a Series

This paper focuses on eight independent indicators in the proposed conceptual model: coverage (skill, knowledge, and attitude), frequency (number of safety training classes in single year), reaction (degree of interest in learning), learning (the degree of acquiring skill, knowledge, and attitude), behavior (the degree of applying the lessons learned), communication (the degree of involvement and the understanding of the communication contents), physical work environment (the quality of the work environment including hazards/controls, level of task fit physically, usability of resources, etc.) and the margin of personal life (the margin of time that is quantified by subtracting the required working time including normal break time from the available time in a single day to meet personal needs). The first five indicators were used to infer about safety training effectiveness as the exogenous factor. The remaining three indicators were used to deduce stress-based tension as another exogenous factor. These two factors act independently and conversely affect the criterion as previously highlighted.





The effects of the aforementioned exogenous factors seem indirectly associated with the probability of falling from a height through two mediators in a series (routine perception-based errors and motivation problem to take shortcut, respectively). The former is the endogenous factor that has been conjectured by two indicators (feeling-based risks and thinking-based risks). The latter is also endogenous, which was surmised by three indicators (saving time, reducing effort, and gaining value). Thus, the probability of falling from a height is an endogenous outcome inferred by the likelihood of accidents to the individual motivation problem (saving time, reducing effort, or gaining value) to use shortcuts. The proposed conceptual model shown in figure 4 is designed to lead to harmony between the identified exogenous and endogenous factors in this paper. This presents the reasons for unsafe acts while implementing safe work instruction and ultimately contributes to accidents. It has been proposed to find another method to minimize major types of unsafe acts.

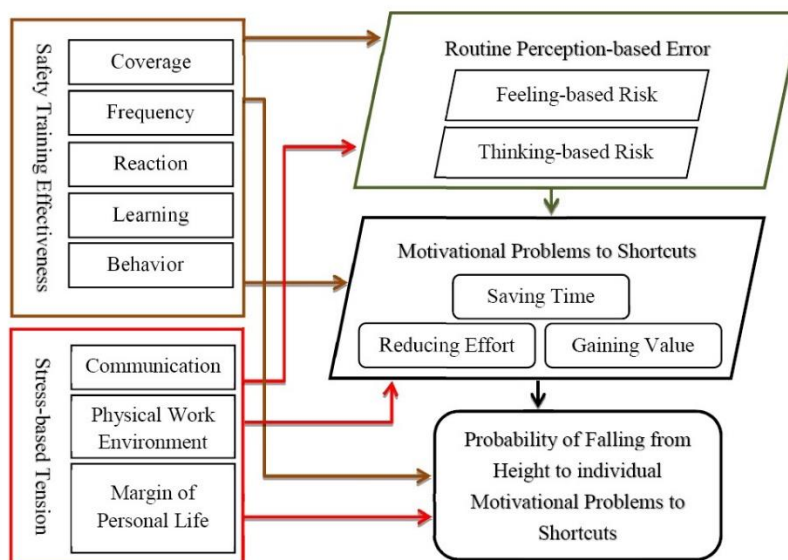


Figure (4): details of the first conceptual model



### 3.3 Specifications of the Moderated Mediation Model

The effect of communication moderated the association between the task fit (task needs, workers' capability, and the use of tools) and safety perception [26,40]. The same author stated that a poor work environment increases the possibility of misunderstanding safety perception. The commitment to the received information may change when the workers are unwilling [37]. These findings indicated the effect of stress-based tension that can moderate the relationship between safety training effectiveness and the motivation problems to take shortcuts. The moderating effect of stress-based tension was employed to examine the strength influences of the relationship in the mediation effect of routine perception-based errors. Based on the literature, the specification of the proposed model has been re-specified to construct the alternative conceptual model shown in figure 5. The latter model explores both effects of moderators and mediators that are integrated to constitute moderated mediation. It was constructed when the feeling of workers varies across the work environment and affects their decisions toward motivational problems to take shortcuts.

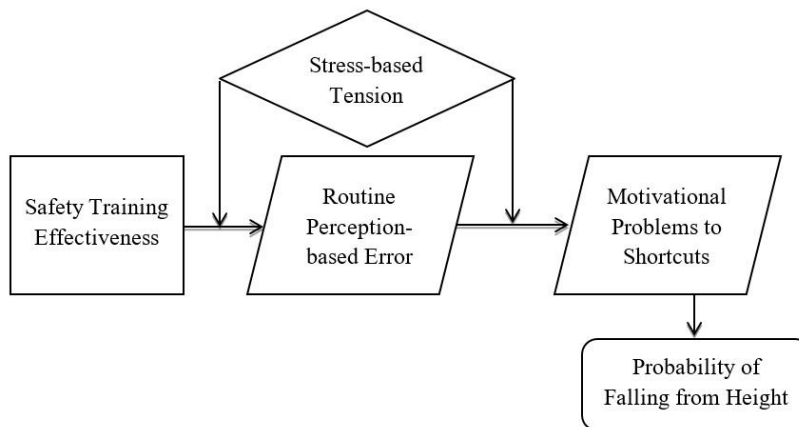


Figure (5): second proposed conceptual model with one moderator intermediators



#### **4. Discussion**

Unsafe acts remain highlighted in the literature as the foremost cause of work-related accidents, causing more than 70% of all work-related accidents. The literature highlighted 62.66% of total unsafe acts as shortcut-based violations [9]. In the contemporary research, most agreements have highlighted habits or mental problems as common reasons to use shortcuts. These causes have been considered as 24% of the total proportion to use shortcuts [11]. That means that 76% of all shortcuts remain unexplained and there is no statistical evidence to understand such ambiguity. Falling from a height is the foremost type of accident that has been highlighted in the literature. In a recent work, a global survey was conducted and concluded that the association between unsafe acts and falling from a height has received inadequate evidence [17]. This finding guides this paper toward a route that explains the aforementioned ambiguity through a statistical designation between exogenous and endogenous factors.

##### *4.1 Variables of Interest in Proposed Conceptual Models*

Four types of variables were used to represent the conceptual models in this paper: independent (predictor), moderator, mediator, and dependent (criterion) variables. The literature has set the main foundation for those variables as shown in figure 4. The following sub-subsections explain those variables and demonstrate the approach for measuring each factor based on the related measurable indicators.

##### *4.2 Statistical Diagram for Constructs and Proposed Hypothesis*

Based on the proposed first conceptual model for all of the possible contributing factors on the probability of the foremost types of construction accidents through two mediators in a series, the final statistical diagram is represented in figure 4. The diagram shown in figure 6 is similar to the model proposed by Hayes (2013) (Model #06) as demonstrated in [41], with few specifications added to the model to represent the



proposed statistical diagram in this paper.

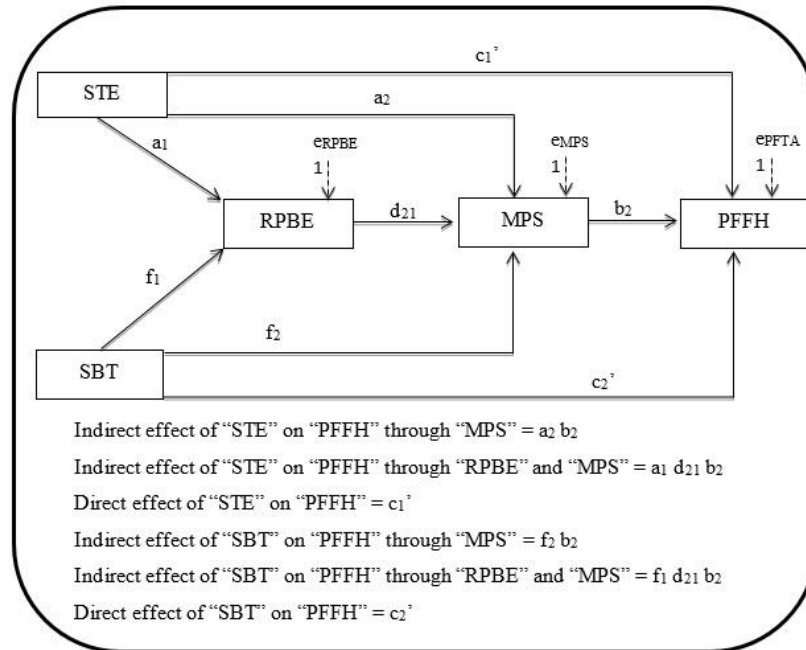


Figure (6): statistical diagram of the first proposed model

Moreover, the proposed hypotheses for this model have been represented as follows:

- The safety training effectiveness (STE) is an influence on the safety training program that is designed for workplace safety to enhance feelings and thinking about the correct safety practices. The routine perception-based error (RPBE) accommodates both negative feelings and thinking to understand the received stimuli and acknowledge the chosen action. The stored knowledge may have negative information about the received stimuli and lead to negative decisions. Therefore, it is hypothesized that an effective safety training has a negative impact on routine perception-based errors.
- Stress-based tension (SBT) is a negative or a positive stimulus that has been received from the workplace during communication, the physical work environment, or the existence of necessary life issues. It is hypothesized that stress-based tension has a positive impact on routine perception-based errors.



- An effective safety training program provides solutions to minimize motivational problems to use shortcuts (MPS) through routine perception-based errors. The design of a safety training program should focus on shortcut-based issues at the workplace. It is hypothesized that an effective safety training program has a negative effect on the motivational problems of taken shortcuts. Moreover, it has been mediated by the effect of routine perception-based errors, which in turn affect the motivational problem of taking shortcuts.
- The work environment consists of different stimuli that act concurrently on the recipients, causing stress-based tension, and the latter directly motivates workers to use shortcuts. It is hypothesized that stress-based tension has a positive effect on the motivational problems of taking shortcuts. Moreover, it has been mediated by the effect of routine perception-based errors, which in turn affect the motivational problem of taking shortcuts.
- The motivational problem of taking shortcuts occurs when the stored negative information does not change the received stimulus and becomes motivation to engage in shortcuts. It is hypothesized that routine perception-based has a positive impact on the motivational problems to take shortcuts. Moreover, the latter has a positive impact on the probability of falling from a height. Also, the association between routine perception-based errors and the probability of falling from a height has been mediated by the motivational problem to use shortcuts.

Based on the scope of this paper, there is an alternate model that has been re-specified from the first proposed model to examine the various effects of stress-based tension inter-mediators. Stress-based tension will be investigated as an independent factor as shown in figure 6 and will also be examined as a moderator as illustrated in the alternate statistical diagram shown in figure 7. This model is called the conditional indirect effect that has a pattern of moderated mediation effect according to the model proposed by Hayes (2013) (Model #58) as demonstrated in [41]. The impact of safety



training effectiveness on the criterion via serial multi-mediators differs depending on the stress-based tension effects. It shows the impact of safety training effectiveness as a latent factor on the criterion through the identified serial multi-mediators has been influenced by a change in the variations of stress-based tension. This research hypothesizes that an impact of effective safety training programs on the probability of falling from a height via routine perception-based errors and the motivation problems to take shortcuts, respectively, are affected based on different levels of stress-based tension.

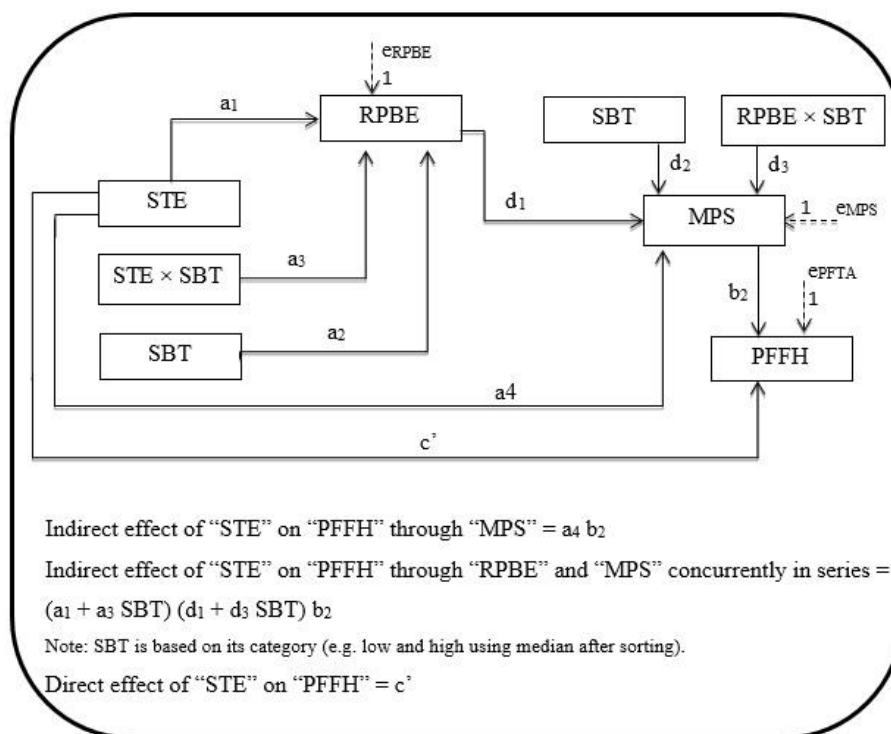


Figure (7): statistical diagram of the second proposed model

### Conclusion

This paper explores the importance of different underlying factors to the sequential mediators, namely, routine perception-based errors and the motivational problems to use shortcuts, which in turn cause the identified foremost type of construction accidents in Page | 14



Saudi Arabia. This context attracted little attention from previous researchers, specifically in obtaining a good fit model that can represent the foremost underlying causes of the major types of unsafe acts (taken shortcuts). The findings from the literature promote a chance of developing two proposals for the aforementioned. This paper proposes different models with varying specifications as follows:

- Diagrammatic representation of the proposed theoretical framework for indirect effects of two exogenous latent factors (safety training effectiveness and stress-based tension) to one endogenous latent factor (probability of falling from a height) via serial multi-mediators (routine perception-based errors and motivational problems to take shortcuts, respectively).
- Diagrammatic representation of the theoretical model for moderated mediation effects. It is also called a conditional indirect effect, which occurs when the variation of the aforementioned mediators differs based on the effect of stress-based tension when it acts as a moderator between those mediators.

### **Future Work**

A questionnaire and a structured interview will be designed based on the aforementioned discussions as the main instruments to collect all of the required data for testing the proposed statistical diagrams using the structure equation technique (SEM). The SPSS AMOS statistical software (software integrated between the Statistical Package for Social Sciences and the Analysis of Moment Structures) is helpful in providing modification indices to improve the tested model if it is not well fit. Suggestions will be collected to improve the tested model in different runs. Then the process will be repeated until a good fit model is achieved that can be used for comparison of the indices with the alternate model. The common procedure of using the SEM and are known as model specification, model identification, model estimation, model testing, and model modification [42,43].



## Conflicts of Interest

All of the contributing authors declare no conflicts of interest.

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