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# Impacts of Accident on Construction Participants Using Structural Equation Modelling

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***Abstract***
*Construction works are impacted by accidents, while losses are recorded in relation to lives and properties. Besides, project delivery is delayed, with quality of works compromised at the occurrence of accident. The paper is prepared to exhume the categories of accident occurring on the building construction sites in Nigeria, and to model the impacts of these accidents on the client, contractor and operative. Of a fact, some studies have been conducted on impacts of accidents, but those studies failed to model the impacts of accident on construction participants. In achieving the aim of the study, three hundred and ten retrieved questionnaires from the construction stakeholders were analysed descriptively and inferentially, using the Statistical Package for Social Sciences and Structural Equation Modelling (Amos Graphics). Result showed that three categories of accident were common on the construction sites in Nigeria; namely vehicle-related accident, collapse accident and exposures to harmful substances. Moreover, accident was established to have adverse impacts on the project participants, which include overall increment of project's cost, delay of project delivery, payment of medical expenses, replacement of damaged property, loss of productivity, cost of rescue operations, legal fees for defence against claims, increased insurance costs, affected psychology, permanent disability, sustained injury, suffering, death, loss of morale among workers, and loss of income. Consequently, a proposed model was developed depicting the impacts of accident on the construction participants. However, the findings of the study serve as a promoter of understanding for the construction stakeholders in taking cognizance of the common accidents on the construction site, and for decision makers to undertake accident prevention initiatives voluntarily.*

***Keywords:*** *Construction operatives, Construction participants, Impact of accident, Structural equation modelling, Building construction site.*

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## I. Introduction

An accident is described by Heinrich et al. [1980] to be "an unexpected, unavoidable, unintentional act resulting from the interaction of host, agent, and environmental factors within situations which involve risk taking and perception of danger". Equally, Pillay (2014) describes accident to be an undesired circumstance which results in ill health, injury, damage to plant, property, products or the environment, or a loss of business opportunity. However, it is a condition or circumstance where a worker or operative is injured at the course of operation, or a situation where material or equipment is damaged on the construction site. Moreover, an accident happens to site workers without their intention, nor any preparation for it. It is a dangerous occurrence that impedes the smooth running of activities on site when it happens. It is sometimes very injurious and disheartening, and has consequential impacts on the clients, the contractors as well as the construction workers. It leads to physical loss, financial loss, and equally attracts psychological effects. Consequent upon the intense impacts of accident on the construction participants, many researchers have identified these impacts so as to create awareness to the construction decision makers in order to undertake accident prevention initiatives voluntarily. Sequel to this, in a report prepared and submitted to Health and Safety Authority in Ireland, Hrymak & Pérezgonzález [2007] identified the impacts of accident on employer to comprise of loss of productivity and business opportunities, salary of the injured employee or of a replacement employee or additional overtime costs, and expenses reimbursed to the injured employee. The authors further included repairs, rental or replacement costs, changes to insurance premiums as well as legal costs. Other impact, as identified by the authors, is the cost to the construction workers, which include loss of salary, loss of payment of overtime, medical and travel expenses, lost savings, retraining costs, and pay differences from any new employer. The psycho-social effects of accident on the employee has something to do with the aspects of work, family, leisure, and community life. Other inclusions are considered to be anxiety, difficulty in carrying out normal activities, upset to family and friends, depression, affected sports and hobbies, sense of loss, feelings of embarrassment, feelings of isolation, stress and boredom. Moreover, Kadiri et al. [2014] identified time loss of the execution of project, extension of the completion period, reputation of firm, psychology of workers, and cost of medical expenses as the consequential effects of construction accidents. Additionally, McKinnon [2000] itemised accidental loss to be potential loss, actual loss in the form of personal injury, property damage, and business interruption. According to Nkurunungi [2005], accident is seen as an unplanned occurrence that happens after a sequence of events resulting in physical harm (injury or death), damage to property, time loss, loss of production, fear and loss of morale among workers as well as loss of money and other resources. Equally, Udo et al. [2016] stressed out that when accidents happen on site, they result to human tragedies, de-motivation of workers, disruption of site activities, delay in project progress, changes in the overall cost of project, productivity loss, and loss of reputation of the firms concerned.

### *1.1 Categories of Construction Accident*

There are different types of accident on the building construction site (BCS). Such accidents include the ones in connection with vehicles [Edwards & Nicholas, 2002], fire outbreak [HSE, 2006], explosion of gas or chemical [Hovden et al., 2008], falls from the roof [Weeks, 2011], and fall of weighty objects during fixing/lifting. Besides, Umeokafor et al. [2014] identified electrical accident, while Orji et al. [2016] discovered fall-related accident. Additionally, Williams et al. [2019] and Maloney [2015] listed a plethora of construction site accidents, which include falls from heights or falls from scaffolding; overexertion; fires and explosions; slips and falls;falling debris (materials or objects); getting caught in-between objects or materials;electrocutions; machinery accidents; collapse of trench; and hit by a machine/vehicle. Moreover, Radmin [2017] elaborately pictured accident to include burns, exposure of workers to chemical, electrocution, collapse of structure and trench, fall-related accident, chemical spills, vehicle-inclined accident, falling of objects, equipment-related type of accident, crushed-between, fires and explosions, and the likes. However, the study categorised accidents into seven viz: Contact with objects accident (welding arc, working tools, electricity etc.); Vehicle-inclined accident (crane accident, overturned vehicle, struck or run over by moving or operating machine); Slip and trip accident; Fall-related accident (fall from building roof, climbing ladder, holes in floor or ground, scaffold, stairs/ramp, same level, falling or flying objects); Collapse accident (structure and trench collapse); Exposure-related accident (gas, fire, and chemical explosion); and Lifting and handling objects accident.

### *1.2 Impact of Construction Accident*

A good number of researchers [McKinnon, 2000; Nkurunungi, 2005; Mthalane et al., 2008; Kadiri, 2014; Udo et al., 2016] have extensively discussed issues in relation to the consequences of site accident. According to Mthalane et al. [2008], the effects of accident are explicitly stated to be production loss, disruption of on-going work, training cost for replacement of operatives, damages to plant and equipment, corrective steps to prevention of further accident, efficiency degradation, cost of purchasing new equipment, slowdown in operations and costs of workman’s compensation. Moreover, Finkelstein & Partners [2016] corroborated other authors to declare that construction accidents impact costs of workman’s compensation, though the compensation benefits may not be enough to cover their expenses. Also, Mthalane et al. [2008] and Udo et al. [2016] claimed that payment on medicals, premium on insurance, costs of rescue operations and equipment, loss of operations and its income, payments for settlements of injury or death claims, legal fees for defence against claims and increased insurance costs adversely affect the construction works through accident. Besides, Perttula [2017] was of the opinion that when accident takes place, the injuries cause pain and suffering to the individuals and their families, mental distress and probably life changes, needless human suffering, direct expenses for workplaces, hurt on the organisation's reputation and public image. The author further asserted that the effect of accident on the public image of the contractor could lead to long-term financial losses. Furthermore, Baksteen et al. [2007] maintained a confirmatory stand that the injuries sustained by construction workers lead to suffering and distress of the victims and their relatives, payment of sick leave and medical treatments, and cost for replacement of labour. According to Asanka and Ranasinghe [2015], who ventured into the study of accidents’ impacts on construction project hammered on the human and financial aspects of accident. However, consequent upon the extensive review of literature on the impacts of accident, they can be summed up to come under the following three categories viz: i) Impact on the client, ii) Impact on the contractor, and iii) Impact on the construction worker.

## II. Materials and Methodology

The research was carried out via a non-probability sampling approach in the administration of questionnaire, while it consisted of three sections viz: the demographic information (Section A) of the respondents, categories of accident (Section B), being based on 5-point Likert scale, and the impacts of accident on the client, contractor and the construction worker (Section C). Collection of data was done through self-administered questionnaires, but prior to the administration of the questionnaires, a pilot study (using construction experts) was carried out, resulting in a Cronbach's alpha value of .977, while the inputs of the construction experts were considerably adhered in order to enrich the questionnaire. In achieving the purpose of the study, the target population included client organisations/project managers, consultants, contractors, safety practitioners and craftsmen, with three hundred and ninety-three (393) questionnaires administered through physical contact and e-mails in the South-western states of Nigeria, being the scope of the study. The missing data were treated and replaced using the SPSS software. Besides, the respondents were drawn from both the contracting and consultancy sectors. At the collection, treatment and screening of the retrieved questionnaires, 310 questionnaires were appropriately filled and found valid for the analysis of the data, representing 78.88% of the administered copies. Besides, exploratory factor analysis, using the SPSS version 22 software was used in establishing the structure of the measurement models, classifying the items into four factors, while the Kaiser-Meyer-Olkin (KMO) as well as the Bartlett's test of sphericity were engaged in confirming the instrument validity by assessing the sample adequacy and multivariate normality of the study variables. Moreover, the structural equation modelling (SEM) further validated the measurement models through the use of AMOS software by establishing satisfactory goodness-of-fit (GFI) indices of the variables of the study.

## III. Results and Discussion

### *3.1 Demographic Information of the Respondents*

The demographics of the respondents of the study are presented in Table 1. In relation to the years spent in the industry, 21% have spent less than 3 years, 22% with 3-5 years, 17% with 6-10 years, while 40% possess above 10 years of experience. However, with the 57% (17% + 40%) of the respondents having an experience above 5 years, their responses are adequately sufficient to rely upon and can be found very useful for the study. Additionally, the academic qualifications show ND (15%), HND (30%), BSc/PGD (30%), MSc (15%), PhD (6%) and others (4%), indicating that 81% of the respondents are holders of degrees. The areas of specialisation (professions) reveal client/project manager (23%), consultant (35%), contractor (27%), safety practitioner (4%), craftsman (3%), and others (6%). In addition, the consultant comprises of the architects, engineers, quantity surveyors and builders. This indicates that the respondents are active participants in construction-related activities. Moreover, the types of project handled by the respondents show low-rise building (57%), high-rise building (18%), infrastructure (19%) and others (6%), which emphasizes the fact that greater percentage of the respondents are involved in building works and they can be relied upon for any information in respect of construction-related accident.

**Table 1: Years of Experience and Highest Academic Qualification**

| Demographic Criteria | Classification | Frequency | Percentage (%) |
|---|---|---|---|
| Year of Experience | Less than 3 years | 65 | 21.0 |
| | 3-5 years | 69 | 22.3 |
| | 6-10 years | 52 | 16.8 |
| | Above 10 years | 124 | 40.0 |
| Highest Academic Qualification | ND | 45 | 14.5 |
| | HND | 94 | 30.3 |
| | BSc/PGD | 94 | 30.3 |
| | MSc/M.Tech | 47 | 15.2 |
| | PhD | 17 | 5.5 |
| | Others | 13 | 4.2 |
| Area of Specialisation | Client | 73 | 23.5 |
| | Consultant | 109 | 35.2 |
| | Contractor | 83 | 26.8 |
| | Safety | 13 | 4.2 |
| | Craftsman | 8 | 2.6 |
| | Others | 24 | 7.7 |
| Type of Project | Low-rise building | 178 | 57.4 |
| | High-rise building | 55 | 17.7 |
| | Infrastructure | 58 | 18.7 |
| | Others | 19 | 6.1 |

Shown in Figure 1 is the demographic background of the study respondents.

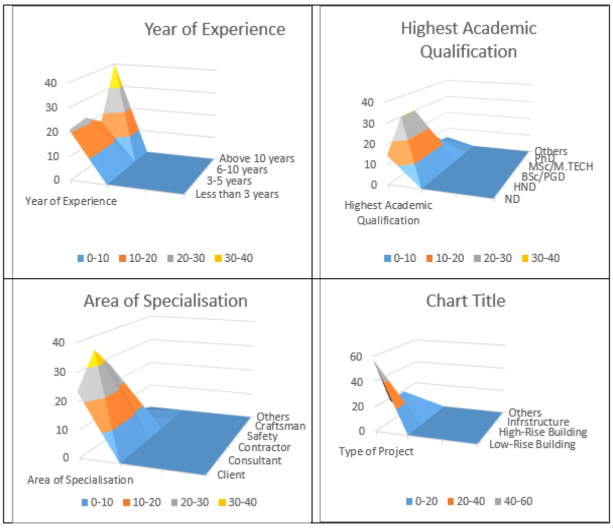


**Figure 1:** Demographic information of respondents

### *3.2 Categories of Accident and their Impacts.*

Few studies supposedly have critically examined the impacts of accident on the client, contractor and the construction workers in the dimension of this study. The study contains seven categories of accident viz: Contact with objects (ACC1); Vehicle/machine-related (ACC2); Slip and trip (ACC3); Fall-related (ACC4); Lifting and handling (ACC5); Collapses (ACC6); and Exposures to harmful substances (ACC7). All these types of accident were generated from past studies [Edwards & Nicholas, 2002; HSE, 2006; Hovden et al., 2008; Weeks, 2011; Umeokafor et al., 2014; Orji et al., 2016; Maloney, 2012; Radmin, 2017]. The three impacts of accident being on the client are: Overall cost of project is increased (ICL1); delay of project delivery due to time loss (ICL2); and interruption of site activities (ICL3). Equally, ten impacts on the contractor are: Loss of image/reputation of the firm (CON1); payment of salary, sick leave and medical expenses of victim (ICON2); repairs or replacement of damaged property (CON3); loss of productivity (ICON4); cost of rescue operations and equipment (ICON5); training cost for replacement of worker (ICON6); legal fees for defence against claims (CON7); cost of change in safety management systems (ICON8); increased insurance costs/compensation (ICON9); and cost of accident investigation time (ICON10). The seven impacts on the site workers are: Psychology of workers is affected (IWK1); permanent disability for the victim (IWK2); injury, pain, suffering and/or death of the victim (IWK3); loss of morale among workers (IWK4); loss of function and operations' income (IWK5); loss of overtime payment (IWK6); and medical and traveling expenses during treatment (IWK7). However, the impacts of accident on the affected client, contractor and the site workers were extracted from the literature [McKinnon, 2000; Nkurunungi, 2005; Hrymak & Pérezgonzález, 2007; Baksteen et al., 2007; Mthalane et al., 2008; Kadiri, 2014; Asanka & Ranasinghe, 2015; Udo et al., 2016**;** Finkelstein & Partners, 2016; Perttula, 2017]. Having the knowledge of these impacts will enable the decision makers to formulate strategies in averting the occurrence of these dangers (accidents), as it was declared by Jo &Janaka [2016] that people employ various strategies to deal with the dangers and uncertainties of life.

### *3.3 Exploratory Factor Analysis*

In relation to the factor analysis, the KMO calculated 0.908 value for both the categories of accident and the impacts. The value is an acceptable one, being above the accepted minimum of 0.5, while the Barlett's test of sphericity is significant ($p < 0.05$). This is shown in Table 2.

**Table 2: KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .908 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 4187.342 |
| | df | 351 |
| | Sig. | .000 |

**Table 3: Rotated Component Matrix**

| Component 1 | | Component 2 | | Component 3 | | Component 4 | |
|---|---|---|---|---|---|---|---|
| ACC1 | .637 | ICL1 | .647 | ICON1 | .600 | IWK1 | .537 |
| ACC2 | .660 | ICL2 | .738 | ICON2 | .612 | IWK2 | .568 |
| ACC3 | .630 | ICL3 | .685 | ICON3 | .571 | IWK3 | .522 |
| ACC4 | .662 | | | ICON4 | .590 | IWK4 | .689 |
| ACC5 | .701 | | | ICON5 | .661 | IWK5 | .731 |
| ACC6 | .740 | | | ICON6 | .635 | IWK6 | .709 |
| ACC7 | .667 | | | ICON7 | .715 | IWK7 | .588 |
| | | | | ICON8 | .674 | | |
| | | | | ICON9 | .703 | | |
| | | | | ICON10 | .710 | | |
| Extraction Method: Principal Component Analysis.<br>Rotation Method: Varimax with Kaiser Normalization. | | | | | | | |
| a. Rotation converged in 7 iterations. | | | | | | | |

Moreover, the total variance explained that depicted eigenvalues of 1 and above was underpinned by the extraction of the components of the categories of accident and the impacts, of which a total variance of 56.78% was calculated. Being based on the factor loading of $\geq 0.50$ [Olugbenga, 2018], all the items were considered significant and reliable, as they were classified into four components as indicated in Table 3. Consequent upon the outcome of the factor analysis, four constructs were classified through the varimax rotation method with Kaiser normalisation.

### *3.4 Instrument Reliability and Confirmatory Factor Analysis*

The results of the reliability test via Cronbach's alpha value indicated type of accident (ACC) = .807; impacts on client (ICL) = .731; impacts on the contractor (ICON) = .912; and impacts on the site worker (IWK) = .871, implicating the level of significance which are high enough and met up with the requirement of significance [Tanko et al., 2018]. Significantly, the proposed model that follows hereafter will enable stakeholders to know the level of impacts of accident on the construction participants, so that effort will be made to fashion out a lasting solution to the occurrence of accidents on the site, as lives are lost through its occurrence. At the confirmatory level of the measurement models, Table 4 shows the summary of the modification indices. In establishing a good model fit, confirmatory factor analysis (CFA), being the initial step of the structural equation modelling analysis, was carried out that comprised each of the constructs, with an inclusion of their revised (adjusted) CFA models. The modus operandi involved in respect to achieving a fitted model was to be sure that every factor loading must be equal to (=) or above (>) 0.6 [Awang, 2015], indicating that factor loading less than 0.6 was unquestionably expunged at confirmatory level. Therefore, Figure 2-5 showed the CFA carried out for the constructs, with the summary of all the CFAs shown in Table 4. The conditions for acceptance of the model was to see that the modification indices, such as Goodness of Fit Index (GFI), Tucker Lewis Index (TLI), Comparative Fit Index (CFI), and Normed Fit Index (NFI) must be higher than 0.90 (>0.9). The Chi-square's ratio (chi-sq) as well as the Degree of freedom (df) must not be higher than 5.0, that is, Chisq/df $\leq$ 5.0. In addition, the Root Mean Score Error Approximation (RMSEA) should cleave to a lower value of 0.08, that is, $\leq$ 0.08. The situation where a revised or adjusted model is needed is where the initial CFA, the hypothesised model, and the structural equation models (SEM) could not fulfil the minimum requirement of the modification indices [Awang, 2015; Oke, 2016].

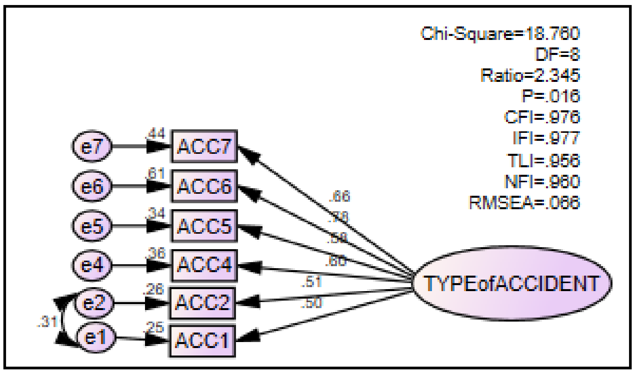

Figure 2: Adjusted CFA of Type of Accident

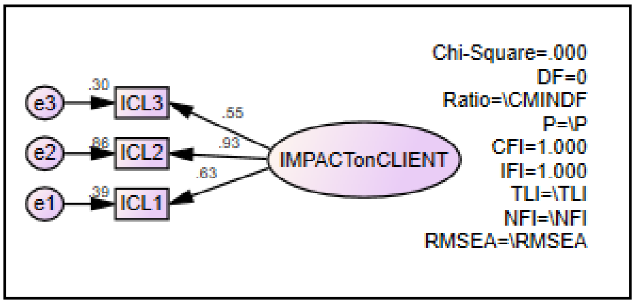


Figure 3: Initial and Adjusted CFA of Impact on

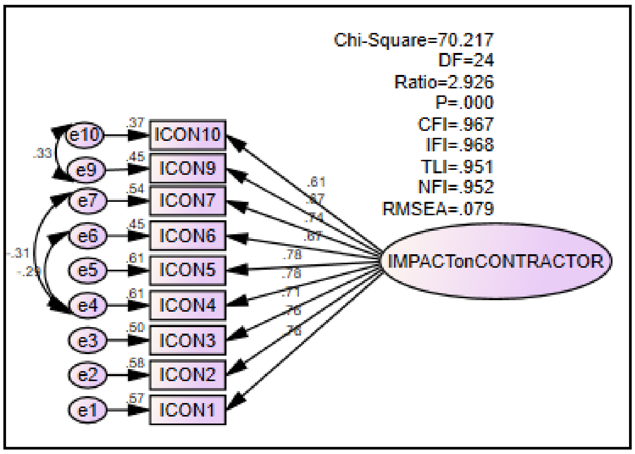


Figure 4: Adjusted CFA of Impact on Contractor

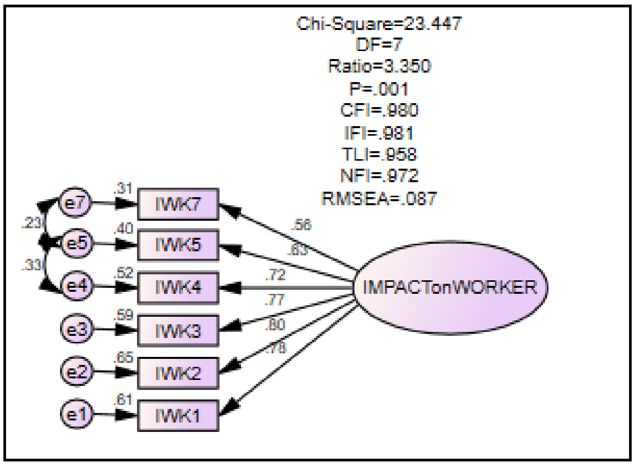


Figure 5: Adjusted CFA of Impact on Contractor

**Table 4: Summary of the Model Fitness Indices**

| | | Chisq | Df | Ratio | P-Value | CFI | IFI | TLI | NFI | RMSEA |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of accident | Initial | 66.177 | 14 | 4.727 | .000 | .907 | .908 | .860 | .886 | .110 |
| | Adjusted | 18.760 | 8 | 2.345 | .016 | .976 | .977 | .956 | .960 | .066 |
| Impact on client | Initial | No Modification (No adjustment) | | | | | | | | |
| | Adjusted | | | | | | | | | |
| Impact on contractor | Initial | 175.634 | 35 | 5.018 | .000 | .913 | .913 | .888 | .894 | .114 |
| | Adjusted | 70.217 | 24 | 2.926 | .000 | .967 | .968 | .951 | .952 | .079 |
| Impact on worker | Initial | 136.132 | 14 | 9.724 | .000 | .877 | .878 | .816 | .866 | .168 |
| | Adjusted | 23.447 | 7 | 3.350 | .001 | .980 | .981 | .958 | .972 | .087 |

For the modification indices of the types of accident, the Chisq=18.760, Df=8, Ratio=2.345, P-Value=0.016, CFI=.976, IFI=.977, TLI=.956, NFI= .960, RMSEA=.066. The same process was applied to other constructs. In reference to the impact on client, the modification indices could not be displayed by the software due to the limited number (three) of the items, but going by the factor loadings arena the items fulfilled the minimum 0.6 [Awang, 2015]. Moreover, the construct was subsequently pooled together with others to establish the relationship among the constructs, and at the same time used in the structural equation modelling.

The requirements of the modification indices of all the constructs were met after making adjustment where necessary, but done in accordance with the specification of past studies [Awang, 2015, Oke, 2016]. Moreover, the first order measurement model was as shown in Figure 6. It was to define the relationship and establish the convergence validity of the measurement model for the types of accident and their impacts. Statistically, the modification indices were given as Chisq= 473.856, Df=203, Ratio=2.334, P-Value=0.000, CFI=.914, IFI=.914, TLI=.902, NFI= .960, and RMSEA=.066. This indicated that the statistics were adequate and fell within the minimum requirement of a good model fit. With the result of the analysis, there was a positive relationship among the constructs. In addition, the validity and reliability tests (Table 5) indicated the appropriateness (validity) of the constructs, which according to literature the composite reliability should be equal or higher than 0.70, while that of the average variance extracted (AVE) should be equal to or higher than a value of 0.50 [Olugbenga, 2018].

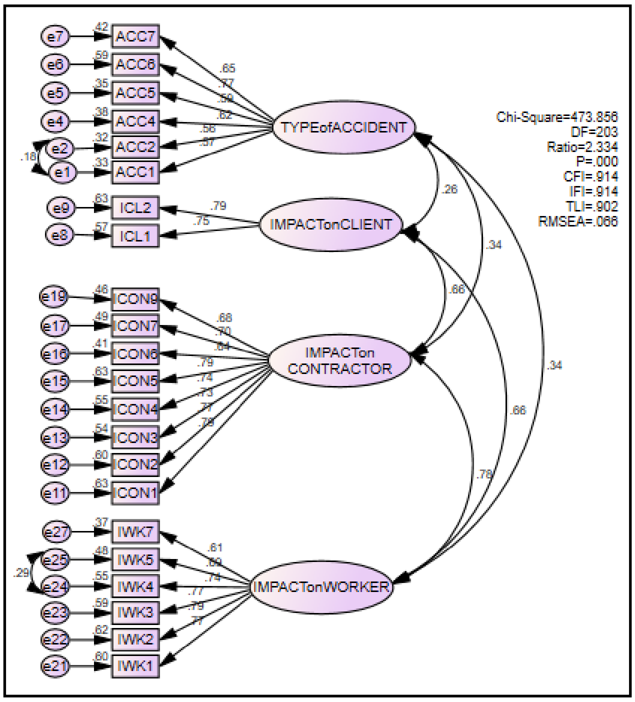


**Figure 6:** Initial and adjusted first order measurement models of constructs

In addition, to establish the validity of the hypothesised model the composite reliability of the constructs and the AVE go thus respectively: Type of accident (0.8; 0.40); impact on client (0.74; 0.59); impact on contractor (0.90; 0.56); impact on worker (0.87; 0.53). The overall average of the composite reliability is 0.83, while that of the AVE is 0.52. All the constructs fulfilled the expected minimum requirements except the AVE of type of accident, of which it is still considered significant following the fact that the composite reliability value is above the minimum requirement. Furthermore, the purpose of the use of SEM was to test the relationship between the first order and the second order constructs of the types of accident and the impacts. Figure 4 show the structural analysis, with the modification indices given as Chisq= 280.355, Df=101, Ratio=2.776, P-Value=0.000, CFI=.918, IFI=.919, TLI=.903, and RMSEA=.076. The results of the structural model were proved to have met the minimum and acceptable requirement, going by all the parameters required for a good model fit. Before the achievement of the model fit, items e2<-->e5, e2<-->e6, e5<-->e6, e15<-->e16, and e21<-->e22 needed to be constrained in order to avoid being redundant. Values of the model showed the path between types of accident and contractor to be 0.78 (standardised estimate), between types of accident and contractor to be 0.53, while between types of accident and worker equaled to 0.90. Consequent upon the trimming of the initial model, six items were left to be significant impacts of accident on the contractor, two (2) on the client, while five on the worker. In the same vein, three out of seven accidents were found to be prominent, which were accidents involving vehicle/machine (ACC2), collapses (ACC6), and exposures to harmful substances (ACC7), of which the result corroborates Williams et al. [2019], who found out that accident in relation to vehicles and/or machines were common on the Nigerian building construction sites.

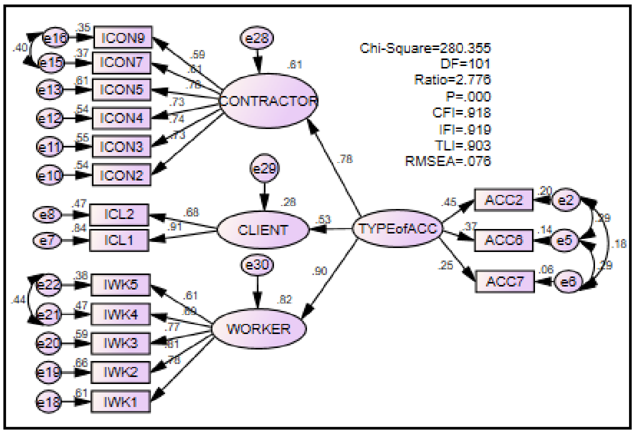


**Figure 7:** Structural equation model of categories of accident and resultant impacts

### *3.5 Model Development*

Consequent upon the results obtained through the structural equation modelling, shown in Figure 5 is proposed model of the interrelationship between accident types and the resultant impacts, though the model could not go through expert's validation, but went through the validation of the SEM (Amos software), though the SEM is considered as a good analytical tool for validation of model.

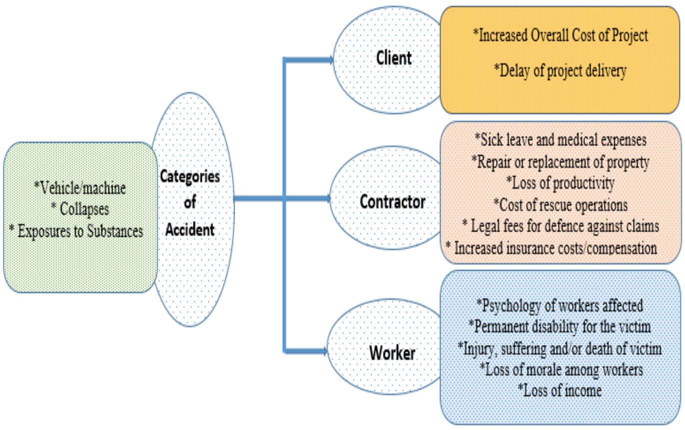


**Figure 5:** Proposed model of impacts of accident on project participants

## IV. Conclusion

The result of the research shows that accident has an advance impact on the client (owner of project), contractor as well as the construction worker. On the client, accident causes delays on project delivery due to time loss, and increment in overall cost of project. On the contractor, he is affected in a way that the salary of the worker, sick leave and medical expenses are being borne by him. The cost of the replacement of damaged properties (machine, vehicle, structure), is another impact. Loss of productivity, as well as cost of rescue operations and equipment, with payment of legal fees for defence against claims, and increased insurance costs/compensation are of significant impacts. To the worker, psychologically he is affected. Sustenance of permanent disability, coupled with injury, pain, suffering and/or death, loss of morale among workers, and loss of income are all statistically found out by the research to be significant impacts of accident on construction operatives. However, in relation to the impacts and the consequential effects of accident, it becomes imperative for researchers to develop a model for accident prevention on construction site, which should not be taken with levity. It is never a trivial issue in researching such accident preventive measures as they will be of great benefit to the client, contractor as well as the construction workers in halting the copious ways in which the impacts of accident are felt by the construction participants. Summarily, since fatalities originate from unsafe acts of people, they can be prevented through the inculcation of a positive safety culture in the Nigerian construction industry.

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