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DEVELOPING AN INTEGRATED DESIGN MODEL FOR CONSTRUCTION ERGONOMICS IN NIGERIA CONSTRUCTION INDUSTRY

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ABSTRACT

Construction is generally believed to be a fragmented industry, integration and coordination among different processes and parties is considered to be the ways of resolving the problems created by the fragmentation on health and safety (H&S) of construction workers. Construction workers experience a higher incidence rate of work related musculoskeletal disorders (WMDs) resulting in days away from work and affect the rate of productivity. Workers' health and safety issues are not built into the design process and the designers of the project have a very little influence on the construction process methods and materials used. This paper aims at promoting the integration of health and safety practitioners and the construction manager early in the design and documentation stage in order to create an integrated design for construction ergonomics which is implemented at the construction phase to allow for the upheld of construction safety of workers against WMDs. Furthermore an integrated model is proposed and developed from both literature and questionnaire survey so as to provide a structured systemic process which practitioners in the building industry can adopt in reducing the impact of WMDs in construction operations in Nigeria construction industry. The findings advocate that the introduction of construction manager and the health and safety practitioner be involved early in the design phase (integrated design team) and as part of integrative monitoring officer at the construction phase. This is found to optimize the operational system of workplace ergonomics among construction workers and promotes safe work practices associated through designing which is believed to be a source to preventing WMDs in the construction field.

Keywords: Health, Safety, Construction, Musculoskeletal, Disorders

INTRODUCTION

The construction industry is a dangerous place to work as its physical processes entail various ergonomic-related problems (Haupt et al., 2004). The construction industry faces many occupational injuries and fatality risks, making it both unique and challenging to study. Construction is always risky because of outdoor operations (Hsiao and Simeonor, 2001). Construction industry is a complex industry that employs a large man power.



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Comparisons have often been made between the construction industry and other industrial sectors and the chance of being disabled by injury or serious illness is much greater than for workers in most other industrial sectors. Construction industry is still one of the highest risk industries as far as its activities are concerned. The industry stands out from other employments as having the highest worker injury and fatality rates which makes it the highest risk sector in regard to work-related musculoskeletal disorders (WMDs). This sector is characterized by the mobility of workers; change of workplaces, tremendous diversity in regard to the importance and type of work performed in an extreme sensitivity to economic instability and large cyclical and seasonal variations in activity level. Construction sector represent strategically important sector in the provision of building and infrastructure on which all sectors of the economy depend. Construction worker face different kind of safety and health hazards while working in their work sites every day. The safety and health problems are tied largely to the construction industry's organisation and how work is performed. Construction workers suffer a disproportionate share of work related injuries and illness which results in considerable human suffering and affect not only the workers directly involved but also their families and communities (Smallwood, 2000a). The industry has typically been described as one with either no or at best, a poor health and safety culture (Agumba, 2008).

Every construction worker is likely to be temporarily unfit to work at some time as a result of injury or health problem after working on a construction site. The terrain is generally not favourable to the safe movement of people, materials and machines. According to Smallwood (2000b), construction is by its very nature a problem in ergonomics. The diverse skills required the outdoor nature, and the ever changing nature, mix and location of the work as it requires, work above shoulder level and below the waist level. The work also requires frequent bending, bending and twisting of the body, vibrations, and poor lighting conditions, pushing and pulling of position loads which are done under difficult circumstances (Gauci and Vella, 2000; Smallwood 2000b; Smallwood et al., 2004). Furthermore workers face several problems at work place. It includes mental, social, psychological, physiological and physical problems. The focus of this paper is not to deal with all the aforementioned problems which workers face at workplace. Instead, the physical injuries, specifically musculoskeletal disorders which would occur at work place were addressed.

However various safety management strategies and approaches have been implemented in construction to reduce injuries and unsafe behavior but enhancing organizational health and safety culture and workplace safety climate can have positive impacts on work environment and safety performance (Oh and Sol, 2008). Safety through designing for operational system for construction workers is a fundamental principle of both ergonomics and occupational health and safety as it helps in reducing the onset of WMDs. Belle (2000) and Gibbs et al.,



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(2000) concludes that the practice of ergonomics in the workplace is premised on designing the job and workplace to meet the capabilities and limitations of construction workers.

A number of research projects have addressed aspects of integration among two or more stages in the building project life cycle. However, there are presently no integration models available that acknowledge the early integration of health and safety practitioner and the construction manager with the designers / consultant to produce an integrated design that can ameliorate the effect of WMDs on workers. There is a gap in research particularly into the development of appropriate integrated models design for construction ergonomics in Nigeria construction industry. The study uses the combination of literature and research data to develop the integrated model for design and construction ergonomics in Nigeria construction industry. An important challenge in the development of integration model is ensuring that the model is consistent, persistent, and able to convey information as well as the underlying design intent and rationale. (Anumba, 2000).

LITERATURE REVIEW

Work related musculoskeletal disorders (WMDs) in construction workers'

The World Health Organization (WHO) has characterized "work-related" diseases as multifactorial to indicate that a number of risk factors (e.g., physical, work organizational, psychosocial, individual, and socio-cultural) contribute to causing these diseases (WHO, 1985). The sum of these challenges affects the working capacity and decreases the satisfaction of the individual. Furthermore, it decreases the profit of the organizations. International commission on occupational health defines MSD as both disorders and diseases of musculoskeletal system that have a casual determinant that is work related. Budnick (2001) defines MSDs as injuries and disorders of the muscles, nerves, tendons, ligaments, cartilage and spinal discs which are directly and indirectly related to work or the work environment. Work related Musculoskeletal disorders (WMDs) are casually linked to physical loads resulting from occupational activities and believe to occur when mechanical workload is higher than physical capacity of human body. However, these relate to different body regions and occupational work.

MSDs are difficult to diagnose as pain is hard to measure and quantify objectively and might be the reason that very few studies examine the prevalence of MSDs based on medical surveillance (Haupt et al., 2004). Construction workers rarely, if ever undergo any form of medical surveillance in their job. Sprains and strains are the most common nonfatal injury while overexertion or lifting too much at one time is the most common occurrence in the construction industry. In Sweden, Musculoskeletal injuries among construction workers were



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studied together with the risk factors that contributed to their injuries, musculoskeletal symptoms were found to be much more prevalent among construction workers than office workers. There was a clear relationship between the demonstration of these symptoms to heavy work and vibration, exposures, frequent use of handled tools, repetitive work and awkward working positions. Furthermore, accurate data on the incidence of WMDs and its prevalence are difficult to obtain and official statistics are difficult to compare across countries. The disorder generates a destructive impact on workers' life such as persistence of pain in work or leisure and even permanent disability. WMDs are not just one of the major occupational health problems worldwide; it is also recognised as an economic burden on the society directly and indirectly in cost. The direct costs are associated with workers' compensation, medical care and rehabilitation while the indirect costs include work quality, retaining costs and diminished morale (Ajayi and Thwala 2011a). The International Labour Organisation (ILO) estimates that some 6000 worker die each day worldwide and 337million people are victims of work related accidents and illness arising from occupational injuries (MLPC, 2008).

In the UK, statistics relative to self-reported work-related illnesses indicate that the construction industry has the highest prevalence of WMDs (HSE, 2004). In the Swedish construction industry more than one in five workers reported work-related injuries (Rwamamara and Holzmann, 2007).

Rwamamara (2007) ascertains that the research studies show that 71.2% of occupational diseases in the industry are MSDs and maintains that occupational injuries such as MSDs are unquestionably wasteful and non- value adding events in construction operation. According to Rowlinson (2003), in a study to estimate the work environment economic impact on construction industries, estimated that 6% of the work-environment related injury costs for medium construction firms and 94% remaining are made up by costs related to productivity loss due to construction worker injury.

Issues of Health and Safety in construction workplace

Smallwood (2000b) reports that many authors maintain that the poor H&S culture of the industry is a major cause. H&S in construction is based on the premise that the hazards exist because they are designed into the permanent features of a project. These features impact on the H&S of those who build it (Rwamamara 2007). Improving the H&S of the construction site work environment has repeatedly shown to save lives, time and money. A study performed interalia, by the Naval Surface weapon center in silver spring, Maryland confirmed that virtually every incident among the construction workers' resulted from poor upstream management and could have been prevented through proper health and safety management (Hallowell, 2008). H&S management ensures that productive work in construction is designed



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and performed with workers' H&S in mind. This involves ensuring the manager to evaluate the H&S risk and that the planned work is resourced so as to prevent occupational injuries or illness that will be detrimental to construction workers. The HSE guide book outlines five key elements for successful H&S management, which includes policy, organizing, planning and implementation, measuring performance and reviewing the performance, to mitigate occupational injuries or illness.

In managing H&S in workplace, there is need for a clearly defined policy, well defined plans, incorporating objectives, strong management commitment, the provision of sufficient resources, systematic training programmes, effective monitoring and reporting of performance and making improvements (Ajayi and Thwala, 2011b).

Operational perspectives for construction workers.

Health and safety management systems are rule and procedures based. The systems are based on the premise that health and safety are both management responsibility and a line function. The top management formulates policy and its actual success depends on the ability of site management and supervisory personnel to ensure that rules and policies are adhered to during daily operations. This perspective is concerned with efficient implementation of H&S rules and policies on construction site. It encompasses the ability to address specific project objectives in relation to H&S, appraisal of physical work environment and workers' constructive involvement. This includes a higher degree of compliance, high level of work force proactiveness, more efficient site layout planning, efficient communication / feedback Systems, safer workplaces and better workers' / supervisors' relationships. In considering these goals, measures would likely relate to elements such as process improvement, frequency of suggestions to improve H&S of construction workers', H&S meetings, plan reviews, extent of accident / incident analysis tasks and ratio of recommended / completed remedial actions, degree of employee empowerment and constructive involvement (Mohamed, 2003; Schneider, 2001). Site operatives are required to plan and organize their operations, ensure that the workers are trained and competent and know the special risks of their trade and raise problems with their site supervisor or safety representative (Adenuga et al., 2007).

In the operationalisation of construction work, job demand is a perceived work characteristic that refers to construction workers' perception of the demand that is imposed upon them by the work and the work environment. However these job demands are considered detrimental to the health of the construction worker as it includes the pressure of accomplishing the workload and intense concentration. Therefore high job demands combined with too low levels of decision latitude results in negative health outcomes. Furthermore construction site is



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one of the primary resources available to the contractor. Site layout planning and facilities is to produce a working environment that will minimise risk and maximize efficiency. Aspects of the site layout planning that need to be addressed include; access and traffic routes; material storage handling; site offices and amenities; construction plant; fabrication workshops; services and facilities; and the site enclosure. Ajayi and Thwala (2011) amplifies that integrated design for construction safety are more likely to provide a high level of safety for the workforce as injuries and illness are lurk in the work environment as the design is being implemented.

RESEARCH METHODOLOGY

In this research both the quantitative and qualitative research approaches were used. The study begins with a review of relevant literature on the impact of design and construction ergonomics and presents the trend of WMDs as it affects the wellbeing of construction workers. The sample consisted of Architects, civil engineers, quantity surveyors, construction project managers, Health and safety managers, contractors and construction workers (The trades of construction workers that were surveyed were limited to bricklaying, plumbing, pavers, painting carpentry and tiling) in Nigeria construction industry. However the questionnaire is limited to the six south western states in Nigeria. The six states are Lagos, Oyo, Ogun, Osun and Ondo Ekiti respectively. The mean number years of experience in construction industry of the respondents is 18. A total of 1450 questionnaires were sent out to the stakeholders of the industry in the south western states and only 825 questionnaires were returned. In this way the questionnaire were designed based on the, knowledge, practice and experiences of their involvement in construction activities and processes. However, various risks are associated with H&S of the workers and construction ergonomics. A total of 825 questionnaires were included in the analysis of the data which make the net response rate to be 57%. The analysis of the data consisted of the calculation of descriptive statistics in the form of frequencies and a measure of central tendency, namely a mean score (MS). The overall mean score is presented in the extreme right column. Given that the difference between 1 and 5 is 4, and that there are 5 points on the scale, there are effectively five ranges which are determined by dividing $4 / 5 = 0.80$. The data were captured using Epi-info statistical package version 3.5.1 and exported to IBM Statistics SPSS version 19 for univariate statistical analysis to measure the relationship between the variables and the frequency distribution.

The model is being developed based on the objective of the paper which is based on producing an integrated design that will promote construction safety of workers in construction site operation in a way to optimize construction ergonomics. The authors believe that the early integration to produce an integrated design for the lifecycle of a project is very relevant in reducing WMDs.



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FINDINGS AND DISCUSSION

Given that construction site and process is full of activities, the respondents were asked based on the list of activities that deemed to be occurring on construction sites. Premised on the respondents experience, the respondents were asked on the perceived extent to which various activities occur on construction sites on a likert scale 1 (minor) to 5 (major) and the calculated mean score (MS) ranging between 1.00 and 5.00. The respondents perceived that the list of activities deemed to occur on construction site with notable MS > 3.00 with activity frequent bending having the mean score (MS) = 4.31, lifting, MS = 4.40, Manually handling heavy and irregular loads MS = 4.22, climbing and descending MS = 4.27, and staying in one position for a long period MS = 4.00. It is evident that these activities are performed on a greater scale on construction sites and could have a resultant effect on workers health.

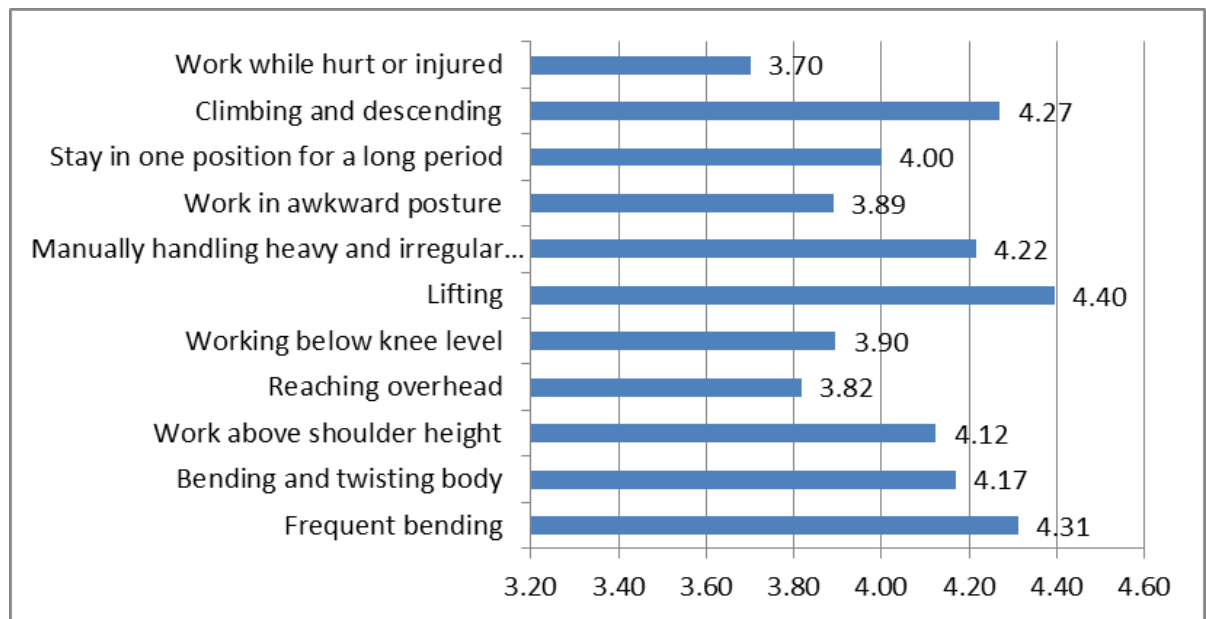


Figure 1: Perceived extent to which various activities occur on construction sites.

Thirteen design and construction intervention issues in construction were drawn from the literature and the respondents were asked to indicate the extent to which these issues optimise construction ergonomics in construction industry on a scale of 1 (minor) to 5 (major) and a MS ranging from 1.00 to 5.00. the result are presented in the table 1.



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Table 1 :Extent to which interventions /issues optimize construction ergonomics

Interventions / Issues	Response (%)						MS
	Minor	1	2	3	4	Major	
Rank	Unsure	1	2	3	4	5	
Reengineering of construction process 1	0.0	0.0	0.0	19.4	45.8	34.8	4.3
Construction experience 2	0.0	5.6	1.1	19.4	51.4	22.5	4.2
Mechanization 3	0.0	0.0	2.4	21.3	52.8	23.6	4.2
Material handling 4	0.0	6.9	0.0	16.7	62.5	13.9	4.2
Workplace organization 5	0.0	2.5	2.2	16.7	64.7	19.4	4.2
Specification of materials 6	0.0	1.1	3.2	18.4	62.1	15.3	4.2
Design of tools 7	0.0	1.2	4.4	16.7	61.1	16.7	4.2
Prefabrication 8	0.0	0.0	8.6	15.1	59.7	16.7	4.2
Training and awareness of workers 9	0.0	0.0	0.0	22.2	62.5	22.2	4.1
Layout planning 10	0.0	5.6	1.4	19.4	56.9	16.7	4.1
Design of workplace 11	0.0	0.0	8.3	13.9	62.2	15.6	4.1
Safe work procedure 12	0.0	5.6	1.4	23.6	50.0	19.6	4.1
General design 13	0.0	0.0	2.8	16.7	73.6	7.0	4.0
H&S knowledge in the design phase 14	0.0	5.6	2.8	18.1	62.5	11.1	4.0
Contractors planning 15	0.0	5.6	1.4	27.8	52.8	12.5	4.0



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Based on the perception of the respondents, the highlighted intervention / issue have all the MSs above midpoint score of 3.00. This indicates that the respondents can be deemed to perceive that intervention / issues are very vital to construction operations and can optimise construction ergonomics. However, the first to eighth ranked intervention / issue have MS $>4.2 \leq 5.00$ indicating that the intervention / issue could optimize between near major to major / major extent while the ninth to fifteenth ranked have the MS $>3.40 \leq 4.20$ indicating that the respondents can be deemed to perceived that the intervention/ issue could optimise construction ergonomics to some extent. It is noteworthy that health and safety knowledge in the design phase as it is peculiar to the designer/ architect is also considered a vital intervention in the optimisation of construction ergonomics with MS =4.0. In general, the cumulative MSs suggest that the design and construction intervention / issues positively optimize construction ergonomics which will help to improve workers health and safety.

- **Impact of stages of design and construction management on construction ergonomics**

The respondents were asked to indicate their perception on extent stages of design and construction management impacts on construction workers health. . The identified stages are Concept and Initiation, Design and development, Construction, Procurement and commissioning. The overall mean scores are presented and ranked in the extreme right hand column of the table. The table below provide the summary of the mean scores (MS) ranging between 1.00 and 5.00 based upon percentage responses to a likert type scale. The overall mean scores are presented and ranked in the extreme right hand column of the table.

Table 2: Extent of stages of design and construction management on construction workers Health

Stages of design and construction	Response (%)							MS	Rank
	Minor.....					Major			
	Unsure	1	2	3	4	5			
Construction	0.0	0.0	1.1	9.9	36.8	52.2	4.4	1	
Procurement	0.0	2.2	6.1	14.9	37.6	39.2	4.1	2	
Design and Development	0.0	4.9	4.4	12.6	47.8	30.2	3.9	3	
Concept and Initiation	0.0	6.1	3.4	11.2	57.5	21.8	3.9	4	



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The mean scores for all stages is above the midpoint score 3.00, this indicates that all the stages are important to construction workers wellbeing. It is notable from the findings that the construction stage is ranked first with MS=4.4 falling within the range $4.2 \leq 5.00$, indicating that the construction stage impacts on construction workers' health between near major to major / major extent.

The probable reason for this is that construction activities present unfavourable challenges which impair construction workers' health. Design and development, concept and initiation were ranked third and fourth having the MS= 3.9 which fall within the range $MS > 3.40 \leq 4.20$ indicating that the respondents perceived the various stages of design and construction management as impacting on construction workers' health between 'an extent' and 'near some extent' / 'to some extent'

• **Optimization of construction ergonomics**

Given the respondents experience in Nigeria construction industry, the respondents were asked to indicate based on their perception to what extent do / does design and construction parameters / intervention issues optimises construction ergonomics in construction industry on a scale of 1 (minor) to 5 (major) and a MS ranging from 1.00 to 5.00. Given the responses relative to identified fifteen design and construction parameters during the various project phases as highlighted in the table 3.

Table 3: Potential of various parameters / intervention to optimise construction ergonomics.

Parameters/ intervention	Response (%)						MS
	Minor.....	Major					
Rank	Unsure	1	2	3	4	5	
Reengineering of construction process 1	1.4	8.1	5.3	30.7	23.4	31.3	4.79
Training and awareness of workers 2	0.0	0.0	0.0	5.3	49.9	50.1	4.46
General design 3	0.0	0.0	2.8	7.8	37.8	51.7	4.4
Design of workplace 4	1.1	0.0	3.4	7.3	43.3	44.9	4.3
Workplace organization 5	0.0	1.7	2.2	12.8	33.0	50.3	4.3
Safe work procedure 6	1.1	2.2	1.7	5.6	42.2	47.2	4.3



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H&S knowledge at the design phase 7	0.0	0.0	5.1	8.7	49.1	36.5	4.23
Construction experience 8	1.0	0.0	1.7	10.7	47.2	39.4	4.2
Material handling 9	0.0	0.0	2.2	14.9	39.2	43.6	4.2
Prefabrication Preassembly 10	1.4	1.7	2.8	19.0	31.8	44.7	4.2
Specification of material 11	0.0	1.1	2.2	12.2	41.1	43.3	4.2
Design of tools 12	0.0	2.8	5.0	18.9	29.4	43.9	4.1
Layout planning 13	0.0	1.1	3.9	18.2	39.2	37.6	4.1
Contractors planning 14	0.0	1.7	3.9	17.1	38.7	38.7	4.1
Mechanization 15	0.0	0.6	5.6	17.8	58.3	17.8	3.9

It is noteworthy that all the MSs are above the midpoint score of 3.00 which indicates that the respondents can be deemed to perceive the various parameters / interventions to have the potential to optimise construction ergonomics. The hierarchy on the table suggests that the respondents are of the opinion that reengineering of the construction process, which is ranked first, may have a great potential to optimise construction ergonomics. Reengineering of the construction process notably predominates with its MS =4.79 effectively higher than the other 10 ranked parameters. Given affirmative response as indicated in the high MS from the findings it is notable that the respondents agree that these identified parameters have a potential to optimise construction ergonomics to a degree. Therefore, it is necessary to consider these parameters when considering improvement in construction ergonomics in Nigeria construction industry

INTEGRATED DESIGN MODEL

The main focus in integrated design modeling for construction ergonomics has been on activities and their interconnections and information that flow between them. The proposed integrated model is based on decision- analytic model type (It helps in deciding on a course of action based on the expected payoffs or outcomes of different scenarios. Decision-analytic models do employ matrices of payoffs for different possible outcomes, which can be displayed as decision trees showing the branching points and paths to the outcomes and probabilities describing the likelihood that each branch or outcome will occur. The objective



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of a decision-analytic model is often to choose the path to the optimum outcome given some criteria for success, whether that is to maximize gain, to minimize risk, or to meet some other criterion).

Construction is generally believed to be a fragmented industry and increased integration and coordination among different processes and parties is considered by many experts as discussed in the literature as one of the ways that can resolve most of the problems created by fragmentation. Therefore the model presents the possibilities of early integration of health and safety practitioner and construction manager in the design and documentation stage of the project lifecycle to achieve a healthy site, reduced of WMDs. It is in the design stage where the requirements of the client are identified and the constructive aspects and the standards of quality are defined through procedures, drawings and technical specifications. Currently, the work within the design stage is split into several temporary sequences, and it is delivered to different specialists for its execution. These fragmentation has been identified to have created health and safety issues that results in WMDs as the design is been carried out by the construction workers.

Thus, some of the consequences of the fragmentation problem that is impeding on the unhealthy systemic process that affects the wellbeing of workers are highlighted below.

- Lack of early integration, coordination and collaboration between the various key functional disciplines involved in the lifecycle of a project.
- Inadequate capturing, structuring, prioritation and implementation of clients' needs.
- Lack of true lifecycle analysis of the construction projects
- Poor communication and design intent and rationale, which leads to unwarranted design changes.
- Inadequate pre and post-design specifications
- Failure to address the health and safety issues of the project at the design stage

In developing the model, the aim was to provide a structured systemic process which practitioners in the building industry can adopt in reducing the impact of WMDs in construction operations stemming from the most significantly influencing factor category, which is project design and implementation stage. Based on the input of construction manager and the health and safety practitioners on the project design and documentation prepared by the designers and consultants, an integrated design is achieved which take cognizance of the feedback monitoring system for H&S of construction workers at the implementation stage. The integration part of the model is the introduction of construction manager, and the health and safety practitioner to be involved early in the design phase (integrated design team) and also serve as integrative monitoring officer at the construction phase. Their various inputs in



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the design and documentation of the project to favour its implementation produce an integrated design for construction ergonomics for the project.

This implies that the construction stage is crucial as it is the operation field for the construction workers where the achieved integrated design by the professional consultant is executed.

However, before design and construction processes begin, there is a stage of pre-project planning which involve the establishment of a project scope by the client. At this stage the construction and design professionals are not involved. Project scope involves project alternatives at a conceptual level, analyzing project risks and economic payoffs, developing a financial plan and deciding upon project organization (Anumba,2000). It is pertinent to note that client’s commitment is very vital for the appointment of a project manager which comes on board as early in a project’s life as possible in order to capitalize on his or her expertise in formulating early decisions for the project. In the model in figure 3 the activity are represented by the boxes and are connected by arrows representing the interconnections to define the activity flow.

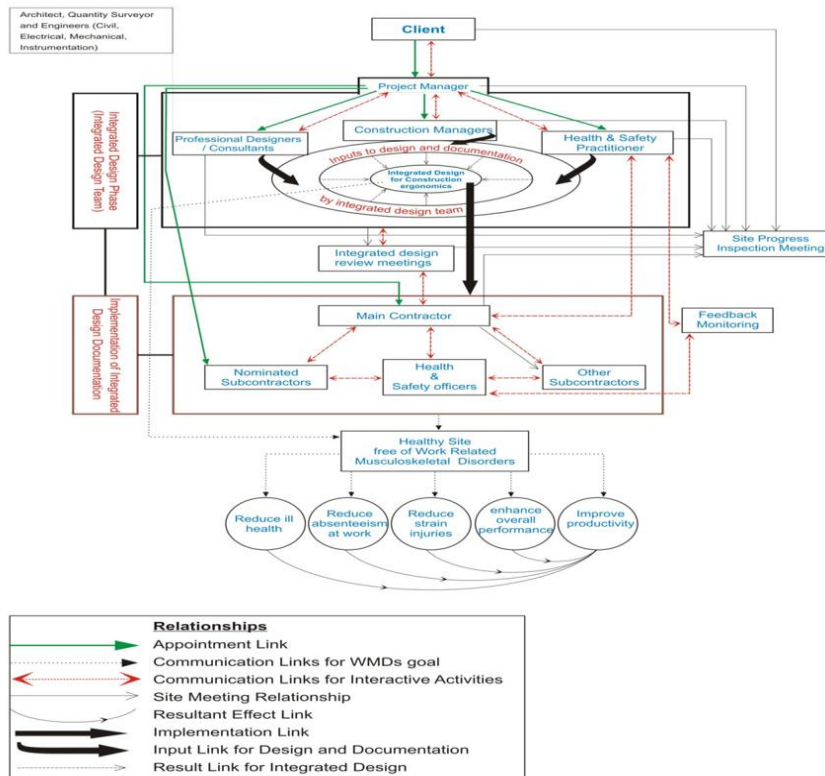


Figure 2: Integrated design model for construction ergonomics



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THE CYCLIC RELATIONSHIP OF THE MODEL.

The proposed model (figure 3) is anchored on the relationships of the stakeholders resulting in a cyclic path that promotes a healthy site which has a positive impact to reduce: ill health, strains and pains injuries, absenteeism, enhanced overall performance and improve productivity and further promotes feedback mechanism for construction monitoring operations. As identified in the literature, the detailed composition of the proposed model's participatory team are as follows; the clients (public or private); the project manager, the design/ consultant professionals (architects, structural / civil engineers, quantity surveyors), the construction manager, the main contractor, and an experienced health and safety practitioners, The integrated design team comprises of Professional designers/ consultants, construction manager, and the health and safety practitioners. The construction implementation stage is led by the main contractor that coordinates the services of the subcontractors and the health and safety officers.

Typically, the client initiates the project appoints a project manager and procures the services of the designer to design and produce documentation and specification for the project. Thereafter the contractor is procured usually through tendering process and upon the appointment of the contractor the actual construction work is implemented and constructed under the monitoring of the construction manager. The procurement method used determines the number of tenders to be done on a project.

However, the contractor engages the construction workers to carry out the construction of the design and the specification. Thus the appointment of sub-contractors in the projects depends on the type of work to be carried out as they could be individual or organisations who enter into an agreement with the main contractor with the aim of completing a section of the project at an agreed sum (this is due to the fact that the main contractor does not have the essential expertise to implement all the different types of work necessary on a project). The model made a provision for the appointment of H&S officers by the client to oversee the health and safety of the worksite as highlighted in the literature. Thus in all the stages of procurement, H&S issues must be integrated so as to reduce the risk experienced by the constructors.

Traditionally, the separation of the design and construction processes, lack of integration due to fragmentation in the tasks and the employment of a whole series of consultants to a design project always has an effect on the health and safety system of a construction project. As a consequence, workers' health and safety issues are not built into the design process and the designers of the project have a very little influence on the construction process methods and materials used. The model take into account the input of the health and safety practitioners, construction manager in the design and documentation as to allow for the upheld of



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construction safety of workers against WMDs in the construction operation. This input from these stakeholders results in integrated design for construction ergonomics which is implemented at the construction phase.

In a bid to evaluate WMDs risk among the construction workers, the proposed model promotes a multidisciplinary participatory team involving the client (through PM), design professionals, construction manager and health and safety practitioner which provide effective monitoring to the construction workers' in all stages of operation. This team forms the management for the construction project.

The proposed integrated model takes into account the inputs of all stakeholders in design and construction processes so as to improve the health and safety risks in construction workplace as this area is not usually considered important in the Nigerian construction industry's operation process. Moreover, because of the dynamic nature of the construction work environment, construction workers have a key part to play in the management of their own health, facilitated by the provision of education and training as part of promoting a healthy site in reducing the impact of WMDs((Gauci and Vella, 2000).

As proposed in the model, the management works together to ensure a healthy site that has regard for health and safety of construction workers thereby reducing the onset of WMDs during as they execute the design to ensure high productivity and reduces absenteeism; enhanced overall performance reduces ill health and strain injuries. Furthermore, the feedback information provided by the constructors to the management promotes the well being in the construction workplace and averts the onset of WMDs by reviewing activities which pose these threats and also helps on how to improve performances. However, with this mechanism, attentions is paid to injury and illnesses and incident data, thereby creating analyses for immediate and underlying causes of the associated risks (events) and also create a healthy site that enhances productivity of workers.

CONCLUSION

A model to promote integrated design for construction ergonomics has been presented. The proposed model promotes a participatory team regarding H&S of construction workers resulting from the consultation and collaboration between the key stakeholders (design/consultants, H&S practitioner and construction manager) that could bring about optimal designs of materials, equipment, permanent work and work tasks (pre-fabricated components should be planned into the production process, to avoid some awkward, heavy and repetitive work tasks and thereby creating a better workplace for construction workers). The paper acknowledged that the work tasks and their definition can be time consuming at the



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inception stage of project operations but for effective ergonomic process, the sequential site operations of construction activities of work tasks must be clearly stated for proper monitoring and communicating link feedback to the management of the project to promote health and safety of the workers inputted and analysed into the design documentation before the implementation of the design.

The study, however, established that various interventions impact on the risks associated with health and safety of the construction workers and construction ergonomics. Based on the findings from empirical survey and the survey of literature, awareness relative to ergonomics is needed in the Nigeria construction industry and there is a need for designers to consider in their designs how to reduce or eliminate construction work injuries such as WMDs.

The study determined that baseline knowledge regarding the WMDs is inadequate as there are major concern about safety procedures and feedback from site employees .The result of the analysis relative to the mean scores indicate that there is need for an increase in training knowledge on strategies to reduce the onset of WMDs among construction workers. Baseline knowledge in the area of health and safety of construction workers is significant to construction site operations of construction workers.

To this end, health and safety plan or programme for construction workers hardly happens. Regrettably, there is no evidence of medical surveillance mechanism to show how the health status of workers was monitored. There is a need to detect early signs of illness in construction workers so that intervention may be taken to prevent permanent health damage resulting from occupational illnesses due to construction tasks.

Furthermore, the study confirmed that construction activities impact negatively on the construction worker as a result of various body actions and affects the workers physically. Thus design dictates most of the activities and, however, contributes to the onset of WMDs. In the conceptual model, the designers are to get inputs from other stakeholders in a construction project in order to adopt a integrated health and safety design that is not detrimental to construction workers during the phases of construction. The result of such partnerships benefits the health and safety of the construction workers, end users and enhanced productivity and quality.

REFERENCES

Adenuga, O. A., Soyingbe, A. A., and Ajayi, M.A.(2007). A study on selected safety measures



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Ajayi, O¹., and Thwala W.D². (2015) Developing an Integrated Design Model for Construction Ergonomics in Nigeria Construction Industry In: Mojekwu, J.N., Ogunsumi, L.O., Ojigi, L.M., Atepor, L., Thwala, D.W., Sackey, S., Awere E., and Bamfo-Agyei, E. (Eds) African Journal of Applied Research (AJAR) Journal, Vol.1, No.1 ISSN 2408-7920 January 2015, Cape Coast, Ghana. 478-495

on construction companies in Lagos, Nigeria. *Proceedings of the construction building research conference of the Royal Institution of Chattered Surveyors*. Georgia tech, Atlanta USA 6-7 September 2007.

Agumba J., and Haupt T. (2008). Perceptions of construction Health and Safety performance Improvements enablers. *Proceedings Third Built environment conference* 6-8 July 2008 Cape Town South Africa . ASOCSA 2008-68

Ajayi, O., and Thwala, W.D. (2011a). Sustaining the strategies for reducing the impact of Work related musculoskeletal disorders in the Nigerian construction industry. *Proceedings ICBEDC 2011 Bendahari Universiti SANS Malaysia* (PM 010): 180-197.

Ajayi, O., and Thwala, W.D. (2011b). Operational system perspective for construction worker's health and safety. *Proceedings of CIDB 2011- 18, University of Pretoria*. South Africa: 168-180.

Anumba, C. J. (2000). Integrated systems for construction challenges for the Millenium. *Proceedings of the International conference on construction information technology (INCITE) 2000*, Hong Kong. 78-92.

Budnick, P. (2001). Ergoweb's Answer to 'What is an Ergonomics Injury'. *Ergonomics Today*. *Quick News* Coble (eds) .Balkema, Rotterdam. ISBN 90 5410847 9 pp 361-364

Belle, R. A. (2000). Benchmarking and enhancing best practices in engineering and construction sector. *Journal of Management in Engineering*, 16(1), 40-47.

Gauci, M., and Vella, N. (2000). Musculoskeletal disorders in the building and construction industry in Malta. <http://mt.osha.europa.eu/publication/msd.doc>. pdf. 1-9 Accessed 11/10/2007

Gibb, A., Haslam, R., Hide, S., and Gyi, D. (2004). The Role of Design in Accident Causality. In *Designing for Safety and Health in Construction Proceedings from a Research and Practice Symposium*, University of Oregon, edited by Hecker, S., Gambatese, J. and Weinstein, M. (Oregon: Labour Education Research Centre).

Hallowell. M. (2008). A formal model of construction safety risk management. *Dissertation (PhD)* Oregon State University.

Haupt, T.C., Deacon, C.H., and Smallwood, J.J. (2004). The threat of Musculoskeletal disorders in older construction workers. *Journal of Occupational Health Southern Africa*, 10(5), 12-16.

Hecker, S.F., Gambatese, J., and Weinstein, M. (2006). Designing for construction safety in the US. Progress, needs and future directions. *Proceedings IEA 2006 Congress*, July 10-15, Maastricht, Netherlands.

Health and Safety Executive (HSE), (2004). Occupational Ill Health Statistics, Updated 2004. Accessed on 10/10/2007(<http://www.hse.gov.uk/construction/pdf>)

Health and Safety Executive (HSE), (2009). Construction Division, the construction intelligence report. Retrieved from: <http://www.hse.gov.uk/construction/pdf/conintrep0405.pdf>.

Hsiao, H., and Simeonor, P. (2001). Preventing falls from roof; A critical review. *Ergonomics*,



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²didibhukut@uj.ac.za

Ajayi, O¹., and Thwala W.D². (2015) Developing an Integrated Design Model for Construction Ergonomics in Nigeria Construction Industry In: Mojekwu, J.N., Ogunsumi, L.O., Ojigi, L.M., Atepor, L., Thwala, D.W., Sackey, S., Awere E., and Bamfo-Agyei, E. (Eds) African Journal of Applied Research .(AJAR) Journal, Vol.1, No.1 ISSN 2408-7920 January 2015, Cape Coast, Ghana. 478-495

44, 537-561

- Idoro, G. I. (2011). Effect of Mechanisation on occupational health and safety performance in the Nigerian construction industry. *Preview Manuscript Journal of construction in developing countries*
- MLPC, (2008). Marxist Leninist Party, Canada, reports, <http://www.mlpc.ca> accessed 4th May 2008.
- Mohamed, S. (2003). Scored approach to benchmarking organisational safety culture in construction. *Journal of Construction and Engineering Management*, 129, 80-88.
- Oh, J.I.H., and Sol, V.M. (2008). The policy program improving occupational safety in the Netherlands: An innovative view on occupational safety. *Safety Science*, 46(2), 155-163.
- Rowlinson, S. (2003b). Overview of construction site safety issues, pp221-232.
- Rwamamara, R., and Holzmann, P. (2007). Reducing the Human cost in construction through Designing for Health and Safety – Development of a conceptual participatory design model. *Second International Conference World of Construction Project Management*, edited by Ridder, H., and Walmelink, J.,
- Rwamamara, R. (2007). Planning the Healthy Construction Workplace through Risk Assessment and Design Methods. *Unpublished Doctoral Thesis*, Lulea University of Technology, Lulea,
- Schneider, S.P. (2001). Musculoskeletal Injuries in Construction: A review of the literature. *Applied Occupational Environmental Hygiene*, 16(11), 1056-1064.
- Smallwood, J.J. (2000a). Ergonomics in Construction: Management and Workers' Perceptions. In *Proceedings of the IEA 2000 / HFES 2000 Congress*, San Diego , 632-635.
- Smallwood, J. J. (2000b). The holistic influence of design on construction Health and Safety (H&S): General contractor (GC) perceptions. In *Proceedings of the Designing for Safety and Health conference, London*, edited by Gibb, A.G.F. 26th – 27th June
- Smallwood, J. J., Deacon, C.H., and Venter, D.J.L. (2000). Ergonomics in Construction: Where does it Hurt? *Proceedings of the 14th Triennial Congress of the International ergonomics association* San Diego, June. pp(5) 644-646.
- Vedder, J., and Carey, E. (2005). *A multi-level systems approach for the development of tools, equipment and work process for the construction industry*. Work Science & Ergonomics, Hilti Corporation, FL-9494 Sachaan, Liechtenstein.
- Vitasini, N., Neitzert, T. R., Rotimi, J. O. B., and Windapo, A. O. (2012). A framework for subcontractor integration in alliance contracts. *International Journal of Construction Supply Chain Management*, 2(1), 17-33