

Human factors issues at selected workplaces in Nigeria: practice, status and future research needs

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Article History

Received September 13, 2022

Accepted July 13, 2023

Published August 02, 2023

Keywords

Artificial intelligence
Ergonomics
Human factors
Productivity

DOI:

[10.24840/2184-0954_007-001_001812](https://doi.org/10.24840/2184-0954_007-001_001812)


ISSN:

2184-0954

Type:

Review

 Open Access

 Peer-Reviewed

 CC BY

Abstract

Human factor or ergonomics animates a productive system with the capability of a community of production factors that are not productive. The current paper aims to identify research and practice issues of human factors (HF) in the existing literature on Nigerian scenarios. The specific objectives include conducting a review on ergonomics awareness, collating thought-provoking lived experiences gained from human factors practice across sectors of the economy, highlighting their status, and offering valuable tips on the emerging future of HF for workplaces in Nigeria. Understanding HF issues helps to plan and improve productivity at workplaces. The issues treated herein were topical subjects in recent debates about the COVID-19 era, work evolution, human factors, or ergonomics (E) practice in Nigeria. This review article applied a cross-sectional approach involving the descriptive survey and qualitative analytical methods. Analysis carried out incorporated computation of frequency of publication on each issue, which aided the discussion on status. Findings have shown that knowledge or awareness of HF/E is low, and applying the practice at work positions is equally low in Nigeria. Furthermore, the results suggested an insignificant rise in the status of HF/E by research studies. Surreptitiously, the high prospects for growth of HF/E and the ancillary factors like AI and robotics are foreshadowed in low levels of both practice and awareness. The analysis mentioned that the rising frequency of HF/E issues at the workplace has all-inclusive and mutually exclusive implications for the employee. The study's outcome can contribute to positive change in organizational productivity, product design and process design since scientific research on the gaps can facilitate advancement in knowledge.

1. INTRODUCTION

A compound of diverse operative elements, which are unproductive, animates a workplace's nature as an effective system. In designing the work system, the industrial engineer arranges those elements to work together to achieve the desired output from the system. The operative components involve equipment, information, facilities, capital, energy, materials, processes and human beings. The human part leads to other components in the productive system and is referred to as human factors (HF), often-called ergonomics (E). Conceptually, HF/E is defined as a scientific study of the relationship between man and his working environment (Brech et al., 1966; Pao et al., 2001; Olabode et al., 2017; Okoye et al., 2018; ISO 9241-11: 2018; IEA, 2003). HF/E takes responsibility for the care and control of other operative components to ensure a good fit or seamless interaction among them. It is also essential for the improvement of the human-machine interface. Today, there are emerging ancillary components with a human-like performance called robots, computers and intelligent machines or artificial intelligence (AI) integrated into human factors. In practice, a breach in this duty of care by the primary and ancillary operative components influences the worker's behaviour or work process. It gives rise to severe human factors or ergonomic problems for debate. The issues can also result from a mismatch between the demands imposed on human

components by work conditions or environment. Often, little is known about those infractions or issues in the literature. Identifying some of these lived experiences in work practice has become timely and necessary because they are topical questions of hot debates in the COVID-19 era. But no work had distinguished between the nuances in the work orders of pre-COVID and COVID-19 periods. For example, what impact has the COVID-19 era had on some vital issues involved in the practice of human factors or their ancillary components, and how can it adversely affect the work evolution and productivity at workplaces in Nigeria? Much as the question is crucial, data about the underlying issues resulting from the interaction of HF/E with work processes are non-existent and considered an oversight requiring urgent care.

The sloppy oversight is a critical problem in this COVID-19 era characterized by uncertainty, which further poses a concern to HF/E workplace experts. Uncertainty is a big problem in an organization that affects line balancing and, ultimately, the throughput (Nwanya and Achebe, 2020). This study was further inspired by the need to explore the emerging future of HF/E in the context of the new work order since the COVID-19 pandemic era provided a new impetus for relegating the human component to a negligible level in productive work systems. The pandemic, execution of plans to solve it, and assessment of its impact on people and work systems is a human problem and a challenge to Nigeria.

Thus, the experience gained in the COVID-19 work orders, the "new normal", has taught engineers lessons. Key highlights of the "new normal" are working from home, social distancing, and mandatory quarantine problems that further dehumanized the work environment. This is the point at which the role of HF/E intricately woven with other operative elements is in jeopardy. Covertly, the orders isolated human factors or ergonomics attributes from the workstation. If these problems are complacently implemented at this evolving stage, the consequence will adversely affect productivity growth. Studies concerning the implications of these new orders on the work process are non-existent in Nigeria. As Gurses et al. (2020) pointed out in the work cited by Albolino et al. (2021) HFE can develop effective mechanisms and tools to follow the recommended COVID-19 practices. Aside from the perspective of pandemic orders, the advent of artificial intelligence is a significant cause for concern among HF/E experts because it diminishes the contents of human factors in productive systems. The cumulative effects of both perspectives are overlooked, but critical questions are raised by thoughtful inclusion in the current article, which brings out valuable insights for HF/E researchers.

The challenging questions for Nigeria at this time include: by fitting these new orders to workers' convenience, how will they benefit the value of HF/E content, or under what circumstances do their application impede productivity in workplaces?; what are the implications of the orders to employees' performance and the evolution of work? Even though there is no reliable answer to these questions in the literature, this study is considered a priority step to highlight deficiencies in HF/E values at the workplace. In summary, identifying the issues with appropriate solutions will help reduce factory closures, loss of man-hours and injury compensation costs. It further revealed opportunities for possible research advances and expressed insightful relations between the human operative system and other elements of a productive system. Given the previous problem context, the study on practice, status and future trends was conducted.

Hence, this work aimed to identify research and practice issues of human factors (HF) by review of the existing literature on Nigeria's scenario. The objectives include confirming what we already knew about ergonomics awareness, collating thought-provoking lived experiences gained from the practice of human factors across sectors of the economy, highlighting the current status of HF/E at workplaces, and discovering trending patterns for future work evolution in Nigeria.

This paper's contents have been structured to present a concise introduction. Then, the research methodology is explained. The survey of categories of prevalent human factors issues in workplaces in Nigeria is shown inclusive of the concept of HF/E interactions in a work process. Then, the analysis and interpretation of survey findings are presented.

The following section applies artificial intelligence (AI) technology in human factors practice and future perspectives for Nigeria. Later, the awareness level and status of human factors practice in Nigeria from 2006 to 2022 is presented. The paper ends with a conclusion and directions for future research.

2. METHODOLOGY

This study conducted a review by theme search strategy of a total of 80 papers published from the year 1983–2022. The documents reviewed were critical to the practice of HF/E, majorly from high-ranking journals and were extracted from different databases. A cross-sectional approach involving the descriptive survey and qualitative analytical methods was applied to establish what exists in Nigeria's subject area. The spectrum of HF/E activities was classified according to sectors ranging from health, agriculture, education, and aviation to manufacturing to collect data from reviewed papers. In evaluating the issues, the conventional ergonomic work segments were grouped under three occupational activities: policy, facilities and awareness creation. A record of the number of times an issue occurred due to the practice of HF/E activity was obtained for each sector. The arrangement of data for practical analysis was in tabular format. Analysis carried out incorporated computation of frequency of publication on each issue which will aid the discussion of status. Also, since the pandemic impacts all facets of the productive system, the scope of this study covered many sectors of the economy.

Also, three occupational activities, such as policy, facilities and awareness creation, were used in evaluating the issues.

- Ergonomic facilities: concerned with working facilities in terms of chairs, tables, computers, typewriters and tools provided to perform office work.
- Ergonomic policy deals with the volume of work given to the worker, the sitting and working time in the office, the age consideration when assigning work, and work breaks/allowances. It also focuses on the work reward system. Using humans as an extension of a machine has safety, health and productivity implications (Gambo, 2020).
- Ergonomic awareness: concerns employee understanding of ergonomic functions in safety and health situations by self without coercion. Raising awareness about rules by publicizing them through seminars, training and union meetings from time to time to create effective means to bridge the knowledge gap in the workplace is the watchword. Based upon the above-highlighted segments as it concerns work environments in Nigeria, significant disparities not under standard practice are revealed.

In these occupational activities, as a general guide, tasks requiring body positions to be in awkward situations increase the risk of WMSDs (Naik and Khan, 2020).

3. RESULTS

3.1 Conceptual approach to Human Factors and Ergonomics interactions in work processes

An ideal interaction is provided by three aspects of the uncategorized human factors, as illustrated in Figure 1.

In Figure 1, Tulfs (2021) demonstrated good knowledge about the interactions within a work process. Still, they could not expose inconsistent HF/E issues that are latent, which can be gleaned from the analysis of the following work segments:

- Tasks, task accomplishment and patterns
- The work environment and workplace design
- Workplace culture and communication
- Leadership and resources
- Organizational policy, programs and procedures
- Worker competency and skill
- Employee attitude, personality and risk tolerance

Thus, [Figure 1](#) is an abstract representation of a productive system. In this regard, it is believed that the interdependence of the HF/E components is complicated and for their inseparable nature, they will create sore points as serious HF/E issues.

The interaction of human factors



Figure 1. Uncategorized interaction of human factors within a workplace (Tulfs, 2021)

The complexity concern is an aspect to which to turn attention because the issue of the internal organization may arise through differences of discipline of experts in the workplace. Hence, HF/E practice faced the challenge of monitoring, evaluating and sanctioning deviation from the extant design specifications of the workplace in Nigeria. Which ancillary human component can carry out the difficult role of effectively monitoring, assessing and sanctioning deviation for HF/E? Herein lies the main argument for AI.

3.2 Prevalent human factors issues from occupational profiles of the productive systems

The HF/E experts in Nigeria have realized that the level of practice of HF/E makes the difference between high-quality and low-quality designs among sectors. Although the extent of practice has recently increased, these are not without concerns. There have been concerns about human factors issues that confront workplaces since the COVID-19 era when restrictions were imposed to avert the spread of the disease. They are accounted for by the changes in adaptive practice (Huntsman et al., 2021), inclusive leadership and adaptive performance (Yu, 2020), which are challenges to employees in a changing workplace.

Hence, enhancing the human factors can serve a wide range of organizational objectives in a productive system, including improved productivity, product design, process (production system) design, and corporate design (Lim et al., 2009). The consequence of failure to align workplace practice with the HF/E standard gives rise to work-related musculoskeletal disorders (WRMSD) issues. Understanding the issues is critical to sustainable planning for diverse workplaces.

Considering the workplace diversity challenge, a work-study approach was employed to unravel human factors that impact employee health at different work segments in Nigeria. Identifying the specific problems with the potential for WRMSD at selected work centers on a sector-by-sector basis is much akin to assessing ergonomic issues from the perspective of natural resources available in various locations in Nigeria, as shown in Figure 2. The reason for this perception is that some of the artisanal trades have widespread practice as depicted in Figure 1. From the Solid Mineral Map (2019), solid mineral exploration is the second largest occupation after agriculture, and both have a large number of citizens participating in similar manual labour (heavy lifting and tilling) with localized ergonomic risk factors.

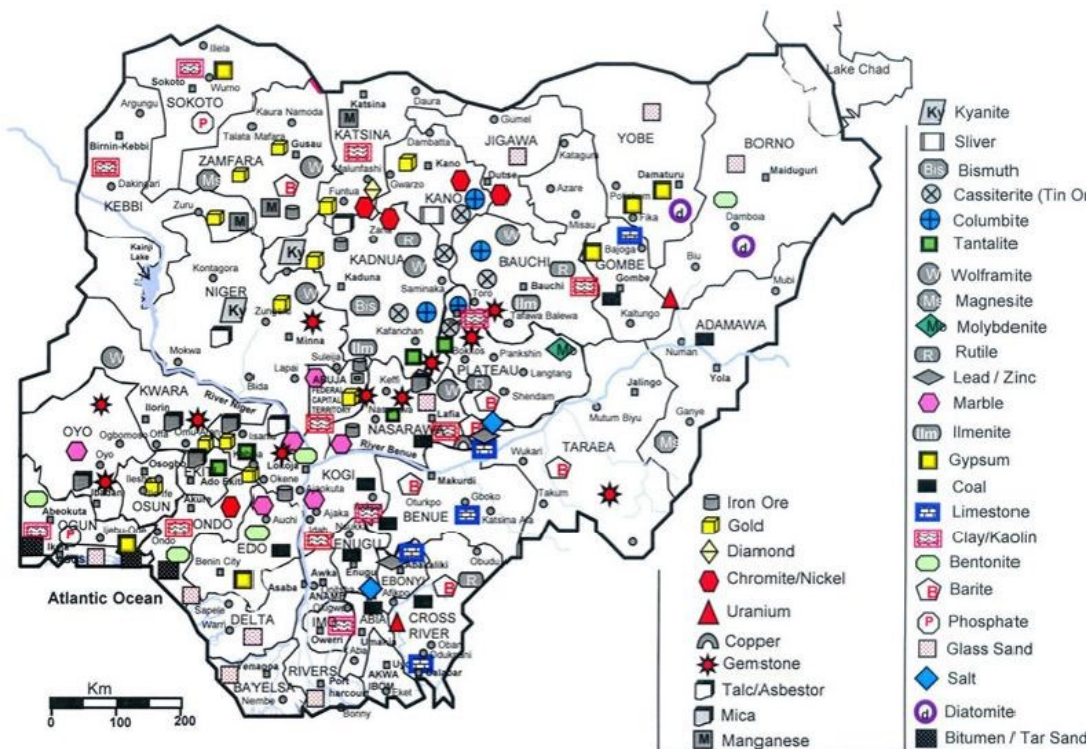


Figure 2. Map of Nigeria showing natural resources from Nigeria akin to occupational activities (Solid Mineral Map, 2019)

In the agricultural sector, diverse issues such as: lifting and carrying heavy loads (over 50 lb.), sustained or repeated full body bending (stoop), and very highly repetitive hand work (clipping, cutting) (Eguoaje et al., 2019) are the major ergonomic problems. Also, weeding, chemical application and harvesting are major management practices engaged by farmers. These practices, according to Olowogbon et al. (2021), expose the farmers to sprayer-borne ergonomic risk factors as they are often found mounting heavy sprayers on their backs for long hours and engaged in repetitive static positioning while applying farm chemicals. Poor work posture, long-range repetitive static positioning and forward bending are characteristics of manually tilling/ridging, weeding, or harvesting operations, leading to musculoskeletal disorders (Ogunsanya et al., 2011). Next to agriculture with endemic WRMSD is the information and communication technology infrastructure.

Information and communication technology (ICT) is classified as an occupational facility or tool that enable computing activity and has wide applications in HF/E. According to Ogunsola and Aboyade (2005), as cited by David-West et al. (2020), ICT introduction into human factors activities led to several issues, including re-organization, changes in work patterns, and demand for new skills and job retraining. Other examples of incident issues of human factors associated with ICT practices are bound. Poor interaction between the computer and the user results in severe health problems, such as eyestrain, backache and swollen wrist. Carpal tunnel syndrome, tennis and golfer's elbow, low back pain, shoulder tendinitis, and bursitis (Momodu et al., 2014; NCTC, 2007; Hadge, 2007). For the telecommunication industry in Nigeria, safety issues, according to Oyedijo

(2012) and Oyeniran and Onikosi (2016), are at the center of the errors caused to human factors, as cited by Kukoyi and Aigbavboa (2019), which have worked against the early development of the industry.

In the maintenance and repair of machine/mechanical equipment, we have issues lifting heavy objects. Improper time management is another ergonomic or HFs issue that cuts across most organizations in Nigeria. Inaccurate standard time has been a critical barrier to high productivity gains and entrepreneurial growth (Nwanya and Chukwu, 2019). As the work process evolves in the era of AI, the attention of ergonomists should focus on developing a synergy between AI and HFs on the one hand, while on the other hand, promoting awareness and the integration of AI in workplace areas for capacity development and ameliorating those issues of concern.

In automobile workshops, the risks factors that characterized the workplace include artisans' poor educational background, environmental pollution from exhaust, used oil and grease droppings, poor house-keeping, defective facilities layout, poor attitude to safety guidelines, and accidents with varying degrees of hazards (Onawumi et al., 2022; Ukoha, 2022). However, little is known about the workers' perception of the preventability of these problems (Afolabi et al., 2022). Hence, in this study, the authors exposed how informal automobile artisans in Nigeria perceive the preventability of occupational safety and health (OSH) problems and possible barriers to prevention. Workplace heat exposure is a significant issue affecting informal artisans in Nigeria. Excessive workplace heat is well-known to portend occupational health and productivity constraint since high body temperature or dehydration causes heat exhaustion and heat wave (ILO, 2019). Fatigue distorts human internal balance (homeostasis). As the authors' comment revealed, maintenance professionals in countries with decent work deficits are most affected by heat stress and have higher rates of working poverty, informal employment, and subsistence agriculture.

This study also explored the nexus between HF/E and the safety of aviation activity which is in-depth and robust. The safety of air transport is the most crucial HF/E issue, and the lack of it accounts for the inability to develop strong and viable air transport industries in Nigeria. In some airports, basic infrastructures such as perimeter fences are lacking, and for some, access roads are in poor condition (Nwaogbe et al., 2013). In addition, there have also been recurring issues of poor air traffic control (ATC), which are assignable to HF/E. Also, highway traffic safety administrations in Nigeria record a high rate of accidents arising from sleep-deprived drivers (Aworemi et al., 2010). Nigeria has a high-stress level considering human factors in safety and security, population density, socio-political stability, air, light, noise pollution levels, traffic congestion and weather conditions.

Safety and health practices are integral elements of HF/E issues in a construction site. But, the current status of occupational safety and health practices in Nigeria is at low esteem due to a lack of functional legislation and adequate enforcement (Waziri, 2015). In the Nigerian construction industry, various authors have decried the topical issues prevailing in the sector, which include labour-intensive activities, low safety consciousness and culture, poor organizational relationships and low-skill labour force composition resulting in the prevalence of hazards and accident occurrences as well as inadequate documentation and reporting culture (Idoro, 2011; Ogodor, 2020; Edem and Akinsola, 2021; Okoye et al., 2017; Agwu and Olele, 2014). Also, in Aniekwu (2007) and Udo et al. (2016), as cited by Williams et al. (2019), construction activities take place in Nigeria mostly under inclement weather conditions. The harsh weather predisposes the workers to stress and accidents. Also, in block-making, subsector workers suffer from lifting-related injuries, including fatigue and back and shoulder pains, because manual lifting aggravates forces on the humans spine (Adeyemi et al., 2020). It has been suggested that lifting loads should be at a neutral posture (body not twisted) (EGMH, 2007).

Applications of human factors with assistance from ICT in the health sector have increased in Nigeria. ICTs have the opportunity to support patients in carrying out activities of daily living at various levels (Harrington et al., 2020). Arguably, the Nigerian health sector has successfully trained indigenous health personnel. Still, it has a problem

of a rugged work environment which accelerates the migration rate of these personnel overseas. Prevalent ergonomic issues in the health sector include work-related stress associated with excess workload, long working hours, numerous shift duties and many patient attendances without adequate compensation package (Ephraim-Emmanuel et al., 2019). Work-related musculoskeletal disorders (WRMSDs) can arise due to unhealthy ergonomic work conditions (Vural and Sutsunbuloglu, 2016). The authors' statement corroborates that the workplace environment, as shown in Figure 1, is a critical element for a harmonious interaction and can make or mar other human factors in a productive system.

A range of other HF/E issues treated in the health sector under tasks, workload and work patterns abound in Nigeria. For example, Orji et al. (2022) researched common occupational health hazards among healthcare workers. They found work-related stress (83.3%), needle-stick injuries (75.6%), bloodstains on the skin (73.1%), sleep disturbance (42.3%), skin reactions (37.2%), assault from patients (24.3%) and hepatitis (8.9%) as significant issues. The first four issues relate to task allocation, work environment and patterns which are core HF/E problems. According to Elaho and Odion (2022), the productivity of employees in any organization is one of the significant administrative subjects that have gotten noteworthy attention from HF/E. But excess task workload can result in human performance issues such as slower performance and errors such as slips, lapses or mistakes. It should also be noted that under-load can lead to human performance issues such as boredom, loss of situation awareness and reduced alertness (HSE, 2021). Hence, the health sector in Nigeria is predominantly exposed to work environments with various psychosocial and ergonomic stressors. More so, there has been policy inconsistency owing to frequent changes of governance from the civilian to military and within the army and back to the civilian administration with different policies (Omoleke and Taleat, 2017).

The identified categories of HF/E errors affecting the economic sectors arguably can be attributed to relapsed synergy among organizational policies, facilities and procedures, as shown in Figure 3.

The human factors in a productive system are in part directed to the manipulative and operative tasks and mental processes such as deciding, designing and calculating figures. It should be noted that the success of these tasks and methods rest on organizational policies, programs and procedures. The HF/E issues arising from them include constantly changing or inconsistent work schedules and fatigue, leading to drowsiness and unreliable workplace performance (Heizer and Render, 2009).

In the educational sector, the range of HF/E problems in the industry is broad, and they are no trivial matters to be neglected. The high involvement of human labour (cognitive and visionary) in the sector has been increasing concerns for HF/E considerations in designing physical teaching and learning facilities, particularly for Nigerian educational systems experiencing poor budgetary allocation. Cases of poor sitting or standing work postures, uneven work schedules like night reading, and irregular working hours have been reported (Amoakohene, 2020). The prevalent case in the sector is the mismatch between students' body characteristics and table width and height (Fidelis et al., 2018; Onawumi et al., 2016). Also, issues like leg pains and psychosocial damage due to long hours of experiments in the laboratory are experienced in the sector. Some of these cases are scarcely reported, but the impacts are appalling to students and teachers. The conformity to safety standards and the quality of an educational institution's learning environment directly impact the graduates' output (Uche and Fanny, 2015). The typical safety standard is the need for humans to sit upright (Hooton, 1945). According to Dainoff (1994), one needs to have a cubist posture when sitting, in torso and elbow positions which are aimed at preventing ergonomic risk factors capable of resulting in health disorders and discomfort.



Figure 3. Human errors due to relapsed synergy among organizational policies, facilities and procedures (DMI, 2022)

Along with other issues of HF/E, poor communication at work has a strong and in-depth impact on employee productivity. Asamu (2014) examines the significant relationship between transmission and workers' performance in some selected organizations in Lagos. Based on the findings of this research, the study revealed that effective communication creates mutual understanding between management and workers, which helps build genuine relationships among both parties in the organizations. Considering the increase in digital workplace services, telecommuting offers a new window of opportunity for work communication. Telecommuting requires provision for proper furniture, equipment, computer, printer and scanner, and telephone. Adequate internet connectivity and trained personnel are essential requirements for the system's success (Odu, 2017). Ejohwomu et al. (2017) reported that ineffective reporting systems and poor leadership were ranked as the most significant barriers to effective communication in the construction industry. Besides, communication at work occupies more time than any other activity and often makes the difference between success and failure for the organization (Adler and Elmhorst, 2002).

3.3 Analysis and interpretation of survey findings on prevalent HF/E issues in workplaces in Nigeria

The articles reviewed in section 3 published topical issues prevailing in Nigerian workplaces as summarized in Table 1 and numbered from A1 to A23. Concisely, some of the problems can directly lead to MSDs (for example, injuries to the bone or muscles), while some only predispose (for example, physical hazards- noise, vibrations, hypothermia and hyperthermia) the worker to MSDs. The rest can be classified as various psychosocial stressors (exposure to unhealthy elements, weather conditions and emotional abuse) because it is not convenient to enumerate all the possibilities of HF/E issues. For easy understanding, the HF/E issues were consolidated through Table 1 for timely reference. Table 1 was structured to 1) show various workstations with prevalent characteristic risks or occupational and environmental work conditions and 2) furnish researchers with background material for studying HF/E in the Nigerian scenario. The weak aspects of the articles include the failure to incorporate perspectives of AI and 4IR as future components in the workplace. Considering recent advances, future directions of HF/E in developing countries such as Nigeria will be technology driven for work evolution under the new order. Thus, the issues raised in this paper represent huge research and policy prospects. These challenges can provoke debate on multidimensional aspects, which may include scientific research, political, economic and

psychosocial analysis and can change mind sets and increase awareness towards HF/E practice, primarily through self-directed learning in the future. This is important because continuous exposure to hazardous issues has been shown elsewhere to result in musculoskeletal system disorders for the exposed persons (Ephraim-Emmanuel et al., 2019). From these categories of problems, it is arguable that most workplaces fall short of responsible HF/E duty of care at various stages of the work operations.

Table 1. Reviewed articles with Nigerian data on issues in human factors activities

Author, year	Workplace involved	Research focus & issues raised
Aniekwu, 2007	Construction industry	Prevalence of hazards and accident occurrences, poor documentation, inclement weather conditions in construction industry
Aworemi et al., 2010	Highway Transport	The study revealed that, duration of driving, stress, sleep deficit, alcohol contributed significantly to the causes of driver's fatigue both at 5% and at 10% significant levels.
Agwu and Olele, 2014	Construction industry	Prevalence of hazards and accident occurrences, poor documentation, inclement weather conditions in construction industry.
Asamu, 2014	All workplaces	Significant relationship between communication and workers' performance. Ineffective reporting system
Amoakohene, 2020	Education	Inconsistent work schedule and fatigue leading to drowsiness and unreliable workplace performance
Adeyemi, 2020	Construction industry	Safeguards against hazards and fatigue, back and shoulder pains of manual lifting in block industry
Afolabi et al., 2021	Automobile	Workers' perception of the preventability of occupational safety and health (OSH) problems.
Daramola, 2014	Aviation	Safety of air transport
David-West et al., 2020	ICT	Incident issues of human factors associated with ICT practices (retraining, varying job patterns)
Ejohwomu et al, 2017	Communication	Barrier to effective communication and worker's performance: poor leadership and communication skills.
Eguoaja et a.l, 2019	Agriculture	Highlight major ergonomic problems in agriculture: full body bending (stoop), load lifting, clipping, and cutting led to musculoskeletal disorders (MSD).
Ephraim-Emmanuel et al., 2019	Health Sector	Prevalence of work-related musculoskeletal disorders and inadequate compensation package.
Edem and Akinsola, 2022	Construction industry	Prevalence of hazards and accident occurrences, low safety conscientiousness, poor documentation, inclement weather conditions in construction industry.
Elaho and Odion, 2022	All work places	Excess task workload, productivity and performance (slips, lapses or mistakes) and under-load allocation (boredom, loss of situation awareness).
Fidelis et al., 2018	Education	Prevalent case of mismatch between students' body characteristics and table width and height.
Gambo, 2020	All workplaces	Implications of volume of work to reward system, safety, health and worker's productivity.
Hooton, et al., 1945	Education	Safety standards on seating
Hadge, 2007	ICT	Steps for ergonomic arrangement for a computer
Heizer and Render, 2009	All work places	Inconsistent work schedule and fatigue leading to drowsiness and unreliable workplace performance
Harrington et al., 2020	Health sector	Applications of human factors in health technology assisted by ICT
Idoro, 2011	Construction industry	Prevalence of hazards and accident occurrences, low safety conscientiousness as well as poor documentation in construction industry.
Kukoyi and Aigbavboa, 2019	Communication	Safety Issues in telecommunication industry (eyestrain, backache and swollen wrist, carpal tunnel syndrome, tennis and golfer's elbow, low back pain).
Momodu et al., 2014	ICT	Ergonomic deficiencies in workstations (eyestrain, backache and swollen wrist, carpal tunnel syndrome, tennis and golfer's elbow, low back pain)

Author, year	Workplace involved	Research focus & issues raised
NCTE, 2007	ICT	Ergonomic deficiencies in workstations(eyestrain, backache and swollen wrist, carpal tunnel syndrome, tennis and golfer's elbow, low back pain)
Nwaogbe, et al., 2013	Aviation	Infrastructural deficit in aviation sector, sleep deprivation, traffic congestion, and safety.
Nwanya and Chukwu, 2019	Manufacturing	Inaccurate time management for ergonomics and HFs.
Ogunsola and Aboyade, 2005	ICT	Incident issues of human factors associated with ICT practices (retraining, varying job patterns).
Ogunsanya et al., 2011	Agriculture	Poor work-posture such as manually tilling/riding and health consequences like MSD.
Oyedijo, 2012	Communication	Safety Issues in telecommunication industry (eyestrain, backache and swollen wrist, carpal tunnel syndrome, tennis and golfer's elbow, low back pain).
Onawumi et al., 2016	Education	Prevalent case of mismatch between students' body characteristics and table width and height.
Oyeniran and Onikosi, 2016	Communication	Safety Issues in telecommunication industry (eyestrain, backache and swollen wrist, carpal tunnel syndrome, tennis and golfer's elbow, low back pain).
Odu, 2017	All workplaces	Low internet connectivity and digital services in workplace in Nigeria.
Okoye et al, 2017	Construction industry	Prevalence of hazards and accident occurrences, low safety conscientiousness, poor documentation, inclement weather conditions in construction industry.
Okoye et al, 2018	Construction industry	Prevalence of hazards and accident occurrences, low safety conscientiousness as well as poor documentation in construction industry.
Omoleke and Taleat, 2017	All work places	Health issues and policies
Ogodor, 2020	Construction industry	Prevalence of hazards and accident occurrences, low safety conscientiousness as well as poor documentation in construction industry.
Olowogbon, et al., 2021	Agriculture	Major management practices : chemical hazards & risk factors(weeding, chemical application and harvesting), static load mounting can lead to MSD
Onawumi et al., 2022	Automobile	Occupational hazards among automobile repairs (pollution from exhaust, spent/used oil and grease) and low artisan education.
Orji et al., 2022	Health Sector	Common occupational health hazards among health care workers (stress, sleep disturbance, bloodstains on skin, assault from patients).
Uche, 2015	Education	The impact of conformity to safety standards and quality of the learning environment of an educational institution.
Udo et al., 2016	Construction industry	Prevalence of hazards and accident occurrences, poor documentation, inclement weather conditions in construction industry
Ukoha, 2022	Automobile	Occupational hazards among automobile repairs (awkward posture, stooping led to MSD, pollution from exhaust, heat exhaustion, low artisan education).
Vural and Sutsunbuloglu, 2016	Health Sector	Prevention of the occurrence of work-related musculoskeletal disorders.
Waziri et al., 2015	Construction industry	Prevalence of hazards and accident occurrences, low safety conscientiousness as well as poor documentation in construction industry.
William et al., 2019	Construction industry	Prevalence of hazards and accident occurrences, low safety conscientiousness, poor documentation, inclement weather conditions in construction industry.

The findings in this review show that the emerging work evolution requires a technology-based strategy as a solution. While [Table 1](#) summarized the main HF/E problems encountered in some Nigerian workplaces, many essential details had to be omitted; for want of a better way of presenting information on the 23 variables in [Table 1](#), the frequency distribution was computed and illustrated in [Figure 4](#).

Figure 4 shows the heavily dominant HF/E problem among the sectors was low safety and health consciousness (A2). Other issues and their codes include disproportionate workload allocation (A1), inaccurate workers' productivity measure (A3), body bending/stoop (A4), direct MSD (A5), changing job patterns (A6), retraining /training needs (A7), carpal tunnel/syndrome (A8), eye strain (A9), inaccurate time (A10), pollution/noise (A11), awkward posture (A12), inclement weather/excess heat (A13), unawareness to hazard prevention (A14), poor documentation/reporting (A15), lifting problems (A16), inadequate compensation (A17), sleep deprivation (A18), assault (A19), policy inconsistency (A20), anthropometric problems (A21), poor communication (A22), and poor internet connectivity (A23). It is well known that the challenges were not the same for all sectors, but they affected the behavior and productivity of workers, either collectively or individually.

Individually, it is essential to prioritize the implications of each problem on HF/E and productivity in the workplace. In this paper, preference for poor internet connectivity (A23) overrides interest in other issues considering the role of ICT in HF/E practice as established elsewhere in the literature. Experts have noted that network user experience or internet connectivity was affected by network behavior (network signals and reliabilities) influenced by changing weather conditions (Faleti et al., 2021). Delivery delays characterized the data communications environment. As a result, the cost of processing and transmission, as seen by the user, was also affected by the data communications environment.

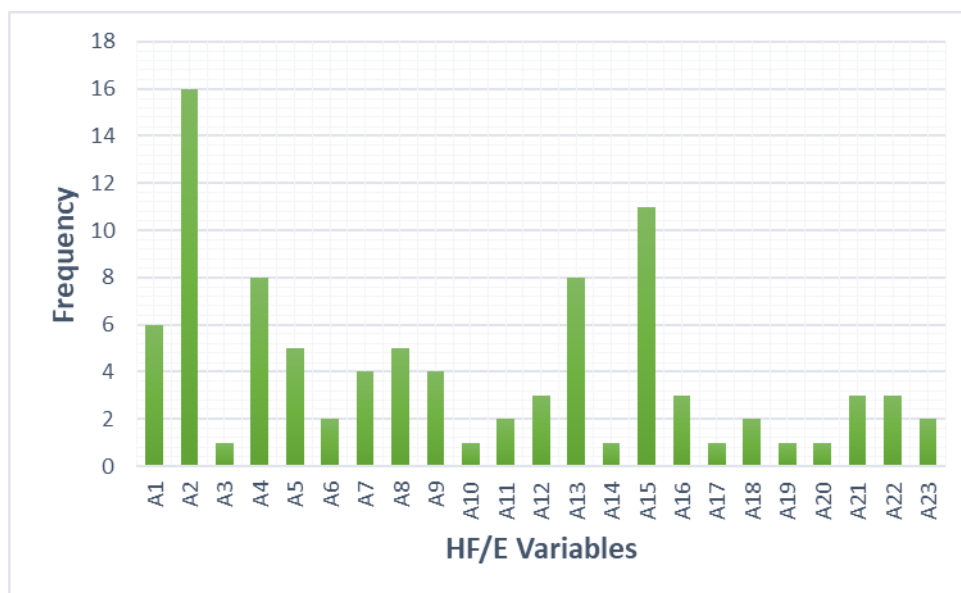


Figure 4. Frequency of HF/E issues occurrence against the number of issues (variables)

From this assertion and implication, low connectivity alone significantly affects HF/E practice in Nigeria and consequently impacts productivity growth. On health impact, for example, due to loss of sleep, this has been confirmed by Silva et al. (2020).

On a collective level, the interactions of the HF/E practice with a workplace were complex. The issues evaluated in the preceding section comprise the dimensions of facility, policy and awareness. Hence, the construction sector is one industry where the different variants of HF/E issues have the possibility of occurrence and this finding share similarity with the work by Salomäki et al. (2022). The implication of selecting control measures or resolving conflict from these interactions, as illustrated in Figure 1, is multitasking. It requires contributory actions of expert knowledge (people), management skills, and the workplace (deploying standard equipment and environment). Arising from the preceding reasons, the implication of the variables' frequency trend in the workplace, as shown in Figure 4, is that they are all-inclusive and mutually exclusive.

4. DISCUSSION

4.1 Applications of artificial intelligence technology in HF/E and future perspectives for Nigeria

In recent times, many authors have described the relationship between the human component and AI in a productive system as collegial. Although debate on the collegial connection is outside this article, there are salient points to be noted to situate AI's contributions to arduous tasks of HF/E in a productive system. While HF/E functions on natural cognitive, learning and creative abilities, the AI has the same capacities as unnatural attributes but acts faster and more precisely. For the AI, those attributes are superimposed by training on a machine device, and it uses transductive reasoning capability. With the transduction capacity, AI minimizes functional errors in the outputs of HF/E and trains until probable approximate convergence occurs. Hence, AI affects HF/E in things that need a flair for speed and precision actions by its transductive reasoning capability. The question now is to what extent has AI technology been integrated with HF/E components in the productive system in Nigeria?

From the review, few results were related to AI that is affiliated with Nigerian case scenarios. Artificial Intelligence has a much larger technology range, such as machine learning, natural language processing (NLP), learning systems, gaming systems and object detection, than robotics (Greenberg, 2017). Other types include reinforcement learning, neural network, deep learning, augmented reality, big data, virtual try-ons, and avatars and chat bots. From the technology range, every field of endeavor that can be imagined would benefit from the applications of AI in prediction, measurement, evaluation, decision-making and implementation (Obe, 2022). AI technologies' strength lies in using interactive computational intelligence algorithms to build manipulative systems applications. Based on reviewed papers, HF/E has scarcely exploited its share with AI research in Nigeria. Arguably, both practice and research activities are necessary for building a solid AI capacity, but starting with scientific research is a fair action to rectify already existing hazardous work environments. From the research standpoint, a considerable stimulus to progress can be derived from technical innovation as an outcome of painstaking research and development. It may be questioned what contents of scientific research are there for AI in the HF/E work evolution. Interestingly, since data abet AI, the discrimination of data to avoid fake or integrity problems is a potential research area. Other areas include data sensing and identification, modelling object detection systems and analysis, and model validation for model fidelity.

Audio and video-driven HF/E designs in the film industry have witnessed an upsurge recently, and using AI to enhance productivity in this sector has great prospects. In the work by Onwubere and Osuji (2020), the intensity of geospatial data and artificial intelligence technologies applications in communication is rapidly growing among youths. AI technology can modify or influence the youths' attitudes toward people and their environment. Outside the communication sphere, almost everything in Nigeria is done manually (Robinson, 2018), though we now live in a time when AI has taken over many jobs in developed countries. The implication is that there are prospects for facility management using AI in Nigeria. Mobayo et al. (2021) confirm the expressed optimism by adopting AI in the power sector. The rationale is to provide a stable power supply and reduce waste (time, money and material). However, outdated power systems infrastructure, cellular technologies, dearth of qualified experts and data scientists have been identified as the significant challenging factors to adopting AI in Nigeria (Mobayo et al., 2021); other challenges identified include AI human interface, cultural and religious barriers, software malfunction, and a decline in investment (Robinson, 2018); and in supply chain management there are issues such as cost of AI deployment, cultural challenges and need for specialized skill, such as computing and analytical proficiency (Agbai, 2020). In the cognitive aspect of HF/E, Oluwole et al. (2020) propose a model using the Artificial Neural Network (ANN) function to forecast the safety level of women on domestic duty.

In manufacturing, Nsude (2020) posit that robot, a complex type of AI, can perform mental tasks such as sorting raw materials, transporting and stocking, and other quality-

related jobs unsuitable for human beings. AI has become an essential part of the technology in the industry (Bekuru and Nwinyokpugi, 2021). Using AI technology eliminates processes that do not add value to the products and will lead to lowering production costs and increment in efficiency. In this context, Adizue et al. (2020) developed and applied an artificial neural network (ANN) model as a solution for the prediction of standard time in palm oil production. Compared with that obtained through direct time study by stopwatch, the result shows that time standardization through ANN provides a savings of 21.54%. This finding implies that increased efficiency is an essential attribute of AI applications. From the literature analytical perspective, few applications of AI exist in the extant literature and signify AI as a hotspot of future growth for HF/E in Nigeria.

4.2 Awareness, practice level and status of human factors in Nigeria from 2006 till 2022

Awareness is an important attribute in the measurement of visibility. This is true with the inauguration of the Ergonomics Society of Nigeria (ESN), an umbrella body for ergonomists practicing in Nigeria. The Society was inaugurated on September 14th, 2006. The initiative is a benchmark for assessing awareness or some progress in ergonomic practice in Nigeria, and it is a milestone.

ESN provides a platform for ergonomists to learn from each other (Adaramola, 2013). However, it is uncertain whether the prevalence of HF/E issues in workplaces has a correlation with awareness level and practice or otherwise. For this reason, ranking the practice of the profession is a needful exercise. While it is possible to use inauguration as a criterion to measure awareness level, it is difficult to rank the success or failure of HF/E practice.

From the standpoint of human factors' lived experience, the underpinning activities for evaluating the HF/E practice under any review can follow the understated procedures and subject headings:

- The measurement of the dimensions of the human body
- The limits of muscular force applications in related-work
- The practical application of anthropometric data
- Energy expenditure and physical fatigue by a worker

Application of research techniques to psychology or mental problems of human work:

- Display of information/ communication methods
- Analysis of perceptual elements in operator skill
- Psychological aspects of fatigue
- Use of psychological research of skill in operator training
- Fault finding and diagnosis
- Effect of age on human skills

Environmental conditions at workplaces:

- Lighting, heating and ventilation
- Noise and vibrations
- Effect of cold on human performance

The works in extant literature in the previous headings fall under human factors and if they are evaluated, the indices for the ranking HF/E practice in Nigeria can be obtained.

However, awareness about HF/E in the above subject areas is graded according to levels. Ismaila (2010) reported that the present level of ergonomic understanding in Nigeria is very poor. This sentiment collaborates with the opinion of some authors regarding the ergonomic awareness level obtained in educational institutions between professionals in the university (Atueyi et al., 2021), among information and communication technology experts (Momodu et al., 2014), and physiotherapists (Adje, 2019). Succinctly stated, knowledge awareness and practice of HF/E is relatively low in Nigeria. There is a good level of knowledge of HF/E principles but a poor practice level at workplaces. In this way, Adaramola (2013) intuitively sum up these problems in the

urgent “need in Nigeria to develop ergonomics in all sectors of the economy”. This expression raised to consciousness the enormity of human factors or ergonomic problems faced in Nigeria. It can further be interpreted as an indirect call for concerted commitment towards eliminating hazards in the work centers. Resolving work-related hazards is critical future task for HF/E protagonist, which must be in the forefront of which Ergonomics Society of Nigeria (ESN).

Status expresses penetration level and, empirically too, the number of surveyed functional organizations with published activities or the ranking of HF/E compliance indicators among disciplines in work situations. In this study, such organizations were categorized according to sectors for ease of identification. Also, several journal articles have been compared year by year to find a period with the greatest HF/E issues as an indicator of penetration level. Since HF/E seeks to change the things people use and the environments in which they use those things through technology, status also indicates the position attained through the process of change. In Nigeria, the awareness and penetration level of HF at workplaces is impeded by a lack of a comprehensive database and legislative act of parliament (Agumba and Haupt, 2012). Another major factor that cannot easily be quantified is the effect of implementing HF/E in the organization (Boatcaa and Cirjaliub, 2015). Legislative act forms the framework to which ergonomist or human factors engineer activities have direct relation. Taking inspiration from Table 1, we observed an increase in research studies focused on HF/E in workplaces from 2006 to 2022 as the aftermath of ESN inauguration. Although the penetration level was at low ebb, the studies favor activities related to agriculture, information and communication technology, education, health and construction activities. All these indicate increased status or penetration of HF/E in some workplaces in Nigeria.

4.3. Future trends and advances in HF/E towards Nigerian work environment

HF/E connects every human endeavor based on findings from this study. Hence, what future directions of HF/E should someone expect? There was a lot of overlap among the different challenges experienced in the different sectors based on the review carried out, which has important future consequences. The challenges intellectually appeal to future research interests in varying magnitude of analysis irrespective of the causes. In this regard, future HF/E projections and analysis should eschew generalization and theory-building but emphasize value-centered contribution to the working people and work environment; this trajectory would then engender healthy work culture and ensure bountiful future productivity at workplaces.

In the short term, the evolving work order will promote incorporating AI and robotics technologies in HF/E functions for Nigeria. Digitalization of service aspects in the productive systems and application of HF/E principles will give rise to more computer stations in Nigeria. Consequently, information flows associated with data communications will characterize further development in ICT for Nigeria. With digital-based ICT, the need for a high-speed transactional network and cost-friendly bandwidth or bit rate will be a challenge in the future. In the evolving work process, artificial intelligence is a highly rated technology to drive the process, while the language of communication is computer software, and data is the fuel flowing within the medium. As HF/E practice penetrates more workplaces, tools for data processing such as automation, data clouding and the computer would be in high demand alongside more ergonomists and data scientists. Hence, in the quest to meet 4IR evolution, much depends on a number of tools and experts available to cope with rising services and corporate resources, respectively. In summary, robotics and AI as technologies for independent living and in-home as well as long-distance work scenes will determine HF/E future prospects in Nigeria. It may be questioned how AI will affect HF/E in this regard in the future.

Now, the trend in work processes is the replacement of humans by AI. An intelligent machine replaces the muscle power of humans and takes up decision-making responsibilities in routine tasks. This trend is gradually evolving in the service sector and institutional intervention regarding coordinating directions of HF/E and the roles of AI in this new work evolution. ESN should brace up, plan and consolidate the system, even

for the real sector. Other emerging ancillary areas of knowledge include machine learning, the Internet of Things, and big data management. ESN should get involved by encouraging its members to train on the emerging areas for the future work process. Strong institutions have been recognized as agents of lasting changes (Anonymous author, 2021). It is hoped that ESN will try carving out a niche for itself in this regard.

In Nigeria, however, significant problems limiting the evolution of work include the inability to gain exposure to state-of-the-art practices by supposedly human factors practitioners. According to Obi (2015), the unpopular use of ergonomics design and inputs in Nigeria is a problem. By extension, the primary cause is the failure to implement the tenets of human factors to become a habit, a fact partly attributed to the lack of appropriate enforcement of HF/E act of parliament at workplaces. Of course, a pattern formed is challenging to wane.

5. CONCLUSIONS

In light of the evolving new work order, HF/E issues at selected workplaces in Nigeria have been addressed. The study concludes that proper implementation of principles of HF/E in the daily processes and in the organizational culture will create the proper context for improvements. It has been shown in the foregoing that the HF/E practice, status and awareness are growing in Nigeria. This growth is with varying concerns regarding heavily dominant issues that impede safety, a healthy work environment and productivity. The ergonomic issues prevalent among workplaces in Nigeria were identified and discussed. The rising issues symbolized future research prospects for the growth of HF/E and ancillary factors like AI and robotics in Nigeria. Focusing on human factors can serve various organizational objectives, including improved productivity, product design, process (production system) design, and organizational design (Lim et al., 2009). The authors are optimistic that the issues raised here can be surmounted using AI as an intervention agent. AI as a change agent will accelerate the degree of work process evolution in Nigeria. The observation here is that most of the issues are glossed over because of inadequate enactment of Act, enforcement of appropriate legislation or both. For this reason, in many of the situations when the issues occur, the liability of the culprit is absolved by the system.

On the status of HFs functions, the advancement in practice is yet to record significant progress in workplaces. Much improvement will be achieved with great stimulus for progress when HF/E uses more AI in research and professional work. Although the level of HF/E practice is gradually penetrating the sectors, it is at the preparatory stage, considering the period under review. Adapting emerging knowledge of AI, machine learning and the Internet of Things can provide a ladder for HF/E in-depth penetration and a leap into the desired future work process.

A strong ESN is crucial for effective HFs or ergonomics practice in Nigeria. As a professional body, ESN has a crucial role in the evolving modern work order. With automation, robotics and AI, ergonomists will, therefore, become more concerned with man's information processing capabilities in the future. Cooperation between AI and HFs is necessary for an efficient work process, and ESN can energize it by encouraging research collaboration among experts in both fields. The actions will rub off on advancing scientific knowledge and translating findings in the work process. The treatise is hoped to have added value to extant Nigerian literature on the subject area.

ACKNOWLEDGEMENTS

The authors express their gratitude to the staff of University of Nigeria, Nsukka library for data assistance and those who anonymously reviewed the manuscript.

CONFLICT OF INTEREST

No conflict of interest is declared. This research has not received any grant or funding.

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