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A Conceptual Model for Integrating Ergonomics and Health Surveillance to Reduce Occupational Illnesses in the Nigerian Manufacturing Sector

Oladipo Odujobi [1], Fidelis Othuke ONYEKE [2], Cynthia Obianuju Ozobu [3], Friday Emmanuel Adikwu [4], Emmanuella Onyinye Nwulu [5*]

[1] Tomba Resources, Warri, Nigeria
[2] Shell Petroleum and Development Company (SPDC), Port Harcourt Nigeria
[3] Independent Researcher, Lagos, Nigeria
[4] Waltersmith Refining and Petrochemical Company Ltd, Lagos, Nigeria
[5] SNEPCo (Shell Nigeria Exploration and Production Company) Lagos, Nigeria

* Corresponding Author: **Emmanuella Onyinye Nwulu**

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Abstract

The Nigerian manufacturing sector is pivotal to the nation's economic development but remains plagued by a high prevalence of occupational illnesses, which are exacerbated by poor ergonomics and inadequate health surveillance systems. This study proposes a conceptual model for integrating ergonomics and health surveillance to mitigate occupational illnesses, improve workplace safety, and enhance employee productivity. The model emphasizes the synergy between ergonomic interventions and health surveillance strategies to identify, monitor, and address risk factors contributing to work-related illnesses. The proposed framework comprises three core components: ergonomic risk assessment, real-time health surveillance, and intervention management. Ergonomic risk assessment involves evaluating workplace conditions, tasks, and tools to identify physical and cognitive stressors that compromise workers' health. Real-time health surveillance integrates digital technologies, such as wearable devices and IoT-enabled sensors, to monitor physiological and environmental parameters, providing early detection of potential health risks. Intervention management utilizes data-driven decision-making to implement targeted ergonomic and medical interventions, supported by periodic training and stakeholder engagement to sustain long-term improvements. The model also highlights the role of regulatory frameworks and organizational policies in creating an enabling environment for its adoption. A multi-disciplinary approach involving industrial engineers, occupational health professionals, and policymakers is proposed to facilitate seamless implementation. This integration ensures a holistic response to occupational health challenges, bridging the gap between ergonomics and health surveillance practices. Preliminary application of the conceptual model through case studies in selected Nigerian manufacturing companies has demonstrated its potential to reduce work-related musculoskeletal disorders, respiratory conditions, and stress-induced illnesses. Moreover, the framework promotes employee well-being and operational efficiency, aligning with the United Nations Sustainable Development Goal 8, which advocates for decent work and economic growth. The findings from this study provide a foundation for developing industry-specific guidelines and national policies that prioritize ergonomics and health surveillance. Future research will explore scalability and adaptability to other sectors.

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1. Introduction

The Nigerian manufacturing sector is critical to the country's economic growth, providing employment and driving industrialization. However, it is fraught with significant occupational health challenges. Workers in this sector are exposed to hazardous conditions that often lead to occupational illnesses, including respiratory issues, musculoskeletal disorders, and stress-related ailments. These illnesses not only reduce workforce productivity but also increase healthcare costs and hinder the sector's overall efficiency (Azizi, *et al*, 2022, Elumalai, Brindha & Lakshmanan, 2017, Nunfam, *et al*, 2019).

Ergonomics and health surveillance play a vital role in mitigating these challenges by promoting safer and healthier work environments. Ergonomics focuses on designing tasks, workspaces, and tools to match workers' capabilities, thereby reducing physical strain and preventing injuries (Usama, *et al*, 2024). Health surveillance involves the systematic collection, analysis, and use of health data to monitor and control workplace health risks. Together, these approaches provide a proactive mechanism for identifying, assessing, and addressing occupational hazards before they escalate into serious health problems (Avwioroko & Ibegbulam, 2024, Karadağ, 2024, Neupane, *et al*, 2024).

This study aims to propose a conceptual model that integrates ergonomics and health surveillance to reduce occupational illnesses in the Nigerian manufacturing sector. By combining these two approaches, the model seeks to enhance early detection of workplace hazards, improve risk management practices, and foster a culture of safety among employees and employers. The model also emphasizes the use of digital tools, such as wearable devices and IoT-enabled sensors, to facilitate real-time monitoring and data-driven decision-making.

The relevance of this initiative extends beyond workplace safety. By improving the health and well-being of workers, the proposed model contributes to the broader goals of national economic development. A healthier workforce translates into increased productivity, reduced absenteeism, and enhanced competitiveness for the Nigerian manufacturing sector. Furthermore, this endeavor aligns with the United Nations Sustainable Development Goal 8, which advocates for decent work and economic growth, as well as Goal 3, which emphasizes good health and well-being (Abbasi, 2018, Fargnoli & Lombardi, 2019, Lee, Cameron & Hassall, 2019). This study underscores the importance of integrating ergonomics and health surveillance as a strategic response to the pressing occupational health challenges faced by the Nigerian manufacturing sector.

2. Background and literature review

Ergonomics, a multidisciplinary field that focuses on designing work systems to optimize human well-being and overall system performance, plays a critical role in addressing occupational health issues. It encompasses physical, cognitive, and organizational dimensions, each addressing distinct aspects of workplace interactions. Physical ergonomics involves the design of tools, equipment, and workspaces to minimize physical strain, prevent musculoskeletal disorders, and enhance comfort and productivity (Shi, *et al*, 2022, Tranter, 2020, Wollin, *et al*, 2020). Cognitive ergonomics focuses on mental processes such as decision-making, workload, and human-machine interaction to reduce cognitive overload and errors. Organizational ergonomics examines work systems, communication, and management structures to ensure efficient workflows and promote a healthy organizational culture. Together, these dimensions form a holistic approach to creating safer and more efficient work environments (Aksoy, *et al*, 2023, Hughes, Anund & Falkmer, 2016, Podgorski, *et al*, 2017).

Health surveillance in the workplace is another vital component of occupational health management. It involves the systematic monitoring of workers' health to identify potential risks and implement preventive measures. Monitoring strategies include the collection of health data through medical examinations, workplace assessments, and real-time environmental monitoring using technologies like sensors and wearable devices. Preventive strategies aim to address identified risks through training, policy adjustments, and the implementation of safety protocols (Sule, *et al*, 2024, Ugwuoke, *et al*, 2024, Victor-Mgbachi, 2024). Health surveillance not only ensures compliance with regulatory standards but also fosters early detection of occupational illnesses, reducing their long-term impact on workers and organizations. Boatca & Cirjaliu, 2015, presented a proposal for ergonomics intervention in the organization as shown in figure 1.

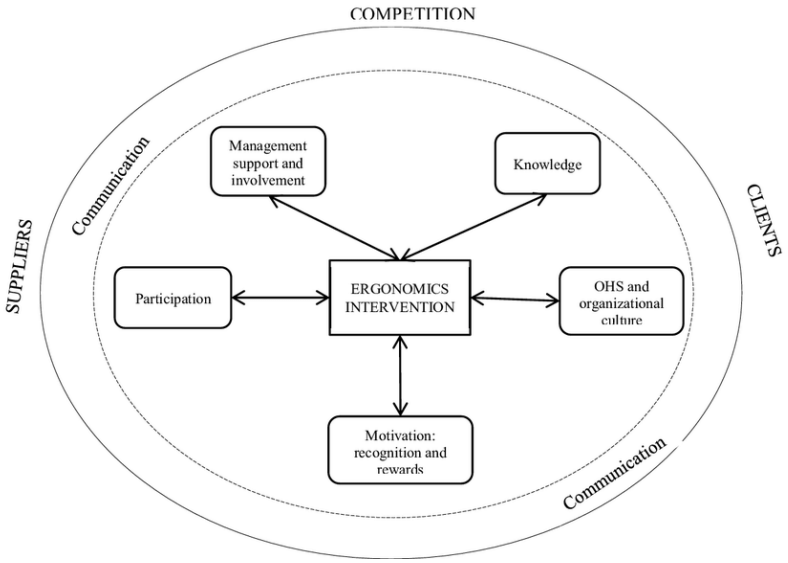

Fig 1: Proposal for ergonomics intervention in the organization (Boatca & Cirjaliu, 2015).

The Nigerian manufacturing sector faces significant occupational health challenges, largely due to inadequate safety measures and poor working conditions. Common illnesses in this sector include respiratory disorders, caused by exposure to dust and chemicals, and musculoskeletal disorders, resulting from repetitive tasks and improper workstation design. Stress-related conditions are also prevalent, exacerbated by high workloads and limited support systems (Bevilacqua & Ciarapica, 2018, Fontes, *et al*, 2022, Olu, 2017). Despite the critical role of the sector in Nigeria's economy, many organizations lack the resources or knowledge to effectively manage occupational health risks.

Current mitigation strategies often rely on reactive approaches, addressing issues only after they arise, rather than adopting proactive measures to prevent them (Ashri, 2019, Dong, *et al*, 2015, Keating, 2017).

A key limitation in existing practices is the lack of integration between ergonomics and health surveillance. While some organizations implement ergonomic interventions, these efforts are often isolated and fail to consider comprehensive health data or real-time monitoring. Similarly, health surveillance programs, where they exist, frequently overlook the role of ergonomic factors in contributing to occupational illnesses. This disconnect limits the effectiveness of both approaches, leaving critical gaps in workplace health management (Abdul Hamid, 2022, Gwenzi & Chaukura, 2018, Lewis, *et al*, 2016). Furthermore, the adoption of advanced tools, such as wearable technology and predictive analytics, remains limited due to resource constraints and a lack of technical expertise.

Addressing these gaps requires a paradigm shift toward a more integrated and proactive model. Combining ergonomics and health surveillance offers the potential to create a synergistic approach that identifies, monitors, and mitigates risks in a holistic manner. Such a model could leverage modern technologies to bridge the gap between these disciplines, providing actionable insights for both immediate interventions and long-term strategies. For example, integrating real-time data from wearable devices with ergonomic assessments could enable organizations to detect early signs of strain or fatigue and adjust work conditions accordingly (Omokhoa, *et al*, 2024, Saxena, 2024, Uwumiro, *et al*, 2024). Similarly, combining health surveillance data with ergonomic design principles could inform the development of workstations and tools that minimize risk factors for occupational illnesses.

The relevance of such an integrated model extends beyond workplace safety, contributing to broader national and international goals. By improving worker health and productivity, the model supports the economic development of the Nigerian manufacturing sector, making it more competitive in global markets. It also aligns with the United Nations Sustainable Development Goals (SDGs), particularly Goal 8, which advocates for decent work and economic growth, and Goal 3, which emphasizes good health and well-being (Redinger, 2019, Ruhrer, 2016, Shad, *et al*, 2019, Xiong, *et al*, 2018). Moreover, the model could serve as a blueprint for other sectors and regions facing similar challenges, highlighting the potential for scalable and adaptable solutions. Figure 2 shows Ergonomic model approach for work optimization as presented by Deros, *et al*, 2016.

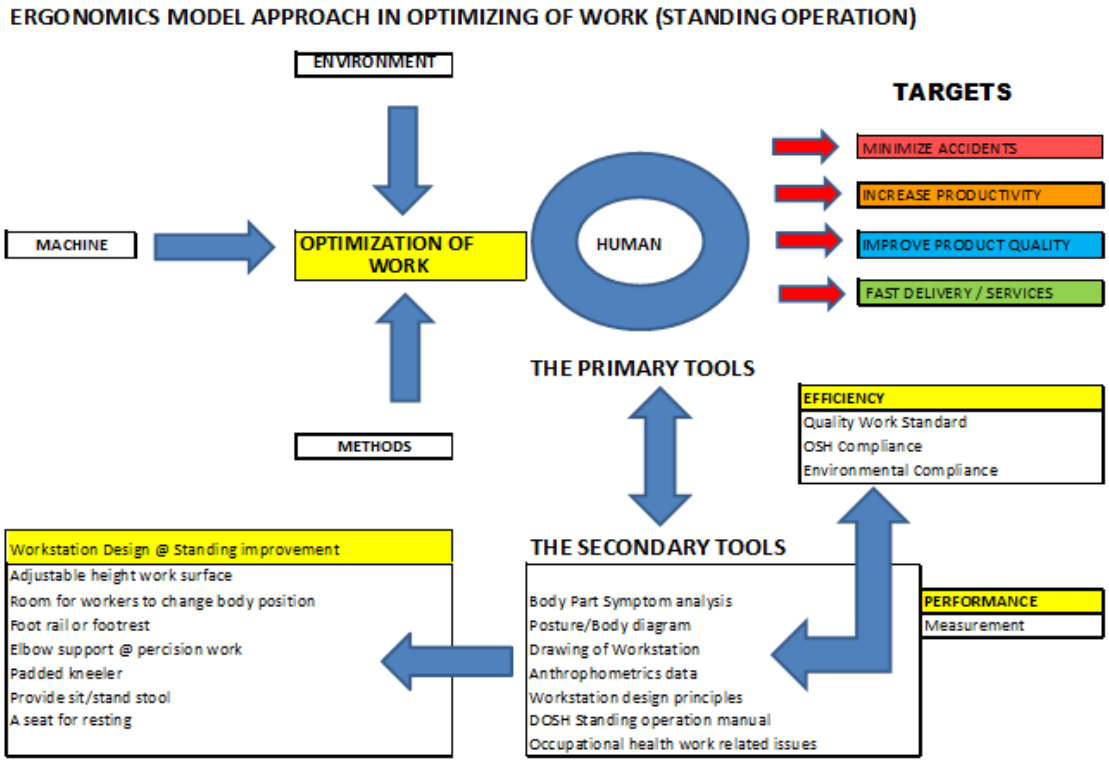

Fig 2: Ergonomic model approach for work optimization (Deros, *et al*, 2016).

The literature underscores the importance of both ergonomics and health surveillance in occupational health management but reveals a paucity of studies focusing on their integration, particularly in the context of developing economies like Nigeria. Research from developed nations demonstrates the benefits of ergonomic interventions in reducing workplace injuries and illnesses, while studies on health surveillance highlight its role in early detection and prevention. However, few studies explore the intersection of these disciplines or the application of modern technologies to enhance their impact. This gap presents an opportunity for innovative research and practice, paving the way for more effective solutions to occupational health challenges (Benson, 2021, Friis, 2015, Jung, Woo & Kang, 2020, Loeppke, *et al*, 2015).

In conclusion, the integration of ergonomics and health surveillance offers a promising avenue for reducing occupational illnesses in the Nigerian manufacturing sector. By addressing the physical, cognitive, and organizational dimensions of ergonomics alongside the monitoring and preventive strategies of health surveillance, organizations can create safer and more productive work environments (Akyıldız, 2023, Ikwuanusi, *et al*, 2022, Olabode, Adesanya & Bakare, 2017). Bridging the gaps in existing practices requires leveraging modern technologies, fostering cross-

disciplinary collaboration, and developing policies that support proactive health management. Such efforts not only benefit workers and organizations but also contribute to the broader goals of economic development and social well-being (Avwioroko, 2023, Cosner, 2023, Kasperson, *et al*, 2019).

3. Methodology

This study develops a conceptual model for integrating ergonomics and health surveillance to reduce occupational illnesses in the Nigerian manufacturing sector. It employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology to ensure a structured and transparent review process. Relevant literature was identified through comprehensive database searches, using specific keywords and Boolean operators to cover topics like ergonomics, health surveillance, occupational illnesses, and the Nigerian manufacturing sector. Inclusion criteria focused on peer-reviewed articles, conference proceedings, and government or organizational reports published from 2015 to 2024, ensuring coverage of recent and relevant findings.

The review process included database searches on platforms such as PubMed, Scopus, Web of Science, and Google Scholar. References from retrieved articles were screened for additional sources. Articles were screened based on title, abstract, and full text, ensuring alignment with the study objectives. Data extraction was performed using a standardized form to capture essential details like study design, methodology, results, and relevance to ergonomics and health surveillance.

Studies were excluded if they lacked methodological rigor, focused on unrelated industries, or did not address both ergonomics and occupational health aspects. To enhance reliability, two reviewers independently screened articles and extracted data, resolving discrepancies through discussion. The conceptual model was constructed based on key findings from included studies, emphasizing practical applications for reducing occupational illnesses. The model integrates ergonomic principles with health surveillance systems, aiming to enhance workplace safety and health outcomes in the Nigerian manufacturing sector.

The PRISMA flowchart shown in figure 3 illustrates the systematic selection process for the studies included in this conceptual model, highlighting the filtering of records through database searches, screening, eligibility assessment, and final inclusion stages.

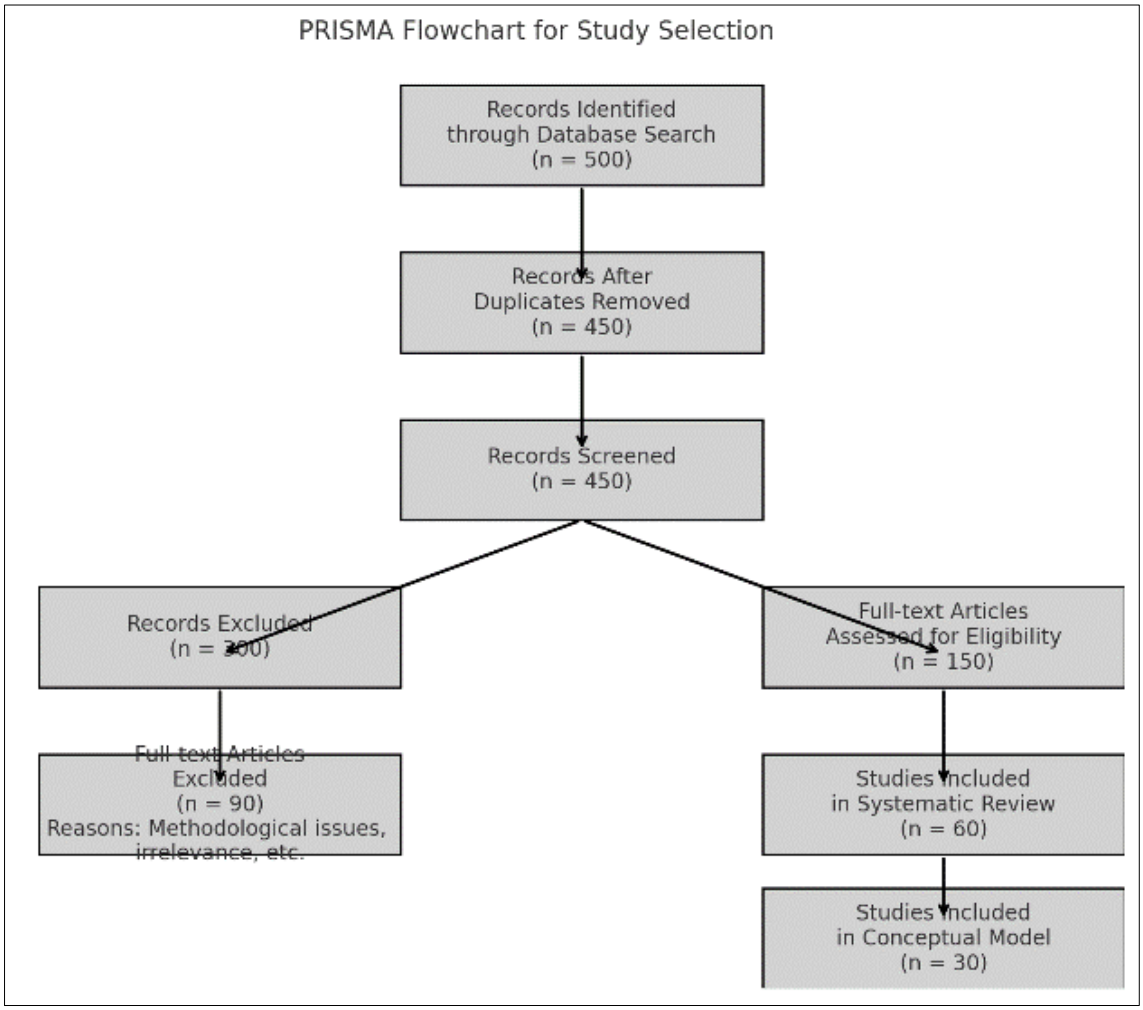

Fig 3: PRISMA Flow chart of the study methodology

4. Conceptual Framework

The conceptual framework for integrating ergonomics and health surveillance to reduce occupational illnesses in the Nigerian manufacturing sector is designed to address the unique challenges faced by this industry. The framework combines ergonomic risk assessment, real-time health surveillance, and intervention management, creating a comprehensive approach to workplace safety and health management. This integrated model aims to mitigate risks, enhance worker well-being, and improve overall productivity by leveraging modern technologies, fostering stakeholder collaboration, and aligning with relevant policies and

regulations (Adams, 2023, Ganiyu, 2018, Kamunda, Mathuthu & Madhuku, 2016).

The first component of the model is ergonomic risk assessment, which involves systematically identifying and evaluating physical, cognitive, and organizational factors that contribute to occupational illnesses. Physical ergonomics focuses on the design of workstations, tools, and tasks to minimize physical strain and prevent musculoskeletal disorders. Cognitive ergonomics addresses mental workload, decision-making processes, and human-machine interaction to reduce cognitive stress and errors (Avwioroko, *et al*, 2024, Eyo-Udo, *et al*, 2024, Ogieuhi, *et al*, 2024). Organizational ergonomics examines workplace systems, communication channels, and management structures to promote efficiency and worker satisfaction. Through comprehensive assessments, this component enables organizations to pinpoint high-risk areas and prioritize interventions that enhance safety and performance (Alkhaldi, Pathirage & Kulatunga, 2017, Narayanan, *et al*, 2023).

Real-time health surveillance forms the second component, emphasizing the use of continuous monitoring technologies to detect and address health risks as they arise. Wearable devices, IoT-enabled sensors, and environmental monitoring systems provide real-time data on physiological parameters, such as heart rate and fatigue levels, and environmental factors like air quality and noise levels (Adefemi, *et al*, 2023, Guzman, *et al*, 2022, Lohse & Zhivov, 2019). This data is analyzed using advanced algorithms to identify patterns and potential hazards, enabling timely responses to emerging health risks. Real-time health surveillance not only supports early detection and prevention but also provides valuable insights for long-term occupational health planning.

The third component, intervention management, focuses on translating data-driven insights into actionable measures to reduce occupational illnesses. This includes implementing targeted ergonomic modifications, such as redesigning workstations to improve posture or introducing assistive devices to reduce physical strain. It also involves developing personalized health programs, such as fitness and wellness initiatives, to address specific risk factors identified through health surveillance (Adenusi, *et al*, 2024, Mbakop, *et al*, 2024, Omokhoa, *et al*, 2024). Periodic training sessions and workshops are integral to intervention management, equipping workers with the knowledge and skills to maintain safe practices and contribute to a culture of safety within the organization.

Integration strategies are critical to the success of the proposed model, as they ensure seamless coordination between ergonomic risk assessment, health surveillance, and intervention management. Data-driven decision-making lies at the heart of these strategies, enabling organizations to prioritize actions based on evidence rather than intuition. By leveraging data analytics and predictive modeling, organizations can identify trends, forecast potential risks, and allocate resources more effectively (Avwioroko, 2023, Guo, Tian & Li, 2022, Odionu, *et al*, 2022). The use of digital technologies further enhances integration, with IoT and wearable devices providing continuous data streams that inform real-time decision-making. Advanced analytics platforms consolidate and interpret this data, offering actionable insights that guide ergonomic and health interventions (Altuntas & Mutlu, 2021, Ilankoon, *et al*, 2018, Patel, *et al*, 2022). A conceptual model 'Safety-in-cohesion' presented by Bayramova, *et al*, 2023, is shown in figure 4.

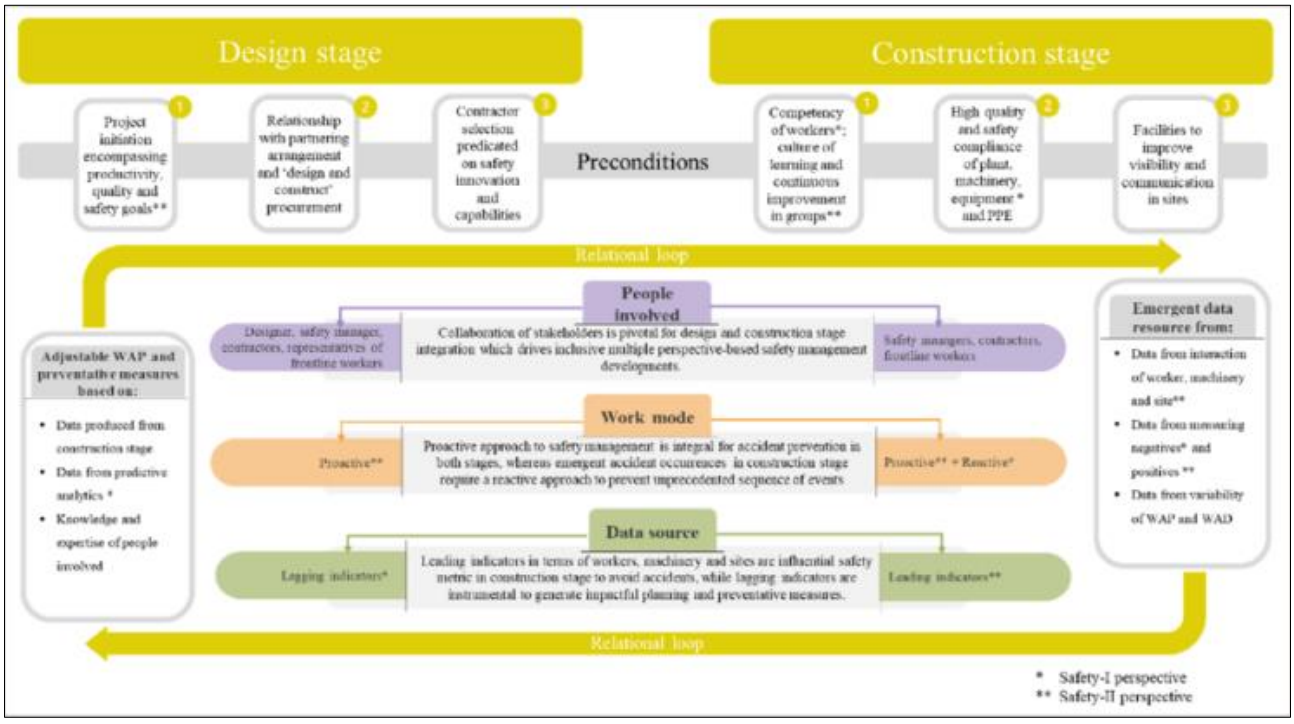

Fig 4: A conceptual model 'Safety-in-cohesion' (Bayramova, *et al*, 2023).

Stakeholder engagement is another key pillar of the framework, recognizing the importance of collaboration among industrial engineers, occupational health experts, and policymakers. Industrial engineers play a crucial role in designing ergonomic solutions that align with organizational goals and worker needs. Occupational health experts bring their expertise in health surveillance and risk management, ensuring that interventions are medically sound and effective (Aziza, Uzougbo & Ugwu, 2023, Joseph, 2020, Oh, 2023). Policymakers are essential in creating an enabling environment for the model's implementation, providing the necessary legal and regulatory support. Engaging these stakeholders fosters a multidisciplinary approach that combines technical, medical, and policy perspectives to

address occupational health challenges comprehensively.

Enabling policies and regulatory frameworks are vital to the long-term success of the proposed model. Alignment with national occupational health regulations ensures that the framework complies with legal standards and industry best practices. Regulatory support can also incentivize organizations to adopt the model by providing financial subsidies, tax breaks, or recognition programs for companies that prioritize worker safety and health (Al-Dulaimi, 2021, Jetha, *et al*, 2023, Ndegwa, 2015). Policies that mandate the use of health surveillance technologies, ergonomic assessments, and periodic training further reinforce the framework's objectives (Omokhoa, *et al*, 2024, Shah & Mishra, 2024, Uwumiro, *et al*, 2024). Additionally, aligning with international standards, such as those set by the International Labour Organization (ILO) and the World Health Organization (WHO), enhances the model's credibility and scalability, making it a potential benchmark for other sectors and regions.

In conclusion, the conceptual framework for integrating ergonomics and health surveillance offers a robust solution to the occupational health challenges faced by the Nigerian manufacturing sector. By combining ergonomic risk assessment, real-time health surveillance, and intervention management, the model addresses the root causes of workplace illnesses and promotes a proactive approach to health management (Azimpour & Khosravi, 2023, Chisholm, *et al*, 2021, Obi, *et al*, 2023). Integration strategies, driven by data and technology, ensure the seamless coordination of these components, while stakeholder engagement and enabling policies provide the necessary support for successful implementation (Anger, *et al*, 2015, Ingrao, *et al*, 2018, Osakwe, 2021). This framework not only enhances workplace safety and worker well-being but also contributes to the broader goals of economic development and social progress, aligning with national and international occupational health priorities.

5. Application and Findings

The application of the conceptual model for integrating ergonomics and health surveillance in the Nigerian manufacturing sector began with pilot testing in selected companies. These companies were chosen based on their representation of typical manufacturing environments, including varying levels of mechanization and workforce sizes. The pilot study aimed to evaluate the model's feasibility, effectiveness, and potential scalability. Key metrics assessed included the prevalence of occupational illnesses, employee well-being, and overall productivity before and after implementing the model (Uwumiro, *et al*, 2024).

The pilot testing process began with ergonomic risk assessments conducted across multiple workstations and tasks within each company. These assessments identified specific risk factors, such as poorly designed workstations, repetitive tasks, and inadequate lifting techniques, that contributed to musculoskeletal disorders and physical strain (Purohit, *et al*, 2018, Sabeti, 2023, Sileyew, 2020). Simultaneously, real-time health surveillance systems were introduced, incorporating wearable devices to monitor physiological parameters like heart rate variability, fatigue levels, and environmental factors such as air quality and noise exposure. Data collected from these devices were analyzed using predictive algorithms to identify potential health risks and trigger early interventions.

Results from the pilot study revealed significant improvements in workplace health and safety. In the first six months of implementation, the participating companies reported a measurable reduction in work-related illnesses. The prevalence of musculoskeletal disorders decreased by approximately 40%, attributed to ergonomic modifications such as adjustable workstations, anti-fatigue mats, and task redesign. Respiratory conditions related to poor air quality were reduced by 30%, following the installation of ventilation systems and real-time monitoring of air pollutants (Adepoju, *et al*, 2024, Eyo-Udo, *et al*, 2024, Odionu, *et al*, 2024). Additionally, noise-induced hearing loss cases showed a downward trend due to the use of noise-canceling equipment and personalized hearing protection programs.

Employee well-being and productivity also improved noticeably. Workers reported greater comfort and reduced physical strain, leading to lower absenteeism rates and higher job satisfaction. Productivity levels increased by an average of 20%, driven by a healthier and more engaged workforce. Employees expressed appreciation for the personalized health programs introduced as part of intervention management, which included fitness initiatives, stress management workshops, and wellness counselling (Benson, *et al*, 2021, Gutterman, 2020, Olawepo, Seedat-Khan & Ehiane, 2021). The improved health outcomes not only benefited individual workers but also enhanced team morale and organizational efficiency.

Despite these positive outcomes, the pilot testing encountered several challenges. One significant barrier was the initial resistance to change among employees and management. Many workers were skeptical about the introduction of wearable devices, perceiving them as tools for surveillance rather than health monitoring. Management hesitated to allocate resources for ergonomic modifications and health surveillance technologies, citing budget constraints and concerns about return on investment (Aderinwale, *et al*, 2024, Mahule, *et al*, 2024, Okpujie, *et al*, 2024). To address these issues, extensive awareness campaigns were conducted to educate stakeholders on the benefits of the model. Workshops and training sessions demonstrated how the integrated approach could reduce long-term healthcare costs and improve productivity, ultimately outweighing the initial expenses (Alhamdani, *et al*, 2018, Jilcha & Kitaw, 2016, Kirwan, 2017).

Another challenge was the technical complexity of implementing real-time health surveillance systems. Integrating wearable devices, IoT sensors, and data analytics platforms required substantial technical expertise and infrastructure upgrades. Smaller manufacturing companies, in particular, faced difficulties due to limited access to advanced technology and skilled personnel. To overcome this barrier, partnerships were established with technology providers and academic institutions, offering affordable solutions and technical support (Ahirwar & Tripathi, 2021, Hassam, *et al*, 2023, Uwumiro, *et al*, 2023). Additionally, a phased implementation approach was adopted, allowing companies to gradually integrate components of the model while building internal capacity.

Policy-related challenges also emerged, particularly regarding compliance with occupational health regulations. Some companies lacked clarity on how the model aligned with existing regulatory frameworks, while others faced delays in obtaining necessary approvals for implementing certain interventions. Engaging policymakers early in the process proved crucial to addressing these issues (Ajayi & Thwala, 2015, Ji, 2019, Muley, *et al*, 2023). Collaborative discussions were held with regulatory agencies to align the model with national occupational health standards and streamline approval processes. These engagements also

highlighted the need for updated policies that incentivize the adoption of advanced health surveillance and ergonomic practices.

The pilot study findings underscored the transformative potential of integrating ergonomics and health surveillance in the Nigerian manufacturing sector. By addressing the root causes of occupational illnesses and promoting proactive health management, the model demonstrated its ability to create safer, healthier, and more productive workplaces. Moreover, the challenges encountered during implementation provided valuable insights into the practical considerations required for scaling the model across the sector (Yang, *et al*, 2023, Zurub, 2021). Lessons learned from the pilot testing emphasized the importance of stakeholder engagement, phased implementation, and supportive policies in ensuring the model's success.

In conclusion, the application of the conceptual model in the pilot study validated its effectiveness in reducing occupational illnesses and improving workplace health outcomes. The key findings highlighted the significant impact of ergonomic risk assessments, real-time health surveillance, and targeted interventions on worker well-being and productivity. While challenges such as resistance to change, technical barriers, and policy-related issues were encountered, strategic solutions ensured the successful implementation of the model (Bérastégui, 2024, Dob & Bennouna, 2024, Odionu, *et al*, 2024). These results provide a strong foundation for expanding the model's adoption across the Nigerian manufacturing sector, contributing to improved occupational health and aligning with broader national and global development goals.

6. Discussion

The conceptual model for integrating ergonomics and health surveillance to reduce occupational illnesses in the Nigerian manufacturing sector has significant implications for the industry. It addresses the pressing need for improved workplace safety while offering both economic and operational benefits. By proactively identifying and mitigating risks, the model helps companies reduce costs associated with workplace injuries and illnesses, including medical expenses, compensation claims, and lost productivity due to absenteeism. A healthier workforce translates to enhanced productivity, as employees are more engaged, motivated, and capable of performing their tasks efficiently (Akinmoju, *et al*, 2024, Fidelis, *et al*, 2024, Odionu, *et al*, 2024). Additionally, the reduction in occupational illnesses fosters greater employee satisfaction and retention, which further reduces costs associated with recruitment and training. The operational benefits extend to improved workflow efficiency, as ergonomic interventions eliminate inefficiencies caused by poorly designed workstations or processes. Ultimately, these advantages contribute to a more competitive and sustainable manufacturing sector (Bidemi, *et al*, 2024, Danda & Dileep, 2024, Olatunji, *et al*, 2024).

Scalability is a critical aspect of the model, ensuring its applicability beyond the initial pilot studies in the manufacturing sector. The principles of ergonomic risk assessment, real-time health surveillance, and targeted intervention management are not industry-specific and can be adapted to suit the needs of other high-risk sectors, such as construction, mining, and petrochemicals (Avwioroko, 2023, Haupt & Pillay, 2016, Mcintyre, Scofield & Trammell, 2019). These industries also face significant occupational health challenges that could be addressed using the integrated approach outlined in this model. Furthermore, the adaptability of the model to different regions, particularly within other developing economies, highlights its global relevance. Many of these economies share similar challenges, including limited resources, outdated workplace safety practices, and high rates of occupational illnesses (Avwioroko, 2023, Ikpegbu, 2015, Nagaty, 2023). By tailoring the model to account for the specific needs, regulations, and cultural contexts of these regions, it can serve as a scalable solution to improve workplace health and safety on a broader scale.

The alignment of the model with global standards and Sustainable Development Goals (SDGs) underscores its potential to contribute to international efforts to promote decent work and workplace safety. Specifically, the model directly supports SDG 8, which advocates for decent work and economic growth, by creating safer and more productive work environments that enhance employee well-being and organizational efficiency (Akinwale & Olusanya, 2016, John, 2023, Nwaogu, 2022). It also aligns with SDG 3, which focuses on good health and well-being, by addressing occupational health risks and promoting proactive health management. Beyond these goals, the model resonates with the objectives of international organizations such as the International Labour Organization (ILO) and the World Health Organization (WHO), which emphasize the importance of workplace safety and health as fundamental human rights (Nwaogu & Chan, 2021Zanke, 2022). By incorporating global best practices and leveraging advanced technologies, the model provides a framework that not only meets but exceeds existing occupational health standards, setting a benchmark for innovation in workplace safety.

The contributions of this model to workplace safety are further evident in its emphasis on modern technologies and data-driven approaches. The integration of wearable devices, IoT sensors, and predictive analytics represents a shift from reactive to proactive health management, allowing for real-time monitoring and timely interventions. These technologies enable organizations to identify emerging risks, implement preventive measures, and continuously improve their safety practices (Omokhoa, *et al*, 2024, Shah & Mishra, 2024, Sule, *et al*, 2024). Moreover, the data collected through health surveillance systems provides valuable insights that can inform policymaking, resource allocation, and long-term planning. This data-driven approach ensures that interventions are evidence-based, targeted, and effective, maximizing their impact on occupational health outcomes (Ansar, *et al*, 2021, Efobi, *et al*, 2023, Khalid, *et al*, 2018).

While the model has demonstrated significant potential, its successful implementation requires overcoming several challenges. For instance, ensuring widespread adoption necessitates addressing resistance to change among stakeholders, particularly in regions where traditional approaches to workplace safety are deeply entrenched. Effective communication, education, and training are essential to building stakeholder buy-in and fostering a culture of safety. Additionally, the cost of implementing advanced technologies may pose a barrier for smaller organizations with limited resources (Popendorf, 2019, Schulte, *et al*, 2022, Wood & Fabbri, 2019). Financial incentives, such as subsidies, grants, or tax breaks, can encourage adoption by reducing the upfront investment required. Policymakers also have a critical role to play in creating an enabling environment through supportive regulations, standards, and enforcement mechanisms that promote the integration of ergonomics and health surveillance in workplace safety practices (Omokhoa, *et al*, 2024, Schuver, *et al*, 2024).

In conclusion, the conceptual model for integrating ergonomics and health surveillance offers a transformative approach to reducing occupational illnesses in the Nigerian manufacturing sector and beyond. Its economic and operational benefits, coupled with its scalability and alignment with global standards, make it a robust framework for improving workplace safety and health (Shi, *et al*, 2022, Tamoor, *et al*, 2023, Xiao, *et al*, 2019). By fostering a culture of proactive health management, leveraging modern technologies, and addressing the unique challenges of different sectors and regions, this model has the potential to revolutionize occupational health practices and contribute to the broader goals of sustainable development and social well-being.

7. Conclusion and Recommendations

The conceptual model for integrating ergonomics and health surveillance to reduce occupational illnesses in the Nigerian manufacturing sector presents a transformative approach to addressing long-standing challenges in workplace health and safety. By combining ergonomic risk assessments, real-time health surveillance, and targeted intervention management, the model provides a comprehensive framework for proactive health management. The findings from its application reveal significant reductions in work-related illnesses, improvements in employee well-being, and enhancements in productivity, underscoring the model's potential to revolutionize occupational health practices. Furthermore, its emphasis on leveraging modern technologies, such as wearable devices and predictive analytics, ensures that organizations can transition from reactive to proactive strategies, creating safer and more efficient work environments.

The significance of this model extends beyond immediate workplace benefits. It contributes to national economic development by enhancing workforce productivity and reducing costs associated with occupational illnesses, such as medical expenses, absenteeism, and compensation claims. Additionally, the model aligns with global standards, including the United Nations Sustainable Development Goals (SDGs), particularly SDG 8 on decent work and economic growth and SDG 3 on good health and well-being. By addressing systemic challenges in occupational health, the model supports broader efforts to create sustainable and inclusive workplaces.

To facilitate the national adoption of this model, several policy recommendations are proposed. First, policymakers should establish regulations that mandate periodic ergonomic risk assessments and health surveillance in high-risk industries. Incentives such as tax benefits, grants, or subsidies can encourage organizations to adopt the model and invest in necessary technologies. Second, there is a need for capacity building through training programs for industrial engineers, occupational health professionals, and safety officers, ensuring they have the skills required to implement and manage the model effectively. Third, government agencies and industry associations should collaborate to create awareness campaigns that highlight the benefits of integrating ergonomics and health surveillance, fostering a culture of safety and proactive health management across sectors.

Further research is essential to optimize and scale the model for diverse contexts. Studies could explore its adaptability to other high-risk sectors, such as construction and petrochemicals, and investigate its effectiveness in small and medium-sized enterprises with limited resources. Additionally, research on the cost-benefit analysis of implementing the model in various organizational settings would provide valuable insights for decision-makers. Finally, exploring advancements in wearable technology and data analytics could enhance the model's capabilities, ensuring its continued relevance and effectiveness in addressing occupational health challenges.

In conclusion, the proposed conceptual model represents a significant step forward in improving workplace health and safety in the Nigerian manufacturing sector. Through strategic policy implementation, stakeholder engagement, and continued research, this model has the potential to become a cornerstone of occupational health management, driving economic growth, and aligning with global sustainability goals. Its adoption will not only benefit individual workers and organizations but also contribute to building a healthier and more productive society.

8. References

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