

Development of an Ergonomics Model to Enhance Healthcare in Developing Nations

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Abstract

Healthcare systems in most of the developing countries face many challenges that negatively influenced the performance and safety of healthcare personnel, as well as patients' satisfaction. This study reviews the current literature on the implementation of ergonomics models to enhance healthcare services delivery in developing nations. The authors reviewed a total of 39 articles in three different categories as follows: healthcare workers' performance (13 articles), the safety of healthcare workers and patients (16 articles), and quality of healthcare service (10 articles). Lack of efficient healthcare service delivery, especially in the performance of healthcare workers, safety, and quality, was noticed. Several factors, including community and traditional standards, economic, education, environment, policy of health system, and health system practice, determine the performance of healthcare workers. The safety of healthcare workers is influenced by potential infections by diseases such as HIV, HBV, and HCV, and potential injuries such as the MSDS. Finally, the satisfaction of patients and their perspectives on the healthcare services provided were reviewed. Healthcare in developing countries can be improved by developing an ergonomics model that incorporates the three categories.

Keywords

Healthcare, Performance, safety, service quality and developing countries.

1. Introduction

In this paper, a review of the current literature on the challenges that face healthcare workers was provided. It includes the safety of healthcare workers and their environments, improving the efficiency and safety of healthcare workers, and enhancing the quality of service in low and middle-income countries. Thirty nine articles were identified in this review and classified as follows: thirteen articles discussed the performance of healthcare workers in the developing countries; Sixteen articles explores the safety of healthcare workers; and finally ten articles reviews the quality of healthcare service delivery in the developing countries. The articles reviewed in this study included countries from Africa including South Africa, Kenya, Uganda, Ghana, Malawi, and Botswana and countries from Asia including Pakistan, Bangladesh, India, and Thailand.

To achieve the Sustainable Development Goals (SDGs), it is essential to enhance the delivery of healthcare service. Governments are expected to use the SDGs in their planning and policies as they approach 2030. The aim of SDGs is to achieve economic growth, protect the planet, and protect the environment by following 17 global goals and 169 targets (Stafford-Smith et al. 2016). Improving the delivery and access to service should lead to increasing the national income of any country. In fact, providing access to healthcare service that meets the lowest quality standards has been the primary function of the healthcare system. It is essential to identify the factors that describe the excellence of the healthcare service delivery to monitor its actual progress. These factors include quality, accessibility, continuity, and coverage. It might be difficult to determine if these factors exist in the health system especially in the developing nations (INDICATORS, 2010). Table 1 provides a summary of the literature review conducted in this study.

Table 1 Summary of literature review

Database	Other Keywords	Results
Web of Science	Human factors/ergonomics discipline, human factors/ergonomics profession, service systems, performance, healthcare delivery, developing country, quality improvement	6
PubMed	High-quality HFE, healthcare systems approach, design-driven, and performance and well-being goals, human factors/ergonomics discipline, growth country	8
Science Direct	Service quality, future of ergonomics, work systems, community health-care rural area	3
ProQuest	Ergonomics, human factors, healthcare, mhealth, developing nations, customer satisfaction, risks to health care workers in developing countries	5
EBSCOhost	Service quality perceptions, patient satisfaction, hospitals in a developing country, health service delivery models in low- and middle-income countries, quality improvement, community health-care workers	8
Google Scholar	All of the above	9
Total		39

2. Literature review

2.1 Healthcare service delivery in developing nations

Challenges that face healthcare systems in the developing countries include lack of financial resources, lack of access especially by patients residing in the rural areas, lack of health knowledge, and poor management (Andaleeb, 2001; Bhattacharyya et al. 2010). These challenges have a significant and negative influence on the safety and performance of healthcare workers as well as the quality of the services provided. To improve the quality of the healthcare service, a comprehensive movement from the government and the society in the developing countries is needed (Leatherman et al. 2010). One of the most important priorities in the developing nations is to increase the quality of healthcare service (Sharma & Narang, 2011). This is because healthcare providers in the developing countries have ignored patient's perception of healthcare service delivery which has led to poor quality of service.

2.2. Performance of healthcare workers

One of the objectives of developing an ergonomics model in healthcare systems in the developing countries is to improve the performance of healthcare workers and achieve the SDGs. Thus, it is essential to understand the factors that affect the performance healthcare workers so that it assists the decision makers in managing the human resources in healthcare (Chopra et al. 2008). These factors include community and traditional standards, economy, education, environment, policy of health system, and health system practices.

The first factor that influence the performance of healthcare workers is the community and traditional standards, and it includes sexual category rules. For example, pregnant women in Pakistan traditionally give birth to their babies in parent's houses, and they stay there for as long as forty days after delivery (Bhutta et al. 2011). Similarly, mothers and babies are isolated after delivery in Bangladesh (Azad et al. 2010). These cases illustrate some of the difficulties that healthcare workers face when dealing with mothers and their new-born.

The second factor that influence the performance of healthcare workers is the economy which consists of the cost of healthcare services and the financial rewards. Interestingly, studies have shown that financial rewards alone does not improve the performance of healthcare workers (Franco et al. 2004; Kotzee & Couper, 2006). Thus, other rewards should be integrated with the financial rewards to enhance the performance of healthcare workers. Studies showed that the salaries of healthcare workers in the developed countries are higher than those in the developing countries (Franco et al. 2004). Besides financial rewards, the economic factor also includes the cost of healthcare service. For example, Health Surveillance Assistants (HSAs) were unable to collect medicines from their nearest centers in some areas as this service was not free compared with the same service provided in the governmental areas (Callaghan-Koru et al., 2013).

The third factor that influences the performance of healthcare workers is education, which includes healthcare worker's level of knowledge and continuing education. The level of knowledge of healthcare of the population in countries such as Kenia and Uganda made the tasks of healthcare workers very challenging (Takasugi & Lee, 2012). Continuing education of healthcare workers such as training support increases their performance and their efficiency (Mukherjee & Eustache, 2007). Besides, training, especially for young health professionals, increases the ability to deal with everyday job requirements in a professional way (Reid, 2004).

Fourth, the environment such as the need to cover a wide geographical area may reduce the performance of healthcare workers. For instance, it has been reported that families living within one kilometer from healthcare facility receive nearly 73% of healthcare service (Mukanga et al. 2012). On the contrary, families living within one to three kilometers from a healthcare facility were 81% less to receive service provided by healthcare workers compared with families living within one kilometer from healthcare facility (Azad et al., 2010).

Fifth, the policy of healthcare systems including human resources policies and health service occupations also contribute to the performance of healthcare workers. Lack of clear vision and policy led to lack of support to healthcare workers in Thailand (Sranacharoenpong & Hanning, 2011). In South Africa, although the public healthcare workers adopted a framework policy, the majority of healthcare workers in this countries were not working under the government which has made the challenges of healthcare workers unresolved (Jack et al. 2012). The policy of health systems also includes health service occupations such as instruments, sources, and logistic support significantly influences the performance of healthcare workers. In fact, healthcare workers in Pakistan were dissatisfied due to lack

of medicine and food which led to reducing the performance of healthcare workers and decreasing the level of patients' satisfaction (Burn, 2008).

Finally, health system practice such as career development has an effect on the performance of healthcare workers. lack of chances in career development is very prominent in urban areas and represents a big challenge to healthcare workers (Kotzee & Couper, 2006). Healthcare workers assume a high level of motivation when they feel that there is a chance to improve their performance. Thus, all the preceding factors play a significant role in enhancing the performance of healthcare workers in the developing countries. Healthcare systems in the developing countries should realize the importance of these factors and provide support to facilitate their application so that healthcare workers can provide high quality services. Indeed, the after mentioned factors should be involved in any ergonomics model aiming to improve the performance of healthcare workers.

2.3. Safety of healthcare workers

The Occupational Safety and Health Administration (OSHA) was established in 1970s as part of the US Department of Labor to ensure that the working environments for workers are safe and healthy (Lori et al. 2016). It is a challenging task to protect the medical staff in the developing countries because it is not a priority task in these countries (Board, 2001).

2.3.1 Infectious Blood-Borne Pathogens

The first infection of a healthcare worker was with human immunodeficiency virus (HIV) by a sharp injury occurred in 1984 (STEIGLEDER, 1985). Due to great technological development, the Federal Needlestick Safety and Prevention Act became law in November 2000 (Jamu et al. 2006). In fact, more than three millions were exposed to blood-borne pathogens, and the majority of those cases (96%) occurred in the developing countries which makes this profession the most dangerous profession in the globe (Kane et al. 1999). Many studies investigated the exposure of healthcare workers to blood-borne pathogens. For example, the prevalence of HIV, Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV) diseases among healthcare workers were investigated. The study reported that lack of protection programs for healthcare workers, lack of sufficient data, lack of primary healthcare, and prevalence of diseases among the population were contributing factors to the prevalence of these diseases. In South Africa, the management of needle stick injuries among medical practitioners was explored (Ledibane, 2015). The study reported that lack of awareness, overuse, and unsafe injection practices were among the contributing factors that pose a risk of dangerous diseases (Ledibane, 2015) (Figure 1).

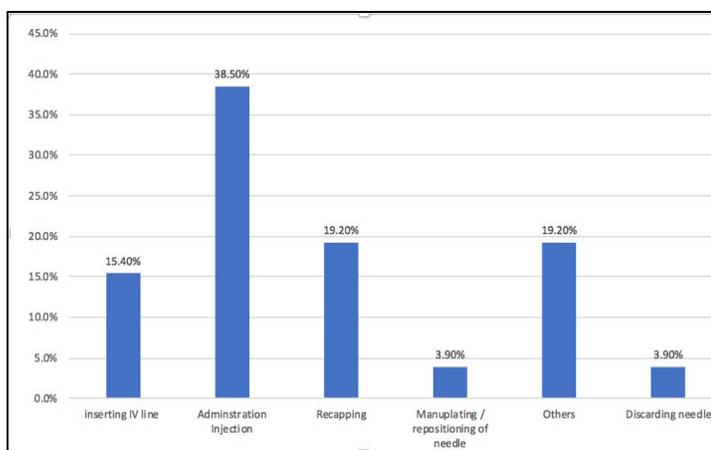


Figure 1. Activities performed by healthcare workers at the time of the reported NSI (N=34) (Ledibane, 2015)

Similarly, an investigation was conducted on the occurrences of sharp injuries to nurses in the emergency department in Ghana (Lori et al., 2016). The study stated that more than 28% of the nurses reported sharp injuries as follows: 45.5% reported one injury, 18.2% reported two injuries and 36.3% reported four injuries over a period of 12 months.

A cross-sectional study was conducted to investigate the epidemiology aspect of the percutaneous exposure in a public healthcare center in Botswana (Jamu et al. 2006). The study reported a high risk of percutaneous exposure with sharp working objects with more than 11% of the medical staff, especially among nurses, experience more injures during the study period. Another study examined the occupational transmission of different diseases among healthcare workers in the developing countries (Arya et al. 2010). The study reported an increase in the number of HIV-positive healthcare workers in the communities due to lack of knowledge and information.

2.3.2 Musculoskeletal disorders (MSDs) and related injuries

According to many studies, Musculoskeletal Disorders (MSDs) are among the main causes of injuries, disabilities, absence, and incapacity of healthcare workers in the developing countries. In one study, the relationship between the perceived demand and the musculoskeletal disorders among nurses working in the operating room in Shiraz city hospital in Iran was explored (Choobineh et al. 2010). Two factors were examined in this study namely, the risk factor and the demographic characteristics and psychosocial factors (Figure 2). The study reported that both factors have a strong influence on the prevalence of MSDs among male and female nurses. Also, another study investigated the impact of work-related stress and psychosocial risks on healthcare systems in the developing countries (Kortum et al. 2010). The study indicated that the major barriers to the policy shift include lack of resources, lack of awareness of the risk, and fear of unionization. Figure 3 illustrates the significant concerns in occupational health and safety (see Figure 3.). The physical and psychosocial risk-factors concerning arms, neck and shoulders (CANS) injuries among computer office workers in the developing countries were evaluated (Ranasinghe et al., 2011). The study surveyed a sample of 2500 office workers and evaluated their awareness of OSHA standards. The study reported that daily computer usage, incorrect body posture, bad work-habits, work overload, poor social support and poor ergonomic knowledge significantly influenced the severity of CANS. Zakerian and his colleagues investigated the association workplace conditions and musculoskeletal disorders among nurses in developing countries (Zakerian et al., 2013). The study aimed to increase the awareness among nurses to participate in the required training to avoid stress-related disorders. Five factors that may contribute to the risk of musculoskeletal disorders were identified. The study reported that more than 50% of the 335 participants had complaints of musculoskeletal disorders. The study also indicated that lack of work ergonomics and hazard awareness are prominent in the developing countries. To reduce such risks, the study suggested that healthcare systems in the developing countries should focus on improving the workplace environment.

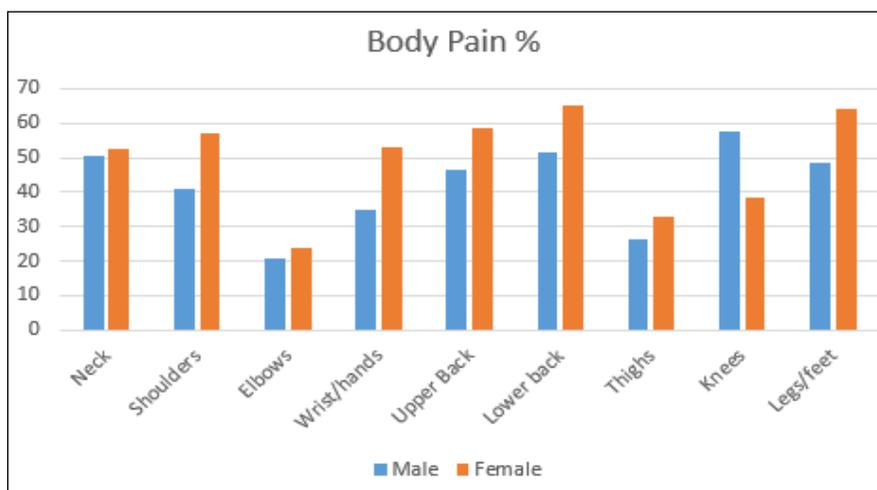


Figure 2. Percentage of body Pain (Choobineh et al., 2010)

Another study investigated the frequency of lower back pain among theatre nurse in Nigeria (Hinmikaiye & Bamishaiye, 2012). The study indicated that negligence in most of the developing countries increased the risk of disabilities including lower back pain. The study also reported that 78% of the medical practitioners such as nurses complained of lower back pain (Figure 4).

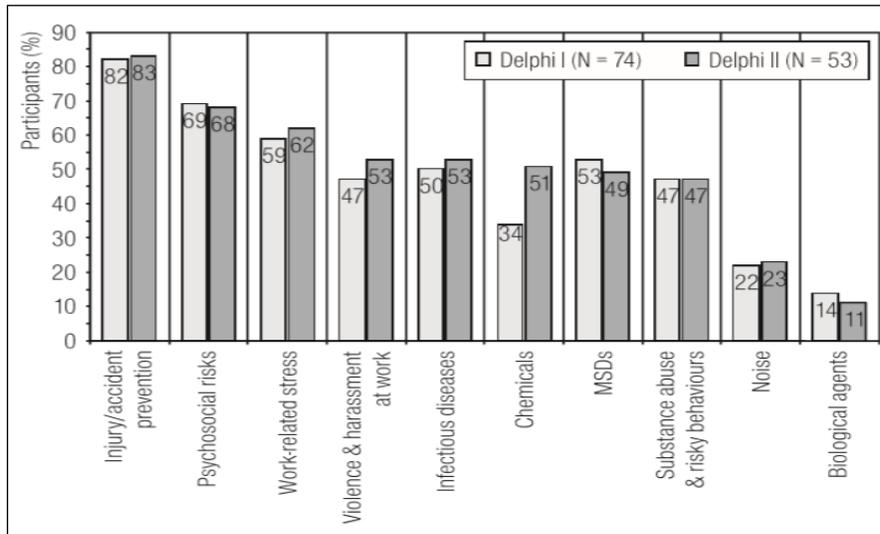


Figure 3. Major concerns in occupational health and safety (Kortum et al., 2010)

Similarly, Barzideh and his colleagues explored the influence of work-related stress on musculoskeletal disorders among nurses in Iran (Barzideh et al. 2014). The study revealed that lower back and legs/feet related injuries were the highest frequency while elbows related injuries were the lowest frequency. Figure 5 shows the frequency of the reported symptoms for different injuries.

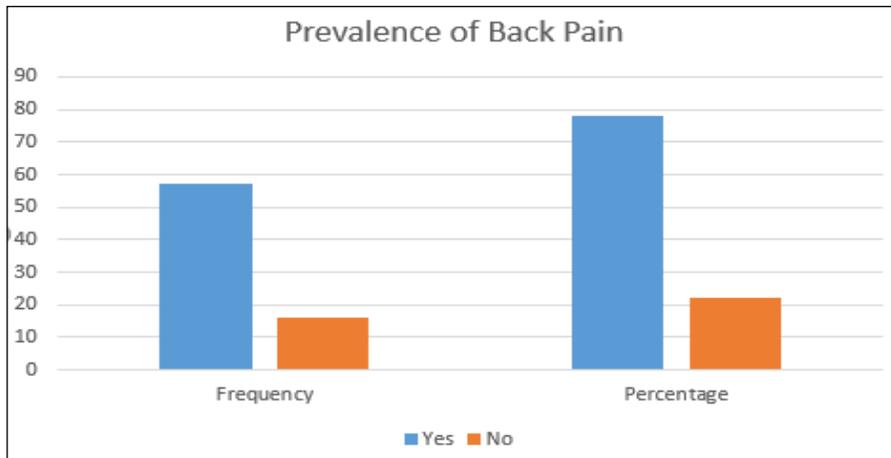


Figure 4. Prevalence of Back Pain (Hinmikaiye & Bamishaiye, 2012)

In the same context, the association between the workload and the musculoskeletal disorders among nurses in two hospitals in Qom, Iran was examined (Khandan et al., 2017). The study reported a high potential of pain in neck and back that could limit the nurses' attention at work and reduce their productivity. To avoid fatigue resulting from performing tasks for long periods, the study recommended to introduce an intervention program to control the increasing rate of body pain.

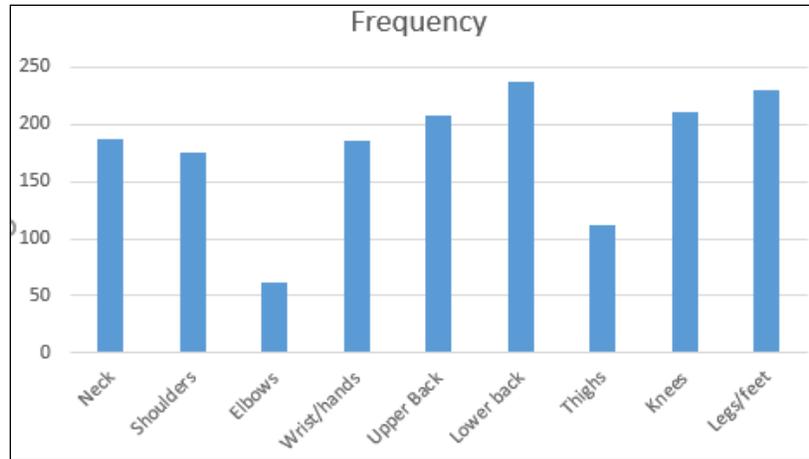


Figure 5. Frequency of reported symptoms frequency (Barzideh et al., 2014)

The quality of healthcare facilities and the safety of patients in the developing countries were addressed by many authors in the literature. The quality of treatment depends on the risk of an infection, medication errors, maternal and perinatal care, and overall healthcare quality. A comparison of the quality of healthcare services in South Asian countries with the healthcare services provided in the developed countries was assessed using a large-scale survey (Harrison et al. 2015). The study reported that there is a significant gap in the level of knowledge between the developing and developed countries. Also, the study found a lack of proper training and guidance at training centers and universities which contributed to the risk of infections and other hazards at the workplace. Furthermore, the risk of musculoskeletal disorders among nurses in Kenya was explored (Tanui, 2016). The study reported that a lot of the body muscular tissues are affected by the work-related fatigue factors. Permanent disabilities caused by excessive fatigue may jeopardize the life of nurses. The study also stated that lack of proper training and awareness among the nurses as well as working at the same posture for long periods increasing the pressure on specific tissues and ruptures them are considered the leading factors for musculoskeletal disorders. Figure 6 illustrated the percentages of work-related musculoskeletal disorders among nurses who only work in nursing compared with working in other fields.

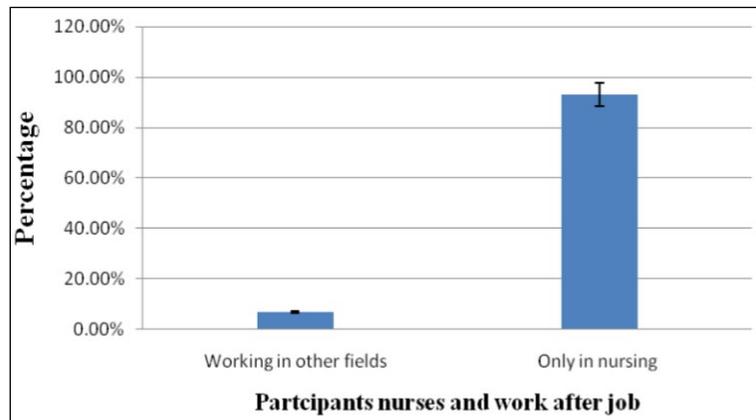


Figure 7. Nurses working in other fields causing WMDS (Tanui, 2016)

2.3.3 Quality of healthcare service

The concern of patients' safety and quality of facilities in the developing countries has been addressed. The study revealed that major factor of concern regarding the quality of treatment being provided was a risk of infection, medication error, maternal and perinatal care, and overall healthcare quality. The researchers emphasized on a large-scale survey of South Asian healthcare organizations, to compare the quality of service in these organizations as compared to organizations in the developed countries and provide suggestions for improvement accordingly. One of the major gaps identified in this research was the level of knowledge between both types of countries. It was found that lack of proper training and guidance at training centers or universities led to increasing the risk of infections and other hazards at the workplace (Harrison et al. 2015). Health security including national development and security contribute to the productive capacity and general health of the community residents. The effectiveness of governance and commitment of health managers to the quality of services lead to improving the quality of healthcare services. Effective healthcare policies as well as the use of technology were adopted in the developing countries to improve healthcare services. Such strategies were reported to be effective in resolving the challenges that limit healthcare systems from providing high quality services (Chikotie, 2013). Regardless, many developing countries have been successful in maintaining good healthcare quality. On the contrary, developing countries with large populations face many challenges to provide high quality healthcare services. Also, the poor in many of the developing countries lack the access to high quality healthcare services (Audibert & Mathonnat, 2013).

Many studies reviewed the quality of healthcare services in the developing countries. Andaleeb (2001) investigated the association between patients' satisfaction and selected service quality factors namely, responsiveness, assurance, communication, discipline, and bribe money. The study revealed that these factors significantly influenced patients' satisfaction. Sharma and Narang (2011) reviewed the quality of healthcare services provided to patients in rural India based on a selected factors. The study showed that healthcare delivery and financial and physical access to care have a significant influence on the intention to repeat visit among male patients. Also, drug availability, health personnel conduct, and healthcare delivery were found to have a significant influence on female patients. Also, Aldana and colleagues evaluated the level of patients' satisfaction in a governmental healthcare center in Bangladesh (Aldana, Piechulek, & Al-Sabir, 2001). The study indicated that the behavior of healthcare provider such as respect and politeness were more important than the technical aspect of the treatment such as patients' waiting time and consultation times. In another study, the healthcare service delivery in a public hospital in south Africa was explored (De Jager, Du Plooy, & Ayadi, 2010). The service quality was assessed based on patients' expectations and perceptions. The study revealed that factors such as the 'proper explaining of hospital procedures' and 'speediness of services by medical staff' were found to be the most important factors that influence patients' expectation and perception.

Quality improvement (QI) methods were also used to improve the quality of healthcare service delivery in the developing countries. Leatherman and his colleagues documented four barriers to the implementation of QI methods namely, the need to cognizable of the issue, the currentt excess of universal and territorial healthcare activities, the troubles related to implanting QI inside existing wellbeing framework structures, and the financing of QI (Leatherman et al., 2010). The study proposed a modified version of the World Health Organization's (WHO) framework for the healthcare system. The study also reported many recommendations to eliminate the aforementioned barriers and ensure successful implementation of QI methods. A literature review of healthcare service delivery models and their influence on the quality care provided to patients in the developing countries was carried out (Bhattacharyya et al., 2010). The study reported that healthcare organizations were innovative in areas such as marketing, finance, and operations, but they lack data concerning the quality of care. To increase the quality of care and reduce costs, Demirkan (2013) developed a Smart Healthcare Systems Framework (SHSF). The author stated that implementation of previous and similar frameworks were efficient in increasing the quality of healthcare service and reducing the cost of treatment and asserted that similar results could be obtained in the developing countries. Table 2 shows a summary of the research articles on healthcare service in the developing countries with a specific focus on three main area namely, the quality of healthcare service, the performance of healthcare workers, and the safety of healthcare workers.

Table 2: Summary of literature review of ergonomics models in the developing countries

Author	Year	Model	Perspective
Andaleeb	2001	Survey	Service quality affects patient satisfaction
Bhattacharyya et al.	2010	Literature review	Introduction of innovations in healthcare service to improve the quality of healthcare service
Leatherman et al.	2010	Literature review	The adoption of quality improvement methods to improve the quality of healthcare service in the developing nations
Sharma & Narang	2011	Survey	Evaluation of service quality in rural India
Harrison et al.	2015	Literature review	Identify current interventions on patient safety and quality of care in the developing countries of Southeast Asia
Itam & Adindu	2012	Literature review	Examining the quality of healthcare service in Africa
Chikotie	2013	Case study	The role of Information and Communication Technologies (ICTs) in improving the delivery of healthcare service in South Africa
Audibert & Mathonnat	2013	Literature review	Promoting access to healthcare service in developing countries
Aldana, et al.	2001	Survey	Assess the relationship between patient satisfaction and the quality of healthcare provided in rural Bangladesh
De Jager et al.	2010	SERVQUAL	Determinants of patient satisfaction on the quality of healthcare service in the developing countries
Demirkan	2013	Smart Healthcare Systems Framework	Effectiveness of smart healthcare systems in providing high-quality healthcare service
Chopra et al.	2008	Literature review	Effects of policy options on human resources in healthcare
Bhutta et al.	2011	Cluster randomized trial	Evaluating the effectiveness of a community-based intervention on the reduction of perinatal and neonatal mortality in a rural Pakistan
Azad et al.	2010	Cluster-randomized controlled trial	Assessing the effectiveness of women's groups on providing maternal and neonatal care rural Bangladesh
Franco et al.	2004	Exploratory research	Factors influencing the motivation of healthcare workers in Jordan and Georgia
Kotzee & Couper	2006	Survey	Identifying the factors influencing the retention of doctors in hospitals in rural South Africa
Callaghan-Koru et al.	2013	Survey	Evaluating the effectiveness of National community-based health worker (CBHW) programs in Malawi
Takasugi & Lee	2012	Survey	Identifying the factors influencing healthcare workers to volunteer in Kenya
Mukherjee & Eustache	2007	Survey	The role of community health workers (CHWs) in the prevention and treatment of HIV in Haiti
Reid	2004	survey	Explore medical students' attitudes towards working in the NE and to identify factors determining such attitudes
Mukanga et al.	2012	Survey	The role of community health workers (CHWs) in providing healthcare access to patients with Malaria in Uganda
Sranacharoenpong & Hanning	2011	Survey	Investigating the barriers to implementing a diabetes prevention education program for community health-care workers Thailand
Jack et al.	2012	Survey	Identifying the factors influencing healthcare workers to volunteer in Uganda
Lori et al.	2016	Survey	Determining the frequency of sharps injuries among emergency department nurses in Ghana
Board	2001	Literature review	Risks to healthcare workers in developing countries
Kane et al.	1999	Literature review	Evaluate the prevalence of unsafe injections and transmission of bloodborne pathogens in the developing countries
Ledibane	2015	Literature review	Documenting the needle-stick injuries (NSIs) among healthcare workers in Mangaung, South Africa
Jamu et al.	2016	Survey	Assessment of the level and distribution of needlestick and sharp object injuries in the Botswana public health sector

Table 2: Summary of literature review of ergonomics models in the developing countries

Author	Year	Model	Perspective
Arya et al.	2010	Exploratory research	Occupational exposure to potentially infectious body fluids & blood places healthcare workers at risk for acquisition of bloodborne pathogens.
Barzideh et al.	2014	Survey	Investigation of job stress dimensions and their relationship to musculoskeletal disorders (MSDs) among nurses of Shiraz University of Medical Sciences (SUMS) hospitals
Kortum et al.	2010	Survey	Evaluating the perceptions of experts regarding psychosocial risks and work-related stress in the developing countries
Ranasinghe et al.	2011	Survey	Documenting the complaints of arms, neck, and shoulders among computer office workers
Hinmikaiye & Bamishaiye	2012	Survey	Determine the incidences of low back pain among theatre nurses
Zakerian et al.	2013	Survey	Evaluating the association between the nurses' awareness of ergonomic principles and workplace conditions and the work-related injuries in Iran
Khandan et al.	2017	Survey	Investigating the relationship between fatigue and work-related musculoskeletal disorders (WRMSDs) in Iran
Tanui	2015	Survey	Assess work-related musculoskeletal disorders among nurses working in private and public hospital in Mombasa County
Burn	2008	N/A	Evaluate the effectiveness of nurses' performance in Pakistan
STEIGLEDER	1985	Case study	Reports a case of needlestick transmission of human T-lymphotropic virus type III (HTLV-III) infection to a health care worker in the UK from a patient who was presumably infected while in Africa
Choobineh et al.	2010	Survey	Determine the prevalence of MSDs and to examine the relationship between perceived demands and reported MSDs among nurses

Based on the literature, it is evident that there is a need for a comprehensive implementation of ergonomics models, especially in the developing countries as research on healthcare service delivery in the developing countries is scant. Also, the effectiveness of ergonomics models in delivering healthcare services in the developing countries has not been widely explored. Table 3 summarizes the research on healthcare service in the developing countries.

Table 3 Main areas of healthcare in developing nations that were explored in the literature

	Quality of healthcare service	Performance of healthcare workers	Safety of healthcare workers	Diseases infection of healthcare workers	Injuries of healthcare workers	Effectiveness of ergonomics models in healthcare
Andaleeb, 2001	×					
Bhattacharyya et al., 2010	×					
Leatherman et al., 2010	×					
Sharma & Narang, 2011	×					
Chopra et al., 2008		×				
Bhutta et al., 2011		×				
Azad et al., 2010		×				
Franco et al., 2004		×				
Kotzee & Couper, 2006		×				
Callaghan-Koru et al., 2013		×				

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	Quality of healthcare service	Performance of healthcare workers	Safety of healthcare workers	Diseases infection of healthcare workers	Injuries of healthcare workers	Effectiveness of ergonomics models in healthcare
Takasugi & Lee, 2012		×				
Mukherjee & Eustache, 2007		×				
Reid, 2004		×				
Mukanga et al., 2012		×				
Sranacharoenpong & Hanning, 2011		×				
Jack et al., 2012		×				
Burn, 2008		×				
Board, 2001			×	×		
STEIGLEDER, 1985				×		
Kane et al., 1999				×		
Ledibane, 2015				×		
Lori et al., 2016			×	×		
Jamu et al., n.a.				×		
Arya et al., 2010				×		
Choobineh et al., 2010				×		
Kortum et al., 2010			×			
Ranasinghe et al., 2011			×			
Arya et al., 2010				×		
Choobineh et al., 2010				×		
Kortum et al., 2010			×			
Ranasinghe et al., 2011			×			
Hinmikaiye & Bamishaiye, 2012					×	
Zakerian et al., 2013					×	
Barzideh et al., 2014					×	
Khandan et al., 2017					×	
Harrison et al., 2015	×		×			
Tanui, 2016					×	
Itam & Adindu, 2012	×					
Chikotie, 2013	×					
Audibert & Mathonnat, 2013	×					
Aldana, et al., 2001	×					

Table 3 Main areas of healthcare in developing nations that were explored in the literature

	Quality of healthcare service	Performance of healthcare workers	Safety of healthcare workers	Diseases infection of healthcare workers	Injuries of healthcare workers	Effectiveness of ergonomics models in healthcare
De Jager et al., 2010	×					
Demirkan, 2013	×					
Khan et al., 2018						×

3. Methods

This article reviews journal articles focused on the performance of healthcare workers, the safety of healthcare workers, and the quality of healthcare services in the developing countries. An ergonomics model for healthcare service delivery in the developing countries can be used to improve these factors. After removing duplications, 798 records were identified. The process of title and abstract screening resulted in 71 articles that fulfilled the inclusion criteria and copies of the full publications were obtained for further evaluation. Subsequently, a total of 39 articles were identified as eligible from the full text review and were included in the literature review. Figure 8 shows the selection process using PRISMA flow diagram.

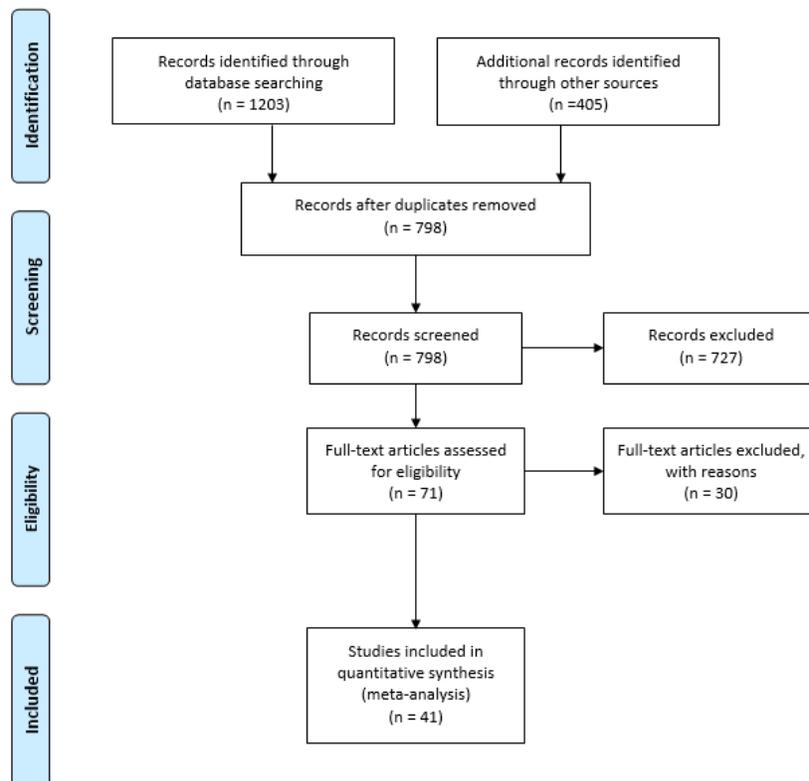


Figure 8. PRISMA flow diagram for applications of ergonomics models in the developing nations

4. Discussion

This article reviews the applications of ergonomics models in the developing countries. Specifically, the article investigates the challenges the face healthcare workers in performing their everyday duties, the safety of healthcare workers, and the quality of healthcare services in the developing countries. The performance of healthcare workers were found to be influenced by many factors namely, community and traditional standards, economy, education, environment, policy of health system, and health system practices. The influence of these factors were prominent in African and South Asian countries including South Africa, Kenya, Uganda, Pakistan, Bangladesh, and Thailand. Among the challenges that jeopardize the safety of healthcare workers are infectious blood-borne pathogens such as HIV, HBV, and HCV and MSDs and related injuries. The transmission of blood-borne diseases were common in countries such as South Africa, Ghana, and Botswana. On the other hand, MSDs injuries among healthcare workers were examined in countries such as Kenya, Nigeria, and Iran. Figure 9 shows the distribution of articles that reviews the infectious blood-borne pathogens and MSDs and related injuries.

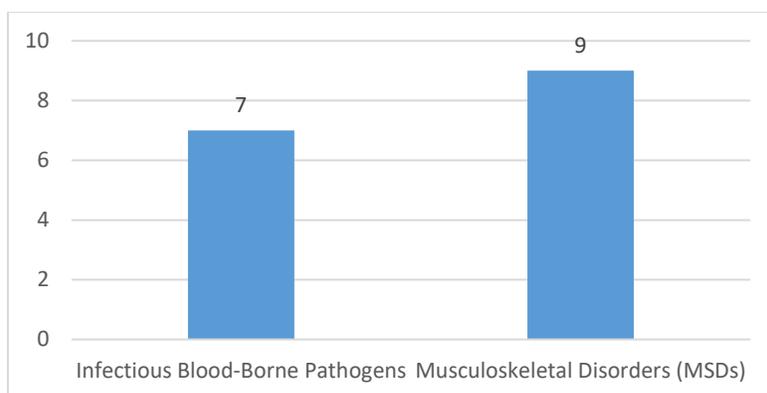


Figure 9. Distribution of articles exploring safety of healthcare workers in the developing countries

5. Conclusion

The current study reviewed the implementation of ergonomics models in the developing countries focusing on three main areas namely the performance of healthcare workers, the safety of healthcare workers and patients, and the quality of healthcare services provided. The performance of healthcare workers is influenced by many factors such as community and traditional standards, economic, education, environment, policy of health system, and health system practice. In the safety of healthcare workers and patients, two topics were reviewed namely the potential infections of healthcare workers by diseases such as HIV, HBV, and HCV and the potential injuries that healthcare workers may experience such as MSDs when handling patients for long periods.

References

- Aldana, J. M., Piechulek, H., & Al-Sabir, A. Client satisfaction and quality of health care in rural Bangladesh. *Bulletin of the World Health Organization*, 79(6), 512-517, 2001.
- Andaleeb, S. S. Service quality perceptions and patient satisfaction: a study of hospitals in a developing country. *Social science & medicine*, 52(9), 1359-1370, 2001.
- Arya, S. C., Agarwal, N., Agarwal, S., & Jain, A. Occupational transmission of bloodborne diseases to healthcare workers in developing countries: meeting the Challenge. *Journal of Infection Prevention*, 11(5), 178-179, 2010.
- Audibert, M., & Mathonnat, J. Facilitating access to healthcare in low-income countries: a contribution to the debate. *Field Actions Science Reports. The journal of field actions*(Special Issue 8), 2013.
- Azad, K., Barnett, S., Banerjee, B., Shaha, S., Khan, K., Rego, A. R., . . . Prost, A. Effect of scaling up women's groups on birth outcomes in three rural districts in Bangladesh: a cluster-randomised controlled trial. *The Lancet*, 375(9721), 1193-1202, 2010.
- Barzideh, M., Choobineh, A., & Tabatabaee, H. Job stress dimensions and their relationship to musculoskeletal disorders in Iranian nurses. *Work*, 47(4), 423-429, 2014.
- Bhattacharyya, O., Khor, S., McGahan, A., Dunne, D., Daar, A. S., & Singer, P. A. Innovative health service delivery models in low and middle income countries-what can we learn from the private sector? *Health Research Policy and Systems*, 8(1), 24, 2010.
- Bhutta, Z. A., Soofi, S., Cousens, S., Mohammad, S., Memon, Z. A., Ali, I., . . . Wall, S. Improvement of perinatal and newborn care in rural Pakistan through community-based strategies: a cluster-randomised effectiveness trial. *The Lancet*, 377(9763), 403-412, 2011.
- Board, S. Risks to health care workers in developing countries. *N Engl J Med*, 345(7), 2001.
- Burn, H. Attrition of female health workers: an insight into the reasons why lady health workers resign from Pakistan's national programme for family planning and primary health care. Leeds: University of Leeds, 2008.
- Callaghan-Koru, J. A., Gilroy, K., Hyder, A. A., George, A., Nsona, H., Mtumuni, A., . . . Bryce, J. Health systems supports for community case management of childhood illness: lessons from an assessment of early implementation in Malawi. *BMC Health Services Research*, 13(1), 55, 2013.
- Chikotie, T. T. ICTs and Public Healthcare Service Delivery in a Developing Country Context: Critical Factors towards Addressing the Health Divide. *Journal of Health Informatics in Africa*, 1(1), 2013.
- Choobineh, A., Movahed, M., Tabatabaie, S. H., & Kumashiro, M. Perceived demands and musculoskeletal disorders in operating room nurses of Shiraz city hospitals. *Industrial health*, 48(1), 74-84, 2010.
- Chopra, M., Munro, S., Lavis, J. N., Vist, G., & Bennett, S. Effects of policy options for human resources for health: an analysis of systematic reviews. *The Lancet*, 371(9613), 668-674, 2008.
- De Jager, J., Du Plooy, A., & Ayadi, M. F. Delivering quality service to in-and out-patients in a South African public hospital. *African Journal of Business Management*, 4(2), 133, 2010.
- Demirkan, H. A smart healthcare systems framework. *IT Professional*, 15(5), 38-45, 2013.
- Franco, L. M., Bennett, S., Kanfer, R., & Stubblebine, P. Determinants and consequences of health worker motivation in hospitals in Jordan and Georgia. *Social science & medicine*, 58(2), 343-355, 2004.
- Harrison, R., Cohen, A. W. S., & Walton, M. Patient safety and quality of care in developing countries in Southeast Asia: a systematic literature review. *International Journal for Quality in Health Care*, 27(4), 240-254, 2015.
- Hinnikaiye, C. D., & Bamishaiye, E. I. The incidence of low back pain among theatre nurses: A case study of University of Ilorin and Obafemi Awolowo University Teaching Hospital. *International Journal of Nursing Science*, 2(3), 23-28, 2012.
- INDICATORS, A. H. O. MONITORING THE BUILDING BLOCKS OF HEALTH SYSTEMS, 2010.
- Itam, I. H., & Adindu, A. Health Security in Africa and Quality of Health Services, 2012.
- Jack, B. A., Kirton, J. A., Birakurataki, J., & Merriman, A. The personal value of being a palliative care community volunteer worker in Uganda: a qualitative study. *Palliative medicine*, 26(5), 753-759, 2012.
- Jamu, S. M., Gabaitiri, L., Mudongo, K. K., & Mwaniki, N. K. Epidemiology of percutaneous exposure to needlestick and sharp object injuries in the Botswana public health sector: A health facility cross sectional study. *Global Journal of Medicine and Public Health*, 5(2), 1-8, 2016.
- Kane, M., Zaffran, M., Simonsen, L., Lloyd, J., & Kane, A. Unsafe injections in the developing world and transmission of bloodborne pathogens: a review. *Bulletin of the World Health Organization*, 77(10), 789, 1999.
- Khandan, M., Momenyan, S., Manesh, L. A., Khosravi, Z., Eyni, Z., & Koohpaei, A. The Relationship Between Fatigue and Job Content with Musculoskeletal Disorders Among Nurses. *Jundishapur Journal of Health Sciences*, 9(2), 2017.

- Kortum, E., Leka, S., & Cox, T. Psychosocial risks and work-related stress in developing countries: health impact, priorities, barriers and solutions. *International journal of occupational medicine and environmental health*, 23(3), 225-238, 2010.
- Kotzee, T., & Couper, I. What interventions do South African qualified doctors think will retain them in rural hospitals of the Limpopo province of South Africa. *Rural Remote Health*, 6(3), 581, 2006.
- Leatherman, S., Ferris, T. G., Berwick, D., Omaswa, F., & Crisp, N. The role of quality improvement in strengthening health systems in developing countries. *International Journal for Quality in Health Care*, 22(4), 237-243, 2010.
- Ledibane, T. The profile and management of needle-stick injuries among healthcare workers in a primary health sub-district in Mangaung from 2008 to 2011: original research. *Occupational Health Southern Africa*, 21(6), 17-21, 2015.
- Lori, J. R., McCullagh, M. C., Krueger, A., & Oteng, R. Sharps injuries among emergency department nurses in one tertiary care hospital in Ghana. *International emergency nursing*, 28, 14-19, 2016.
- Mukanga, D., Tibenderana, J. K., Peterson, S., Pariyo, G. W., Kiguli, J., Waiswa, P., . . . Pagnoni, F. Access, acceptability and utilization of community health workers using diagnostics for case management of fever in Ugandan children: a cross-sectional study. *Malaria journal*, 11(1), 121, 2012.
- Mukherjee, J. S., & Eustache, F. E. Community health workers as a cornerstone for integrating HIV and primary healthcare. *AIDS care*, 19(sup1), 73-82, 2007.
- Ranasinghe, P., Perera, Y. S., Lamabadusuriya, D. A., Kulatunga, S., Jayawardana, N., Rajapakse, S., & Katulanda, P. Work related complaints of neck, shoulder and arm among computer office workers: a cross-sectional evaluation of prevalence and risk factors in a developing country. *Environmental Health*, 10(1), 70, 2011.
- Reid, S. Monitoring the effect of the new rural allowance for health professionals. Durban: Health Systems Trust, 1-7, 2004.
- Sharma, J., & Narang, R. Quality of healthcare services in rural India: the user perspective. *Vikalpa*, 36(1), 51-60, 2011.
- Sranacharoenpong, K., & Hanning, R. M. Developing a diabetes prevention education programme for community health-care workers in Thailand: formative findings. *Primary health care research & development*, 12(04), 357-369, 2011.
- Stafford-Smith, M., Griggs, D., Gaffney, O., Ullah, F., Reyers, B., Kanie, N., . . . O'Connell, D. Integration: the key to implementing the Sustainable Development Goals. *Sustainability Science*, 1-9, 2016.
- STEIGLEDER, G. NEEDLESTICK TRANSMISSION OF HTLV-III FROM A PATIENT INFECTED IN AFRICA: GROSSE VERLAG GMBH KURFURSTENSTRASSE 112-113, W-1000 BERLIN 30, GERMANY, 1985.
- Takasugi, T., & Lee, A. Why do community health workers volunteer? A qualitative study in Kenya. *Public health*, 126(10), 839-845, 2012.
- Tanui, B. C. Assessment of Work-Related Musculoskeletal Disorders among Nurses in Mombasa County, Kenya. COHES, JKUAT, 2016.
- Zakerian, S. A., Monazzam, M. R., Dehghan, S. F., Mohraz, M. H., Safari, H., & Asghari, M. Relationship Between Knowledge of Ergonomics and Workplace Conditions with Musculoskeletal Disorders among Nurses: A Questionnaire Survey. *World Applied Sciences Journal*, 24(2), 227-233, 2013.

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