

An Overview of the Effectiveness of mHealth Technology in the Developing Countries

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Abstract

The healthcare system in most of the developing countries has been struggling to provide high-quality services. This limitation has negatively affected the performance and safety of healthcare personnel, as well as patients' satisfaction. The objective of this paper is to provide an overview of the current knowledge of integrating human factors/ergonomics technologies to improve healthcare service delivery in developing nations. The authors reviewed the current literature focusing on mhealth interventions in developing countries. This review included the integration of mobile phone applications as well as short messaging service (SMS). Previous research on the integration of mhealth in developing countries focused on the use of mobile phone applications and SMS text messaging. However, the effectiveness of such programs has not been reported in most of these studies. Although little research was found in the implementation of mhealth technologies such as the SMS to improve healthcare service delivery in the developing nations, the effectiveness of such programs has not been reported. Therefore, future research should focus on evaluating the outcomes of mhealth interventions to ensure that patients in developing countries have access to high-quality healthcare services.

Keywords

Healthcare, mhealth, Mobile Phone, Developing Countries

1. Introduction

The medical technology is continuing to be developed since the media and telecommunications have been created. The mobile medical technology is updated regularly to increase patient satisfaction. However, medical knowledge is still a big challenge in the world specifically in developing countries (Chow et al. 2016). For instance, hypertension in developing countries is considered a high-risk factor that affects the global disease crisis (Chow et al. 2016). The aim of this research is to develop a literature review for the interference of mobile health in the developing countries and also mobile phone integration. A summary of the literature review in this study is represented in Table 1.

Table 1: Summary of literature review

Database	Other Keywords	Results
ProQuest	healthcare, mhealth, mobile phone, SMS, developing countries	27
EBSCOhost	healthcare system, healthcare, mhealth, mobile phone, smartphone, developing countries, developing nations	149
Google Scholar	All the above	60
Web of Science	Healthcare, mhealth, mobile phone, SMS, developing countries	110
PubMed	mobile phone, Healthcare, developing countries	120
Science Direct	mhealth, mobile telephone, SMS, economically developing nations	50
Total:		516

2. Literature Review

Healthcare systems in developing countries face many challenges that limit the capacity of such systems from providing high-quality services. One of these challenges is the lack of qualified medical staff, including nursing and physicians (Coovadia et al. 2009). This shortage leads to limiting the quality of services provided to patients, especially those with noncommunicable diseases, as they require regular care and follow up on a daily basis. Another challenge facing healthcare systems in developing countries is the lack of financial resources (Bloomfield et al. 2014). These challenges are more prominent in rural areas where access to healthcare facilities is very challenging (Mars 2013). To address this problem, efforts have been made in various countries to improve the quality of healthcare services delivery. Among these interventions is the adoption of mobile health technology, simply mhealth (Mechael 2009a). The term “mhealth” may be defined as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, and personal digital assistants” (Chow et al. 2016).

The adoption of mhealth applications in developing countries started to gain some emphasis from researchers and healthcare systems. One study reviewed the feasibility of adopting mhealth in developing countries namely Uganda, South Africa, Rwanda, Bangladesh, Laos, and Egypt (Mechael 2009b). Among the limitations that the study identified was the cost of mobile phone services, reliability, and safety of using mobile phones in healthcare services, and the low quality of healthcare services. Another study proposed a model to evaluate the potential contribution of mhealth in providing healthcare services in developing nations (Kahn et al. 2010). In this study, some applications of mhealth were classified into categories namely social networking such as mobile text messages, web surfing such as providing information to patients via the internet, electronic mailing lists, web-based learning to help provide workers with appropriate training programs, and web-based data entry. In addition, it discussed the benefits and risks of the mhealth applications on regional, community, and individual levels. The study indicated that future research should focus on measuring the economic and clinical outcomes of mhealth interventions.

In the same context, a study reviewed the literature on the applications of mhealth in the developing countries and identified the factors that may influence these applications (Chib et al. 2015). The study proposed inputs-mechanisms-outputs heuristics to classify a set of selected mhealth studies. The study concluded that the majority of the studies focused on the introduction and implementation of mhealth applications (inputs), while less research reported improvements in healthcare delivery services using mhealth (outputs). Additionally, the study also reported a lack of healthcare outcomes measured in the current literature. Accordingly, the study suggested that future research should focus on establishing theoretical and measurement standards as well as focusing on implementations of mhealth technology.

Moreover, another study aimed to identify the factors that may affect the use of mhealth techniques by patients in Bangladesh (Hoque et al. 2017). The factors included were perceived usefulness, perceived ease of use, privacy, and

antitrust. These factors have been evaluated from patients' perspectives using the technology acceptance model (TAM). To collect data, a survey was designed, and 350 participants from both private and public hospitals in Dhaka were included. The results confirmed that perceived ease of use, perceived usefulness, and trust significantly affected patients' intent to use mhealth techniques.

In addition to those studies that discussed feasibility and critical success factors of mhealth applications in the developing countries, the literature also includes studies that examined the motivation of patients to engage in mhealth projects (O'Connor et al. 2016). It assessed indirect patients' first impression in participating in mhealth pilot projects in rural Malawi, Africa. The authors proposed a conceptual model consisting of 11 hypotheses and designed a survey to collect data from 96 respondents who were randomly selected to participate in this experiment for one month. The results of the study showed that patients' first impression influenced their participation in a large-scale mhealth project.

3. Methods

This review article focused on searching journal articles discussing mobile health intervention in developing countries. This review included the integration of mobile phone applications as well as Short Messaging Service (SMS). PRISMA flow diagram for the mhealth and SMS has been developed, as shown in Figure 1.

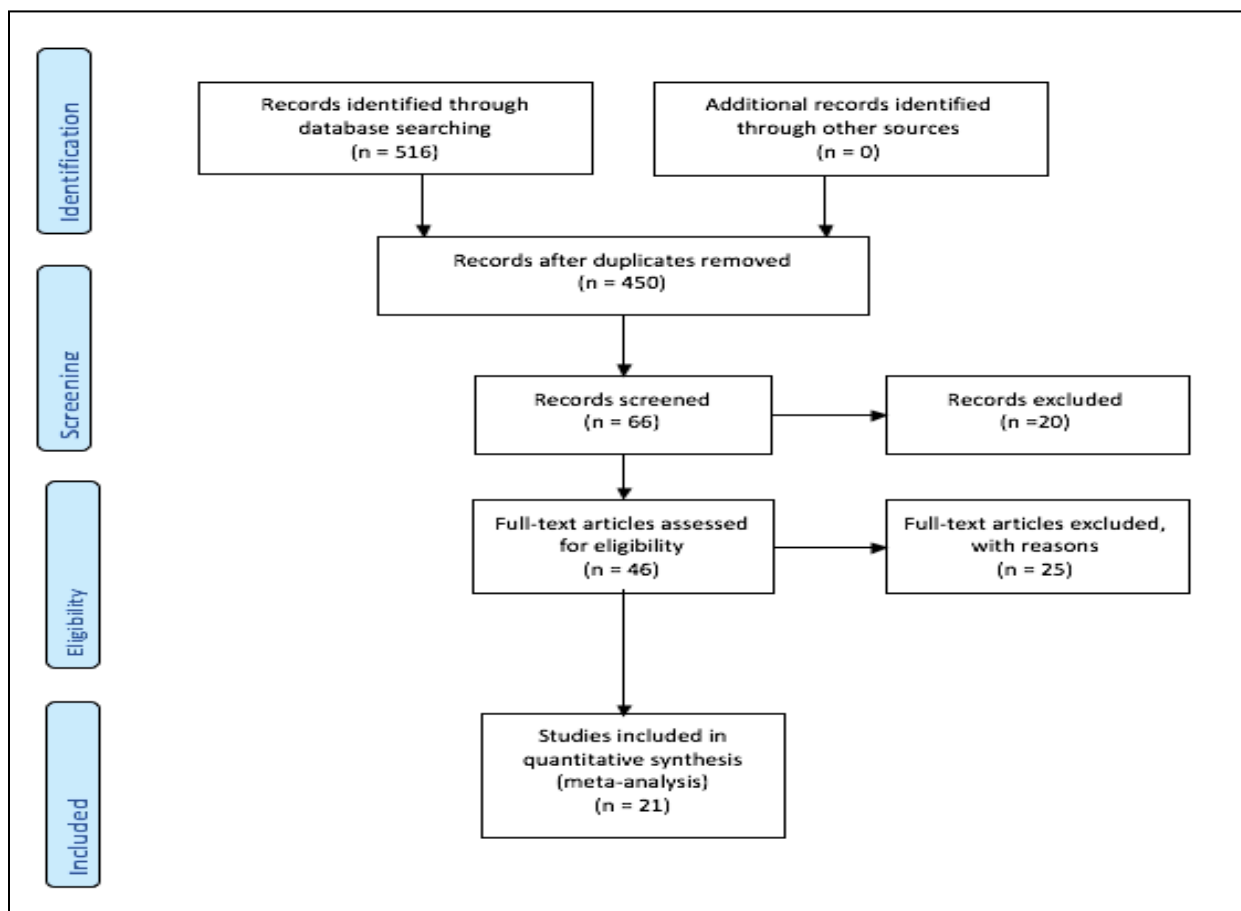


Figure 1: PRISMA flow diagram for mobile health applications and short text message in the developing nations

3.1. Mhealth Interventions in Developing Countries

Few studies have examined the intervention of mhealth to improve healthcare outcomes in developing countries. One study examined the role of mhealth intervention in promoting care and prevention from diseases such as the human immunodeficiency virus (HIV) in Africa (Forrest et al. 2015). The study classified the applications of mhealth into three categories namely "patient-care focused applications, such as health behavior change, health system-focused

applications, reporting and data collection, and population health-focused applications, including HIV awareness and testing campaigns.” Among the interventions of mhealth that the study reported was the use of SMS text messaging to increase patients’ adherence to antiretroviral therapy (ART) in Kenya and Uganda. A systematic review of the literature was conducted by Hamine et al. (2015) aimed to measure the effectiveness of mhealth interventions to patients’ adherence to chronic disease management – known as mAdherence. The authors evaluated the effectiveness of mAdherence regarding usability, feasibility, and acceptability among patients and health care providers. The study classified the tools within mAdherence into four categories: “SMS; phone plus software or application; phone plus specific instrument (a medical device connected to a phone via a cord); or phone plus wireless or Bluetooth-compatible device.” It has been found that the SMS was the most widely used tool in mAdherence, which was used to streamline medication reminders, collect data, and help patients communicate with healthcare providers (Hamine et al. 2015).

Another study investigated the potential relationship between the adoption of mhealth technology and the health conditions of patients with type-2 diabetes within a low-income environment (Nelson et al. 2015). Eighty patients with type-2 diabetes were selected in the study. Participants received daily text messaging concerning evaluation and adherence to medication over a 3-month intervention program. The study found no relationship between participants’ gender, income, health literacy, diabetes duration, and time of exposure to the intervention program and patient’s response to text messaging (Nelson et al. 2015).

3.2. Mobile Phone Applications

Little has been reported about the use of mobile applications or simply mobile apps to provide healthcare service in developing nations. Abbas et al. (2016) introduced three Information and Communication Technology (ICT) applications to improve patient care in Pakistan. The first application – DoesLab – was designed to find nearby physicians and laboratories. The second application – Drugs-Pharma – was designed to provide general information about different kinds of drugs. The third application – Healthcare App – was designed to provide information about different kinds of diseases. Although these applications were used, their outcomes have not been evaluated (Abbas et al. 2016).

3.3. SMS Text Messaging

One of the mhealth tools that is widely used in healthcare service delivery and broadly discussed in the literature is the Short Message Service (SMS). Indeed, according to DeKoekkoek, 2015, more than six billion people own cell phones in the world as cited by (DeKoekkoek et al. 2015). In the developing countries where a scarcity of resources and lack of healthcare personnel are prominent, the use of SMS in delivering healthcare service facilitates patients’ access to such services in these countries. Several studies have reported the use of SMS within healthcare systems. These studies are reviewed in the remaining part of this section.

In Kenya, Lester et al. (2010) investigated the potential effect of an SMS text messaging intervention to improve medication adherence of patients with HIV using a randomized control trial. A total of 538 patients were randomly selected, with 273 patients assigned to the SMS intervention and 265 to the control group. The study revealed that around 61% of patients received the SMS intervention reported adherence to medication comparing to only 50% of the patients reported medication to adherence in the control group (Lester et al., 2010). To explore the aspects of implementing mhealth within clinical psychology, Clough and Casey (2015) conducted a study on the use of text messaging and identified the advantages of mhealth devices, current trends, limitations, and directions for future research. Also, the study presented some of the recent applications of mhealth (Clough and Casey 2015). For example, the study demonstrated that, according to literature, the use of text messaging might have significantly improved patients’ behavior. However, mixed findings regarding the use of SMS as appointment messaging reminders in psychology clinics have been reported. A similar study conducted an integrative review to investigate the role of SMS in increasing patients’ adherence to medications (DeKoekkoek et al. 2015). The study classified the intervention of text messaging into two categories as follows: the first categorization is in regards to content: (1) text messaging with message content that was standardized; and (2) text messaging with messages that had content tailored to the individual. The second set of categories was: (1) one-way text messaging from healthcare service providers to individuals; and (2) two-way text messaging, from healthcare service providers to individuals and vice versa. The study found that adherence to medication improved by a rate of at least 15% in nine of the 13 reviewed studies since using the text messaging intervention.

To evaluate the effectiveness of mhealth intervention in reducing blood pressure and preventing the progression of hypertension in pre-hypertensive patients, a study conducted in three low-income countries in Latin American namely

Argentina, Guatemala, and Peru (Diez-Canseco et al. 2015). The study divided the subjects into two groups. The first group included the participants with mhealth intervention for a year. The second group included participants who received traditional non-mhealth treatment messaging. A total of 108 participants, 36 of each country, were included in the study. It has been found that 96.7% of the participants reported an adequate understanding of the information included in the text messaging. A survey was used to measure the appeal of each SMS text message using a scale from 1 to 10, with 10 points being the highest appeal score. It has been found that the grand average of the appeal score of text messaging was 8.7 points. A detailed discussion of the results among the three countries was reported.

To explore the effect of short-term cell phone disconnection on providing healthcare delivery service to patients in a low-income environment, seven healthcare workers and 37 patients were interviewed (Gonzales et al. 2016). The majority of the patients are HIV+ and have had a landline phone service. The study reported that most of the patients interviewed did have contract phones or carrier services causing them to experience frequent short-term cell phone disconnection, which led those patients to miss SMS text messages from their healthcare providers regarding regular follow-ups and appointment reminders.

Moreover, a study presented an implementation of the mhealth application in a public clinic in South Africa (Wolff-Piggott et al. 2017). The mhealth application – MomConnect – was designed to provide information to pregnant women during different stages of pregnancy. The aim of the study was to estimate clinic workers' feedback regarding the use of the application. To collect relevant information regarding workers' experience with the implementation of the mhealth program, interviews and observation sessions were carried out. The authors identified the hierarchical relationships between professional nurses and support staff as one of the significant factors that influenced the performance of the MomConnect.

4. Discussion

Based on the literature, various studies classified the intervention of mhealth in resource-limited countries. One of these studies classified the mhealth application into five categories namely social networking, web surfing, electronic mailing lists, web-based learning, and web-based data entry (Kahn et al. 2010). Another study classified mhealth projects into three categories: patient-care projects, health system-focused projects, and population health-focused projects (Forrest et al. 2015). Nonetheless, the majority of the mhealth projects that were conducted in the developing countries have focused on the use of SMS text messaging to provide healthcare services such as promote patients' adherence to medication, provide care and follow up, and provide awareness of certain diseases although mixed findings have been reported.

A similar classification of mhealth projects has been reported in high-income countries. For instance, (Free et al. 2013) reviewed the literature on the effectiveness of mhealth applications in improving healthcare service delivery. The authors classified the mhealth applications into two categories. The first category included the applications of mhealth to healthcare providers, whereas the second category included the interventions of mhealth to the communications between healthcare services and users or patients. The results revealed that significant improvements were realized, especially in nurse/surgeon communications, diagnoses, and appointment messaging.

Nonetheless, different areas of mhealth interventions in developing countries have been explored in the literature. These areas include the feasibility of adopting mhealth interventions, the evaluation of patients' intention to use mhealth applications, a general review of mhealth interventions, and reporting of mhealth implementations (Table 2). However, the effectiveness of such interventions has not been reported, which represents a gap in the literature that need to be filled.

5. Conclusion

This paper provides an overview of the mhealth applications in developing countries. Specifically, the article addresses the feasibility of adopting mhealth practices to improve healthcare service delivery. Also, the potential contribution of mhealth projects to provide healthcare services to patients in the developing nations were reported. Besides that, the article reviewed the recent interventions of mhealth in developing countries providing the various classifications of mhealth applications. Although few studies implemented mhealth projects in the developing countries, the effectiveness of these studies was neither evaluated nor reported. Therefore, future research should consider the effectiveness of potential mhealth projects in enhancing the quality of care provided to patients in developing countries.

Nonetheless, several issues regarding the current mhealth interventions have been identified. One of these problems is the lack of long-term studies or research. Another problem is the absence of large-scale implementation of mhealth practices. A third problem is the lack of emphasis on the evaluation of the mhealth interventions in terms of measurable healthcare outcomes for both patients and healthcare personnel. Lastly, linking the mhealth interventions to the Sustainable Development Goals (SDGs) (Stafford-Smith et al., 2016) has not been reported. Therefore, future research should consider these limitations in order to evaluate the quality and effectiveness of mhealth applications from all aspects.

Table 2: Summary of mhealth interventions including identification of the gap in the literature

	Feasibility of adopting mhealth	Intention to use mhealth	Review of mhealth interventions	Implementation of mhealth interventions	Effectiveness of mhealth
The case for mHealth in developing countries	×				
'Mobile' health needs and opportunities in developing countries	×		×		
mHealth adoption in low-resource environments: A review of the use of mobile healthcare in developing countries	×				
Investigating factors influencing the adoption of e-Health in developing countries: A patient's perspective	×	×			
First impressions are lasting impressions: Intention to participate in mobile health projects within developing countries		×			
Mobile health applications for HIV prevention and care in Africa			×		
Disparities in the use of a mHealth medication adherence promotion intervention for low-income adults with type 2 diabetes		×	×		
Few ICT applications for improved healthcare service delivery in developing countries			×		
mHealth SMS text messaging interventions and to promote medication adherence: an integrative review			×		
Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WeTel Kenya1): a randomized trial				×	
Design and multi-country validation of text messages for an mHealth intervention for primary prevention of progression to hypertension in Latin America				×	
Cell phone disconnection disrupts access to healthcare and health resources: A technology maintenance perspective	×				
The clinic-level perspective on mHealth implementation: a South African case study		×			
This study					×

References

- Abbas, Z., Burney, S. A., and Bari, A., Few ICT applications for improved healthcare service delivery in developing countries,
- Bloomfield, G. S., Vedanthan, R., Vasudevan, L., Kithei, A., Were, M., and Velazquez, E. J., Mobile health for non-communicable diseases in Sub-Saharan Africa: a systematic review of the literature and strategic framework for research, *Globalization and Health*, 10(1), 49, 2014.
- Chib, A., van Velthoven, M. H., and Car, J., mHealth adoption in low-resource environments: a review of the use of mobile healthcare in developing countries, *Journal of Health Communication*, 20(1), pp. 4-34, 2015.
- Chow, C. K., Ariyaratna, N., Islam, S. M. S., Thiagalingam, A., and Redfern, J., mHealth in cardiovascular health care. *Heart, Lung and Circulation*, 25(8), pp. 802-807, 2016.
- Clough, B. A., and Casey, L. M., The smart therapist: a look to the future of smartphones and mHealth technologies in psychotherapy, *Professional Psychology: Research and Practice*, 46(3), 147, 2015.
- Coovadia, H., Jewkes, R., Barron, P., Sanders, D., and McIntyre, D., The health and health system of South Africa: historical roots of current public health challenges, *The Lancet*, 374(9692), pp. 817-834, 2009.
- DeKoekkoek, T., Given, B., Given, C. W., Ridenour, K., Schueller, M., and Spoelstra, S. L., mHealth SMS text messaging interventions and to promote medication adherence: an integrative review, *Journal of Clinical Nursing*, 24(19-20), pp. 2722-2735, 2015.
- Diez-Canseco, F., Zavala-Loayza, J. A., Beratarrechea, A., Kanter, R., Ramirez-Zea, M., Rubinstein, A., Martinez, H., and Miranda, J. J., Design and multi-country validation of text messages for an mHealth intervention for primary prevention of progression to hypertension in Latin America, *JMIR mHealth and uHealth*, 3(1), e19, 2015.
- Forrest, J. I., Wiens, M., Kanters, S., Nsanzimana, S., Lester, R. T., and Mills, E. J., Mobile health applications for HIV prevention and care in Africa, *Current Opinion in HIV and AIDS*, 10(6), pp. 464-471, 2015.
- Free, C., Phillips, G., Watson, L., Galli, L., Felix, L., Edwards, P., Patel, V., and Haines, A., The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis, *PLoS Med*, 10(1), e1001363, 2013.
- Gonzales, A. L., Ems, L., and Suri, V. R., Cell phone disconnection disrupts access to healthcare and health resources: a technology maintenance perspective. *New Media & Society*, 18(8), pp. 1422-1438, 2016.
- Hamine, S., Gerth-Guyette, E., Faulx, D., Green, B. B., and Ginsburg, A. S., Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review, *Journal of medical Internet Research*, 17(2), 2015.
- Hoque, M. R., Bao, Y., and Sorwar, G., Investigating factors influencing the adoption of e-Health in developing countries: a patient's perspective, *Informatics for Health and Social Care*, 42(1), pp. 1-17, 2017.
- Kahn, J. G., Yang, J. S., and Kahn, J. S., 'Mobile' health needs and opportunities in developing countries, *Health Affairs*, 29(2), pp. 252-258, 2010.
- Lester, R. T., Ritvo, P., Mills, E. J., Kariri, A., Karanja, S., Chung, M. H., Jack, W., Habyarimana, J., Sadatsafavi, M., Najafzadeh, M., Marra, C. A., Estambale, B., Ngugi, E., Ball, T. B., Thabane, L., Gelmon, L. J., Kimani, J., Ackers, M., and Plummer, F., Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WelTel Kenya1): a randomized trial, *The Lancet*, 376(9755), pp. 1838-1845, 2010.
- Mars, M., Telemedicine and advances in urban and rural healthcare delivery in Africa. *Progress in Cardiovascular Diseases*, 56(3), pp. 326-335, 2013.
- Mechael, P. N., The case for mHealth in developing countries, *Innovations: Technology, Governance, Globalization*, 4(1), pp. 103-118, 2009a.
- Mechael, P. N., The case for mHealth in developing countries, *Innovations*, 4(1), pp. 103-118, 2009b.
- Nelson, L. A., Mulvaney, S. A., Gebretsadik, T., Ho, Y. -X., Johnson, K. B., and Osborn, C. Y., Disparities in the use of a mHealth medication adherence promotion intervention for low-income adults with type 2 diabetes, *Journal of the American Medical Informatics Association*, 23(1), pp. 12-18, 2015.
- O'Connor, Y., Heavin, C., and O'Donoghue, J., First impressions are lasting impressions: intention to participate in mobile health projects within developing countries, *Journal of Decision Systems*, 25(2), 173-190, 2016.
- Stafford-Smith, M., Griggs, D., Gaffney, O., Ullah, F., Reyers, B., Kanie, N., Stigson, B., Shrivastava, P., Leach, M., and O'Connell, D., Integration: the key to implementing the Sustainable Development Goals, *Sustainability Science*, pp. 1-9, 2016.
- Wolff-Piggott, B., Coleman, J., and Rivett, U., The clinic-level perspective on mHealth implementation: a South African case study, *Information Technology for Development*, pp. 1-22, 2017.

Biographies

Nawaf Khan is an Assistant Professor in Industrial Engineering. He has his BS degree in Electrical Engineering, and MS and Ph.D. degrees in Industrial Engineering. He worked in the field of electrical engineering at a Saudi Electricity Company between 2003 and 2010. His area of research is mobile health applications in service industry.

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Haitham Bahaitham is an Assistant Professor in the Industrial and Systems Engineering Department at College of Engineering, University of Jeddah (UJ). He has his BS degree in Electrical Engineering (Bio-Medical and MS and PhD degrees in Industrial Engineering. He worked in the field of medical imaging services between 1996 and 2006 at Middle East Diagnostic Imaging, GE Elseif Medical Services, and Siemens Limited Medical Solutions. In addition, he taught at the Management Science Department MIS Track at Yanbu University College (YUC) and at the Industrial Engineering at Faculty of Engineering-Rabigh at KAU between 2012 and 2019. While he serves as the Dean of College of Applied Studies at UJ since 2017, he served as the Head of Industrial Engineering Department and the Vice Dean for Development at the Faculty of Engineering-Rabigh at KAU. His area of research is quality applications in service industry especially those related to healthcare.

Hamzah Mohamed is a lecturer, and head of the Department of Industrial and Manufacturing Systems Engineering at the University of Benghazi. He earned B.S. in Industrial Engineering from the University of Benghazi, Libya, and Master of Science in Industrial Engineering from University of Central Florida. He has published journal and conference papers focusing on service quality in healthcare

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