Employee Competencies Development Framework for Industry 4.0 Adaptation in the Healthcare Sector

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Abstract

The emergence of Health 4.0 has become significant due to the development of technologies worldwide. Hence, the latest technologies have to be attuned and the competencies of employees should be altered to adapt the features of Industry 4.0. An empirical gap has been identified in the field of health 4.0 in a global context with expert reviews based on a pilot study. Still, assessing employee proficiencies in health 4.0 remains relatively unexploited. Therefore, identification of the needed competencies and transition is vital for the healthcare industry globally. The overall objective of this study is to seek the potential for the adaptation of industry 4.0 for the healthcare sector and to investigate the required level of employee competencies to yield maximum benefits from the technology implementation. A systematic review of the literature has been carried out to investigate the different assessments and models of studies existing. A keyword-based search was conducted in research databases through three main domains namely, technologies required for industry 4.0, healthcare sector and employee competency assessment for industry 4.0 for selecting 50 relevant research papers that have been published and proven as valid, to extract the knowledge for this study. According to the relevance, 33 articles were selected for the literature review. A framework was developed to benchmark and acquire the key processes of healthcare, the latest technologies and the applications used in health 4.0, as well as employee competencies required for each level of technology adaptation. It is expected that this framework can be improved and validated empirically through case studies in the Sri Lankan healthcare sector as to future research.

Keywords: Health 4.0, Industry 4.0, Employee Competencies Development

1 Introduction

Today we are experiencing the 4th industrial revolution where the computers and automation come together in a new way. This is termed as Industry 4.0.; an industrial concept which influences individualization and virtualization across different industrial domains where most companies and operations tend to be service-oriented rather than product oriented.

Industry 4.0 is the current trend in automation and data exchange in manufacturing technologies. The industrial revolution started from factory production using steam power, water power and mechanization (Industry 1.0) and moved into mass production, assembly line and electricity (Industry 2.0). The third industrial revolution started with computerization and automation. The fourth is the move towards digitization. Industry 4.0 uses the Internet of Things (IoT), Cyber-Physical Systems (CPS) such as sensors, big data, and powerful analytics, and communication infrastructures. Smart factories will be the heart of Industry 4.0, in which CPS monitors the physical processes of the

factory and make decentralized decisions. The physical systems become the Internet of Things, and communicate and cooperate with each other and with humans in real-time via the wireless web.

Industry 4.0 requires a certain level of employee skills for handling its specific technologies. The evolution of jobs and skills for the successful implementation of Industry 4.0 is of significant contemporary interest and importance to researchers, policymakers and practicing managers.

These demands and challenges show the importance of qualification and human resource development in the near future. It makes clear that industry 4.0 is more than just a technology. The human resource might probably be even more important in times of industry 4.0. These demands are transferred into the training scheme of the industry 4.0 learning factory of the authors. The learning factory should cover the following three categories of skills:

- Technical skills (e.g. install and operate IT devices: RFID-tags, tablets or automatic guided vehicles (AGV))
- Transformation skills (e.g. propose and realize changes in all three stages of the production system; learn to adapt transformation principles in their home plants)
- Social skills (e.g. teamwork, knowledge transfer, knowledge acquiring, collaboration for synchronization of processes and delivery dates and analyzing defects)

(Schallock et.al,2018)

The introduction of the latest automation and digital technologies in manufacturing such as Cyber-Physical Systems, the Internet of Things, Cloud computing and Big Data is envisaged to significantly affect work processes and the work environment. Employee jobs are expected to change in terms of content and new types of jobs are also being created. As a consequence, novel skill requirements are foreseen. (Pinzone et.al,2017)

When industry 4.0 is applied to healthcare, it becomes Health 4.0. The emergence of Health 4.0 has become significant due to the development of technologies worldwide. Health is a significant component in any developing country. Hence, the latest technologies have to be attuned and the competencies of employees should be altered to adapt the features of Industry 4.0. An empirical gap has been identified in the field of health 4.0 in a global context with expert reviews based on a pilot study. Still, assessing employee proficiencies in health 4.0 remains relatively unexploited. Therefore, identification of the needed competencies and transition is vital for the healthcare industry globally.

With the increasing aging population and the technological advances, the need for improvement in performance has become a mandatory requirement to satisfy the patients. The significant increases in costs are mainly due to the operational inefficiencies raised during different processes like administration, medical service delivery, logistics, etc. (Koning and Mast, 2005). This can be mostly seen in the government sector.

Most of the developed countries are now adopting the new technological advancements and Industry 4.0 concepts to minimize the inefficiencies and improve the efficiency of the medical services provided. Sri Lanka also needs to keep the steps to embrace the technology to improve the efficiency and effectiveness of healthcare delivery by government and private hospitals, pharmaceutical companies and medical practitioners.

Hospitals can allocate their available beds, staff, doctors, medical equipment, drugs, and other available resources according to the data gathered through a pre-medical diagnosis of a certain disease. This helps hospitals to manage their processes and operations with improved efficiency.

Nurses need to be aware that technology is the main driver for disruptive innovation in nursing education and practice, which requires them to understand what life looks like now with digital technology, compared to what it looked like before. In nursing education, the change is seen from paper-based to online-based education, which includes the innovation of e-learning, long-distance learning, mobile platforms, virtual learning, social media, video conferencing, and other methods. (Aungsuroch and Gunawan.,2019)

"*Health 4.0 is a tactical deployment, and managerial model for healthcare inspired by the Industry 4.0. Health 4.0 has to allow gradual virtualization to support the healthcare personalization close to real-time for patients, workers, and both formal and informal caretakers. This healthcare personalization calls for the substantial usage of CPSs, cloud computing, the extended specialized IoTs and Internet of Everything (IoE) including appliances, services, people, and surfacing 5G communication networks. With the help of the CPS paradigm, software fit for distributed*

systems and algorithms, and objects will be virtualized employing a spatial-temporal matrix. The virtualization permits the inspections of small space-time windows of the real world in real-time and, thus, allows for the diagnostics in personalized and precise medicine." (Monteiro et.al.,2018)

Although the employees can be trained, the organizations can recruit skilled employees rather than training. A cost is occurred due to training, therefore, the research aim is to investigate the reason for not implementing industry 4.0 in the human resource approach. A skilled employee is more significant for industry 4.0. There is no point in implementing industry 4.0 in Sri Lanka if there is no skilled labour for handling equipment. Healthcare in Sri Lanka provides more contribution to the Sri Lankan economy as well as the GDP. In this study most the technical, Personal and social competencies are focused

In a global context, the technologies used for Health 4.0 are discussed in several research papers. The applications of those technologies were identified through articles. Assessments that have been done for employee competencies for industry 4.0 were identified separately. Authors have developed a framework including processes of healthcare, technologies in industry 4.0 for those applications of identified technologies. There is no other framework or a model for industry 4.0 identified technologies, applications and employee competency assessments for healthcare processes. Research was conducted to find the technologies and application for those technologies in Health 4.0. Industry 4.0 applications such as sensors are used to detect patients' real-time movements and RFID (Radio Frequency Identification) is used to track patients and physicians in the global healthcare sector. RFID is helpful, for example, to monitor that the right patient is getting the right blood product with increasing efficiency.
Not many researches have been conducted to find out the employee competencies required for industry 4.0 in order to increase the efficiency of healthcare globally. A theoretical gap is identified for the necessity to conduct a study based on how the industry 4.0 technologies, applications and employee competencies increase the efficiency of healthcare processes.

2 Methodology

The literature review aimed at identifying the current studies that have been performed on Industry 4.0, employee competencies on industry 4.0, technologies of industry 4.0 for healthcare processes and how Industry 4.0 has been applied in the healthcare industry in order to improve the operational performance by increasing employee competencies. This systematic review was based on the content analysis as the approach to gathering the state of knowledge in the selected areas of Industry 4.0, employee competencies and healthcare industry. The initial step of this analysis was to search the articles relevant to the study. Databases such as PubMed, Emerald Insight, Semantic Scholar, Science Direct and Google Scholar were used by the authors to cover the relevant publications in the selected areas. The search criteria included keywords like "Industry 4.0", "Health 4.0", "employee competencies for industry 4.0", "operational efficiency", "healthcare" and likewise.
A comprehensive literature review was done related to the study area with the aim of emphasizing the gap of knowledge uncovered. This analysis consists of the selected articles belonging to the period from 2000 to 2019 considering the knowledge updates and relevance. The papers cited were retrieved from publications related to the healthcare industry, Industry 4.0, employee competencies for industry 4.0, big data analytics and cloud computing in healthcare.
This broad search strategy was necessary since the papers on Industry 4.0 have been published in a wide range of journals in many subject areas. Fifty articles were selected at the initial step. These articles were chosen based on their title and abstract and for further screening. Each paper was deeply scrutinized to eliminate the irrelevant articles to the study. The dissimilarities found in comparing the articles were discussed by the researchers and finally thirty-three articles were selected for the analysis. The selection procedure of the articles based on relevance is shown in 'Figure 1'. The references section of this paper lists the articles reviewed in this analysis. Even though each article was scrutinized in depth, it was believed that this analysis would deliver the actual gap of the knowledge areas uncovered by the previous researches.
Based on the findings from the literature review as well as feedback from healthcare professionals, a content analysis was done and a framework was developed considering the performance factors.

After reviewing the literature, a content analysis was done to identify the main themes for the conceptual framework. First, the literature was thoroughly read and the words that capture the key thought or the concept were highlighted. Then the processes of healthcare and industry 4.0 technologies applied in for those processes and the applications were identified and developed a framework according to the relevance. After that, the competencies for all the technologies were identified.

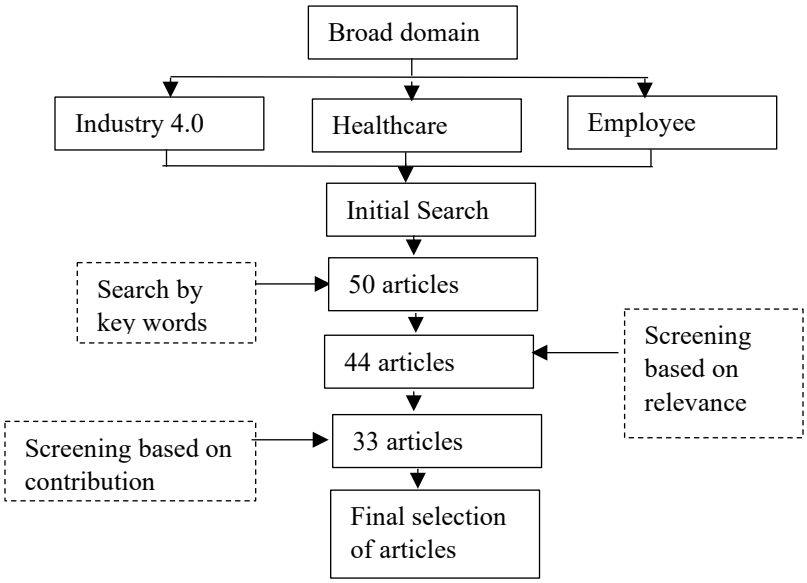

Figure 1. Screening process of systematic review of literature

3 SYSTEMATIC REVIEW OF LITERATURE

3.1 Industry 4.0 and Health 4.0

1st industrial revolution is related to the transformation to mechanization by the exploitation of hydropower and steam power. 2nd industrial revolution took place around the flip of the twentieth century, with the usage of electricity. Then the third industrial revolution started around 1969. It is the implementation of knowledge and communication technology to realize accumulated automation of producing processes. With this industrial revolution, the automation trade is improved by worker intelligent systems like industrial artificial intelligence and therefore the domain of "intelligent mechatronics and robotics". Presently a new era has to dawn with the fourth industrial revolution. New ideas of this revolution are Cyber-Physical Systems (CPS) that combine the Internet of Things (IoT) (Gökalp et al.2017)

Industry 4.0 main technologies are identified as the Internet of things (IoT), Big data, Cloud computing, and cyber-physical systems. IoT includes technologies or equipment such as sensors, RFID and smart devices (Khan 2012).Big data includes Enterprise resource planning data and records of inpatient and outpatient departments (Yao et.al,2010). Cloud computing as emails and data recovery systems (Benesovaa and Tupaa 2017)
The fourth is the move towards digitization. Industry 4.0 uses the Internet of Things (IoT), Cyber-Physical Systems (CPS) such as sensors, big data, and powerful analytics, and communication infrastructures. Some of the articles which discuss about Health 4.0 were selected to measure the frequency of mentioning the industry 4.0 components. In table 1, a cross symbol is marked if the particular reference discussed about the relevant technology.

Table 1. Technology analysis

	Technologies of industry 4.0			
References	Internet of things	Big data	Cloud computing	Cyber-physical systems
(Monteiro et.al,2018)	X	X	X	X
(Wang et.al,2006)	X			
(Thuemmler and Chunxue, 2017)	X	X	X	X
(Yao et.al,2010)	X	X		
(Yang and Rhee,2000)	X			
(Poulymenopculou et.al,2011)			X	
(Kabir et.al, ,2015)	X			

Seven articles were examined in the process. Six papers out of the seven papers discussed about the internet of things such as sensors and RFID (Radio Frequency Identification), three articles were about the application of big data, three papers are about how the cloud computing apply for healthcare sector and cyber-physical systems are discussed in only two of the papers out of seven papers.

3.2 Assessing employee competencies for industry 4.0

Gabriel and Pessl (2016) point out that "The main objective of Industry 4.0 is to strengthen and extend the long-term competitiveness of the company by increasing the flexibility and efficiency of production through communication, information and intelligence" (p. 133). This new revolution involves three areas that are very important, such as automation, robotics or the digitization of everything, but the aspect that plays a key role is the internet of things or rather the internet of everything (Basl, 2016).
With mobile Internet of Things (mIoT) and 5G, a wide range of video and sound material identified with asthma instruction can be conveyed to the portable terminals of asthma patients, improving patients learning about asthma and coordinating pharmaceutical and non-pharmaceutical treatment. mIoT makes the evaluation and observing of asthma simpler. For an instance, asthma patients could finish their asthma control tests and asthma control surveys on their mobile phones routinely, with the goal of doctors screening the state of their patients consistently. Further, wellbeing experts and specialist co-ops could use the mIoT to survey the elements of the condition and the connection with natural or social components. (Thuemmler and Bai, 2017)

According to the World Economy Forum's (WEF) survey (2018), 84% of organizations are probably automating to work in response to the growing skills gap, with an equal share trying externally to acquire qualified workers to figure with new technology. Additionally, new job roles are rising. Growth is anticipated for data analysts, operations managers, supervisors, and network professionals (WEF, 2018). However, skills shortages within the workforce are making it increasingly troublesome to attract new talent because the labour market for qualified candidates becomes increasingly competitive, which means that organizations will have to develop skills internally and invest in training. (Krachtt 2018)

The research was centered on the use of a psychological instrument for evaluating capabilities required. The capabilities map needed for the evaluation and selection of the human resource fit to work in the industry 4.0

environment was designed after the application of a complex system of evaluation on successive series of students from the University POLITEHNICA of Bucharest. (Cotet et.al,2017)

Competencies are divided into four main categories as technical competencies, social competencies, personal competencies and methodological competencies in most of the references.

1. Technical competencies (e.g. install and operate IT devices: RFID-tags, tablets)
2. Social competencies (e.g. - language skill, communication skills, intellectual skill. teamwork, leadership skills)
3. Personal competencies (e.g. - Ability to adapt, flexibility, ability to work under pressure)
4. Methodological competencies (e.g. - Decision making, analytical skill, research skill, creativity, problem-solving)

In table 2, a cross symbol is marked if the particular reference discussed about the relevant competency.

Table 2. Competency analysis

	Competencies			
References	Technical competencies	Social competencies	Personal competencies	Methodological competencies
Hecklaua et al.(2016)	X	X	X	X
Bermúdez and Juárez(2017)	X	X	X	X
Grzybowska and Łupicka (2017)				X
(Noah Krachtt 2018)	X	X		X
WHITEPAPER Skill Development for Industry 4.0	X		X	X

Five papers were selected to conduct the systematic literature review. Four out of five papers have considered technical competencies, three papers have discussed about social competencies, three papers have discussed about personal competencies and all papers have measured the methodological competency.

4 Results

The framework shown in Table 3 was developed to benchmark and acquire the latest technologies used in health 4.0 such as big data, internet of things, smart systems and cyber-physical systems, as well as employee competencies required for each level of technology adaptation. A comprehensive investigation was conducted to identify key processes of the healthcare sector such as patient care observation, emergency health processes, and surgery and pharmaceutical operations. Then the technologies, applications and competencies such as knowledge about ICT, ability to work with data, technical knowhow and personal skills to use technologies were summarized through selected research papers. For example, ring sensors are used to observe the patients, therefore employees should have the knowledge to interact with them.

Table 3. Framework for Health 4.0 technologies and applications

Process	Equipment and technologies	Application	Competencies end-users should posses	Source
Emergency health +process (ambulance service and hospitals)	Cloud-based EMS services Smart Medical Plants Mobile emergency system Internet of Things and cloud computing	Clouds are used to store data Mobiles are used to call any time	knowledge of big data, cloud computing and emerging technologies Knowledge and management of software and interfaces	Monteiro et.al,2018 Yao et.al,2010 Poulymenopculou et.al,2003 Poulymenopculou et.al,2011
Patient observation	RFID, tags Asthma inhalers (Micro sensors) Smartphone Embedded devices (Physiological sensors, environmental sensors) Ring sensor (LED photodetectors) Internet of Things and	RFIDs use to track patient, Physicians medical suppliers Sensors use to Monitor personal health conditions (elderly and disabled people) Ring sensor use to monitor patient health status 24 hours a day for monitor pulse waves and blood oxygen saturation	Data analysis ability and the use of tools for understanding the business, Ability to use and interact with computers and smart machines like robots, tablets etc.	Monteiro et.al,2018 Wang et.al,2006 Thuemmler and Chunxue, 2017 Health and Healthcare in the Fourth Industrial Revolution Global Future Council on the Future of Health and Healthcare Yao et.al,2010 Yang and Rhee,2000 Bermúdez and Juárez(2017)
Homecare treatments	Infrared camera weight sensor in the floor Pressure-sensitive floor tile Internet of Things	Treatments from home without coming to the hospital	Understanding data security	(Monteiro et.al,2018) Thuemmler and Chunxue, 2017 Yao et.al,2010
Ward rounding	Electrical patients' records -Internet of Things	Diagnosed results noted down during ward rounds	Knowledge and management of software and interfaces	Yao et.al,2010
Diagnosing	Biosensors -Internet of Things Holography	Biosensors use to take decisions about critical outer and inner patient conditions and sends these signals	Decision making under pressure, persistence	Monteiro et.al,2018 (Javaid and Haleem 2019)

		Industry 4.0 uses holography to display medical data of the whole patient in a three-dimensional tomographic image		
pharmaceuticals	Smart Devices - Internet of Things	Real-time data accessing	Inter-disciplinary & generic knowledge about technology	Monteiro et.al,2018 Holzinger et.al,2015
Surgery	CPS, biosensors RFID RFID enabled CEP Smart devices robots } Internet of Things and Cyber physical system	Equipment connected to smart devices RFIDs reduce patient waiting time Identify the right patient for surgery. After surgeries tags on disposable enable us to see materials patients used will be discarded. RFIDs use to Identify the correct patient to operate	Ability to visualize and track the patient details by smart devices Ability to gather information, articulate, analyze, solve complex problems, and make decisions. Ability to use and interact with computers and smart machines like robots, tablets etc. Understanding machine to machine communication, IT security & data protection	Monteiro et.al,2018 Wang et.al,2006, Health and Healthcare in the Fourth Industrial Revolution Global Future Council on the Future of Health and Healthcare Holzinger et.al,2015 (Javaid and Haleem 2019)
Laboratory activities	Care Lab (mobile and integrated devices) RFID } Internet of Things	Care Lab is to evaluate elderly people care concept RFID use to get the right product to the right patient and to store blood in the right temperature	Knowledge and management of software and interfaces, logical thinking includes skills such as comparing, evaluating and selecting. It provides a logical framework for problem solving Understanding machine to machine communication, IT security & data protection	Yao et.al,2010 Wang et.al,2006
Health education	mIOT Smart Devices } Internet of Things	Assessing illness patient care control tests questionnaires using cell phones doctors can observe decision	Decision making is the process of making choices by identifying a decision, gathering information	Monteiro et.al,2018

		making, service providers Video downloading therapy recommendation		

In table-3 RFID tags are used in several processes such as patient observation, homecare treatments, surgeries and laboratory activities in the healthcare sector. Some smart devices are used in emergency health processes, patient observation, pharmaceutical, surgeries, laboratory activities and health education. Sensors are the initial equipment in industry 4.0 technologies and they are used for patient observation, diagnosing and surgeries. Drones are one of the new concepts to conduct research to investigate the application of drones for the healthcare sector. It is very helpful for the delivery of drugs, blood products during disasters and emergencies. For example, RFID is used in surgeries to reduce patient waiting time and to identify the right patient for surgery. After surgeries tags on disposable materials enable us to see materials patients used will be discarded and RFIDs are used to identify the correct patient to operate. The employees should be able to visualize and track the patient details by smart devices. Internet of Things includes equipment such as RFID, sensors, smart devices and mobile. Most of the processes use Internet of Things for the technology in healthcare processes.
Industry 4.0 requires more technical competencies other than those competencies there are personal and social competencies. Based on the research which the competencies, a framework for competencies is developed in “Table 4”.

Table 4. Framework developed for Competencies

Technical competencies	Personal competencies	Social competencies	Source
1. Knowledge of big data, cloud computing and emerging technologies 2. Knowledge and management of software and interfaces 3. Ability to use and interact with computers and smart machines like robots, tablets etc. 4. Understanding machine to machine communication, IT security & data protection 5. Ability to process and analyze data and information obtained from machines 6. Understanding visual data output & making decisions 7. Basic statistical knowledge	8. Creativity in designing strategies to introduce new practices, 9. Ability to adopt new models of work and organization (open to change), 10. Decision making under pressure, persistence, 11. Increasing virtual work makes employees become time and place independent; 12. Work-task rotation further requires employees to be flexible with their job responsibilities 13. More frequent work related change makes it mandatory for employees to be willing to learn	14. Being able to understand and communicate with global partners and customers 15. Growing team work and shared work on platforms expects the ability to follow team rules 16. More responsible tasks and flattened hierarchies make every employee becoming a leader, negotiations, 17. Emotional intelligence, 18. Collaboration.	Bermúdez and Juárez(2017) WHITEPAPER Skill Development for Industry 4.0 Hecklaua et al.(2016)

5 Conclusion

This paper conducts a comprehensive review of literature for Industry 4.0 and presents an overview of its content, scope, and technologies, examining existing literature in all databases within Web of Science and Google Scholar. The selected 33 papers are grouped into five research categories and reviewed. This paper presents a state-of-the-art survey of the ongoing research on Industry 4.0. An empirical gap has been identified in the field of health 4.0 in a global context with expert reviews based on a pilot study. Still, assessing employee proficiencies in health 4.0 remains relatively unexploited. Therefore, identification of the needed competencies and transition is vital for the healthcare industry globally.
This framework can be used by the healthcare sector practitioners as a guideline to acquire new talents in planning for training programmes compatible with the technologies in use. It is suggested that this framework can be improved and validated by industry and academic experts empirically through case studies in Sri Lankan healthcare sector as future research.

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