HEALTH 4.0: ROLE OF HEALTH INFORMATION SERVICES-A REVIEW

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Abstract:
The health industry is vast, interdisciplinary, and multinational in nature and has global importance. The paper describes the basics, 4Ws and 2Hs of Health-4.0 (a subset of Industry 4.0). Health 4.0 is in the initial stage of development and yet to be reached to the masses for its uses and applications. Hence, it is essential here to define, clarify, overview its availability, affordability, and adaptability. The main objective of the study is to find out the various possibilities to use Internet of Medical Things (IoMT), Internet of Services (IoS), healthcare/medical devices, and applications that enable personalized patient-specific devices and care programmes. The descriptive research method has been used in the study. The result suggests that the concept of Health 4.0 needs to be promoted through appropriate policies and programmes. It can be concluded that in the fast-changing, technologies, techniques, tricks as well as high completion it is need of the time to keep pace with digitization and other ICT innovations at different levels to implement Health 4.0 concept.

Keywords: Health 4.0, Industry 4.0, Medicine, Health Electronics, Health Industry, Production, Medicals, Paramedical, Cyber-Physical Systems, Internet, Cloud Computing, Big Data, Artificial Intelligence (AI), Information and Library Science and Cognitive Computing, etc.

Introduction

We are passing through age of transition, completion, the fourth industrial revolution, a new fast growing as well as obsolescing digital ICT virtual era. Health is an important component of our lives next to our basic needs and fundamental rights i.e. food, cloth and shelter. The health/ medical, industry is very vast, mostly interdisciplinary and multinational in nature and also has global importance. In the healthcare sector composes of hospitals, academic organizations, research institutes, health information system (HIS), patient information system, and clinical information system. Health-4.0 (subset of Industry 4.0), a strategic concept of healthcare domain, which is now a buzzword and the latest fourth industrial revolution denoting current trend of automation, digitization, virtualization and communication/ interaction/ data exchange (man to machine vis-à-vis) of proper information to proper users at proper time. It is also expected that traditional, manual and mechanical industrial systems are going to be gradually replaced with industry 4.0/Health 4.0 i.e. modern sensors, embedded systems, cyber-physical systems (CPS), robot, big data, artificial intelligence (AI), cloud computing (CC), the Internet, ICT, Library and Information Science (LISc) tools, 4G/5G mobile technology, cognitive computing, etc and other new emerging subset technologies e.g. Internet of -Technology, Services, People i.e. IoT, IoS, IoP techniques to create a new reality to revolutionize human life. It is based on vertical and horizontal virtualization, service integration creating a new above fully automation/ digital services. There are not only enough opportunities, advantages but more challenges too, while using Health 4.0 for our social, personal, physical, organisational and psychological lives. The literature review suggests that there are various reasons and evidences to adopt Health 4.0 (1, 9, 12, 14, 15, 19-21).

Need of Study

It is fact that when economy of a country does not grow the next generation i.e. children are going to be penalized and we, present generation is responsible for coming phases. There are various reasons to carry out the present descriptive study.

- Today our lives are full of competitions and health industries are no exception to it. To remain competitive, medical device manufacturers as well as consumers need the ability to innovate and respond quickly to the changing healthcare systems, ways and means in which patients can now be treated. Hence, it needs Health 4.0 for biomedical healthcare devices manufactures, patient care worldwide through above innovations. It includes above numerous devices. Consequently, any delay, missing link in the process of adoption and/or any stage in the product release and delivery will lead/ result to press the various challenges, opportunities/ loss of market. It is also expected that implementation of Health 4.0 is certainly going to boost the whole healthcare system (12-15, 19, 21).

- Health 4.0 has already arrived and ready to change not only trade and business but also social as well as personal and organisational factors (15).
- Customization of patient-specific devices will require high quality, high mix production that particularly lends itself to the greater automation and higher levels of intelligence provided by the Health 4.0 model. Physical objects passing through production processes will incorporate their own aforesaid embedded Software and Computing Power (CSP) to interact with more intelligent machines, Cyber-Physical Production Systems (CPPS) on the plant floor. Intelligent exchanges of information within this completely networked environment will enable production to be self-managing and self-optimizing. (7-8, 12, 15, and 20).
- In general sense, industry is a place to produce goods at the mass level and/or related services within a budgetary provision as it provides the major source of revenue of any country. To have a competitive advantages effectively and efficiently, it is essential to have a strong health information system (HIS) due to information revolution, scattering and seepage to provide pinpointed information to proper users at proper time and also to support Health 4.0 (5, 7-8, 15).
- Health 4.0 device manufacturers are experiencing challenges with the increasing demand for updation, opportunities i.e. pricing, quality, quantity, profit margin and speed. They also are facing issue related to 4Ms: money (prices and benefits), materials (quality and quantity), machines (infrastructure, hardware, software, speed, etc.), as well as manpower (workforce), 4Ws and 2Hs (i.e. what, why, where, when and how and how much) of Health-4.0 (5, 7-9, 15).
- Health 4.0, has already been arrived and being used and applied in the various healthcare/ biomedical sectors viz. diagnoses, treatment, integrating electrocardiogram capability or blood pressure cuffs, surgery, eye lenses, etc. within a device increases its value (5, 15-21).
- The CPS has arrived and also been adopted in various healthcare/ medical sectors, however, yet the Big Data, CPS, Robot, AI, CC, ICT, LISc tools are to be used, tested to be and reach to the masses. Various steps have been initiated in this direction but miles to go (5, 14, 5, 11, 15, 18, 19-21).

Objective of Study

- To investigate various recent developments, components, its availability, applicability, affordability, scalability of Health 4.0 in healthcare/medicine sectors viz. bio-sensors, huge amount of data acquisition (Big Data) systems, ICT based computer network, CC, AI, etc.
- To present an overview and find out the various opportunities and challenges that arise out of it i.e. Health 4.0/Industry 4.0 and also suggest solutions for these.
- To have a suitable subject based discipline-wise HIS to support Health 4.0 concept.

Scope and Limitations

This study is descriptive in nature and limited to biomedicine, healthcare and other related subjects and devices viz. healthcare industries, electronic devices using Health 4.0 for the diagnosis and treatment of human diseases, as well as mass production of these devices.

Healthcare's Digital Revolution

There is considerable amount of technological evolution has been experienced in the healthcare digital technologies. Health 4.0/Industry 4.0 combines a wide set of technologies at different stages of maturity, supported by new enabler technologies and propositions. The smart phones/ mobiles are now widely available; CC has reflected the potential for almost infinite storage with atleast/ reasonable cost is also available. There are four factors in Health 4.0 to play viz. digital data, interconnectivity, automation, and digital customer interface (1-5, 9, 12, 15, 18-21). A brief comparative view of Today's traditional current factories and modern Health 4.0 has been summarized in Table-1.

Table 1: Comparison of Today's Healthcare Factories and Health 4.0/Industry 4.0

Data Source		Today's Healthcare Factories		Healthcare 4.0/Industry 4.0	
		Attributes	Technologies	Attributes	Technologies
Component	Sensor	Precision	Smart Sensors & Fault Detection	Self aware Self Predict	Degradation Monitoring & Remaining Useful Life Prediction
Machine	Controller	Predictability & Performance	Condition-based Monitoring & Diagnostics	Self-aware Self-Predicted Self Compare	Uptime with predictable Health Monitoring

Production System	Network System	Productivity & OEE	Lean Operation: Work and Waste Reduction	Self-Configure Self Maintain Self Organize	Worry Free Productivity

Source: Jay Lee, Behrad Bagheri, Hung-An Kao, (2015) (12)

Table-1 summarizes that there are big differences between current and traditional health factories. In the Health 4.0 the industrial application of these digital transformations is radically changing value creation in every market. In this study, we also examined the impact it is making on the healthcare industry (3, 9, 12, 15, 18-21). Other developments are:

i. Health 4.0/Industry 4.0 Revolution-, involves usage of smart mobiles making connections never like before, delivering solutions in innovative new areas such as patient-specific devices and 'Lab on a Chip' i.e. electronic diagnostic, testing, robotics assisted surgery, 'Internet of Medical Things' (IoMT) (1-9, 12-15, 19- 21).
ii. Automation and Digitization- a modeled on a Value Chain Organisation, using the IoT and the IoS and IoP (2, 9, 11, 15, 19-21).
iii. Value-based care- device sensors or self-monitoring (1, 8-11, 14-15, 19-21).
iv. Healthcare/Medical Industries and Health 4.0- from producing smaller product viz. syringe to manufacturing sophisticated hospitals products/equipments e.g. surgical advanced equipments viz. motors devices.

In a classic example of "Siemens AG's -electronics plant in Amberg produces printed circuit boards (PCB) that show what product-driven manufacturing is all about. Each printed circuit board is given an individual barcode that enables it to communicate with the machines and the manufacturing machines to access the individual file of the each printed circuit board. The components also receive individual codes so that they "know" at which point in the process and at what point in time they are needed. The components are then automatically directed to their destination on the basis of the information the transport system receives through the code. As soon as the blank enters the machine, it is recognized by the barcode. The machine can retrieve all processing information from the file system in real time. The plate is then loaded with various components, such as microchips. Each component and the subsequent steps are also documented and monitored in real time by numerous scanners. The machines also indicate in good time if a certain component is no longer available or a technical problem occurs. Inspection engineers monitor the entire value chain of the circuit board on the computer (Vermeshan (2016)." A particular application for drugs is the use of a data matrix code that makes drugs more counterfeit-proof. The digital code gives the packaging for each cough syrup a specific identity, enabling the drug to be clearly identified after it has left the company. This makes it traceable across the entire logistics chain, and consequently more difficult to counterfeit (9-13, 15, 19-21)." Therefore, Health 4.0/ Industry 4.0 applications go beyond production and encompass the entire value chain."

Review of Literature

It has been written as well as spoken much about Industry 4.0 followed by Health 4.0 as subset of Industry 4.0 at various platforms in different ways (1-21). The term "Industry 4.0" was used in public for the first time at Hannover Messe in 2011, and subsequently integrated into the German Government's high-tech strategy. The term Industry 4.0, as defined by the German Academy of Engineering and the Science and Industry Research Union (Forschungsunion Wirtschaft–Wissenschaft), "is the technical integration of Cyber-Physical Systems (CPS) into production and logistics, as well as the application of IoT and services in industrial processes–including the resulting consequences for value creation, business models and downstream services and work organizations. Industry 4.0 is the digitalization of production, which then leads to the provision of associated services (smart services, servitisation) (19, 2016)". Since, it is a new concept of industrial fourth generation industrial revolution/development (2, 18), it is essential and right time to communicate, use to the masses. Lee et al. (14, 2014), in this paper, unified 5-level architecture which is proposed as a guideline for implementation of CPS. Herman, et al. (7, 2015) reviewed 51 publications related to patient care related to Industry 4.0 based manufacturing system including interoperability, virtualization, visualization, decentralization, real time capability, service orientation, and modularity. Hermann further proposed four components/factors for Industry 4.0 viz. CPS, IoT, IoS, and smart factory. However, Pott (19, 2015) describes, "Industry 4.0 in the medical technology and pharmaceutical industry sectors." Partner Morris Hosseini (9, 2015) describes transformation in healthcare space.

Thuemmler Chritoph and Bai Chunyue, eds. (20, 2017) edited a book entitled, "Health 4.0 Applications of Industry 4.0 Design Principles and Future Asthma Management", describe how the creation of new digital services-through vertical and

horizontal integration of data coming from sensors on top of existing legacy systems-that has already had a major impact on industry is now extending to healthcare. It also deals the fourth industrial revolution (i.e. Health 4.0) (2, 18), which is based on virtualization and service aggregation and shows how sensors, embedded systems, and CPS are fundamentally changing the way industrial processes work, their business models, and how we consume, while also affecting the health and care domains (Internet book review). A Conference Proceeding (2017) entitled, "Medical Technologies National Congress (TIPTEKNO)", summarizes that Industry 4.0 will affect all sectors including the daily social life in fact as if it seems that it effects only factories (17, 2017). Many topics, including to achieve higher accuracy and quickness in diagnosis, to establish more secure hospital information systems, to make medical devices more efficient, innovative and useful also by using the basic principles by coming out from Industry 4.0, are dealt with the concept of Health 4.0 and Industry 4.0 (1, 5, 9, 13-15, 19-21). Lee EA (13, 2008), Acatech (2011), Collins FS and Varmus H (4, 2015), Hermann M et al. (8, 2016), Hosseini P Morris (9, 2015)-digital transformation in healthcare space, Lee, et al. (14, 2014), Bagheri B, Yang S, Kao HA, Lee J, et al. (1, 2015), Lobo, et al. (15, 2016), deal with a Cyber-Physical Systems Architecture for Industry 4.0-based Manufacturing Systems, Vermeshan O and Friess, Thuemmler and Bai (20, 2017) deals with digital revolution, digital transformation, etc.

Research Method

Since Health 4.0 is a new and the latest concept, and practical scientific experience can be shared here, hence the descriptive a literature based method has been used for the study and also supported by studies of the other contributors in the field.

Health4.0;HistoricalDevelopments, Principles and Components

The ICTs are an integral part of the human environment till today. The term "Industry 4.0" was first introduced and coined by German Industry Science Research Alliance in 2011, denoting smart factory by complete networking via, modern sensors, embedded systems, CPS, robot, big data, AI, CC, internet, ICT, LISc tools, 4G/5G mobile technology and cognitive computing, etc. and/or combinations of other new emerging technologies, techniques in shaping is digital discourse. However, Health 4.0 is now being used as subset of Industry 4.0 using above devices for healthcare/ medicine sectors and currently it is more as vision and mission of any industry due to increasing digitization for production and services than a reality (1, 11-14, 20-21).

The major developments in the field are presented by Lee EA (13), Acatech (2011), Collins FS and Varmus H (4), Hermann M et al. (8), Hosseini P Morris (9)-digital transformation in healthcare space, Lee, et al. (14), Lobo, et al. (15) Jazdi J et al. (11,2014), Vermeshan O and Friess (11, 20), Thuemmler and Bai (20), which describe the technology behind the shift of point of care to point of need and away from hospitals and institutions; how care will be delivered virtually outside hospitals; that services will be tailored to individuals rather than being designed as statistical averages. Furthermore, other studies (2-3, 5-7, 10, 16-21) describe CPS, big data, manufacturing/ production, Industry 4.0, Health 4.0, data analytics, revolution, principles, design, precision, smart devices; ICT, LISc tools and pharmaceuticals industries, big data, internet, e-health, Precision Medicine, 5G Mobile and Health, etc. The subject-wise developments are: Principles of Health 4.0 (8, 15, 19-21), Interconnection-Internet and Integrations (3, 19-21), Information Transfer, Transparency/ Communication/Exchange (3, 6, 12, 14, 15, 17, 19-21), Technical Assistance, Autonomy/decentralization Decisions (1, 14, 15, 19). Hence, Health 4.0 autonomy is an essential factor to take on spot decision in case of urgency/ necessity.

Components of Health 4.0

The Computer, Modern Sensors, Cloud Computing (CC), Cognitive computing, Internet of Things (IoT) and Internet of Services (IoS), embedded system, Cyber Physical System (CPS), Industrial Internet of Things(IIoT), Artificial Intelligence (AI), Robot, Big Data, 4G/5G Mobile Technology, Smart Factories modern ICT, LISc tools are the main components of Health 4.0/Industry 4.0. (5, 7-9, 12, 15-21). It has minimum human control and the modular machine is part of a digital network and is monitored via a human-machine interface, which also includes quality checks, maintenance by a connected service technician and an immediate alert from the machine as soon as it realizes that a certain component will soon be unavailable. A particular application for drugs and or any product is the use of a data matrix code that makes drugs/product more counterfeit-proof. The digital code gives the packaging for each product e.g. cough syrup a specific identity, enabling the drug to be clearly identified after it has left the company. This makes it traceable across the entire logistics chain, and consequently more difficult to counterfeit. Therefore, the Health 4.0/Industry 4.0 application goes beyond production and encompasses the entire value chain (1, 12-15, 19-21).

Robotic technology is being used in almost all the scientific and industrial sectors now-a-days. Other areas of innovation in Health 4.0 include robotic-assisted surgery; diagnosis, next generation of advance equipments and medicines, smart inhalers that track inhaler use, avoid triggers and warn of asthma attacks, and biometric stamps that act as a 'lab on a chip' (LOC) alternative to reagents and chemicals.

Health industry is full of data ranging from start of product to arrival and use of it. Big data analytics consists of 7Cs in the integrated Health 4.0/ Industry 4.0 and cyber physical systems environment. 7Cs: (Connection-sensor networks, Computer, Cyber-model and Memory, Communication, Community/customization-personalization and value, Cloud computing, and Cognitive computing). Hence, the role of big data in Health 4.0 and adoption of Health 4.0 is much more than others. It is an undisputed fact that IoT as well as Things, IoT, IoS and Internet of People IoP are playing crucial role in healthcare industry and supporting in various decision processes making as well as ambient living. These will create added value, general growth and prosperity (Vermeshan et al.). It is going to be value added service to have better healthcare devices as well as prosperity using Health 4.0. The digitalisation of industry affects the entire value chain. From individual products to digitising workflows in companies and connecting companies with clients and service providers via the IoT –Industry 4.0 makes completely new manufacturing processes possible and requires new and specific business models (15, 19).

Opportunities and Advantages

The Health 4.0 has more opportunities than the challenges. Today, in a Health 4.0/Industry 4.0 factory, machines are connected as a collaborative community. Such evolution requires the utilization of advance- prediction tools, so that data can be systematically processed into information to explain uncertainties, and thereby make more "informed" decisions. The CPS-based manufacturing and service innovations are two inevitable trends and challenges for manufacturing industries (1, 12-14). These are: Medical Device Manufacturers, Value-based care (15), Patient Information (1-15, 18-21), Internet of Medical Things (IoMT), and other technology, medical devices and applications that enable personalized patient-specific devices and care programmes (15, 21).

Challenges and Problems

Though there are more benefits and better opportunities using Health 4.0 but there are challenges and problem too. The main problems faced/to be faced are: Competition, Finance/ Budget/Investment and management -cross industrial collaboration (1, 15, 19-21), Data Ownership and Data Security (agreements, MOU, data encryption, etc.), Legal issues (IPR, Specification, agreement, maintenance, monitoring) (15, 19-21), Standards i.e. product registration, employment and skill development, standardization, employment, etc. Health 4.0 is directly related to factory/industrial production hence, product registration, employment and skill development are the main factor to be taken into consideration, while adopting it.

Results and Major Findings

- It has been observed based on review of literature that efforts have been made to adopt recent development of Health 4.0 devices, however it is restricted to developed countries and multinational industries and yet to be reach to developing and underdeveloped countries. The overview of the literature also indicates that various major opportunities viz. applications of medical device manufacturing, value based care, patient information, suitable standard HIS, LISc tools, other tools and techniques, etc. are not up to the mark and needs advertisements at global level to make the health devices more effective, efficient, innovative and useful.
- It has been observed that the uses of Health 4.0 is increasing but with a very slow speed hence investment and management, international and cross industrial collaboration, still remain missing.
- It indicates that since Health 4.0 is in its initial stage the concept of data ownership and security (agreements, MOU, data encryption, etc.) are considered only very few cases. Some steps have been considered but much more to be done related to legal issues, IPR, specification, agreement.
- It reveals that the provision of maintenance and monitoring of various processes are there but differ from factory to factory in various aspects of Health 4.0.
- Standards (i.e. product registration, employment and skill development), are the regular and routine process and are being adopted in the majority of cases. The study also indicates that there is no uniformity in Standardization, and employment procedure while adopting Health 4.0.

Suggestions

- The concept of Health 4.0 is new and very initial stage of development need to be promoted through appropriate policies and programmes.
- Since the concept of CPS is playing a major role in Health 4.0 as sub set of Industry 4.0 are in their initial stages of development, it is essential and suggested to clear skill and knowledge about it before adopting and implementing it (15).
- The ICLs should provide information services to support Health 4.0. They should make use of makerspace, Google Glass, context aware technology, internet of things, more personalize services, big data, CC, and augmented reality as a symbiosis web, reading, writing, and executing simultaneously,

web OS, middleware, and a massive web allowing intelligence interaction just like a human brain.

Conclusions

It can be concluded that in the fast changing- technologies, techniques, tricks as well as high completion, it is need of the time to keep pace with digitization and other ICT innovations at different levels to implement Health 4.0 concept. Many sub-topics need to be included to achieve higher accuracy and quickness in diagnosis, to establish more secure hospital information systems, to make medical devices more efficient, innovative and useful. "The health industry is going through an exciting time with many new opportunities in innovative routes to patient care. Those that ignore the opportunities, Health 4.0 offers will be in serious danger of not being able to compete in the near future as others drive down manufacturing costs and increase business agility in response to developing technologies (15)".

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