

## REVIEW

# Research, Technology, Education & Scholarship in the Fourth Industrial Revolution [4IR] : Influences in Nursing and the Health Sciences

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**Abstract :** The Fourth Industrial Revolution (4IR) generated considerable interests among scholars, informaticists and educational leaders around the globe. This industry shift brings with it exciting opportunities and inevitable challenges to various industries and professional practices including the health sciences. The purpose of the article is to illuminate the influences of the Fourth Industrial Revolution on the research, education and technology on Nursing and the Health Sciences. This article is organized as follows : the historical developments in the evolution of nursing images, industries and technologies in healthcare praxis, juxtaposing of current and impending trends and their impact on education, research and scholarship, and education in the healthcare sector. This article concludes with shared insights on several creative and proactive solutions in preparing for, creating new technologies, and mitigating the effects of the upcoming revolution. *J. Med. Invest.* 66 : 3 - 7, February, 2019

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## INTRODUCTION

The fundamental framework of developing innovative learning ecosystems (e.g. big data, artificial intelligence, robotics, smart technology) poses great value as the healthcare sector prepares for the impact of the Fourth Industrial Revolution (4IR) or the Industry 4.0. What makes 4IR daunting is its exponential progression of technologies (1), which creates a lot of issues and challenges for nursing and health sciences. Since technology solution and innovation are crucial in knowledge societies (2), 4IR can be a double-edged sword in advancing sustainable development—*an opportunity or uncertainty*.

The enduring notion of informatics as a catalyst to enhance evidence-based practice, innovate problem-solving (3), inform policy briefing (4), and enrich research activities has been the expected vision to many to improve quality of life. Healthcare leaders, educators, and researchers have ascertained the need for every practitioner to participate in healthcare informatics (5) that is the use of information and communications technologies (ICT) in the mining of data, use of information and development of knowledge to support healthcare practice (6). Informatics concepts, from the keynote addressee's point of view underscore several elements, namely : (a) information, (b) reliability, management, technology, intelligence, computers and standards (Figure 1). Informatics competencies (7) are increasingly becoming a global imperative for professionals in the healthcare field. However, preparation for 4IR requires expanded competency on new technologies (8) and tailor fit it to different healthcare environments.

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Figure 1. Concepts in Informatics

Fourth Industrial Revolution on the research, education and technology on Nursing and the Health Sciences.

## CONCEPTS IN INFORMATICS

Health technology solutions are considered as the backbone of all health systems and are deemed essential tools to address health inequalities. One thing is for certain, 4IR involves wide-ranging new media and transformative technologies with hyper connectivity. In facing Industry 4.0, there is a need to ascertain its potential to situate nursing at the heart of health sciences and related services by a) mapping the historical development of nursing, b) understanding the fourth industrial revolution, and c) exploring 4IR challenges. Substantial solutions in nursing and health science challenges can be identified through critical analysis of the Industry 4.0.

## HISTORICAL DEVELOPMENT OF NURSES AND NURSING IN PICTURES

Nursing portraits captured from open source internet media are presented to illustrate extant technologies. The notion, “pictures paint a thousand words”, is further linked with Darwin’s theory of evolution as anchors to nurses and change (Figure 2).

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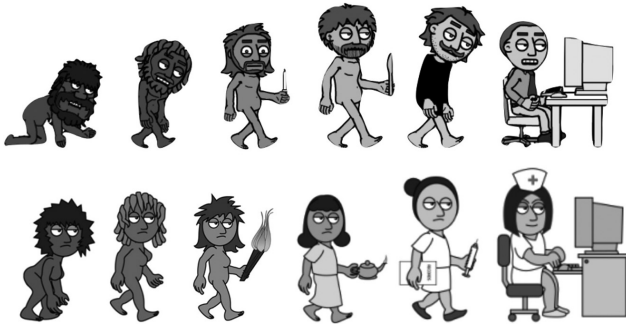


Figure 2. The Evolution of Nurses as juxtaposed with Darwin's Evolution of Man

In illustrating the evolution of nurses as juxtaposed with Darwin's Evolution of Man, the rich history of nursing was made evident with several celebratory images of the 'white women' (9) across the centuries. Correspondingly, the changing faces, phases and paces of the profession were documented in a number of scholarly works (10, 11). Clearly, on the documented images, the overall impact of nurses is centered on themes such as caring (13, 14), good and expert (15), safety and comfort (16), and overall well-being and nurturance (17).

The changing image of a professional nurse was attributed to the breadth and wealth of exponential changes in the environment. For example, the parallel growth between population ageing and computers reinforces nurses to improve their geriatric competencies while becoming better in computer literacy. In addition, information explosion in the healthcare field (18) expands information science resources of both nurses and nursing students. In sociology, the emergence of the multi-generations (19) in one practice setting emotionally toughen nurses and be cognizant of the value of healthy work environments.

The scarcity of nursing images associated with technology is surprising in light of recent advancements in technology. Though few historical images of nurses highlight technology as their fundamental tool, the amalgamation of technology and caring in the present time is claimed to be best exemplified in the nursing profession (20). For instance, literatures from consequent recent years (21-23) healthcare robots to nurses. As institutes of nursing continuously strive on shaping professionals of the future workforce, it is inevitable to separate technology with the image of a contemporary nurse.

## THE FOURTH INDUSTRIAL REVOLUTION (4IR)

Industries, like nursing images are evolving, since the beginning of the 18<sup>th</sup> century. Consequently, the human race experienced three (3) dramatic and distinct technological change and innovation driven by mechanization (1st industrial revolution), utilization of electrical energy (2<sup>nd</sup> industrial revolution), and automation with electronics (3<sup>rd</sup> industrial revolution) (24). The emergence of cyber-physical systems and smart technologies signal a historical turning point towards the 4<sup>th</sup> industrial revolution (4IR) as more studies are geared on its possible integration into professional practice (25). Succinctly, 4IR definitions are various and it introduces several technologies that are predicted to change the landscape of the industries including Nursing : Big Data, Internet of Things, Cloud Computing, Wireless Sensor Systems, Augmented Reality, Robots and Simulation (26, 27). Researchers, for their part, have generated co-word analyses for Industry 4.0 in the last five years and discovered cyber physical systems and cloud computing as the dominant themes in this phenomenon (28).

## EMERGING TRENDS, ISSUES AND CHALLENGES FOR NURSING AND HEALTH SCIENCES

Industry 4.0 has the potential to situate nursing at the heart of health sciences and related services, as it responds to the call for major transformations to operate fully from the year 2020 and beyond (29). Prominent changes concerning health industry transformations are visible and overlapping on areas of research and scholarship, education and praxis sectors.

### Health Science Education

The Fourth Industrial Revolution has drawn considerable attention from the academic sector as a new trend towards automation, and a positive response to address feeble growth of emerging industries (30). The healthcare schools of the future are predicted to use advanced technology that has the potent to disrupt existing? educational models.

The pervasiveness of computer in the contemporary healthcare education goes beyond the utilization of traditional desktop computers (31, 32). In schools of healthcare, the preponderance of touch and mobile devices as contemporary technologies has supported a wide variety of information and communication needs of mentors and mentees. For instance, iPads as one of the most popular others (33) were reported to be beneficial in accessing a variety of educational resources from the internet among healthcare students and personnel (34). Smartphones, as the device of choice among most nurses, were proven beneficial in education and rendering the health process (35), however, a previous study (36) declared that computers may be a potential source of confidentiality breach.

The integration of machine learning and artificial intelligences generated from the academia will significantly alter theory and education, and will influence how students learn (37). Electronic learning materials shall provide an open source resource for education along with simulation learning (38) and virtual reality (39) that will both provide meaningful real-world scenarios under the problem based approach (40).

### Health Science Praxis

The healthcare industry experienced slow transitions to emerging technologies during the first three industrial revolutions. This changeover is evident from the healthcare nascent stage beginning 1970s (tagged as Healthcare 1.0) to a more advanced phase from 2006-2015 (Healthcare 3.0) spanning several dormant periods.

By and large, the provision of quality healthcare services appears to be a challenging task in the community across the centuries. Such challenge entails the need to organize the bulk of client information in the face of burgeoning population vis-à-vis with the strict reliance to the ideology that quality information available to the healthcare professionals has a proven impact on the outcomes of care. It is a no wonder that the advanced phase of healthcare innovation is propelled by the emergence of the Electronic Health Records (EHR). The EHRs has been beneficial in processing administrative and clinical data for quality healthcare information. Despite being patient-centered, a number of these technologies have a fractional consideration of the human-computer interaction, which affects the healthcare professionals as end-users.

The emergence of electronic paperless databases as an alternative to the conventional paper records seems more inevitable in the contemporary society (41). Any health professionals can effortlessly appreciate the direct benefits of EHR for both administrative and clinical data, which are accessible, comparable, communicable and confidential (42). As observed, paper-based records are oftentimes prone to errors, information gaps and unauthorized use (43).

Telehealth technologies are also becoming more inescapable as a heap of research findings supported the inclusion of such to mainstream health promotion, diagnostics, disease prevention and health recovery activities. Telehealth, or healthcare delivery at a distance, is believed to have gained popularity in the contemporary society and is considered to be the 'next big thing' healthcare provision (44). Its prominent existence can be seen from the application of various health technology platforms. Telehealth is commonly delivered through the integrative use of communication media such as telephone, internet, data monitor, and video monitor (45). In some situations, Telehealth exists as simple as webcam interaction, yet it can be very complex by combining multiple channels and devices together (46). Among the platforms of Telehealth, the use of videos in web-based communication (videoconferencing) is considered the most popular and most effective. Cyber physical systems as an emerging technology in Industry 4.0 (47) offer bright future solutions to transform healthcare operations in hospitals and communities.

#### Health Science Research

Literatures concerning the Fourth Industrial Revolution has gained momentum in recent years since its inception by the German government in Hannover Fair in 2011 to promote computerization in manufacturing (48). In the health sciences, the introduction of new approaches with its new terminologies warrants further investigations and pilot studies. Research in the health sciences continue to posit the attributes of comparability, reliability, acceptability, validity and explicitness, or the C.R.A.V.E factors [Figure 3], and the utilization of technologies in writing is increasingly recognized in the academe (49).

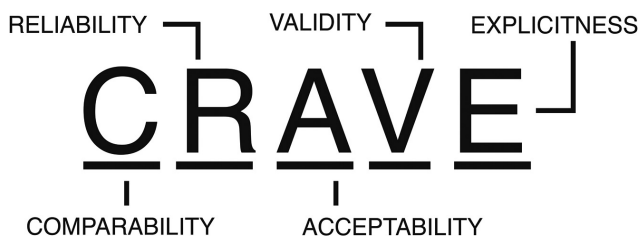


Figure 3. The C.R.A.V.E. Factors of Research Quality

#### PROPOSED SOLUTIONS

Industry 4.0 has an ill-structured nature that leads to a problem space with no definitive solutions. Lessons learned from the progressive evolution of man and revolution of industry can be a great source of inspiration in finding creative solutions for the exponential 4IR. The C.R.A.V.E. Factors in Research Quality provide a structural delineation of strategies to invigorate quality in knowledge synthesis.

First is to use the "lookback and lookout" strategy. It is important to lookback at previous industrial revolutions from macro to micro levels. After understanding the past challenges and solutions, 4IR can be addressed initially by looking out strategically for threats, opportunities, weakness, and strengths. Surprisingly, these simple activities are the fundamentals of research, technology, education, and scholarship.

Creating a solution for a problem follows a similar pattern with any given problem. The next step is to identify a problem-solving framework that is relevant to the perceived issues and challenges of 4IR. Since there is no single, correct approach, finding a creative solution can emanate from established and emergent strategies. Borrowing theories and models are also worthwhile in ensuring

effective interprofessional collaborations. A simple approach would be defining the problem-solution spaces by stating the a) philosophy, b) purpose, c) process, and d) people.

The philosophy should clearly describe the core values of the intended solutions. In terms of Cyber Physical Systems (CPS), the notable challenges for researchers and professionals are how to design and implement CPS to become usable and reliable. It was initially beheld that information technology applications have both 'automate' and 'informate' capacities. However, the caring is not a linear process of delivering healthcare services. Setting the philosophy at the very start could guide the future of CPS solution in healthcare. Similarly, specifying the intended purpose of the CPS solution can bring out its meaningful function—promotive, preventive, curative, and rehabilitative health services.

Knowing the philosophy and purpose could give a visionary picture, but these would only provide answers to what the CPS solution is. Thus, mapping the essential processes on creating a CPS solution should be planned and designed accordingly. This step is critical due to the ill-structured 4IR. Collaboration and teamwork are seen beneficial in identifying key processes. As a result, healthcare as an essential social service needs to be prioritized. Similar to other industries (e.g., mechanical, electrical, and civil), healthcare also undergoes significant changes from 1.0 to 4.0 revolutions. Despite the progressive 4IR, healthcare industry is still in its nascent state due to several health challenges and inequalities. There could be similar philosophy and purpose, but the key processes would most likely be different depending on the healthcare contexts. What is important is to ensure in having a systems-approach so as to prevent disintegration of processes.

Undeniably, the primary driver of Industry 4.0 is people. It is widely acknowledged that humans form a vital system in the performance of a computer (or technology). However, the human-computer interaction requires in-depth evaluation. Technology solutions and innovations are usually originated from non-health sectors, particularly the fields of engineering. Thus, future CPS solutions should determine all stakeholders—designers, administrators, users, recipients among others. There will always be issues and challenges in developing CPS solution for healthcare, because of limited workforce on healthcare (or biomedical) engineering and informatics. Likewise, not all health providers have the CPS capability. Such problem can be addressed by being vigilant of the social subsystem of a solution.

#### CONCLUDING REMARKS

On the whole, the proposed solution for 4IR in nursing and healthcare is not to react randomly, but to proact scholarly. Humanity has proven itself capable of learning and evolving with its ever-changing environment. Nurses and health professionals can likewise address the challenges of Industry 4.0 through research, technology, education and scholarship. Knowledge transfer and exchange (KTE) and continuing professional development (CPD) activities are essential strategies in improving awareness and initiating actions towards planning, implementing, and evaluating desired outcomes for 4IR in nursing and healthcare. Valuable scientific conferences such as the Second International Seminar and Workshop of the Technological Competency as Caring in the Health Sciences by the Faculty of Health Sciences is a remarkable avenue to discuss Industry 4.0, as health professionals stays true to the noble vision of preserving care amidst technological advances (50). Quoting Dan Brown (51) from his book, the Origin: "May our philosophies keep pace with our technologies. May our compassion keep pace with our powers, and may love [caring], not fear, be the engine of change". Through the lens of scholars and the general public, Nursing and nurses are and will always be centered in



caring.

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## CONFLICT OF INTEREST

There is no actual or potential conflict of interest that exist in this manuscript.

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