Summer Report Presentation

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SECONDARY RESEARCH TOPIC

Study on the Application of 3D Printing Technology to Combat Global Supply Chain Disruption in Hospitals during COVID-19 Pandemic.

INTRODUCTION

There is growing international concern regarding the shortage in supply chain of critical one-time-use personal and protective equipment (PPE). PPEs are heat sensitive and are not, by their manufacturer's design, intended for reprocessing. Most conventional sterilization technologies used in hospitals, or in terminal medical device sterilization providers, cannot effectively reprocess PPE due to the nature and severity of sterilization modalities. Contingency planning for PPE stock shortage is important.

Due to supply chain disruption, the COVID-19 pandemic has caused severe shortages in personal protective equipment (PPE) for health care professionals. Local fabrication based on 3D printing is one way to address this challenge, particularly in the case of simple products such as protective face shields.

INTRODUCTION

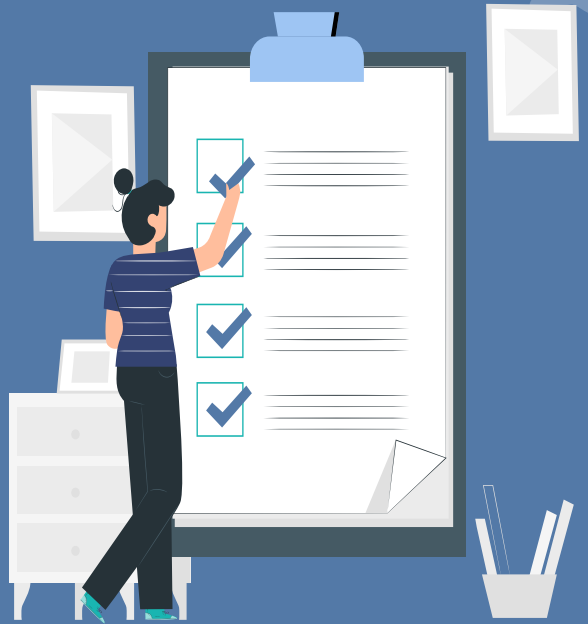
Additive manufacturing (AM) including 3-dimensional (3D) printing have gained popularity in manufacturing of medical devices. Advantages of AM technology includes ease in fabricating complex geometric structures, allowing the creation of engineered porous structures, tortuous internal channels, and internal support structures that would not be easily possible using traditional (non-additive) manufacturing approaches.

The reshaping of supply chains, as a result of increased use of 3D printing, is expected to bring important benefits within the main functions of the entire supply chain.

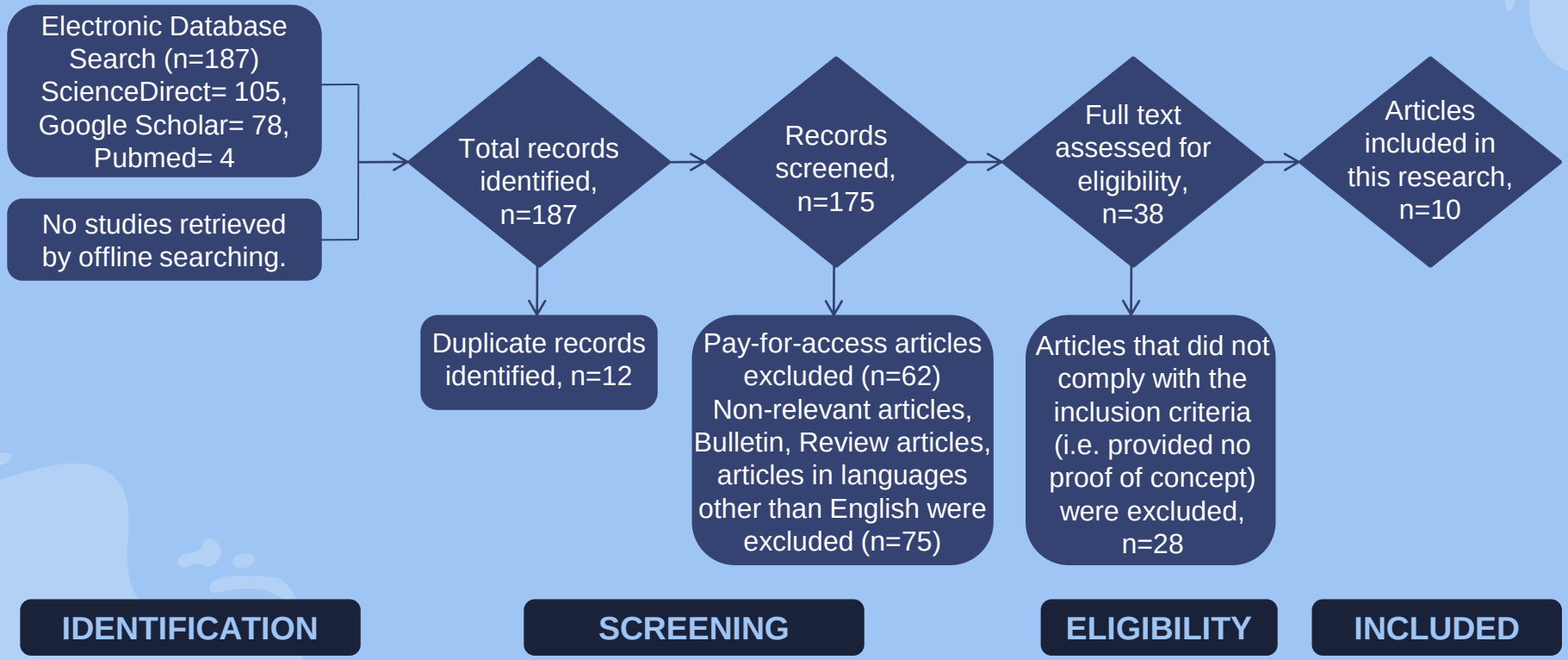
OBJECTIVES

1. To study the use of 3D printing technology to meet global supply chain demands during COVID-19 pandemic.

2. To study the strengths and shortcomings of products manufactured using 3D printing technology as an alternative during COVID-19 pandemic.



METHODOLOGY



RESULT- SWOT Analysis

STRENGTH

1. Addresses the emerging need of PPE,
2. Easy to manufacture and produce,
3. Helps in the fabrication of complicated equipments,
4. Gives design flexibility,
5. Re-usability.

WEAKNESS

1. Possibility of developing skin lesions due to long term use,
2. Requires individual fit modifications,
3. Lack of research,
4. Less suited for mass production,
5. High cost of capital,
6. Affordability.

OPPORTUNITIES

1. Product innovation opportunity,
2. Provide opportunity to local designers and manufacturers to get into the field of 3D printing technology,
3. Enhancing PPE design and development,
4. Research and development for production of other 3D manufactured products useful for post-COVID scenario.

THREATS

1. Regional and country approval on the use of 3D manufactured products,
2. Risk of using products with a lack of rigorous testing for critical healthcare situations,
3. Environmental impact,
4. Cost of material outsourcing and manufacture in countries where the technology is still in a premature stage.

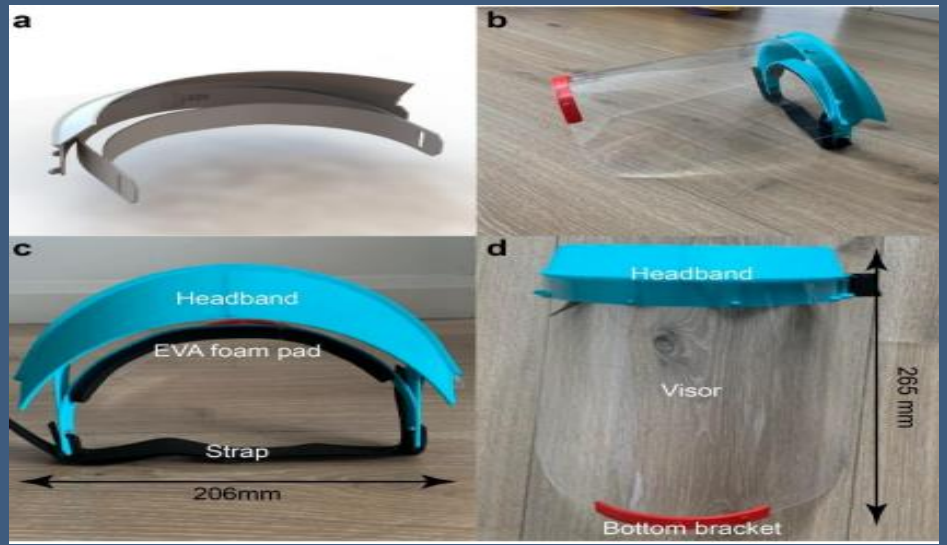
3D PRINTED PPE DEVELOPED BY RESEARCHERS.

Clinical images of the 3D-printed face mask, in combination with protection glasses and a face shield.

Custom-made individualized 3D-printed protective face mask: (a) reusable 3D-printed face mask and (b) filter membrane support; (c) polypropylene (PP) non-woven melt-blown particle filter and (d) 3D image of the prototype.

Fig 1: Swennen, G. R., Pottel, L., & Haers, P. E. (2020).[1]

3D PRINTED PPE DEVELOPED BY RESEARCHERS.



A) Headband CAD image B) final face shield prototype C) headband, foam pad, and strap image with dimensions D) headband, visor, and bottom bracket image with dimensions.

Fig 2: Mostaghimi, A., Antonini, M. J., Plana, D., Anderson, P. D., Beller, B., Boyer, E. W., Fannin, A., Freake, J., Oakley, R., Sinha, M.S., & Smith, L. (2020).[3]

CONCLUSION

1. The additive manufacturing industry is more evolved in the high-income and middle-income countries.
2. 3D printing companies require support, participation, and investment from IT hardware and software companies. Most of which are outsourced from countries like the United States, China, and Europe.
3. The supply chain dependency poses constraints for 3D printing technology in developing countries to scale.
4. the future growth of this industry in the post COVID-19 scenario depends on the response by the Indian 3D printing players to cope up with the supply chain shortage.

REFERENCES

1. Swennen, G. R., Pottel, L., & Haers, P. E. (2020). Custom-made 3D-printed face masks in case of pandemic crisis situations with a lack of commercially available FFP2/3 masks. *International Journal of Oral and Maxillofacial Surgery*.
2. Rowan, N. J., & Laffey, J. G. (2020). Challenges and solutions for addressing critical shortage of supply chain for personal and protective equipment (PPE) arising from Coronavirus disease (COVID19) pandemic–Case study from the Republic of Ireland. *Science of The Total Environment*, 138532.
3. Mostaghimi, A., Antonini, M. J., Plana, D., Anderson, P. D., Beller, B., Boyer, E. W., Fannin, A., Freake, J., Oakley, R., Sinha, M.S., & Smith, L. (2020). Rapid prototyping and clinical testing of a reusable face shield for health care workers responding to the COVID-19 pandemic. *medRxiv*.
4. Neupane, B., & Giri, B. (2020). Current understanding on the Effectiveness of Face Masks and Respirators to Prevent the Spread of Respiratory Viruses.
5. Haddud, A., Khare, A., & Ishikura, H. (2020). The Evolution and Strategic Operations Perspective on 3D Printing: The Global and Japanese Experience. In *Transforming Japanese Business* (pp. 227-245). Springer, Singapore.
6. Amin, D., Nguyen, N., Roser, S. M., & Abramowicz, S. (2020). 3D Printing of Face Shields During COVID-19 Pandemic: A Technical Note. *Journal of Oral and Maxillofacial Surgery*.
7. Erickson, M. M., Richardson, E. S., Hernandez, N. M., Bobbert II, D. W., Gall, K., & Fearis, P. (2020). Helmet modification to PPE With 3D printing during the COVID-19 Pandemic at Duke University Medical Center: A novel technique. *The Journal of Arthroplasty*.
8. Maracaja, L., Blitz, D., Maracaja, D. L., & Walker, C. A. (2020). How 3D Printing Can Prevent Spread of COVID-19 Among Healthcare Professionals During Times of Critical Shortage of Protective Personal Equipment. *Journal of cardiothoracic and vascular anesthesia*.
9. Nicholson, K., Henke-Adams, A., Henke, D. M., Kravitz, A. V., & Gay, H. A. (2020). Modified full-face snorkel mask as COVID-19 personal protective equipment: Quantitative results.

10. Wesemann, C., Pieralli, S., Fretwurst, T., Nold, J., Nelson, K., Schmelzeisen, R., Hellwig, E., & Spies, B. C. (2020). 3-d printed protective equipment during COVID-19 pandemic. *Materials*, *13*(8), 1997.
11. Chichester, D. L., Hix, J. D., Johnson, J. T., Ocampo Giraldo, L. A., Watson, S. M., Mortensen, B. T., & Angell, C. Z. (2020). *Evaluation of an Additively Manufactured Respirator for Personnel Protection from Particulates* (No. INL/MIS-20-57929-Rev000). Idaho National Lab.(INL), Idaho Falls, ID (United States).
12. Liu, D. C. Y., Koo, T. H., Wong, J. K. K., Wong, Y. H., Fung, K. S. C., Chan, Y., & Lim, H. S. (2020). Modifying reusable elastomeric respirators to utilise breathing system filters with 3D printed adapters, a safe alternative to N95 during COVID-19. *medRxiv*.
13. Provenzano, D., Rao, Y. J., Mitic, K., Obaid, S. N., Pierce, D., Huckenpahler, J., Berger, J., Goyal, S., & Loew, M. H. (2020). Rapid prototyping of reusable 3D-printed N95 equivalent respirators at the George Washington University.
14. Wadekar, N., "Kenya's 3D printing community is making COVID-19 equipment to fill a deficit as caseloads rise", *Quartz Africa*, 2020. [Online]. Available: https://qz.com/africa/1838608/kenyas-3d-printing-community-making-COVID-19-equipment/. [Accessed: 24- May- 2020].
15. "Winsun 3D prints isolation wards to curb coronavirus outbreak - 3Dnatives", *3Dnatives*, 2020. [Online]. Available: https://www.3dnatives.com/en/winsun-coronavirus-260220205/. [Accessed: 24- May- 2020].
16. Essop, A., Vialva, T., Sertoglu, K., Hanaphy, P., 3. Industry & Petch, M., "3D printing community responds to COVID-19 and coronavirus resources - 3D printing industry", *3D Printing Industry*, 2020. [Online]. Available: https://3dprintingindustry.com/news/3d-printing-community-responds-to-COVID-19-and-coronavirus-resources-169143/. [Accessed: 24- May- 2020].

The research paper has been published and is cited as,

Murtaza, A., Majumdar, P. (June 2020). Study on the Application of 3D Printing Technology to Combat Global Supply Chain Disruption in Hospitals during COVID-19 Pandemic. *International Journal of Research in Technology and Management*.

INTERNATIONAL JOURNAL OF RESEARCH IN TECHNOLOGY AND MANAGEMENT (IJRTM)
ISSN 2454-6240
www.ijrtm.com

STUDY ON THE APPLICATION OF 3D PRINTING TECHNOLOGY TO COMBAT GLOBAL SUPPLY CHAIN DISRUPTION IN HOSPITALS DURING COVID-19 PANDEMIC

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ABSTRACT

Additive Manufacturing Technology or 3D printing technology has been used in healthcare previously for manufacturing prosthetics, implants, etc. 3D printing has been recognized as an innovative strategy to overcome supply chain shortage during the COVID-19 pandemic. However, there exist various strengths and shortcomings of the Personal Protective Equipments (PPEs) developed using this technology.

Methodology: In this research, we searched three online databases and included articles that provided proof of concept by developing prototypes of the PPEs and testing or evaluating them.

Results: From a total of 187 search results, 10 research articles met our inclusion criteria and were included in this research study. Most of these studies have been conducted in high-income countries and show that it is possible to use 3D printing to manufacture Personal Protective Equipments (PPEs) but there is a requirement of rigorous quality testing before implementation in clinical use.

Conclusion: This study has found various opportunities and obstacles of the 3D manufactured Personal Protective Equipments (PPEs) and the difficulties that low income, middle income and low-middle income countries might face in implementing this strategy to overcome supply chain shortage.

Keywords—3D printing, Additive manufacturing, Supply chain

I. INTRODUCTION

Epidemic diseases that spread across a large region of the world, such as the 1918 influenza pandemic (Spanish flu), the 2009 flu pandemic (H1N1), and the current 2019 coronavirus disease (COVID-19),1, 2 can pose a challenge to healthcare resources worldwide. Basic measures such as personal hand cleaning and social distancing are crucial. However, according to World Health Organization (WHO) guidelines, protective material is essential for all healthcare providers [1].

There is growing international concern regarding the shortage in supply chain of critical one-time-use personal and protective equipment (PPE). PPE are heat sensitive and are not, by their manufacturer's design, intended for reprocessing. Most conventional sterilization technologies used in hospitals, or terminal medical device sterilization providers, cannot effectively reprocess PPE due to the nature and severity of sterilization modalities. Contingency planning for PPE stock shortage is important [2].

Due to supply chain disruption, the COVID-19 pandemic has caused severe shortages in personal protective equipment (PPE) for health care professionals. Local fabrication based on 3D printing is one way to address this challenge, particularly in the case of simple products such as protective face shields[3]. Additive manufacturing (AM) including 3-dimensional (3D) printing have gained popularity in manufacturing of medical devices. Advantages of AM technology includes ease in fabricating complex geometric structures, allowing the creation of engineered porous structures, tortuous internal channels, and internal support structures that would not be easily possible using traditional (non-additive) manufacturing approaches [4]. The reshaping of supply chains, as a result of increased use of 3D printing, is expected to bring important benefits within the main functions of the entire supply chain. Such benefits may include shorter time-to-market and speedy deliveries, reduced warehousing and transportation costs, reduced manufacturing costs, and more efficient packaging, minimizing stock keeping, and faster response to customer demands through on-time and on-demand production. While such benefits may act as strong motives to businesses to adopt 3D printing technology approach, the use of this technology continues to face some challenges and difficulties associated with its implementation, particularly those related to the required materials, cost of acquiring the technology itself, cost of large production runs, slow production time for large production and, finally, the issues related to intellectual property protection [5].

II. AIMS AND OBJECTIVES

1) To study the use of 3D printing technology to meet global supply chain demands during the COVID-19 pandemic.
2) To study the strengths and shortcomings of products manufactured using 3D printing technology as an alternative during the COVID-19 pandemic.

III. RESEARCH METHODOLOGY

A. Process of collecting Literature

Online databases like ScienceDirect, Google Scholar, and Pubmed were used to search for articles and published literature using a set of keywords as in Table 1.

These keywords gave access to all the literature that represented the concept of this research study. The first set of keywords was used to identify with the different references to the COVID-19 pandemic. Secondly, 3D printing was also identified to be referred to as additive manufacturing in some articles hence the use of different keywords. Lastly, this research aims to study the use of 3D printing technology to overcome the supply chain shortage with respect to Personal Protective Equipments (PPEs) like masks, face shields, etc. for the frontline healthcare workers hence the use of the last set of keywords.

ONLINE COURSES

PATIENT SAFETY SPECIALIZATION

PATIENT SAFETY AND QUALITY IMPROVEMENT: DEVELOPING A SYSTEMS VIEW (PATIENT SAFETY I)

- Course Description
- Course Objectives
- Course Methodology
- Course Contents
- Course Learnings

SETTING THE STAGE FOR SUCCESS: AN EYE ON SAFETY CULTURE AND TEAMWORK (PATIENT SAFETY II)

- Course Description
- Course Objectives
- Course Methodology
- Course Contents
- Course Learnings

PATIENT SAFETY AND QUALITY IMPROVEMENT: DEVELOPING A SYSTEMS VIEW (PATIENT SAFETY I)

PATIENT SAFETY AND QUALITY IMPROVEMENT: DEVELOPING A SYSTEMS VIEW (PATIENT SAFETY I)

COURSE DESCRIPTION:
In this course, one will be able develop a systems view for patient safety and quality improvement in healthcare.

COURSE OBJECTIVES:
By the end of this course, would be able to:

1) Describe a minimum of four key events in the history of patient safety and quality improvement,
2) Define the key characteristics of high reliability organizations, and
3) Explain the benefits of having strategies for both proactive and reactive systems thinking.

COURSE METHODOLOGY: Videos and Reading Material

PATIENT SAFETY AND QUALITY IMPROVEMENT: DEVELOPING A SYSTEMS VIEW (PATIENT SAFETY I)

MODULE I. The History of Patient Safety and Quality Improvement.

MODULE II. Definitions in Patient Safety and Quality Improvement: An Overview

MODULE III. High Reliability Organizing and Why it Matters

MODULE IV. Applying a Systems Lens to Healthcare

PATIENT SAFETY AND QUALITY IMPROVEMENT: DEVELOPING A SYSTEMS VIEW (PATIENT SAFETY I)

In order to redesign the Healthcare delivery system the following should be done,

1. **Apply evidence to healthcare delivery;**
2. **Maximize use of Information Technology;**
3. **Align payment models with quality improvement and**
4. **Prepare the workforce.**

The course describes two types of organizations:

•HIGH RISK ORGANIZATIONS- These organizations operate technologies sufficiently complex to be subjected to catastrophic accidents.

•HIGH RELIABILITY ORGANIZATIONS- These organizations are a subset of high risk organizations designed to manage and avoid catastrophic accidents.

The Model of High Reliability Organizations depend on:

•Leadership

•Safety Culture

•Robust Process Improvement

SETTING THE STAGE FOR SUCCESS: AN EYE ON SAFETY CULTURE AND TEAMWORK (PATIENT SAFETY II)

SETTING THE STAGE FOR SUCCESS: AN EYE ON SAFETY CULTURE AND TEAMWORK (PATIENT SAFETY II)

COURSE DESCRIPTION:
Safety culture is a facet of organizational culture that captures attitudes, beliefs, perceptions, and values about safety. A culture of safety is essential in high reliability organizations and is a critical mechanism for the delivery of safe and high-quality care. It requires a strong commitment from leadership and staff. In this course, a safe culture is promoted through the use of identifying and reporting patient safety hazards, accountability and transparency, involvement with patients and families, and effective teamwork.

COURSE OBJECTIVES:
Reviewing essential elements of a safety culture.
Describing how healthcare organizations identify and mitigate safety hazards.
Identifying how patients and family members contribute to developing a safety culture.
Identifying strategies for improving communication and team work.

COURSE METHODOLOGY: Videos and Reading Material

SETTING THE STAGE FOR SUCCESS: AN EYE ON SAFETY CULTURE AND TEAMWORK (PATIENT SAFETY II)

MODULE I. Patient Safety Culture and Just Culture

MODULE II. Patient Safety, Quality, and the Patient Experience

MODULE III. Event Reporting and Second Victims

MODULE IV. Strengthening Safety Culture Through Teamwork

SETTING THE STAGE FOR SUCCESS: AN EYE ON SAFETY CULTURE AND TEAMWORK (PATIENT SAFETY II)

This course describes three types of behaviors.
•**Reckless Behavior-** behavioral choice to consciously disregard a substantial and unjustifiable risk.
•**At Risk Behavior-** behavioral choice that increase risk, where risk is not recognized or mistakenly believed to be justified.
•**Human Error-** Inadvertent action, slip, lapse or mistake.

Just Culture is a concept related to systems thinking which emphasizes that mistakes are generally a product of faulty organizational cultures, rather than solely brought about by the person or persons directly involved. It should be adopted in healthcare organizations because:
•It promotes patient safety and quality improvement.
•Balances individual accountability with system accountability.
•Holds leaders accountable for designing safe systems.
•Promotes learning from errors.
•Differentiates incidents resulting from human error.

Healthcare organizations must focus on patient satisfaction through patient and family centered care (PFCC). **Patient Satisfaction** is a subjective concept which is related to expectation and **Patient Experience** is meant to elicit factual data that can be easy to interpret.

HEATH CARE IT: CHALLENGES AND OPPORTUNITIES

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- Course Description
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- Course Learnings

HEATH CARE IT: CHALLENGES AND OPPORTUNITIES

COURSE DESCRIPTION:

This course covers the modern application of information technology that is critical to supporting the vision and operational knowledge of the health care leaders in managing the health care organization. Heath care decision-makers have to meet head-on the dynamic challenges of health care delivery quality, cost, access, and regulatory control. Additionally, this course integrates the Healthcare Information System as integral to the Quality Assurance Tracking Programs including measurement of systems inputs, processes, and outputs with special emphasis on systems outcomes research and organizational accountability to its various stakeholders, not the least of which are government regulators.

COURSE OBJECTIVES:

1. To understand what is Health IT
2. To understand the challenges behind adoption of advanced technology in healthcare
3. To understand various forms of Health IT that exist

COURSE METHODOLOGY: Videos and Reading Material

HEATH CARE IT: CHALLENGES AND OPPORTUNITIES

MODULE	I.	Where are we today and how did we get here? The legal and regulatory framework of Health IT
MODULE	II.	A Patient's Perspective to Health IT
MODULE	III.	A Patient's guide to the Doctors' Secret World of technology
MODULE	IV.	A Focus on Digital Medicine
MODULE	V.	The rise of the electronic medical record - Beyond EHRs

HEATH CARE IT: CHALLENGES AND OPPORTUNITIES

This course describes the perspective of three different drivers of health IT.

PATIENT PERSPECTIVE

1. Easy access to health information,
2. Easy access to their clinician,
3. They want clinicians to be able to share information with one another,
4. Use their technology to find out more about their health conditions.

CLINICIANS PERSPECTIVE

1. Want their patients to be informed,
2. Want to use technology to make their practices work better,
3. Want to be able to coordinate by communicating with one another,
4. Want to meet their patients expectations.

PAYERS PERSPECTIVE

1. They need to measure clinician effectiveness,
2. Want to ensure patient safety,
3. Want to ensure value and identify variation.

VARIOUS FORMS OF HEALTH IT:

•Apps, mhealth or mobile application.

•Fitness wearable's, step counters, some are equipped with heart rate monitors, and also even GPS positioning devices.

•There are also posture detectors, like the Lumo Lift that will vibrate, if you're slouching.

•A spire is clipped onto our shirt, and it can possibly measure how we are breathing.

THANK YOU.