

Feasibility of smart engineering solutions in hospitals to tackle with pandemic situation in smart cities

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Abstract

Operations management in healthcare sector is required for providing healthcare services what the doctor has ordered in this swiftly changing field. Giving hospital services worth of best cost to patients is challenging job. Main task is to arrange proper funding and using that wisely and perfectly to provide essential and beneficial services to patients. It is understood from the literature review and discussions with engineers and IT experts in hospitals that use of smart engineering tools by application of operations management are rare and less applied in the field of health care. Presently, hospitals are required to be smart to tackle such pandemic situation to serve patients smartly and satisfy them. Hence in this study smart city based smart hospital concept is highlighted.

Aim of this study is to provide effective engineering solutions for smart hospital in smart City through operations management. The Objectives of this study are to optimize patient centric services using engineering tools and to empower smart hospitals equipped with innovative smart IoT based tools. The scope of study is use of smart engineering solutions to staff of hospital using engineering solutions and basically are not directly focusing on patients & their relatives, customer-patients who are not acquainted with IT. This study focus on how hospitals can adopt operations management with optimistic vision by giving reliable, affordable, highest quality medical services to needy patients without any discrimination with keeping objective of patient centric services as the top most priority.

A hypothesis of study is: Application of different methods of smart technical majors in daily routine of hospitals in different departments can help to improve performance of hospital and treatment quality towards patients for their better lives.

Subject Classification: 54-XX.

Keywords: Emergency, Engineering, Healthcare, Hospitals, IoT, Operations managements, Pandemic, Smart technology, Smart city.

1. Introduction

Health care is much widely spread sector that includes various hospitals, practitioner doctors who provide their health related services to patients that includes diagnosis, treatments, and preventive measures from injury, diseases, illness and other psychological problems. Social, political, environmental, economical conditions of society affect the healthcare industry largely. Forming different policies in institutions to run the system smoothly and efficiently is main task in front of operational management team in hospitals. Arranging finance, well trained and satisfied medical and non medical staff well maintained health facilities, reliable services, creating comfort for patients while treatments are primary things to be maintained by operational management (OM) team in healthcare and hospitals.

This sector is dynamic and constantly changes. Hence the person working in operational management (OM) team need to constantly update himself/herself with the new change to adopt the style of work and enhance skills required to manage the work. Presently technology plays huge role in the healthcare sector .Data analysis, smart applications, IOT based applications, useful software, big data drives, smart purchase platforms, smart maintenance planners, fast patients discharge systems, smart inventory solutions, smart Operation theatres , OPD, IPD solutions, smart bed information displays, smart security solutions, smart parking assistance solutions, smart HVAC solutions, smart engineering solutions are very much essential in hospitals to make it smart hospital. Health care sector should be prepared for emergencies. It should have plans for mass causalities or pandemics such as COVID-19. In such pandemic situations sudden conversions of different wards to ICU wards beds, normal treatment areas to critical treatment areas, arranging all essential material PPE kits for the staff, arranging medical equipments is huge task.

Hence smart pre planning of such situations can help the hospitals to tackle with such pandemics easily and with greater confidence. In healthcare sector operational management (OM) comes under sudden load of challenges in such pandemic situations like COVID-19. Arranging funds, medical non medical staff, availability of medical equipments, material, patient beds, medicines, building temporary arrangements in vacant spaces for patient treatments, taking support from government for rules and regulations becomes essential task for operational management (OM) team in hospitals. Hospital mainly with more than 500 beds can be considered as large hospital which requires Board of directors, Medical director with a team of Administrator, Public relation officer and Managers of all different departments and skilled full medical as well as non medical staff and smart options of technical solutions to ease their work.

2. Literature review

Lei Yu & Yang Lu (2012) discussed part of technosavvy hospital supported Internet of Things (IOT) so as to beat the bad effects of this data system . The key technologies and construction approaches of smart hospital are presented. Also, understanding of the concept of smart hospital is explained [1].

Sebastian MP (2019) clarify about new techniques that are mostly in applied for the in conversation of old practice aid to needy centric care. Expectedly, the old practiced aid cannot entirely get replaced by local

domestic health systems, rather asking them to become smart. The longer term smart hospitals are expected to possess Artificial intelligence (AI) tools for performing the patient diagnosis and robots for performing surgeries. The physician will have the managing key role which might be performed through a touch screen. This paper explores the challenges and opportunities related to smart hospitals, and the way they contribute to the target of best aid support for everybody [2].

Haluk Demirkan (2013) proposes a Smart Healthcare System framework for conceptualizing information driven, portable and cloud-empowered savvy human services frameworks. With the selection of savvy medicinal services frame works, human services associations can give financially savvy quality social insurance, administrations with less IT set-up costs and decreased dangers [3].

Vikas, Neils, Ulrica & Johan (2017) give details of four key zones of center inside the emergency clinics, the board and activities that ought to be understood by all clinics then building up their own Savvy building Agenda of understanding sevas and hmi, care procedures and arrangement, coordination and backend services association and Capability structure .

In building up their aim of a Smart Hospital over these four spaces, medical clinics need to recognize the effect on their Med Tech Infrastructure, Facility Design, IT Infrastructure and Operations and the in general data Management approach. [4].

In white paper by Alcatel lucent (2019) it is stated that there is no compelling reason to hang tight for a structure blast to coordinate developing innovations into emergency clinic tasks. Various computerized arrangements could be actualized now or in the close future to improve operational efficiencies and clinical results. Medical clinics could execute remote patient checking, tele health, progressed investigation, and wearable's to all to completely connect with patients for improved quality and results [5].

According to Oksana Ilyashenko, Igor Ilin, and Dmitry Kurapeev (2018) at present, the human services as one of the need improvement zones for the state requires unique consideration of the inventive administration models dependent on the utilization of cutting edge clinical ideas and computerized innovations. Consequently, the change to the Smart clinic model and the arrangement of a proper design arrangement becomes genuine for wellbeing associations in which key errand is the change to the advanced space and reinforcing their situations in the clinical administrations showcase. Before beginning the advancement of the Smart

Medical clinic, compositional model is applied to the particular wellbeing association,

It is prudent to utilize a study model that will consider the essential revenue and IT prerequisites of, as far as possible and utilized advancements. The making of the reference SmartHospital compositional arrangement is gone before by a preliminary stage that permits uncovering the design and cutoff prerequisites. The article proposes the motivating force expansion based on which the prerequisites and cutoff points are defined for the study model of the Smart clinic structural arrangement [6].

According to Naveen Ananda Kumar J, Shivanisuresh (2019) there has been a fast move in the clinical business from the administration perspective. More significance is being given to tolerant consideration and consumer loyalty than at any other time previously. The need to keep the clients content with the emergency clinic's administration has expanded to handle patient's encounter, considerably more is on the off chance that they incorporate cloud, IOT, ML, and AI into their framework. This would help the clinical segment to accomplish customization which would empower them to address the requirements of their clients all the more productively what's more, offering customized arrangements. In this paper, authors are proposing a novel model which centers around a keen emergency clinic data, the executives framework that runs by utilizing half breed cloud, IoT, ML, and AI. Its will assist just from the medical clinics point of view yet additionally from the patient's

side also. People to be treated and specialists encourage the whole procedure much increasingly proficient and simpler. The advances occurring in the field of AI and ML because of cloud-based figuring are incredibly valuable for the clinical business. By coordinating these segments alongside IoT it is conceivable for multi-forte emergency clinics and super strength medical clinic to be ready to set up a keen emergency clinic data the board framework [7].

In one more observation by Lakhua Mohamed Najeh (2019) there has been a fast move in the clinical business from the administration perspective. More significance is being given to tolerant consideration and consumer loyalty than at any other time previously. The need to keep the clients content with the emergency clinic's administration has expanded quickly and can upgrade a patient's encounter, considerably more is on the off chance that they incorporate artificial intelligence into their framework. This would help the clinical segment to accomplish as per requirement which would empower them to address the requirements of their clients all the more productively what's more, offering customized

arrangements. In this paper, authors are suggesting new model which centers around a keen emergency clinic data and the executives framework that runs by utilizing half breed multiple advance tools. This framework would be useful not just from the medical clinics point of view yet additionally from the patient's side also. Patients and specialists interesting ID would make the whole procedure much increasingly proficient and simpler. The advances occurring in the field of AI and ML because of cloud-based .figuring is incredibly valuable for the clinical business. By coordinating these segments alongside IoT it is conceivable for multi-forte emergency clinics and super strength medical clinic to be ready to set up a keen emergency clinic data the board framework [8].

Haibin Zhang (2018) confirm that there has been a fast move in the clinical business from the administration perspective. More significance is being given to tolerant consideration and consumer loyalty than at any other time previously. The need to keep the clients content with the emergency clinic's administration has expanded quickly and considerably more in advance machine learning.

What's more, offering customized arrangements. In this paper, authors are explaining centers around a keen emergency clinic data and the executive framework . This framework would be useful not just from the medical clinics point of view yet additionally from the patient's side also. Patients and specialists interesting ID would make the whole procedure much increasingly proficient and simpler. The advances occurring in the field of Advance tools, because of web -based figuring is incredibly valuable for the clinical business. By coordinating these segments alongside . AIOT it is conceivable for new emergency clinics and super strength medical clinic to be ready to set up a keen emergency clinic data the board framework [9].

Zenon,Venkateshprasad (2010) state that a noteworthy bit of the Hospital Information Frameworks at present comprises of different individual heritage applications that must be coordinated, to convey a more bound together arrangement. The exhibition, unwavering quality and different elements of these applications can modify the exhibition, unwavering quality and different qualities of coordinated discussion , the Smart care places the executives System (SHS). The SHS being a foundation part depends vigorously on the genuine assets made accessible to it for its legitimate working, activity and upkeep [10].

3. Research Methodology

The research done in this study is based on descriptive research. This study describes issues of health care population in resurgence corona pandemic situation, and application of operation management phenomenon. It focuses on answering the how to tackle covid situation with smart engineering solutions, what could be the consequences of this application, when and where smart solution can be implemented.

This study is based on data collected from various research papers and by conducting oral interviews and discussions with experts and facility engineers working in hospitals. Data is classified and prepared for making further inquiries. This research study is most prominently done to exploit smart engineering solutions for operations management in hospitals and to understand whether it is possible to efficiently manage and run hospital in smart city.

4. Analysis

Various departments in Hospitals for Smart engineering solutions

Mainly talking about large hospitals 500 bed and more requires perfect set up to run its system smoothly and steadily to serve patients with highest quality medical treatments. Different smart engineering solutions can be adopted to save time energy and man power. In non medical departments Engineering department, IT department, Biomedical department, Computer department, Purchase department, Account department, HR department, Housekeeping, Billing department, Public relation department, security department, Kitchen and canteen department, Linen department are present. In medical departments Operation theatre department, OPD, IPD, ICU, Pharmacy, Causality, Pathology, Radiology, Rehabilitation department exist. (Figure 1)

In all these mentioned departments various smart engineering tools and solutions can be used to make them more efficient for operations management. These solutions can encourage staff to use technology and save their energy to do more conclusive and fruitful work. India consists of worlds one of the largest population after China. Due to aging, life style diseases, habitual issues, genetically diseases, accidents, pregnancy for various treatments for daily checkups, health consciousness, medical tourism, availability of insurances of health, people approaches hospitals easily so that it has become now trend to keep the hospitals up to date and

attractive, aesthetically perfect and create convenient environment for patients and their accompanied relatives.

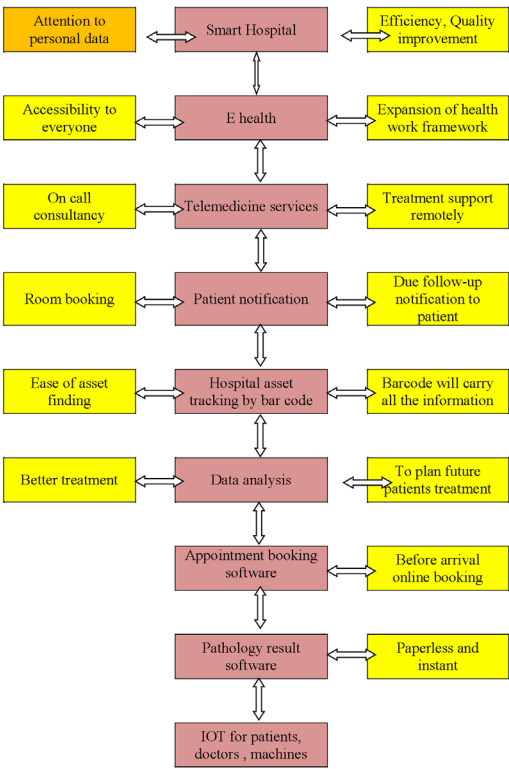


Figure 1
Smart Hospital Concept

5. Results

Smart Engineering solutions for smart hospital block diagram

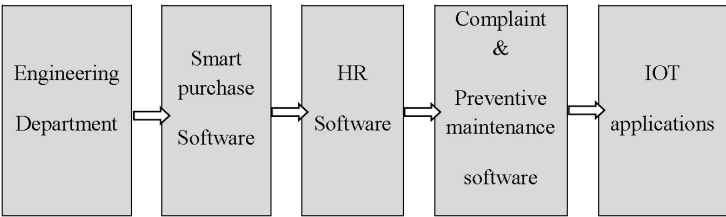


Figure 2
Block diagram of Smart Engineering solutions for smart hospital

Following departments are present: Engineering: Manages all electrical, plumbing, HVAC, Carpentry related maintenance and Projects. Smart purchase software : In this software paperless process for purchase of any part, equipment is possible. HR software: Attendance related to activities can be tracked and monitored by employees by use of fingertips or desktop. Complaint and PM software: Using QR, bar code pasted on machines PM checklist can be scanned and online complaint can be posted related any machine. IOT applications: Real time monitoring is possible using this application for machines. (Figure 2)

Engineering Department

This department is an essential department in hospitals as all the major operations management of facility maintenance, electrical supply, electrical equipments and machines, medical gas pipe line systems, fire fighting system , new constructions and projects, renovation of buildings, HVAC ,water supply, furniture etc comes under engineering department of hospital. All above mentioned sub departments requires continuous monitoring hence smart tools like building management system can be very useful in such instance. Building management system (BMS) tool has features of user friendly software that provides a well programmed platform which is connected to all the essential equipments. BMS fetch signals from those equipments to the cloud based server, stores the data. BMS further let user access the real time monitoring of major equipments remotely to keep watch on change second by second to effectively maintain system healthy and increase system reliability.

Maintenance software can be used for preventive maintenance of different listed machines which comes under engineering department. Barcodes can be stick to various machines such as elevators ,escalators, electrical machines,fans,AC units etc., so that the maintenance technicians can scan that barcode easily to stored checklist inside barcode from provided mobile phone to do the maintenance as per planned. Hence preventive maintenance of machines can be done as per planning without any malpractice and data can be accessed and store any time. With this software breakdown maintenance can be attended and the details related that breakdown can be filled inside that software.

Captive generation is best way to feed electricity demand of hospitals. Sometimes grid connected electrical supply can fail and during that time of resuming electrical supply, some operation can get stuck in between .Life saving machineries can show problems due to interruption in

electrical supply. Hence ,hospitals anyhow requires uninterrupted power supply ,and so perfect model can be followed. Gas engines generating electricity can be installed in side campus of hospital considering demand and load .These engines can have backup and standby engine with another backup of diesel generators so that during breakdown of gas engines, diesel engine can cater the load for some time. Such perfect solution can be used to keep demand of uninterrupted electrical power supply of hospital.

HVAC- Air handling units can be installed with smart temperature sensors which can be connected to BMS system and can be controlled remotely and programmed for start and stop time as per requirement to save electricity and wastage of energy. Exhaust heat of gas engines installed inside hospital can be utilized by using that heat and vapors to heat the water required for relatives and patients washroom bath purpose. Further, waste vapors and moisture from gas engines can be treated and cooled up to low temperature for cooling water required for air conditioning purpose. Such waste heat recovery methods can save tremendous amount of energy, cost, time and resources to do energy conservation.

Purchase department Software

As being located in hospital it is very much obvious that many parts, material, medical tools,beds etc. would be required constantly in considerable amount. Many departments can send request of purchase and it would become tedious task to segregate it and supply it in required time. Hence, central online purchase software which can be accessed from desktop and mobile phones with individual login id password can be useful to fulfill requirement of various departments. Particular items can be classified as per their specifications and suppliers can be registered with their details. Items can be given unique item number so that by searching and putting that number required item can indented. Further, purchase order with perfect indent quantity can be sent to registered vendor without any confusion.

HR and personnel Department Software

All the staff working in huge hospitals need to get paid every month according to their presence and absence in workplace.For this, HR department can effectively use software integrated to biometric attendance sensor, fixed at every floor, so that staff of particular floor can punch their attendance conveniently and HR and personnel department can fetch that data using software to do the calculations after each month's completion.

Further, staff of hospital also can access that attendance software through their login to apply for leaves and monitor his / her attendance regularly. This approval can be done by that staff's superior using his/her login so such efficient system can save time, energy of manual attendance and leave forms system.

6. Implementation of Smart engineering solutions with design

PMS (Preventive maintenance software)

Following figure clearly shows section head and technician i.e. superior and junior staff respectively can see their preventive maintenance app in their gadget (smart phone, tab). In smart hospitals, assets will be having asset code in the form of barcode or QR code those can be scanned in the PMS (Preventive maintenance software). Further, checklist will get opened and concern technician can go through it, moreover these technician will do the preventive maintenance of that assets (machine, equipment, patients room etc.). After this the technician will send it for approval to his superior, that is section head. If maintenance is done properly then section head will approve it and it will get completed. In this process time, energy, paper work gets saved. Paper less technology like this can be adopted in smart hospitals. (Figure 3)

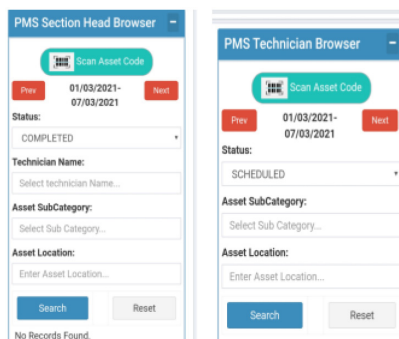


Figure 3
Preventive maintenance software design for smart hospital's assets maintenance

IOT based monitoring of engineering equipment

Following areas can be critical and need to be consider in IoT based monitoring: Elevators, Cryogenic Oxygen tanks, Electricity generators,

Critical equipments. Advantages are as follows: Using IoT Monitoring of elevators 24/7 gives all the details of floor level, overweight, common faults etc. IoT based technology can give real time level and pressure data to oxygen suppliers to plan their tanker for supply of oxygen.

Future scope

IoT is future of nation's progress. It is a very important tool to get the real time data quickly and accurately to get the knowledge of actual site situation by sitting at remote area. IoT based application will be more helpful in hospital industry to make more smart hospitals to drive smart cities. A study of smart hospital in India using operations management for patient/customer can also be done. Further, effect of implementation of smart engineering solutions on cost to customer can be studied.

Limitation of study

The application of smart engineering solutions with operations management are not directly focusing on patients/customers & their relatives and people who are not acquainted with IT. Further network based system like smart hospital solutions with operations management can collapse without network support.

Discussions

Cities drive Nations and Smart cities power Nations. Smart cities are most integral part of any nation's progress and its development. Hospitals and healthcare sector is considered as tremendously growing sector among the all other fields in the globe for private as well as public players. Covid -19 pandemic has significantly impacted hospital sector. Coordination of overall activities necessitates improved management. Thus, it is important to have a technical support for any field in the globe to make it more efficiently work in this era of globalization.

Conclusion

Smart Engineering solutions in itself is a self explanatory term which is a need of the service industry. Health sector is one of the patient service industry and to be more efficient, quick and precise towards patient care one could not skip the Engineering teams contributions to the health sector. This paper focused on the smart Engineering solutions for the

hospitals who are tackling with global pandemic and such situations where their available infrastructure and back end is challenged. Smart hospitals are need of situation in tackling pandemic situation like covid-19. In this present tough time, to tackle with patient inflow and service them, smart engineering solutions can be comparably more handy than traditional practices. Covid-19 pandemic has poured more pressure on hospital sector and to keep balance of this, need of hour is smart actions. Smart hospital concept need to be implemented in smart cities, inevitably reducing excess burden on staff and hospital administration. Advantages of feasible smart engineering solutions in hospitals to tackle with pandemic situation in smart cities are occurrence of less human errors using automation, saving in energy-time-manpower, improves grading of hospital at global level etc. Giving highest quality, reliable and cost effective services to patients is most vital aspect in healthcare operations management. A hypothesis of study is accepted. As a result, application of different methods of smart technical majors in daily routine of hospitals in different departments can help to improve performance of hospital and treatment quality towards patients for their better lives. This Study is unique in the manner that the proposed concept is not available readily in the hospital sector and attempt to implement this study is possible.

References

- [1] Lei Yu, "Smart Hospital based on Internet of Things", *Journal of Networks*, Vol. 7, No. 10 (October 2012).
- [2] Sebastian MP, "Smart Hospitals: Challenges and Opportunities, *Working Paper IIMK/WPS/315/ITS/2019/02*
- [3] H. Demirkan, "A Smart Healthcare Systems Framework," in *IT Professional*, vol. 15, no. 5, pp. 38-45, Sept.-Oct. (2013), doi: 10.1109/MITP.2013.35.
- [4] Little Arthur D, "Building the Smart Hospital Agenda: A comprehensive approach for Hospitals executives to develop their Smart Hospital Strategy and Implementation program", January (2017). https://www.adlittle.com/sites/default/files/viewpoints/ADL_Smart%20Hospital.pdf.
- [5] <https://www.al-enterprise.com/-/media/assets/internet/documents/hospital-of-the-future-white-paper-en.pdf>/ February 2019.

- [6] OksanaIlyashenk, Igor Ili, and Dmitry Kurapeev, "Smart Hospital concept and its implementation capabilities based on the incentive extension", SHS Web of Conferences 44, 00040 (2018), IV International Scientific Conference "The Convergence of Digital and Physical Worlds: Technological, Economic and Social Challenges" (CC-TESC2018),<https://doi.org/10.1051/shsconf/20184400040>.
- [7] J. NaveenAnanda Kumar and S. Suresh, "A Proposal of smart hospital management using hybrid Cloud, IoT, ML, and AI," 2019 International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, pp. 1082-1085 (2019), doi: 10.1109/ICCES45898.2019.9002098.
- [8] Najeh LM. Study and Analysis of Sensors in a Smart Hospital System. *Int J Sens.*; 1(1): 1001 (2019).
- [9] H. Zhang, J. Li, B. Wen, Y. Xun and J. Liu, "Connecting Intelligent Things in Smart Hospitals Using NB-IoT," in *IEEE Internet of Things Journal*, vol. 5, no. 3, pp. 1550-1560, June (2018), doi: 10.1109/JIOT.2018.2792423.
- [10] Z. Chaczko, C. Chiu, Avtar Singh Kohli and V. Mahadevan, "Smart Hospital Management System: An integration of enterprise level solutions utilising open group architecture framework (TOGAF)," 2010 3rd International Conference on Computer Science and Information Technology, Chengdu, China, pp. 8-15 (2010), doi: 10.1109/ICC-SIT.2010.5564121.