Healthcare Delivery Framework for Urgent Care at Home

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Abstract

Minimizing crowd volumes at Emergency Departments (ED) of healthcare delivery systems is of paramount importance to healthcare providers. One of the most promising option for doing so is the designing of at-home healthcare delivery system and its successful implementation to avoid the visits to the ED by patients with non-critical ailments. In this research, various concepts of providing healthcare services in out of hospital environments have been studied and their merits have been identified and studied. By integrating these approaches with recent technological advancements, an improved design of the urgent care at home delivery system is proposed in providing better services to patients. This study takes into consideration various pilot projects on delivering healthcare at patient's home, and identifies opportunities and approaches to improve this system. The study works as a guideline in developing strategies for implementing continuous improvement philosophy in system design, in techno-economic analysis of decision regarding outsourcing vs. self-implementation of system's components, in performing feasibility studies of integrating technological tools and implementing enterprise resource planning environment in healthcare delivery system. The study also provides approaches for integration of Information Technology tools for better system performance.

Keywords
Urgent care at home, Healthcare delivery, Integrated healthcare, Emergency department.

1. Problem Definition

According to National Health Expenditure Reports (2014), in the year of 2014, the total cost of healthcare cost in the United States was $3.0 trillion 17.5 % of its GDP. One of the most crucial contributor to this colossal cost of healthcare is the cost incurred at Emergency Departments (ED) at healthcare provider facility throughout the country. Overcrowding at ED is considered as a crisis and it results in patient dissatisfaction and sub-optimal service. According to National Hospital Ambulatory Medical Care Survey (2011), in 2009, there were 136 million visits to the ED, and the proportion of non-critical visits varied from 4.8% to 90% with a median of 32% as per Durand *et al* (2011). Patients visiting the ED with non-critical or non-urgent ailments can be treated outside of ED with lower cost of treatment and it will lower burden on limited resources of ED. Patients with non-urgent ailments continues to be the most important contributor to the congestions at the ED, which results in longer waiting time for patients to get treatment, poor utilization of resources at ED. The study done by Pitt *at el* (2010) suggests that only 4% of all doctors nationwide that are staffed at the EDs provide services to 28% of all the patients with acute ailments.

Introduction of the Affordable Care Act (ACA) have posed the healthcare providers in the United States with new challenge, which is a sharp rise in demand for healthcare services for the last few years and this trend is still in effect. Besides, some states, like Massachusetts, have their own healthcare systems which guarantees a minimum level of healthcare for those unable to afford private insurance. Also, under the healthcare safety net, ED must provide healthcare services to anyone either insured or uninsured. Healthcare providers are striving to come up with better ways to serve these large number of patient needs with limited resources efficiently.

One of the challenges that healthcare providers face is how the efficiency of the Emergency Department can be improved, as opined by Darlet and Richards (2000). EDs play a crucial role in determining how an incoming patient will be serviced, e.g. instant treatment, sent to inpatient care, prescribed for tests or medicine, sent to another provider etc. A large number of ED visits are avoidable, since the treatment of such ailments do not require the expertise of a trained physician or nurse. Presence or visits of such patients with non-urgent (acute non-critical and chronic) conditions result in longer waiting times and inefficient use of medical professionals' time. These patients can be provided with medical services by trained paramedics outside of ED and thereby enable utilizing of ED resources only for critical ailments. The research problem is to improve the performance of such a care delivery system by implementing methodologies and tools of Industrial Engineering and Information Technology.

In this research, a framework for integrated healthcare system is developed for providing safe and quality urgent care at patients' homes to reduce ED visits of non-critical patients. The concepts and merits of related delivery systems, e.g. Emergency Medical Services (EMS), Mobile Integrated Healthcare (MIH), and Community-Paramedicine (CP) are studied in detail, and approaches for implementation of various Industrial Engineering tools to design an effective and efficient system are discussed. The goal is to provide guidelines for designing the care delivery system as a closed loop system with provisions for continuous quality measurements, error proofing, and performance improvement properties. Few of the measurable outcomes of this study are:

1. Increased patient satisfaction by reducing waiting times experienced by patients (both at ED and at home).
2. Optimal allocation of healthcare provider's resources by reducing ED congestion.
3. Long term cost savings by establishing a system for continuous improvement.
4. Creating a benchmark for healthcare delivery at home service.

Several small scale projects aiming at providing urgent care delivery at home have reported savings in healthcare cost per beneficiary. This is a promising solution to the ED crowding problem, and this study provides a framework for establishing such services integrated into the whole healthcare delivery system. In the following subsection a brief overview of the concepts of EMS, MIH, and CP are given.

1.1 Emergency Medical Services (EMS)

Traditionally EMS is regarded as the service for providing on-spot treatment and transporting patients to a healthcare provider's ED in the event of a distress call from people with probable life threatening situation. EMS are staffed by Emergency Medical Technicians (EMT), with varying levels of expertise, e.g. basic, intermediate, and advanced. Paramedics with more advanced training are also employed by EMS. There are established structure for acquiring certification for different levels of EMT.

According to the whitepaper 'Innovation Opportunities for Emergency Medical Services (2013)', 15.8% of all the patient visits to EDs in 2009 were facilitated by EMS. Upon responding to a 911 call from patients, EMS team responds and during hand-off of patients to the healthcare facilities, the communication between EMS team and the receiving person at ED must include pre-hospital data according to Powers (2015):

1. Patient demographics.
2. Primary ailment.
3. Treatment modalities and response.
4. Emergency contact person.
5. EMS follow-up contact number.

The categories above provide a background for the minimum information needed to be communicated and shared between ED and the mobile unit out for healthcare delivery. Another important aspect of EMS, which is of great importance to this study, is the standard system of performance measurement used in EMS delivery system. The EMS Performance Measure Project began in 2002 and concluded in 2007, which provided with specifically defined measures for system and service performance. The project report by U.S. Department of Transportation (2009) proposed 35 consensus based measures for such evaluations categorized in the following 7 categories:

1. System design and structure.
2. Human resources (culture, training, safety, credentialing).
3. Clinical care and outcome.
4. Responses.
5. Funding.
6. Quality management.
7. Community demographics.

This is a well-documented performance measuring system, which can be modified and improved to fit the urgent care at home delivery system, and used for the evaluations of the system efficiency and service quality. As new technology becomes available and new concepts are implemented, there is always opportunity for adding new performance measuring metric and for updating existing ones.

1.2 Mobile Integrated Health (MIH)

MIH is considered as patient centered, round-the-clock services designed to provide care services to a range of patients, with mobile resources in an out of hospital environment. The needs-based services include at home integrated acute care, chronic care and prevention services, as opined by Beck *et al.* (2013). MIH provides the integration service in a local setting by forming partnership with patients, payers, healthcare providers, EMS systems etc. and coordinate the delivery of healthcare service tailored to patient's needs. Taking advantage of technological advancement, MIH system uses procedures like electronic health records and health information exchange, telemedicine, real-time call processing and mobile care services, and thus can provide patients with access to a coordinated care service as per their needs.

MIH, in effect is an integrated system that provides decisions on how to allocate medical resources to meet patients' needs so that the decision is optimal for all the stakeholders of the healthcare system. The primary building block of According to Kize *et al.*(2013), MIH is the intelligent use of information contained in data collected from diverse sources. Data sources include electronic health record, census and public health data, community resource data, EMS dispatch data, healthcare resource utilization data, insurance claims data, and financial and cost data.

Data from disparate sources are sorted, processed and analyzed using data analytics tools to generate actionable information based on which decisions are made. The methodology of MIH can be utilized to make optimal decisions regarding healthcare delivery services by taking a system wide approach and by taking the advantages of technological advancement in mobile data collection and management information system.

1.3 Community Paramedicine (CP)

CP is a relatively new and evolving model for providing community based healthcare services by paramedic units; CP model facilitates more appropriate use of emergency healthcare resources and for medically underserved population; it helps in providing more enhanced access to primary healthcare services. Six potential CP services have been outlined in two categories by Kize *et al.* (2013):

1. Pre-hospital services:
    a. Transport patient with non-urgent condition to non-emergency department locations.
    b. Determine whether patient needs to be transported to ED after primary treatment.
    c. Provide preventive primary care and social services to frequent 911 callers.
2. Post-hospital or community health services:
    a. Provide follow up care for patients recently discharged from hospital to reduce the probability of readmission.
    b. Provide support to patients with chronic conditions.
    c. Provide preventive care in partnership with primary care providers.

The CP model for providing healthcare services to patients with non-urgent ailments outside of ED is promising. Under the supervision of a physician, EMT and paramedics can provide primary care along with their traditional emergency response service. Until now, the CP program is still in pilot project phase, and its fit with EMS system is still unclear. The concepts and approaches of CP, along with those of EMS and MIH can be combined to develop an efficient urgent care delivery at home system integrated with the primary healthcare provider. The system includes:

1. Customer Satisfaction Promises (CSP) of the delivery system.
2. Performance measurement metrics of the care delivery system.
3. Optimal mobile service units.
4. Data driven models for optimal decision making.
5. Feedback collection and handling systems.
6. Information technology to integrate different sub-systems.

Healthcare information technology is a great tool for ensuring that various entities of the healthcare system is working efficiently to provide service to the patients optimally. The Health Information Technology for Economic and Clinical Health (HITECH) act, which came into life in 2009 is instrumental in accelerating the use of IT in healthcare sector. In an integrated healthcare system, adoption of IT not only make it possible to real-time transmission of information between segments of the system, it also enables the provider to make better decision in to better accommodate patient needs based on quantitative and qualitative data. Patients' feedback handling system and care delivery performance measuring systems are greatly benefitted by the adoption of IT in healthcare.

2. Healthcare Delivery Framework

In the background of every healthcare delivery service event, several sub-systems must be working continuously so that the provider can make the optimal decisions regarding the service to the patient. These can be categorized in four broad classes:

1. Data management system
2. Decision support system
3. Service delivery system
4. Feedback handling system.

Figure 1 shows the framework for urgent care at home delivery system. Healthcare provider gathers data concerning patients, and services before, during, after the services are provided. The system is a closed loop one, where the feedback from the patients (survey, complaints), and performance evaluations of the system are continuously fed back into the system to improve performance of various elements of the system. in the following subsections, mechanisms of these systems are briefly discussed.

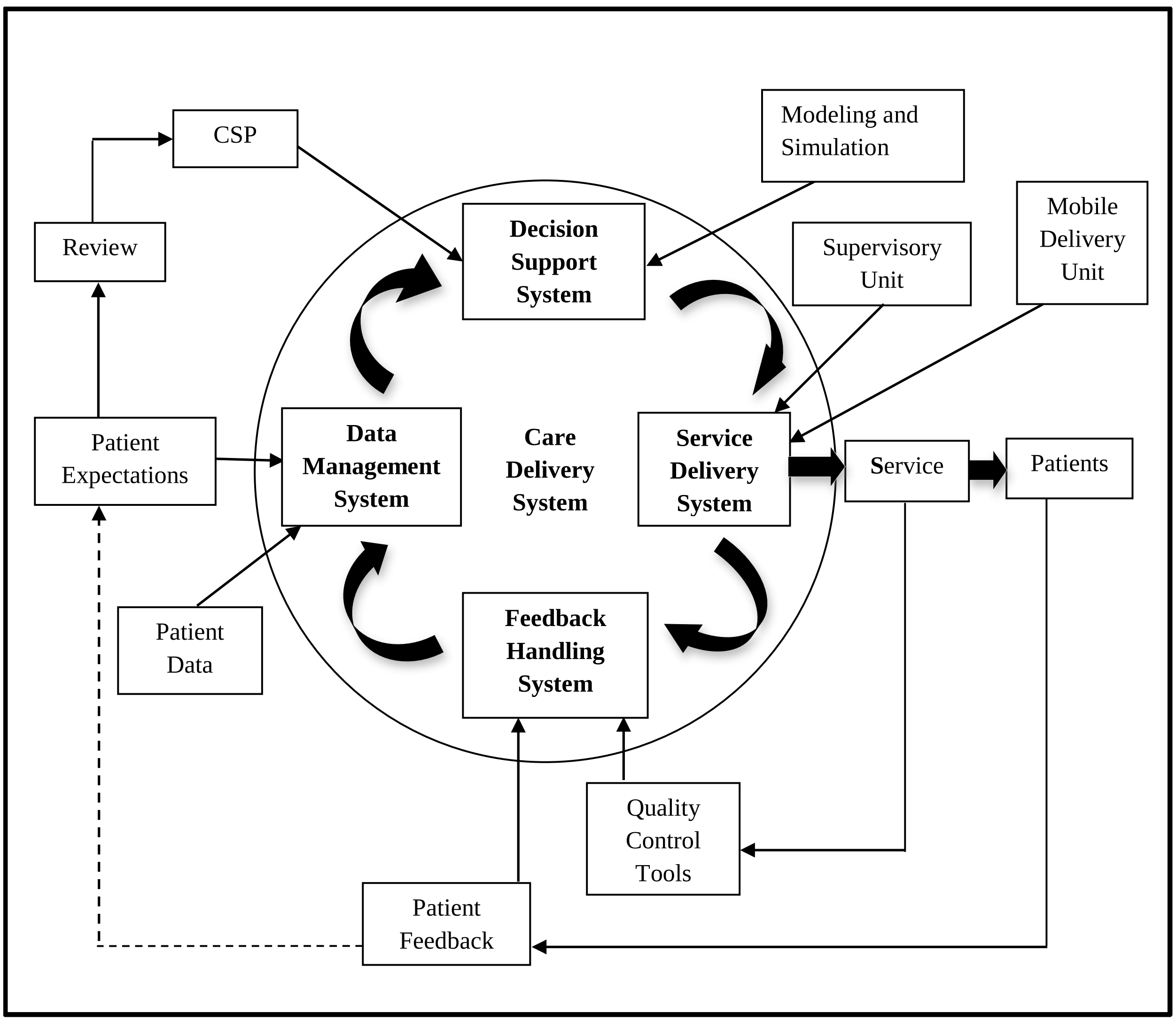

Figure 1. Urgent care at home delivery framework.

2.1 Data Management System

In healthcare service environment, well managed data collected from diverse sources about patients, and correct interpretation of this data leads to safe and effective treatment, good communication between patient and the provider, and quality of healthcare. The HITECH Act mandates that all providers must adopt the Electronic Health

Record (EHR) system and follow the Health Information Exchange (HIE) protocol for sending to or receiving patient data from other healthcare providers. This culture of IT adoption along with the advancement in intelligent devices (smart phones, wearable monitoring devices, etc.) and wireless technology have enabled healthcare providers the capability to continuously collect health data from patients upon their approval.

A central, digitally organized and updated database management system needs to be maintained for ensuring safe and quality healthcare services to the patients. Following are some of the categories of data that need to be collected:

1. Complete medical history of eligible patients, i.e. EHR.
2. Data about health insurance provider, details about included coverages.
3. Location of the patients.
4. Feasibility of installing health monitoring devices
5. Other information, e.g. language barriers, home conditions, emergency contacts, etc.

For some of the information categories new questionnaires are needed. For example, questions about technological knowledge or if one would like to opt for a health monitoring device are not available in general medical records. A well-designed and comprehensive questionnaire can provide very useful and service specific information for tailoring services according to patients' needs.

2.2 Decision Support System

This subsystem utilizes the information generated from data and considered as input for making operational decisions about the system to deliver urgent care to patients' home in an optimal way. Similar to the previous subsystem, it is dynamic in nature and always updating with new information to modify decisions without compromising service level and at minimum cost to the provider. We briefly discuss the components and tools of this subsystem below.

2.2.1 Customer Satisfaction Promise (CSP) Design

When visiting a healthcare provider's facility or in case visited at home by a mobile care unit, a patient holds some expectations that the healthcare provider will deliver promises that the system guarantees; these promises can be mentioned either explicitly or implicitly. A healthcare provider must prepare a complete list of promises or guarantees, clear explanations of the promises, measures for checking if the promises are being kept, and the actions taken in cases of failure to deliver. To make the healthcare services more customer-centered, in the decision support system, customer expectations are converted into formal CSP. In this aspect, the ISO guidelines for organization's code of conduct to attain customer satisfaction can be a good starting point. Khan and Karapetrovic (2015a, 2015b) developed a framework for establishing a Customer Satisfaction Promise (CSP) for an inpatient care system based on ISO 10001: 2007. This approach can be used to develop CSPs for urgent care at home delivery system.

An important tool for translating patients' expressed or implicit expectations into tangible deliverables is Quality Function Deployment (QFD). It helps turning the vague Voice of Customers (VOC) into measurable operational definitions and requirements. It also prioritizes various elements of the service to be performed. Under the QFD umbrella, House of Quality (HOQ) is a useful tool to prioritize patients' needs and provider's attention and to better coordination between these two.

Once the patients eligible for urgent care at home delivery are identified and all relevant data are collected, expectations of these patients (and their family members) need to be collected formally. These expectations need to be periodically updated to stay relevant in the face of competition and technological advancements. For a system of urgent care at home, patients' expectations include but not limited to:

1. Safe service, i.e. correct diagnose of health problems and correct treatments
2. Timely service
3. All procedures are well communicated and explained to the patients
4. Following up on treatment, corrective actions are taken if required.

Combining information from all of the above sources, CSP are developed for the urgent care at home delivery. Each CSP element are explained in detail regarding:

1. What are the deliverables for each promise?
2. What actions will be taken for each deliverables?
3. Who are the person responsible to carry out an action?
4. What are the measures for ensuring promises are kept?

5. What are the feedback procedure?
6. What corrective actions will be taken in case of negative feedback?

Based on the developed CSP and the patient data, different decision making modules are utilized make optimal decisions regarding urgent care at home delivery for maximizing patient satisfaction.

2.2.2 Modeling and Simulation

To efficiently allocate paramedics group to the patients' destination with minimal waiting time, optimum number of paramedics team needs to be set up. Also a presence of a dispatcher or preferably an automated and dynamic vehicle routing system must be in place. To identify optimum decisions, data driven mathematical models need to be developed that describe the system's behavior in the presence of various constraints and variables; by solving these models, optimum decisions that maximize the patient satisfaction within the constraints. Several methods will be applied in formulating such models.

2.2.2.1 Queuing Modeling

This analysis tool can be used for better delivery system design to reduce waiting times of patients in the presence of resource limitation. Queuing models are based on three important variables, e.g. arrival rate of patient request, service time, and number of servers. From historical data, average arrival rates of various categories of service requests and the corresponding service rates can be determined. In order to provide services that meet patient satisfaction, there has to be a trade-off to between costs and benefits. Through analyzing the service costs against the benefits of reduced waiting times, queueing models can help in identifying optimum number of paramedic teams and their placements..

2.2.2.2 Stochastic and Dynamic Programming

From historical data, probability distributions can be approximated for locations of demand realizations, demand volumes, service times, waiting times etc. From these distributions, different sets of feasible scenarios can be determined that can represent the uncertainty of the system behavior. Stochastic mathematical models can be formulated that can take into account every possible scenario and by solving these models robust decision sets can be identified that can keep the system's total cost at the minimum while maintaining desired service levels. As the system get larger with larger number of patients and resources, simultaneous and real time decision making becomes a norm. With the advancement in real time location updating tools, e.g. GPS, GIS etc., dynamic version of the stochastic models can be formulated to automate the process of dynamic resource routing and allocation. The study done by *Zhi et al.* (2015) is a good example of using dynamic programming for EMS location planning. By solving the dynamic mathematical models, optimal location and allocation decisions of EMS mobile units and optimal personnel schedules can be determined which would be of great importance in maintaining service levels at minimum costs.

2.2.2.3 Knapsack Programming

To serve the patients with diverse category of urgent care requirements with the same mobile delivery unit, optimum design of the unit is necessary. In forming such a unit, knapsack programming approach can be used that aims to maximize the value of such unit while satisfying the budgetary, personnel and dimensional constraints. A mobile delivery unit designed through such an approach can cover maximum number of patients with diverse requirements. If the service spectrum is broad enough, there may be diverse kinds of mobile units each with different capability. Following data are needed to design mobile delivery units:

1. Services that will be offered
2. Required number of personnel
3. Required personnel expertise
4. Required tools and appliances to perform the services
5. Devices for connecting to the central information system.

2.3. Service Delivery System

Service delivery system is consisted of two broad categories of servers, one is the on-the-field mobile delivery unit or the team of EMTs or paramedics, and the other is the supervising team of physician (s) and nurse (s). Once a patient request for healthcare delivery service is received by the dispatcher or the call-in center, the dispatcher assigns mobile delivery team and supervising team for the patient's service. The selection and allocation decision are taken by decision support system based on patient and resource availability data. The mobile delivery unit with appropriate capabilities travels to the patient's home and provide the treatment. In the event of any complication, mobile unit contacts the supervisory unit of expert physician and nurse through teleconferencing. In Figure 2, the service delivery system's responses upon receiving a service request from a patient are shown.

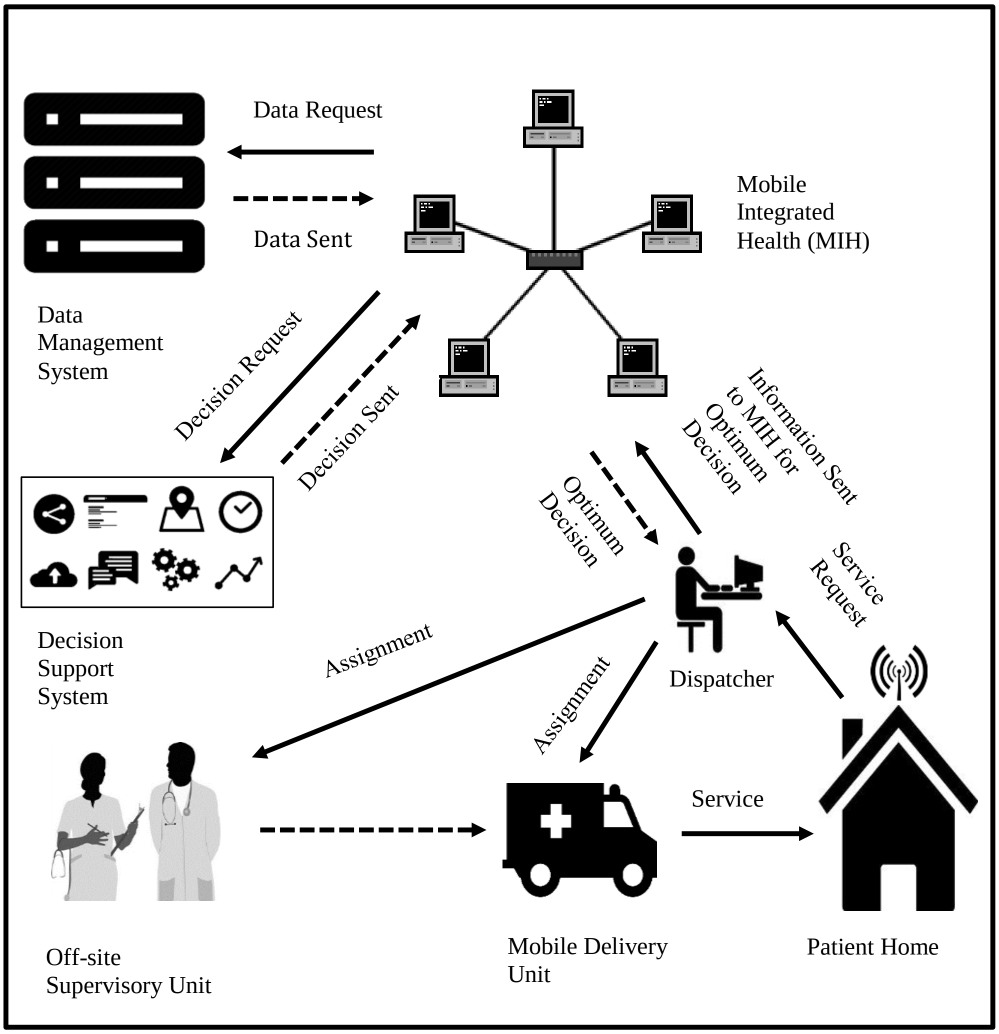

Figure 2. Urgent care at home service delivery system.

2.3.1 Mobile Delivery Unit

This unit is made up of EMTs with different levels of expertise, and paramedics. The number of such units and each unit's combination of expertise and other medical resources are determined by the decision support system based on target patients, frequency of request from patients, availability of resources, cost effectiveness, etc. Detailed work flow chart are in place for care delivery process taking in consideration all the emergencies and contingencies. Paramedics document every task performed at the patient's location, they are also tasked with collecting feedback from the patient after service is done if possible. Otherwise patient can be reminded later for submitting their feedback. Periodic feedbacks from the paramedics regarding possible improvements, requirement for training or resources are also collected and action plans are made and implemented accordingly.

Industrial engineering and lean manufacturing tools like Value Stream Mapping (VSM), Root Cause Analysis (RCA), and Poka-Yoke (error-proofing) can be used to analyze the efficiency of the work flow chart that is followed by the mobile unit. Any task that is not adding any value to the service will be eliminated. Any failure to conform to the flow chart is investigated systemically and root causes are identified and flow charts are modified so that mistakes do not take place. As new methods and technologies become available, some tasks in the work flow chart can be reduced, eliminated, or combined to make the service better suited to patient requirements and more cost effective.

2.3.2 Supervisory Unit

This unit is a backup unit of expert physicians and nurses located at the healthcare provider's facility or other location that can communicate with the mobile unit wirelessly. In case the field unit faces any complication, this supervisor unit provided directions and authorizations to take necessary actions that are out of field unit's jurisdiction. Number of physician and nurses in the unit and their expertise can be determined by the volume of target patients, number of field units etc. From this unit, feedback regarding the mobile unit's efficiency and service performance can also be collected for necessary corrective actions.

2.4 Feedback Handling System (FHS)

Feedback from patients is one of the most valuable sources of information regarding the system's performance. Feedback in terms of surveys and complaints can provide valuable insights regarding quality improvement and risk management. A Feedback Handling System (FHS) can be developed based on the ISO 10002:2004 and catered to the service that this system promises to provide. This complaints specific standard can be augmented by ISO 10004:2012, which is a standard for customer satisfaction. Following the steps of previous study done by Khan and Karapetrovic (2015c), FHS for the system of urgent care delivery at home can be developed with new activities and items that were not covered by the existing standards.

It is important to educate the patients of the feedback handling system and make correct form of feedback collection procedure available to them. Feedback collection procedure needs to be catered to the patient's comfort. It can be collected in written forms, in mobile applications, as voice messages etc. The assigned person needs to check the feedback repository periodically. In the event of negative feedback, associated performance measures need to be studied. An action plan to rectify the situation needs to be developed and person responsible for the service needs to be notified. The patient would be notified of the action taken. If the patient is satisfied, this feedback loop would be closed, but record would be kept for future references.

2.4.1 Performance Measurement

During and after the service, system's performance needs to be checked against the targets determined according to the CSP. A variety of quality measures for at home care delivery services have been identified in the U.S. Department of Transportation report (2009). Collection of data for performance measurement is easy and many of the procedures can be automated with integrated enterprise management system tools and wireless connected devices. For some data inputs, participation of the mobile unit personnel and patients would be necessary. In addition to the service itself, performance measures for other background system units, for example, data collection system, decision support system, and feedback handling system need to be developed and relevant data needs to be collected. These data can be uploaded, and stored in the central data management system, where it would be processed and analyzed with various quality control tools for determining system performance. To analyze the performance of each of the elements of the system, and the quality of service, various quality control tools can be used. The tools that can be of immense importance are:

1. Pareto charts for identifying error prone areas of the system
2. Control charts for analyzing performance consistency
3. ANOVA, MANOVA, Regression, Hypothesis testing, DOE tools for identifying quantitative variation in performance by different factors
4. Root Cause Analysis for determining the prevalent reason for performance deterioration qualitatively.

In case a perceivable disruption in the system performance is identified, the root cause of the disruption would be identified, entities responsible for the reason would be notified, and corrective actions would be taken. All such incidents with the details of steps taken from identification to remedy would be entered and stored into the system for trend and pattern analyses and for future references.

Quality improvement projects following the Six-Sigma methodology can be utilized in determining realistic targets and in reducing deviations in service levels. Sub-methodology of the Six-Sigma, e.g. DMADV, which indicates the Define, Measure, Analyze, Design, and Verify are of immense importance in designing the delivery system, and in verifying the effectiveness of the system. Once the system is in place, the DMAIC (Define, Measure, Analyze, Improve, and Control) methodology can be implemented to continuously improve the efficiency of the system.

3. Roles of Enterprise Management and Technological Innovations

Enterprise Management is a way of communicating and working, in an organized system wide approach supported by an information system. Implementing an Enterprise Resource Planning (ERP) environment allows all the subsystems work under an umbrella towards the same goal. According to Mucheleka and Halonen (2015), successful implementation of ERP system in healthcare organizations would result in better services and profitability. With the distributed network architecture it is now possible to transmit information in real-time across the system. Healthcare IT (HIT) plays a great role in ensuring that all the stakeholders of the system are accessing the updated information to make optimum decisions. An example of such enabler technology is the internet of things (IOT). Case study done by Liu *et al.* (2014) demonstrated success of an IOT-based home care delivery system in China. Patients are connected to the service provider through mobile device, e.g. smartphone or a monitoring device. Internet of things can make collecting data and monitoring patients much easier than before. There are now ample available applications where one or more smart sensors can be connected to a device and have that device stream data to healthcare providers via wireless technology. Lee *at al.* (2009) showed the efficacy of monitoring blood glucose and EKG through mobile phone was studied, and it was found to be promising. Telemedicine has been found to be a safe and cost effective service medium for chronically ill patients by Lawrence (2010). An important tool for telemedicine is picture archiving and communication system (PACS), which is a medical imaging technology that enables economical storage and convenient access to and transmission of diagnostic images. IOT has made the use of wearable monitoring devices in preventive healthcare treatments a promising and realistic option. Urgent care at home delivery system can reap great benefits from the use of these new technological advancements and by utilizing enterprise management system to gather data, perform intelligent analyses and develop and solve relevant mathematical models to make optimum decisions that will meet patients' expectations.

Finally, the following Table 1 will help the reader to get a summarized version of the tools and methods, and their intended purposes to develop and maintain an urgent care at home delivery system:

Table 1: Proposed tools and methods, and their intended applications in urgent care at home delivery system.

Tools/methods	Area of application	Purpose
Quality Function Deployment (QFD)	Customer Satisfaction Promise (CSP) design	Turning patient requirements into measurable operational requirements
House of Quality (HOQ)	Customer Satisfaction Promise (CSP) design	Prioritizing patient requirements and operational decisions
Queuing modeling	Decision support	Identifying optimal number of servers
Dynamic programming	Decision support	Optimal location and allocation of servers
Knapsack Programming	Decision support	Optimal designing of servers
Value Stream Mapping (VSM)	Process design for mobile delivery unit	Analyzing the efficiency of the care delivery process
Root Cause Analysis (RCA)	Process design for mobile delivery unit	Identifying the causes of errors in the care delivery process
Poka-Yoke	Process design for mobile delivery unit	Designing the care delivery process to reduce the probability of errors
Statistical tools	Performance measurement	Analyze the performances of sub-systems
Quality control tools	Performance measurement	Analyzing existing quality and identifying opportunities for improvement
Six-Sigma methodology	Performance measurement	Designing the service delivery system and for its continuous improvement

4. Conclusion

Urgent care at home delivery is a viable and much needed option for reducing patient congestion at emergency department. In this study, a framework for establishing a system for delivering such services has been proposed. Various existing concepts for at home care delivery have been discussed and their merits have been analyzed. Approaches for aggregating these concepts with different techniques of optimization, industrial engineering methods, lean manufacturing tools, and information technology to develop an integrated healthcare delivery system have been explored in details. This study can serve as a guideline for developing an integrated system for urgent care at home delivery. Some pilot projects have been run with the same intent, but with limited scope and limited involvement of the rest of the segments of the healthcare delivery system. However, the case studies of these projects have provided insights about the difficulties in implementing urgent care at home delivery program without involving the rest of the healthcare delivery system. A system wide approach along with unambiguous mission statement and appropriate strategic and operational planning can result in a successful development and sustenance of such a system. Implementation of the concepts and methods concurrently as described in this paper can lead to an effective and efficient system for urgent care at home.

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Biography

Tasnim Ibn Faiz is pursuing his PhD in Industrial Engineering at Northeastern University. He earned his B.S. in Industrial Engineering from Bangladesh University of Engineering and Technology, Bangladesh, and Masters in Industrial Engineering from Louisiana State University, USA. He has published journal and conference papers, worked in academic research projects as well as in industrial sector. His research interests include optimization, scheduling, healthcare and renewable energy. He is a member of IIE and INFORMS.

Ali Al-Muflih is a PhD student in the Department of Mechanical & Industrial Engineering at Northeastern University. He worked for Industrial Engineering department as a Teacher Assistant for about 12 months at King Khalid University (KKU) in Saudi Arabia. Currently, he is a faculty member at King Khalid University (KKU) in the Department of Industrial Engineering as a Lecturer. He received a full scholarship from the Ministry of Higher Education in Saudi Arabia to pursue his graduate degree. His research interest lies in the intersection of operations management and data analytics, in particular, as applied to healthcare delivery system framework, supply chain engineering and lean concepts. He also completed a M.Sc. degree in the Department of Mechanical & Industrial

Engineering at Northeastern University (NEU) in 2015 and a B.Sc. in the Department of Industrial Engineering from King Khalid University(KKU) in 2011.

Md Noor-E-Alam is an Assistant Professor in the Department of Mechanical & Industrial Engineering at the Northeastern University. Prior to his current role, he was working as a Postdoctoral Research Fellow at Massachusetts Institute of Technology. He has completed his PhD in Engineering Management in the Department of Mechanical Engineering at the University of Alberta (UofA) in 2013. His current research interests lie in the intersection of operations research and data analytics, particularly as applied to healthcare, manufacturing systems and supply chain. Before coming to the UofA, he served as a faculty member (first as a Lecturer and then as an Assistant Professor) in the Department of Industrial and Production Engineering at Bangladesh University of Engineering & Technology (BUET). He also previously received a B.Sc. and M.Sc. in Industrial and Production Engineering from BUET.