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Research Article

# A Survey on Analyzing Treatments in Healthcare Workflow

S.Yamuna Rani[1], Dr.Sumagna Patnaik[2]

## Abstract

Workflow technology has expanded substantially into the healthcare industry over the last year. Hospitals are embracing this technology as a means to improve operational efficiency, achieve patient safety goals, and positively influence the quality of care. Healthcare Workflow analysis identifies areas for improvement, such as redundant tasks or processes, bottlenecks, lack of efficiency or conformity with best practice. There are limited resources in healthcare workflow analysis modelling and analysis. In this paper we present brief literature review for treatment analysis in healthcare workflow under various scenario including Pandemic Covid -19 situation, Internet of things (IoT) assisted healthcare workflow monitoring, management of unintended situation in workflow, TMS workflow analysis. We further explore various workflow modelling techniques including Petri Net modelling for healthcare workflow analysis. Finally, we discuss some open challenge and future work in this direction.

***Keywords*--**Workflow Analysis, Healthcare system, Internet of Things (IoT), Workflow Modelling.

## 1. Introduction

Healthcare industry is one of the most critical and domination industries that demand confronted with higher demands for qualitative service with reduced operational costs and higher revenue [1]. Hospitals and other healthcare department constantly facing various challenges and other operational issue due to improper management. For instance, with increase in medical issue, number of patients at hospital constantly growing while number of beds, and other amenities are still the same that demand effective use of hospital assets with excellent clinical assistance and high-quality patient care. Furthermore, emergency department exceeds the capacity and hospital loses money while treating the patients. Also, shortage of staff across clinical jobs leads various issues including emergency department overcrowded, facilities of emergency patients is being altered, number of operated beds reduced to assist patients, increased period of patients stay and delayed their discharge time, which in turn decrease patient satisfaction and demands to tackle this all these operational issues. However, these issues do not change the fact that patient deserve and demand safe and top-quality care. Patients put their trust in hospitals to treat them according to best

[1]Research Scholar, JNTU Hyderabad yamunaa26@gmail.com
[2]Professor Department of CSE, Department of IT JB Institute of Engineering and Technology, Moinabad, Hyderabad. iqac@jbiet.edu.in

practices, to ensure they receive the appropriate tests, medications, and interventions for their conditions. Delayed care delivery, unnecessary tests, medication errors, or preventable complications due to an omitted step in a plan of care increases the likelihood of poor patient outcomes. To address this issue healthcare industry is verge on the peak for gaining significant attention from researcher to work in the direction of process optimization, efficiency enhancement and throughput improvement. Workflow technology which is earlier used in manufacturing industry can be designed and applied in healthcare industry to help hospitals and their clinical department to deliver the right service work to the right patient at the correct time, with best care and quality of service.

Workflow technology is the order of events executed autonomously or collaboratively by the several representatives/units in the organization [2]. The representatives in a medical system comprise, of clinicians, medical technologies, equipment and care delivery procedures. The influence of healthcare workflow on patient protection has been extensively recognized for some time [3]. Clinical error analysis that compromises safety, security and care, has always been an intricate plan. However, main issue in healthcare industry for researcher in regards with patient care and safety is that healthcare industry is the group of entities dependent on each other and clinical errors can seldom be attributed to a single entity. Any adverse effect or clinical errors are typically indications of flaws elsewhere in the whole system or mere single entity or process [4]. As healthcare system is intricate and collective system, the study of medical activities and communications with clinical specialists and support systems, can help us better understand the care delivery process and consequently, the workflow. The Health Information Technology for Economic and Clinical Health (HITECH) Act, passed as part of the American Recovery and Reinvestment Act (ARRA) of 2009, introduced incentives for healthcare organizations to adopt and use EHRs [5]. This has led to a significant increase in EHR adoption and as of 2015, 96% of US non-federal acute care hospitals reportedly possessed certified EHR technology and 84% had adopted a basic EHR which was up from 9.4% in 2008 [6]. The electronic healthcare record (EHR) systems have presented a new horizon to healthcare workflow. This, shared with the quality reportage necessities under “evocative practice” [7] have seen administrations adopt a diversity of rules and technologies to accumulate and compute healthcare workflow to aid in writing of events. However, current study has revealed that the influence of EHRs into healthcare workflow has not been without some substantial disadvantages extending from a lack of patient appointment to adverse influence on medical doctor efficiency [8,9] suggesting the necessity for an exhaustive study of EHRs influence on workflow. However, an evocative analysis of healthcare workflow is a time-consuming and task intensive process, the intricacy of which gages in relation to the intricacy intrinsic to the experimental surroundings [2]. Conventionally, healthcare workflow analysis elaborates the use of one or numerous approaches by means of a human witness to seize various data streams of interest relevant to the surroundings. In this context the most commonly used method has been ethnography [10–12]. Ethnography in medical atmospheres that explore the study of individuals across the surroundings and elaborate their interactions with surrounding environment including, including their preconceptions, impact over clinician performance and outcome for patient care. Ethnographic remarks combined with the other techniques like questionnaires, interviews, surveys, help to find error in healthcare workflow however, they all also have certain limitations. Precisely, they depend deeply on single or multiple human observers at concurrent times by processing multiple, streams of data [13]. In order to make system more

efficient a greater number of human observers requires however it can become troublesome to the healthcare atmosphere. Moreover, logical challenges such as the prerequisite to train the human observers to accumulate consistent data with high consistency ad reliability, may be a highly cost-intensive. These challenges are aggravated in the emergency department (ED) [14], and it subsequently poses a substantial challenge for scholars and researchers. The tasks accomplished in the ED are particularly non-linear, distributed and, complex [15]. Therefore, to supplement ethnographically derived metrics, healthcare workflow needs to be turned down towards information technology freeing the scholars to devote more time for IT based healthcare workflow analysis.

IT enabled healthcare workflow analysis improve quality of service and patient care with more reliability and safety. However, unplanned introduction of healthcare IT led to unintended consequences [16]. The term "unintended consequences" refers to unforeseen or unpredicted results to a specific action [17]. These unintended consequences can be optimistic, pessimistic, or impartial. Tremendous research has been carried out understand the unintended consequences of healthcare IT [18-24]. While, [16] explores healthcare workflow analysis for unintended consequences and describe how implementation of healthcare IT may involuntarily introduce adversative consequences to healthcare workflow. Healthcare IT become more advance with development of advanced mobile healthcare application and digital technologies[25]. With advancement in mobile healthcare application, several healthcare stakeholders require effective workflow to access patient data. Also required efficient healthcare workflow permission to make hard copy or digital data of all this work and ensure the confidentiality that this data should not be distributed for any commercial or financial benefits without permission to any unauthorized party. To ensure this confidential and quality of service, graphical workflow architecture using petri net is explored in [26] that provide consistency for this all sort of services with access and processing of patient data by several healthcare stakeholders. In this paper petri net are used as treatment pathway in healthcare workflow analysis of patients. Many of researchers and scientist used Computer-Aided Healthcare Workflows [27] that facilitate healthcare workflows includes process, entities, medical guidelines, medical procedures, medical devices, medical practitioners, medical staff and healthcare information systems (HIS). The typical healthcare workflow architecture is shown in figure 1.

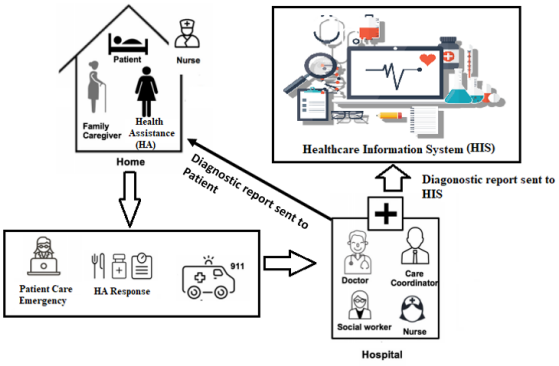



**Figure 1. Typical Healthcare Workflow**

The healthcare workflow process must be kept dependable with all stakeholders at all times.

## 2. Background and related work

In clinical surroundings, healthcare workflow analysis is particularly imperative to evaluate the effect of an intrusion or other variations of everyday clinical processes. Zheng et. al [27] attempted to enumerate the effect of Healthcare-IT implementations on healthcare workflows. They acquaint with a new set data analysis procedure for evaluation of effect and establish a way of using data visualization to make intricate information more legible and valuable for faster valuations. Ethnographic techniques, as mentioned above, can sometimes be flawed or logistically challenging. Moreover, the interpretations made from the information can be problematic to simplify. So, finally, various IT enable automated methods have been technologically advanced to improve data gathering in medical surroundings.

### 2.1 Workflow Simulation

The first techniques used in this context is workflow simulations and analysis. Wang et. al [28] instigated an agent-based workflow simulation to improve and identify bottlenecks (congestion or jams) in the emergency department (ED) workflow. This system recognizes and then change constraints related with radiology and triage processes that could attain a development in average waiting time of patient and reduce length of patient stay. Wang et al. [29] proposed concept-based model for ED to determine the behavior change of physician or medical practitioner based on numerous metrics measure including the behavior change after per hour diagnostic of new patient role, and the length of patient stay. These techniques are sufficient enough to simulate multifaceted surroundings where the collected data may not always be steady and consistent. Though, the simulation analysis is typically performed via professional expert which is valuable enough but at the same time insufficient. Such techniques do not sufficient to incorporate real world data as they would not give consistent performance for real-time quantitative metrics.

### 2.2 IoT assisted workflow analysis

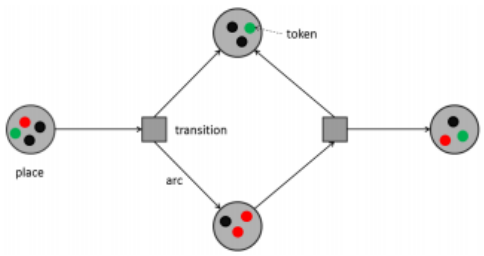
To tract down the activities of patients, recently sensor technology is used in healthcare workflow analysis. Internet of Things (IoT) sensors plays significant role in developing healthcare workflow for real world data. Several researches have been carried out using this sensor technology that include various IoT sensor techniques including ZigBee [33], Wi-Fi [30], Bluetooth [31], and Radio Frequency Identification (RFID) [32] in healthcare workflow to automate the data analysis and track down the activity of workflow entities such as clinicians, patients, staff, to other hospital personnel across clinical settings. Fry et.al [34] proposed RFID based MASCAL model that keep track the activities of clinical resources and its surrounding including medical equipment, hospital staff, or patients in real time and efficiently handle mass casualties in emergency events including natural disaster, and other calamities. Ajami et. al [35], integrated RFID technology in healthcare workflow and perform RFID based real time data analysis that ensure patient safety and reduce diagnostic, medical and medication error. Kannampallil et al. [36] proposed another method based on RFID technology to handle the ED workflow with a set of procedures that formalize the study of clinical events. Presently, real-time location system (RTLS) gaining significant popularity especially Bluetooth technology as it release low energy that means consume minimum power just like other low energy consumption technology including ZigBee [37] leading to an better-quality lifespan of Bluetooth slave devices i.e. tags [38]. Anderson et. al [39] established the beacon by implementing low energy Bluetooth device for door locking system based on proximity. Frisby et. al, [40], exploiting RTLS based Bluetooth technology to handle dynamic environment of ED workflow and demonstrate data accumulation by preserving chronological relationship between pragmatic events.

### 2.3 Healthcare workflow analysis using Time and motion studies (TMS)

Aigner et. al [41] provide a generalizable framework for the visualization of temporal data. Loorak et al. [42] established TimeSpan modeling system that demonstrate time-based patient data visualization with numerous dimensions. Time and motion studies (TMS) are another frequently used technique for healthcare workflow analysis in a very complex and simultaneous task-based medical atmospheres where time-based directive is relevant. TMS are mainly led by means of efficient and qualitative annotations [43,44]. These studies offer valuable understanding into the time-based study and visual conception of workflow. Yen et al., 2016 [45] directed a TMS techniques to evaluate nursing staff workflows in which they used visual conception techniques that reports on multiple task activity and observed their communication with time-duration. The visual conception of multi-task activity includes splitting the visual events into communication, practical tasks, and location of study. The sensor technologies and TMS provide a valuable insight and perform efficient analysis with real-world data in more consistent way.

### 2.4 Healthcare Workflows modeling technologies

Recently, workflow management gains significant attention from various research scholars that explores workflow solution for both hospital personnel and patients. The healthcare workflow can be modelled using various technologies including Event driven Process Chains (EPCs) [46], Business Process Modeling Notation (BPMN) [47, 48], Unified Modeling Languages (UML), Bayesian networks [49], or Markov chains [50] and High-Level Petri Nets (HLPNs) [51]. High-Level Petri Net gain significant popularity among all the other modelling technology. HLPN were developed to model synchronization and concurrency in distributed systems in real-time scenario. Petri nets, or HLPNs are consist of four elements including places, tokens, transitions, and arcs and their typical architecture is shown in Figure 2.




Places contain tokens while token contain the detailed information of state. Transition represents the activity or event while arc is an edge that connect transition and places. Here we present few researches works that elaborate workflow for the healthcare industry using Petri Net. In [52], Hughes et al. proposed healthcare system using petri net for planning and resource management. The flow of patients is modelled to provide relevant information about healthcare and associated facilities to healthcare manager and also evaluate the performance of existing amenities. In [53], Bertolini et al presented collaboration model for healthcare workflow using petri net that functional and non-functional requirement of healthcare system. In [54], Augusto et. al projected a modelling method of healthcare events for instant planning and task scheduling. This method can also be used for simulation of health care systems. To meet the requirement of patients and old-age people to live independently, Fanti et al. [55] propose workflow monitoring model using a Petri net that monitors their day-to-day activities, detect and communicate any abnormal activity or accidental event to their family care giver, professional medical expert and emergency service station. Whittaker et al. [56] projected choice-

point nets, which are an augmented form of Petri nets to analyse health-care procedures and to prototypical possible selections. The authors fixated on how the selections among health decisions can be determined and simulated. Mahulea et al. [57, 58] disclosed that healthcare procedures can be demonstrated by Petri nets with state machine. In this work as open Petri nets is not used therefore the medical resources remain unaffected and no real-time communication with the real-world data is represented.

## 2.5 Healthcare workflow in COVID-19 Pandemic Situation

Several studies have investigated various problems that occur in hospitals caused by Coronavirus. In Italy, Bettinelli et al. [59] studied the workflow of an orthopedic clinic during the COVID-19 pandemic. They summarized all the changes that had to be made to prevent the healthcare system's downfall in the most affected areas and provided an effective flowchart. They proposed a model that shows the workflow for patients arrived in the emergency room (ER) in an Orthopedic Hub during the coronavirus disease emergency, as given in Figure 2. In the model, the hub and spoke organization was enforced by an immediate-effect regional decree.

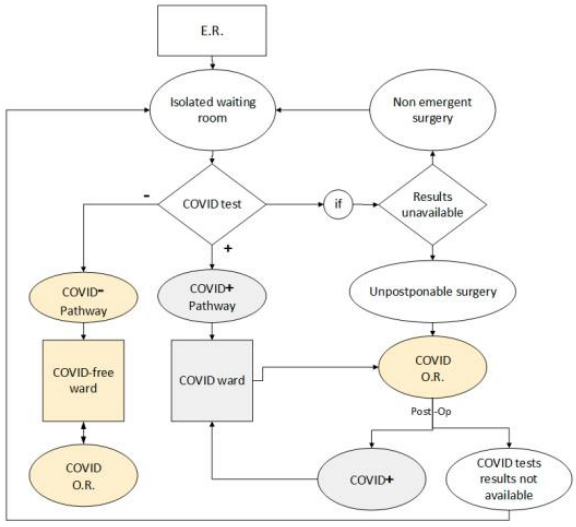



**Figure.2 Healthcare workflow during Pandemic Covid-19 Situation**

In another study, Wei et al. [60] improved the workflow of radiotherapy procedures during the COVID-19 pandemic in a cancer hospital in Wuhan. They affirmed that a stringent COVID-19 screening protocol was implemented at their center, and the workflow of radiotherapy was optimized for combating the epidemic. Simulation techniques have been used in several hospital-related studies. This technique makes a safe analytical lens into the process; therefore, flow can be optimized, and risk minimized [61]. Das [62] studied the effect of the COVID-19 outbreak on the workflow of an endoscopy Centre. This study developed a discrete event simulation-based model to measure the impact of the changes on the performance indicators related to COVID-19-related workflow and cost per case compared with the pre-COVID-19 baseline. The results show that the post-COVID-19 suggested workflow changes have a significant impact on productivity and operational metrics and, in turn, adversely impact financial indicators. There has been a substantial reduction in staff utilization resulting in a growth in total patient waiting time, facility time, and

cost per case due to a bottleneck caused by pre-procedure COVID-19 testing and screening while practicing. Diaz and Dawson [61] used simulation to develop a COVID-19 resuscitation procedure in the emergency department of pediatrics. They concluded that simulation might be used to formulate COVID-19 spaces, processes, and workflows.

### 2.6 Healthcare Workflow for unintended consequences

Health IT implementation may unintentionally introduce adverse consequences to clinical workflow, with the following two goals. First, we attempt to characterize the chain of impact by distinguishing primary unintended consequences that lead to changes in workflow from secondary unintended consequences that originate from the workflow alterations. Second, we attempt to provide a discussion on the causes of and some proposed solutions for these workflow-related unintended adverse consequences.

### 2.6.1 Describing Unintentional Consequences in Healthcare workflow

Understanding health IT's impact on workflow can be challenging due in part to the fact that workflow encompasses all activities around clinical care. The introduction of health IT is often associated with direct changes in established workflow, such as new types of work and new task interdependencies, which has been widely noted in the literature [63,64]. We refer to these as primary unintended consequences. In addition, there are other indirect impacts that occur as a result of these primary consequences. For example, some studies have found that clinicians may adopt unsafe workarounds in response to disrupted and fragmented workflow, which can lead to an increase in errors resulting in patient safety threats [65,66,67]. This cascading effect, from workflow consequences to other secondary impacts, is illustrated in Figure 3.

3.2.1 Workflow Issues: Primary Unintended Consequences

In many cases, unintended consequences of health IT implementation directly affect the work practices of both clinicians (e.g., physicians, nurses, pharmacists) and nonclinical staff (e.g., medical billing and coders, receptionists, and IT staff), even though the former is far more frequently studied. Unintended consequences to clinicians' workflow, as documented in the literature to date, include new or increased workload [68, 69], delayed work or time inefficiencies [70,71 72], interruptions or distractions [71,73,74,75], duplicated work practices [73, 68, 76] and changed or disrupted communication [75].

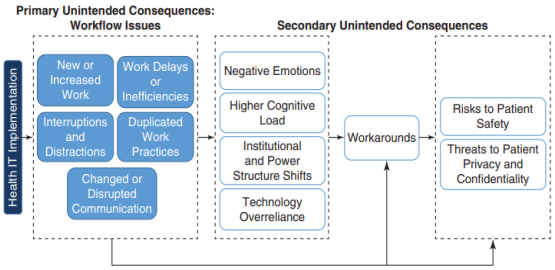



**Figure 3 Healthcare workflow demonstrating unintended consequences of Health IT**

### 2.6.2 Secondary Unintended Consequences Resulting from Workflow Issues

As a result of the workflow issues, clinicians often face secondary consequences, such as negative emotions, higher cognitive load, shifts in institutional and power structure, and overreliance on technology. When clinicians are overburdened or upset, they may resort to workarounds in an attempt to ease these secondary consequences. These workarounds, and the workarounds that directly result from the workflow issues, can negatively impact patient safety and privacy.

Workflow issues that result from health IT adoption can impact clinicians in many unintended and negative ways, including provoking negative emotions [77,78], increasing task fragmentation [66,71], changing institutional and power structure [77] and creating an overreliance on technology [77]. As healthcare providers try to learn an new computerized system and contest with changes to their work processes, they may experience guilt, annoyance, sadness, hostility, and disgust [78] Changes and disruptions to established workflow can also result in task fragmentation reflected as higher frequencies of task switching and multitasking [66,71].

Workarounds are mitigating strategies commonly employed by clinicians to overcome barriers to their work introduced by a variety of factors, including primary unintended consequences and their secondary effects. Workarounds can be individual, managerial, or artifact-based, depending on who initiates the workaround and how it is enacted. Common examples of workarounds include using paper and other software systems as intermediaries [79,80] and staying logged into the system under a coworker's credential to save time [81]. In the context of test result management, [79] found that among the primary care clinicians studied who used workarounds, 70% reported using paper-based methods and 22% reported using a combination of paper and computer-based approaches. Sometimes workarounds can become a routine practice to address workflow issues [82]. For instance, to combat inefficiencies and to facilitate care coordination, clinicians may write down patient information on a piece of paper [79] or take photos of the screen of a computer workstation [83]. Generally, workarounds are aimed at alleviating secondary consequences that emerge as a result of workflow issues, rather than addressing the underlying workflow issues directly.

The most concerning adverse impact as a result of workflow issues and/or unsafe workarounds is added risks to patient safety [68,79,80]. Disruptions to workflow can increase the likelihood of errors, leading to serious adverse events [65,73,77,79,80, 84,85]. Poor usability of health IT also contributes to the problem. For example, poorly designed software user interfaces may make it much easier for clinicians to select the wrong option or input an order for the wrong patient. Schiff et al. [86] provided an overview of common design problems of CPOE, including an illustration of how the overwhelming number of acetaminophen choices displayed on a computer screen could facilitate new types of errors. In addition, health IT requires complete and structured data, which can also cause cognitive overload that makes clinicians more susceptible to making mistakes [87,88].

Lastly, workflow issues and unsafe workarounds can adversely affect patient privacy and confidentiality. Particularly, the use of workarounds such as paper notes, screenshots, and photos to improve memory and efficiency can threaten patient privacy and confidentiality by recording and transferring sensitive patient information in an unsecure manner. Although there are often privacy policies and security measures in place in clinical environments, clinicians may work around them when they deem these policies and measures as inhibitors to their work practices [83,89,90].

## 3 Discussion: Challenges in Healthcare workflow

This section discusses the challenges from the healthcare workflow application point of view, which might not be directly related to software development (e.g., the legal issues), but motivates software research. Those issues might exist for developing other software as well. However, they are essential for the wide use of computer aided healthcare workflow systems.

**3.1 From Data Characteristic Perspective:**

- Different healthcare providers and their HIS/knowledge bases often use different terminologies and data value scale/representations. This makes integration and deployment of workflow systems difficult.
- How to collect accurate, yet sufficiently large volumes of data for workflow analysis and validation, without interfering with or unduly burdening the workflow? We have seen that while analyzing current practice (which was believed to be inefficient) is agreed to be useful, no one is willing to collect the data because of the workload.
- Clinical data collection/analysis needs a long time to validate certain workflows and check on the effectiveness of their computer support (e.g., long-term care data collection for chronic diseases).

**3.2 Data Integration with IT technologies:**

- How different kinds of workflows (e.g., administrative, clinical treatment) can be integrated, although supported by different software applications? How to plug external medical guidelines easily into hospital workflows?
- How to integrate both event forecasting (e.g., a patient will come to ICU in 30 minutes), and data propagation (e.g., providing all relevant, timely data for the new patient)?
- How to test feasibility or ensure reliable execution of the integration of multiple inter-related workflows without causing interference?

**3.3 Legal/regulatory:**

- Does a latest technology equipped clinical workflow need to be approved by FDA?
- Is the workflow vendor responsible for workflow definition incompleteness or for errors in executing the deployed workflow support?
- Who would own the intellectual property on the computerized workflows if their manual versions are results of many medical research efforts?

**3.4 Usability:**

- Computer intelligence-based workflows need to be evaluated in a real healthcare setting to ensure their efficiency and usability while not disturbing the workflow itself.
- Avoid overloading the tasks for a staff. If a workflow brings 50 alerts a day, it will become too overwhelming to respond. It should provide guidance for the priority of the tasks (e.g., to address the safety critical nature of the clinical workflows) and support easy switching among those tasks.
- How to design the appropriate interactions among usability and security features in a workflow system so that the hindering from each other can be avoided.

**3.6 Multiple Views:**

Different medical roles (e.g., nurse, doctor) often have different understandings of the same workflow. The view of each role is focused only on one aspect and their views may conflict since their concerns can be different. Also, a single role may require different views, depending on context and activity (e.g., a nurse in ICU performs many different activities: patient assessment, dispensing medication, and fluid treatment, which would be better facilitated with different views.)

### 3.6 Adaptability:

- Medical guidelines often need to adapt to the healthcare environments (e.g., availability of certain medicines and equipment).
- Workflows need to be adaptable to different healthcare providers. Physicians (even of the same specialty) may differ in their workflows because of their different personal experiences or training, and thus they require the workflow system to support doing things their way.

### 3.7 Maintenance:

- Implementations of workflows, particularly clinical guidelines, need to be upgraded with advances of medical guidelines.
- Administration workflows need to respond to legislative and regulatory changes (e.g., add privacy notification to check-in process, change in Medicare allowances)

### 3.8 Software Challenges

This section summarizes the challenges in applying the software technologies to support the healthcare workflows:

- Guideline validation: How to check the completeness, execution feasibility/reliability, and syntax of the workflows? Software technology can easily identify syntax errors. However, it is limited in identifying semantics-related errors (e.g., insufficient safety checks) without additional information.
- Model mapping: How to integrate medical guidelines with other medical information systems (e.g., patient monitoring, radiology information systems, electronic patient records)?
- Formalizing the medical guidelines: How to formalize the values in the guidelines to allow a computer to analyze or execute guidelines?
- Support a variety of control/execution flows: Need to be able to support flexibility in executing workflows, especially for exception conditions, which might need special recovery and rollback mechanisms.
- Support adaptability: How to make the workflow execution adaptable to different medical purposes (screening, disease management, surveillance); different healthcare roles; and different kinds of healthcare organizations (e.g., clinic vs. hospitals). A highly adaptable system could be overly complex and have too much overhead (e.g., performance). Achieving a good balance is the challenge.
- Support capturing real-time information: Workflow support should be provided with the most recent medical and patient information since the medical environment and the patient information change frequently. Software techniques could be used to identify promptly and adjust accordingly the guidance that is based upon out-of-date information, all without undue overhead to the system.

## 4. Conclusion and future work

Healthcare is a complex environment with various challenges and opportunities. Healthcare industry faces technical, clinical, and cultural challenges. Despite various challenges, workflow analysis with latest technologies improves patient care and operational efficiencies and healthcare industry powerful. In this paper we present review of various research article that present the healthcare workflow under different medical situation and demonstrated that workflow

can be applied in any healthcare environments. Healthcare workflow analysis is a feasible movement and vision for the future of healthcare.

The advances of technologies, such as wireless networking and sensor technologies, will make it more feasible to apply software technologies to healthcare workflows. However, there is still scope to added some human intelligence knowledge to make workflow fully automated. Thus, a comprehensive set of software-related requirements with some artificial intelligence technology in healthcare workflow would be needed to introduce into this application area. The software analysis technologies might be applied to analyze the correctness of the healthcare workflows; the data extraction technologies will provide the required data for the clinical diagnosis. Data mining technologies will help acquire knowledge about the workflows and their executions. The software integration technologies will automate the clinical operational and laboratory workflows. Additionally, using a framework to classify healthcare workflow requirements will ease the communications between healthcare staff and software professionals. Without such classification, as indicated by our prior experience, the requirements would have to be developed from scratch and thus take more effort to develop. Another thing that needs to added in healthcare workflow is some data analytical techniques like Big Data for analyzing real-time healthcare data from various IoT sensor, WSN and body sensor network (BSN). In addition, with artificial intelligence and data analytics, there is also a need to elaborate some cloud-edge-Fog based computing technologies for reducing time delay and energy consumption. Our work as presented here with an aim achieving all this goals and develop advanced and automated healthcare workflow that analyze the treatment with latest technologies, and minimum delay.

## References

1. Jonathan Emanuele and Laura Koetter. 2007. Workflow Opportunities and Challenges in Healthcare. Technical Report. Siemens Medical Solutions, Malvern, PA.
2. M. Vankipuram, K. Kahol, T. Cohen, V.L. Patel, Toward automated workflow analysis and visualization in clinical environments, J. Biomed. Inform. 44 (2011) 432–440.
3. Institute of medicine, Committe on Quality of Health Care in America, To Err Is Human: Building a Safer Health System, 2000.
4. K. Henriksen, E. Dayton, M.A. Keyes, P. Carayon, Chapter 5 . Understanding Adverse Events : A Human Factors Framework Human Factors — What Is It ?, Saf. Qual. An Evidence-Based Handb. Nurses. (2008) 67–86.
5. D. Blumenthal, M. Tavenner, The “Meaningful Use” Regulation for Electronic Health Records, N. Engl. J. Med. 363 (2010) 501–504.
6. J. Henry, Y. Pylypchuk, T. Searcy, V. Patel, Adoption of Electronic Health Record Systems among U.S. Non-Federal Acute Care Hospitals: 2008-2015, ONC Data Brief, No. 35. (2016).
7. H.H.S. Centers for Medicare & Medicaid Services (CMS), Medicare and Medicaid programs; electronic health record incentive program. Final rule., Fed. Regist. 75 (2010) 44313–44588.
8. M.F. Furukawa, J. King, V. Patel, C.J. Hsiao, J. Adler-Milstein, A.K. Jha, Despite substantial progress in EHR adoption, health information exchange and patient engagement remain low in office settings, Health Aff. 33 (2014) 1672–1679.
9. S.T. Mennemeyer, N. Menachemi, S. Rahurkar, E.W. Ford, Impact of the HITECH act on physicians’ adoption of electronic health records, J. Am. Med. Informatics Assoc. 23 (2016) 375– 379.

10. S. Malhotra, D. Jordan, E. Shortliffe, V.L. Patel, Workflow modeling in critical care: Piecing together your own puzzle, J. Biomed. Inform. 40 (2007) 81–92.
11. V.L. Patel, J. Zhang, N.A. Yoskowitz, R. Green, O.R. Sayan, Translational cognition for decision support in critical care environements: A review, J. Biomed. Inform. 41 (2008) 413–431.
12. A.Laxmisan, F. Hakimzada, O.R. Sayan, R.A. Green, J. Zhang, V.L. Patel, The multitasking clinician: Decision-making and cognitive demand during and after team handoffs in emergency care, Int. J. Med. Inform. 76 (2007) 801–811.
13. M. Vankipuram, K. Kahol, T. Cohen, V.L. Patel, Visualization and analysis of activities in critical care environments., AMIA Annu. Symp. Proc. 2009 (2009) 662–666.
14. S.C. Brailsford, V.A. Lattimer, P. Tarnaras, J.C. Turnbull, Emergency and on-demand health care: modelling a large complex system, J. Oper. Res. Soc. 55 (2004) 34–42.
15. T. Kannampallil, Z. Li, M. Zhang, T. Cohen, D.J. Robinson, A. Franklin, J. Zhang, V.L. Patel, Making sense: Sensor-based investigation of clinician activities in complex critical care environments, J. Biomed. Inform. 44 (2011) 441–454
16. Eikey, Elizabeth & Chen, Yunan & Zheng, Kai. (2019). Unintended Adverse Consequences of Health IT Implementation: Workflow Issues and Their Cascading Effects. 10.1007/978-3-030-16916-9_3.
17. Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. Types of unintended consequences related to computerized provider order entry. J Am Med Inform Assoc. 2006;13:547–56.
18. Zadeh PE, Tremblay MC. A review of the literature and proposed classification on e-prescribing: functions, assimilation stages, benefits, concerns, and risks. Res Social Adm Pharm. 2016;12:1– 19.
19. Marcilly R, Ammenwerth E, Vasseur F, Roehrer E, Beuscart-Zephir MC. Usability flaws of medication-related alerting functions: a systematic qualitative review. J Biomed Inform. 2015;55:260–71.
20. Kim MO, Coiera E, Magrabi F. Problems with health information technology and their effects on care delivery and patient outcomes: a systematic review. J Am Med Inform Assoc. 2017;24:246–60.
21. Salahuddin L, Abidin WZ, Ismail Z. A systematic literature review on safe health information technology use. J Teknol. 2016;78:1–7. https://doi.org/10.11113/jt.v78.8225.
22. Gephart S, Carrington JM, Finley B. A systematic review of nurses' experiences with unintended consequences when using the electronic health record. Nurs Adm Q. 2015;39:345–56.
23. Kuziemsky CE, Randell R, Borycki EM. Understanding unintended consequences and health information technology: contribution from the IMIA Organizational and Social Issues Working Group. Yearb Med Inform. 2016:53–60.
24. Vanderhook S, Abraham J. Unintended consequences of EHR systems: a narrative review. Proc Int Symp Hum Factors Ergon Healthc. 2017;6:218–25.
25. Health and Food Safety Directorate General. 2017. Public Health: Midterm Review of Digital Single Market Strategy includes areas for enhanced action in digital health and care. e-News. (10 May 2017).
26. Boudko, Svetlana, and Wolfgang Leister. "Treatment pathways as petri nets in patient workflow management." In Proceedings of the 19th International Conference on Information Integration and Web-based Applications & Services, pp. 511-518. 2017.

27. K. Zheng, H.M. Haftel, R.B. Hirschl, M. O'Reilly, D.A. Hanauer, Quantifying the impact of health IT implementations on clinical workflow: a new methodological perspective, J. Am. Med. Informatics Assoc. 17 (2010) 454–461
28. Lu Wang, An agent-based simulation for workflow in Emergency Department, in: 2009 Syst. Inf. Eng. Des. Symp., IEEE, 2009: pp. 19–23
29. B. Wang, K. McKay, J. Jewer, A. Sharma, Physician shift behavior and its impact on service performances in an emergency department, in: Proc. 2013 Winter Simul. Conf. - Simul. Mak. Decis. a Complex World, WSC 2013, 2013: pp. 2350–2361.
30. J.H. Youn, H. Ali, H. Sharif, J. Deogun, J. Uher, S.H. Hinrichs, WLAN-based real-time asset tracking system in healthcare environments, in: 3rd IEEE Int. Conf. Wirel. Mob. Comput. Netw. Commun. WiMob 2007, 2007.
31. G. Han, G.J. Klinker, D. Ostler, A. Schneider, Testing a proximity-based location tracking system with Bluetooth Low Energy tags for future use in the OR, in: 2015 17th Int. Conf. E-Health Networking, Appl. Serv., IEEE, 2015: pp. 17–21.
32. M. Vankipuram, K. Kahol, T. Cohen, V.L. Patel, Toward automated workflow analysis and visualization in clinical environments, J. Biomed. Inform. 44 (2011) 432–440.
33. H.C. Tung, K.F. Tsang, K.L. Lam, H.Y. Tung, B.Y. Shing Li, L.F. Yeung, K.T. Ko, W.H. Lau, V. Rakocevic, A mobility enabled inpatient monitoring system using a ZigBee medical sensor network, Sensors (Switzerland). 14 (2014) 2397–2416.
34. E.A. Fry, L.A. Lenert, MASCAL: RFID Tracking of Patients, Staff and Equipment to Enhance Hospital Response to Mass Casualty Events, AMIA Annu. Symp. Proc. 2005 (2005) 261–265.
35. S. Ajami, A. Rajabzadeh, Radio Frequency Identification (RFID) technology and patient safety, J. Res. Med. Sci. 18 (2013) 809–813.
36. T. Kannampallil, Z. Li, M. Zhang, T. Cohen, D.J. Robinson, A. Franklin, J. Zhang, V.L. Patel, Making sense: Sensor-based investigation of clinician activities in complex critical care environments, J. Biomed. Inform. 44 (2011) 441–454.
37. Dementyev, S. Hodges, S. Taylor, J. Smith, Power Consumption Analysis of Bluetooth Low Energy, ZigBee and ANT Sensor Nodes in a Cyclic Sleep Scenario, (n.d.). (accessed May 25, 2017).
38. Gomez, J. Oller, J. Paradells, Overview and Evaluation of Bluetooth Low Energy: An Emerging Low-Power Wireless Technology, Sensors. 12 (2012) 11734–11753.
39. T. Andersson, Bluetooth Low Energy and Smartphones for Proximity-Based Automatic Door Locks, 2014. (accessed May 25, 2017).
40. J. Frisby, V. Smith, S. Traub, V.L. Patel, Contextual Computing: A Bluetooth based approach for tracking healthcare providers in the emergency room, J. Biomed. Inform. 65 (2017) 97–104.
41. W. Aigner, S. Miksch, W. Müller, H. Schumann, C. Tominski, Visualizing time-oriented data-A systematic view, Comput. Graph. 31 (2007) 401–409.
42. M.H. Loorak, C. Perin, N. Kamal, M. Hill, S. Carpendale, TimeSpan: Using Visualization to Explore Temporal Multi-dimensional Data of Stroke Patients, IEEE Trans. Vis. Comput. Graph. 22 (2016) 409–418.
43. J.I. Westbrook, L. Li, A. Georgiou, R. Paoloni, J. Cullen, Impact of an electronic medication management system on hospital doctors' and nurses' work: A controlled pre-post, time and motion study., J. Am. Med. Inform. Assoc. 20 (2013) 1150–8.

44. C. Sinsky, L. Colligan, L. Li, M. Prgomet, S. Reynolds, L. Goeders, J. Westbrook, M. Tutty, G. Blike, Allocation of physician time in ambulatory practice: A time and motion study in 4 specialties, Ann. Intern. Med. 165 (2016) 753–760.
45. P.-Y. Yen, M. Kelley, M. Lopetegui, A.L. Rosado, E.M. Migliore, E.M. Chipps, J. Buck, Understanding and Visualizing Multitasking and Task Switching Activities: A Time Motion Study to Capture Nursing Workflow., AMIA ... Annu. Symp. Proceedings. AMIA Symp. 2016 (2016) 1264–1273
46. Willibrordus Martinus Pancratius van der Aalst. 1999. Formalization and Verification of Event-driven Process Chains. Information & Software Technology 41, 10 (1999), 639–650
47. Matthias Weidlich, Gero Decker, Alexander Großkopf, and Mathias Weske. 2008. BPEL to BPMN: The Myth of a Straight-Forward Mapping. In OTM Conferences (1) (Lecture Notes in Computer Science), Robert Meersman and Zahir Tari (Eds.), Vol. 5331. Springer, 265–282.
48. OMG. 2011. Documents associated with Business Process Model and Notation (BPMN), Version 2.0. Technical Report. Object Management Group (OMG)/Business Process Management Initiative (BPMI). http://www.omg.org/ spec/BPMN/2.0/ accessed: 7 August, 2017
49. Stuart Russel and Peter Norvig. 2003. Artificial Intelligence - a modern approach. Pearson Education.
50. Andrey Markov. 1971 (1906). Extension of the Limit Theorems of Probability Theory to a Sum of Variables Connected in a Chain. In Dynamic Probabilistic Systems (Volume I: Markov Models), R. Howard (Ed.). John Wiley & Sons, Inc., New York City, Chapter Appendix B, 552–577
51. Kurt Jensen and Grzegorz Rozenberg (Eds.). 1991. High-level Petri Nets: Theory and Application. Springer-Verlag, London, UK.
52. M. Hughes, E. R. Carson, M. Makhlouf, C. J. Morgan, and R. Summers. 1998. A Petri net based model of patient-flows in a progressive patient-care system. In Proceedings of the 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. Vol.20 Biomedical Engineering Towards the Year 2000 and Beyond (Cat. No.98CH36286), Vol. 6. 3048–3051 vol.6. https://doi.org/10.1109/ IEMBS.1998.746134
53. Cristiano Bertolini, Zhiming Liu, and Jiří Srba. 2013. Verification of Timed Healthcare Workflows Using Component Timed-Arc Petri Nets. In Foundations of Health Information Engineering and Systems: Second International Symposium, FHIES 2012, Paris, France, August 27-28, 2012. Revised Selected Papers, Jens Weber and Isabelle Perseil (Eds.). Springer, Berlin, Heidelberg, 19–36
54. V. Augusto and X. Xie. 2014. A Modeling and Simulation Framework for Health Care Systems. IEEE Transactions on Systems, Man, and Cybernetics: Systems 44, 1 (Jan 2014), 30–46.
55. M. P. Fanti, A. M. Mangini, W. Ukovic, J. J. Lesage, and K. Viard. 2014. A Petri net model of an integrated system for the Health Care At Home management. In 2014 IEEE International Conference on Automation Science and Engineering (CASE). 582–587.
56. M. P. Fanti, A. M. Mangini, W. Ukovic, J. J. Lesage, and K. Viard. 2014. A Petri net model of an integrated system for the Health Care At Home management. In 2014 IEEE International Conference on Automation Science and Engineering (CASE). 582–587.
57. Cristian Mahulea, Liliana Mahulea, Juan Manuel García Soriano, and José Manuel Colom. 2017. Modular Petri net modeling of healthcare systems. Flexible Services and Manufacturing Journal (11 Mar 2017), 1–29. https://doi.org/10.1007/ s10696-017-9283-9

58. Cristian Mahulea, Liliana Mahulea, José Manuel GarcÃa-Soriano, and JoséManuel Colom. 2014. Petri nets with resources for modeling primary healthcare systems. In 2014 18th International Conference on System Theory, Control and Computing (ICSTCC). 639–644.
59. Bettinelli, G.; Delmastro, E.; Salvato, D.; Salini, V.; Placella, G. Orthopaedic patient workflow in CoViD-19 pandemic in Italy. J. Orthop. 2020, 22, 158–159. [CrossRef] [PubMed]
60. Wei, W.; Zheng, D.; Lei, Y.; Wu, S.; Verma, V.; Liu, Y.; Wei, X.; Bi, J.; Hu, D.; Han, G. Radiotherapy workflow and protection procedures during the Coronavirus Disease 2019 (COVID-19) outbreak: Experience of the Hubei Cancer Hospital in Wuhan, China. Radiother. Oncol. 2020, 148, 203–210. [CrossRef]
61. Diaz, M.C.G.; Dawson, K. Use of simulation to develop a COVID-19 resuscitation process in a pediatric emergency department. Am. J. Infect. Control 2020, 48, 1244–1247. [CrossRef] [PubMed]
62. Das, A. Impact of the COVID-19 pandemic on the workflow of an ambulatory endoscopy center: An assessment by discrete event simulation. Gastrointest. Endosc. 2020, 92, 914–924. [CrossRef] [PubMed]
63. Gephart S, Carrington JM, Finley B. A systematic review of nurses' experiences with unintended consequences when using the electronic health record. Nurs Adm Q. 2015;39:345–56.
64. Kuziemsky CE, Randell R, Borycki EM. Understanding unintended consequences and health information technology: contribution from the IMIA Organizational and Social Issues Working Group. Yearb Med Inform. 2016:53–60.
65. Ash JS, Sittig DF, Campbell E, Guappone K, Dykstra RH. An unintended consequence of CPOE implementation: shifts in power, control, and autonomy. AMIA Annu Symp Proc. 2006:11–5.
66. Yen P-Y, Kelley M, Lopetegui M, Rosado AL, Migliore EM, Chipps EM, Buck J. Understanding and visualizing multitasking and task switching activities: a time motion study to capture nursing workflow. AMIA Annu Symp Proc. 2017;2016:1264–73.
67. Coiera E. Technology, cognition and error. BMJ Qual Saf. 2015;24:417–22. https://doi.org/10.1136/bmjqs-2014-003484.
68. Gephart SM, Bristol AA, Dye JL, Finley BA, Carrington JM. Validity and reliability of a new measure of nursing experience with unintended consequences of electronic health records. Comput Inform Nurs. 2016;34(10):436–47.
69. Van den HB, Hafkamp L. Dealing with dissonance: misfits between an EHR system and medical work practices. ICIS 2017 Proceedings; 2017. p. 0–17.
70. Zadeh PE, Tremblay MC. A review of the literature and proposed classification on e-prescribing: functions, assimilation stages, benefits, concerns, and risks. Res Social Adm Pharm. 2016;12:1– 19.
71. Zheng K, Haftel HM, Hirschl RB, O'Reilly M, Hanauer DA. Quantifying the impact of health IT implementations on clinical workflow: a new methodological perspective. J Am Med Inform Assoc. 2010a;17:454–61.
72. Ramaiah M, Subrahmanian E, Sriram RD, Lide BB. Workflow and electronic health records in small medical practices. Perspect Health Inf Manag. 2012;9:1d.
73. Nanji KC, Rothschild JM, Boehne JJ, Keohane CA, Ash JS, Poon EG. Unrealized potential and residual consequences of electronic prescribing on pharmacy workflow in the outpatient pharmacy. J Am Med Inform Assoc. 2014;21:481–6.

74. Sergeeva A, Aij K, Van Den Hooff B, Huysman M. Mobile devices in the operating room: intended and unintended consequences for nurses' work. Health Informatics J. 2016;22:1101–10.
75. Wu RC, Lo V, Morra D, Wong BM, Sargeant R, Locke K, Cavalcanti R, Quan SD, Rossos P, Tran K, Cheung M. The intended and unintended consequences of communication systems on general internal medicine inpatient care delivery: a prospective observational case study of five teaching hospitals. J Am Med Inform Assoc. 2013;20:766–77.
76. Cifuentes M, Davis M, Fernald D, Gunn R, Dickinson P, Cohen DJ. Electronic health record challenges, workarounds, and solutions observed in practices integrating behavioral health and primary care. J Am Board Fam Med. 2015;28:S63–72.
77. Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. Types of unintended consequences related to computerized provider order entry. J Am Med Inform Assoc. 2006;13:547–56.
78. Sittig DR, Krall M, Kaalaas-Sittg J, Ash JS. Emotional aspects of computer-based provider order entry: a qualitative study. J Am Med Inform Assoc. 2005;12:561–8.
79. Menon S, Murphy DR, Singh H, Meyer AND, Sittig DF. Workarounds and test results follow-up in electronic health record-based primary care. Appl Clin Inform. 2016;7:543–59.
80. Cresswell KM, Mozaffar H, Lee L, Williams R, Sheikh A. Workarounds to hospital electronic prescribing systems: a qualitative study in English hospitals. BMJ Qual Saf. 2017;26:542–51.
81. Ser G, Robertson A, Sheikh A. A qualitative exploration of workarounds related to the implementation of national electronic health records in early adopter mental health hospitals. PLoS One. 2014;9:e77669.
82. Salahuddin L, Abidin WZ, Ismail Z. A systematic literature review on safe health information technology use. J Teknol. 2016;78:1–7.
83. Eikey EV, Murphy AR, Reddy MC, Xu H. Designing for privacy management in hospitals: understanding the gap between user activities and IT staff's understandings. Int J Med Inform. 2015;84:1065–75.
84. Voshall B, Piscotty R, Lawrence J, Targosz M. Barcode medication administration work-arounds. J Nurs Adm. 2013;43:530–5.
85. Pirnejad H, Bal R, Shahsavar N. The nature of unintended effects of Health Information Systems concerning patient safety: a systematic review with thematic synthesis. Stud Health Technol Inform. 2010;160:719–23.
86. Schiff GD, Hickman TTT, Volk LA, Bates DW, Wright A. Computerised prescribing for safer medication ordering: still a work in progress. BMJ Qual Saf. 2016;25:315–9.
87. Chao CA. The impact of electronic health records on collaborative work routines: a narrative network analysis. Int J Med Inform. 2016;94:100–11.
88. Coiera E. Technology, cognition and error. BMJ Qual Saf. 2015;24:417–22.
89. Chen Y, Xu H. Privacy management in dynamic groups: understanding information privacy in medical practices. In: CSCW 2013; 2013.
90. Murphy AR, Reddy MC. Privacy practices in collaborative environments: a study of emergency department staff. In: Proc 17th ACM Conf Comput Support Coop Work Soc Comput; 2014. p. 269–82.