

# Impact of Health Informatics Implementation on Clinical Workflow: A Review

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**Abstract—** This paper reviews the literature on health informatics implementation in actual hospital settings. The aims are to find out (1) the impact of implementation of Health Informatics Applications (HIAs) on clinical workflows and work processes of its users in various clinical settings and (2) the type of workarounds needed to be performed by its users to bypass the system limitations. A literature search was conducted on four electronic databases: Pubmed/Medline, ScienceDirect, Web of Knowledge and Scopus. The poor integration of HIAs with the clinical workflow and/or incompatibility of the HIA design with the clinical users' actual workflows might lead to the use of workarounds, increase in user cognitive load, introduction of unnecessary, additional non-medical tasks, redundancy of documentation or work and reduced collaboration. It is therefore necessary that the HIAs should have minimal negative impact on user current workflows and work processes.

**Index Terms—** Computerized health information system, medical record systems, health informatics, workflow impact

## I. INTRODUCTION

The integration of Health Informatics Applications (HIAs) into clinical workflow and its environment is necessary in order to reap the full benefits of the technology. Healthcare environment comprises the workflows and work processes of health professionals/providers responsible for delivering patient care. Thus, such integration should have minimal interference with the clinical workflow. Studies have investigated how HIAs implementation has negatively or adversely impacted workflow of its clinicians before, during and after implementation [1-4]. Among the workflow issues or concerns that have impacted on patient care delivery through the use of HIAs are: the need to unnecessarily maneuver different screens, templates and forms [5], the need to manage alerts or pop-ups [5], the need to have typing ability [5, 6], the need to enter data during patient interaction [4], the need to perform tasks that are not part of clinical workflows [5, 7], disruption or change of clinicians autonomy and power structure [8], inconvenience locations of computer terminal [9] and changes to team coordination and communication patterns [10]. Some of

these workflow issues had contributed to more or new works being introduced that consequently resulted in unfavorable workflow changes.

Unfavorable workflow changes might include healthcare delivery that is more complex thus increasing risks and errors, as reported in [11]. The introduction of workflow blocks thus necessitating the need for system workarounds, is also another consequence of improper integration [5, 12, 13]. Communication breakdown might also happened such as reported in [12] and also work redundancies or work duplication as reported in [7].

A large number of studies have been undertaken to measure and evaluate the impact of the implementation of HIAs on cost and quality of patient care [14, 15], error prevention [16-18], health providers' satisfaction [19] and patient outcomes [14, 20] but there are relatively few studies on the impact of the implementation on clinical workflow [7, 21-23]. This paper presents a review of literature on the impact of HIAs implementation on work processes and work practices of its users from socio-technical perspectives. The aim of the review is to examine: (1) the impact of HIAs implementation of various clinical settings on clinical workflows and work processes of its users and (2) the type of workarounds needed to be performed by its users to bypass the system limitations. HIAs include electronic records, Computerized Patient Order Entry (CPOE), clinical dashboards, clinical documentation systems, radiology information systems and patient information systems of various clinical settings such as emergency care, critical care and in-patient wards. This paper is a part of a larger study to investigate the impact of the implementation of HIAs on clinical workflows and work processes of HIAs' users.

## II. MATERIALS AND METHODS

### A. Data Sources

A literature search was conducted on four electronic databases: Pubmed/Medline, ScienceDirect, Web of Knowledge and Scopus. Keywords used include Electronic Medical Records (EMR), Electronic Personal Records (EPR), Electronic Health Records (EHR), Health Informatics Applications (HIAs), health informatics, medical informatics, workload, workflow, work processes, adoption. A combination of free-text and keywords were also used, for example health records and workflow, impact of HIAs, emergency department workflow and clinical workflow.

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Related citations provided by these articles were also reviewed. No date restriction was applied but the search was restricted to articles that were published in English.

### B. Study Selection

Papers that were selected are based on the following criteria: (1) description of the impact the HIAs have on clinical workflow and work processes, (2) the study was carried out in actual hospital settings, (3) description of unintended consequences such as medical errors (if any), (4) description of workflow blocks generated and workarounds needed to be performed (if any) and (5) the results of the study were analyzed qualitatively and quantitatively. These selection criteria allow the investigation of socio-technical issues that span multiple care settings and evaluation of inputs from various user groups in terms of their experiences in using and interacting with health information systems [24, 25]. In addition, it was found that qualitative observation was the most common method used for workflow studies as indicated in Table I. In qualitative observation, issues such as users' work activities, interruption and coordination among users are observed. In addition, opportunistic interviews and interviews were carried out to better clarify observed activities and to gain a better understanding of the issues. Quantitative methods were not completely excluded as some of the studies were using both methods. This method allows evaluation of data that requires a statistical approach such as data related to time, i.e., time using the computer, time to perform clinical tasks and idle time (time motion study).

## III. RESULT

The findings described in TABLE I are actual HIAs implementation in various hospital settings. The table is organized in such a way that describes how the HIAs are used in the clinical setting and the intended consequences such as workarounds performed to 'bypass' or to "get around" the system limitations.

## IV. DISCUSSION

The poor integration of HIAs design with the clinical workflow and/or incompatibility of the HIAs design with the clinical users' actual workflows might lead to unintended consequences such as the need to perform workarounds that might lead to medical errors thus jeopardizing patient safety, increased users cognitive load, increased need for multitasking, increased redundancy or duplication of work, decreased team work and coordination, and increased workload or the introduction of administrative workload for clinical users.

Various HIAs in different settings require each to be evaluated separately in terms of requirements of the settings. A HIA implementation, for example, in critical care and emergency department that serve multiple care providers, team work and coordination are important aspects to be considered when designing information systems in these settings. HIAs, such as electronic records, that are used in normal hospital wards in comparisons to ICU might also be significantly different. For example, ICU nurses are required to be well informed about patient conditions and the technology used, such as the display technology must be able to create alerts.

HIAs that are implemented correctly may improve clinical care. For example, in [26] the drug prescribing practice of physicians for in-patients at an urban hospital was improved by the use of CPOE. This is possible by having recommendations and guidelines available to the physicians at the appropriate time during their interactions with the CPOE. However, there is also resistance from this type of alert pop-ups such as demonstrated by the study in [13] in which workarounds are performed to 'get around' the system alerts. Another example of a successful fully integrated system used in a hospital was discussed in [27]. Although the success of the information system (known as Brigham Integrated Computing System) is partly contributed by how the system managed to provide workflow support by having programs and screens that are based on actual clinical works, however the order entry and ambulatory record applications have caused a significant change in the work processes of their users.

Further research is necessary to study clinical workflow in different settings and how the used of HIAs have impacted the workflow and its users' work processes. The findings could be used to design specific HIAs for a particular setting based on the needs of the setting. Workflow studies might be useful in investigating how clinicians and non-clinicians work collaboratively and communicating with each other in delivering patient care. The study on interactions of clinical and non-clinical users with HIAs and the information need of these users might also be useful in designing programs and screens that are able to support the actual workflows and work processes.

## V. CONCLUSION

It can be concluded from this review that, in order to enhance HIAs adoption, the implementation must be well integrated into clinical workflows and work processes of its intended users. Redesign or re-engineering of work processes and/or HIAs that are designed appropriately to depict the actual work of its users is required for successful implementation. It is also necessary to realize that a one-size-fit-all solution might not be possible as different care settings come with myriad of clinical workflows that are unique for that environment and its users.

TABLE I  
COMPARISON OF HIAs AND ITS SETTINGS

HIA	Setting	Process change	Unintended consequences / workarounds	Method	Article
PCIS - Order entry systems - Medical record systems - Radiology information systems - Patient information systems	- US, Australia & Dutch hospitals	- Entry of information into the computer system vs. direct communication with other providers - Alerts to new orders via printers vs. direct communication via phone - Entering of orders after patient round vs. during patient round	- Information entering & retrieval errors - Communication & coordination errors - In case of emergency, medication is given by nurses before being activated by physician - Entering of medication after it has been administered - Medication ordered by nurses instead of by physician - Automatic triggers & alerts were ignored or turned off	Qualitative method: Observation & semi-structured interviews	(Ash, Berg and Coiera, 2004)
EMR system - Electronic documentation i.e MD notes	- Hospital ED	- Documenting responsibility shifted to resident physician vs. responsibility of attending physician - Use of paper notes (informally) as an aid to transfer information from patient bedside to workstation	- Increased cognitive load of the physician - Increase in resident workload, in turn this reduced amount of collaboration with other providers - Increase charting time - Aggravated physicians' multitasking - Reduced physician-patient interaction & physician-nurses work collaboration	Qualitative method: Observation & semi-structured interviews	(Park, Lee and Chen, 2012)
EMR	- 2 hospital EDs with different reliance on EMR	- Patient's chart comes with physical marker (paper-ED) vs. Colour-coded patient entry (EMR) - Content of patient demographic data such as address and insurance that might change physician work practice (EMR) - Workload distribution is clearly visible on the chart rack (paper-ED) vs. clearly visible continuous work progress monitoring (EMR) - Open-format medication ordering (paper-ED) vs. structured format medication ordering (EMR) - More open customization (paper-ED) vs. used of checkboxes as option for customization (EMR)	- Hinder coordination of parallel work (EMR) - Insufficient log record information such as author identifier & justification for certain actions, might affect continuity of work by multiple providers (EMR)	Qualitative method: Observation	(Feufel, Robinson and Shalin, 2011)

HIA	Setting	Process change	Unintended consequences / workarounds	Method	Article
EMR	- Hospital ED	<ul style="list-style-type: none"> <li>- Physicians used paper records to retrieve patient information and to record details of patient encounter. After patient evaluation information is transfer to EMR</li> <li>- Physicians rely heavily on workstations located in the centre of the ED</li> <li>- The EMR supports multifaceted functionalities i.e clinical &amp; administrative. These functionalities are organized into tabs</li> </ul>	<ul style="list-style-type: none"> <li>- Information loss</li> <li>- Information duplication</li> <li>- Redundancy of physician's effort to record information both on paper &amp; in EMR</li> <li>- Create dependency on paper records if information is not transferred to EMR</li> <li>- Movements between patients' room, nurses' station &amp; central workstation resulted in extra physical &amp; mental (cognitive load) efforts</li> <li>- The tab organization method might cause some information to be hidden</li> <li>- Information on a patient and is fragmented i.e different views for medication, radiology etc, that would take extra clicks to have an overall view of a patient</li> </ul>	Qualitative methods: observation, shadowing, interviews	(Abraham, Kannampallil and Reddy, 2009)
CPOE	- Community & academic hospitals	<ul style="list-style-type: none"> <li>- Use of paper notes (informally) as an aid to transfer information from patient bedside to workstation</li> <li>- More lenient dosage of medication vs. more structured format</li> <li>- 'Automatic' alert to the nurses when prescription is paper written by physician vs. no automated alert by the CPOE when physician entered an order</li> <li>- Verifying orders by nurses vs. verifying orders by pharmacists once prescription is ordered by physician</li> <li>- In academic hospitals: Orders are done collaboratively by resident &amp; attending physicians vs. entering orders solely by attending physicians</li> </ul>	- Reduced collaboration among healthcare providers	Qualitative method: semi-structured interview	(Aarts, Ash and Berg, 2007)
CPOE & computerized documentation system	- ED of a hospital	<ul style="list-style-type: none"> <li>- Standardize &amp; structured documentation</li> <li>- Elimination of intermediary steps in laboratory order &amp; radiology order processing</li> <li>- Decreased number of verbal orders.</li> <li>- Decreased need to search for charts</li> </ul>	- Order icon that remained unchanged after medications were administered would result in users not being able to recognise new orders	Qualitative method: Questionnaires & observation in time motion study	(Banet, et al., 2006)

HIA	Setting	Process change	Unintended consequences / workarounds	Method	Article
Barcode medication administration	- Acute and long-term care of small, medium & large hospitals	<ul style="list-style-type: none"> <li>- For patient identification process, the nurse scans a SSN bar-coded patient's wristband that would bring up the medication record</li> <li>- For medication administration process, all medications due for a particular patient is scanned, the medications are then poured into a labelled cup and finally given to the patient</li> </ul>	<ul style="list-style-type: none"> <li>- Nurses bypass actual patient identification process by typing patient SSN or scanning a "surrogate" wristband that is not on the patient</li> <li>- Medications are administered to several patients before actual medication scanning takes place</li> </ul>	Qualitative method: observation & opportunistic interviews	(Patterson, et al., 2006)
CPOE	- ICU of a hospital	<ul style="list-style-type: none"> <li>- Nurses to write physician verbal orders vs. orders submitted &amp; signed by physicians only</li> <li>- Nurses were able to verify orders to patient bedside or by viewing paper chart vs. checking verification at terminals not located at patient bedside</li> <li>- Nurses to administer medication before orders were send vs. medication orders need to be submitted first by physician via the CPOE</li> <li>- Unstructured paper medication order vs. very structured medication order</li> </ul>	<ul style="list-style-type: none"> <li>- Delay in paper printout for medication already supplied to be given to bedside nurses would result in delays in administering the medication</li> <li>- Other physicians are able to submit orders for patients not directly under their care i.e on behalf of other physicians</li> <li>- Physical location of computer terminals for physician to enter medication orders created workflow disruption by increasing cognitive workload</li> <li>- Logging inconvenience because of time-out resulted in physicians 'logging-in' with other physician's credentials</li> </ul>	Qualitative method: observation	(Cheng, et al., 2003)
Electronic medication administration record (eMAR)	- 5 nursing homes	<ul style="list-style-type: none"> <li>- A touch screen application accessed through wireless laptops,</li> <li>- With alerts that warned the users of potential medication safety issues</li> <li>- Require the users to record both medication preparation and medication administration documents (dual documentations)</li> <li>- After each medication order, individual sheet of paper is printed and faxed to pharmacy</li> </ul>	<ul style="list-style-type: none"> <li>- If an alert warned regarding excessive order of medication, the user would submit multiple orders of the same medication to achieve the full dose</li> <li>- Both preparation &amp; administration documents are prepared before actual medication is administered</li> <li>- Cumbersome fax communication between nursing homes &amp; pharmacy resulted in medication order without the use eMAR &amp; generating a lot of phone communications</li> <li>- Cumbersome application screens resulted in the use of paper &amp; communication with other staff to obtain patients' information</li> <li>- Some users would simply administered medication without performing any steps for medication ordering</li> </ul>	Qualitative methods: observation, interviews, field notes review & process mapping	(Vogelsmeier, Halbesleben and Scott-Cawiezell, 2008)

HIA	Setting	Process change	Unintended consequences / workarounds	Method	Article
Clinical documentation (known as Electronic Admission Referral Process), decision support & workflow tools	- A suburban hospital & an urban hospital	<ul style="list-style-type: none"> <li>- Information on patient requiring an admission, data on the patient is recorded by an admission nurse using wireless computer at patient bedside while interviewing the patient &amp; reviewing paper documents</li> <li>- Online admission document has over 80 data items in which patient's previous admission details are pulled to populate many of the field items. Approximately 12 to 18 minutes is required for the process</li> <li>- The decision support rules are activated once the nurse electronically signed the online form resulting in any of the 11 ancillary departments being notified</li> <li>- The ancillary department maintain its own online work lists in addition to the admission's list created from the nurses' online admission. The work lists enable prioritization and accountability for each of the ancillary departments</li> <li>- Once the task from each of the departments, the original order created during admission is marked as 'complete' with notification sent to all department involved for that particular order</li> </ul>	<ul style="list-style-type: none"> <li>- Data on surgical patients are not completely aligned with the online admission form</li> <li>- Issue with patient encounter while completing the online forms</li> <li>- Data from emergency department not fully integrated resulting in duplicate documentation</li> <li>- Ancillary departments need to understand what the admission nurses' need in order to gain meaning and context of the received notifications</li> </ul>	Qualitative methods: observation, interviews	(Guite, et al., 2006)

HIA	Setting	Process change	Unintended consequences / workarounds	Method	Article
CPOE	- Five hospitals (county, partners & community)	<ul style="list-style-type: none"> <li>- Physicians entering orders for several patients at once vs. handwritten orders one after another after patient encounter</li> <li>- Structured documentation for e.g. default selection which is the least expensive option</li> <li>- Tracking of physicians ordering patterns</li> <li>- Information on costs of medication and test to discourage use of expensive ones</li> <li>- .Pop-ups alerts during ordering</li> </ul>	<ul style="list-style-type: none"> <li>- Shifts in power structure</li> <li>- (Perceived) loss of control by the physicians</li> </ul>	Qualitative methods: observation & interviews	(Ash, et al., 2006)
Computerised consultation management	- 9 specialty clinics & three primary care clinics	<ul style="list-style-type: none"> <li>- The primary care providers use templates designed by specialty service (if any) to request for consultation. The receiving specialist is notified and can either deny the consultation or schedule the patients to be seen</li> <li>- Papers are still being used, for example to view consult details, to track all the active consults or because greater trust is placed on printed consultations compared to computerised system</li> <li>- Use of Excel spreadsheet (that is separate from the system) to track active consultations which allow the clinic to have greater flexibility and functionality</li> </ul>	<ul style="list-style-type: none"> <li>- Used of paper documentation by the specialists may result in gaps in EHR or/and produced unverified medical orders if it is not electronically signed or scanned into the system</li> <li>- Paper-based consults that may be sent directly to speciality clinics without completing the required template of the computerised system</li> <li>- Communication breakdown: 1) primary care staff are not always notified when the consultations are completed, 2) patients are expected to schedule consultation with the speciality clinic but do not do so, 3) consultation request being directed to wrong speciality clinic and 4) priority of the consultation not communicated to speciality clinics</li> </ul>	(Qualitative method: Observation & semi-structured interviews)	(Saleem, et al., 2011)

HIA	Setting	Process change	Unintended consequences / workarounds	Method	Article
Clinical dashboard	- Operating room & ICU	<ul style="list-style-type: none"> <li>- Operating room: <ul style="list-style-type: none"> <li>1) Data reflects patient transition from one stage of surgery to another i.e. all stages (data: patient information, OR team members), pre-operative stage (data: supplies, surgeon preferences), operative stage (data: physiological status, surgical equipment readings)</li> <li>2) unobtrusive to the physician performing surgery</li> </ul> </li> <li>- Critical care: <ul style="list-style-type: none"> <li>1) Data that provides continuous care for multiple providers that change according to working shifts</li> <li>2) Patients are relatively located at the same bed of the ward</li> <li>3) Real-time patients that can create trigger or alarm (obtrusive)</li> </ul> </li> </ul>	- Not stated -	Methodology not stated	(Egan, 2006)
EPR	- Neurological ward	<ul style="list-style-type: none"> <li>- Medication orders solely performed by doctors vs. by nurses</li> <li>- More time needed for doctors to order medication</li> <li>- Nurses can no longer administer medication before the doctors submitting medication order</li> <li>- Searching of information requiring the nurses to navigate different menus in which switching between menus are not possible</li> <li>- Used of prefixed words limit the ability to provide detail description of patients' psychological, social or emotional condition</li> </ul>	<ul style="list-style-type: none"> <li>- In case of emergency, 'agent for' order can be used by nurses to order medication but the nurses are also using it in non-emergency situations</li> <li>- Because switching between menus is not possible, nurses have to use two computers simultaneously to speed up information seeking process</li> </ul>	Qualitative methods: Interviews & Observation	(Goorman and Berg, 2000)



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