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Cognitive workload changes for nurses transitioning from a legacy system with paper documentation to a commercial electronic health record

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ABSTRACT

Objective: Healthcare institutions worldwide are moving to electronic health records (EHRs). These transitions are particularly numerous in the US where healthcare systems are purchasing and implementing commercial EHRs to fulfill federal requirements. Despite the central role of EHRs to workflow, the cognitive impact of these transitions on the workforce has not been widely studied. This study assesses the changes in cognitive workload among pediatric nurses during data entry and retrieval tasks during transition from a hybrid electronic and paper information system to a commercial EHR.

Materials and methods: Baseline demographics and computer attitude and skills scores were obtained from 74 pediatric nurses in two wards. They also completed an established and validated instrument, the NASA-TLX, that is designed to measure cognitive workload; this instrument was used to evaluate cognitive workload of data entry and retrieval. The NASA-TLX was administered at baseline (*pre*-implementation), 1, 5 and 10 shifts and 4 months *post*-implementation of the new EHR.

Results: Most nurse participants experienced significant increases of cognitive workload at 1 and 5 shifts after "go-live". These increases abated at differing rates predicted by participants' computer attitudes scores ($p = 0.01$).

Conclusions: There is substantially increased cognitive workload for nurses during the early phases (1–5 shifts) of EHR transitions. Health systems should anticipate variability across workers adapting to "meaningful use" EHRs. "One-size-fits-all" training strategies may not be suitable and longer periods of technical support may be necessary for some workers.

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1. Introduction

Hospitals around the world have been and are transitioning to electronic health records (EHRs). In the US, the federal government set criteria for implementation and use of EHRS ("meaningful use") and reduced reimbursements to healthcare institutions who failed to meet sequential meaningful use deadlines. In 2012, approximately 40% of US hospitals met stage 1 "meaningful use" (data capture criteria) and only 5% met stage 2 "meaningful use" (advance clinical processes) [1]. In order to avoid reduced reimbursements through failure to meet meaningful use stages by certain deadlines, the remaining US hospitals are likely to purchase and implement commercial EHR products certified to meet "meaningful use" objectives [2].

1.1. *Commercial EHRs and "top-down" implementations*

Commercial EHRs are built by vendors that may have originally designed their system for billing purposes. In the US, these vendors have added functionalities to their established platform in order to meet specific meaningful use criteria. When these EHRs are implemented, administrations disable the legacy system and transition all workers to use of the commercial product ("top-down" implementation). A commercial EHR differs from a "home-grown" EHR that is introduced to a clinical workforce gradually (whose rate of adoption provides feedback to the developers), and iteratively improved as workflows and technology mutually adapt [2]. In mandated implementations, worker *adoption* of new technology is moot [3]; workers cannot work if they do not use the new technology. In this setting, worker *adaptation* to new technology, adjusting their workflow to the new tool, may better describe the process. During a period of adaptation, workers must gain new technology skills as well as adapt established workflows to accommodate the mandated EHR.

EHR implementations may present challenges to patient safety and healthcare workflow. The effects of such implementations on patient outcomes and safety are relatively unknown [4–6], and while EHRs are often touted as bringing safety benefits, they can bring unintended negative consequences [7–9]. A systematic review of decision support systems suggests that maximum benefit of such support is achieved when a system is developed locally and gains gradual acceptance by staff [7]. Adaptation of technology to staff behavior through iterative design promotes successful adoption of health IT [10,11], whereas mandated implementations can be hindered by poor staff acceptance [12–16]. Rapid implementation thus raises safety concerns [17,18].

1.2. *Impact of large health information technology transitions*

Large health information technology implementations bring a massive and rapid change to practice and can lead to physical, mental, and emotional exhaustion of a workforce [3,4]. The workforce that actually interacts with the patient at the point of care is considered to practice at the "sharp end" of the health system [19] and includes nurses who are physically and temporally close to the patient and the care. Changing work demands at the "sharp end" due to EHRs have been noted to increase work stress amongst nurses [20,21]. Nursing work is cognitively demanding, requiring effective prioritization of tasks and little margin for error [22]. Additionally, nurses describe losing track of their patients as they concentrate on learning a new technology system [12,13,23]. Consequently, altering the cognitive load of routine nursing tasks may affect care and patient safety.

A report from the AMIA 2009 Health Policy Meeting focusing on unintended and unanticipated consequences of health IT and policy called for research on human factors and cognition [24]. The science of human factors instructs that "computing technology and artifacts are integral parts of [the] cognitive process and should be designed to correspond to human characteristics of reasoning, memory, attention, and constraints (human-centered design" [25]. Only a few studies have looked at the impact of EHRs at the "sharp end" from a cognitive view [4,26–28].

1.3. *Goal of study*

We studied the immediate impact on pediatric hospital nurses as they transitioned from a legacy system with paper documentation to a commercial EHR that was implemented in a top-down manner. Seeking a quantitative and reliable measure, we chose an instrument developed and validated by NASA, the Task Load Index (NASA-TLX) [29], to measure workload. We studied serial cognitive workloads for data retrieval and entry (documentation) tasks experienced by pediatric nurses in two ward settings before and at multiple intervals after the workplace introduction of the new system ("go-live"). We hypothesized that NASA-TLX scores would increase immediately after the introduction of the new system, and then decrease. However, we wished to study how high scores would rise, for how long, and if they rose, would they eventually return to baseline, or a different level. We also measured additional variables to see if we could predict this pattern for different individuals.

2. Materials and methods

2.1. *Study setting*

The institution studied is a 131-bed Children's Hospital within an academic tertiary care healthcare system. Nurse participants worked on either an inpatient ward ("Ward") or a neonatal intensive care unit ("NICU"). For three decades, this system relied on a hybrid electronic and paper information system. A computerized practitioner order entry (CPOE) had been used since the 1970s (Medical Information System, or MIS), and independent lab and radiology (PACS) electronic systems had been added later. Clinical documentation was paper-based and each patient had a binder with their documentation hole-punched and inserted. In March 2011, the legacy computer systems and paper documentation were discontinued and all in-patient units went "live" over one night with a comprehensive commercial EHR.