



Special Communication

Development and classification of a robust inventory of near real-time outcome measurements for assessing information technology interventions in health care



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ABSTRACT

Objective: To develop and classify an inventory of near real-time outcome measures for assessing information technology (IT) interventions in health care and assess their relevance as perceived by experts in the field.

Materials and methods: To verify the robustness and coverage of a previously published inventory of measures and taxonomy, we conducted semi-structured interviews with clinical and administrative leaders from a large care delivery system to collect suggestions of outcome measures that can be calculated with data available in electronic format for near real-time monitoring of EHR implementations. We combined these measures with the most commonly reported in the literature. We then conducted two online surveys with subject-matter experts to collect their perceptions of the relevance of the measures, and identify other potentially relevant measures.

Results: With input from experienced health care leaders and informaticists, we developed an inventory of 102 outcome measures. These measures were classified into a taxonomy of commonly used measures around the categories of quality, productivity, and safety. Safety measures were rated as most relevant by subject-matter experts, especially those measuring medication processes. Clinician satisfaction and measures assessing mean time to complete tasks and time spent on electronic documentation were also rated as highly relevant.

Discussion: By expanding the coverage of our previously published inventory and taxonomy, we expect to help providers, health IT vendors and researchers to more effectively and consistently monitor the impact of EHR implementations in near real-time, and report more standardized outcomes in future studies. We identified several measures not commonly assessed by previous studies of IT implementations, especially those of safety and productivity, which deserve more attention from the broader informatics community. **Conclusion:** Our inventory of measures and taxonomy will help researchers identify gaps in their measurement approaches and report more standardized measurements of IT interventions that could be shared among researchers, hopefully facilitating comparison across future studies and increasing our understanding of the impact of IT interventions in health care.

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1. Background and significance

Positive outcomes associated with Electronic Health Record (EHR) systems adoption in both ambulatory and non-ambulatory settings [1–8], and financial incentives provided by the Centers

for Medicare and Medicaid (CMS) Meaningful Use program, contributed to unprecedented EHR adoption in the U.S. [9]. In 2009, EHR adoption among office-based physicians was estimated to be 48% [10]; after implementation of Meaningful Use Stage 1, studies of the same population demonstrated that adoption had increased to 72% [11]. The observed changes in adoption and use of EHR systems have also contributed to an increasing number of studies assessing the impact on clinical practice of health information technology (health IT) adoption. Several studies evaluating the

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impact of such interventions have been published in the last decades, and were discussed by a sequence of recent systematic reviews [12–15]. In one of the reviews, Buntin et al. [14] identified that studies at settings that implemented EHRs containing more functionality required by the Meaningful Use criteria, observed more positive findings as compared to those with less functionality. In another recent study commissioned by the Office of the National Coordinator for Health IT (ONC), Jones et al. [15] concluded that most studies evaluating health IT adoption projects report positive outcomes. However, despite the increasing number of positive findings, Jones et al. concluded that the results of current research are still mixed, failing to increase our understanding of the effectiveness of IT interventions in health care settings. According to their analysis, more information and evidence are necessary to understand why some organizations thrive, while others struggle when adopting health IT tools. Possible contributing factors to these gaps include insufficient information describing the implementation settings, implementation strategy and EHR capabilities, and inconsistent sets of outcome measurements [15]. In a first attempt to fill these gaps, we identified the outcome measures most commonly reported in the studies reviewed by Jones et al. and developed a taxonomy of measurements. We also identified characteristics of implementation settings and IT interventions reported in those studies [16].

In the present study, we assess if the measures identified in our previous study provide a comprehensive coverage of clinical and administrative processes by interviewing leadership from a large care delivery system implementing a commercial EHR. We identify other measures not commonly reported in the literature. We then combine the new suggested measures with those identified in our previous study, collect subject-matter experts' perceptions of the relevance of these measures, and obtain suggestions for additional measures. We also update our previously published taxonomy with the resulting measures to create an enhanced inventory. Finally, we compare the measures in our inventory to those included in reporting systems commonly required by policy makers and government agencies to assess the potential availability of data required to calculate these measures. We expect that the resulting inventory and taxonomy will help researchers select measures in future studies and identify gaps in their measurement approaches, hopefully facilitating comparison of health IT outcomes across future studies and enabling improved understanding of the impact of IT interventions in health care.

2. Materials and methods

In our previous study [16] we identified the 79 most common measures, reported in the literature, to assess the impact of health IT interventions. Since frequency of use does not necessarily assure usefulness of measure, we followed a multi-method and iterative approach to determine whether those measures provide a comprehensive coverage of clinical and administrative processes that can be impacted by the implementation of a new EHR system. The components of the method include: (1) conduct interviews with clinical and administrative leaders from a large care delivery system implementing a commercial EHR; (2) combine the newly suggested measures with those reported earlier [16] in the literature, to produce an enhanced inventory of measures; (3) collect subject-matter experts' perceptions of the relevance of the combined inventory of measures and identify additional measures suggested by these experts; (4) update our previously published taxonomy with the larger measure inventory; and (5) compare the measures in our inventory to those included in reporting systems commonly required by policy makers and government. These steps are described in detail in the subsequent sections. Fig. 1 illustrates the multi-method approach.

2.1. Step 1 – semi-structured interviews with Intermountain Healthcare leadership

We conducted semi-structured interviews with clinical and administrative leaders at Intermountain Healthcare, a not-for-profit integrated care delivery system of 22 hospitals and over 185 ambulatory care clinics covering the entire state of Utah and southern Idaho. Intermountain is conducting a large commercial EHR implementation, replacing a group of legacy systems developed and operated by Intermountain for several decades [17,18]. The aim of our interviews was to identify measures used to evaluate the impact of this transition to Intermountain's clinical and administrative processes supported by electronic data collected or impacted by their EHR systems. We first selected a convenience sample of interviewees from the Medical Informatics Department, representing eight clinical areas: Behavioral Health, Cardiovascular, Intensive Medicine, Oncology, Pediatrics, Primary Care, Surgical Services, and Women and Newborn. Given the size and complexity of the Intermountain care delivery system, we used snowball sampling [19] to obtain referrals to other potential interviewees. We asked each informant representing the clinical areas above for referrals to other personnel from the same clinical areas, or areas that work in conjunction with them. Interviews were conducted until we had interviewed at least two representatives of each clinical area and/or had no more referrals. In addition to the initial eight clinical areas, we also asked for referrals to employees from other departments such as human resources, risk management, pharmacy, implementation teams, or other departments considered relevant by the interviewees. Interviews were conducted in person or by phone according to the convenience of participants. Interviewees were asked to suggest outcome measures they consider relevant and would recommend to be tracked for monitoring the impact of the EHR implementation over time, and to classify their suggestions into the categories *quality of care*, *productivity* and *patient safety*, according to their use at Intermountain or interviewee's expertise. We considered only measures that can be calculated with data available in electronic format in order to detect the impact of the implementation in near real-time. The complete list of questions can be found in the [online supplement](#).

2.2. Step 2 – development of a compiled inventory of outcome measures

We compared and combined the measures suggested by Intermountain interviewees with the measures reported before [16] as the most commonly used in the literature. This comparison resulted in an expanded inventory of outcome measures.

2.3. Step 3 – online surveys with subject-matter experts

Since the measures in our list include suggestions from leaders of a single care delivery system, we designed two online surveys to collect perceptions of subject-matter experts from around the country. One survey contained measures used in ambulatory settings, and the other included measures used in non-ambulatory settings. The surveys have three parts: Section 1: Respondent information (required); Section 2: Questions about the relevance of proposed outcome measures (required); and Section 3: Open-ended question for suggestions of additional measures (optional). In the questionnaire, a short description of each measure was provided. The measures were grouped by the categories *quality of care*, *productivity*, and *patient safety* according to their classification in our previous study [16] or as suggested by Intermountain interviewees. Respondents were asked to provide their perceptions about the relevance of each proposed measure when used for assessing the impact of EHR implementations in the target setting

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