Journal of Biomedical Informatics 63 (2016) 33–44

Contents lists available at ScienceDirect

Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

Special Communication

Health information technology adoption: Understanding research protocols and outcome measurements for IT interventions in health care

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ARTICLE INFO

Article history:
Received 8 April 2016
Revised 3 June 2016
Accepted 19 July 2016
Available online 20 July 2016

Keywords:
Electronic health records
Medical informatics applications
Adoption
Review

ABSTRACT

Objective: To classify and characterize the variables commonly used to measure the impact of Information Technology (IT) adoption in health care, as well as settings and IT interventions tested, and to guide future research.
Materials and methods: We conducted a descriptive study screening a sample of 236 studies from a previous systematic review to identify outcome measures used and the availability of data to calculate these measures. We also developed a taxonomy of commonly used measures and explored setting characteristics and IT interventions.
Results: Clinical decision support is the most common intervention tested, primarily in non-hospital-based clinics and large academic hospitals. We identified 15 taxa representing the 79 most commonly used measures. Quality of care was the most common category of these measurements with 62 instances, followed by productivity (11 instances) and patient safety (6 instances). Measures used varied according to type of setting, IT intervention and targeted population.
Discussion: This study provides an inventory and a taxonomy of commonly used measures that will help researchers select measures in future studies as well as identify gaps in their measurement approaches. The classification of the other protocol components such as settings and interventions will also help researchers identify underexplored areas of research on the impact of IT interventions in health care.
Conclusion: A more robust and standardized measurement system and more detailed descriptions of interventions and settings are necessary to enable comparison between studies and a better understanding of the impact of IT adoption in health care settings.

1. Background and significance

Health Information Technology (health IT) tools such as Electronic Health Record (EHR) systems have the potential to improve health care outcomes and decrease health care cost [1–3]. Based on previous studies showing such improvements, the U.S. federal government issued an executive order in 2004 to provide financial incentives to increase health IT adoption in the U.S., and five years later the HITECH act was signed into law establishing the Meaningful Use criteria [4,5] as a financial incentive to increase health IT adoption. Such efforts have contributed significantly to increasing EHR adoption in both outpatient and inpatient settings [6]. A basic EHR had been adopted by 48% of office-based physicians in 2013, and by 76% of US hospitals in 2014 [7,8].

Several researchers have assessed the impact of health IT adoption in individual health care settings, and a large number of studies in this area can be found in four systematic reviews covering the period 1995–2013 [9–12]. Research in this area includes studies of interventions in U.S. and non-U.S. ambulatory and non-ambulatory settings with a wide range of characteristics [13–17]. The measurements used to evaluate the effect of the interventions cover many different dimensions of care such as quality of care, efficiency, satisfaction and patient safety.

Although EHR systems comprise a large set of modules and functionality, health IT adoption studies have focused primarily on specific components such as clinical decision support (CDS)

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http://dx.doi.org/10.1016/j.jbi.2016.07.018
1532-0464/

and computerized provider order entry (CPOE) [11,12]. Furthermore, research in this area has shown mixed results of the effectiveness of IT interventions. While some studies show positive results in health care outcomes [18], others show the opposite, even within highly computerized environments [19,20]. In a recent systematic review commissioned by the Office of the National Coordinator for Health IT (ONC), Jones et al. [12] analyzed studies published between 2010 and 2013 and concluded that in addition to mixed results, the current literature has not increased our understanding of the effect of health IT adoption or how it can contribute to improving health care outcomes. Possible contributing factors to these findings include insufficient measurement and reporting of information regarding the implementation and context of health IT use, such as settings, implementation approach, and IT intervention details, as well as the use of non-standardized protocols and simple measurement approaches. Jones and colleagues analyzed and classified the results from the studies according to outcomes (positive or negative), health IT infrastructure (commercial vs. homegrown), and meaningful use functionality used. They did not analyze or categorize the individual outcome measures used to evaluate the effect of IT interventions in health care, nor did they report the characteristics of settings and IT interventions tested. Using the same studies reviewed by Jones et al. [12], here we analyze and categorize the different variables used to evaluate the effectiveness of IT interventions in health care settings. We then use these results to identify potential ways to create a common set of measurements that can be used to evaluate both individual interventions as well as to compare interventions across different settings. We further explore the context of past studies identifying IT interventions tested and the characteristics of settings in which they were examined.

2. Materials and methods

We conducted a descriptive study of the articles included in the review by Jones et al. [12]. We further analyzed these studies according to the following steps: (1) identify the outcome measures used; (2) create a hierarchy and a taxonomy of commonly used measures; (3) compare the measures used in research studies to those commonly required by policy makers and government; and (4) identify characteristics of settings and IT interventions tested. The procedures for these steps are described in the subsequent sections.

2.1. Previous systematic review by Jones et al. [12]

Studies evaluating the impact of IT interventions in health care settings are more commonly available with the increased adoption of EHR systems; as a result, the ONC requested an updated systematic review of such literature. The systematic review was conducted by Jones et al. [12], and the articles included in their final sample are used in the present study for secondary analysis. The search strategy employed by Jones et al. was originally developed by Chaudhry et al. [9], and updated by Goldzweig et al. [10] and Buntin et al. [11]. It includes peer-reviewed, English-language publications evaluating the impact of health IT interventions with functionality encompassed by the meaningful use program. Their final sample includes 236 "hypothesis-testing" and "descriptive quantitative" studies indexed in PubMed covering the period of January 2010 to August 2013. A 5-person technical expert panel guided the systematic review process that included abstracted information about study design; research sites; health IT type (commercial or homegrown); meaningful use functionality; context and implementation details; and study outcomes. Quality appraisal of the studies was performed by dual-review and conflicts were resolved through consensus [12].

2.2. Settings inclusion and exclusion criteria

We excluded studies assessing exclusively specialty care clinics, nursing homes and children's hospitals because these settings are more likely to have patient populations with specific characteristics, and may use specific outcome measures that are not easily generalizable to other settings. Using these exclusion criteria, we first screened the title and abstract of all 236 articles included in Jones et al. [12] original systematic review and excluded 17 studies; in a second screening assessing the methods and results sections we excluded another 11 studies. Fig. 1 presents the procedure for inclusion and exclusion criteria.

2.3. Step 1 - Identification of individual outcome measures

From the 208 studies that fit the inclusion criteria, we identified each individual outcome measure used and mentioned in the methods and/or results sections of the publication. We looked for any measure used as a dependent variable and identified the targeted population. This analysis produced 429 unique measures.

2.4. Step 2 - Development of a taxonomy of commonly used measures

To create a taxonomy of commonly used measures, one of the authors (TKC) first conducted a bottom-up analysis, grouping the measures by similarity into a hierarchy. Similarity was defined by comparing the dependent variables and their targeted populations to identify the variables that measure similar outcomes. In some cases, the terms reported as dependent variables were searched in UpToDate [21] to determine if they are synonyms or if they measure a similar outcome. For example, we searched definitions for the terms "Eye exam", "Retinal exam" and "Retinopathy test" combined with "diabetes mellitus", to determine if they could be labeled as "Diabetic Retinopathy Screening", which was the final term chosen to be used in our hierarchy. We additionally searched some terms in the Systematized Nomenclature of Medicine - Clinical Terms (SNOMED-CT) browser available at the Unified Medical Language System (UMLS) [22], to determine if they are synonyms or share the same parent in the SNOMED-CT hierarchy. Some variables measuring volume of medical orders or health care utilization, such as "laboratory orders" and "readmission rate", were not found in the resources we used and were grouped according to the expert opinion of the authors. Similar to the process used by Wright et al. for creating a taxonomy of CDS tools [23], we conducted a modified Delphi process where the first version of the hierarchy was shared with the study co-authors, who then provided suggestions iteratively until consensus was reached. We also used the Delphi process to reach consensus about the most appropriate nomenclature for each measure, combining the terms used in the included studies, found in online resources, and obtained from the study co-authors. Measures that could not be grouped into a less specific category because they were too specific or unique (used in only one study) were excluded from the hierarchy. After identifying the least specific measures in the highest level of the hierarchy, we grouped them by similarity to identify the taxa that represent these measures. Fig. 2 presents the procedure to identify measures and create the taxonomy, and Fig. 3 provides an example of the bottom-up analysis used to create the hierarchy. Jones et al. [12] classified the studies included in their analysis into three commonly used dimensions of care: quality of care, patient safety and efficiency, according to the aspects of care assessed. In the present study, we refer to the latter as productivity. We categorized the measures included in our hierarchy according to the