



## A six-year repeated evaluation of computerized clinical decision support system user acceptability



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### ABSTRACT

**Objective:** Long-term acceptability among computerized clinical decision support system (CDSS) users in pediatrics is unknown. We examine user acceptance patterns over six years of our continuous computerized CDSS integration and updates.

**Materials and methods:** Users of Child Health Improvement through Computer Automation (CHICA), a CDSS integrated into clinical workflows and used in several urban pediatric community clinics, completed annual surveys including 11 questions covering user acceptability. We compared responses across years within a single healthcare system and between two healthcare systems. We used logistic regression to assess the odds of a favorable response to each question by survey year, clinic role, part-time status, and frequency of CHICA use.

**Results:** Data came from 380 completed surveys between 2011 and 2016. Responses were significantly more favorable for all but one measure by 2016 (OR range 2.90–12.17, all  $p < 0.01$ ). Increasing system maturity was associated with improved perceived function of CHICA (OR range 4.24–7.58,  $p < 0.03$ ). User familiarity was positively associated with perceived CDSS function (OR range 3.44–8.17,  $p < 0.05$ ) and usability (OR range 9.71–15.89,  $p < 0.01$ ) opinions.

**Conclusion:** We present a long-term, repeated follow-up of user acceptability of a CDSS. Favorable opinions of the CDSS were more likely in frequent users, physicians and advanced practitioners, and full-time workers. CHICA acceptability increased as it matured and users become more familiar with it. System quality improvement, user support, and patience are important in achieving wide-ranging, sustainable acceptance of CDSS.

### 1. Introduction

Clinical decision support systems (CDSS) are increasingly integrated into patient care and electronic health record systems. They provide services ranging from simple reminders to complex risk-prediction algorithms. Their efficacy depends on clinician acceptance and use [1–3]. Prior studies have acknowledged the difficulties and successful aspects of implementing computerized CDSS into clinical practice [4].

A large systematic review of CDSS identified 19 CDSS implementation trials that also included provider satisfaction measures [5]. Most described a generally positive user satisfaction, but only four showed significantly improved satisfaction compared to usual care or no CDSS. Six studies reported provider dissatisfaction. Most studies examined CDSS effects over 6–12 months, and only one study described results for more than three years.

A more recent systematic review of factors influencing guideline-

based CDSS implementation identified several knowledge gaps, including user satisfaction and service quality [6]. The authors also did not find any studies reporting on satisfaction with specific CDSS functions or benefits from efficiency or error reduction.

Healthcare technology adoption requires time and institutional effort, and theories such as the Technology Adoption Model illustrate how perceived ease-of-use and perceived usefulness influence adoption [7]. In addition, software-based technology is often updated to fix unanticipated consequences and offer new features. As a result, satisfaction may change over time, necessitating assessment of CDSS acceptability over the long term.

The Child Health Improvement through Computer Automation (CHICA) system is an evidence-based, computerized CDSS that has been in use since 2004 at several urban community clinics in Indianapolis, IN [8]. The CHICA team regularly reviews weekly usage patterns, holds quarterly user meetings to solicit feedback, and continuously refines the

**Abbreviations:** CHICA, Child Health Improvement through Computer Automation; CDSS, Clinical decision support system; PSF, Pre-screener form; PWS, provider worksheet; EHR, electronic health record; TAM, technology acceptance model

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system with upgrades based in part on these data [9]. Formative evaluations are an efficient method to understand user and system needs for iterative improvements. As part of ongoing quality improvement, CHICA users complete annual surveys on the acceptance, usability, and perceived efficacy of the system. Results from the first two years of these surveys demonstrated short-term improvement and general, qualitative acceptance [9]. To our knowledge, long-term acceptability results are not reported among computerized CDSS users, let alone in pediatrics. The current study examines user attitudes and opinions over six years of continuous computerized CDSS integration and updates. We determine factors related to acceptability, and present results through the perspective of the Technology Adoption Model.

## 2. Materials and methods

### 2.1. CHICA

CHICA has been previously described in technical and clinical literature [8,10–12]. It is a computerized CDSS that uses patient data to generate patient screening questionnaires (Pre-Screener Form, PSF) that are completed in the waiting room. These answers are uploaded to the CHICA server, which combines them with previous answers and medical history from the patient’s medical record. CHICA uses medical logic modules with embedded priority scores [13] written in Arden Syntax (a programming language for encoding medical knowledge [14]) to compute a prioritized list of recommendations for providers. Along with blood pressure, heart rate, temperature, growth information, and an area to document a physical exam, the six highest priority recommendations are displayed on a Provider Worksheet (PWS). Providers can document their responses to the prompts by checking boxes. Responses go back into the CHICA database to inform future encounters and aid clinical research. See online Supplement B for samples and screenshots of CHICA user interfaces. CHICA also produces “just-in-time” handouts to reinforce provider counseling or collect further patient information. Finally, CHICA generates a prose note that includes the patient-identified risks from the PSF, information presented on the PWS, as well as provider answers to the PWS prompts. This text can be quickly imported into the clinical note. All CHICA interactions with patients, including PSF questions and handouts, are available in English and Spanish. Non-provider clinic personnel primarily interact with CHICA by distributing and collecting PSFs, PWSs (when using paper versions), and handouts.

CHICA started within one healthcare system (System A) in 2004 with one clinic and gradually expanded to five clinics by 2013. This healthcare system used the Regenstrief Medical Record System, a homegrown electronic health record (EHR), with origins starting in 1972 [15,16]. The surveys in this study extended through the last few months of use before the System A transitioned to a vendor-based EHR (Epic®, Epic Systems Corporation, Verona, WI), within which CHICA is currently integrated. In 2015, a second health system (System B) adopted CHICA, where it was integrated into a different vendor-based EHR (Cerner®, Cerner Corporation, Kansas City, MO) (See Fig. 1 for

timeline).

### 2.2. Paper to electronic conversion

Over the course of this study, the interfaces and workflow of CHICA changed from scanned paper to electronic methods. Prior to 2013, patients completed a paper PSF that was scanned into image-recognition software, which encoded their response in a database. The PSF was converted to a tablet interface through a staged rollout over 11 months between the survey administrations in 2012 and 2014 [17]. The basic functionality of prioritized screening questions remained the same. Soon afterwards, the PWS was converted to a webpage that recreated the paper functionality. Providers could access the webpage through a link in the EHR. Between the 2015 and 2016 surveys, providers could use either the webpage or paper versions of the PWS, though paper use dwindled closer to the 2016 survey. The paper PWS version was officially disabled after the conclusion of the 2016 survey. The ability to import the CDSS-generated documentation into the clinic note remained unchanged throughout this process.

### 2.3. Surveys

The CHICA user acceptability survey consisted of 12 core questions (Table 1, which also includes abbreviations used hereafter) and several provider characteristic questions (e.g., clinic role, percent time in clinic).

Five core questions were positively worded and seven were negatively worded. We note that the item “CHICA often makes mistakes” was aimed towards clinical accuracy, and “CHICA makes lots of errors” was oriented more towards technical issues. The survey also included other items relating to specific decision support modules under evaluation, implementing, for example, medical-legal guidance, autism screening guidelines, and Attention-Deficit/Hyperactivity Disorder (ADHD) management. Only core questions—which address the general acceptability of the system—are included in this study. They were prepared as Likert items with a 5-point ordered response scale of strongly agree, somewhat agree, neutral, somewhat disagree, and strongly disagree. In order to encourage candid responses and suggestions for improvement, we did not collect identifiable information from participants.

We distributed surveys within System A annually in summer between 2011 and 2016, except for 2013 due to lack of funding (Fig. 1). System B received the survey in 2016 only. As this survey was intended as a census rather than a representative sample, a research assistant (RA) from an independent research support network approached all CHICA users, including administrative staff, nurses, medical assistants, advanced practitioners, and physicians (residents and faculty). The RA identified herself as separate from the CHICA developers, reviewed the anonymous nature of survey, and invited the CHICA users to complete the surveys. A \$5 gift card was offered as compensation. The surveys were completed before new intern physicians started in the clinics each year.

The surveys focused on a variety of concerns, and were both summative and formative, consistent with health information technology evaluation recommendations [18]. The CHICA development team implements continuous quality improvement and regular feature upgrades informed by this survey and regular contact with users [9].

Study data were collected and managed using REDCap, a web-based survey and database tool, hosted at Indiana University [19]. We dichotomized responses into favorable versus unfavorable with respect to the CHICA system (negatively worded questions were reverse scored). Since our primary outcome was an explicitly favorable response, neutral responses were categorized as unfavorable. We classified these core questions into questions about how CHICA functions or users’ usage of CHICA (Table 1). Clinic role was defined as provider (physician or advanced practitioner) or non-provider (nurse, MA, administrative

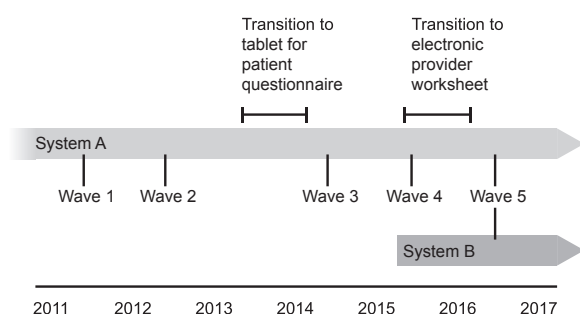


Fig. 1. Timeline of relevant CHICA events and survey waves.

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