



Comparative usability evaluation of consultation order templates in a simulated primary care environment

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ABSTRACT

Communication breakdowns in the referral process negatively impact clinical workflow and patient safety. There is a lack of evidence demonstrating the impact of published design recommendations addressing contributing issues with consultation order templates. This study translated the recommendations into a computer-based prototype and conducted a comparative usability evaluation. With a scenario-based simulation, 30 clinicians (referrers) participated in a within-group, counterbalanced experiment comparing the prototype with their present electronic order entry system. The prototype significantly increased satisfaction (Cohen's $d = 1.80$, 95% CI [1.19, 2.41], $p < .001$), and required significantly less mental effort ($d = 0.67$ [0.14, 1.20], $p < .001$). Regarding efficiency, the prototype required significantly fewer mouse clicks (mean difference = 29 clicks, $p < .001$). Although overall task time did not differ significantly ($d = -0.05$ [-0.56, 0.47]), the prototype significantly quickened identification of the appropriate specialty clinic (mean difference = 12 s, $d = 0.98$ [0.43, 1.52], $p < .001$). The experimental evidence demonstrated that clinician-centered interfaces significantly improved system usability during ordering of consultations.

1. Introduction

Through medical referrals, clinicians seek advice, request procedures, and coordinate evaluation and management of their patients (Forrest, 2009). Since 1999, the frequency of outpatient visits that lead to medical referrals in the United States has more than doubled (Barnett et al., 2012). Despite the benefits and frequency of collaboration between primary care practitioners and specialist consultants, the computerized process to request a consultation has contributed to communication breakdowns in clinical care (Giardina et al., 2013; Wu et al., 2016). Some of these breakdowns delay patients' access to consultants and medical treatment (Institute for Healthcare Improvement, 2017; Mehrotra et al., 2011).

To improve communication of referrals among clinicians using electronic health record (EHR) systems, especially initial communication, a common approach is to create templated forms for order entry (Walsh et al., 2013). Medical information entered into templates conveys key questions and details to consultants. In many settings, the

initial information transfer directly affects patients' access to consultants, because the information is first used to determine whether a consultation request should be accepted or rejected. This information transfer is also important for patients' quality of care, because the referral is generated to improve some aspect of clinical evaluation or management.

Poor design of referral templates can decrease usability and, in turn, obstruct communication about referrals (Hysong et al., 2011). In the U.S. Department of Veterans Affairs (VA), which runs the nation's largest integrated health care system, consultation orders are often rejected without an appointment because of unclear or incomplete communication. Reasons include failing to perform prerequisite testing, selecting the wrong consultant (inappropriate service), or providing incomplete supporting clinical details (Singh et al., 2010). Adverse events and medical errors from poor usability of EHRs have been documented across health care systems (Middleton et al., 2013).

Thus, there is an urgent need to better understand the interaction between referring clinicians and electronic consultation orders.

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Table 1

Key issues in communication and decision making during consultation ordering, potential negative impacts to referral processes and patient safety, and recommended solutions derived from health services research.

Issue during consultation ordering	Negative impact to referral processes and patient safety	Recommended solution
Unstated or unclear goal in referral (Conley et al., 2009; Gandhi et al., 2000; Goldman et al., 1983)	Consultants reject orders pending additional information (Saleem et al., 2011a,b); consultations re-ordered unnecessarily (Gandhi et al., 2000); patients or caretakers must provide missing details (Stille et al., 2007)	With each order, require a specific clinical question or reason for referral, if one is clear (Conley et al., 2009; Esquivel et al., 2012; Salerno et al., 2007).
Insufficient clinical details (Gandhi et al., 2000; Saleem et al., 2011a,b; Weiner et al., 2010)	Orders cancelled; scheduling delayed (Saleem et al., 2011a,b)	Automatically include all pertinent clinical details (Esquivel et al., 2012; Militello et al., 2016).
Ambiguous level of urgency (Esquivel et al., 2012; Goldman et al., 1983; Saleem et al., 2011a,b; Salerno et al., 2007)	Scheduling delayed (Saleem, Russ, et al.); patients assume burden of coordinating care (Stille et al., 2005; Vimalananda et al., 2018)	Permit different possible levels of urgency. With each order, require a statement of urgency (Esquivel et al., 2012; Salerno et al., 2007).
Unclear whether a consultation is warranted (Esquivel et al., 2012; Singh et al., 2013)	Inappropriate referrals ordered (Mehrotra et al., 2011); consultant requires more communication (Lowry et al., 2014)	Clarify consultants' scope of practice (Esquivel et al., 2012; Militello et al., 2016).
Unclear with which service to consult (Saleem et al., 2011a,b; Singh et al., 2013)	Orders misdirected (Saleem, Russ, et al.)	Facilitate finding the appropriate consulting service (Esquivel et al., 2012; Militello et al., 2016; Saleem et al., 2011a,b).
Unclear what the consultant needs (Deckard et al., 2010; Esquivel et al., 2012)	Necessary tests not ordered (Gandhi et al., 2006); diagnoses missed or delayed (Gandhi et al., 2006)	Clarify consultants' prerequisites for consultation (Esquivel et al., 2012; Militello et al., 2016).
Unclear how to contact the consulting service (Esquivel et al., 2012)	Scheduling delayed (Saleem, Russ, et al.)	Facilitate real-time discussion with consultants (Esquivel et al., 2012; Militello et al., 2016).
Difficulty explaining findings (Esquivel et al., 2012)	Decisions delayed or made with incomplete or fragmented information (Lowry et al., 2014)	Make order forms flexible for complex scenarios (Esquivel et al., 2012; Militello et al., 2016).

Improving the usability of consultation order user interfaces (UIs) is likely to improve communication and increase patient safety (Middleton et al., 2013; Shneiderman, 2011). Addressing key communication and decision-making issues, design recommendations for consultation orders have been published (Bergus et al., 2006; Conley et al., 2009; Esquivel et al., 2012; Gandhi et al., 2000; Militello et al., 2016; Saleem et al., 2011a,b; Salerno et al., 2007). However, evidence from user testing and experimental evaluation linking redesigned consultation order UIs to usability improvements is insufficient (Akbari et al., 2008; Hendrickson et al., 2016). This study was designed to address this lack of evidence that could improve the understanding and transformation of clinician's user experience when ordering consultations. With the application of human factors principles, the design recommendations for consultation orders were translated into a computer-based prototype. Then, a comparative usability evaluation was conducted to assess impact.

2. Background and significance

2.1. Referral process

In many health care systems, to generate a referral, the clinician orders a consultation using the EHR system. Ideal consultation order templates afford three major benefits: guide referring clinicians through the consultation request process, provide structure to help ensure that the referral is appropriate and complete, and facilitate diagnostic testing and any other prerequisites before the patient's appointment with the consultant (Piterman and Koritsas, 2005; Tattersall et al., 2002). Both referrers and consultants agree, however, that the current approach and its specific implementation of templates are flawed (Mehrotra et al., 2011; O'Malley and Reschovsky, 2011; Saleem et al., 2011a,b).

2.2. Consultation templates and user interfaces

Flaws in UIs for ordering consultations have been identified through several approaches. According to physician surveys, physician interviews, and chart reviews, EHR-mediated consultation orders frequently lack clear clinical questions, supporting clinical details, and clarity about the urgency of the consultation (Conley et al., 2009; Saleem et al., 2011a,b; Salerno et al., 2007). According to interviews and observations with referrers and specialists, inadequately designed consultation ordering templates impede the referral process owing to poor support

for clinicians' cognitive processes (Militello et al., 2016). Specific cognitive demands include determining whether a consultation is warranted, which subspecialty should be consulted, what the consultant will need to know, and how to communicate with the consulting service (Militello et al., 2016). Furthermore, using a purposive sample of VA consultation ordering templates, an expert-led usability inspection identified design heuristics (general rules) that were violated most repeatedly, including poor support for unstructured communication (Savoy et al., 2017).

Clinician communication and decision-making issues have been linked to negative impacts to the referral process and patient safety (Table 1). To potentially address these issues and negative impacts at the computer interface level, some design recommendations for consultation orders have been published (Table 1). For example, to support referrers' decision making, UIs for ordering consultations could directly display the requirements of consulting services and autofill (pre-populate) all relevant clinical information. This would reduce navigation away from the template while collecting clinical details (Militello et al., 2016; Savoy et al., 2017). To meet communication needs, the UIs could use uniform templates, include both structured and free-text fields, and require a reason for referral, with a specific question to be answered (Esquivel et al., 2012).

Although these recommendations were based on identified flaws, evidence of the recommendations' impact is needed. Sociotechnical frameworks guiding interface design and usability evaluation of clinical information systems are based on the foundational theory that socio-technical work systems produce processes that shape outcomes (Berg, 1999; Holden et al., 2013; Saleem et al., 2011a,b; Sittig and Singh, 2010). To quantify the impact on usability related to clinician outcomes, we translated the recommendations into an electronic UI prototype. For the prototype, design choices were focused on two goals. The first goal was addressing major issues in communication and decision making associated with consultation orders (Table 1). The second goal was applying established human factors principles (Table 2). Following this, we conducted a comparative usability evaluation with the prototype and control UIs from an EHR used currently in the United States' largest integrated health care system. Based on the prototype's user-centered design, we hypothesized improvements to referring clinicians' satisfaction, perceived workload, and efficiency (Table 2). Regarding satisfaction, we hypothesized that the prototype would yield greater satisfaction among clinicians than the control UI. Concerning workload, we hypothesized that the prototype would decrease

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