Impact of Participatory Design for Drug-Drug Interaction Alerts. A Comparison Study Between Two Interfaces

Daniel LUNA[a,b,1], Carlos OTERO[a], Marcelo RISK[b], Enrique STANZIOLA[a] and
Fernán GONZÁLEZ BERNALDO DE QUIRÓS[a]

[a] *Health Informatics Department, Hospital Italiano de Buenos Aires, Argentina*
[b] *Instituto Tecnológico de Buenos Aires (ITBA), Argentina*

Abstract. Decision support systems for alert drug-drug interactions have been shown as valid strategy to reduce medical error. Even so the use of these systems has not been as expected, probably due to the lack of a suitable design. This study compares two interfaces, one of them developed using participatory design techniques (based on user centered design processes). This work showed that the use of these techniques improves satisfaction, effectiveness and efficiency in an alert system for drug-drug interactions, a fact that was evident in specific situations such as the decrease of errors to meet the specified task, the time, the workload optimization and users overall satisfaction with the system.

Keywords. Decision support systems, drug-drug interaction, user centered design, usability, human computer interaction.

1. Introduction

In the process of development of computer systems, human-computer interaction is a fundamental aspect to consider [1]. The User Centered Design (UCD) focuses on the people who will use a piece of software to be developed, taking them into account for the entire process, from the initial requirements analysis to testing and assessment software system [2]. This process is regulated by ISO 9241-210 "Human-centered design for interactive systems" [3], which systematizes the steps for this practice.

Medication prescription is the main source of errors in medicine, covering up to a quarter of total mistakes [4], and while most do not produce serious consequences to patients, there are few causing variable damage including severe injuries and even death. Almost 50% of these events are generated during prescription [5]. Some of them are related to drug-drug interactions (DDI) that occur when a drug changes another drug expected metabolism [6,7]. Adverse drug reactions related to DDI are mostly preventable, but health professionals fail to identify them at least half of the times. Against this backdrop, it is easy to understand why the use and application of information technologies have shown improvements in both quality of care and resources optimization [8-10]. One potential solution is the implementation of electronic prescription systems with real-time detection of DDI [11-13].

Hospital Italiano de Buenos Aires developed an in-house electronic health record with DDI alert system by mid 2000s. Traditional software engineering requirements

---

[1] Corresponding Author: daniel.luna@hospitalitaliano.org.ar

and techniques were used. Since the override rate was very high, we decided to redesign the alert system using UCD techniques, as they have demonstrated to increase adoption and usage efficiency of health IT tools [14].

The aim of this study is to compare the usability (in terms of effectiveness, efficiency and satisfaction) of an alert system for DDI developed under UCD techniques against another alert system with traditional software development.

2. Methods

2.1. Methodological design:

Our study had an experimental crossover design where each participant was exposed to 4 laboratory clinical cases randomly assigned, twice. Twelve clinical cases (4 for each clinical setting: outpatient, non-critical inpatient and critical inpatient) were developed by experts, using one frequent DDI example extracted from a yearly prescription database. For each clinical case the participant should complete the instructions (regarding prescription of certain drugs) and take actions when the system showed the DDI alert. There were two different interfaces of DDI alerts: the old one (developed under traditional techniques. See Fig.1) and the new interface generated under UCD techniques (See Fig.2). Both systems had the same knowledge database and inference engine, but differed in the elements and the action-oriented aim of the new one [15].
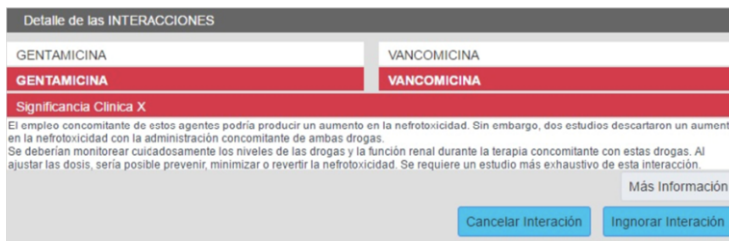

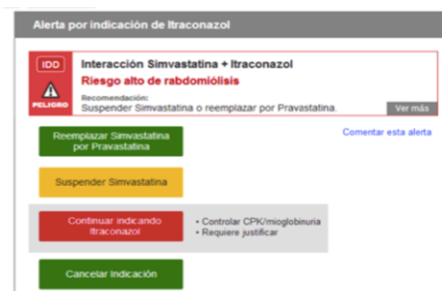**Figure 1.** Original software version.

Figure 2. UCD refined prototype.

Each participant was individually exposed to both interfaces, with a wash out period in between. The order of the interface type was randomized. We delivered 4 randomly selected clinical cases to every participant and gave them instructions for the test. They were asked to describe their actions while solving the alerts (think aloud), and to answer a questionnaire afterwards. Direct observation was performed.

2.2. Study population

Physicians selected by random sampling within each clinical setting (outpatient, non-critical and critical inpatient) were included.

2.3. Setting

The sessions took place in the usability laboratory of the Department of Health Informatics of Hospital Italiano de Buenos Aires (HIBA). Morae 3.2 (TechSmith Corporation) software was used for recording (audio and video) of the whole session.

2.4. Sample calculation

The sample calculation was performed with the Power and Precision software version 3.2.0. To test the null hypothesis of equality in the percentage of failed prescriptions between the two interfaces, with an expected difference at least between 45% and 20%, with a type 1 error of 5% and a power estimated 80%, it was determined necessary to include 30 doctors in total, of which plan to distribute in 10 doctors *per stratum.*

2.5. Measurements

Efficiency was measured by three variables: the time spent in solving the alert, the number of mouse clicks and the number of words at text entry.

The user effectiveness was rated as successful, successful with problems or failed. Being a laboratory test, it was possible to measure the error for each user interface.

After the sessions, users were invited to complete a satisfaction questionnaire based on the System Usability Scale (SUS) [16]. Finally, a brief semi-structured interview was conducted to collect suggestions, weaknesses and strengths of the system.

2.6. Statistic analysis

Descriptive statistics were presented for all variables in the study. Interval variables were parameterized by mean and standard deviation, and for categorical variables the observed frequency (total number of observations within the category) and the relative frequency percentage were used. Statistical analysis for all tests was performed using the R environment for statistical computing project (https://www.r-project.org/). Statistical significance was considered if probability was lower to 0.05.

Efficiency statistical study was performed with a three-way Analysis of Variance (ANOVA). Efficiency measures (time, clicks, words) were dependent variables, and the three independent variables were the pathways: the Design methodology (traditional and DCU), the Clinical Setting (Outpatient, Critical and Non-critical Inpatient) and the User. The ANOVA was performed in order to test the null hypothesis that "efficiency variables are not different regarding design methodology", and the clinical setting and the user were control variables. Interaction graphs for each ANOVA were performed.

Effectiveness was studied with categorical variables from reports, using Fisher's exact test for 2x2 table. The Odds Ratio was calculated in order to estimate the

association between design methodologies and the proportion of responses with or without errors (confidence interval of 95%).

For user satisfaction analysis as a percentage, the student's test for repeated measurements was used, each user being measured twice, one for each interface design.

3. Results

From 191 physicians (potential candidates) we detected 150 (50 of each clinical setting: outpatient, critical and noncritical inpatient) and invited them to study participation. We randomly selected 10 participants from each stratum so 30 physicians were included. Table 1 shows the demographics for each variable and group.

Table 1. Demographics for each variable and group.

	Total (N=30)	Outpatient (10)	Critical Inpatient (10)	Non-critical Inpatient (10)	p
Age[1] (years)	34.3 (3.4)	34,2 (3.4)	36 (1.2)	32.7 (4.1)	0,084
Female (%) [2]	56,7 (17)	60 (6)	50 (5)	60 (6)	0,873
Graduated[1] (years)	9.6 (2)	9.5 (2.2)	10.6 (0.8)	8.3 (2.3)	0,079
EHR use[1] (years)	6.7 (0.9)	6.8 (1.1)	6.6 (0.8)	6.6 (0.8)	0,864
Time between evaluations[1] (days)	16 (2.6)	17.1 (3.4)	15.7 (1.9)	15.7 (2.1)	0,245
1. average (standard deviation); 2. Relative frequency in percentage (amount).					

The efficiency analysis for Time spent by users, Clicks and Words was performed with the statistical model: XXX ~ design methodology + clinical setting + User (being XXX each of them). Table 2 shows the results of ANOVA for each pathway, and Figure 3 the interaction graphs.

Table 2. Efficiency analysis: probability table of three-way ANOVA.

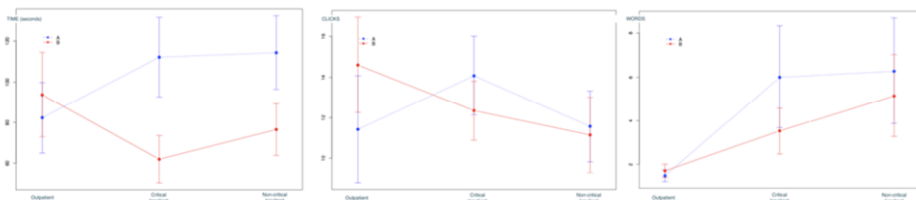| ANOVA	p for Time	p for Clicks	p for Words
Design methodology	0.0004	0.69	0.094
Clinical Setting	0.58	0.15	<0.0001
User	0.59	0.70	0.21

Figure 3. efficiency interaction graphs by Time spent, Clicks and Words where A is the traditional design methodology interface, and B is UCD; points are the mean and error bar ± 2 standard error.

Effectiveness categorical variables (see Table 3) were analyzed with Fisher's exact test for 2x2 tables, and showed a p = 0.045, with an odds ratio (odds ratio) of 10.2 (95% CI 1.1 to 514).

Table 3. effectiveness analysis between interface designed with the traditional method vs UCD methodology.

DDI reports	traditional design	UCD
Incomplete performance or complete with severe errors	7 (39%)	1 (6%)
Complete without errors and mistakes	11 (61%)	17 (94%)

Regarding user satisfaction, traditional methodology had an average satisfaction of 87.4%, while UCD had 92%, p = 0.024. From 30 participants of the study, 19 felt more satisfied using the UCD interface versus traditional methodology.

Regarding preferences, 9 users (33.33%) preferred the old interface, 19 (59.27%) preferred the UCD interface and 2 (7.4%) were indistinct.

4. Conclusion

Incorporating user-centered design techniques in the development of support tools for DDI was a positive experience, as it showed to improve usability (in terms of effectiveness, efficiency and user satisfaction) compared with the previous interface made with traditional techniques. The work also enabled the software developers to understand not only the tasks but also the complexity of the process. The incorporation of UCD in the development process is a useful tool, as it optimized use of the support system, prevented errors and increased user satisfaction.

References

[1] A. Sears, J.A. Jacko, Human-Computer Interaction: Development Process. CRC Press, Boca Raton, 2009.
[2] D.A. Norman, S.W. Draper (Eds.), User Centered System Design: New Perspectives on Human-computer Interaction, 1 edition. CRC Press, Hillsdale, N.J., 1986.
[3] ISO 9241-210. Ergonomics of human-system interaction - Part 210 Human-centred design for interactive systems, International Organization for Standarization. ISO, 2010.
[4] L.T. Kohn, To Err Is Human: Building a Safer Health System, IOM, National Academies Press, Washington, D.C. 2000.
[5] L.L. Leape, D.W. Bates, D.J. Cullen, J. Cooper, H.J. Demonaco, T. Gallivan, R. Hallisey, G. Laffel et al., Systems analysis of adverse drug events. ADE Prevention Study Group. JAMA 274 (1995), 35–43.
[6] T.J. Bright, A. Wong, R. Dhurjati, E. Bristow, L. Bastian, R.R. Coeytaux et al. Effect of Clinical Decision-Support Systems A Systematic Review. Ann Intern Med 157(2012): 29–43.
[7] G.J. Kuperman, A. Bobb, T.H. Payne, A.J. Avery, G. Burns et al. Medication-related clinical decision support in computerized provider order entry systems: a review. JAMIA 14 (2007), 29–40.
[8] B. Chaudhry, J. Wang, S. Wu, M. Maglione, W. Mojica, E. Roth, S.C. Morton, P.G. Shekelle, Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care. Ann. Intern. Med. 144 (2006), 742–752.
[9] J.J. Coleman, H. van der Sijs, W.E. Haefeli, S.P. Slight, S.E. McDowell, H.M. Seidling et al. On the alert: future priorities for alerts in clinical decision support for computerized physician order entry identified from a European workshop. BMC Med Inform Decis Mak 13 (2013), 1–8.
[10] M. Xie, M.B. Weinger, W.M. Gregg, K.B. Johnson. Presenting multiple drug alerts in an ambulatory electronic prescribing system: a usability study of prototypes. Appl Clin Inform 5 (2014), 334–48.
[11] H. van der Sijs, J. Aarts, A. Vulto, M. Berg. Overriding of drug safety alerts in computerized physician order entry. JAMIA 13 (2006), 138–47.
[12] F.G.B. Quirós, D. Luna et al. Incorporación de tecnologías de la información y comunicaciones en el Hospital Italiano de Buenos Aires. CEPAL, Available at: http://goo.gl/7IcxP2; 2012.
[13] D. Luna, M. Waldhorn, A. Ianicelli, M. Risk, F.G.B. Quirós. Drug-drug interaction in a healthcare network of Argentina: frequency and characteristics. CBIS, Proceedings of the Brazilian Congress of Medical Informatics, Brazil, 2012.
[14] D. Luna, M. Quispe, Z. Gonzalez , A. Almerares, M. Risk, M. Garcia Aurelio et al. User-centered design to develop clinical applications. Literature review. Stud Health Technol Inform 216 (2015) 967.
[15] D. Luna, C. Otero, A. Almerares, E. Stanziola, M. Risk; F.G.B. Quirós. Participatory design for drug-drug interaction alerts. Stud Health Technol Inform 210 (2015), 45–9.
[16] P. W. Jordan, B. Thomas, B. A. Weerdmeester, A. L. McClelland. SUS: a "quick and dirty" usability scale. Taylor and Francis, London, 1996.