

Original Paper

# A Shared Decision-making Tool for Drug Interactions Between Warfarin and Nonsteroidal Anti-inflammatory Drugs: Design and Usability Study

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## Abstract

**Background:** Exposure to life-threatening drug-drug interactions (DDIs) occurs despite the widespread use of clinical decision support. The DDI between warfarin and nonsteroidal anti-inflammatory drugs is common and potentially life-threatening. Patients can play a substantial role in preventing harm from DDIs; however, the current model for DDI decision-making is clinician centric.

**Objective:** This study aims to design and study the usability of DDInteract, a tool to support shared decision-making (SDM) between a patient and provider for the DDI between warfarin and nonsteroidal anti-inflammatory drugs.

**Methods:** We used an SDM framework and user-centered design methods to guide the design and usability of DDInteract—an SDM electronic health record app to prevent harm from clinically significant DDIs. The design involved iterative prototypes, qualitative feedback from stakeholders, and a heuristic evaluation. The usability evaluation included patients and clinicians. Patients participated in a simulated SDM discussion using clinical vignettes. Clinicians were asked to complete eight tasks using DDInteract and to assess the tool using a survey adapted from the System Usability Scale.

**Results:** The designed DDInteract prototype includes the following features: a patient-specific risk profile, dynamic risk icon array, patient education section, and treatment decision tree. A total of 4 patients and 11 clinicians participated in the usability study. After an SDM session where patients and clinicians review the tool concurrently, patients generally favored pain treatments with less risk of gastrointestinal bleeding. Clinicians successfully completed the tasks with a mean of 144 (SD 74) seconds and rated the usability of DDInteract as 4.32 (SD 0.52) of 5.

**Conclusions:** This study expands the use of SDM to DDIs. The next steps are to determine if DDInteract can improve shared decision-making quality and to implement it across health systems using interoperable technology.

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**KEYWORDS**

shared decision-making; user-centered design; drug interaction; clinical decision support

## Introduction

### Background

Drug-drug interactions (DDIs) are preventable adverse events that are responsible for 5% to 14% of adverse drug reactions in patients that are hospitalized [1,2], are a major risk factor for hospitalization [3], and occur in up to 13% of older adult ambulatory patients [4-6]. Exposure to life-threatening DDIs occurs despite the widespread use of clinical decision support. Alarming, up to 24% of patients on warfarin receive a prescription for a nonsteroidal anti-inflammatory drug (NSAID), which increases the risk of gastrointestinal bleeding up to twofold [7,8].

Most electronic health records (EHRs) implement DDI clinical decision support functionality with underlying logic provided by drug knowledge base vendors, but DDI alerts continue to be overridden at rates as high as 90% [9-11]. The current model for DDI decision-making is highly clinician-centric in spite of the fact that patients can play a substantial role in preventing potential harm due to DDIs. Studies that have explored different clinical decision support for DDIs [12,13] indicate that interactive decision dashboards have the potential to foster informed decision-making by patients [13]. These decision aids allow patients and clinicians to deliberate together about the advantages and disadvantages of different therapies and arrive at decisions that are concordant with the best available evidence, clinician knowledge, and patient preferences [14,15].

Accordingly, the overarching goal of this study is to incorporate patient-centered shared decision-making (SDM) for addressing DDIs, an advance from clinician-centric decision-making models. SDM is a conversation where patients share their values and preferences to choose a treatment that aligns with their goals [16,17]. Electronic decision aids can support this conversation; however, SDM is uncharted in the DDI domain [18].

### Objectives

The purpose of this study was to design and evaluate the usability of DDInteract, an SDM tool for the warfarin and NSAID DDI.

## Methods

### Overview

The design and usability assessment of DDInteract was guided by user-centered design principles and an SDM framework. The user-centered process included iterative and overlapping steps of prototyping (ie, low fidelity, stable, and high fidelity), stakeholder feedback, and usability heuristics and testing [19-24]. The SDM framework consists of five steps: (1) seek your patient's participation, (2) help your patient explore and compare treatment options, (3) assess your patient's values and preferences, (4) reach a decision with your patient, and (5) evaluate your patient's decision [25]. Figure 1 depicts a summary of the design and usability process. This study was approved by the University of Utah Institutional Review Board.

**Figure 1.** Summary of the design and usability process for DDInteract. IPDAS: International Patient Decision Aid Standards Collaboration.



### Design

The design team consisted of multidisciplinary experts in DDIs, clinical decision support, patient and provider communication, SDM, and pharmacotherapy outcomes. The process began with an artifact appraisal of SDM tools, DDI alerts, and clinical practice materials relevant to anticoagulants. Information from this appraisal was used to sketch low-fidelity feature prototypes, which were reviewed and discussed with the design team in weekly meetings. Features and functionality deemed important by the design team were retained for future iterations. Features were linked to the SDM steps and checklist items from the International Patient Decision Aid Standards Collaboration [26]. Once the design team coalesced on preliminary feature designs, these were combined into an initial prototype of the complete user interface using Adobe XD (Adobe Inc).

Target users (ie, 2 physicians and 1 pharmacist) were individually shown the initial complete user interface prototype and asked to provide feedback on the usefulness, aesthetics, proposed functionality, and content. Several iterations were made in collaboration with these target users until no substantial feedback was provided. At this point the prototype was

considered stable enough for a heuristic evaluation. The heuristic evaluation was based on knowledge of Nielsen's 10 Usability Heuristics for User Interface Design [27,28] and was performed by two experts with training and experience in human-centered design, psychology, and medical informatics. The goal of the heuristic evaluation was to identify design flaws that could be addressed prior to conducting resource-intensive testing. Specific feedback regarding design that might impede users' goals were noted and shared in a team meeting along with a discussion of potential solutions for each flaw. Once the stable prototype was modified to address findings from the heuristic evaluation, it was considered high fidelity and ready for usability testing.

### Usability

Usability assessments consisted of two parts: (1) patient interviews with simulated clinic visits and (2) clinician task performance assessments and usability surveys. DDInteract was designed to be used by clinicians at the point of care. Since patients would not use DDInteract without a clinician present, we did not test task completion success and efficiency with patients.

## Patients

Patient participants were recruited from the anticoagulation service at the University of Utah. Participants were required to be on warfarin for a chronic condition such as atrial fibrillation. The perceived usability and usefulness of DDInteract was assessed with participants individually through two simulated clinical scenarios and a semistructured interview. Participants were given two short clinical vignettes to read before the session ([Multimedia Appendix 1](#), Table S1). The decision associated with each vignette was whether to start an NSAID for pain. The vignettes were designed to test the range of responses based on a patient's risk (ie, high risk and low risk) of gastrointestinal bleeding. In the high-risk vignette, the patient had multiple risk factors for gastrointestinal bleeding including age older than 65 years, use of an antidepressant, and history of a gastrointestinal bleeding. In the low-risk vignette, warfarin was the only risk factor. Participants simulated SDM based on the clinical vignettes with a provider (author KM). Following the clinical scenarios, patients were asked questions pertaining to aspects of DDInteract, the use of DDInteract for SDM, and the utility of SDM for DDIs. The interviews were conducted online with

audio and screen recording. The audio was transcribed and coded into general topics.

## Clinicians

Physicians and pharmacists with anticoagulation therapy experience were recruited by snowball sampling. The overarching goal of the clinician usability assessment was to obtain objective and subjective data on the use of DDInteract. Participants were asked to complete a task performance assessment and a perceived usefulness survey. Participant characteristics were collected as part of the survey. Links to the instructional video, task performance assessment, and survey were emailed to participants. The instructional video was a brief introduction to DDInteract. The task performance assessment was web-based and recorded the participant's screen. The survey was based on the System Usability Scale and included a free-text section for feedback [29,30]. Tasks consisted of eight key navigation and functionality tasks ([Table 1](#)). Performance was measured by task completion rates and the time to complete each task. After a task was completed, the app reset to the home screen. The time was measured from when the home screen was displayed to when the task was completed.

**Table 1.** Clinician task prompts and actions performed that result in successful completion.

Tasks	Success
1. Your patient has questions about what a gastrointestinal bleed is. Please navigate to patient education about a gastrointestinal bleeding.	Navigating to and clicking on the drop-down arrow for "What is a gastrointestinal (Stomach) bleed?"
2. With previous patients, you have found it confusing for them to understand the drug class NSAIDs <sup>a</sup> . Please find the picture of multiple NSAIDs to illustrate how not only ibuprofen is an NSAID.	Navigating through the "What is a drug-drug interaction" drop-down and clicking on the "NSAID" hyperlink
3. Your patient informed you that they stopped taking fluoxetine. Please remove fluoxetine (Prozac) as a risk factor to show how their risk has changed.	In the patient Risk Profile section, the toggle for "On Selective Serotonin Reuptake Inhibitor" was preconfigured in the on position. The successful action was clicking the toggle off.
4. Assume your patient would like to take a medication then click the button to view medication options.	Navigating to the decision tree questions and clicking on the "Medication" button
5. Your patient has decided to try non-NSAID medication options. Please select acetaminophen (Tylenol) and lidocaine (Lidoderm).	Navigating to the second question of the decision tree and clicking "Other medications" then selecting "acetaminophen (Tylenol) 500mg" and "lidocaine (Lidoderm) 5% patch"
6. Your patient believes NSAIDs help the most with pain but would like to reduce their risk. Please select the oral NSAID option with the least gastrointestinal bleed risk. Then select that a stomach acid reducer is not needed.	Navigating to the second question of the decision tree and clicking on "Oral NSAID" then selecting "celecoxib"
7. Your patient insists on taking medications only once per day. Please select the oral NSAID option with the most risk and add esomeprazole (Nexium).	Navigating to the second question of the decision tree and clicking on "Oral NSAID" and selecting "meloxicam." Then clicking on "Stomach acid reducer" and selecting "esomeprazole."
8. Please place any order in the queue for one of the treatment options.	Navigating through the decision tree and clicking "Accept"

<sup>a</sup>NSAID: nonsteroidal anti-inflammatory drug.

## Results

### Design

Although DDIs are a novel application for SDM, we did assess several relevant electronic decision aids such as those used for cardiovascular and diabetes management [31]. We compared a variety of relevant decision aids to the SDM steps and the International Patient Decision Aid Standards checklist [26].

Generally, decision aids lacked features to elicit patient values and preferences. Additionally, decision aids varied on the content provided to make treatment decisions including price, effectiveness, and side effects of treatment [32].

Several features from relevant decision aids were adapted to the DDI use case. Features included the icon array, personalized risk, and ability to simulate risk based on patient factors and treatments. Features and functionality evolved through multiple

iterations. For example, icon arrays have shown promise in communicating risk to patients and clinicians [33-35]. Figure 2 depicts how the icon array changed over two iterations. Icon array features were based on findings from the literature and expert feedback [36,37]. Once features such as the icon array were acceptable from the design team’s perspective, they were adapted and placed into the complete user interface (ie, stable prototype). Figure 3 depicts the stable prototype used for the

heuristic evaluation. Overall, 2 major, 13 moderate, and 14 minor issues were identified. One of the two major issues was associated with the number four in Figure 3. The evaluators thought that users may not correctly interpret “Substitute” and “Add” when selecting treatment options. In response, we removed the order entry context, which will avoid a user from referencing the warfarin or NSAID order in process.

Figure 2. Icon array evolution, from left to right, through two iterations. NSAID: nonsteroidal anti-inflammatory drug.

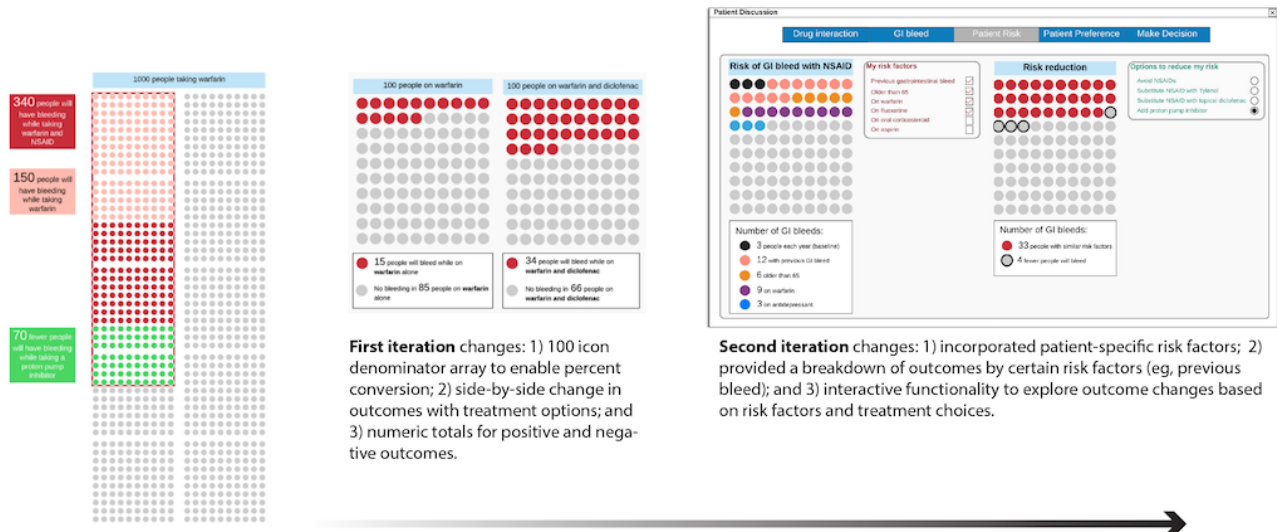
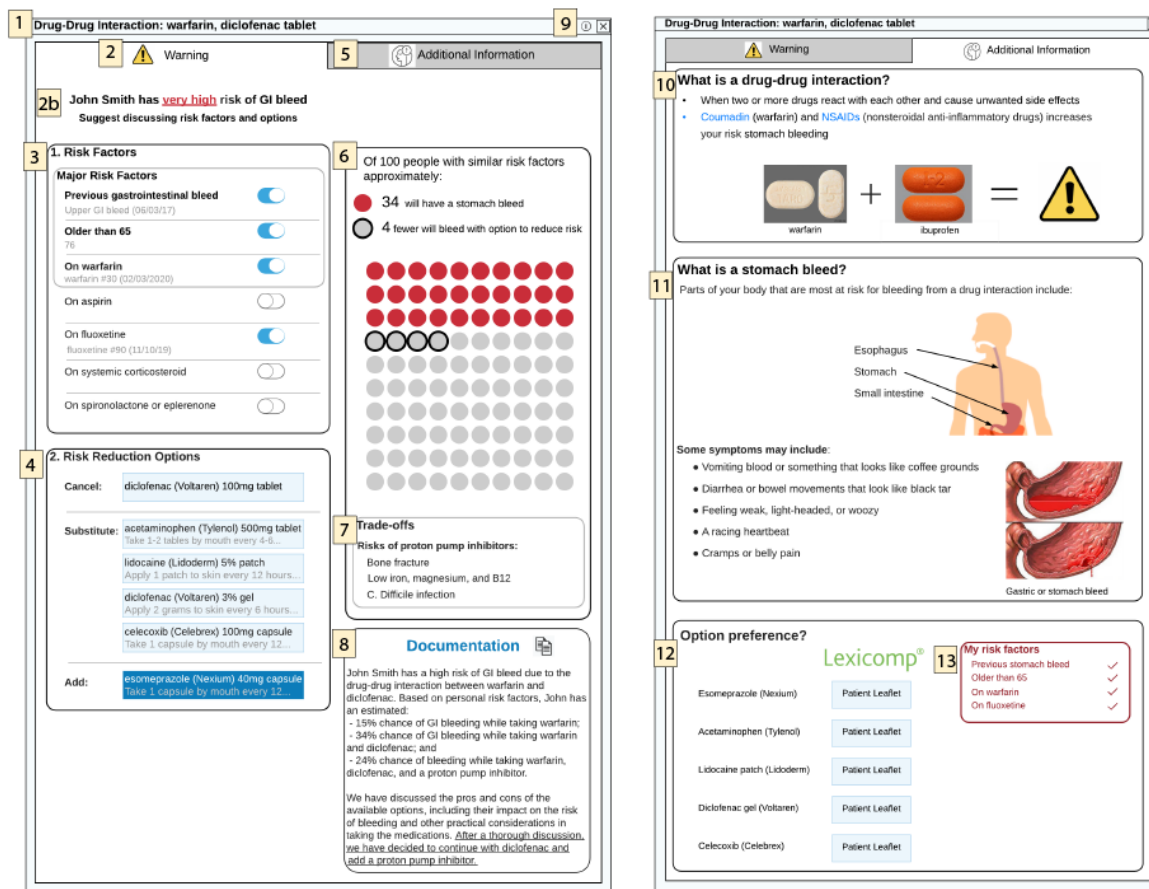


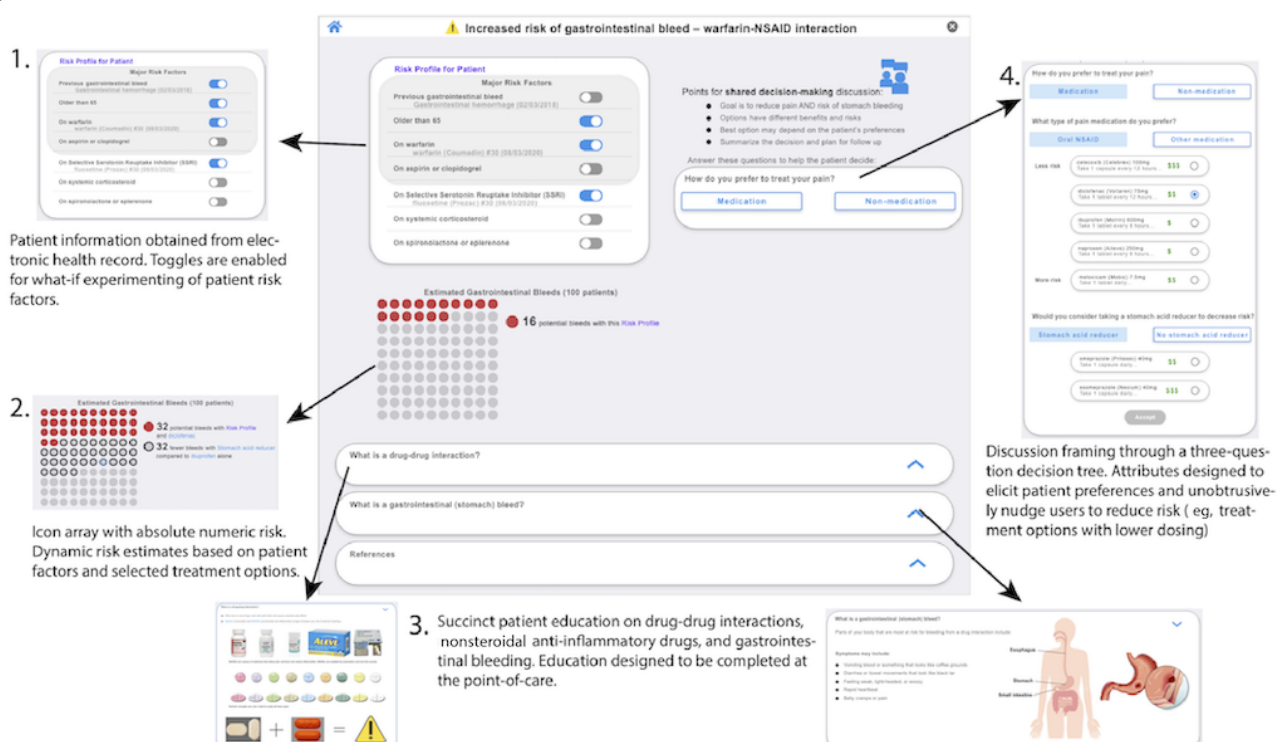
Figure 3. Stable prototype used for heuristic evaluation. Numbers refer to items described in the heuristic report. GI: gastrointestinal.



The DDInteract prototype used for evaluating usability consisted of four sections. The first section in the top left corner of Figure 4 is a patient-specific risk profile. Substantiated risk factors for gastrointestinal bleeding are listed and stratified by risk and supporting evidence. When patient-specific risk factors are pulled from the EHR, the toggle is on (ie, blue). Toggles can be manually changed to account for data not in the EHR or for clinicians to test different scenarios such as adding an antidepressant. The second section in the bottom left is a dynamic risk icon array. The icon array changes with risk factors and treatment options. Absolute numeric risk is provided along the visualization. The third section on the bottom of Figure 4 provides patient education and supporting evidence. Succinct and image-oriented patient education is provided for DDIs and

gastrointestinal bleeding. Since risk factors and estimates are evidence based, information is provided on how these aspects were derived. The fourth section is a decision tree with three questions that help structure the conversation and support treatment decision-making. The questions were created and validated by clinicians with the aim to streamline the SDM process in the context of patient care appointments. Question attributes were designed to elicit patient values and preferences associated with bleeding risk and pain treatment. Unobtrusive nudges to reduce risk were used through prepopulated NSAID dosing and default proton pump inhibitor (PPI) selection when an NSAID is chosen. Finally, functionality for generating documentation of the SDM discussion was provided.

**Figure 4.** Final DDInteract high-fidelity prototype used in the usability study along with feature description. NSAID: nonsteroidal anti-inflammatory drug.



## Usability

### Patients

All 4 participants were aged 65-85 years and had taken warfarin for more than 5 years. A provider (KM) and a facilitator (author TJR) interviewed each patient for approximately 1 hour. For the high-risk vignette (patient with multiple risk factors), all participants chose a combination of nonmedication (eg, physical therapy) and acetaminophen. For the low-risk scenario (patient with minimal risk factors), most participants chose a short course of celecoxib or ibuprofen, with a PPI.

Although participant knowledge about the warfarin-NSAID DDI varied, all participants appreciated the ability to see DDInteract while the provider discussed risk and treatment options. One participant stated:

*If I wasn't able to see the [treatment] options, I wouldn't know what to ask*

Furthermore, participants felt empowered to participate in making decisions that aligned with their preferences by referring to the decision aid during discussion:

*I personally don't like taking medications and want two avoid taking more. It looks like I can try other ways to relieve my pain and I would prefer trying those*

Participants wanted to have access to the decision aid or a printout, outside the encounter, to review what was discussed and decided. One participant stated:

*I usually forget what we [patient and provider] talk about during the appointment, so I would go to my After Visit Summary to review what we talked about.*

Most participants believed SDM was novel and different from past decision-making experiences with providers:

*Doctors usually make decisions like these for me.*

Two patients were unaware that the NSAID class included more than ibuprofen. Generally, participants valued SDM and using DDInteract with the provider. Furthermore, participants preferred to avoid additional medications and wanted to reduce the risk of gastrointestinal bleeding as much as possible.

### Clinicians

A total of 11 clinicians participated in the usability evaluation (Table 2). Of the 11 participants, 3 stopped the task study after the first task. Of those 3 participants, 2 were pulled to clinical

duties. The other participant failed to complete the second task and chose to stop the study rather than skipping the task. Of the 8 participants who completed the study, all were successful on each task. The mean time to complete eight tasks was 144 (SD 74) seconds. Table 3 delineates the task prompt and the mean time for completion. Screen capture was used to determine how participants navigated through the tool. A total of 11 participants completed the usability and satisfaction survey, with an overall mean rating of 4.32 (SD 0.52) of 5. Table 4 delineates mean ratings for each survey item.

**Table 2.** Participant characteristics for the usability evaluation.

	Participants, n	Specialty (n participants in each group)	Participant years of experience, n				Participant clinical percent effort, n				Self-assessed experience with warfarin from 0 to 100, mean (range)
			<5	6-10	11-15	>16	<21	21-40	61-80	>80	
Physicians	7	Family medicine (4), emergency/critical care (2), hematology (1)	2	2	2	1	0	2	3	2	67 (29-88)
Pharmacists	4	Anticoagulation/ambulatory care (3), general (1)	0	0	2	2	1	0	1	2	93 (87-100)

**Table 3.** Mean and SD for task time in seconds across usability participants (n=8).

Tasks	Mean time in seconds (SD)
1. Your patient has questions about what a gastrointestinal bleed is. Please navigate to patient education about a gastrointestinal bleeding.	39 (48)
2. With previous patients, you have found it confusing for them to understand the drug class NSAIDs <sup>a</sup> . Please find the picture of multiple NSAIDs to illustrate how not only ibuprofen is an NSAID.	42 (34)
3. Your patient informed you that they stopped taking fluoxetine. Please remove fluoxetine (Prozac) as a risk factor to show how their risk has changed.	2 (1)
4. Assume your patient would like to take a medication then click the button to view medication options.	3 (4)
5. Your patient has decided to try non-NSAID medication options. Please select acetaminophen (Tylenol) and lidocaine (Lidoderm).	30 (48)
6. Your patient believes NSAIDs help the most with pain but would like to reduce their risk. Please select the oral NSAID option with the least gastrointestinal bleed risk. Then select that a stomach acid reducer is not needed.	32 (35)
7. Your patient insists on taking medications only once per day. Please select the oral NSAID option with the most risk and add esomeprazole (Nexium).	13 (4)
8. Please place any order in the queue for one of the treatment options.	15 (10)

<sup>a</sup>NSAID: nonsteroidal anti-inflammatory drug.

**Table 4.** Clinician usability survey items and responses (n=11). Responses were on a 1 to 5 Likert scale where 1 is strongly disagree and 5 is strongly agree.

Survey items	Mean (SD)
I found the decision tool to be logical.	4.36 (0.67)
I found the decision tool to be efficient.	4.18 (0.75)
The decision tool was effective in the decision-making process.	4.36 (0.67)
The shared decision-making was valuable.	4.27 (0.79)
The decision tool was valuable.	4.36 (0.67)
I thought the decision tool was easy to use.	4.27 (0.65)
I enjoyed the experience.	4.36 (0.81)
I learned something new from this experience.	4.36 (0.67)

Clinician participants provided a variety of comments on the purpose and usefulness of DDInteract after completing the survey. Two participants thought the app would be helpful for patient education:

*I think half the time they [patients] just think we're [clinicians] being mean by telling them they shouldn't take their NSAIDs. And the visual for how that can be mitigated is great. I actually think that the educational section of the tool would be helpful when we're doing new educations for warfarin/DOACs [direct oral anticoagulants] even if we're not doing a shared decision-making type thing.*

*Have you considered using this as a tool not just in the clinical setting but in the medical education setting?*

Two participants had questions on where and when the app would be used:

*Is this an app that will be on the provider's phone or the intention is for the patient to download this app and fill it out themselves? Or will this be a website that is pulled up during an office visit where both parties are present in the room?*

*I'm not completely clear on the exact clinical situation in which this tool would be used and the point in the workflow in which that would happen.*

One participant thought the tool could be expanded with a general guide on interpreting risk of gastrointestinal bleeding:

*I know it is individualized, but I like how there are some general guidelines with the HAS-BLED score. It would be nice to have something similar. Also, at what risk is a PPI strongly recommended.*

Finally, participants thought the dynamic risk calculation would be a feature they would return to the tool to use. The ability to toggle between risk factors and treatment options helped to quantify risk and explore different treatment options. Generally, participants believed DDInteract was easy to use and would support SDM.

### Prototype Changes

Key changes were made in response to the patient interviews. Changes included expanding nonmedication and non-NSAID treatment options, adding functionality for selecting more than

one non-NSAID treatment (eg, physical therapy and acetaminophen), and creating a printable handout and an after visit summary that patients can access outside the encounter. Based on the duration to complete certain tasks and how clinicians navigated through DDInteract, we made feature changes regarding tasks one and two (Table 3). The modifications included enabling the user to see the entire app without scrolling to the drop-down items for patient education and automatically displaying the images.

## Discussion

### Principal Findings

This study designed and assessed the usability of a tool for SDM with DDIs (Figure 4). Overall, it appears that SDM can be enhanced by using a tool that displays risks of harm and alternatives. The process of designing DDInteract was rigorous, applying user-centered design principles through iterative prototyping (Figure 2). Target users found DDInteract easy to use and believed it could be useful for supporting SDM (Tables 3 and 4). Given that DDI clinical decision support has been traditionally clinician centric, this study may contribute to a major shift in the way certain medication alerts are developed and used. Through the process designing and evaluating DDInteract with clinicians and patients, lessons were learned regarding patient decision-making and their understanding of the warfarin-NSAID DDI. Furthermore, lessons were learned from clinicians about when in the workflow DDI alerts are addressed and implementing SDM in routine patient care.

Not all DDIs are amenable to SDM, and clinicians should use their judgement before opening a discussion about certain DDIs. Although patients appreciated discussing the warfarin-NSAID DDI with the provider, only the low-risk scenario seemed to be relevant. Certain high-risk DDIs should be avoided without SDM. Additionally, although these patients had been on warfarin for multiple years, knowledge about DDIs and treating pain while taking warfarin was limited. This aligns with what others have found on patient knowledge about anticoagulant therapy [38,39]. Knowledge about which medications are NSAIDs and symptoms of bleeding should not be assumed despite experience with warfarin. Regardless of the decision to avoid an NSAID, patient education about the DDI is needed. Finally, patients mentioned that after previous provider encounters it was difficult to recall information about treatment decisions. Consideration

for allowing patients to reference the tool after an encounter may help with comprehension and adhering to decisions; however, DDInteract and other similar tools would need to be adapted to and tested with patients to understand decision-making without provider assistance.

Clinicians had questions about when and how DDInteract would be used. Medication prescribing often occurs at the end of an encounter without the patient. If DDInteract was triggered when an NSAID is ordered, the patient might not be available for discussion. Opportunities to use an SDM tool for DDIs earlier in the workflow may be needed. For example, triggering DDInteract for a patient who is having pain or starting warfarin are additional use cases. Triggering on pain is especially relevant for patients on warfarin due to frequent use of over-the-counter NSAIDs. Although DDInteract was designed to mitigate risk associated with DDIs, clinicians requested decision support for other aspects of anticoagulant therapy, such as deciding to start an anticoagulant or which anticoagulant to use. To achieve broad uptake of SDM for DDIs, the scope of DDInteract may need to be expanded to other decision-making and clinician workflow opportunities.

### Future Research

The next step is to conduct a formative evaluation of DDInteract to understand how it impacts measures of decision-making, satisfaction, and clinician workflow. To maximize dissemination and enable integration with EHR systems, we have developed

an interoperable DDInteract app using emerging clinical decision support standards including Clinical Quality Language, Clinical Decision Support Hooks, and SMART on Fast Healthcare Interoperability Resources (FHIR) [40]. A SMART on FHIR prototype of DDInteract is available on Logica Sandbox, and we have successfully implemented DDInteract in an EHR test environment at the University of Utah. Further research is needed to understand how SDM with DDIs can be integrated with overarching decisions surrounding anticoagulant therapy. Finally, research is needed to explore how decision aids in the EHR can be adapted to clinical workflows to enable SDM in routine patient care.

### Conclusion

This study describes the design and usability testing of DDInteract. The findings contribute to knowledge about implementing SDM in routine patient care and expand the use of SDM to DDIs. A multidisciplinary design team collaborated with patients, clinicians, and health information technology experts to design a tool that provides a patient-specific risk calculation, elicits patient preferences, and guides both the patient and clinician to a decision. The rigorous design process resulted in a usable and potentially useful tool. Through the design process and usability testing, key lessons were learned from the patient and clinician perspectives. The next step is to evaluate the utility of DDInteract in a clinical setting, and if successful, to implement it across EHRs using interoperable technology.

### Conflicts of Interest

This study was funded by the Agency for Healthcare Research and Quality (U18 PA-18-792 and R18HS026198). Outside of the described work, KK reports honoraria, consulting, sponsored research, licensing, or codevelopment in the past 3 years with McKesson InterQual, Hitachi, Pfizer, Premier, Klesis Healthcare, RTI International, Mayo Clinic, the University of Washington, the University of California at San Francisco, MD Aware, and the US Office of the National Coordinator for Health IT (via ESAC and Security Risk Solutions) in the area of health information technology. KK was also an unpaid board member of the nonprofit Health Level Seven International health information technology standard development organization, he is an unpaid member of the US Health Information Technology Advisory Committee, and he has helped develop a number of health information technology tools outside of the described work, which may be commercialized to enable wider impact. None of these relationships have direct relevance to the paper but are reported in the interest of full disclosure. Other authors have no competing interests to declare.

### Multimedia Appendix 1

Clinic vignettes used for patient interviews.

[\[DOCX File, 14 KB-Multimedia Appendix 1\]](#)

### References

1. Magro L, Moretti U, Leone R. Epidemiology and characteristics of adverse drug reactions caused by drug-drug interactions. *Expert Opin Drug Saf* 2012 Jan;11(1):83-94. [doi: [10.1517/14740338.2012.631910](https://doi.org/10.1517/14740338.2012.631910)] [Medline: [22022824](https://pubmed.ncbi.nlm.nih.gov/22022824/)]
2. Hines LE, Murphy JE. Potentially harmful drug-drug interactions in the elderly: a review. *Am J Geriatr Pharmacother* 2011 Dec;9(6):364-377. [doi: [10.1016/j.amjopharm.2011.10.004](https://doi.org/10.1016/j.amjopharm.2011.10.004)] [Medline: [22078863](https://pubmed.ncbi.nlm.nih.gov/22078863/)]
3. Juurlink DN, Mamdani M, Kopp A, Laupacis A, Redelmeier DA. Drug-drug interactions among elderly patients hospitalized for drug toxicity. *JAMA* 2003 Apr 02;289(13):1652-1658. [doi: [10.1001/jama.289.13.1652](https://doi.org/10.1001/jama.289.13.1652)] [Medline: [12672733](https://pubmed.ncbi.nlm.nih.gov/12672733/)]
4. Qato DM, Alexander GC, Conti RM, Johnson M, Schumm P, Lindau ST. Use of prescription and over-the-counter medications and dietary supplements among older adults in the United States. *JAMA* 2008 Dec 24;300(24):2867-2878 [[FREE Full text](#)] [doi: [10.1001/jama.2008.892](https://doi.org/10.1001/jama.2008.892)] [Medline: [19109115](https://pubmed.ncbi.nlm.nih.gov/19109115/)]
5. Hastings S, Schmader K, Sloane R, Weinberger M, Pieper CF, Goldberg KC, et al. Quality of pharmacotherapy and outcomes for older veterans discharged from the emergency department. *J Am Geriatr Soc* 2008 May;56(5):875-880. [doi: [10.1111/j.1532-5415.2008.01648.x](https://doi.org/10.1111/j.1532-5415.2008.01648.x)] [Medline: [18341519](https://pubmed.ncbi.nlm.nih.gov/18341519/)]



6. Hanlon JT, Perera S, Newman AB, Thorpe JM, Donohue JM, Simonsick EM, Health ABC Study. Potential drug-drug and drug-disease interactions in well-functioning community-dwelling older adults. *J Clin Pharm Ther* 2017 Apr;42(2):228-233 [FREE Full text] [doi: [10.1111/jcpt.12502](https://doi.org/10.1111/jcpt.12502)] [Medline: [28111765](https://pubmed.ncbi.nlm.nih.gov/28111765/)]
7. Delaney JA, Opatrny L, Brophy JM, Suissa S. Drug drug interactions between antithrombotic medications and the risk of gastrointestinal bleeding. *CMAJ* 2007 Aug 14;177(4):347-351 [FREE Full text] [doi: [10.1503/cmaj.070186](https://doi.org/10.1503/cmaj.070186)] [Medline: [17698822](https://pubmed.ncbi.nlm.nih.gov/17698822/)]
8. Malone D, Hutchins D, Hauptert H, Hansten P, Duncan B, Van Bergen RC, et al. Assessment of potential drug-drug interactions with a prescription claims database. *Am J Health Syst Pharm* 2005 Oct 01;62(19):1983-1991. [doi: [10.2146/ajhp040567](https://doi.org/10.2146/ajhp040567)] [Medline: [16174833](https://pubmed.ncbi.nlm.nih.gov/16174833/)]
9. van der Sijs H, Aarts J, Vulto A, Berg M. Overriding of drug safety alerts in computerized physician order entry. *J Am Med Inform Assoc* 2006;13(2):138-147 [FREE Full text] [doi: [10.1197/jamia.M1809](https://doi.org/10.1197/jamia.M1809)] [Medline: [16357358](https://pubmed.ncbi.nlm.nih.gov/16357358/)]
10. Weingart SN, Toth M, Sands DZ, Aronson MD, Davis RB, Phillips RS. Physicians' decisions to override computerized drug alerts in primary care. *Arch Intern Med* 2003 Nov 24;163(21):2625-2631. [doi: [10.1001/archinte.163.21.2625](https://doi.org/10.1001/archinte.163.21.2625)] [Medline: [14638563](https://pubmed.ncbi.nlm.nih.gov/14638563/)]
11. Bryant A, Fletcher G, Payne T. Drug interaction alert override rates in the Meaningful Use era: no evidence of progress. *Appl Clin Inform* 2014;5(3):802-813 [FREE Full text] [doi: [10.4338/ACI-2013-12-RA-0103](https://doi.org/10.4338/ACI-2013-12-RA-0103)] [Medline: [25298818](https://pubmed.ncbi.nlm.nih.gov/25298818/)]
12. Heringa M, Floor-Schreuderling A, Wouters H, De Smet PAGM, Bouvy ML. Preferences of patients and pharmacists with regard to the management of drug-drug interactions: a choice-based conjoint analysis. *Drug Saf* 2018 Feb;41(2):179-189 [FREE Full text] [doi: [10.1007/s40264-017-0601-7](https://doi.org/10.1007/s40264-017-0601-7)] [Medline: [28965265](https://pubmed.ncbi.nlm.nih.gov/28965265/)]
13. Dolan JG, Veazie PJ, Russ AJ. Development and initial evaluation of a treatment decision dashboard. *BMC Med Inform Decis Mak* 2013 Apr 21;13:51 [FREE Full text] [doi: [10.1186/1472-6947-13-51](https://doi.org/10.1186/1472-6947-13-51)] [Medline: [23601912](https://pubmed.ncbi.nlm.nih.gov/23601912/)]
14. Tiedje K, Shippee ND, Johnson AM, Flynn PM, Finnie DM, Liesinger JT, et al. 'They leave at least believing they had a part in the discussion': understanding decision aid use and patient-clinician decision-making through qualitative research. *Patient Educ Couns* 2013 Oct;93(1):86-94 [FREE Full text] [doi: [10.1016/j.pec.2013.03.013](https://doi.org/10.1016/j.pec.2013.03.013)] [Medline: [23598292](https://pubmed.ncbi.nlm.nih.gov/23598292/)]
15. Sandman L, Munthe C. Shared decision making, paternalism and patient choice. *Health Care Anal* 2010 Mar;18(1):60-84. [doi: [10.1007/s10728-008-0108-6](https://doi.org/10.1007/s10728-008-0108-6)] [Medline: [19184444](https://pubmed.ncbi.nlm.nih.gov/19184444/)]
16. Elwyn G, Frosch D, Thomson R, Joseph-Williams N, Lloyd A, Kinnersley P, et al. Shared decision making: a model for clinical practice. *J Gen Intern Med* 2012 Oct;27(10):1361-1367 [FREE Full text] [doi: [10.1007/s11606-012-2077-6](https://doi.org/10.1007/s11606-012-2077-6)] [Medline: [22618581](https://pubmed.ncbi.nlm.nih.gov/22618581/)]
17. Charles C, Gafni A, Whelan T. Shared decision-making in the medical encounter: what does it mean? (or it takes at least two to tango). *Soc Sci Med* 1997 Mar;44(5):681-692. [doi: [10.1016/s0277-9536\(96\)00221-3](https://doi.org/10.1016/s0277-9536(96)00221-3)] [Medline: [9032835](https://pubmed.ncbi.nlm.nih.gov/9032835/)]
18. Légaré F, Adekpedjou R, Stacey D, Turcotte S, Kryworuchko J, Graham ID, et al. Interventions for increasing the use of shared decision making by healthcare professionals. *Cochrane Database Syst Rev* 2018 Jul 19;7:CD006732 [FREE Full text] [doi: [10.1002/14651858.CD006732.pub4](https://doi.org/10.1002/14651858.CD006732.pub4)] [Medline: [30025154](https://pubmed.ncbi.nlm.nih.gov/30025154/)]
19. Wright M, Dunbar S, Macpherson B, Moretti E, Del Fioli G, Bolte J, et al. Toward designing information display to support critical care. A qualitative contextual evaluation and visioning effort. *Appl Clin Inform* 2016 Oct 05;7(4):912-929. [doi: [10.4338/ACI-2016-03-RA-0033](https://doi.org/10.4338/ACI-2016-03-RA-0033)] [Medline: [27704138](https://pubmed.ncbi.nlm.nih.gov/27704138/)]
20. Reese TJ, Kawamoto K, Del Fioli G, Weir C, Tonna J, Segall N, et al. Approaching the design of an information display to support critical care. 2017 Aug 23 Presented at: 2017 IEEE International Conference on Healthcare Informatics; August 23-26, 2017; Park City, UT. [doi: [10.1109/ichi.2017.64](https://doi.org/10.1109/ichi.2017.64)]
21. Abras C, Maloney-Krichmar D, Preece J. User-centered design. In: Bainbridge W, editor. *Encyclopedia of Human-Computer Interaction*. Thousand Oaks, CA: Sage Publications; 2004:445-456.
22. Mao J, Vredenburg K, Smith PW, Carey T. The state of user-centered design practice. *Commun ACM* 2005 Mar 01;48(3):105-109. [doi: [10.1145/1047671.1047677](https://doi.org/10.1145/1047671.1047677)]
23. Nelson S, Del Fioli G, Hanseler H, Crouch B, Cummins M. Software prototyping: a case report of refining user requirements for a health information exchange dashboard. *Appl Clin Inform* 2016;7(1):22-32 [FREE Full text] [doi: [10.4338/ACI-2015-07-CR-0091](https://doi.org/10.4338/ACI-2015-07-CR-0091)] [Medline: [27081404](https://pubmed.ncbi.nlm.nih.gov/27081404/)]
24. Heaton N. What's wrong with the user interface: how rapid prototyping can help. 1992 Nov 11 Presented at: IEE Colloquium on Software Prototyping and Evolutionary Development; November 11, 2002; London, UK p. 1-7.
25. The SHARE Approach—essential steps of shared decisionmaking: quick reference guide. Agency for Healthcare Research and Quality. URL: <https://www.ahrq.gov/health-literacy/professional-training/shared-decision/tools/resource-1.html> [accessed 2020-11-15]
26. Elwyn G, O'Connor A, Stacey D, Volk R, Edwards A, Coulter A, International Patient Decision Aids Standards (IPDAS) Collaboration. Developing a quality criteria framework for patient decision aids: online international Delphi consensus process. *BMJ* 2006 Aug 26;333(7565):417 [FREE Full text] [doi: [10.1136/bmj.38926.629329.AE](https://doi.org/10.1136/bmj.38926.629329.AE)] [Medline: [16908462](https://pubmed.ncbi.nlm.nih.gov/16908462/)]
27. Nielsen J. Usability inspection methods. In: *Conference Companion on Human Factors in Computing Systems*. 1994 Apr 28 Presented at: CHI '94; April 24-28, 1994; Boston, MA p. 413-414. [doi: [10.1145/259963.260531](https://doi.org/10.1145/259963.260531)]

28. Nielsen J, Molich R. Heuristic evaluation of user interfaces. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. 1990 Mar 01 Presented at: CHI '90; April 1-5, 1990; Seattle, WA p. 249-256. [doi: [10.1145/97243.97281](https://doi.org/10.1145/97243.97281)]
29. Brooke J. SUS: a 'Quick and Dirty' usability scale. In: Jordan PW, Thomas B, McClelland IL, Weerdmeester B, editors. Usability Evaluation in Industry. London: CRC Press; 1996.
30. Bangor A, Kortum PT, Miller JT. An empirical evaluation of the system usability scale. Int J Hum-Computer Interaction 2008 Jul 30;24(6):574-594. [doi: [10.1080/10447310802205776](https://doi.org/10.1080/10447310802205776)]
31. Mayo Clinic Shared Decision Making National Resource Center. care that fits. URL: <https://carethatfits.org/shared-decision-making/> [accessed 2020-11-14]
32. O'Connor AM, Bennett C, Stacey D, Barry MJ, Col NF, Eden KB, et al. Do patient decision aids meet effectiveness criteria of the international patient decision aid standards collaboration? A systematic review and meta-analysis. Med Decis Making 2007;27(5):554-574. [doi: [10.1177/0272989X07307319](https://doi.org/10.1177/0272989X07307319)] [Medline: [17873255](https://pubmed.ncbi.nlm.nih.gov/17873255/)]
33. Galesic M, Garcia-Retamero R, Gigerenzer G. Using icon arrays to communicate medical risks: overcoming low numeracy. Health Psychol 2009 Mar;28(2):210-216. [doi: [10.1037/a0014474](https://doi.org/10.1037/a0014474)] [Medline: [19290713](https://pubmed.ncbi.nlm.nih.gov/19290713/)]
34. Sheridan SL, Halpern DJ, Viera AJ, Berkman ND, Donahue KE, Crotty K. Interventions for individuals with low health literacy: a systematic review. J Health Commun 2011;16 Suppl 3:30-54. [doi: [10.1080/10810730.2011.604391](https://doi.org/10.1080/10810730.2011.604391)] [Medline: [21951242](https://pubmed.ncbi.nlm.nih.gov/21951242/)]
35. Garcia-Retamero R, Galesic M, Gigerenzer G. Do icon arrays help reduce denominator neglect? Med Decis Making 2010;30(6):672-684. [doi: [10.1177/0272989X10369000](https://doi.org/10.1177/0272989X10369000)] [Medline: [20484088](https://pubmed.ncbi.nlm.nih.gov/20484088/)]
36. Trevena LJ, Zikmund-Fisher BJ, Edwards A, Gaissmaier W, Galesic M, Han PKJ, et al. Presenting quantitative information about decision outcomes: a risk communication primer for patient decision aid developers. BMC Med Inform Decis Mak 2013;13 Suppl 2:S7 [FREE Full text] [doi: [10.1186/1472-6947-13-S2-S7](https://doi.org/10.1186/1472-6947-13-S2-S7)] [Medline: [24625237](https://pubmed.ncbi.nlm.nih.gov/24625237/)]
37. Spiegelhalter D, Pearson M, Short I. Visualizing uncertainty about the future. Science 2011 Sep 09;333(6048):1393-1400. [doi: [10.1126/science.1191181](https://doi.org/10.1126/science.1191181)] [Medline: [21903802](https://pubmed.ncbi.nlm.nih.gov/21903802/)]
38. Taylor FC, Ramsay ME, Tan G, Gabbay J, Cohen H. Evaluation of patients' knowledge about anticoagulant treatment. Qual Health Care 1994 Jun;3(2):79-85 [FREE Full text] [doi: [10.1136/qshc.3.2.79](https://doi.org/10.1136/qshc.3.2.79)] [Medline: [10137589](https://pubmed.ncbi.nlm.nih.gov/10137589/)]
39. Tang EOY, Lai CS, Lee KK, Wong RS, Cheng G, Chan TY. Relationship between patients' warfarin knowledge and anticoagulation control. Ann Pharmacother 2003 Jan;37(1):34-39. [doi: [10.1345/aph.1A198](https://doi.org/10.1345/aph.1A198)] [Medline: [12503930](https://pubmed.ncbi.nlm.nih.gov/12503930/)]
40. Mandel JC, Kreda DA, Mandl KD, Kohane IS, Ramoni RB. SMART on FHIR: a standards-based, interoperable apps platform for electronic health records. J Am Med Inform Assoc 2016 Sep;23(5):899-908 [FREE Full text] [doi: [10.1093/jamia/ocv189](https://doi.org/10.1093/jamia/ocv189)] [Medline: [26911829](https://pubmed.ncbi.nlm.nih.gov/26911829/)]

## Abbreviations

- DDI:** drug-drug interaction
- DOAC:** direct oral anticoagulant
- EHR:** electronic health record
- FHIR:** Fast Healthcare Interoperability Resources
- NSAID:** nonsteroidal anti-inflammatory drug
- PPI:** proton pump inhibitor
- SDM:** shared decision-making

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