

Links between usability flaws, usage problems and negative outcomes in the work system

| | Usability flaw | | | Usage problem | | | Negative outcome | | |
|--------------|---|---------------|----------------------|--|------------|--------------------------------------|--|--------------------------------------|--|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category | |
| [22] [29] | "Alert does not provide clear information on relative risk of harm for a given patient" "Although some alerts are categorized by risk, (e.g., some are marked as "significant" and others are "critical"), this notation was not always sufficient for prescribers"; "Risk rating/degree of risk: Prescribers wanted a more clear indication of risk and suggested that alerts display a quantitative rating" [Inferred: there is no clear risk information in the alert] | Compatibility | Alert content issues | "If there's more than one [alert in a popup window], I don't read through them all, honestly" | Behavioral | Voluntarily ignoring alerts | "Ordering decisions were hampered"; "alerts (...) impeded medication ordering processes."; | Medication management process issues | |
| [22] [29] | "Alert does not provide clear information on relative risk of harm for a given patient" "Although some alerts are categorized by risk, (e.g., some are marked as "significant" and others are "critical"); this notation was not always sufficient for prescribers"; "Risk rating/degree of risk: Prescribers wanted a more clear indication of risk and suggested that alerts display a quantitative rating" [Inferred: there is no clear risk information in the alert] | Compatibility | Alert content issues | "It's gotten to the point that I don't hardly look at significant (interactions) anymore" | Behavioral | Voluntarily ignoring alerts | "Ordering decisions were hampered"; "alerts (...) impeded medication ordering processes."; | Medication management process issues | |
| [22] [29] | "Alert is not evidence-based, does not provide a reference to evidence that does exist, and/or the actual or perceived level of evidence is low." "The alerts themselves do not present the evidence nor do they provide links to any supporting documentation" "Quality/strength of alert evidence; guidance on actions to take: Prescribers wanted alert to provide: references or links to evidence (...) some alerts were not evidence-based" "The actual or perceived level of evidence is low"; "unclear if the warnings were "evidence-based"; "extend of evidence is fair, stemming mainly from a few case reports" | Compatibility | Alert content issues | "This lack of information led to prescriber cynicism." | Emotional | Cynicism | | | |
| [27] | "erroneous system messaging [about how to solve the problem]" | Compatibility | Alert content issues | "Resorted to trial-and-error behavior exemplified by the extra mouse clicks and keystrokes they needed for locating and executing the right action in response to the message" | Behavioral | Increased workload | "Impaired the ordering efficiency" | Medication management process issues | |
| [27] | "erroneous system messaging [about how to solve the problem]" | Compatibility | Alert content issues | "Physicians were lost » | Behavioral | Users lost | "Impaired the ordering efficiency" | Medication management process issues | |
| [27] | "erroneous system messaging [about how to solve the problem]" | Compatibility | Alert content issues | "Precluding the physicians to understand the problem that generated the alert or how to solve the problem." | Cognitive | Difficulties to understand the alert | "Impaired the ordering efficiency" | Medication management process issues | |
| [29] | "The alert did not provide essential patient information for the prescriber, even though it existed elsewhere in the EHR. For example, decision-making for some drug interaction alerts (e.g., amloride and lisinopril, which can cause hyperkalemia) depend on patient labs (e.g., potassium). This missing, or more accurately, 'hidden' patient data triggered varying responses." | Compatibility | Alert content issues | "Spent time searching for information in the EHR afterwards to validate their decision." | Behavioral | Increased workload | | | |

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| [29] | "The alert did not provide essential patient information for the prescriber, even though it existed elsewhere in the EHR. For example, decision-making for some drug interaction alerts (e.g., amiloride and lisinopril, which can cause hyperkalemia) depend on patient labs (e.g., potassium). This missing, or more accurately, 'hidden' patient data triggered varying responses." "The alert did not provide essential patient information for the prescriber, even though it existed elsewhere in the EHR. For example, decision-making for some drug interaction alerts (e.g., amiloride and lisinopril, which can cause hyperkalemia) depend on patient labs (e.g., potassium). This missing, or more accurately, 'hidden' patient data triggered varying responses." "Another in-clinic user stated that the system would be more helpful if it gave more detailed information on "how to switch or discontinue drugs." "There were cases in which clinicians reached a dead end within the CR system, with no reasonable option to proceed." "We observed instances in which none of the available options to satisfy the CR applied to the patient or situation." "There were cases in which clinicians reached a dead end within the CR system, with no reasonable option to proceed." "We observed instances in which none of the available options to satisfy the CR applied to the patient or situation." "Options within the dialogue box of the CRs do not always match the patient's response or there is not an appropriate option for indicating why the provider has decided not to order a test, for example." | Compatibility | Alert content issues | "Others overrode the alert" | Behavioral | Voluntarily ignoring alerts | | |
| [29] | | Compatibility | Alert content issues | "Made assumptions about the patient history"; "Some prescribers relied solely on their memory of the patient profile" | Cognitive | Increased memory load | | |
| [36] | | Compatibility | Alert content issues | "The system would be more helpful" [currently not sufficiently helpful] | Attitudinal | Questioning usefulness | | |
| [37] | | Compatibility | Alert content issues | "The existence of dead-end scenarios is a barrier to the effective use of the reminders since it impedes the ability to satisfy them" | Behavioral | Ineffective use | | |
| [37] | | Compatibility | Alert content issues | "Additionally, we observed one nurse and one provider become "stuck" trying to satisfy a CR because the appropriate option was not available to them." | Behavioral | Users lost | | |
| [37] | | Compatibility | Alert content issues | "Finally, two providers reported using workarounds to satisfy reminders because of the inflexibility of the dialogue options". "Provider arbitrarily selected a date to satisfy the reminder"; "The provider had to leave the reminder unsatisfied." | Behavioral | Workarounds | | |
| [29] | "Alerts cannot be pulled up later, as needed, hindering alert resolution"; "Sometimes, prescribers wanted a way to retrieve an alert that had been displayed, but the alert system did not support this function." "The use of CRs automatically generates text that is added to the progress note, but that text is not integrated with the template information and is generally added to the bottom of the note." | Compatibility | Alert features issues | "Prescribers sometimes forgot what alert(s) appeared" | Cognitive | Information involuntarily missed | "Hindering alert resolution"; "Hinder Technology effectiveness issues" | |
| [37] | | Compatibility | Alert features issues | "This integration of the clinical topic addressed by the reminder into the template aligns it more directly into the nurse's workflow, thus facilitating its effective use." [currently not effective use] | Behavioral | Ineffective use | | |

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| [10] | "CPOE provides feedback on drug allergies, but only after medications are ordered." | Compatibility | Alert presentation issues | "Some house staff ignored allergy notices (...) and, most important, post hoc timing of allergy information." | Behavioral | Voluntarily ignoring alerts | "House staff claimed post hoc alerts unintentionally encourage house staff to rely on pharmacists for drug allergy checks, implicitly shifting responsibility to pharmacists." | Workflow issues |
| [24] | "They said that pop-up alerts particularly were annoying or unhelpful if they popped up "too early" in the encounter, or on the wrong screen." | Compatibility | Alert presentation issues | "They said that pop-up alerts particularly were (...) unhelpful"; "The alerts were most likely to be helpful if they presented when the users were entering orders or were otherwise at the point of making a decision about the issue in question or closely related issues." | Attitudinal | Questioning usefulness | | |
| [24] | "Some acknowledged they were unlikely to respond, or perhaps they were intrusive." [Inference: alerts not sufficiently intrusive in this case] | Compatibility | Alert presentation issues | "Some acknowledged they were unlikely to respond, or perhaps even be aware of alerts, unless they were intrusive." [missing an alert] | Cognitive | Information involuntarily missed | | |
| [24] | "They said that pop-up alerts particularly were annoying or unhelpful if they popped up "too early" in the encounter, or on the wrong screen." | Compatibility | Alert presentation issues | "Partly because of the disruption of the thought process" | Cognitive | Users interrupted | | |
| [24] | "However, even some of these users acknowledged that "pop-up" alerts can be very annoying. ..." | Compatibility | Alert presentation issues | "Pop-up" alerts can be very annoying"; "Well, I think anything that keeps recurring to me is [annoying]" | Emotional | Annoyance | | |
| [24] | "They said that pop-up alerts particularly were annoying or unhelpful if they popped up "too early" in the encounter, or on the wrong screen" | Compatibility | Alert presentation issues | "Pop-up" alerts can be very annoying"; "Well, I think anything that keeps recurring to me is [annoying]" | Emotional | Annoyance | | |
| [25] | "The institutional guideline for heparin administration (...) triggered later in the process when the planning stage of the order is generally completed" | Compatibility | Alert presentation issues | "Six subjects computed, estimated or used a heuristic to get the dose amount at some point before the system-calculated dose presentation" | Behavioral | Workarounds | "Consequently they did not derive all the speed and accuracy benefit and did not reduce their cognitive effort the feature was in part designed to." | Technology effectiveness issues |
| [28] | "Intrusive alerts presented at the wrong time in the workflow" | Compatibility | Alert presentation issues | "Several prescribers described rapidly overriding these alert types once they recognized that they had seen the alert before. One prescriber noted that she had "memorized the location of the override button" for these situations." | Behavioral | Voluntarily ignoring alerts | | |
| [28] | "Intrusive alerts presented at the wrong time in the workflow" | Compatibility | Alert presentation issues | "These alerts that caused frustrations" | Emotional | Frustration | | |
| [29] | "Technology lags/down-times" "Even 10-15 second computer delays between the order and subsequent alert" | Compatibility | Alert presentation issues | "There were several cases where inadequate alert design (...) disrupted their workflow." | Cognitive | Users interrupted | "Hindering alert resolution"; "Hinder alert effectiveness" | Technology effectiveness issues |
| [29] | "Technology lags/down-times" "Even 10-15 second computer delays between the order and subsequent alert" | Compatibility | Alert presentation issues | "View as "very troublesome"" | Emotional | Annoyance | | |
| [29] | "Technology lags/down-times" "Even 10-15 second computer delays between the order and subsequent alert" | Compatibility | Alert presentation issues | "Place prescribers under pressure" | Emotional | Stress | | |

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| [35] | "Too many alerts or alerts at an inappropriate time: "Now we get alerts when we go to charting, which in my workflow is the last step. It's after the patient's gone. Now I get warned they've got some drug interaction. Great!" | Compatibility | Alert presentation issues | "There were numerous complaints about getting too many alerts or alerts at an inappropriate time" | Attitudinal | Negative feelings | | |
| [35] | "Too many alerts or alerts at an inappropriate time: "Now we get alerts when we go to charting, which in my workflow is the last step. It's after the patient's gone. Now I get warned they've got some drug interaction. Great!" | Compatibility | Alert presentation issues | "Or alerts at an inappropriate time" [too late, once the patient is out, the information is missed] | Cognitive | Information involuntarily missed | | |
| [37] | "The CRs appear on this cover sheet but are delayed in loading and displaying (Site 3 reported an average delay of 8 seconds for the CRs to load)." | Compatibility | Alert presentation issues | "We observed providers and nurses use strategies such as clicking on the progress notes tab before the reminders have displayed (...) or report setting a default tab to bypass the cover sheet, thereby lessening the visibility of the reminders" | Behavioral | Workarounds | | |
| [32] | "You do not get the warning again, and there is no button to get it [the second alert] back" | Compatibility | Alerts features issues | "You do not get the warning again" [missed information] | Cognitive | Information involuntarily missed | | |
| [28] | "Prescribers reported that alerts presenting during medication order entry were often (...) difficult to interpret in content and purpose" | Workload | Concision | "Several prescribers described rapidly overriding these alert types once they recognized that they had seen the alert before. One prescriber noted that she had "memorized the location of the override button" for these situations." | Behavioral | Voluntarily ignoring alerts | | |
| [28] | "Prescribers reported that alerts presenting during medication order entry were often (...) difficult to interpret in content and purpose" | Workload | Concision | "Difficult to interpret in content and purpose"; "Some reported difficulty with (...) the length of the text." | Cognitive | Difficulties to understand the alert | "Slowed down their work" | Medication management process issues |
| [34] | "Pregnancy alerts would be more useful if they showed the category of alert (A, B, C, etc.) rather than narrative information..." | Workload | Concision | "There are too many things popping up at me"; "(alert fatigue)" | Attitudinal | Alert fatigue | | |
| [34] | "Pregnancy alerts would be more useful if they showed the category of alert (A, B, C, etc.) rather than narrative information..." | Workload | Concision | "It's just crying wolf"; "Difficult to interpret the validity of many alerts" | Attitudinal | Questioning the validity | | |
| [34] | "Pregnancy alerts would be more useful if they showed the category of alert (A, B, C, etc.) rather than narrative information..." | Workload | Concision | "Many clinicians ignore potentially serious alerts"; "Once you realize that most of the information is useless or superfluous or not relevant, you stop looking at it." | Behavioral | Voluntarily ignoring alerts | | |
| [34] | "Pregnancy alerts would be more useful if they showed the category of alert (A, B, C, etc.) rather than narrative information..." | Workload | Concision | "Trivial alerts often interrupt workflow." | Cognitive | Users interrupted | | |
| [40] | "Every doctor reported that the alerts contained too much text and should be shortened." | Workload | Concision | "If you spend time to read it" | Behavioral | Increased workload | | |
| [40] | "Every doctor reported that the alerts contained too much text and should be shortened." | Workload | Concision | "It pops up so often which can be a very bad thing because you're dismissing it so often that you develop this sort of mechanism"; "Most doctors either admitted to not reading the warnings"; "It's so much easier to click that button" | Behavioral | Voluntarily ignoring alerts | | |

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| [37] | "However, there was no means to cancel the CR without losing the data already inputted for the previous CRs." [Inference: the system does not act as the user asks] | Explicit control | Explicit user actions | [Inference: user cannot perform the action as he intends to] | Behavioral | Users lost | "Introduces the possibility of losing data previously inputted." | Technology effectiveness issues | |
| [37] | "However, there was no means to cancel the CR without losing the data already inputted for the previous CRs." [Inference: the system does not act as the user asks] | Explicit control | Explicit user actions | "A workaround is to select each CR individually from the list rather than using the Next button to navigate through a sequence of CRs." | Behavioral | Workarounds | | | |
| [29] | "Interface, which did not adequately support all prescriber types." | Adaptability | Flexibility | "Prescribers unaware that they could turn off some alerts"; "Prescribers' ability to act on alerts was impeded by the alert interface" | Behavioral | Ineffective use | "We call the pharmacist and spend time looking up information."; "physicians often come and ask [the pharmacists] about an alert triggered by the combination of amiodarone and simvastatin"; "physicians and nurse practitioners found it helpful, and sometimes necessary, to have real-time, face-to-face communication with clinical pharmacists to be able to interpret and resolve alerts" | Workflow issues | |
| [29] | "Interface, which did not adequately support all prescriber types." | Adaptability | Flexibility | "Prescribers were sometimes unsure (...) what an alert was attempting to convey"; "Language of alerts is difficult for prescriber to interpret 'I do not know what that means.'" | Cognitive | Difficulties to understand the alert | "We call the pharmacist and spend time looking up information."; "physicians often come and ask [the pharmacists] about an alert triggered by the combination of amiodarone and simvastatin"; "physicians and nurse practitioners found it helpful, and sometimes necessary, to have real-time, face-to-face communication with clinical pharmacists to be able to interpret and resolve alerts" | Workflow issues | |
| [22] | "Overuse of Pop-ups, other, non-medication related pop-ups contribute to prescriber alert desensitization" - Overuse of other, non-alert pop-up windows may contribute to desensitization" | Guidance | Grouping/distinction | "Prescriber desensitization"; "Even prescribers with a very positive view of the alert system showed signs of desensitization" | Attitudinal | Alert fatigue | | | |
| [28] | "Cost and health maintenance alerts that were intrusive to the workflow" | Guidance | Grouping/distinction | "Viewed as (...) most annoying" | Emotional | Annoyance | | | |
| [29] | "Difficult to distinguish different alert types (e.g., duplicate drug versus duplicate drug class alerts)" | Guidance | Grouping/distinction | "Difficult to distinguish different alert types (e.g., duplicate drug versus duplicate drug class alerts)" | Cognitive | Difficulties to understand the alert | | | |
| [32] | "I did not look through the new screen, and then I hit the button and suddenly it was gone" | Guidance | Immediate feedback | "The physician may overlook the second alert, thinking that the override button for the (first) alert has not worked properly"; "thereby unintentionally override the second alert." | Cognitive | Information involuntarily missed | "wrong selection (followed incorrect dose recommendation)" | Patient safety issues | |

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| [22] [26] [29] | Workload | Information density | "If there's more than one [alert in a popup window], I don't read through them all, honestly" | Behavioral | Voluntarily ignoring alerts | "Hindering alert resolution"; "Hinder alert effectiveness" | Technology effectiveness issues | |
| [22] [26] [29] | Workload | Information density | "It's gotten to the point that I don't hardly look at significant (interactions) anymore" | Behavioral | Voluntarily ignoring alerts | "Hindering alert resolution"; "Hinder alert effectiveness" | Technology effectiveness issues | |
| [22] [26] [29] | Workload | Information density | "Prescribers were sometimes unsure (...) what an alert was attempting to convey"; "Language of alerts is difficult for prescriber to interpret "I do not know what that means." | Cognitive | Difficulties to understand the alert | "Hindering alert resolution"; "Hinder alert effectiveness" | Technology effectiveness issues | |
| [22] [26] [29] | Workload | Information density | "Prescribers were sometimes unsure (...) what an alert was attempting to convey"; "Language of alerts is difficult for prescriber to interpret "I do not know what that means." | Cognitive | Difficulties to understand the alert | "We call the pharmacist and spend time looking up information." ; "physicians often come and ask [the pharmacist] about an alert triggered by the combination of amiodarone and simvastatin"; "physicians and nurse practitioners found it helpful, and sometimes necessary, to have real-time, face-to-face communication with clinical pharmacists to be able to interpret and resolve alerts" | Workflow issues | |
| [22] [26] [29] | Workload | Information density | "Many prescribers overwhelmed by (...) multiple alerts presented in one pop-up" | Emotional | Annoyance | | | |
| [22] [26] [29] | Workload | Information density | "Reading them is ugly" | Emotional | Ugly experience | | | |
| [25] | Workload | Information density | "Two subjects did not use the decision support feature because they misidentified the alert as a general guideline reminder and did not notice the dose calculations embedded in text." | Behavioral | System not used at all | | | |
| [25] | Workload | Information density | "They misidentified the alert as a general guideline reminder and did not notice the dose calculations embedded in text." | Cognitive | Difficulties to identify alerts' components | | | |

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| [29] | "Extraneous information decreases alert value: Prescribers wanted a brief description of the problem: e.g. "it needs to be 10 words or less"" [Inference: the problem description is too long] | Workload | Information density | "Sometimes, when alerts contain a lot of text, prescribers rely instead on their "own clinical judgment" | Behavioral | System not used at all | "Hindering alert resolution"; "Hinder alert effectiveness" | Technology effectiveness issues | |
| [33] | "Visualization of drug-drug interaction alerts where one drug has interactions with several others" [Inference: too much information in the alert] | Workload | Information density | "They already find it difficult to understand visualization" | Cognitive | Difficulties to understand the alert | | | |
| [36] | "[It is hard to use the tool when sitting with a patient because it is in paragraph form. It would be better if factoids or outlines and standardized approaches are numbered or outlined and in lists.]" | Workload | Information density | "It is hard to use the tool when sitting with a patient" | Attitudinal | Negative feelings | | | |
| [36] | "The page is too convoluted. When there are 10 different things on the screen, providers aren't going to read any of it." | Workload | Information density | "Providers aren't going to read any of it." | Behavioral | Voluntarily ignoring alerts | | | |
| [22] | "According to participants, alert displays were problematic since much of the alert text was in all capital letters" | Guidance | Legibility | [inference: hard to read the text] | Cognitive | Difficulties to understand the alert | "Hindering alert resolution"; "Hinder alert effectiveness" | Technology effectiveness issues | |
| [29] | "Stylistic interface features support or hinder alert effectiveness: all capital letters ..." | Guidance | Legibility | "Reading them is ugly" | Emotional | Ugly experience | | | |
| [22] | "According to participants, alert displays were problematic since much of the alert text was in all capital letters" | Guidance | Legibility | [inference: hard to read the text] | Cognitive | Difficulties to understand the alert | "Hindering alert resolution"; "Hinder alert effectiveness" | Technology effectiveness issues | |
| [29] | "Lack of spacing between alert text" | Guidance | Legibility | [inference: hard to read the text] | Cognitive | Difficulties to understand the alert | | | |
| [22] | "Low alert signal to noise ratio: numerosness of alerts" | Compatibility | Low signal-to-noise ratio | "Prescriber desensitization"; "Even prescribers with a very positive view of the alert system showed signs of desensitization" | Attitudinal | Alert fatigue | | | |
| [22] | "Some medication alerts may not be supported by pharmacy data. One pharmacist stated, "Sometimes, a doctor will call me about an interaction. I check in Micromedex®. [Micromedex® is a well-respected medication interaction database] Sometimes, there is no interaction shown in Micromedex® [for that alert]. I tell the doctor, 'I don't know. There is no information on it in the [Micromedex®] database.'" | Compatibility | Low signal-to-noise ratio | "Some prescribers were skeptical of alerts because it was unclear if the warnings were "evidence-based"; also, prescribers sometimes questioned the quality and strength of evidence." | Attitudinal | Questioning the validity | | | |
| [22] | "Alert conflicts with VAMC practices that are in place and/or standard medication practices." | Compatibility | Low signal-to-noise ratio | "Influence prescribers' perceptions of the credibility and trustworthiness of the alert system as a whole" | Attitudinal | Questioning the validity | | | |
| [29] | "Alert conflicts with common medication practices" | Compatibility | Low signal-to-noise ratio | "If there's more than one [alert in a popup window], I don't read through them all, honestly" | Behavioral | Voluntarily ignoring alerts | "Ordering decisions were hampered"; "alerts (...) impeded medication ordering processes. "; | Medication management process issues | |
| [22] | "Repeated alerts within the same encounter or over multiple encounters for a given patient"; "alerts were sometimes excessively redundant (...). The observer noted: we have now seen the same alert 4 times in the last 10 min or less." | Compatibility | Low signal-to-noise ratio | | | | | | |
| [29] | "Redundant alerts within a given patient encounter. Often triggered by renewing interacting medication pairs. E.g., Same alert appears a 3rd time" | Compatibility | Low signal-to-noise ratio | | | | | | |

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| [22] | "Repeated alerts within the same encounter or over multiple encounters for a given patient"; "alerts were sometimes excessively redundant. (...). The observer noted: we have now seen the same alert 4 times in the last 10 min or less." | Compatibility | Low signal-to-noise ratio | "It's gotten to the point that I don't hardly look at significant (interactions) anymore" | Behavioral | Voluntarily ignoring alerts | "Ordering decisions were hampered"; "alerts (...) impeded medication ordering processes"; |
| [29] | "Redundant alerts within a given patient encounter. Often triggered by renewing interacting medication pairs. E.g., Same alert appears a 3rd time" | | | | | | |
| [22] | "Repeated alerts within the same encounter or over multiple encounters for a given patient"; "alerts were sometimes excessively redundant. (...). The observer noted: we have now seen the same alert 4 times in the last 10 min or less." | Compatibility | Low signal-to-noise ratio | "NP gestures to the screen, "See – three times!"" | Emotional | Annoyance | |
| [29] | "Redundant alerts within a given patient encounter. Often triggered by renewing interacting medication pairs. E.g., Same alert appears a 3rd time" | | | | | | |
| [22] | "Repeated alerts within the same encounter or over multiple encounters for a given patient"; "alerts were sometimes excessively redundant. (...). The observer noted: we have now seen the same alert 4 times in the last 10 min or less." | Compatibility | Low signal-to-noise ratio | "A nurse practitioner voiced her frustration" | Emotional | Frustration | |
| [29] | "Redundant alerts within a given patient encounter. Often triggered by renewing interacting medication pairs. E.g., Same alert appears a 3rd time" | | | | | | |
| [24] | "Repetitive alerts are both annoying and unnecessary." | Compatibility | Low signal-to-noise ratio | "Users complained vociferously »" | Attitudinal | Negative feelings | |
| [24] | "Repetitive alerts are both annoying and unnecessary." | Compatibility | Low signal-to-noise ratio | "Pop-up" alerts can be very annoying"; "Well, I think anything that keeps recurring to me is [annoying]." | Emotional | Annoyance | |
| [24] | "However, even some of these users acknowledged that "pop-up" alerts can be very annoying, especially when they are "not right" for some reason." | Compatibility | Low signal-to-noise ratio | "Pop-up" alerts can be very annoying"; "Well, I think anything that keeps recurring to me is [annoying]." | Emotional | Annoyance | |
| [26] | "V.A's alert system did not match his/her (pharmacist) mental model of how an alert system should be designed (...) sometimes significant order checks really aren't significant (...) Now critical interactions (...) they are so many that are significant." | Compatibility | Low signal-to-noise ratio | "Sometimes significant order checks really aren't significant (...) Now critical interactions (...) they are so many that are significant" | Attitudinal | Questioning triggering/sorting model | |
| [26] | "V.A's alert system did not match his/her (pharmacist) mental model of how an alert system should be designed (...) sometimes significant order checks really aren't significant (...) Now critical interactions (...) they are so many that are significant." | Compatibility | Low signal-to-noise ratio | "It's gotten to the point that I don't hardly look at significant (interactions) anymore" | Behavioral | Voluntarily ignoring alerts | "Ordering decisions were hampered"; "alerts (...) impeded medication ordering processes"; |
| [26] | "I see it does say "active" though. Technically, the [old] medication [order] isn't "active" because I just changed them to "discontinued" "Some meds should have been discontinued but were 'active', leading to extra alerts" | Compatibility | Low signal-to-noise ratio | "Did it accept my changes?" [doubts] | Attitudinal | Questioning the behavior | |
| [29] | "I see it does say "active" though. Technically, the [old] medication [order] isn't "active" because I just changed them to "discontinued" "Some meds should have been discontinued but were 'active', leading to extra alerts" | | | | | | |
| [26] | "I see it does say "active" though. Technically, the [old] medication [order] isn't "active" because I just changed them to "discontinued" "Some meds should have been discontinued but were 'active', leading to extra alerts" | Compatibility | Low signal-to-noise ratio | "This order check [appearing now for a second time] might freak someone out" | Emotional | Annoyance | |
| [29] | "I see it does say "active" though. Technically, the [old] medication [order] isn't "active" because I just changed them to "discontinued" "Some meds should have been discontinued but were 'active', leading to extra alerts" | | | | | | |

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| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category |
| [28] | "Alerts (...) repeatedly encountered" | Compatibility | Low signal-to-noise ratio | "Several prescribers described rapidly overriding these alert types once they recognized that they had seen the alert before. One prescriber noted that she had "memorized the location of the override button" for these situations." | Behavioral | Voluntarily ignoring alerts | | |
| [29] | "Same alerts appear for a patient across one or more med renewals; E.g., Alert says 'Previous adverse reaction to antidepressants'... Phys types in override reason, 'Has been on venlafaxine for 5 yrs now.'" | Compatibility | Low signal-to-noise ratio | "Phys types in override reason, 'Has been on venlafaxine for 5 yrs now.'" | Behavioral | Voluntarily ignoring alerts | | |
| [29] | "Number of alerts is problematic"; "Potential problems are overdetected or underdetected" | Compatibility | Low signal-to-noise ratio | "Many prescribers overwhelmed by (...) multiple alerts presented in one pop-up" | Emotional | Annoyance | | |
| [31] | "When the physician used CPOE in the office area, a medication alert appeared saying 'duplicate order', which indicated that the patient was getting iron from both VA and non-VA sources (i.e. over-the-counter or non-VA pharmacy). Upon seeing this alert, the physician stated, 'That's not true to my knowledge. The patient doesn't like to take it; I doubt he's taking it [from a non-VA source].'" | Compatibility | Low signal-to-noise ratio | "That's not true to my knowledge. The patient doesn't like to take it; I doubt he's taking it [from a non-VA source]." | Attitudinal | Questioning the validity | | |
| [31] | "When the physician used CPOE in the office area, a medication alert appeared saying 'duplicate order', which indicated that the patient was getting iron from both VA and non-VA sources (i.e. over-the-counter or non-VA pharmacy). Upon seeing this alert, the physician stated, 'That's not true to my knowledge. The patient doesn't like to take it; I doubt he's taking it [from a non-VA source].'" | Compatibility | Low signal-to-noise ratio | "The physician proceeded with the order and went back to the exam room to talk with the patient, where s/he confirmed that the patient was not obtaining iron from an outside source." | Behavioral | Increased workload | "The physician (...) talk[s] with the patient, where s/he confirmed that the patient was not obtaining iron from an outside source." | Workflow issues |
| [32] | "too low dose limits" | Compatibility | Low signal-to-noise ratio | "Could further add to alert fatigue"; "Remarks suggesting alert fatigue" | Attitudinal | Alert fatigue | | |
| [32] | Furthermore, residents referred to other aspects that could further add to alert fatigue: (...) DDIs that should be suppressed because of low incidence of adverse events" | Compatibility | Low signal-to-noise ratio | "Could further add to alert fatigue"; "Remarks suggesting alert fatigue" | Attitudinal | Alert fatigue | | |
| [32] | Furthermore, residents referred to other aspects that could further add to alert fatigue: (...) DDIs that should be suppressed because of low incidence of adverse events" | Compatibility | Low signal-to-noise ratio | "If I have to consider every DDI, than I am busy with it, all day, and that is not my job." | Behavioral | Increased workload | | |
| [32] | Furthermore, residents referred to other aspects that could further add to alert fatigue: (...) DDIs that should be suppressed because of low incidence of adverse events" | Compatibility | Low signal-to-noise ratio | "I am often inclined to rapidly click them away; you get all those DDIs reported; you simply skip them." | Behavioral | Voluntarily ignoring alerts | | |
| [32] | There are so many drug-drug interactions that are irrelevant, that I am often inclined to rapidly click them away [resident in internal medicine]. | Compatibility | Low signal-to-noise ratio | "I am often inclined to rapidly click them away; you get all those DDIs reported; you simply skip them." | Behavioral | Voluntarily ignoring alerts | | |
| [32] | Furthermore, residents referred to other aspects that could further add to alert fatigue: (...) DDIs that should be suppressed because of low incidence of adverse events" | Compatibility | Low signal-to-noise ratio | "All those drug-drug interactions and all those things you get reported drive you mad." | Emotional | Annoyance | | |

| | Usability flaw | | | Usage problem | | | Negative outcome | | |
|------|--|---------------|---------------------------|---|-------------|--------------------------------|-----------------------|---|--|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category | |
| [33] | "Reminder alerts that should be given the last day of hospitalization (<i>i.e.</i> , bacteriological tests), a day the system cannot forecast. This leads to an alert every day." | Compatibility | Low signal-to-noise ratio | "This leads to an alert everyday and therefore to (...) alert fatigue." | Attitudinal | Alert fatigue | | | |
| [33] | "Alerts once entered in the system can be outdated. The processes how to keep them up-to-date is not yet implemented (<i>i.e.</i> for patients who were carrier of methicillin-resistant staphylococcus aureus (MRSA) and who are now readmitted to the hospital)." | Compatibility | Low signal-to-noise ratio | "Some brought up issues make the CPOE less utile" | Attitudinal | Questioning usefulness | | | |
| [33] | "Reminder alerts that should be given the last day of hospitalization (<i>i.e.</i> , bacteriological tests), a day the system cannot forecast. This leads to an alert every day." | Compatibility | Low signal-to-noise ratio | [inference: alerts voluntarily ignored] | Behavioral | Voluntarily ignoring the alert | "low compliance rate" | Lowering alerting system expected effectiveness | |
| [34] | "According to clinicians, the sensitivity of alerts was often set too high while the specificity was too low." | Compatibility | Low signal-to-noise ratio | "There are too many things popping up at me"; "(alert fatigue)" | Attitudinal | Alert fatigue | | | |
| [34] | "Alerts are often fired for drug combinations that conform to clinical guidelines and are recommended by specialist colleagues. Examples include aspirin with angiotensin converting enzyme inhibitors in patients with heart disease or diabetes." | Compatibility | Low signal-to-noise ratio | "There are too many things popping up at me"; "(alert fatigue)" | Attitudinal | Alert fatigue | | | |
| [34] | "Appropriate polypharmacy is not acknowledged" "In psychiatric care, mood stabilizers are often used intentionally in combination or "augmentation" therapy with antidepressants." | Compatibility | Low signal-to-noise ratio | "There are too many things popping up at me"; "(alert fatigue)" | Attitudinal | Alert fatigue | | | |
| [34] | "Pregnancy alerts would be more useful (...) if they were suppressed for male patients and women of non-child-bearing age." | Compatibility | Low signal-to-noise ratio | "There are too many things popping up at me"; "(alert fatigue)" | Attitudinal | Alert fatigue | | | |
| [34] | "Within-class interactions typically reflect an out-of-date medication list – such as an antibiotic interacting with another antibiotic – rather than a true interaction." | Compatibility | Low signal-to-noise ratio | "There are too many things popping up at me"; "(alert fatigue)" | Attitudinal | Alert fatigue | | | |
| [34] | "According to clinicians, the sensitivity of alerts was often set too high while the specificity was too low." | Compatibility | Low signal-to-noise ratio | "It's just crying wolf"; "Difficult to interpret the validity of many alerts" | Attitudinal | Questioning the validity | | | |
| [34] | "Alerts are often fired for drug combinations that conform to clinical guidelines and are recommended by specialist colleagues. Examples include aspirin with angiotensin converting enzyme inhibitors in patients with heart disease or diabetes." | Compatibility | Low signal-to-noise ratio | "It's just crying wolf"; "Difficult to interpret the validity of many alerts" | Attitudinal | Questioning the validity | | | |
| [34] | "Appropriate polypharmacy is not acknowledged" "In psychiatric care, mood stabilizers are often used intentionally in combination or "augmentation" therapy with antidepressants." | Compatibility | Low signal-to-noise ratio | "It's just crying wolf"; "Difficult to interpret the validity of many alerts" | Attitudinal | Questioning the validity | | | |
| [34] | "Since most pediatric drugs are used off-label, pediatricians find it difficult to interpret the validity of many alerts." | Compatibility | Low signal-to-noise ratio | "It's just crying wolf"; "Difficult to interpret the validity of many alerts" | Attitudinal | Questioning the validity | | | |

| | Usability flaw | | | Usage problem | | | Negative outcome | |
|------|---|---------------|---------------------------|---|-------------|-----------------------------|------------------|----------|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category |
| [34] | "Within-class interactions typically reflect an out-of-date medication list – such as an antibiotic interacting with another antibiotic – rather than a true interaction." "According to clinicians, the sensitivity of alerts was often set too high while the specificity was too low." | Compatibility | Low signal-to-noise ratio | "It's just crying wolf"; "Difficult to interpret the validity of many alerts" | Attitudinal | Questioning the validity | | |
| [34] | "Alerts are often fired for drug combinations that conform to clinical guidelines and are recommended by specialist colleagues. Examples include aspirin with angiotensin converting enzyme inhibitors in patients with heart disease or diabetes." "Appropriate polypharmacy is not acknowledged" "In psychiatric care, mood stabilizers are often used intentionally in combination or "augmentation" therapy with antidepressants." | Compatibility | Low signal-to-noise ratio | "Many clinicians ignore potentially serious alerts"; "Once you realize that most of the information is useless or superfluous or not relevant, you stop looking at it." | Behavioral | Voluntarily ignoring alerts | | |
| [34] | "Alerts are often fired for drug combinations that conform to clinical guidelines and are recommended by specialist colleagues. Examples include aspirin with angiotensin converting enzyme inhibitors in patients with heart disease or diabetes." "Appropriate polypharmacy is not acknowledged" "In psychiatric care, mood stabilizers are often used intentionally in combination or "augmentation" therapy with antidepressants." | Compatibility | Low signal-to-noise ratio | "Many clinicians ignore potentially serious alerts"; "Once you realize that most of the information is useless or superfluous or not relevant, you stop looking at it." | Behavioral | Voluntarily ignoring alerts | | |
| [34] | "Pregnancy alerts would be more useful (...) if they were suppressed for male patients and women of non-child-bearing age." "Within-class interactions typically reflect an out-of-date medication list – such as an antibiotic interacting with another antibiotic – rather than a true interaction." | Compatibility | Low signal-to-noise ratio | "Many clinicians ignore potentially serious alerts"; "Once you realize that most of the information is useless or superfluous or not relevant, you stop looking at it." | Behavioral | Voluntarily ignoring alerts | | |
| [34] | "According to clinicians, the sensitivity of alerts was often set too high while the specificity was too low." "Alerts are often fired for drug combinations that conform to clinical guidelines and are recommended by specialist colleagues. Examples include aspirin with angiotensin converting enzyme inhibitors in patients with heart disease or diabetes." | Compatibility | Low signal-to-noise ratio | "Trivial alerts often interrupt workflow." | Cognitive | Users interrupted | | |
| [34] | "Alerts are often fired for drug combinations that conform to clinical guidelines and are recommended by specialist colleagues. Examples include aspirin with angiotensin converting enzyme inhibitors in patients with heart disease or diabetes." "Appropriate polypharmacy is not acknowledged" "In psychiatric care, mood stabilizers are often used intentionally in combination or "augmentation" therapy with antidepressants." | Compatibility | Low signal-to-noise ratio | "Trivial alerts often interrupt workflow." | Cognitive | Users interrupted | | |
| [34] | "Pregnancy alerts would be more useful (...) if they were suppressed for male patients and women of non-child-bearing age." "Within-class interactions typically reflect an out-of-date medication list – such as an antibiotic interacting with another antibiotic – rather than a true interaction." | Compatibility | Low signal-to-noise ratio | "Trivial alerts often interrupt workflow." | Cognitive | Users interrupted | | |
| [35] | "There are too many [alerts]" | Compatibility | Low signal-to-noise ratio | "Physicians ignoring alerts because there are too many" | Behavioral | Voluntarily ignoring alerts | | |

| | Usability flaw | | Usage problem | | | Negative outcome | |
|--------------|---|---------------|---------------------------|---|-------------|-----------------------------|---|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt |
| [37] | "Clinicians (...) faced with a long list of them for each patient." | Compatibility | Low signal-to-noise ratio | "Become desensitized to the CRs" | Attitudinal | Alert fatigue | |
| [37] | "Clinicians reported that they faced situations in which CRs could not be removed and therefore continued to appear." | Compatibility | Low signal-to-noise ratio | "CRs could not be removed" | Behavioral | Users lost | "CRs (...) continued to appear" Technology effectiveness issues |
| [38] | "Reminders did not always apply given the context of a particular patient."; "The third barrier to following the advice of a clinical reminder was inapplicability to the specific situational context. For example, a recommendation to begin Highly Active Anti-Retroviral Therapy (HAART) was not followed because the patient had experienced multiple intolerances to the medication in the past." | Compatibility | Low signal-to-noise ratio | "Clinical reminders were not [always] used" | Behavioral | System not used at all | |
| [40] | "Most prescribers believed that most (alerts) were redundant." | Compatibility | Low signal-to-noise ratio | "Some doctors recognized that they had become desensitized to the alerts." | Attitudinal | Alert fatigue | |
| [40] | "Most prescribers believed (...) that they received too many alerts ..." | Compatibility | Low signal-to-noise ratio | "It pops up so often which can be a very bad thing because you're dismissing it so often that you develop this sort of mechanism"; "Most doctors either admitted to not reading the warnings"; "it's so much easier to click that button" | Behavioral | Voluntarily ignoring alerts | |
| [41] | "excess alerts - e.g., asthma and opiate, warfarin and paracetamol" | Compatibility | Low signal-to-noise ratio | "The physician reported that specific features of the system (...) were hindering the use" | Behavioral | Ineffective use | |
| [41] | "Too low triggering threshold with drug interaction alerts" | Compatibility | Low signal-to-noise ratio | "I never bother to read them" | Behavioral | Voluntarily ignoring alerts | |
| [41] | "excess alerts - e.g., asthma and opiate, warfarin and paracetamol" | Compatibility | Low signal-to-noise ratio | "Irritating drug interaction and contraindication alerts" | Emotional | Annoyance | |
| [22] [29] | "(...) scrolling were problematic" [Inference: user needs to scroll to see the whole information]; "poor screen display: alert display does not support alert resolution and/or prescriber workflow" "they have to manipulate the alert to see all of the information" | Workload | Minimal action | "There were several cases where inadequate alert design prompted prescribers to take extra steps in the medication ordering process. For example, prescribers sometimes had to manipulate the alert to see all of the information" | Behavioral | Increased workload | "Hindering alert resolution"; "Hinder alert effectiveness" Technology effectiveness issues |
| [22] [29] | "(...) scrolling were problematic" [Inference: user needs to scroll to see the whole information]; "poor screen display: alert display does not support alert resolution and/or prescriber workflow" "they have to manipulate the alert to see all of the information" | Workload | Minimal action | "There were several cases where inadequate alert design (...) disrupted their workflow." | Cognitive | Users interrupted | "Hindering alert resolution"; "Hinder alert effectiveness" Technology effectiveness issues |

| | Usability flaw | | | Usage problem | | | Negative outcome | | |
|--------------|--|----------|----------------|--|-------------|--------------------------------------|---|-----------------------|--|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category | |
| [22] [29] | "(...) scrolling were problematic" [Inference: user needs to scroll to see the whole information]; "poor screen display: alert display does not support alert resolution and/or prescriber workflow" "they have to manipulate the alert to see all of the information" | Workload | Minimal action | "View as "very troublesome"" | Emotional | Annoyance | | | |
| [29] | "Time needed to resolve alerts: Justification requirement often viewed as time burden" [Inference: justify an the irrelevance of an alert requires several actions that take time] | Workload | Minimal action | "Justification requirement often viewed as time burden" | Attitudinal | Negative feelings | | | |
| [30] | "Some had difficulty identifying the patient's risk factors for the interaction. Successfully answering this question required clicking on the Risk Factors tab to reveal the data (see Figure 3)." "The most commonly cited design concerns were the unnecessary use of tabs (7 subjects)" | Workload | Minimal action | "I had difficulty identifying the patient's risk factors for the interaction" | Cognitive | Difficulties to understand the alert | "Successfully answering this question (...) required clicking on the Risk Factors tab" [error in answering a clinical question] | Patient safety issues | |
| [32] | "Necessity for scrolling down the whole alert text to find the conclusion" | Workload | Minimal action | "Could further add to alert fatigue"; "Remarks suggesting alert fatigue" | Attitudinal | Alert fatigue | | | |
| [32] | "Necessity for scrolling down the whole alert text to find the conclusion" | Workload | Minimal action | "Necessity for scrolling down" [increased workload] | Behavioral | Increased workload | | | |
| [32] | "Necessity for scrolling down the whole alert text to find the conclusion" | Workload | Minimal action | "The physician may overlook the second alert, thinking that the override button for the (first) alert has not worked properly"; "thereby unintentionally override the second alert." | Cognitive | Information involuntarily missed | "wrong selection (followed incorrect dose recommendation)" | Patient safety issues | |
| [32] | "Necessity for scrolling down the whole alert text to find the conclusion" | Workload | Minimal action | "Misinterpretation (...) high numbers of wrong or inapplicable rules and reasoning." | Cognitive | Misinterpretation of alerts' content | "wrong selection (followed incorrect dose recommendation)" | Patient safety issues | |
| [37] | "Five nurses and two providers were observed to skip all or some of the reminders and explained that this was because they perceived that they did not have enough time to "satisfy" the reminders by entering data."; "Completing the CRs creates "double documentation" burdens for some providers (...) as they generally keep track of this information without the CRs (e.g., in a health maintenance list within the progress note)." [Inference: satisfy the reminders requires time] | Workload | Minimal action | "Completing the CRs creates "double documentation" burdens for some providers (...) as they generally keep track of this information without the CRs" | Behavioral | Increased workload | | | |
| [37] | "Five nurses and two providers were observed to skip all or some of the reminders and explained that this was because they perceived that they did not have enough time to "satisfy" the reminders by entering data."; "Completing the CRs creates "double documentation" burdens for some providers (...) as they generally keep track of this information without the CRs (e.g., in a health maintenance list within the progress note)." [Inference: satisfy the reminders requires time] | Workload | Minimal action | "Five nurses and two providers were observed to skip all or some of the reminders" | Behavioral | Voluntarily ignoring alerts | | | |
| [38] | "At all sites, at least one provider never satisfied reminders that were not clinically relevant, which required data entry such as when a patient received a vaccine at another hospital." [data entry cumbersome] "additional workload" | Workload | Minimal action | "Lack of time to follow documentation procedures within the CR noting why the reminder's advice was not followed." | Behavioral | Increased workload | | | |

| | Usability flaw | | | Usage problem | | | Negative outcome | |
|------|--|-----------------------|-----------------------|--|------------|---|------------------------------------|--------------------------------------|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category |
| [38] | "At all sites, at least one provider never satisfied reminders that were not clinically relevant, which required data entry such as when a patient received a vaccine at another hospital." [data entry cumbersome] "additional workload" | Workload | Minimal action | "At least one provider at all eight sites conducted documentation activities, including satisfying clinical reminders (...), after the patient had left the room. (...) at least one provider conducted documentation activities after the clinic closed, normally within 36 hours. (...) case managers documented clinical reminders (...) after the physicians did not." | Behavioral | Workarounds | | |
| [41] | "Reminders' texts are sometimes too strict in the short version. If you don't move the cursor over the text and see the whole reminder, the wording doesn't work." | Workload | Minimal action | "If you don't move the cursor over the text and see the whole reminder (...)" | Behavioral | Increased workload | | |
| [41] | "Reminders' texts are sometimes too strict in the short version. If you don't move the cursor over the text and see the whole reminder, the wording doesn't work." | Workload | Minimal action | "(...) the wording doesn't work" | Cognitive | Difficulties to understand the alert | | |
| [36] | "Several users in the simulation-based testing did not notice the arrows under the clinical recommendations or did not realize they provided additional, more detailed information about the basic recommendation when clicked on." [inference: the arrow is not intuitive enough] | Significance of codes | Non intuitive icons | "Several users did not notice the arrows under the clinical recommendations or did not realize they provided additional more detailed information about the basic recommendation when clicked on." | Cognitive | Difficulties to identify alerts' components | | |
| [37] | "When defaulting past the cover sheet, feedback for the presence of due CRs is signified by a question mark icon in the upper right corner of the display. We observed three providers misinterpret this question mark to indicate that the patient had no CRs due, when in actuality it meant the system was still evaluating data to determine which CRs were due." [inference: non intuitive enough symbol] | Significance of codes | Non intuitive icons | "We observed three providers misinterpret this question mark" | Cognitive | Difficulties to identify alerts' components | | |
| [24] | "Yeah, you see it, but you have to do something to even find out what it means." [Inference: passive alerts are not sufficiently informational to support a quick triage] | Significance of codes | Non intuitive wording | "Users said they would like more information available with less effort so they can evaluate and act on alerts and reminders more easily." | Behavioral | Increased workload | | |
| [27] | "Use of abbreviations and expressions that were not understandable by physicians, confusing terminology in labelling of buttons" | Significance of codes | Non intuitive wording | "Precluding the physicians to understand the problem that generated the alert or how to solve the problem." | Cognitive | Difficulties to understand the alert | "Impaired the ordering efficiency" | Medication management process issues |
| [27] | "Use of abbreviations and expressions that were not understandable by physicians, confusing terminology in labelling of buttons" | Significance of codes | Non intuitive wording | "Physicians became frustrated" | Emotional | Frustration | | |
| [36] | "A user thought that the appearance of the "stamp" window implied that the patient had a chronic pain problem or diagnosis. In actuality, the "stamp" indicated that the patient had a scheduled appointment within a 5-day window and that ATHENA-OT had recommendations available should the provider consider OI for that patient." [inference: stamp wording not intuitive enough] | Significance of codes | Non intuitive wording | "A user thought that the appearance of the "stamp" window implied that the patient had a chronic pain problem or diagnosis" [misinterpretation] | Cognitive | Misinterpretation of alerts' components | | |

| | Usability flaw | | | Usage problem | | | Negative outcome | | |
|------|---|-----------------------|-----------------------|--|------------|---|---|--------------------------------------|--|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category | |
| [39] | "Two participants misinterpreted the meaning of "When" to represent the last time the current patient received the intervention instead of the frequency the intervention is due for all patients." | Significance of codes | Non intuitive wording | "Two participants misinterpreted the meaning of "When "" | Cognitive | Misinterpretation of alerts' components | | | |
| [23] | All alerts include an acknowledgement comment field, only some alerts are marked as requiring acknowledgement. Even those alerts which require acknowledgement only require that the acknowledgement button be pressed, not that a comment be left, although clinicians may have misinterpreted the directive. | Guidance | Prompting | "although clinicians may have misinterpreted the directive." | Cognitive | Misinterpretation of alerts' content | "The absence of a specific order critique in this alert, combined with the required acknowledgement, may be related to the relatively high proportion of content free comments" | Technology effectiveness issues | |
| [24] | "It was somewhat surprising that users did not always seem to understand how to use and manage the alerts effectively." [Inference: alert's management is not intuitive] | Guidance | Prompting | "Not always seem to understand how to use and manage the alerts effectively" | Behavioral | Ineffective use | "This resulted in some unnecessary repetition of alerts" | Technology effectiveness issues | |
| [24] | "It was somewhat surprising that users did not always seem to understand how to use and manage the alerts effectively." [Inference: alert's management is not intuitive] | Guidance | Prompting | "This (...) contributed to user frustration." | Emotional | Frustration | | | |
| [26] | "The programmers' mental model, as reflected in the system image, did not adequately match prescribers' mental models (...): Physician (MD) orders [VA] aspirin - 162 mg. An order check [alert] appears. Says duplicate drug order. Non-VA ASPIRIN. [Alert] mentions 325mg....MD is looking at it also and [appears] confused" | Guidance | Prompting | "MD clicks through [the alert] [accepts order]" (accepts without understanding the alert) | Behavioral | Advice blindly followed | "MD goes back to the medication list. Aspirin is now listed both under VA list and non-VA medication list" [double order of aspirin] | Patient safety issues | |
| [26] | "The programmers' mental model, as reflected in the system image, did not adequately match prescribers' mental models (...): Physician (MD) orders [VA] aspirin - 162 mg. An order check [alert] appears. Says duplicate drug order. Non-VA ASPIRIN. [Alert] mentions 325mg....MD is looking at it also and [appears] confused" | Guidance | Prompting | "This led to confusion during the prescribing process"; "MD to Observer: What's it going to do? Is it going to switch the patient to 325mg?" | Cognitive | Difficulties to understand the alert | "MD goes back to the medication list. Aspirin is now listed both under VA list and non-VA medication list" [double order of aspirin] | Patient safety issues | |
| [27] | "unclear information or guidance" in the messages | Guidance | Prompting | "Resorted to trial-and-error behavior exemplified by the extra mouse clicks and keystrokes they needed for locating and executing the right action in response to the message" | Behavioral | Increased workload | "Impaired the ordering efficiency" | Medication management process issues | |
| [27] | "unclear information or guidance" in the messages | Guidance | Prompting | "Physicians were lost » | Behavioral | Users lost | "Impaired the ordering efficiency" | Medication management process issues | |
| [27] | "unclear information or guidance" in the messages | Guidance | Prompting | "Precluding the physicians to understand the problem that generated the alert or how to solve the problem." | Cognitive | Difficulties to understand the alert | "Impaired the ordering efficiency" | Medication management process issues | |
| [28] | "Prescribers reported that alerts presenting during medication order entry were often (...) difficult to interpret in content and purpose" | Guidance | Prompting | "Several prescribers described rapidly overriding these alert types once they recognized that they had seen the alert before. One prescriber noted that she had "memorized the location of the override button" for these situations." | Behavioral | Voluntarily ignoring alerts | | | |

| | Usability flaw | | | Usage problem | | | Negative outcome | | |
|------|---|----------|-----------|---|------------|--------------------------------------|--|--------------------------------------|--|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category | |
| [28] | "Prescribers reported that alerts presenting during medication order entry were often (...) difficult to interpret in content and purpose" | Guidance | Prompting | "Difficult to interpret in content and purpose"; "Some reported difficulty with (...) the length of the text" | Cognitive | Difficulties to understand the alert | "Slowed down their work" | Medication management process issues | |
| [29] | "Prescribers unaware that they could turn off some alerts" | Guidance | Prompting | "Prescribers unaware that they could turn off some alerts"; "Prescribers' ability to act on alerts was impeded by the alert interface" | Behavioral | Ineffective use | | | |
| [29] | "Salience: Alert visibility and distinction: Prescriber wanted more visual emphasis on high risk alerts" [Inference: no sufficient visual emphasis on high risk alerts] | Guidance | Prompting | "Difficult to distinguish different alert types (e.g., duplicate drug versus duplicate drug class alerts)" | Cognitive | Difficulties to understand the alert | | | |
| [30] | "Two areas of minor criticism were the layout of buttons and checkboxes"; "Some users did not see the tab or did not realize it was selectable." [Inference: they are not salient enough to be seen] | Guidance | Prompting | "I had difficulty identifying the patient's risk factors for the interaction" | Cognitive | Difficulties to understand the alert | "Successfully answering this question (...) required clicking on the Risk Factors tab" [error in answering a clinical question] | Patient safety issues | |
| [30] | "Many [users] missed a question regarding data in the alert that should reduce the level of clinical concern (attenuating information)" [rephrasing: this information is missed because of the organization of the information in the alert: it is outside the center of the alert] | Guidance | Prompting | "Many missed a question regarding data in the alert that should reduce the level of clinical concern (attenuating information)." | Cognitive | Information involuntarily missed | "the patient had been taking both medications for many years and most physicians would be reassured by this fact. However, only 58% of subjects made this connection." [error in understanding patient data] | Patient safety issues | |
| [32] | "The interviews suggest that both unclear alert texts and texts read incompletely play a role."; alert presentation was unclear (two DDI alerts in one screen provoking oversight) | Guidance | Prompting | "The physician may overlook the second alert, thinking that the override button for the (first) alert has not worked properly"; "hereby unintentionally override the second alert." | Cognitive | Information involuntarily missed | "wrong selection (followed incorrect dose recommendation)" | Patient safety issues | |
| [32] | "The interviews suggest that both unclear alert texts and texts read incompletely play a role."; alert presentation was unclear (two DDI alerts in one screen provoking oversight) | Guidance | Prompting | "Misinterpretation (...) high numbers of wrong or inapplicable rules and reasoning." | Cognitive | Misinterpretation of alert content | "wrong selection (followed incorrect dose recommendation)" | Patient safety issues | |
| [33] | "Some alerts are out of the visual focus region when using the system" | Guidance | Prompting | [inference: alert unnoticed] | Cognitive | Information involuntarily missed | "Leading to low response levels to the alerts" | Technology effectiveness issues | |
| [41] | "Reminders' texts are sometimes too strict in the short version. If you don't move the cursor over the text and see the whole reminder, the wording doesn't work." | Guidance | Prompting | "If you don't move the cursor over the text and see the whole reminder (...)" | Behavioral | Increased workload | | | |
| [41] | "Reminders' position on the left side of the screen" [Inference: position outside their focal visual field] | Guidance | Prompting | "The physician reported that specific features of the system (...) were hindering the use" | Behavioral | Ineffective use | | | |
| [41] | "Reminders' texts are sometimes too strict in the short version. If you don't move the cursor over the text and see the whole reminder, the wording doesn't work." | Guidance | Prompting | "(...) the wording doesn't work" | Cognitive | Difficulties to understand the alert | | | |

| Usability flaw | | Usage problem | | | Negative outcome | |
|----------------------|------------------|---------------------------------------|---|-------------|--------------------------------------|--|
| Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt |
| [22] [26] [29] | Error management | Quality of error messages | "Prescribers were sometimes unsure (...) what an alert was attempting to convey"; "Language of alerts is difficult for prescriber to interpret "I do not know what that means." | Cognitive | Difficulties to understand the alert | "We call the pharmacist and spend time looking up information.;" physicians often come and ask [the pharmacist] about an alert triggered by the combination of amiodarone and simvastatin"; "physicians and nurse practitioners found it helpful, and sometimes necessary, to have real-time, face-to-face communication with clinical pharmacists to be able to interpret and resolve alerts" |
| [10] | Compatibility | Tasks and control distribution issues | "The CPOE system does not display information available on other hospital systems. For example, only the pharmacy's computer provides drug interaction and lifetime limit warnings." [missing information] | Cognitive | Information involuntarily missed | "Pharmacists call house staff to clarify questionable orders" |
| [29] | Compatibility | Tasks and control distribution issues | "I'm unsure if pharmacists review these [override justifications]" | Attitudinal | Questioning the behavior | |
| [37] | Compatibility | Tasks and control distribution issues | "Paper-based workarounds were employed to alert providers to positive findings from the screening, including printing the nursing note for the provider (Site 1), placing a post-it note or using handwritten abbreviations on the patient's routing form (Sites 2 and 4), and marking a check box next to the appropriate item on a "green card" that the patient then gave to the provider (Site.3)." | Behavioral | Workarounds | |
| [22] [29] | Compatibility | Transparency issues | "I am not confident it's checking all the interactions that I want it to check.;" "No, I'm not clear. I'm not clear what the triggers are." | Attitudinal | Questioning triggering/sorting model | |
| [22] [29] | Compatibility | Transparency issues | "Prescribers unaware that they could turn off some alerts"; "Prescribers' ability to act on alerts was impeded by the alert interface" | Behavioral | Ineffective use | "We call the pharmacist and spend time looking up information.;" physicians often come and ask [the pharmacist] about an alert triggered by the combination of amiodarone and simvastatin"; "physicians and nurse practitioners found it helpful, and sometimes necessary, to have real-time, face-to-face communication with clinical pharmacists to be able to interpret and resolve alerts" |

| | Usability flaw | | Usage problem | | Negative outcome | |
|------|--|---------------|---------------------|--|------------------|--------------------------------------|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. |
| [24] | "There are instances where users expect the system to 'be aware' of and utilize patient information that exists in the database." | Compatibility | Transparency issues | "There are instances where users expect the system to 'be aware' of and utilize patient information that exists in the database, to more accurately target eligible patients." | Attitudinal | Questioning triggering/sorting model |
| [25] | "Three subjects expressed their need for better understanding of the dose calculation by the system. (...) users would not be able to 'validate' the system's reasoning without resorting to calculation that is more complicated" [Inference: users are not sure that the system based its recommendation on the same assumptions they would have made] | Compatibility | Transparency issues | "Subjects wanted to be sure that the system based its recommendation on the same assumptions they would have made" | Attitudinal | Questioning the behavior |
| [26] | "A specific medication alert did not appear, even though the pharmacist was expecting it to come up for a patient. (...) Pharmacist: "The patient is 85yrs old. It's not good if he is on a full dose of aspirin and Plavix. These are both anti-platelets [medications]..." [later, while ordering medications for this patient:] An order check appears [after the] pharmacist change[s] [the] aspirin dose. [Alert] says duplicate drug class - hydrocodone. This was the only order check alert listed in the window. Pharmacist: "This is because the patient is on hydrocodone. It pulled-up that one, but not the Plavix [alert] which is interesting." "" Programmer and prescriber mental model mismatches were evident when a prescriber expected an alert to appear, but the system did not display that alert: (...) physician [is] ordering [renewing] naproxen... No order check [alerts] appear." | Compatibility | Transparency issues | "The pharmacist was expecting it to come up for a patient." | Attitudinal | Questioning triggering/sorting model |
| [29] | "Ambiguity about alert management; need for closed-loop feedback; E.g, Phys: "I want [the alert system] to have user control. I am not confident it's checking all the interactions that I want it to check." | Compatibility | Transparency issues | "I am not confident it's checking all the interactions that I want it to check.""; "No, I'm not clear. I'm not clear what the triggers are". | Attitudinal | Questioning triggering/sorting model |
| [29] | "System capabilities and limitations are ambiguous" | Compatibility | Transparency issues | "I am not confident it's checking all the interactions that I want it to check.""; "No, I'm not clear. I'm not clear what the triggers are". | Attitudinal | Questioning triggering/sorting model |
| [29] | "System capabilities and limitations are ambiguous" | Compatibility | Transparency issues | "Prescribers unaware that they could turn off some alerts"; "Prescribers' ability to act on alerts was impeded by the alert interface" | Behavioral | Ineffective use |

"We call the pharmacist and spend time looking up information."; "physicians often come and ask [the pharmacists] about an alert triggered by the combination of amiodarone and simvastatin"; "physicians and nurse practitioners found it helpful, and sometimes necessary, to have real-time, face-to-face communication with clinical pharmacists to be able to interpret and resolve alerts"

| | Usability flaw | | | Usage problem | | | Negative outcome | |
|------|--|---------------|---------------------|--|-------------|--------------------------------------|---|-----------------------|
| | Excerpt | Category | Sub-cat. | Excerpt | Category | Sub-cat. | Excerpt | Category |
| [33] | "some express doubts on whether the system has up-to-date information (for instance for weight-based drug dosage alerts in pediatrics or drug interactions in cardiology where they often introduce new drugs)." | Compatibility | Transparency issues | "Some express doubts on whether the system has up-to-date information " | Attitudinal | Questioning the validity | | |
| [38] | "Users were uncertain how long the reminders would be turned off for each dialog option." | Compatibility | Transparency issues | "Users were uncertain how long the reminders would be turned off for each dialog option" | Attitudinal | Questioning the behavior | | |
| [42] | "The reason for this is that the registration of an allergy is based on the ATC code, and the same drug can be registered under several codes if the drug has various indications." "The older version of the CPOE system only warns the user if the same drug code appears twice and not if the same drug (registered under different ATC codes) appears twice." [Inference: there would be no alert for a medication] | Compatibility | Transparency issues | [Inference: users are unaware of gaps in the data] | Cognitive | Misinterpretation of alerts' content | "There are various examples of complex registration that lead to medication errors" | Patient safety issues |