

Online Supplemental Material

Online supplemental table A. Example quotes related to problem detection: cues that ‘flagged’ an initial concern and helped the participant notice a renal-drug issue.

THEME	Example(s) from the Incidents
Vigilance	<p><u>Medications</u>: “I review meds for each patient towards beginning of patient visit, in part to look for drug-disease interactions and red-flag meds that require renal dosing” [MD]</p> <p><u>Patient status/renal function</u>: “First thing in morning, I looked for acute changes from overnight. I look at all my patient’s renal functions throughout the morning. I want to catch it [any issues] before the 10 am dose” [PharmD], “Intentionally check for patient’s renal function during prep for patient appointment” [MD]</p> <p><u>Specific monitoring</u>: “If patient is on tenofovir, we do an annual urinalysis to look for protein in urine. It’s just a screening test that the Department of Health recommends and we do it when they’re on the tenofovir” [MD]</p>
Alert	<p>“I was not aware that this patient had a decreased CrCl –until [the EHR] basically beat me over the head with it, which I appreciated” [PharmD]</p> <p>“I entered the drug valganciclovir, [EHR alert] popped up and said this person has a CrCl [32.5]”, “[EHR] caught me” [MD]</p>
Dosing regimen	<p>“600mg Gabapentin TID is a ‘hefty dose’” [MD]</p>
Abnormal laboratory value	<p>“Pt came in for routine visit in April 2013 and did routine labs. That was the first time that I really noted that it [SCr] was abnormal [1.5], and over the desired [SCr] for continuation for metformin” [MD]</p> <p>“Pt’s electrolytes being off, were another marker that his kidneys were failing. K+ was 7.9” [MD]</p>
Trends in laboratory value	<p>“Noticed that SCr had now almost doubled, 0.9 to 1.6. Meets criteria for acute renal failure” [PharmD]</p>
Nephrotoxic medication	<p>“Not concerned that other meds the patient is taking might be the cause; losartan is ‘notorious’ for causing renal problems. ‘Kind of medicine’ losartan is, they’re called ARBs and ACEs, and those tend to cause injury to the kidney...the creatinine to go up. That’s something that happens because of the way that the drug works” [NP]</p>
New medication	<p>“Patient had been taking bunch of anti-inflammatories for acute pain 2 weeks prior to appointment, thought these were the culprit since had recently started these meds” [MD]</p> <p>“When I saw enoxaparin, I immediately started thinking, was it the right drug for the patient, was it the right route? Was it the right dose?” [PharmD]</p>
Renally cleared medication	<p>“Gabapentin is a notorious med that is renally cleared/eliminated so it ‘always jumps out’” [MD]</p>
Risk factor(s)	<p>“Elevated SCr, plus pt being 90 years old tells me patient has CKD” [MD]</p> <p>“So the dehydration, on top of that medicine [Losartan], can cause a problem [renal decline]” [NP]</p> <p>“Pt had several reasons for having elevated SCr: patient in OR night before, had a history of nephrectomy [one kidney removed] learned from rounding team, so his creatinine, was potentially going to be elevated anyway, then he for whatever reason was hypotensive as well” [PharmD]</p>
Subsequent detection	<p>“Pt had stopped anti-inflammatories, but BUN: 33; SCr: 2.1; both worse [than before]. Health tech alerted me to the results” [MD]</p>

Tipped off	<p>“When reviewing last renal note, I just happened upon this statement that was in all caps that said ‘DO NOT SEND HIM HOME ON AN ACE OR AN ARB’” [MD]</p> <p>“[Physician] fellow told me SCr was 1.9 and we looked up eGFR. Fellow mentioned patient’s renal function is getting worse” [MD]</p>
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Abbreviations. ACE(s): Angiotensin converting enzyme inhibitors; ARB(s): Angiotensin receptor blockers; BUN: Blood Urea Nitrogen; CKD: Chronic Kidney Disease; eGFR: estimated Glomerular Filtration Rate; EHR: Electronic Health Record; OR: operating room; SCr: Serum Creatinine; TID: three times daily

Participant’s type in brackets. MD: physician; NP: nurse practitioner; PharmD: pharmacist

Online supplemental table B. Example quotes related to additional information gathering to respond to the incident

THEME	Example(s) from the Incidents
Logistics	<p>“I service rejected it back to the provider but it, once again it was a resident and they were here once a week so they didn’t see it till the next week and then it actually kind of became this huge snowball effect because it was delayed initially because a resident was involved in ordering the medication” [PharmD]</p> <p>“I do like to keep the file because I feel like sometimes the doctors don’t address things appropriately and I have to go back and make sure that they have and in this situation it worked out so” [PharmD]</p> <p>“It was getting to be about the time patient was going to show up; therefore must move quickly to avoid patient receiving higher dose” [PharmD]</p>
Medication	<p>“For fenofibrate, the cutoff dose is 60. [Below CrCl of 60 fenofibrate needs to be adjusted] looked up appropriate dose in a reference” [PharmD]</p> <p>“Colchicine isn’t removed by dialysis source of cue is that the reference says to wait 2 weeks before giving the medication, again” [PharmD]</p> <p>“Pt was taking 2 Aleve BID, 4 Advil BID” [MD]</p>
Renal function	<p>“If CrCl was 20-40, that would match patient’s current dose of Piperacillin/tazobactam IV, but patient’s CrCl was below 20. I used CrCl calculator and found CrCl was 18.6 mL/min” [PharmD]</p> <p>“Given patient on dialysis, I estimated GFR to be 10-15 mL/min” [PharmD]</p> <p>“I calculate eCrCL for the older pts. 80, 90 [year old], frail little guys” [PharmD]</p> <p>“Usually look at the last 3-4 labs” [PharmD]</p> <p>“Calculate CrCl because when you look up drug information like in Micromedex or LexiComp for the package insert, when they do talk about renal adjustment, it usually goes off a CrCl, not so much like a SCr, or a eGFR. CrCl is ‘like the standard’” [PharmD]</p>
Renal patho-physiology	<p>“[Order extra labs to test my hypothesis] ordered a urine protein and creatinine, spot urine creatinine, urine eosinophils since anti-inflammatories can cause interstitial nephritis” [MD]</p>
Risk factor(s)	<p>“‘Right radical’ in notes indicates the patient’s whole kidney was removed” [PharmD]</p>

Abbreviations. BID: twice daily; CrCl: Creatinine Clearance; eCrCl: estimated Creatinine Clearance GFR: Glomerular Filtration Rate; IV: Intravenous

Participant’s type in brackets. MD: physician; NP: nurse practitioner; PharmD: pharmacist

Online supplemental table C. Example quotes related to actions taken to help address the incident, including the participants' rationale for their approach.

THEME	Example(s) from the Incidents
Actions related to treatment interventions	
Avoid risky medications	<p>“Avoid NSAIDs as an alternative because they are hard on kidneys and this is a dialysis patient” [PharmD]</p> <p>“[The] only other fibrate available is gemfibrozil, but we can’t use that because can’t use gemfibrozil in patients with renal failure” [MD]</p>
Continue medication	<p>“I left piperacillin/tazobactam dose the same because [patient] was not at that CrCl cutoff yet. Cutoff is CrCl of 20 and patient’s [estimated] CrCl was 26” [PharmD]</p> <p>“There aren’t a lot of alternative medications for gabapentin to treat peripheral neuropathy – duloxetine or pregabalin. For the alternatives that exist, they require special approval, have to ‘jump through hoops’” [MD]</p> <p>“Tenofovir is the backbone of almost all of our regimens and so if you lose it then you’re kind of limited by what alternatives you have to treat people with so you have a high threshold for switching that medication out.” [MD]</p>
Medication dose selection	<p>“Patient’s SCr [is] worse, and CrCl [is] now below the cutoff for Piperacillin/tazobactam so [I] adjusted Piperacillin/tazobactam. Reduced it from 3.375 grams every 6 hours to 2.25 grams every 6 hours” [PharmD]</p> <p>“[I wanted to] avoid splitting the [colchicine] tablet. Patient may not do it right or may get confused. Seek simple dose for patient: easier for patient to take one dose than split pill and take at intervals” [PharmD]</p>
Restart medication	<p>“We noticed on the day of discharge he [his blood pressure] started trending up a little bit. It was in the 145 over 70 range so it was a good time to restart the lisinopril” [NP]</p>
Stop medication	<p>“His renal function was [previously] stable but then when it had that bump when he went into renal failure on [date] and had acute kidney injury, I decided that it wasn’t worth [it to keep patient on tenofovir containing combo pill]. Wasn’t worth [risk of further kidney damage, to keep patient on tenofovir]” [MD]</p> <p>“Since lab results did not support anti-inflammatories as cause, [I] asked patient to stop HCTZ/Lisinopril” [MD]</p> <p>“Piperacillin/tazobactam was stopped because the patient had no medication indication for it” [PharmD]</p>
Switch medication	<p>“In order to switch [to abacavir] you have to do a genetic test [HLA B5701] –To make sure that he doesn’t have a hypersensitivity, thankfully he didn’t to the new regimen and that came back negative so he was ready then to start on [it]” [MD]</p> <p>“Since 3 days and nothing growing, recommended switching antibiotic and de-escalating” [PharmD]</p>
Non-drug treatment	<p>“I gave him some heel wedges for his shoes which is another non-operative treatment for osteoarthritis of the knee” [MD]</p>
Actions not related to treatment interventions	
Contingency plan	<p>“I thought about calcium channel blocker, amlodipine, as an alternative med for HCTZ/Lisinopril since it doesn’t cause renal impairment as much, but blood pressure was normal and decided to watch blood pressure instead and see if it trends up without meds” [MD]</p>

	<p>“There were other medications [piperacillin/tazobactam] on his list [besides famotidine] that if it [SCr] had gotten worse would have needed to be adjusted, but I just waited because I was trying to see whether it would get better or worse” [PharmD]</p> <p>“If the patient is more at risk for bleeding and complications then I’ll err on the side of caution and adjust the dose [of enoxaparin], if they aren’t, then I will follow the package insert and not adjust the dose” [PharmD]</p>
Counsel patient	<p>“I told the patient ‘look, based on your renal function, you probably shouldn’t continue with [naproxen]’” [MD]</p> <p>“I told patient I think we should reduce the dose of gabapentin because it can cause grogginess. [I] explain[ed] there is a risk of becoming comatose, unarousable, risk of extreme grogginess and coma.” [MD]</p>
Document in EHR	<p>“I view alerted the provider via an addendum to one of my notes. Goals were: to let them know patient should be on 48 mg fenofibrate (lower dose), to make provider aware of the poor kidney function, so provider can also go back and look at my [original] note [about lowering fenofibrate dose]” [PharmD]</p>
Follow up	<p>“I would have checked patient’s trough next on the 10th or 11th, but since pts SCr changed [and kidneys are unlikely to be clearing the vancomycin] I checked the trough earlier in the week [1-2 days earlier than expected] on the 9th” [PharmD]</p> <p>“So this time I just looked at his labs, because I knew from the day before that it [Piperacillin/tazobactam] was probably going to be a problem” [PharmD]</p> <p>“Schedule patient’s follow-up appointment sooner than usual – 2 months instead of 3 or 4 - so patient can see dietician and we can check how patient is doing without the fenofibrate” [MD]</p>
Weigh risk verses benefit	<p>“I don’t think there are any circumstances with the nitrofurantoin and this patient where the benefits of the med would outweigh the risks. There are other antibiotics we could give the patient” [PharmD]</p>
Weigh act verses recommend	<p>“I deferred to patient’s PCP because: patient had a history of tendinitis, I didn’t know the patient personally, wanted to see if levofloxacin dose should be decreased, given patients decreased kidney function” [PharmD]</p> <p>“[I] changed the gabapentin order myself [rather than relying on original prescriber] because: I get the sense gabapentin is one of those meds that’s frequently prescribed and not as much attention [monitoring] paid to it” [MD]</p>

Abbreviations. CrCl: Creatinine Clearance; EHR: electronic health record; ER: emergency room; HCTZ: Hydrochlorothiazide; HLA: human leukocyte antigen; NSAIDs: Non-Steroidal Anti-Inflammatory Drugs; PCP: Primary Care Physician; SCr: Serum Creatinine; TID: Three Times Daily

Participant’s type in brackets. MD: physician; NP: nurse practitioner; PharmD: pharmacist

Online Supplemental Table D. Template for the decision requirements table used in this investigation. Column headings were selected from among those commonly used in decision requirements tables^{1,2} and then adapted for this study as needed. Time expenditures in the last two rows were captured during the interview whenever possible.

Decision or Judgment <i>made by the expert; often end in 'ing'</i>	Why Difficult? <i>Reasons difficult for the expert or could be difficult for those with less experience</i>	Cue (Source) <i>Cue: salient information or signals applied when making a decision (Source: where information came from that was used to make the decision)</i>	Strategies <i>Used to make the decision and the actions that were taken to address the decision</i>	Potential Errors <i>Errors that could occur or that non-experts may tend to make</i>	Design Seeds <i>Design ideas that may improve healthcare systems, care coordination, IT designs, etc.</i>
1. [decision point]					
2. [decision point]					
<i>[rows added to accommodate the number of decision points in the case]</i>					
Time spent looking up information in references:					
Total time spent resolving issue:					

REFERENCES

1. Militello LG, Klein G. Decision-centered design. *The Oxford handbook of cognitive engineering*. 2013:261-271.
2. Crandall B, Klein GA, Hoffman RR. *Working minds: A practitioner's guide to cognitive task analysis*. Mit Press; 2006.