Co-designing to Improve Practice in Treating Urinary Tract Infections: a case study of reducing inappropriate antibiotic treatment

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Although co-design has made important contributions to practice in many fields, healthcare has only recently employed it for shaping best practices. This paper explores an aspect of medical practice that challenges many hospitals: the decision-making process for ordering urine testing and the use of antibiotics, specifically, in treating Urinary Tract Infections (UTI) and Asymptomatic Bacteriuria (ASB). The case investigates how physicians and nurses make decisions about testing urine for infection and the use of antibiotics. To explore the issue, the researchers conducted three co-design workshops to (1) uncover the medical decision-making process in ordering urine testing and treating UTI and ASB, (2) determine the needs of clinicians as they make such decisions, and (3) collectively design a decision aid that would fit users' cognitive, emotional and physical needs. The case shows how human-centered design approach led to an evidence-based decision-making tool – guiding clinicians to improve their practices by reconsidering when and if to order urine testing and prescribe antibiotics.

K e y w o r d s **–**
human-centred design,
co-design,
collaboration,
healthcare,
clinicians,
urinary tract infections,
asymptomatic bacteriuria

1. Introduction

This case study applies a human-centered approach to improve medical practice. Human-centered design is a framework to improve people's way of living, working, and doing other essential daily activities that focuses attention on people's capacities and needs, seeks to define the problem and its underlying causes collectively, and uses iterative cycles to design and evaluate prototypes (based on Meyer & Norman, in press). While human-centered design approaches have flourished in healthcare practice improvement, few studies describe the processes followed and provide a detailed account about how to engage stakeholders in the design process. In healthcare, medical expertise has tended to drive the creation of communication tools – such as patient education materials, guidelines, and decision aids – written and designed, for the most part, by healthcare professionals.

Recently, increased collaboration between experts in design and healthcare is emerging (Breslin et al., 2008; Hargraves, 2018; Noël et al., 2019; Roberts et al., 2016; Witteman et al., 2015). This article demonstrates how human-centered design can help reduce unnecessary antibiotic prescription. This case illustrates the process and methods used to support medical practice change.

This study begins with an overview of both the medical problem and the communication design problem faced. The study elaborates how we engaged clinicians with heavy demands in co-design and together co-created a decision aid. Co-design is a human-centered design method, where "the person who will… be served through the design process is given the position of 'experts of their experience,' and plays a large role in knowledge development, idea generation and concept development" (Sanders & Stappers, 2012, pp. 23-24).

The medical problem: Confronting and changing lore

Urinary tract infections (UTIs) are a common bacterial infection that doctors diagnose during Emergency Department visits. According to Abbo and Hooton (2014), "10.8 million patients in the United States visited an Emergency Department (ED) for the treatment of a UTI between 2006 and 2009" (p. 175). There is great variation in practices regarding when to order a urine test, how to interpret symptoms of UTI, and when to initiate antibiotic treatment (Beckford-Ball, 2006). It is common practice to order urine testing (both urinalysis and urine cultures) in the absence of typical UTI symptoms, such as dysuria (discomfort) and urinary frequency (Flokas et al., 2017; Nicolle et al., 2019). This practice occurs partly because diagnosis of UTI is difficult in older adults with non-specific symptoms, as they are more likely to have bacterial colonization of the bladder (Beckford-Ball, 2006, p. 1). Criteria for the diagnosis of urinary tract infection varies,

depending on the patient and the context: symptoms / no symptoms, men / women, pregnant women / non-pregnant women, catheter / no catheter, adult / children, and so on (Scottish Intercollegiate Guidelines Network (SIGN), 2012).

ASB occurs with a positive urine culture but without local or systemic symptoms of a UTI. Except in certain cases, such as pregnancy and prior to invasive urological procedures, treating ASB with antibiotics is not beneficial and is potentially harmful. Clinicians often find it difficult not to treat positive urine culture results, and patients are exposed to unwarranted antibiotic therapy (American College of Radiology, 2012; Barlam et al., 2016; Fleming-Dutra et al., 2016).

Antimicrobial exposure can, for example, contribute to the development of bacterial resistance, result in adverse and allergic reactions in patients, and have unintended consequences, such as *Clostridium difficile* infections. These bacteria can cause problems for patients – ranging from diarrhea to life-threatening inflammation of the colon (File et al., 2014). Antimicrobial stewardship endeavours to limit antimicrobial exposure to cases where it is absolutely necessary.

Problematically, established practices, professional lore, and public beliefs show unawareness of the diagnostic criteria of UTI and that treating ASB with antibiotics is not beneficial.

Motivation for study

This case study was initiated by the "Appropriateness of Care: Asymptomatic Bacteriuria (ASAB)" initiative of Alberta Health Services (Canada), which sought to reduce the inappropriate urine culture testing and use of antibiotics in hospitals and long-term care facilities. In particular, the health service explored the following beliefs and practices:

- Beliefs that non-specific clinical status changes or cloudy/smelly urine (particularly in older adults or catheterized patients) are the result of UTI (Rowe et al., 2014).
- Beliefs that a positive urinalysis or a test of urine cultures is always indicative of UTI (Juthani-Mehta, 2015).
- 'Routine' and 'opportunistic' collection of urinalysis and urine cultures (as part of a panel of investigations) as accepted practice (Rowe et al. 2014).

The ASAB group partnered with the Physician Learning Program (PLP) at the University of Alberta to better understand the problem and to collaborate on the design of an antimicrobial and diagnostic stewardship decision-making tool that would ultimately improve patient care.

Reframing the design problem: Achieving safer outcomes

In 2017, the PLP applied a human-centered design approach to advance health practice. Human-centered design has shown to increase the effectiveness of communication tools in healthcare, particularly decision aids and patient information aimed at translating new evidence into practice (Erwin & Krishnan, 2016; Garvelink et al., 2016; Thornhill et al., 2017; Noël et al., 2018; Ragouzeos et al., 2019; Adam et al., 2019; Zeballos-Palacios et al., 2019).

The ASAB team provided a draft of an educational toolkit for patients and clinicians. In this article, we focus on the co-design of one key component of this toolkit: An evidence-based decision aid designed to improve clinicians' decision-making about when to test urine for infection. To see the complete final toolkit, visit https://www.albertahealthservices.ca/info/Page15718.aspx.

The design problem we faced was not only to optimize the decision aid through more effective visual and verbal language. The designer worked with the partner collaborators to reframe the problem and its scope–from improving a visual tool to supporting decision making to achieve safer health outcomes.

Situating co-design and collaboration

We tried to create the optimal conditions for sharing, reflection, collective reasoning, and exploration through co-designing. If the decision aid was to be successful, it would need to encourage clinicians to make decisions based on recent evidence. Co-designing helps participants feel ownership of the project. Each participant has a role in creating a better reality.

Co-design promotes the collective understanding of what is occurring (Britton, 2017, p. 40). Healthcare change practices benefit from co-design because it gives the community a major say in the process (Meyer & Norman, 2020, p. 17). Understanding the diverse needs and perceptions of a situation people have is essential to change practices. Others refer to this as the human dimensions of change (NHS Institute for Innovation and Improvement, 2005). However, engaging very busy healthcare professionals (physicians, nurses, and pharmacists) in co-design is not straightforward. People do not always have in mind what could help (Flores, 2012, p. 4). Part of the role of the human-centered designer was to develop a strategy to engage clinicians in reflecting about a problem that some were not aware of, with participants sensing and becoming increasingly aware of divergent perspectives, and ultimately, connecting, understanding, exploring, and solving issues collaboratively.

The designer creates activities and facilitation tools to foster engagement, and the sharing of information, perspectives, and knowledge to re-construct and adapt new problem representations. If the designer facilitating the process is unable to create suitable activities, problem exploration and reframing will not happen.

Some healthcare leaders tend to refer to the practice of producing knowledge with stakeholders as co-creation (Greenhalgh et al., 2016). They view co-creation as a collaborative process in which academics and stakeholders produce knowledge, rather than only translating it into action. Elwyn et al. (2019) consider that co-production fosters learning healthcare systems. "Coproduction also makes a connection between practice improvement and organizational design by leveraging the power of learning health systems towards the increasing focus on value-based care" (p. 715). This learning requires iterative processes of questioning and re-thinking (Senge, 2006, p. 324).

We see co-design as a process of mutual learning, exploring possibilities, and making them visible through visual and verbal language – a process in which designers and non-designers work collaboratively (Sanders & Stappers, 2008). Increasingly, collaboration and facilitation skills are becoming more relevant to designers' work (Voûte et al., 2020, p. 63).

During co-design, participants typically reveal aspects of the problem that the leading team does not have access to and is unaware of. Multiple perspectives help the team both modify their representation of the problem and restructure it to account for the team's collective expertise. As participants re-represent their task, they engage in reframing the problem.

2. Methods

Rarely, publications reporting on antibiotics stewardship discuss the team's design process and methods, making it difficult to see the contribution of design to the project (Betsch et al., 2018; Formoso et al., 2013). This section outlines how we engaged clinicians and how we gained knowledge.

We strove to understand the people using the tool – their knowledge, assumptions, and misconceptions. Human-centered design means learning about people, their worlds, and their goals (Frascara, 2017).

To build understanding from the UTI and ASB problem from the clinicians' perspectives, we created three co-design workshops to collectively:

1. Uncover the medical decision-making process in assessing UTI and ASB.
2. Identify ways to guide clinicians to make more evidence-based decisions about diagnosing and treating UTI and ASB.

3. Design a tool that would meet the cognitive, emotional, and physical needs of healthcare providers.

Participants

We recruited participants through the University of Alberta Hospital. Our protocol was approved by the Health Research Ethics Board of the Faculty of Medicine and Dentistry at the University of Alberta.

Forty-four people volunteered to participate in three co-design sessions. Participants were nurse practitioners, nurse educators, nursing students, pharmacists, and physicians from the Emergency, Gastroenterology, and Orthopedic Departments of the University of Alberta Hospital. Volunteers were excluded if their daily routine did not include urine testing.

The role of the participants is to bring different voices, their experiences, and deep knowledge of the caring process; to share their ways of doing; their learnings. The role is to engage in dialogue and collaborate in designing more appropriate care practices shaping their future ways of practicing.

Timeframe

Two workshops were conducted in September of 2017, with six participants and eight participants, respectively. A third workshop took place in March of 2018, with thirty participants: unit managers, clinical nurse educators, registered nurses, licensed practical nurses, and patient care managers. Participants co-created in groups. Each workshop was conducted for 90 minutes.

After the first two co-design sessions, the ASAB steering committee met to discuss the learnings, and changes proposed, and approved them. The decision aid was revised in December 2017, piloted in January 2018, and revised again in February 2018. At this point, the team decided to hold a third co-design workshop. Between March 2018 and January 2019, the decision aid was revised, piloted, and approved by the ASAB steering committee.

Tools and materials

To examine the problems associated with assessing and treating UTI and ASB, we created:

1. **Poster-sized quotes**: To encourage participants to think about the problem, we extracted 15 quotes from 'Urinary Tract

Infection—Requiem for a Heavyweight' (Finucane, 2017). The A3 quotes were hung on a wall.

2. **Scenarios**: To situate participants, we explored the following: *"Suppose I* (facilitator) *am a patient…?"* and *"If this is the process…"*

3. **Dialogue prompters**: To help participants engage in collective thinking, we designed tools for fostering dialogue, reflection, and problem representation.

4. **Provotypes and prototypes**: Provotypes help provoke initial exploration. Prototypes help team members think through a design problem by testing solutions.

Procedures and activities

Participants were invited to immerse themselves in reflection to think about how to change the situation. They were recognized as having valuable experience and knowledge – without which, the problem could not be effectively understood. We asked participants for their help in thinking through how to help clinicians change their routine practices.

Together, the team introduced the problem from medical and design perspectives. From a medical perspective, the problem definition was framed using research evidence (Blakiston & Zaman, 2014; Flokas et al., 2017), local data, and knowledge about the local clinical setting and circumstances. The basic medical problem was as follows:

> *There is no clinical benefit obtained by treating individuals with ASB, particularly older adults. However, the belief that cloudy or smelly urine is indicative of UTI leads to overdiagnosis and unnecessary antibiotic use. This promotes antimicrobial resistance. In Alberta, there are more than 610,000 urine cultures processed annually. These tests result in costs exceeding $9,000,000 (CAD). How can we improve this?*

This setup allowed the group to embrace a common interest and mission, to become a "pledge group" (Von Krogh et al., 2000, p.15). The design problem built on the medical problem and explored:

> *What is the current decision-making process when assessing UTI and ASB, and how can we better help clinicians to quickly decide when it is appropriate to order urinalysis and urine cultures to test urine for infection?*

The two perspectives helped us build a common goal to pursue. Each co-design activity began with a set of instructions that were read aloud and discussed. The instructions were a series of steps, showing how to explore the problem by breaking it into smaller and simpler problems (Rumelhart, 1992).

The three co-design sessions were facilitated by the physician lead, who specializes in infectious diseases, and the designer. The role of the physician lead was to bring her depth of knowledge about UTI and ASB, the current problem we were facing, and clinical practice. The role of the designer was to orchestrate activities to help clinicians immerse in a problem space, reflect on the problem situation, help see the problem from diverse perspectives, foster engagement reasoning, and enable creativity and imagination. The designer observed interaction dynamics, posed questions, noted how the diverse collective activities (listening, reasoning, imagination) were going, and adapted or proposed changes to keep momentum and achieve the goals.

Activity 1:

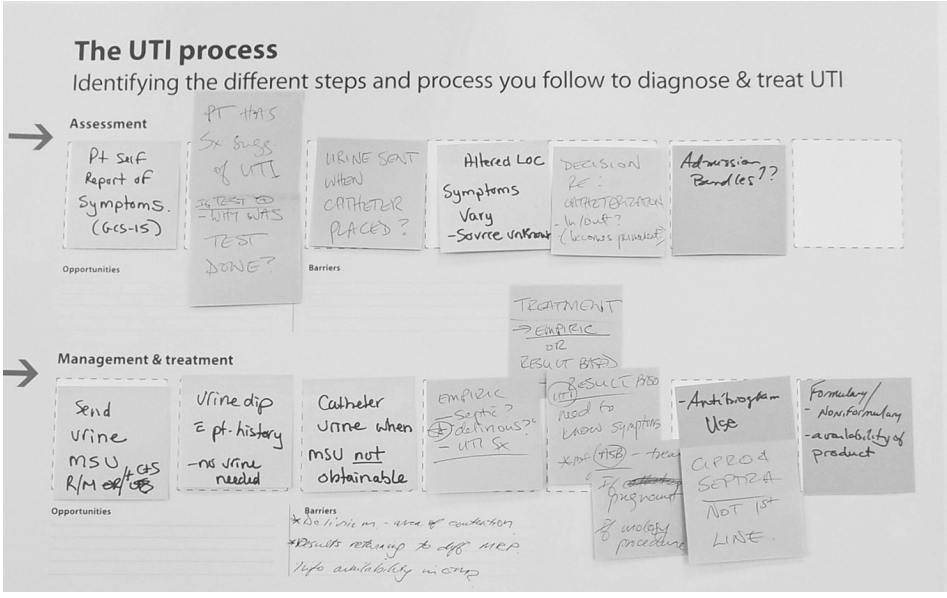
Process mapping

We invited participants to begin by reading the 15 poster-sized quotes. In the first 10 minutes, participants co-created a process map. We engaged in a simulation to identify the decision-making process that healthcare professionals typically follow when assessing UTI and ASB. The goal was to help participants situate themselves in daily practice—to think, raise awareness, and reflect about what they do. We presented the following scenario: *Suppose I* (facilitator) *am a patient waiting in the Emergency Room; what steps would you* (clinician) *take to diagnose and treat UTI?* Then the groups discussed the process map, each group describing the procedures they would follow.

To help clinicians engage in process mapping, we use dialogue prompters to pre-structure activities and encourage the team to think collectively about the problem (see Figure 1).

Figure 1.

The dialogue prompter used to facilitate reflection about the process.



These tools create a shared communication space (Frascara, 2016, p. xix-xx). The dialogue prompters were visible to the participants throughout the process.

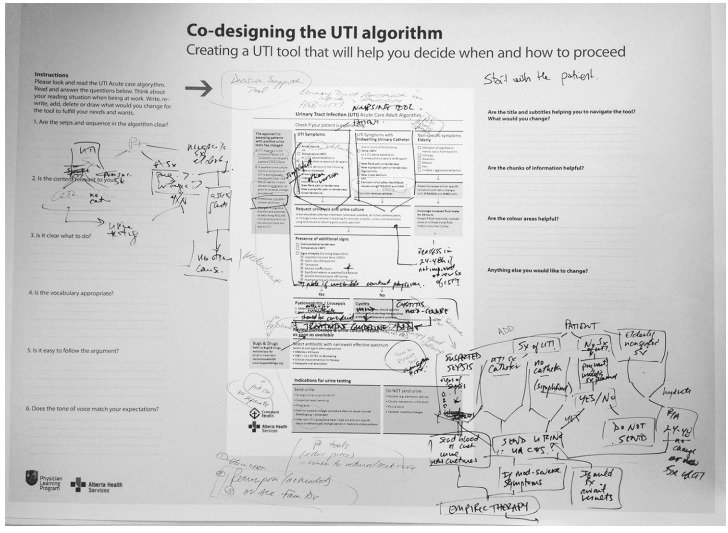
Activities 2 & 3:
Co-analysis & co-design of the decision aid

For a second co-design activity, we designed another dialogue prompter (see Figure 2) with the following scenario*: If this is the process you follow, in what way does this decision aid assist in decision making*? The dialogue prompter helped participants reflect on the sequence of information, the relevance and clarity of the content, the appropriateness of the vocabulary, the tone of voice, and other aspects. The groups had 20 minutes to co-design the *decision aid* and 10 minutes to share their reflections. This activity was repeated for each workshop.

The dialogue prompter (Figure 2) included a provotype of the decision aid called "UTI Algorithm." Our goal was to provoke discussion about the suitability of the content and its visual presentation. Previous work suggests that provotypes can help participants explore possible solutions at early stages of the design process (Erwin & Krishnan, 2017; Boer & Donovan, 2012). We wanted to learn about how clinicians would interact with the decision aid and use that understanding to generate ideas for improvement. This activity helped arrive at initial performance requirements (Frascara & Noël, 2012).

Figure 2.

Dialogue prompter with the provotype and the changes suggested by the participants. The diagrammatic sketch at the bottom-right of the image reveals the thinking process participants were following to adapt the algorithm to their practice processes.



The diagrammatic sketch at the bottom-right in Figure 2 provided the basis for the first prototype used in Workshop 2 (Figure 3). The group made the decision points more apparent.

Figure 3.

Dialogue prompter with the emergent prototype created by the co-design participants in workshop 2.

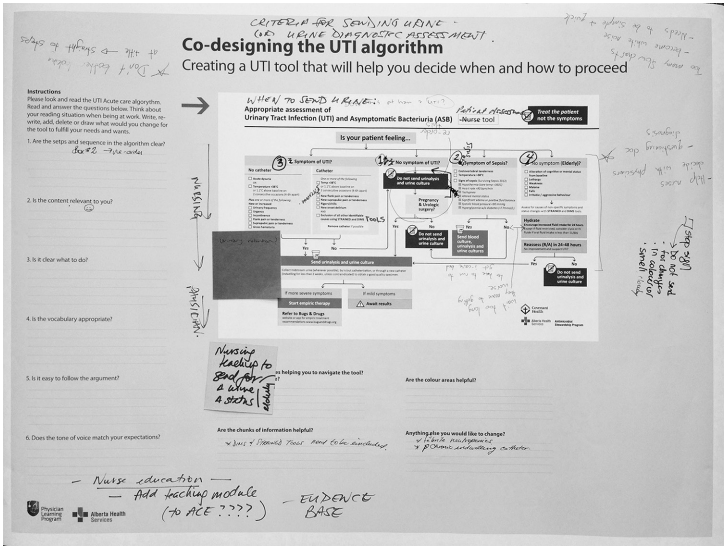


Figure 4.

Participants during the third workshop engage in co-design of the prototype and make changes so the tool better fits the cognitive, emotional, and physical context of the users.

The third activity focused on co-designing the decision aid (see Figure 4). It integrated the thinking that resulted from previous activities. The goal was to foster the collective framing of the problem from the perspective of people with different medical roles and to design a better tool.

Table 1. Summary of co-design activities and tools and their roles in orchestrating collaboration

Activities	Goals	Tools & roles
1. Process mapping	• To identify the decision-making process participants follow when assessing for possible UTI and ASB. • To assist clinicians to situate and articulate their current practices. • To recognize barriers and areas for improvement.	Dialogue prompter, markers, quotes, scenarios, and dialogue help participants situate themselves in daily practice. To engage in a simulation to identify the decision-making process. The dialogue prompter helps to pre-structure the mapping activity and encourages participants to think collectively about the problem. To recognize different roles, diverse practices, and interrelationships in the process.
Discussion	• To learn from others, sharing and gaining understanding. • To identify and articulate existing knowledge.	Filled-in dialogue prompters, dialogue. To encourage collective and reflective listening. To discover different ways of practicing, knowledge gaps, and biases. To start re-framing the problem collectively.
2. Co-analysis of the existing algorithm (decision aid)	• To explore whether the algorithm assists the decision-making process. • To identify information needs.	Second dialogue prompter, scenarios, a provotype (in the first workshop), prototypes (in the second and third workshop), dialogue. The dialogue prompter guides reflection. The Provo/prototype fosters reasoning, providing a model to evaluate and mentally simulate the use of the tool to improve clinicians' decision-making. It promotes critical thinking, assessing decision points and their consequences. It helps engage in problem-solving, identifying constraints, flaws, and ways to overcome them. Both tools help express diverse needs, perspectives, and fears.
3. Co-design of the decision aid The mapping and simulation, the listening, analysis, and exploration from the previous activities served to d the basis for the co-design of a new decision aid.	• To engage clinicians in the design of the decision aid. • To collectively establish what the tool should help achieve and how to achieve it. • To design a tool that fits the users' cognitive, emotional and physical context.	The dialogue prompters employed in the previous activities, dialogue. The second dialogue prompter with Provo/prototype helps reason through the problem and generate ideas to design a decision aid that supports better practice processes. The prototype fosters reasoning by model manipulation and adaptation (the notes and changes suggested reflect that). It helps explore hypotheses (problem-solving) and draw while thinking (creative thinking). The prototype facilitates reasoning, problem-solving and helps design a new decision aid.
Discussion	• To identify different needs, opinions, perspectives. • To share and gain understanding.	The completed filled-in dialogue prompters, dialogue. They help articulate understanding: what was modified and what was gained.

Data analysis

We took verbatim notes during the workshops and aggregated participants' comments about the tools. Three of the co-authors participated in an iterative process to group, label, and code the data. We analyzed the data through affinity diagramming, allowing theme identification (Hartson et al., 2012). Affinity diagrams can reveal the scope of participants' problems and help develop performance requirements (Beyer & Holzblatt, 2017).

We used the findings from the affinity diagramming to develop performance requirements and guide design decisions.

This process transformed our research findings – from what people did and why they did it – to what they needed to do and what the design should do to get them there.

3. Findings

The co-design activities helped participants to understand the project's goals and flesh out their own decision-making process. Participants uncovered knowledge gaps, identified points of resistance to the message, and brought to the surface fears about implementing the new process. Participants pointed to content that needed improvement and to information requirements for making an informed decision. Immersing participants in the activities allowed us to co-design a tool that fits clinicians' capacities and needs.

Our findings shed light on how co-design facilitated (1) thinking through the problem space while mobilizing participants' knowledge and skills, and (2) developing an actionable decision aid for diverse healthcare providers and settings.

Thinking through the design space

Co-design helped participants navigate the problem by creating a safe space for collaboration, uncovering tacit knowledge, seeing and thinking through the problem, and recognizing fears and beliefs about diagnostic decisions.

Design facilitation: Creating a safe space

Asking participants for their help was key in setting an appropriate atmosphere for co-design. We made it clear that each participant's expertise was relevant to building an actionable decision aid. Introducing the problem from both medical and design perspectives helped us build a common understanding. Articulating the goals for each activity established a structure for working together. By making goals explicit and allowing participants to see how their ideas would form the basis for the decision aid, we set up the conditions for participants to feel comfortable about voicing their opinions and collaborating. We created a safe space.

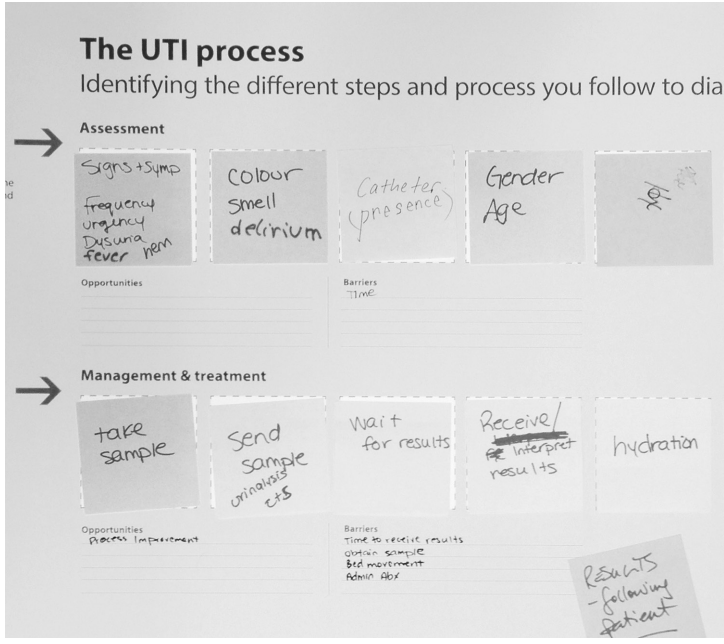
Process mapping: Uncovering tacit knowledge

Process mapping allowed us to uncover participants' tacit knowledge. The maps revealed variations in how UTI and ASB are diagnosed and treated. Participants indicated a need for a standardized practice, which became a motivator. The maps raised awareness about

current practices and knowledge gaps. For example, that some care teams considered cloudy or smelly urine as indicative of UTI. Other teams used urinalysis to rule-out UTI, while others used urine dipsticks (a diagnostic tool used to determine changes in urine) (see Figures 5 & 6). These variations confirmed that some practices were inconsistent with those suggested by best practices (as shown in Figure 5).

Figure 5.

For this care team, the second step in the process was to check changes in a patients' urine for cloudiness or smell. However, recent evidence shows that they are not necessarily indicative of UTI.



The content needed improvement in two areas: to educate about the benign nature of ASB; and to clarify that cloudy or smelly urine is not indicative of UTI. Other aspects that needed improvement included:

— To prompt providers to look for other potential causes of non-specific changes, such as loss of consciousness, agitation, lethargy, and falls in older adults.

— To improve processes, to ensure that test results follow the patient during the hospital journey.

— To change the laboratory requisition to include the reason for urine testing.

Participants identified that the time it took to collect and receive the lab results, particularly in the emergency department, are barriers to appropriate assessment. In emergency departments, wait times and length of admission are considered benchmarks of quality. Other barriers were:

— Delirium in older patients is perceived as a UTI symptom; this is an area of contention. Physicians are afraid of missing something.

— Lack of information about urinary catheters, particularly regarding whether the catheter is new, intermittent, or chronic.

— Difficulties obtaining a quality urine sample.

Process mapping helped us to understand the decision-making process clinicians followed. It led us to uncover current practices, collectively identify areas for improving information, and at the same time, recognize barriers to appropriate care.

Dialogue prompters: Seeing and thinking through the problem

The dialogue prompter fostered co-analysis of the provotypes and prototypes (Figure 3) by drawing on participants' unique expertise as part of a shared problem space. Rather than quickly focusing on the solution, "the dialogue process attempts to slow down the conversation to allow participants to reflect" (Schein, 2017, p. 111). The prompter provided a visual representation for discussing problems clinicians faced.

Participants pointed out that the decision aid was not entirely about ASB; it was also about appropriate urine testing. They felt the tool needed to specify the intended audience. As a consequence, we added a heading to help users quickly identify the intended readers.

Participants found that the decision aid contained two types of information: content to guide decision-making and content to educate healthcare providers. These types of content served competing purposes. On the one hand, content for decision-making encouraged users to draw on working memory and act. On the other, content for learning was intended to activate users' long-term and working memory – triggering users' prior knowledge, fostering reflection, and promoting the integration of old and new knowledge. Because participants felt that content directed at learning did not suggest immediate action, they recommended that this educational content be placed elsewhere in the toolkit. We moved the educational information to a "physician tool" to focus the redesign exclusively on content for decision-making.

Participants also indicated that not all of the content presented in the algorithm's decision boxes actually guided them to a satisfactory decision. For example, the advice "Hydrate and reassess in 24 hours" was problematic for the emergency department clinicians, given that the patient might not stay there for 24 hours.

The advice to assess changes in a patient's mental state created resistance. Clinicians felt that asking emergency department

personnel to assess mental states negatively influenced their willingness to use the algorithm. This led us to remove the advice.

Prototypes: Recognizing fears and beliefs about diagnostic decisions

The visual nature of the prototypes created an enabling context that helped to recognize fears and beliefs related to diagnosing UTI. Parts of the decision were revised to alleviate participants' reservations about the guidance. For example, participants suggested that the advice relating to 'No UTI symptoms' was problematic because physicians may have fears of missing a diagnosis of sepsis (a life-threatening condition). As Collins (2018) explained, "when humans are given a choice between their own judgment and that of a demonstrably superior algorithm, they will generally choose the former" (Paragraph 9). It became apparent that the problem was not merely to guide decision-making but to show that the process we were proposing would *lead to safer outcomes*.

Three sets of requirements for the decision aid

Results from the co-design workshops provided a basis upon which to develop performance requirements. Co-design also guided our understanding of how to organize the content so that it followed a typical decision path a healthcare provider might pursue. We summarize these requirements in Table 2.

Uncovering clinicians' needs through iterative co-design

Participants thought that the title of the algorithm needed to communicate that the advice was, in fact, evidence-based. Consequently, the title went through a series of iterations – from "Urinary Tract Infection (UTI) Acute Care Algorithm" – to "Evidence-Based Criteria for Urinary Infection Testing."

Participants also wanted a visible and prominent sign that reminded users that cloudy and smelly urine is not indicative of UTI. We added a warning sign to address their concern.

In the first co-design workshop, participants stated that to match the users' mental process, the tool needed to start with the patient. They felt the algorithm should present different scenarios the healthcare team considers when diagnosing UTI and ASB. Participants suggested organizing the algorithm into four main groups: sepsis, UTI symptoms, no UTI symptoms, and older adults with no symptoms.

Table 2. Requirements for the decision aid.

User requirements	1. It should be easy to identify the intended audience. 2. It should work for both emergency and acute care clinicians. 3. It should avoid resistance and promote adoption. 4. It should not promote other decision tools.
Writing requirements	5. Reading-to-do and reading-to-learn should be separated. 6. The title should clearly state that the decision aid is based on evidence. 7. The title should clearly communicate the function of the tool. 8. It should use terms and language familiar to clinicians (Schriver, 2017). 9. It should present only necessary information and avoid being text-heavy. 10. Advice should be clear, for example: Do not test urine for changes in color or smell. 11. It should clearly indicate to send urine for testing only if there are UTI symptoms. 12. In the case of delirium, it should indicate the patient's need for hydration.
Structure requirements	13. The reading order should be very apparent to users: left to right, or top to bottom. 14. It should be easy to identify the different scenarios: symptoms, no symptoms, others. 15. Every box should lead to a decision. 16. The box for sepsis should be part of the main symptoms to consider.

thought it would be more effective to have two main groups: patients presenting UTI symptoms and patients not presenting UTI symptoms, as shown in the bottom right prototype of Figure 6.

Twenty-two iterations were made before arriving at the final prototype. Clinicians were involved in all iterations (as co-design participants or as members of the clinical committee). The final document was approved by the ASAB Steering Committee, the group responsible for oversight of the content. Figure 6 shows the main iterations of the decision aid over the co-design process. Figure 7 presents the final prototype.

Figure 6.

Transformations of the decision aid—from original to provotype to prototypes.

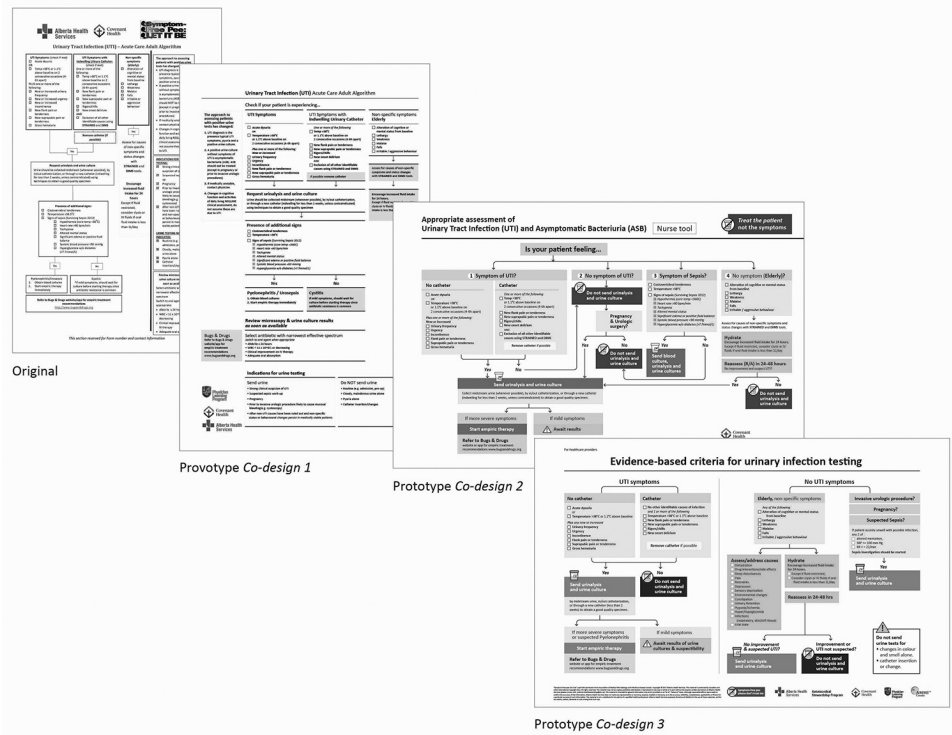
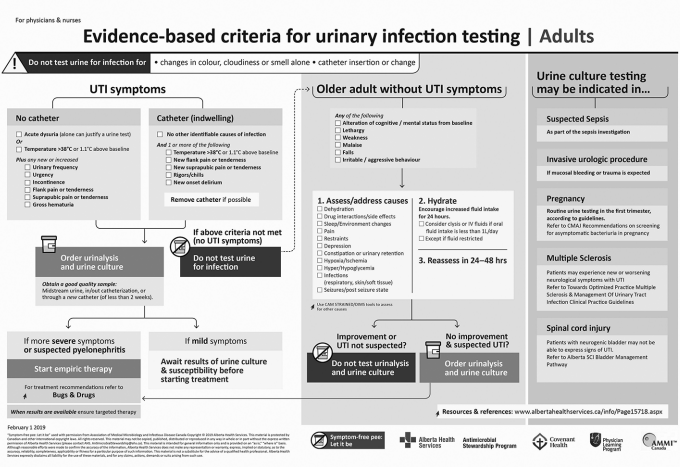


Figure 7.

The final prototype of the decision aid.



4. Discussion

Our findings show that co-design both helped participants navigate the problem space and enabled them to develop a human-centered decision aid. But our research also led us to realize that the goals we were pursuing: to examine the problems associated with assessing and treating UTI and ASB and the evidence regarding when to order urine testing, was not always viewed by clinicians as a problem. We found that some participants needed to accept the evidence before they could believe that "overusing urine testing" was even an issue. As Lefebvre (2013) points out, before one offers a solution to a problem, people need to be aware of it and embrace the idea that it actually needs to be improved.

Generating problem awareness through co-design

As we collaborated with participants over the course of the study, we grew to recognize that even if we developed a good evidence-based tool, clinicians might still resist adopting the decision aid because their prior experience might conflict with recent evidence. Some participants did not agree with what the evidence said the "facts" were. For example, the idea that "cloudy or smelly urine is not necessarily indicative of UTI" was a recurring point of discussion—even of contention among some participants. As one nurse said as she read our quotes on the wall, "This is not true." Another participant added, "This is not what I was taught in school." As participants listened to the experiences of the group, they gradually developed an awareness that it was a genuine problem and eventually bought into the idea that it needed improvement.

Building shared vocabulary during co-design

We identified that the language of UTI and ASB was foreign to some participants. As one participant pointed out, "I don't even know how to pronounce *asymptomatic bacteriuria*." We saw that what was straightforward to experts could alienate those trying to improve clinical practice. This acknowledgment led us to avoid using unfamiliar terms. It also made us realize that reflecting on one's practices requires using language to explore what one knows and does not know (for how humans operate in a semantic domain shaped by languages, see Maturana & Varela, 1987, pp. 211-213). We concluded that language could be an impediment to co-design if all participants do not share similar understandings of the key terms being used during discussion. In fact, a lack of shared vocabulary can hinder productive engagement in co-design (Von Krogh et al., 2000, p. 118).

Drawing on external representations to promote co-design

We found that when participants collaborated through discussing an external representation of the problem (mapping practices), they were often prompted to move beyond personal experience. The tools (i.e., dialogue prompters) encouraged participants to reflect on their own practices, attend to the experiences of others, and jointly consider what could be done differently. For example, using the provotype led some participants to argue that it would be useful to know how long urine samples wait in the emergency department before being sent to the lab for analysis. The provotype served to catalyze ideas about what is typically done and allowed participants to better conceptualize ways to improve the process.

External representations offered participants concrete visual artifacts to respond to. As Larkin and Simon (1987) observed, diagrammatic representations allow people to recognize features and make inferences about information that may be otherwise unavailable to them.

We found that visual representations of the problem played a key role in constructing and modifying understanding and in exploring possibilities. Planning for effective collaboration involved thinking about what could emerge during each session, imagining where conversations might lead and how the tools might drive interaction and collective problem solving. Designers have been shifting their role—from facilitator to orchestrator—anticipating what could happen (Aguirre, Agudelo, & Romm, 2017). Facilitators organize and lead a workshop. Orchestrators anticipate the flow of the collective event and "materialize their intent through contextually designed facilitation tools" (Aguirre, Agudelo, & Romm, 2017, p. 207). When designing conversations, there is uncertainty in the collective learning process; dealing with uncertainty requires planned flexibility.

Benefitting from collective learning during co-design

Our co-design process led to an unexpected and favorable outcome. We found that as participants conversed with one another and became more aware of the evidence about UTI and ASB, their resistance to messages that ran counter to their personal experience lessened. By working together on the decision aid, participants who struggled with believing in the evidence changed their minds. Participants who challenged recent "facts" became champions of those newly acquired facts and proved to be instrumental in fostering the adoption of safer care processes.

During the workshops, participants shared situations and problems they experienced that helped group members re-consider their current understanding of UTI and ASB. Over time, their collective knowledge grew more integrated, and their individual knowledge was reconfigured (Huang & Yang-Chieh 2018). The exchange of beliefs, experiences, and medical evidence through "designed conversations" fostered collective group teaching and learning. As Zhao and colleagues (2004) elaborate, "a group [who]…work together demonstrate their common and inter-personal knowledge, while the members of the recipient community share, integrate and synthesize their learning among themselves" (p. 139). During the workshops, for example, participants made comments such as: "It's a nice way of learning," "It's a place to address knowledge gaps," and "It helped me to think critically by having a conversation."

That participants acknowledge knowing more about UTI and ASB as a result of co-design showed that learning can be a consequence of a robust co-design process. As Larson and Christensen (1993) suggest, "the knowledge that something was learned can be quite valuable because it provides a cue for ensuring that what was learned actually came out in discussion" (p. 17). Co-design activities can help teams translate and share their knowledge (Greenhalgh, 2018; Erwin & Krishnan, 2017; Sanematsu & Cripe, 2017; Langley et al., 2018).

The ASAB initiative materials are continuously promoted by the organization's website [see previously shared URL] and as part of ongoing clinicians' education. The tools were used as a pilot education process at a large urban hospital emergency department, which consisted of a blitz of 1:1 education of emergency department nurses, pharmacists, and physicians. After the introduction of the tools, urine culture rates decreased by 17% and were sustained for at least a one-year period.

The tools were also used as part of a quality improvement project at geriatric psychiatric units located in a psychiatric hospital. Coupled with staff and physician education, implementation of the evidence-based tools which resulted in reductions in urine cultures (34%), antibiotic prescriptions (28%), and antibiotic utilization (27%). The toolkit has been promoted by the Association of Medical Microbiology and Infectious Disease of Canada, and Choosing Wisely Canada.

6. Implications & conclusions

This case study shows that co-design can be an effective method toward improving healthcare practices—helping teams to exchange knowledge and develop human-centered tools that work. Even though designers can play a key role in tapping team members' tacit knowledge and in transforming that knowledge into useful tools for particular audiences, the role of the designer in orchestrating co-design is not well understood. Future research should address this knowledge gap. Too often, designers in healthcare are perceived as professionals who make information pretty—who tidy things up at the end of thinking—rather than as interpreters of complex problems, who can help in implementing new evidence and in humanizing healthcare systems.

A key role of the designer when facilitating is empowering participants to determine the nature of their assumptions behind beliefs and processes, to foster dialogue, reflection, and listening.

> The key to initiating this kind of dialogic conversation is to create a setting in which participants feel secure enough to suspend their need to win arguments, to clarify everything they say, and to challenge each other every time they disagree (Schein, 2017, p. 111).

One of the key roles of the designer in this project was to create a safe space for dialogue, knowledge sharing, collective learning, and collaboration to find out how to improve diagnostic testing and treatment of UTI and ASB to provide better care. "Improving the quality of care delivery processes necessarily requires different viewpoints, each grounded in deep knowledge of a different aspect of the process" (Nembhard & Edmondson, 2006, p. 943). This was achieved through the development of activities and tools thought to engage overworked clinicians in practice reflection and exploration, an iterative process of questioning and re-thinking.

This study allowed us to draw a number of implications about applying co-design to effectively engage busy clinicians in practice reflection, learning, and improvement. We suggest the following:

Frame the interaction and set expectations

1. Invite people with diverse disciplinary backgrounds, professional skills, roles, working cultures, and responsibilities to participate.

2. Ensure the co-design goals are relevant to participants. Connect the goals with what participants bring to the table. If known, articulate the human's point of view, not just the technical.

3. Take the rhetorical stance of asking participants for their help. Show that you value their diverse perceptions about the problem. Ensure all participants take part in formulating alternative solutions.

4. Design activities to structure participants' co-identification of the problem, its conceptualization, and co-design of the tool.

Frame the problem, facilitate collective thinking and problem exploration through visual reasoning

5. Present the perception of the problem in a clear and precise manner. Use plain language and avoid ambiguity.

6. Encourage participants to reflect on what, how, when, and why something occurs. Use a process map to investigate this.

7. Inspire participants to discuss options and confront alternative ideas. Give them a sense of the power of co-analysis.

8. Use methods that focus participants on discussing an external representation of the problem, for example, dialogue prompters.

9. Ensure that the route to reason through the problem is workable. When appropriate, offer explicit procedures the group can take.

Be aware of your stance: sense, listen, learn, and orchestrate

10. Structure co-design activities so participants can work at a reasonable pace. Create opportunities for reaching milestones along the way.

11. Make human-centered design a guiding principle in how you interact with participants. Try not to lead the group, but orchestrate it.

When designers effectively structure and implement co-design in healthcare settings, clinicians may not only change their ideas about the value of designers, but they may also more fully recognize the human in human-centered design when devising healthcare solutions. Human-centered design is moving beyond making things easier to use. As Whitney and Nogueira (2020) elaborated, "Imagine that design included broader dimensions of what makes us human, such as happiness and health, in its frameworks and methods" (p. 149).

The perspective of the lead physician on this project highlights the value of seeing and becoming aware, of immersing in new contexts that matter (Scharmer, 2018, p. 84),

> "Observing how users interacted with the prototypes was very illuminating. The developing group and content experts had not anticipated some of the issues that created confusion in users or how some phrases and concepts were being understood. Observing the sessions also illuminated ways in which the algorithm had to be adapted to fit different healthcare scenarios and to address other educational needs. It was clear that what we thought we were saying and what they were actually reading and understanding were much farther apart than we ever would have guessed. In retrospect, I am now nervous about how other clinical guidance documents and tools I have worked on are being interpreted!"

This study adds to the body of knowledge of the role of human-centered design to achieve evidence-based healthcare practices. The knowledge we gained about the overuse of urine testing and unnecessary antibiotic prescriptions allowed us to take action on a pervasive problem of inpatient care with measurable impacts on clinical practice. We hope this knowledge on the role of co-design in evidence implementation for clinical practice improvement will be of value to other teams of clinicians and designers.

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