Co-designing theoretically informed, conceptual prototypes for interventions to increase hand hygiene in hospital settings: A case study

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Word count (main text, inclusive of abstracts, tables, references and figure captions) = 4729

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Abstract

This case study describes a design thinking workshop to develop conceptual prototypes for interventions that may increase hand hygiene in hospital settings. The workshop was held in London, United Kingdom. The workshop brought together nurses, doctors, and infection prevention/control staff with experience working in hospital settings along with behavioural scientists and designers with experience developing theoretically informed interventions. After the workshop, a core design team synthesised the initial conceptual prototypes into a set of five more distinct conceptual prototypes that can inform future interventions. Stanford d.School's five-stage model was used to capture the design thinking process. We propose additional workshops should be conducted wherein multidisciplinary teams of relevant stakeholders (including patients) co-design novel solutions for enduring problems.

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Introduction

Hospital-acquired infections draw public attention, not only because of their frequency and devastating consequences but also because they appear so preventable. To this end, considerable effort has focused on developing and implementing theoretically informed hand hygiene interventions. Systematic reviews (Luangasanatip et al. 2015; World Health Organization 2009) suggest that multimodal strategies (e.g., a combination of training and reminders) are more effective than unimodal strategies (e.g., only training or only reminders). However, while many hospitals already use multimodal strategies, hand hygiene compliance is still well below 100%. Thus, there seems to be a limit in what can be achieved with existing strategies.

External pressures, like COVID-19, can temporarily affect hand hygiene compliance. Moore et al. (2021) tracked hand hygiene compliance in nine hospitals. In January 2020, the average hand hygiene rate was 46%. On the 30th of January 2020, the World Health Organization declared the outbreak of COVID-19 a Public Health Emergency of International Concern. By March 2021, the average hand hygiene rates in the same nine hospitals rose to 64% before dropping to 54% by May 2020. Makhni et al.'s (2021) single hospital study found similar patterns, with rates increasing from 54% in September 2019 to 75% by March 2020 and then reverting to 56% by August 2020. Makhni et al.'s study also noted an inverse relationship between hand hygiene and opportunities to clean their hands, e.g., the number of dispensers.

Clearly, new ideas are needed to sustainably increase hand hygiene compliance. One way to generate new ideas is through design thinking (Micheli et al. 2019). Brown (2008, 86) defines design thinking as "a discipline that uses the designer's sensibility and methods to

match people's needs with what is technologically feasible." The design thinking process is captured in the Stanford d.School's five-stage model (2007), see Figure 1. Stage 1 involves *empathising* with the end-user needs. Stage 2 involves *defining* a challenge that centres around the end-user needs. Stage 3 involves *ideating* to generate multiple candidate ideas. Stage 4 involves consolidating the best parts of those ideas into more focused *prototypes*. Stage 5 involves *testing* the effectiveness of prototypes with real-world users. In practice, the stages are engaged more reflectively and dynamically than the term "stage" suggests (Luchs 2016). Revisions of conceptual prototypes are often needed before building more concrete prototypes for testing, as conveyed by the bottom loop in Figure 1.

To "match" designer thinking with what is technologically feasible, design thinking processes often include interdisciplinary collaborations with end-user input (Micheli et al. 2019). The benefits of co-designing health-related interventions with academics, service providers, and patients are widely promoted (Trischler et al. 2018), but few studies integrate design thinking. A literature review conducted by Micheli et al. (2019) identified 104 records about design thinking published in business and design journals, but few of them focus on healthcare. A further review of creative research methods used to improve healthcare environments located 16 articles, but few of them involve co-design (Jellema, Annemans, and Heylighen 2019). Altman et al.'s (2018) literature review captured 24 evaluated interventions to improve healthcare informed by design thinking methods. Most of these interventions examine the redesign of existing systems, e.g., treatments (McLay et al. 2012), patient-facing communications (Adirim et al. 2012), and displays that assist medical decisions (Luna et al. 2016). None of them describe an initial process for generating a wide variety of theoretically informed, novel ideas to inform future interventions.

In our case study we demonstrate how a design thinking workshop can be conducted to co-design theoretically informed, novel conceptual prototypes to inform future

interventions. We then describe how the initial conceptual prototypes were synthesised into a set of more distinct and refined prototypes. The discussion explores how the synthesised conceptual prototypes may inspire future collaborations, research, and ultimately improve hand hygiene in hospital settings.

Methods

A core design team hosted a one-day Nudgeathon (Nudgeathon 2021). Nudgeathons are competitive, two-stage workshops wherein teams use insights from the behavioural sciences (so called "nudge theory"), augmented by design thinking and drama theory, to generate potential solutions for problems related to human behaviour. The first stage captures the 'empathy' and 'define' stages of the Stanford d.School's (2017) model. The second stage captures the 'ideate' stage with emergent conceptual 'prototypes' evaluated by an expert panel. The core design team met after the Nudgeathon to synthesise the best components of the initial conceptual prototypes, which can be viewed as a further iteration of the 'ideating' and 'prototyping' stages, see the bottom loop in Figure 1. The Nudgeathon does not aim to build more concrete prototypes or to test those prototypes' effectiveness in the real world, and as such, this study does not reach the test stage of the d.School's model.

Setting

The Nudgeathon was conducted at a conference centre in London, United Kingdom. Activities were spread across different rooms. Participants changed rooms as the workshop progressed to attend different activities, see Figure 2.

Participants

Participants included the core design team, judging panel, and five sub-teams. The core design team included two quality improvement experts with experience working in hospital settings and two behavioural scientists. One of the behavioural scientists was the co-founder of Nudgeathon. Both behavioural scientists consult with professional designers and

are co-authors on the present paper (UT and KAS). The judging panel included stakeholders who commissioned the Nudgeathon as well as subject matter experts.

The sub-team participants included behavioural scientists (N = 5), designers (N = 5), and nurses, doctors, and practitioners in charge of infection prevention and control (N = 28). The designers worked in a professional capacity as design thinkers, e.g., for the United Kingdom's Design Council. To minimise power imbalances, sub-teams including different types of practitioners from different hospitals and by holding the event at a neutral location (Farr 2018; Lin et al. 2011). Each of five sub-teams included one behavioural scientist, one designer, and four to six healthcare practitioners. The sub-teams did not include patients because the end-users most relevant to the defined problem were healthcare staff, and we wanted healthcare staff to speak freely about barriers they experienced to cleaning their hands (Gray-Burrows et al. 2018).

Nudgeathon stage 1: Empathising and defining

To help frame the Nudgeathon, the core design team defined two behavioural challenges that participants might choose to solve during the ==workshop==. The challenges were presented to participants before the workshop in the form of a problem brief. The first challenge concerned the silent culture of non-compliance: "How can we nudge patients, nurses, and doctors to speak up when they see someone not complying with hand hygiene practice guidelines?" The second challenge focused on the insufficient use of the alcohol gel dispensers: "How can we nudge clinical staff to use alcohol rub before touching the patients?"

The Nudgeathon began with four activities to promote understanding, teamwork, and creativity (de Bono 1992). Each Nudgeathon incorporates such activities, always customised for the specific even. Here, the first activity highlights the gap between what we see versus what we remember. Participants formed pairs, stood back-to-back, and described what the

other was wearing. This activity demonstrates that human memory is not perfect, which might help participants understand one reason hand hygiene compliance is not perfect. Next, participants were split into five sub-teams. Team members shared their names while making a gesture that represented them, e.g., the hand-jive dance from the movie *Grease*. This activity ensures that team members know each other's names and increases creative thinking through movement and humour (Rominger et al. 2020; Wodehouse, Maclachlan, and Gray 2017).

Next, participants selected one picture from a pre-determined set that best represented their goals for hand hygiene. Team members explained their choices and identified shared interests. The last activity involved creating a team name and a moving tableau other teams could use to guess their team's name (Boal 2002). For example, one team's name was KISS, (Keep It Simple Stupid), and their tableau involved team members blowing air kisses and hitting their heads as if they made a mistake. These activities encourage teamwork with a focus on embodied interaction (Zhou and Hoever 2014). Teams also reported which of the two defined challenges they would concentrate on, either increasing gel use or speaking up, so giving them a sense of ownership over their chosen challenge. Two teams chose to focus on increasing gel use, two on speaking up, and one on both.

Nudgeathon stage 2: ideating, conceptual prototyping, and panel feedback

The second stage started by bringing all participants together to engage in a masterclass about academic models of behavioural change that they could employ to enhance the efficacy of their proposed ideas. The masterclass for each Nudgeathon is customised so that it includes relevant insights to help channel the brainstorming process. For this Nudgeathon, the insights were based on the Behaviour Change Wheel (Michie, Atkins, and West 2014) and the MINDSPACE framework (Dolan et al. 2010). The Behaviour Change Wheel is an eight-step methodology that helps users select appropriate intervention functions

and behaviour change techniques for overcoming identified reasons for suboptimal behaviour. The MINDSPACE framework is a checklist of nine psychological and economic principles policymakers can use to influence or "nudge" behaviour, see Table 1.

Next, the participants split into teams and were given approximately two hours to ideate and develop one conceptual prototype. To promote ideation, we prompted participants to share their personal experiences, to brainstorm without judgement, and to visualise their ideas with available drawing materials (see the "essential tools" described by Micheli et al. 2019). To promote the convergence of ideas a "one conversation at a time" approach was taken. This was facilitated by asking participants to display their ideas on post-it notes before all team members voted on which ideas to take forward. In this approach, post-it notes not selected are removed to ensure only conversation is happening.

Sub-team members played complementary roles as their ideas converged into conceptual prototypes. The behavioural scientists helped their team complete a worksheet guiding them through the Behaviour Change Wheel and MINDSPACE. The healthcare practitioners drew on their lived experiences and professional expertise for a reality check on the proposed ideas' likely acceptance. The designers mediated between these groups, "matching" what practitioners felt they needed with what behavioural scientists felt was needed for research; this is one of the tensions for using design thinking in healthcare research (see Altman et al., 2018).

At the end of the day, the sub-teams reconvened to present their conceptual prototypes. The judges gave feedback and rated each conceptual prototype according to characteristics described by Michie et al.'s (2014) APEASE framework, which describes how Affordable, Practical, Effective, and Acceptable a proposal is and its potential for undesirable Side-effects and inEquity. Before closing the workshop, participants engaged in a reflective discussion about their experience to improve future workshops.

Post-workshop Synthesising: further ideating and prototyping

Following the workshop, the core design team reconvened to synthesise their most promising components. The synthesising process took place as a rough thematic analysis (Braun and Clarke 2008). First, the core design team familiarised themselves with each conceptual prototypes' potential effectiveness, necessary components, and implementation feasibility. Next, the promising components were re-arranged and merged into more distinct conceptual prototypes. The synthesised conceptual prototypes were then discussed with a graphic designer who created an informative and accessible illustration to accompany a written description for each synthesised prototype. The cards were reviewed by frontline healthcare staff and revised based on the comments they provided.

Results

A description of each sub-team's initial conceptual prototype is provided in Supplementary Material A. Below, we present the five synthesised conceptual prototypes. Table 1 contains the main MINDSPACE tools employed in each. The printable set of A4 cards is in Supplementary Material B. The first two prototypes focus on increasing alcohol gel use, and the final three focus on encouraging people to speak up. The results section ends by highlighting some participant feedback to improve future workshops.

Gel dispenser redesign

An external counter is added to the outside of alcohol gel dispensers (Figure 3). The initial count would be an adjustable goal that could be reset daily. The counter could count down to zero to confirm whether the goal was achieved. Some behavioural insights informing this prototype involve gamification, goal setting, and feedback (Fuller et al. 2012; Kapp 2012).

Shifting bed space to home space

The appearance of a hospital's bed space is personalised by patients just as they would their home (Figure 4). Staff could be invited, as a guest, into patients' bed spaces. For example, patient cubicles could be modified to include photos of loved ones or by altering the appearance of hospital curtains. This proposal arose from healthcare practitioners' observations that hand hygiene rates were higher when they visited patients' homes. Some behavioural insights informing this prototype involve automatic motivations and re-framing (Tversky and Kahneman 1981).

Promoting hand hygiene in handovers

Staff watch a presentation about how to constructively give and receive hand hygiene feedback, along with suggesting a non-verbal gesture staff could use to discretely remind each other to clean their hands. Staff could sign a pledge to respond politely to such reminders (Figure 5). To practice using their training, staff would take turns in a 'spotlight' position. While in the spotlight, they would welcome others to remind them about hand hygiene and make an extra effort to respond politely. Some behavioural insights informing this prototype involve social norms and commitments (Rogers, Milkman, and Volpp 2014).

Racoongo Game

This conceptual prototype empowers children to speak up about hand hygiene while playing a card game called 'Racoongo' during their paediatric appointments (Figure 6). On one side of the Racoongo card could be simple facts and pictures about hand hygiene. On the other side could be a metallic scratch panel that children can scratch off when they see staff forgetting to clean their hands. At the end of the day, staff could tally scratches. Some behavioural insights informing this prototype involve game theory and social norms. (Kapp 2012; Miller and Prentice 2016).

"What matters to me" in my personal care plan

Existing paediatric admission documents are modified to include a brief reminder from a parent perspective, e.g., "And please do wash your hands before touching my child" (Figure 7). Following the reminder, a tick box could allow staff to confirm their commitment to wash their hands. Some behavioural insights informing this prototype involve messengers and commitments (Fuller et al. 2012; Larson et al. 2000).

Participant Feedback

Participants believed the warm-up activities helped them open up to strangers. They enjoyed the masterclass on behavioural insights and would have liked an additional masterclass on design thinking. A more critical comment regarded how professional titles were displayed on some PowerPoint slides and printouts, e.g., doctor, nurse, etc. Some participants thought that these professional titles could enhance power imbalances amongst healthcare staff. For example, nurses may mistakenly feel that their knowledge and beliefs are less important than doctors (Darbyshire and Thompson 2017).

Discussion

This case study demonstrates one way to conduct a design thinking workshop where theoretically informed, conceptual prototypes can be developed to inform future interventions. The specific goal was to increase hand hygiene compliance in hospital settings by incorporating insights from behavioural science. Thematically organising the most promising components contained in the initial conceptual prototypes allowed the core design team to develop a distinct set of prototypes that may inspire future collaborations and may ultimately improve hand hygiene in hospital settings.

We conceptualise the end products of the workshop and synthesis process as conceptual prototypes—outputs of stage 4 of the design thinking process—rather than ideas—outputs of stage 3, see Figure 1. One may wonder when an idea becomes a prototype: this is an issue of clarity that the present study does not resolve. According to Buxton (2007),

sketches are rough visualisations of ideas that dominate the ideate stage of design thinking, explore the problem space, and provoke further questions, while prototypes refine ideas and resolve questions. In contrast, Brown (2019) suggests that rough sketches that merge ideas can be prototypes; for Brown, the goal of prototyping is to consolidate ideas into a physical representation that informs the next generation of more refined prototypes. Our conceptual prototypes consolidate present ideas and can inform the next generation of more refined prototypes, and so can be considered prototypes according to Brown's construal.

The prototypes produced here reflect rough, low-fidelity concepts that could be refined to complement—not replace—existing multimodal strategies to increase hand hygiene in hospital settings (Luangasanatip et al. 2015). Presenting a set of initial conceptual prototypes may help channel future collaborative conversations in a manner that enhances the suitability of a particular proposal for a particular hospital context. The importance of contextual factors for healthcare settings was recognised in Altman et al.'s (2018) review. In addition, this continuing conversation aligns with the non-linear nature of design thinking, where designs must be continually adapted to serve new populations. Through these conversations, some initially simpler conceptual prototypes may grow in complexity, while others may become more focused on a particular component.

The present workshop involved frontline staff, some of whom oversaw their hospitals' infection prevention and control strategy. Furthering prototypes of products that do not yet exist, like the countdown dispenser, will require conversations with people outside the hospital setting, like manufacturers. Other prototypes require input from new players within the hospital setting. For instance, safety experts may be consulted to ensure that making hospital beds appear more homely does not increase trip hazards. Some prototypes could benefit from patient input, e.g., the input of parents and children could enhance the Racoongo cards. Patient involvement that informs research should be reported using the GRIPPS2

checklist, which is part of a larger effort to understand how and where public contributions increase the effectiveness of interventions (Staniszewska et al. 2017).

The dynamic nature of design thinking raises questions about whether interventions can be co-designed in a way that consistently minimises power imbalances between clients and end-users (Jørgensen, Lindegaard, and Rosenqvist 2011). As designs unfold, new stakeholders are often identified who experience new practical and motivational barriers to meeting the needs of end-users. These barriers can stunt innovation so that new designs include merely incremental improvements (Norman and Verganti 2014) with the potential to bring only small benefits for end-users. It may take a great deal of work to co-design and implement substantial innovations that bring significant improvements to public health. A stable design team leading the co-design process may be required to represent the perspectives of various stakeholders as the design progresses.

In conclusion, this study demonstrates how a design thinking workshop can be conducted to generate creative and theoretically informed, conceptual prototypes for future interventions. We hope it empowers future quality improvement efforts in healthcare settings to integrate design thinking. Concerns about hand hygiene raised during the COVID-19 pandemic, within and outside of hospitals, present an opportunity to build on these rough concepts and ultimately to increase hand hygiene and public health.

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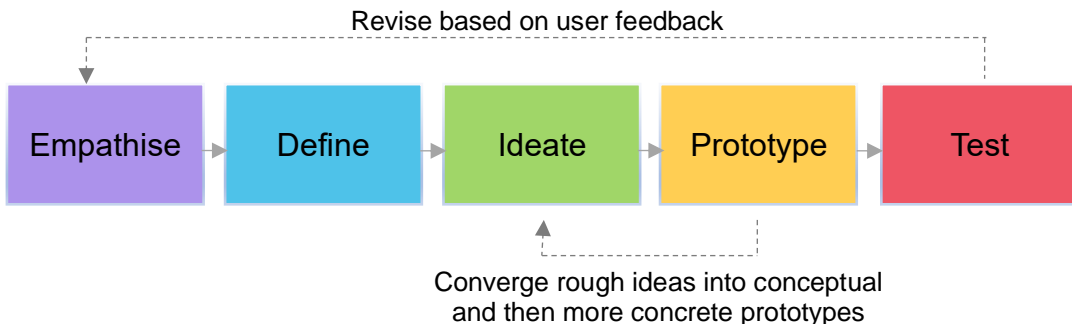
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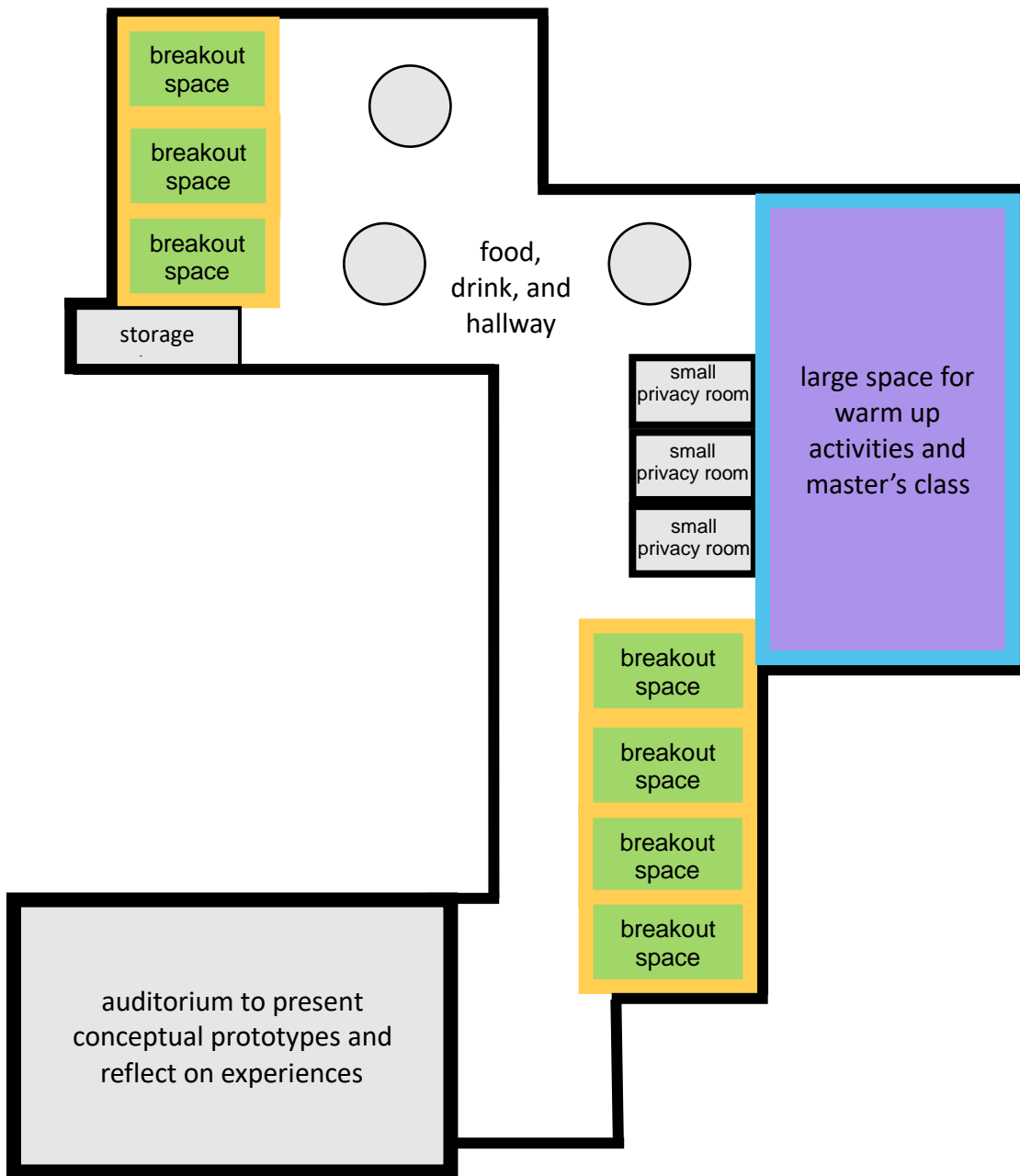
Table 1. MINDSPACE tools and synthesised prototypes that use them.

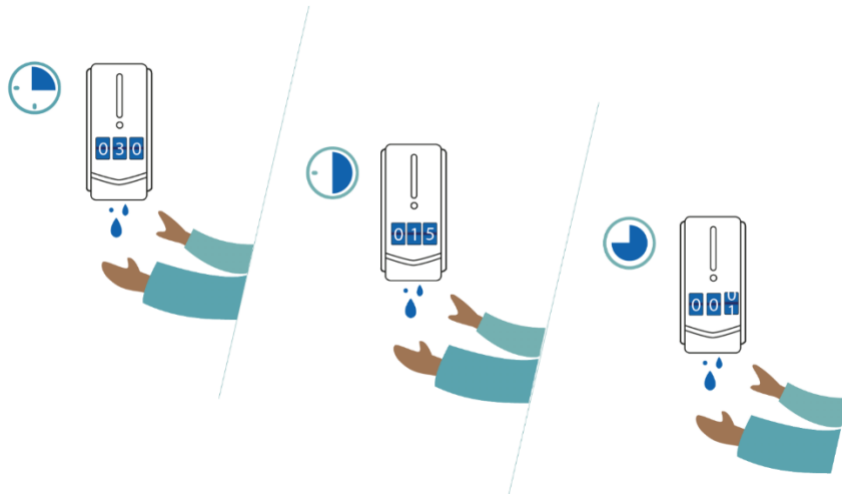|	Definition (from Dolan et al. 2010)	Gel dispenser redesign	Shifting from our bed space to a patient's home space	Promoting hand hygiene in handovers	Racoongo Game	"What matters to me" in my personal care plan
Messenger	We are heavily influenced by who communicates information to us				X	X
Incentive	Our responses to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses	X			X	
Norms	We are strongly influenced by what others do		X	X	X	X
Defaults	We 'go with the flow' of pre-set options					X
Salience	Our attention is drawn to what is novel and seems relevant to us	X				X
Priming	Our acts are often influenced by sub-conscious cues		X			
Affect	Our emotional associations can powerfully shape our actions		X	X	X	
Commitment	We seek to be consistent with our public promises, and reciprocate acts	X		X		X
Ego	We act in ways that make us feel better about ourselves		X			

Figure 1. Five stage model of design thinking with example revision loops

Revise based on user feedback

| Empathise | Define | Ideate | Prototype | Test |

Converge rough ideas into conceptual
and then more concrete prototypes

Figure 2. Layout (floorplan) of the physical space participant moved between during the workshop

breakout space

breakout space

breakout space

storage

food, drink, and hallway

small privacy room

small privacy room

small privacy room

large space for warm up activities and master's class

breakout space

breakout space

breakout space

breakout space

auditorium to present conceptual prototypes and reflect on experiences

Figure 3. Gel dispenser redesign: A gel dispenser than counts down when used to give an indication of normal daily use
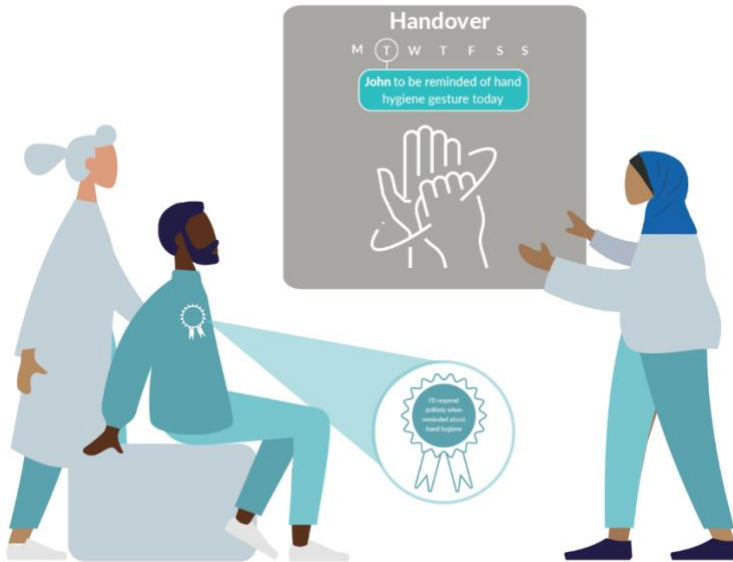
Figure 4. Shifting from our bed space to a patient's home space: Reframing and redesigning the

bedside space to feel and resemble a patient's home space
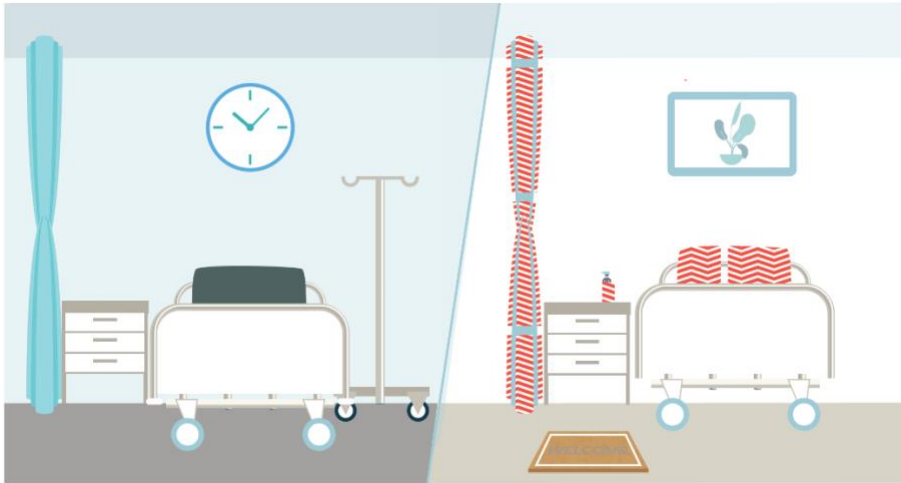
Figure 5. Promoting hand hygiene in handovers: Making speaking up normal through role

modelling at handovers

Figure 6. Racoongo: Gamifying hand hygiene through empowering children, families, and carers to support quality assurance of staff
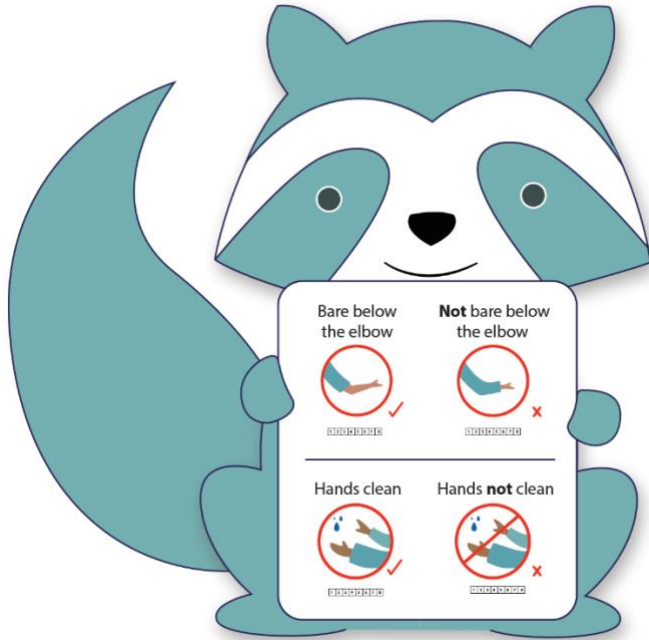
Figure 7. "What matters to me" in my personal care plan: Reminder prompts built into existing forms