

Ins and Outs, a look into supporting bowel care with ubiquitous technology

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1 INTRODUCTION

Individuals who have sustained spinal cord injuries are often left with a limited set of abilities. Most common among these is the inability to properly control one's bowels. Most individuals with full sets of abilities often don't have to track what they intake (food/liquids), however that is a luxury that is not afforded to members of the SCI community. SCI individuals must track their intake, or it will negatively impact their health, such as damage to their kidneys and bladder.

While our research began with just thought of bowel care in mind, our thoughts have expanded to include other ideas that we determined to have merit based on participant feedback from our interviews. This paper will cover our initial ideas for technology that could be developed to aid SCI individuals with their bowel care activities, outline our findings from the two interviews, determine which of our ideas worked and which did not, and present the direction that we think would be the best course of action moving forward.

1.1 Motivation

The motivation for this research came from learning about individuals in the SCI community. Being that this community is small, it seems like not a lot of companies invest time into this demographic because there simply isn't money to be made. Furthermore, even though bowel care is both immensely important, and a big hurdle for SCI individuals, it has garnered little attention in the way of exploratory technology. This is unfortunate and we, as computer scientists and researchers, wanted to help counter this technoableism. We believe through research and understanding the real needs of our users, we could develop technology to aid these individuals in their daily self-care processes.

2 STATEMENT OF CONTRIBUTIONS

Below is a breakdown of our individual contributions. We all discussed aspects of this paper and discussed and brainstormed findings, motivation, methods, future works etc together. To make writing more streamlined we took ownership of parts of the paper and wrote what we had discussed.

2.1 Ashish

Ownership over the methods and appendix section of this report. One storyboard idea: smart water bottle. Conducted interviews.

2.2 John

Created/compiled all storyboards. Ownership over the introduction, motivation, and future work sections of this report. One storyboard idea: food scanning app.

2.3 Jens

IRB revision, Conducted interviews. Ownership on related works and findings section of this report. Two storyboard ideas, Bowel care scheduler and bowel care reflection storyboards.

3 RELATED WORK

This related work explores the existing supports for bowel care from the medical research community, these supports such as flow charts and decision trees lend themselves well to technological implementations, such as self-tracking for diagnoses which are explored along with other tracking technologies in the next chapter. We then conclude the related works by looking at the perception of health technologies, and barriers to their adoption.

3.1 Bowel care resources in a medical context

Bowel management is a crucial self-care task for individuals with Spinal Cord Injury (SCI). Bowel care can sometimes be difficult to manage, as such healthcare professionals and researchers have developed bowel care resources in the form of flow charts, guidelines, and decision trees [1, 2]. These resources help identify practices that may lead to complications in bowel care and suggest appropriate actions. One thing that is common in these resources is the modification of diet and water intake when difficulty in bowel care arises. For instance, when people face difficulty with bowel care it is suggested that they change their diet to be high in fiber and increase their water intake [3]. By utilizing these resources, individuals with SCI can improve their bowel care, though bowel care is one of many self-care tasks that those with SCI must do.

3.2 Tracking intake in CHI

Tracking food and water intake in the context of health has been looked at in HCI literature. Self-tracking to diagnose and manage a health condition is a common practice, especially with the advent of ubiquitous technology and mobile phones. As a result, there has been significant research and exploration of applications for tracking food and water intake in the context of health within the HCI literature. Apps such as Tummy Trials have been developed to help those with irritable bowel syndrome track and experiment with their diet [4]. Smart water bottles have also been explored to help those who want to track their water intake, along with tracking water intake many of these smart water bottles give users reminders of when they should drink water [5, 6, 7]. In addition to water bottles wearables such as smart watches have also been implemented to track water intake [8]. It is clear that technology exists that supports tracking food and water intake,

however, there is little work done on what the implementation of this technology looks like for those with spinal cord injuries and how it supports self-care tasks like bowel care.

3.3 User perception of assistive health technology

While we think that technology can assist those with Spinal Cord Injuries manage bowel care. Recent work has uncovered that there can be resistance to the adoption of health technologies [9]. The patient-doctor relationship is not perfect and the friction in this relationship has been studied extensively [10, 11]. Patients may feel that doctors do not understand their needs fully. This feeling is common in those with rare diseases/conditions. Those with SCI often face significant unmet information needs during acute care [12]. Research has also shown that those with SCI prefer to learn and get advice from those who also have SCI [13]. Thus, it follows that those who have prescribed technology that assists in tracking and health care may resist it for the reasons above. Work has explored technology that supports self-care tasks such as pressure relief [14]. While active resistance was a key finding from this work it is still important to acknowledge potential factors that lead to resisting health technology.

4 METHODS

The study used a qualitative approach to investigate how ubiquitous technology can support bowel care for people with SCI. Two participants were recruited from the Craig H. Neilsen Rehabilitation Center. Semi-structured interviews were conducted with the participants, and storyboards were presented to them during the interview to gather their feedback and insights. The interview data and storyboard feedback were analyzed using thematic analysis to identify patterns and themes. The identified themes were used to develop ideas that would support bowel care for people with SCI. In this section, we describe how we designed our storyboards, recruitment of participant population, our data collection, and our analysis process.

4.1 Storyboard development

In our study, we utilized the needs-validation storyboard approach from the speed dating [14, 15, 16] method to design a range of possible scenarios to help us better understand the needs of our target users. The speed dating method involves using storyboard scenarios to investigate participants' needs, experiences, interactions, and preferences. This approach can be particularly useful when designing speculative futures, as it enables participants to reflect critically on their needs and constraints in the context of the scenarios provided.

Table 1: Origin of storyboards based on literature

Scenario	Concept portrayed in scenario	Literature that motivated the scenario
S1	Bowel care emergency schedule	Bowel care resources in the form of flowcharts, guidelines, and decision trees [1, 2]
S2	Bowel care reflection	Effect of increased dietary fiber intake on bowel function [3]
S3	Food picture	Track and experiment with diets [4]
S4	Smart water bottle	GROW [5], Galef [6], and Co-Drink [7]

Our primary objective in using the speed dating method was not to propose specific technologies that we should build, but rather to elicit users' reactions [14]. The method allowed us to engage participants in a critical reflection on their needs

and constraints, without the burden of real technological implementation. With the use of storyboards, we aimed to gain a deep understanding of our target users and their needs, which would inform our future design decisions.

Drawing on the insights gained from our literature review, we engaged in a brainstorming exercise to develop four bowel care related technology-based scenarios (see Table 1. For bowel care emergency schedule generation, we identified resources in the form of flowcharts, guidelines, and decision trees [1, 2]. For bowel care reflection, we identified the effect of increased dietary fiber intake on bowel function [3]. For food picture app, we identified tracking and experimenting with diets [4]. For smart bottle, we identified GROW [5], Galef [6], and Co-Drink [7]). Stories were designed to create an emotional connection between the user and the technology, helping participants to envision how the technology would fit into their lives and improve their bowel care experience (see Appendix).

Additionally, one of the authors created images with an iPad and an Apple Pencil to create images that were compiled into storyboards in Adobe Photoshop (see Figure 1, 2, 3 and 4).

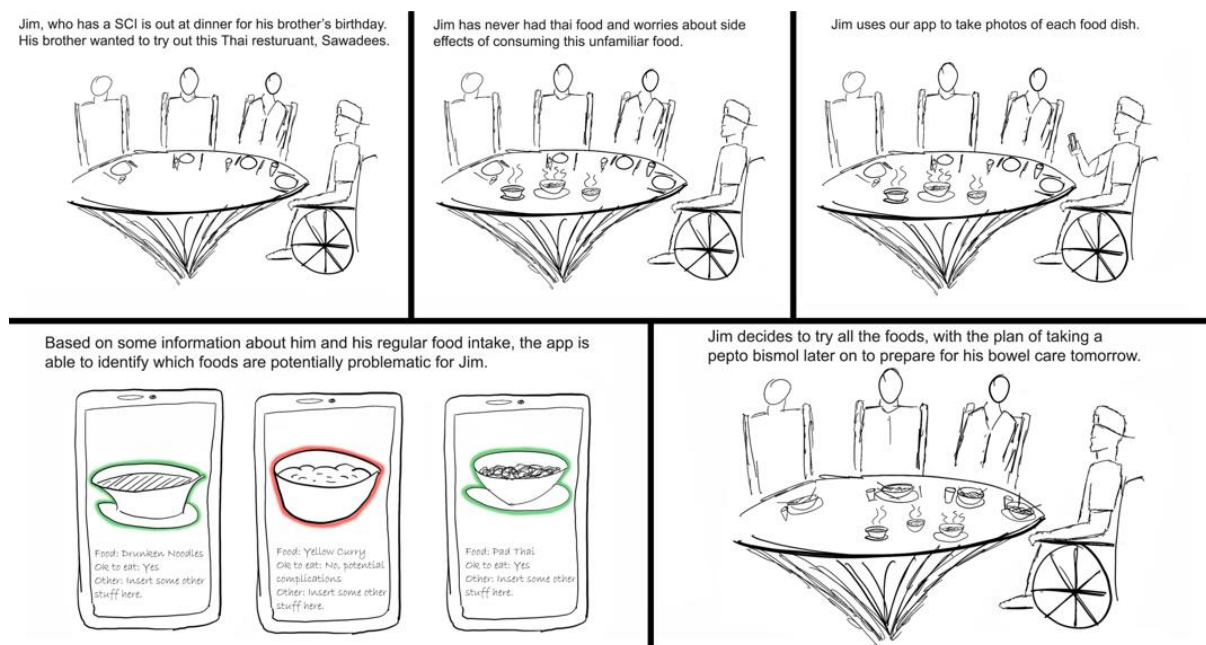
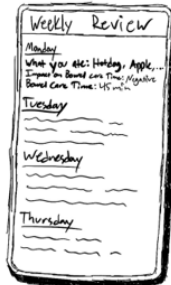
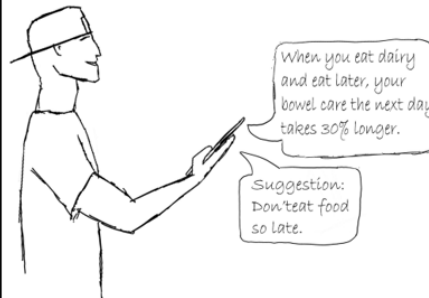


Figure 1: Food picture app

Every week, the app presents users with a review of their bowel care data.



The app provides the user with insights and gives suggestions



The user can use this information to make goals for the coming week to positively impact their bowel care.



Figure 2: Bowel care reflection app

A family emergency has happened and Marco needs to be back as soon as possible.



He schedules the first flight home, but it conflicts with his morning bowel care.



The app provides Marco with detailed alternate schedules that he can choose from.

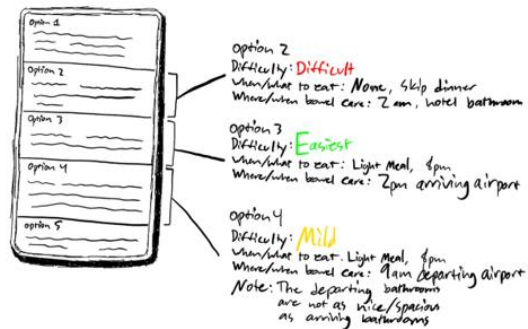


Figure 3: Bowel care schedule generator

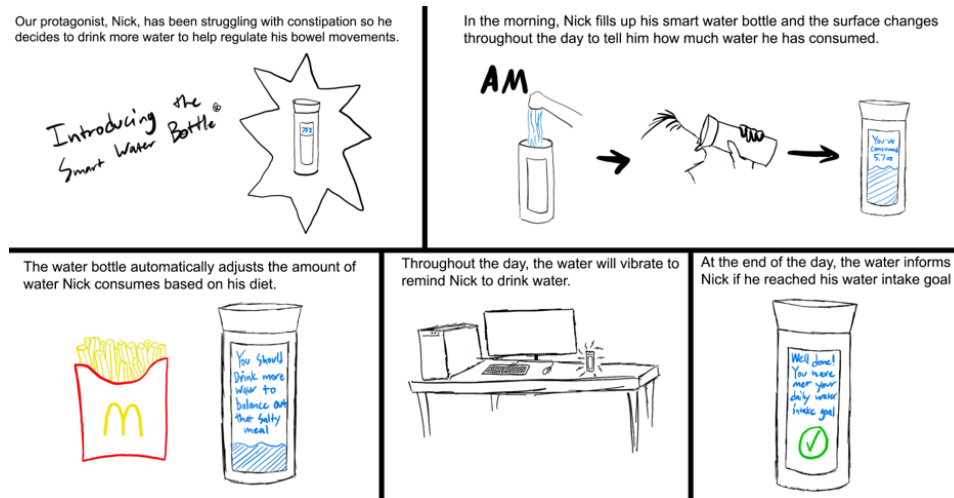


Figure 4: Smart water bottle

4.2 Recruitment

The study involved two participants, one male in his 20s and the other male in his early 70s, who were recruited from the Craig H. Neilsen Rehabilitation Center. Participants provided verbal consent to participate in the study.

4.3 Data collection

The study used a qualitative approach to investigate how ubiquitous technology can help support bowel care for people with spinal cord injuries. The research team conducted semi-structured interviews with the two participants to explore their experiences and perspectives regarding their bowel care routines, and the use of technology to support such routines. The questions were open-ended to allow participants to provide detailed responses in their own words. During the interview, the participants were also presented with storyboards that were developed based on the literature review and were asked for their opinions and feedback on the storyboards. The interviews were audio-recorded with participants' permission and transcribed verbatim for analysis.

4.4 Data analysis

The interviews were recorded and transcribed using Otter.ai, and thematic analysis was used to analyze the transcribed data. The transcripts were read and re-read to become familiar with the content and gain an overall understanding of the participants' experiences and perspectives. The transcripts were analyzed by each researcher independently to identify meaningful and relevant text by highlighting them. The research team discussed the highlighted text in a group to compare and contrast their interpretations of the data. This allowed for a more nuanced understanding of the data and identify themes and patterns. The identified themes were then used to develop ideas that would support bowel care for people with SCI.

5 FINDINGS

The findings section will break down how the two participants responded to our four storyboards. We start off with our first participant P1 then our second participant P2. In our findings we found that those with SCI discharging to rural areas want to be aware of local medical and support resources that they have. We also found that for P1 tracking water intake

and cath amount was very important to him and his caregivers. Whereas P2 did not find it as important. We also observed that P2 had a consistent schedule and results for bowel care and did not see personal value in any of the storyboard technologies involving bowel care, whereas P1 and his caregiver found that tracking food intake is tricky and pinpointing problem foods is difficult, P1s caregiver suggested tracking stool consistency instead. Finally, we observed that P1s caregivers saw technology as a way for their son P1 to gain more independence.

5.1 Interview with P1 and his caregivers (Mom and Dad)

P1 is a male in his early 20's, and a big fan of the God of War video game series. P1 has a high-level injury and is in a power wheelchair, cannot move his arms, and relies on his caregivers (Mom and Dad). In this interview, we found that tracking water intake is an important but tedious task for P1 and his caregivers. We also found that tracking diet to support bowel care is not straightforward and pinpointing issues in diet is hard. Finally, we found that P1s caregivers see technology as a way to give P1 more independence.

5.1.1 Bowel care emergency schedule generator storyboard

The first storyboard we started off with was the storyboard of an app that generates a bowel care schedule for when people have to travel. For p1 they said that this application could be nice for caregivers as they are the ones that do p1s bowel care. This response then prompted a follow-up question by the interviewer asking if this app could allow them to plan their bowel care on their own with the app and then inform their caregiver when they wanted to do bowel care. P1 said that they could see this happening.

5.1.2 Impromptu interview on cathing and water intake

This storyboard also prompted P1 to ask his caregivers about a scheduling system they were talking about. P1s mom mentioned that they track water intake to help with cathing, P1s mom said *"You have to track what he drinks in, and what goes out. So I was looking online for like an app like that could do that for me instead of manually writing it. So I couldn't find one."* While we were not focused on cathing in particular, the fact that P1s mom and P1 himself mentioned it before we got to the smart water storyboard highlights its significance to them. We proceeded to go off script and ask P1s mom what they would want the app to track. P1s mom said that it would be useful for it to track what P1 takes in and P1 cathes out *"I like the volumes, and then I could put in a number like, okay, he drank 600 milliliters of water today. And at four o'clock, he cast 200 to have it easily accessible instead of, you know, carrying around a tablet to write."*

5.1.3 Why do they collect intake and cathing data?

In order to fully understand the reasoning behind tracking water intake and cath amounts we proceeded to ask what they do with this data to collect P1 mom said *"he drinks 600 milliliters of water. And then four hours later, I'm only cathing and I have 100. So you kind of pay attention to what is coming in, and what is going out?"*, P1's dad mentioned comparing intake to how much you cath and can inform the next time you cath. P1s dad said *"I'm gonna cath a little sooner on the next one. If you didn't, yeah. After that, cath more and you didn't get what are you taking originally, you might go wrong, you may blow up."* P1 mom also talked about the consequences of not managing cathing well *"You don't want the bladder to get too big, because then that will cause problems. If you get a urinary tract infection and that kind of stuff."*

5.1.4 Bowel care reflection app storyboard

The next storyboard we gave was that of the weekly reflection app that gave the user suggestions at the end of the week that improved bowel care based on diet. P1 said that it is good to stay away from certain types of food and that this app would inform them about what food they ate, however, it could be that P1 did not want to seem rude and shut down our ideas.

5.1.5 P1s caregivers feedback on bowel care reflection app

P1s mom and dad however had no reservations and began to outline multiple problems with our storyboard. P1s Dad said that it would be hard to know what food causes the problems with bowel care and said that tracking the consistency of the bowel movement would be more helpful as that informs if they need to get an over-the-counter medicine to help the situation. P1s mom said that even if they were able to track food intake the effects of eating something bad may not arise until a few days later. Additionally, P1s mom said that it would be nice to be able to track P1s protein intake as he is on a high-bulk diet, however, P1s mom also stated that they did not want to deprive him because of his diet *“you don't want to deprive him of like, if he wants to In and Out Burger, but you also need to kind of make sure the protein is high”*

5.1.6 Food picture app storyboard

Our next storyboard described an app that the user could use to take pictures of new foods they eat and see its potential consequences. P1 said that while they thought it could be valuable but that it would be hard for the app to figure out how food would affect them. P1 said *“it would be insightful to, to know what, what's going in and what would affect me, but it would be kind of hard to figure that out. Because everyone's different ... So it would be kind of difficult to understand, like, what foods would do what to me?”*.

5.1.7 Smart water bottle storyboard

The final storyboard described a smart water bottle that tracked users' water intake. It is important to note that P1 did not have the ability to move their arms, and so we asked P1 to imagine it as a camel back on the back of their chair. P1 saw value in automated tracking of water intake and said *“there's on the water bottles that we get. There are increments on how much you drink, but there's no real way to like chart it down. So I feel like if it was connected to the app that they were taking on average, it'd be good to be like, Oh, we drink this much. And then to keep refills, it then continues to chart down without you actually having to do it.”*. In addition to this P1s Dad also mentioned that this tracking app could give P1 more independence as currently he has no way to keep track of water intake himself and said *“If he wanted to go out with his friends or something, we dropped them off somewhere. But he could monitor what's happening until we come back or somebody picks him up. He would know that Oh shit, I better go to the bathroom and cath or something.”* P1s dad then gave a useful suggestion on notifications *“It notifies him like oh, you've hit 800 milliliters now. You better think about it.”*

5.2 Interview with P2

P2 is a male in his early 70s, with a low-level spinal cord injury, but according to him has lost some fine motor control in his hands. P2 is a salmon enthusiast and worked in fisheries. No caregiver was present during our interview with him. The significant finding from this interview is that those who are discharging into rural communities with SCI have a hard time knowing what medical resources they have.

5.2.1 Bowel care reflection app storyboard

We started off with the bowel care reflection app, that every week gave users insights on their diet based on bowel care and gave suggestions on how diet could be improved. P2 stated that they don't see themselves using it and that for them bowel care is predictable and efficient but that they could see other people finding value in it. P2 said *"we've kind of gotten into rhythm. And it's very predictable, and it's fairly efficient. And so, I mean, it's probably some fine-tuning that could happen, we seem to have a system down for other people may not be that that easy"*

5.2.2 Food picture app storyboard

Our next storyboard described an app that the user could use to take pictures of new foods they eat and see its potential consequences. P2 said that they said it could be useful as they do not want to eat anything that takes them off their normal pattern. However, P2 proceeded to say that they have not found any food yet that does this and that this would be useful to other people potentially.

5.2.3 Bowel care emergency schedule generator storyboard

Our next storyboard was the storyboard of an app that generates a bowel care schedule for when people have to travel. P2 liked the idea as they are big traveler and like doing road trips. They said it would be useful and their reaction to it was very positive. *"Yeah, that'd be huge. Yeah, I mean, I, I've done a lot of traveling and I hope to get back to doing some of it, but even just not just airports necessarily, but, but just road trips. You know, which motels are are can people use and are set up to do bowel care, and have that kind of thing and know how far our drive is gonna be, like a flight, same thing. Yeah, I think it'd be really helpful."*

5.2.4 Smart water bottle storyboard

The final storyboard described a smart water bottle that tracked users' water intake. P2 said that it could be useful, but that grabbing a water bottle is not easy for them, as to them bottles are "unhandy". P2 said that it could be useful for others as well.

5.2.5 Further reflections prompted by storyboards.

Because P2 did not speak as much as our previous interview, we asked if any support or technology came to P2s mind when discussing the storyboards. P2 talked about how when they get established at home they would like to be made aware of the resources they can access, or who in their community they can turn to when medical issues come up as they live in a rural area. P2 stated that a solution is to use 911 when medical issues arise but that a lot of medical issues do not require 911 attention. In addition to knowing what services are available, P2 said that they would like to know what services are covered by insurance as well. Most importantly this desire to understand resources stemmed from P2s desire to know if they would have to move to a city because of their injury. P2 said *"Can I can I stay here where I really want to live? Or am I gonna have to move to a city? Okay, that's, that's the decision. And you might imagine they live in their rural environment because they don't want to live in a city. but those are the kind of decisions you have to face and if you had an idea of what was available that would help that decision"*

6 FUTURE WORK

A few promising ideas for future work arose from our initial storyboards and interviews with our two subjects. The first being a phone arm that is repositionable by the SCI individual. P1 mentioned the inconvenience of having to call a caretaker

to come reposition his phone periodically. This may also contribute to a limited-ability individual feeling like a burden on those around them. Another, more promising idea for future work is the water tracking backpack.

P1's parents/primary care takers mentioned using notebooks to constantly track his water intake to make sure that his bladder does not get too full. This conversation came about as a result of our smart water bottle storyboard, however the evolution into a backpack seems like a logical one. It is important for all SCI individuals to track their liquid intake, but only those with hand and arm functionality could have used our storyboarded design (smart water bottle). If instead, something like a camel-back backpack, or really any backpack with a liquid bladder inside, were to be fitted to the back of a wheelchair with a sipping straw and flow meter attached, it would allow any SCI individual to easily track their liquids, regardless of abilities. It would have the additional benefit of holding more water than the smart water bottle, would have a longer battery life due to increased space for larger capacity batteries, and it would be much harder to lose.

The water tracking backpack would be a great project to undertake but would require basic skills beyond just knowledge of programming. Water coming out from the backpack bladder would have to be accounted for, either by some sort of flow meter, or by the reduction of bladder weight created by the now absence of some water. Additionally, while the information collected from this backpack system could be sent to an app on the user's phone, it may be easier to wire it to some sort of small display or meter attached to the wheelchair. It would be useful to do some sort of low fidelity prototyping with test subjects, or at the very least take a poll of what actual users would prefer.

The final idea for future work to come from the series of interviews is the itinerary planner. This was an idea that we storyboarded, but the use-case has changed a little bit. P2 mentioned that the ability to know, for example, which hotels, gas stations, or rest stops can easily accommodate bowel care would be especially useful. Participant 2 lives in a rural area of Idaho and will have to travel to Boise (about a 2 hour drive) to stay overnight and get specialized SCI care at the hospital there. He believes some sort of app that can provide him this information would make not only his trips to Boise easier, but it would give him the ability to take road trips again. This project has significant hurdles such as documenting what bathrooms are more hospitable towards bowel care activities and keeping that list up to date as buildings are built/torn down.

The authors' recommendation for future work stemming from the research done for this paper would be to develop the water tracking backpack. It would have the greatest positive impact out of all the proposed ideas since tracking water intake is important for all SCI individuals. Additionally, it would be easier to develop than the itinerary planner.

7 CONCLUSION

The work examined how two SCI patients responded to four storyboards of potential technology that could help with bowel care. We found that while our storyboards and their ideas were far from perfect, that participants saw value in at least one of them. P1 saw value in tracking water intake automatically, whereas P2 saw value in the itinerary generator. We also found that diet is not easy to track and that simply knowing what you eat, and your bowel care results thereafter is not enough to identify problematic foods. Perhaps the most interesting and unintended finding from our research is that P1 and his caregiver value tracking water intake and that they have searched for technology to help them do this but have not found any. From these findings we propose these future works a repositionable phone arm, a water tracking backpack, and an itinerary planner, with the water tracking backpack being the most promising due to its potential positive impact on all SCI individuals and ease of development.

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A APPENDICES

We organized our storyboards based on the following sections:

1. **Struggle:** This includes challenges that people with SCIs face while managing their bowel care routine.
2. **Literary evidence:** This includes the scientific literature that we referred to while designing the storyboards. We relied on existing research to ensure that our storyboards are based on evidence based practices and meet the needs of people with spinal cord injuries.
3. **Modality:** This includes the type of technology or device that is used to deliver the bowel care routine, such as wearable sensors, smart pads, or voice-activated devices.
4. **Points of interaction:** This includes the specific points of interaction between individual and technology, such as inputting data, receiving feedback, or making decisions based on the data collected.
5. **Purpose:** This includes the overall goal of the technology.

6. **Trigger:** This includes the events or actions that prompt the individual to engage with the technology.
7. **Social setting and context:** This includes social and environmental factors that may impact the use of the technology or device, such as the individual's living situation, and support network.
8. **Story in text:** This includes the narrative that we created for each storyboard, describing the scenario, the technology or device used, and the interaction between the individual and the technology.

A.1 Storyboard 1: Bowel care emergency schedule

1. **Struggle:** External circumstances can interrupt the normal routine of bowel care, and finding time to do it can be challenging.
2. **Literary evidence:** Bowel care is often the first self care task to get “routinized” and that it stays “routinized” meaning people don’t change their routine. However applications that support tasks often “fall apart” when people get busy, we want to explore an application designed to alleviate schedule disruptions in the context of bowel care.
3. **Modality:** The system sends notifications via a mobile application or smart speaker when away or using smart room technology.
4. **Points of interaction:** The system could potentially use any application, but it will most likely be a mobile application.
5. **Purpose:** The system's goal is to allow people to be flexible when life happens or their schedule cannot be upheld. It aims to minimize the consequences of a disrupted routine.
6. **Trigger:** The user presses a button to indicate that their bowel care cannot happen at the scheduled time, or the system itself detects this and notifies them on their phone.
7. **Social setting and context:** The system is particularly helpful when traveling.
8. **Story in text:** Marco receives news of a family emergency and has to travel back home as soon as possible. However, the only flight available is in the morning when Marco's bowel care is scheduled. Marco presses the button on the app to indicate the change in schedule. The app then proposes schedules that Marco can follow to still be able to travel and do bowel care based on their new schedule and approximate location. The proposed schedules consist of what Marco wants to eat, when and where they will do bowel care, and the difficulty of each schedule. One schedule suggests that Marco skips dinner, wakes up at 2 am, and does bowel care then, but the app rates this schedule as very difficult and disruptive to Marco's routine. Another two schedules propose that Marco eats dinner and does bowel care either at the departing or arriving airport. The difference between the two schedules is that the departing airport's bathroom is not as nice or spacious as the arriving airport. The app recommends that Marco's easiest option is to eat a light meal and do bowel care at the arriving airport, but that there is always a risk relying on public restrooms. Knowing this, Marco opts to follow the harder but safer schedule. (see Figure 1)

A.2 Storyboard 2: Bowel care reflection

1. **Struggle:** The time it takes to do bowel care can be long and eats valuable time up.
2. **Literary evidence:** Those with SCI often don't change when they do bowel care, therefore a system that supports reflection of tasks secondary to bowel care such as eating might prove more useful. There is also evidence that apps that take in data related to a bodily function help those manage or prepare for them better. Apps that track menstrual cycles have been studied extensively and many people derive value from them. Though bowel care is

different, many variables influence it (like menstruation) and tracking these variables for reflective purposes may be valuable.

3. **Modality:** Notification pop-up on their app.
4. **Points of interaction:** Mobile application.
5. **Purpose:** To give people the opportunity to make meaningful choices with their data and reflect on how the week went. Could perhaps give smart suggestions.
6. **Trigger:** Once a week typically at the end of the week notifies users of their bowel care data.
7. **Social setting and context:** At home, perhaps alone or with a caregiver. Could also send this "report" to the caregiver as well, depending upon user preference.
8. **Story in text:** At the end of every week, the app pops up giving a review of the user's bowel care data, such as time taken to do bowel care, what they ate every day, and how it impacted their bowel care time. The user reflects on their data and makes a plan going forward to alter their behavior to decrease the time taken to do bowel care. The app tells the user that on days where they eat late and eat dairy, their bowel care the following day is about 30% longer than usual. The app suggests not eating food late. The user takes this information into consideration and makes a goal for the next week not to eat food as late to see if that impacts their bowel care. The app also gives the option to send this "report" to the caregiver if desired. (see Figure 2)

A.3 Storyboard 3: Food picture

1. **Struggle:** It is difficult to plan bowel care when encountering new or novel foods. A strange reaction to a certain food could have unfortunate consequences for someone with SCI.
2. **Literary evidence:** According to Cameron et al [1], dietary data is particularly important for many preventive care and chronic disease management goals. Traditional food diaries are often burdensome, and the challenges of data collection can nudge people toward pre-packaged food and other behaviors contrary to their goals. Photo-based diaries can ease the burden of data collection and support reflection on eating behavior and context.
3. **Modality:** A smartphone application. It takes a photo of the food, analyzes it, and gives the user feedback.
4. **Points of interaction:** The application presents the user with a list of red flags that it sees and the potential risks to the user if they eat those foods.
5. **Purpose:** To provide people with SCI's information necessary to make decisions about whether or not to eat foods that may disrupt their normal bowel movements.
6. **Trigger:** The user will open the app and take a picture of their food to trigger the analysis process.
7. **Social setting and context:** Could be any time the user encounters food - restaurants, other people's houses, etc.
8. **Story in text:** Jim, who has a SCI, is out at dinner with his family. It's his brother's birthday and he really want to go to Sawadees, a Thai restaurant in their city. Jim has never been to Sawadees and soon realizes that their whole menu is comprised of delicious, but spicy, food. When the server comes out with yellow curry, pad thai, and drunken noodles, Jim worries about what kind of side effects he will have to deal with as a result of eating this unfamiliar food. Fortunately, he has access to our phone application "GutGuard." He pulls out his phone and snaps a photo of each dish. Based on some previous knowledge it has about Jim and his regular food intake, GutGuard identifies that the yellow curry is potentially disruptive to his regular bowel functions and in what ways it can affect his bowel care (Likely to cause constipation, diarrhea, how much added time it could take). Jim knows that the yellow curry can potentially add 30 more minutes to his bowel care, but because he likes

trying new food and doesn't work tomorrow, Jim eats the yellow curry with the plan of taking Pepto Bismol later to be better prepared for a longer bowel care session tomorrow. (see Figure 3)

A.4 Storyboard 4: Smart water bottle

1. **Struggle:** If the patient is dehydrated, it may lead to constipation and other bowel complications.
2. **Literary evidence:** Low fluid intake has been linked to lower stool output in healthy male volunteers, while increased fluid intake has been shown to increase stool output in normal healthy volunteers.
3. **Modality:** Use the bottle or app notification or other appropriate modality like vibration, etc.
4. **Points of interaction:** Bottle/app.
5. **Purpose:** Optimum fluid intake is crucial for healthy stool. Therefore, the purpose here is to motivate the user to drink enough fluid to achieve healthy stool (i.e., regulate stool softness).
6. **Trigger:** The technology triggers when it thinks the user is not drinking enough fluid (based on fluid/food intake and activity level).
7. **Social setting and context:** The technology itself is mobile, so it applies everywhere (but the technology is smart enough to understand preferences).
8. **Story in text:** Nick struggled with constipation and knew he needed to drink more water to help regulate his bowel movements. He decided to try a smart water bottle that changes its appearance based on how much water a user has drank, giving the user a visual reminder of when to drink water. As he sipped from the bottle, its surface changed, displaying how much water he had consumed. The bottle would suggest him drink more water if he had just eaten a particularly salty meal. Throughout the day, the bottle reminded him to drink more, and he found that he was consuming more water than usual. As the day came to an end, Nick took a few final sips from the bottle, and its surface changed one last time, displaying the message, "Well done! You have met your daily water intake goal." He felt a sense of accomplishment knowing that he had taken care of his bowel health by staying hydrated.