

## STUDY PROTOCOL

## Usability of an automated medication dispensation device and adherence dashboard: A study protocol

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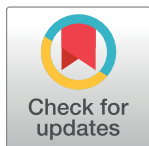
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## Abstract

Non-adherence to prescribed medication regimens can lead to suboptimal control of chronic health conditions and increased hospitalizations. Older adults may find it particularly challenging to self-manage medications due to physical and cognitive limitations, resulting in medication non-adherence. While automated medication dispensing technologies may offer a solution for medication self-management among older adults, these technologies must demonstrate usability before effectiveness can be investigated and products made available for widespread use. This study will aim to measure usability, workload, and unassisted task completion rates of an automated medication dispenser and medication adherence dashboard on the Medipense portal with older adults and their clinicians, respectively. This study is designed as a convergent parallel mixed-methods observational study with older adults and their clinicians. Usability will be examined with the use of the System Usability Scale (SUS) while NASA Load Index (NASA-TLX) will be utilized to assess the workload of both the device and the adherence monitoring platform. Cognitive walkthrough will be utilized prior to usability testing to identify series of steps required to use the automated dispenser and adherence dashboard. The study will assess the unassisted task completion rates to successfully operate the device. Semi-structured interviews with both types of participants will provide qualitative data with which to comprehensively gauge the automated dispenser user experience. The results of this study will allow us to examine usability of both the automated medication dispensing system and the adherence monitoring dashboard from older adult and health-care provider perspectives. The results of this study will highlight and address the challenges with usability that older adults and health-care providers may face with this device and dashboard. The results of this study will be used to optimize the usability

of both the automated medication dispenser and the adherence dashboard. In clinical practice, usability of technology is important to establish prior to full-scale implementation. Products that are not user friendly, add to workload, impact workflow, or are difficult to navigate by both clinicians and population in general may not be adopted. Usability permits an evaluation of the products, to identify problems that must be addressed prior to implementation and to ensure products are useful in clinical practice.

## Introduction

Worldwide, the population is aging and by 2050, there will be 2.1 billion individuals older than 60 years of age, accounting for 1 out of every 5 people [1]. The increased life expectancy is resulting in an increased prevalence of chronic disease comorbidities, functional impairment and concomitant multiple medications use [2–6]. The use of multiple medications introduces new challenges such as adverse effects, drug interactions, drug-induced diseases, complex drug dosing regimens, with resulting negative impact on medication non-adherence and an increase in medication errors [6–9]. Adherence is defined as “the degree to which the person’s behavior corresponds with the agreed recommendations of a health-care provider” [9]. Medication non-adherence is of particular importance in the management of chronic conditions. Non-adherence leads to less than optimal control of chronic health conditions and significant additional costs for the Canadian health-care system estimated at \$4 billion CAD per year [10–14]. There are numerous reasons why patients do not adhere to a medication regimen. Of the five different types of factors identified, [15–18] patient and therapy related factors are of particular importance among older adults. For example, the increasing use of multiple medications to treat increasing numbers of multi-morbidities results in complex therapeutic regimens, which directly impact medication adherence negatively [8, 18, 19]. Older adults, especially those who may have mild cognitive impairment, may become more forgetful, which decreases medication adherence [19]. Beyond forgetfulness and short-term memory impairment, a decline in executive function may reduce the ability of cognitively impaired individuals to organize and plan medication taking activities [20, 21]. In addition, older adults may accumulate physical limitations which impacts medication taking, resulting in medication non-adherence. Vision impairment increases the risk of medication errors [22]. Age-related conditions such as arthritis and Parkinson’s disease impacts the ability to open vials and punch blister packs [23]. According to the World Health Organization, the rate of medication non-adherence in developed countries nears 50% [10].

The well-recognized problem of medication non-adherence has spurred the development of numerous medication adherence technologies. A recent literature review identified 78 devices capable of providing real-time monitoring of medication intake [24]. Among these devices are vials, blister packaging, pillboxes, storage boxes, and injectable and inhaler devices embedded with sensors or other technology that permits real-time tracking of medication. These are taken through opening of vials or pillbox compartments, puncturing of blisters, actuation, or injection [24]. These devices offer a sizeable array of features which may impact the usability of the devices by older adults based on the physical or cognitive limitations they are facing. Usability is defined as the “extent to which a system, product or service can be used by specified users to achieve a specified goal with effectiveness, efficiency and satisfaction in a specified context of use” [25]. In their examination of key usability barriers associated with the use health technology among older adults, Wildenbos et al. proposed a framework of four key

categories: cognitive, physical, perception and motivational barriers, deemed relevant for effective and safe use of technology [26]. Within this framework, cognitive barriers such as declining working memory, spatial cognition, attention, verbal fluency, and reasoning may impact errors in the use of the technology, decrease efficiency, learnability, memorability and satisfaction [26]. Physical ability barriers such as declining speed of performance, grip strength, hand-eye coordination, and flexibility of joints impact errors and efficiency of use [26]. Similarly, vision acuity, contrast detection, color vision, computer literacy, self-confidence also affects learnability, efficiency, errors, and satisfaction with use of technology [26]. Therefore, it is imperative that usability of medication adherence technology is assessed with older adults prior to utilizing these devices to address medication non-adherence.

Unfortunately, very few studies have examined the usability of medication adherence technology in older adults. In one study, where the usability of 21 electronic medication adherence products was investigated in older adults, caregivers and health-care professionals, usability varied widely, with mean usability scores, as measured with System Usability Scale (SUS) per product ranging from 0 to 100 [27]. However, the products tested in this study included electronic blister cards, pillboxes, and prescription vials with electronic caps with a variety of features. None of these electronic medication adherence devices automatically dispensed medications.

In one of the earliest studies examining the perceived usefulness and satisfaction of an automated medication dispensing device, 96 frail older adults receiving home care used one such device, the MD.2 dispenser, for one year after which they reported on the ease of use, reliability, acceptability, routine task performance and medication management assistance [28]. The MD.2 medication dispenser was a 13" by 12" by 14" machine, which held 42 medication cups and could dispense 1 to 6 cups per day. The front of the machine had a delivery ramp, an alert light, an LCD message screen and a dispensing button. The dispenser dispensed the allocated medications in a cup when the dispensing button was pressed. In this study, 94% of participants found the device very easy to use and 84% indicated they would use it in the future. However, the results are not reflective of initial usability, i.e. immediately following the implementation of the device. The study did not address the usability concerns that frail older adults may have faced in the first days or weeks of use. Furthermore, pre-filled cups with unit doses of patients' medications were refilled in the MD.2 every two weeks by nurses and not by the participants. This further limited a true test of usability of the device by participants by limiting the interaction with the machine to one of mere dispensation. Finally, participants were receiving home care and had frequent interactions with health-care providers who assisted with the automated dispensing device.

In their study examining the impact of cognitive impairment on the usability of an electronic medication delivery device, Ligons et al. demonstrated a significant relationship between cognitive impairment, measured using Mini Mental Status Examination (MMSE) scores and percentage of task success. For example, individuals with MMSE scores of 24 and above (no cognitive impairment) were able to successfully complete 69% of the tasks compared to only 34% of those with MMSE scores of <24 ( $p = 0.04$ ) [29]. The automated medication dispenser used in this study was designed to deliver medications from single-dose blister cards based on a schedule programmed by pharmacies. Up to 10 different blister cards could be loaded into this device and users interacted with the device through a touch screen interface. At the time of a scheduled dose, the automated dispenser would beep and display a flashing message on the touch screen, alerting the user to take their medication doses. Participants were then expected to confirm their readiness to take their medication, retrieve the blister card from the dispensing drawer, and extract the dose from the blister. The participants were tested on several usability tasks such as loading and unloading blister cards, removing pills from the

blister cards, manual drop, and viewing inventory. Usability was measured with SUS and observed by researchers as they interacted with the dispenser. Only three of the 19 participants scored SUS at 80 or higher. Task success rates ranged from 10.5% for manual drop to 57.9% for viewing inventory.

In a more recent study, usability, usefulness, satisfaction and impact on caregiver burden of an automated medication dispenser was tested with 58 older adults and 11 caregivers [30]. Usability was measured with a SUS and Usefulness, Satisfaction and Ease of Use questionnaire. In this study, the mean SUS score was 85.74 (SD 12.7, range 47.5–100). More than 75% of participants agreed with the statement that the product was easy to use. The automated medication dispensing system, *spencer*<sup>®</sup>, is a rectangular-shaped device with a touch screen, a narrow opening in the front that allows the dispensation of single multidose medication pouch and opening at the top for loading of refill boxes. It dispenses multidose pouches of the participants' medications at scheduled times. The multidose pouches are packaged in strips by pharmacies and supplied in boxes that are loaded into the dispenser. Pouches can be dispensed with the use of a touch-screen interface. Although most participants found the automated dispenser easy to use, usability was only measured at the end of the 6-month intervention period. Similar to the study conducted with the MD.2 automated dispenser, this study did not capture the usability of the device at the beginning of the intervention. Furthermore, the study did not observe the participants who successfully carried out the tasks and which required more assistance.

While all automated medication dispensers appear to have a touch screen or LCD interface and all appear to dispense medications that are prepackaged into a multidose container, the usability of the different automated dispensers varies. Some digital interfaces may be challenging for some older adults, while others may not be able to complete the loading of refills. We intend to measure both task-specific and overall usability of the automated medication dispenser. Therefore, it is necessary to observe how older adults interact with the automated dispenser at their initial interaction as well as after a period of regular use. Assessment of usability and task success at the initial interaction is necessary to identify whether usability challenges can be addressed prior to long-term implementation. Assessment of long-term usability is necessary to measure learnability of appropriate use of the device to ensure safe medication dispensing.

Therefore, we aim to study the overall and task-specific usability of a new automated medication dispenser with older adults at the start of the study intervention and after 6 weeks of use. We will also examine the usability of a connected real-time medication intake monitoring dashboard with the participants' health-care providers. The dashboard enables clinicians to view the adherence metrics of medications their patients are prescribed while they use the automated medication dispenser. As with measuring the usability of automated dispensers, the usability of accessing and viewing adherence data is also just as important to measure. If there are usability concerns with accessibility of the dashboard, or with interpretability of adherence metrics by clinicians, useful information may not be utilized in clinic to measure adherence to medication.

## Methods

### Study design

This study is designed as a prospective, parallel mixed-methods convergent study. We will utilize both quantitative measures, such as the System Usability Scale (SUS) [31] and NASA Load Index (NASA-TLX) [32], as well as semi-structured interviews with participants to realize the potential barriers to appropriate use of the automated medication dispenser and the

medication adherence tracking platform. Prior to testing the usability of the automated medication dispenser and the adherence tracking platform, we will collaboratively establish steps for an appropriate use through the use of cognitive walkthroughs with the developers of the automated medication dispenser, the adherence dashboard, clinicians, and researchers [33]. An overview of the study process can be found in Fig 1.

The flow diagram describes the detailed process of the study starting with the recruitment and training of participants, the assessment tools such as the SUS, NASA TLX, Cognitive Walkthrough, followed by interviews conducted with participants and health care providers and end with the data analysis.

## Study participants

**Inclusion criteria.** Older adults, aged 65 years and older, will be recruited from patients presenting to one family health team in Ontario, Canada. Our study is focused on older adults as they have a higher prevalence of medication non-adherence due to declining medication self-management capacity resulting from a number of physical, cognitive, sensory limitations. By ensuring the sample is 65 years and older, we hope to avoid selection bias, as medication costs are covered by the Ontario Health Insurance Plan (OHIP). Further, as participants present with at least 3 medications and 2 comorbid conditions, they would likely constitute a fairly homogeneous sample reflective of an older adult population. While we did not include these specific health limitations in pilot study inclusion criteria, we will capture the individual limitations that older adult participants present with, and will favour those with visual or physical impairments, such as macular degeneration, arthritis, tremors, or others.

**Health-care provider participants.** Clinicians, including family physicians, pharmacists and nurse practitioners who are interested in accessing real-time medication adherence data on the adherence dashboard of their patients who have enrolled in the study will also be invited to participate.

**Exclusion criteria.** Older adults participants who are non-French-speaking will be excluded as the Family Health Team primarily serves a French population. Additionally, individuals with a diagnosis of dementia (any type) or cognitive impairment as noted in their electronic medical record will be excluded as this could impact participants' ability to learn and accurately use the dispensing device.

**Health-care provider participants.** Health-care providers whose patients have not enrolled in this study will be excluded.

**Sampling technique.** We will use purposive sampling techniques to recruit both types of participants in this study.

## Sample size

A sample size of 5 is adequate to identify up to 80% of the usability problems with a device; [34] therefore, we will aim to recruit at least 5 and up to 10 older adults and their health-care providers, including their family physician, nurse practitioner and pharmacist, to test the usability of the automated medication dispenser and adherence dashboard.

## Location

This study will be conducted at the Équipe de santé familiale communautaire de l'Est d'Ottawa, which has two sites in Ottawa. Currently, 12 doctors, 4 nurse practitioners, 4 registered nurses, 1 psychologist, 1 social worker, 1 clinical pharmacist, and 1 dietitian serve approximately 9,000 patients (June 3<sup>rd</sup>, 2023).

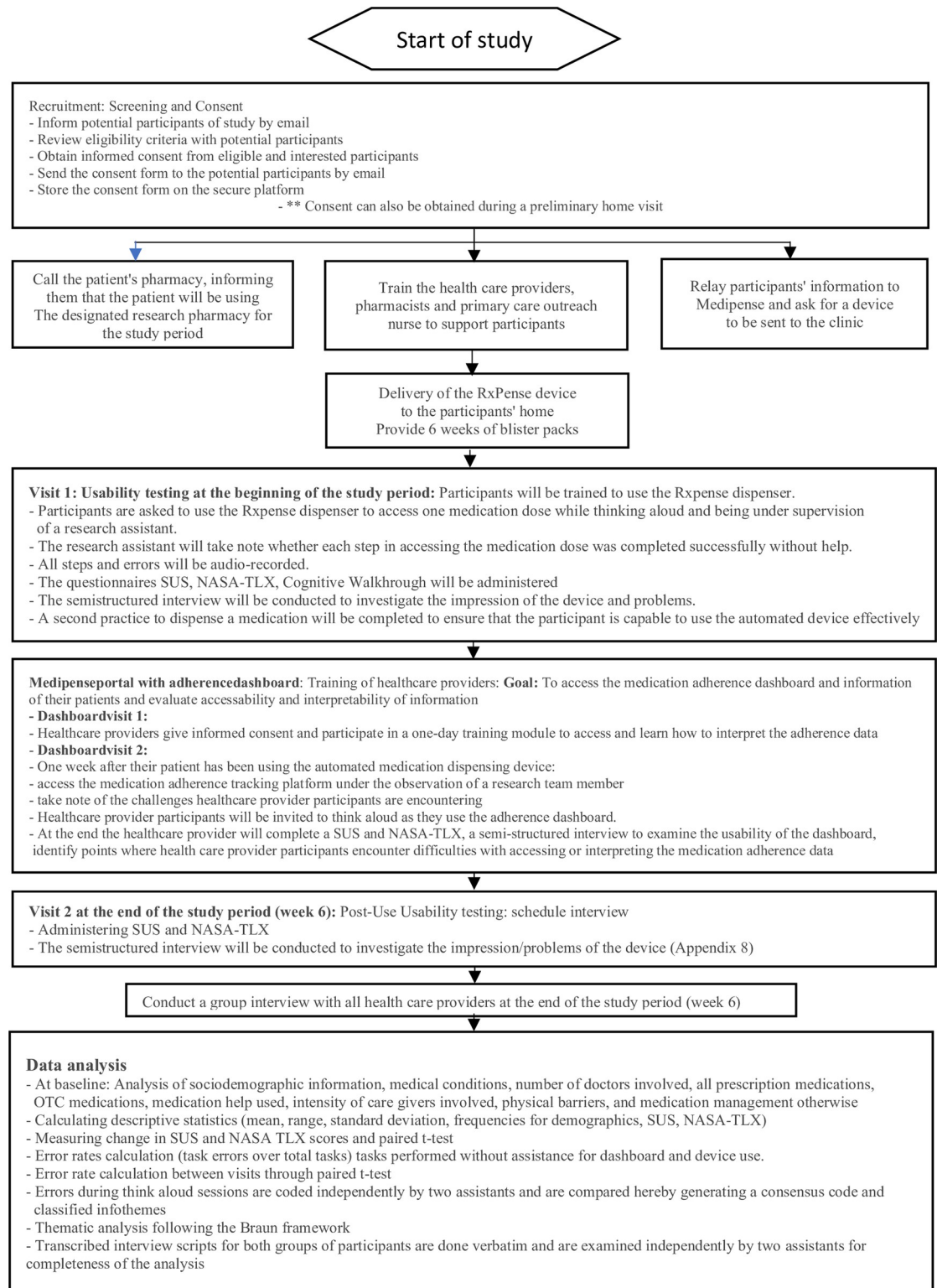


**Fig 1. Description of the study process.**

<https://doi.org/10.1371/journal.pone.0296528.g001>

## Recruitment period

The recruitment period is planned from January 1<sup>st</sup> 2024 to February 28<sup>th</sup> 2024.

## Automated medication dispenser

In this study, we will use Medipense RxPense® dispensing device (9.84” by 14.06” by 18.09”) [35], with a remote monitoring solution that ensures that the user will take the correct medications at the proper time. The medication device has a 7” high resolution color touch screen, speakers and video camera built-in, health monitoring and communication information system (Figs 2 and 3) Medications in this packaging will hold up to two weeks’ worth of medication supply with 56 individual containers delivering up to 8 doses a day. The device notifies users about their forthcoming dose using voice prompts, visual alarms, remote notifications to a wearable alert device, email or SMS alerts. If a user misses a dose, the designated caregivers will be notified through SMS or email. It records and documents the use of all prescriptions, including “as needed” prescriptions and over-the-counter medications. Medications are securely locked into the device and can only be dispensed when the user is authenticated at the proper time using biometric or radio-frequency identification, or a password. Any missed doses will be kept in the RxPense® device. The dispensing mechanism is arthritis friendly, while the display supports visually impaired persons. Verification and audit trail is also provided with images during and following pill dispensation. An audit trail is securely stored (HIPAA and PIPEDA compliant) in the RxPense® Cloud. Instructions are written in big letters, while symbols are easy to read and are supported by voice and acoustic signals audio alarms, chimes, and recorded voice playback of the caregiver or other recognized person as programmed.

The figure describes the technical details including cloud based management features, emergency features, security aspects, language capacities, manual, early and vacation mode medication release features, audit trail information, support, and pricing information.

The figure describes further packaging support information, the device capacity, including PRN dosing, how to fill the device, taking doses, addressing missed doses, the wait time for filling, the validation, authentication, and notification process, contamination handling, notification of caregiver process, and home health monitoring.

The RxPense device is connected to the RxPense® Portal and provides users real-time access to relevant information, monitoring, and adherence by all defined members of the circle of care [36]. The RxPense® Portal allows tracking and reporting of medication adherence on an organizational and patient level. Prior or following medications dispensation, patients can be asked questions about their well-being, health or consumption habits. Additional communication is possible via SMS or email and the caregiver is notified by email or SMS if pills are skipped or not taken. The caregiver can initiate direct video conference with the patient device. The caregiver can access the audit trail. Only the patient, or authorized caregiver may remove the pills when the dose is ready. The patient voice can be used to authenticate and RFID/NFC technology is available and a tap or wave with a registered tag. A verification and audit trail is also provided with images during pill dispensing and after patient takes the pills. A detailed product description is included in the publication appendices. Data collected may be stored and anonymized for further analysis. Reports are displayed to the patient on the RxPense Hub screen. It can also capture, monitor, and store vitals (through external sensors) in the electronic patient record.

## Outcomes

We aim to examine the overall usability with the System Usability Scale (SUS). The SUS has been used to examine the usability of medication adherence products in previous studies [31].

**RxPense® and Wearables**

Direct integration with wearable sensors such as Hexoskin and access to other third-party wearables and sensors via API

**Telemedicine**

Full support for secure video chat, portal access to medication and health data. RxPense® can also support APP-based third-party telemedicine providers.

**Cloud based, Secure Data Storage and Access**

HIPAA and PIPEDA Compliant. Data is accessible via the cloud from authorized devices. Extensive permission-based access rights set for physicians, pharmacists, caregivers, emergency responders. Full audit trail.

**Cloud-based Management and Provisioning**

Secure, cloud-based access to patient profiles and the administration of RxPense® Hubs, regardless of location. Manage individual units or thousands of units across multiple organizations or health care institutions internationally. Each RxPense® is registered online and uniquely assigned to patient, organization, pharmacy...

**Power**

120/240V ~ AC, 50/60Hz, 3A MAX with 12hr+ battery backup.

**Surveys**

Completely integrated custom survey creation and delivery to patients.

**Multilingual**

Language settings are personal and selectable. Patient language setting may be different than caregiver. English, French, and Spanish supported by default. Other language packs are available.

**Connectivity**

WiFi, Ethernet, Bluetooth & RFID, External LTE/5G Adapter (optional).

**Fall Detector & Panic Button**

Our new Panique accessory will immediately notify caregivers and administrators in the event of a fall.

**Mobile friendly**

RxPense® authorized users may access the RxPense® Portal and patient data via any platform connected to the Cloud.

**RxPense® Audit trail**

Complete capture and secure storage of events and activities in the audit trail. Images of medications in the device being dispensed along with operational, access, survey and consumption data are securely stored in the cloud for remote monitoring, reporting and analysis.

**Medical ID/Health Data Report**

Permission-based. Emergency Information Display includes patient medical data, allergies, conditions, medications, emergency contact information and makes this available on Mobile phones and Web.

Data can be emailed or viewed by First Responders or Emergency Room physicians.

**Calendar / Appointment Reminders**

Easily add doctor's appointments and other important events.

**Manual/Early Dose Release**

Simple, if permitted by physician.

Multiple early doses can be dispensed to support day trips or absences from patient's RxPense®.

**Vacation Mode**

Patient can pre-release packages for vacation and use mobile phone for reminders. Patient can take the RxPense® with them for extended trips (snowbirds) and have the local pharmacy fill blister packages since the packaging is industry standard. RxPense® supports international communications.

**Market**

Residences, Clinics, Long Term Care Facilities, Nursing Homes and Patients at home.

**Support**

Telephone, email and online support 24x7.

**Pricing**

More than an iPhone, less than a day in Hospital.

**RxPENSE®**



The most intelligent, secure and automatic pill dispenser for seniors and more!

**Product Brief**

RxPense® is a personal medication dispensing and remote monitoring solution that ensures seniors, disabled veterans or chronic care patients in residences, long-term care facilities or at home, take the correct medications on time and notifies caregivers or health care providers (HCP) if they miss a dose.

It also accurately records and documents the consumption of both PRN ("as-needed") and OTC medications. It can also capture (through external sensors), monitor and store vitals along with the electronic patient record.

Medications are securely locked into the device (physical security) and can only be dispensed when the patient is authenticated at the right time (biometric, RFID or password).

**MediPENSE®**  
255-438 rue Isabey  
Saint-Laurent, QC H4T 1V3

Made in Canada

Medipense.com  
255-438 rue Isabey  
Saint Laurent, QC H4T 1V3

**Fig 2. Description of the Medipense device\_page 1/2.**

<https://doi.org/10.1371/journal.pone.0296528.g002>

It is a quick and easily administered end-of-test subjective assessment of the usability of a product. It consists of 10 statements (5 positive and 5 negative) which are scored immediately after testing a product on a 5-point Likert scale. Scores range from 0 to 100, higher scores indicating enhanced user-friendliness of the product. We will also examine the workload involved in using the automated medication dispenser and the adherence tracking platform. Human mental workload is an important concept associated with usability. It refers to the cost associated with performing a cognitive task and can be used to predict operator and/or system performance [37]. Interaction between workload and usability drive objective performance of technology. Indeed, a previous study demonstrated that higher workload associated with setting up and using a medication adherence product correlated with declining SUS scores [27]. In this study, the NASA Load Index (NASA-TLX) will be used to measure workload [32]. The NASA-TLX consists of six subscales: mental, physical and temporal demands, frustration, effort, and performance. Participants will be asked to rate each of the above-mentioned variables on a 20-point scale that measures from high to low (scored from 0–100). Finally, before we initiate the usability studies, we will conduct a cognitive walkthrough of the automated medication dispenser and adherence tracking platform collaboratively with the developers of

**RxPense® Industry Standard Packaging Support**

DisPill, Eco-Pill and other multidose blister packaging currently used across Canada, USA and Europe. Medications in this packaging are fulfilled by all major pharmacies to their multidose clients.

**Senior-Friendly**

The patient experience and interface including the display, voice identification, notification sounds, visual information and the release of medications has been designed exclusively for Seniors.

**Filling/Re-Filling**

Industry standard DisPill, Eco-Pill and similar blister packs are filled by the pharmacist and delivered to patient's home, residence or LTC facility.

In less than 2 minutes, the RxPense® is loaded with new medications by authorized persons. The RxPense® always remains with the patient. Loading procedure similar to changing a cartridge in a printer.

Each cell of the packaging contains all the pills for an individual dose.

**Wait time for filling**

Very short. Same day. Pharmacists fill the individual blister packs manually using provided templates or automatically with a robotic dispenser at the pharmacy.

**Validation**

Patient Data is automatically captured from the barcode on blister-packages when inserted.

**RxPense® Risk of Contamination**

None. A pharmacist or robot fills the Pill packages and hermetically seals them prior to delivery to the patient. Patient never handles the pills except when they are consumed. Pill compartments are not re-used between sessions (empty pill capsules can be recycled).

**RxPense® Medication Capacity (Daily Doses)**

2 Week supply for one Individual – normally DisPill contains 28 doses, RxPense® can store 2 complete packages or 56 blisters. Dispensing can be set between 0 to 8 times daily.

**As-Needed (PRN) Support**

Other medications not present in blister packaging may be added for reminders and monitoring. Non-solids such as creams and ointments, inhalers and infrequent medications like Aspirin to take as needed may be added.

**Taking Doses**

Series of programmed alerts – machine generated voice prompts, sound and visual alarms, remote notification to patient worn alert devices (e.g. vibrating wrist band), email, SMS alerts, and signals sent by RxPense® to remote connected devices (lamps, sound generators, etc.) via Bluetooth or WIFI.

Patient walks to RxPense®, follows instructions on screen and self-authenticates via RFID scan of patient worn bracelet, voice identification, PIN or secure login credentials. Authentication ensures correct patient takes dose. Events and images are captured.

Successful authentication releases the medications. The front door automatically opens and the pills are provided in an opened pouch, easy to remove and take.

**Missed Dose**

RxPense® will send various alerts to primary caregiver and any designated caregivers. Missed doses are not dispensed. The RxPense® automatically skips the missed dose and prepares for the next dose time. Missed doses remain securely in the RxPense® until removed by the Pharmacist or caregiver at the next fill date, so no risk of patient overdosing.

**Arthritis Friendly**

Yes, pills may be removed with one finger or spoon. Authentication can be verbal or via RFID bracelet if dexterity is an issue.

**RxPense® Support for Visually Impaired**

High resolution 7" color touch screen interface, video instructions, large scalable fonts, voice instructions and alerts.

**RxPense® Security – Tamper Proof**

Physical – locked, tamper resistant package. Electronic locks can only be disengaged by authorized users. Medications contained in the machine are not visible externally. Attempted breaches, failed login attempts, vandalism events are recorded and reported immediately.

**Security – Water and Dust Resistant**

Water and dust resistant. Water/dust/dirt cannot reach the pills or hermetically sealed packaging.

**Security – Patient Only Access**

Only the patient, or authorized caregiver may remove the pills when the dose is ready. RxPense® uses a series of security measures to ensure the right pills are in the right device and dispensed only to the right person at the right time.

- **Voice biometrics:** Patient voice can be used to authenticate
- **RFID/NFC:** Tap or wave a registered tag
- **PIN/Password:** Entering PIN code or full username/password

Verification and audit trail is also provided with images during pill dispensing and after patient takes the pills.

Audit trail is securely stored (HIPAA and PIPEDA compliant) Cloud.

**Notifications**

Programmable and multi-source available including:

- **Audio:** alarms, chimes, recorded voice playback of caregiver or other recognized person
- **Video:** screen display, home automation control – lights, remote speakers
- **Communication:** SMS, email

Caregiver is notified by email or SMS if pills are skipped or not taken. Caregiver can initiate direct video conference with the patient device. Caregiver can access the audit trail.

**RxPense® Home Health Monitoring**

Home health hub ready – permission-based access to third-party wearables and sensors data to provide a consolidated view of data to a health care provider or caregiver. With the RxPense® 7" high resolution color touch screen, speakers and video camera built-in, health monitoring and communication is a snap.

**Fig 3. Description of the Medipense device\_page 2/2.**

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the dispenser and the research team. Cognitive walkthrough methodology examines the level of difficulty in completing particular tasks within a system and will enable the researchers to identify the pain points of using both the automated dispenser and adherence dashboard by older adults and clinicians, respectively [33]. Key tasks for using both the automated dispenser and the adherence dashboard will be determined a priori by investigators. These include key tasks that are completed frequently or critical to complete, as well as those that exhibit the core capabilities of the system. Participants are then invited to “use” the automated medication dispenser or the adherence dashboard while thinking aloud and under observation by investigators; points at which the completion of key tasks fail will be noted for further development and iteration on a cognitive walkthrough checklist. Think aloud refers to participants verbalizing their thoughts as they complete the tasks required to use the automated medication dispenser or the adherence dashboard [38]. Think aloud enables researchers to gain insight into what the participant is thinking and reflect on why errors occur. Unassisted completion rates of all tasks (number of steps completed accurately without assistance/total number of steps) and key errors (and reasons for these errors) will be reported [39].

## Intervention

Patients who agree to participate will test the device at home. All participants will be trained by the developers of the automated dispensing system. A nurse will provide home support to participants. The duration of the usability study will be 6 weeks per older adult participant. We plan 2 visits per participant. During the first visit (Visit 1), which will take place at the beginning of the study period, all participants will provide informed consent and will be trained to use the automated medication dispenser. Following the training, participants will be asked to use the automated dispenser to access one dose of their medication regimen while thinking aloud and being under observation by a research team member. As part of the cognitive walk-through, participants will be observed by a member of the research team as they use the dispenser. A research member will note whether each step in accessing the medication dose is completed successfully without assistance. These sessions will be audio recorded. If the participant encounters problems, these will be noted in detail by the research assistant using the Cognitive Walkthrough data collection sheet. Once this medication has been dispensed, the participant will be asked to complete SUS and NASA-TLX. Following the completion of both tools, each participant will participate in a one-on-one semi-structured interview designed to investigate their impression of the device, the particular problems they encountered with the dispenser, and discuss any assistance they required to successfully complete the task of dispensing the medication. Once the interview is completed, researchers will complete a second round of training with the participant to ensure they are able to use the automated dispenser effectively for the remainder of the study duration. At the end of the 6-week duration of the study, the second visit (Visit 2), the participants will again complete the SUS and NASA-TLX. Another semi-structured interview will be conducted to investigate the participants' user experience of the device over the 6-week period.

Health-care providers whose patients have agreed to participate in the study and who are interested in accessing the medication adherence dashboard will be invited to participate in a one-day training module where they will be trained on the steps required to access and interpret their patients' adherence data. During this training session, they will also be asked to provide informed consent. Once trained, they will be provided access to their patient's medication adherence information. One week after their patients begin using the automated medication dispensing device, they will be asked to access the medication adherence tracking platform while under the observation of a research team member, who will note the challenges the health-care provider encounters while accessing and using the platform. Similar to the older adult participants, health-care provider participants will be invited to think aloud as they use the adherence dashboard. At the end of this session, the health-care provider will complete SUS and NASA-TLX questionnaires and participate in a semi-structured interview designed to further examine the usability of the dashboard, and identify medication adherence data access and interpretation pain points.

At the end of the six-week study period a semi-structured group interview with all health-care providers will be conducted to gather further information about the device experience.

## Data collection

In addition to SUS and NASA-TLX, we will also collect socio-demographics (age, self-identified gender, sex at birth, medical conditions, name and dosing regimen of prescribed and "as needed" prescription and over-the-counter medications, number of doctors and other health-care providers involved in the patient's care, and physical or sensory barriers (for example, physical strength of upper extremities, pain, numbness, tremor in upper extremities, vision or hearing impairment) to medication management. We will ask participants whether they use

any medication taking aids as well as how long they have used these. We will capture the type and intensity of caregiver support that older adult participant access at home. Demographic data (age, self-identified gender, sex at birth, years of practice, discipline, patient roster size) for health-care providers participating in this study will also be collected.

## Analysis

Descriptive statistics (mean, range, standard deviations and/or frequencies) will be reported for quantitative measures (demographic data, SUS and NASA-TLX). Changes in SUS and NASA-TLX scores between the first and second visits among participants using the automated medication dispenser for 6 weeks will be examined for significance with a paired t-test. Statistical analysis will be conducted with the use of R [32].

Error rates will be calculated by dividing the number of tasks errors made by each participant while using the automated medication dispenser or the adherence dashboard divided by the total number of steps required to use the dispenser or dashboard. Unassisted task completion rates will be measured by dividing the total number of tasks completed by each participant without assistance while using the dispenser or dashboard. Error rates, unassisted completion rates between the two visits will be compared with a paired t-test. Errors identified during the think-aloud sessions will be coded qualitatively and classified into themes for each task.

Think-aloud sessions and semi-structured interviews for both groups of participants will be audio-recorded, transcribed verbatim and examined for completeness and accuracy by two independent research team members prior to the initiation of data analysis. The framework by Braun et al. [40] will be used to perform thematic analysis for the semi-structured interviews. Two transcripts for each of the participant types will be coded independently by two research team members to identify preliminary codes. These codes will be compared between the two transcribers to resolve any discrepancies, develop a consensus on codes and their definitions/meaning, and finalize a coding manual. This coding manual will be used as a reference for coding the remaining transcripts by one research team member for each type of participant independently. Codes that are generated will be classified into themes.

## Ethical approval

This research project has undergone ethical review and approval by the Hôpital Montfort Research ethics board (HM-REB) ID 19-20-08-020, Ottawa, Ontario, Canada. Prior to enrolling in the study, participants will be informed, in writing, of the study details and will provide written, informed consent for limited data abstraction from their medical records.

## Impact

Completing the pilot usability study for automated medication dispensing device will permit a determination of whether older adults are able to use the device for its intended purpose at home. Examining the usability of the real-time medication monitoring and adherence portal will be important to identify whether health-care clinicians are able to easily access the adherence data for the management of their patients.

The results of this study will be disseminated through a peer-reviewed publication in scientific journals (nursing–pharmacist journals as well as the Canadian Family Physician journal and Family Medicine Forum), presentations at scientific conferences and discussions with the developers of the dispenser device. The results will be shared locally: Journées Montfort conference, nationally Family Medicine Forum, and internationally, at the North American Primary Care Group (NAPCRG). A data sheet (info graphics) of the results will be shared with Senior's residence groups (Chartwell, Alavida, Amica, etc.) and additional stakeholders such as

pharmacies. This study will provide quality standards for the developers to test and optimize the functionality of the automated medication dispensing device and the adherence monitoring platform to meet the needs of both older adult and clinician end-users. The implementation of the automated medication dispensing device having being tested using the described tools will ensure that older adults are able to use the device appropriately at home as well as ensure that clinicians use the adherence data available to manage medication non-adherence.

## Discussion

Our patient population will be using three or more chronic medications and we will test the device for a 6-week period at home. We expect that the results will reflect the feasibility of the usability, and workload of the device from the patients' perspective. In addition, it will assess three things: the usability of the RxPense platform for health-care providers, patients and, potentially, caregivers; real-time adherence monitoring from a health-care provider perspective; and integration of this system into the primary care sector. Real-time monitoring of adherence will allow caregivers a better understanding of the factors related to non adherence as well as the opportunity for early interventions. Objective, in time adherence information on the patient or aggregate level will help clinicians to unmask and understand the dimensions of non-adherence. It will create a shame- and blame-free environment to ask questions as objective information is discussed. The relationship between clinician communication and adherence has been studied since the 1960s [41]. A meta-analysis by Zolnieriek and colleagues in 2009 points out that physician communication is significantly positively correlated with patient adherence and that there is a 19% higher risk of non-adherence among patients whose physician communicates poorly than among patients whose physician communicates well [42]. Enhanced communication and interaction between the prescriber and the patient will unmask various patient behaviours that can be addressed directly and help to better understand real life at home barriers to adherence. Studies show that patients make changes to their prescription regimen (e.g., adjusting doses, or times) whilst withholding the information from their health provider [43–45]. Improved knowledge of changes may facilitate more conversations with the health provider and lead to improved shared decision-making, or increase needed patient education and information on their medications or prescription regimen, leading to better self-management. The collected information will also have the potential to inform the health provider on side effects the patient may be encountering, thus improving medication adherence. On the aggregated data level, a tailored approach to adherence specific communication processes and routinely asking questions can be developed and can involve patients [45].

## Strengths of the study

The study answers a need to assist patients living with comorbidities who take multiple medications. Adults rarely report the problems they have with medication management. Our study assesses the usability of an innovative device and digital platform from a patient and provider perspective. Patients are recruited from a team-based primary care interdisciplinary environment that serves a middle-income active population (the majority of the population is between 15 and 65 years of age) in suburban Ottawa, Ontario. The study uses standardized, established usability assessment tools as well as targeted questions and semi-structured interviews to understand the system challenges. It assesses adherence in real time, in the patient's home. An advantage of this study is that it provides guidance to future patients who must navigate complex multidrug regimens by eliminating the need for patient decision-making concerning what medications to take, how much, and at what time, thereby improving adherence. Further,

the dispenser mechanism will prevent patient medication overadherence and administration of medication at incorrect time intervals.

The system possesses the ability to wirelessly transmit patient medication adherence data, providing opportunities to assess and monitor patient medication adherence in real time. The information can be interpreted by the patient, caregiver and health-care provider. In addition, health-care providers can interpret information of adherence challenges and attempt to identify specific population characteristics to include the learning in adherence improvement measures. The findings of this study will provide structured information for future research to exclude and avoid identified usability issues of dispensing devices and adherence monitoring systems, will guide policy makers to establish standards for dispensing devices and adherence monitoring systems, and will guide practitioners, caregivers and users in the best possible use of this or similar systems.

### Limitations of the study

Given the novel aspect of the study, the project might heighten the participant's level of anxiety. Participants are asked to test a product they have not been exposed to before for essential health matters, and this could negatively impact the results. In addition, because the opening of the device dispensing drawer is used as a proxy measure for adherence, patient actions such as failing to ingest removed medications can lead to inaccurate estimates of patient medication adherence and raise concerns about their medication adherence monitoring accuracy because of potential patient behaviors.

The sample size and six-week time frame of the study could be too small to detect challenges of the dispensation system and adherence monitoring system. Other, currently unidentified barriers to the use of the device might bias the results in such a way that certain types of information might not be detected or again, information about this information would be detected. The use of technology is a prerequisite, yet the study might include participants who are technology-challenged. As the participants are self-selected, this could lead to selection bias towards participants who favor technology.

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