Development of a clinician guide for electronic medication adherence products in older adults

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ABSTRACT

Background/objectives: The ability to manage medications independently may be affected in older adults due to physical and cognitive limitations. Numerous electronic medication adherence products (eMAPs) are available to aid medication management. Unfortunately, there are no available guidelines to support clinicians in recommending eMAPs. The objective of this study was to create and validate a clinician tool to guide use of eMAPs.

Methods: Pharmacists who previously tested the usability of the eMAPs participated in a focus group to provide feedback on 5 metrics of the clinician guide: unassisted task completion, efficiency, usability, workload and an overall eMAP score. Participants were asked semistructured questions on how they would use the tool to inform recommendations of medication aids to patients. The discussions were audio-recorded and transcribed verbatim and qualitatively analyzed. The clinician guide was modified to reflect feedback.

Results: Five pharmacists (80% female, mean years of practice: 15.8) participated in the focus group. The clinician guide was modified by removing 2 metrics and adding an additional 8 metrics: maximum number of alarms, number of days the product can accommodate for based on a daily dosing regimen, price, monthly subscription, portability, locking feature, average time to set the device and number of steps required to set the device. The definition and calculation for unassisted task completion were modified. Additional instructions and specific patient case examples were also included in the final clinician guide.

Introduction

For patients to take their medications, several steps have to be undertaken in a specific order. The patient has to identify the correct medication to take, open the appropriate container or packaging, know how many tablets or capsules to retrieve, be able to retrieve the correct number of pills and know the process by which to self-administer the medications. This process, the ability to “self-administer a medication regimen as it has been prescribed,” is labeled medication management capacity and requires both physical and cognitive capabilities.

Numerous automated in-home dispensing products are becoming available for patients to use at home. It is imperative for pharmacists and other clinicians to be able to compare the product features, usability and workload involved in using these products before recommending them to their patients.
Older adults’ capacity to manage medications has been shown to be affected in several studies. In 1 cross-sectional survey of 317 patients aged 65 years and older, 28.4% experienced challenges with opening their medication packaging; of these older adults, the relative risk of facing 1 or more challenges with opening peel-off blisters was 3.7 times (95% confidence interval [CI], 2.5-5.5) and with push-through blisters was 1.9 times (95% confidence interval, 1.2-2.8) that of opening a bottle. Aside from the physical strength and dexterity required to open packaging, vision impairment can significantly increase the risk of exceeding the maximum dose, improper dosing and improper dose spacing, as reported by 1 study investigating the impact of visual acuity on the use of nonprescription single and multi-ingredient acetaminophen products. Cognitive impairment has also been correlated with declining medication management capacity in several studies. In addition to these patient-related factors, medication-related factors such as formulation of the medication, polypharmacy and complexity of medication regimens also affect medication management capacity.

Older adults, the majority of whom continue to self-manage their medications, try to address these challenges with medication management by devising a multitude of strategies to improve medication-taking. Patients may use personal systems and routines to remember to take their medications. For example, they may store their medications in specific locations (e.g., the kitchen counter) or take medications at times correlated with certain activities (e.g., while watching television). Many older adults also use reminder systems such as calendars or pill boxes to organize their medications.

A variety of medication organization systems are available on the market. A previous systematic search for electronic products promoted to improve medication-taking among seniors revealed 80 such products available for purchase by the Canadian senior. These electronic medication adherence products (eMAPs) have a variety of features such as integrated alarms and cloud-based dispensers with real-time monitoring. However, an investigation into the usability of 22 of these products demonstrated significant variability in the usability of and workload required to use these products. In addition, this study demonstrated that participants were only able to complete all the steps required to set up a product for use in 103 of 186 tests completed (55.3%; range, 0%-100%).

Visual examination of these products as well as the variability in usability, workload and the number of steps required to set up the products revealed several differentiating features. These included different number and size of compartments for medication storage and organization, as well as different number and type of alarms and cost. These differentiating features could be used to guide clinicians in assisting older adult patients and their caregivers in adopting the appropriate product to address medication-taking. Therefore, the objective of this study was to develop and validate a guide for clinicians to use in clinical practice when determining which electronic medication adherence product may be suitable for an older adult by comparing the different features of the 22 eMAPs tested.

**Methods**

**Study design**

This study was part of a larger mixed-methods research project testing the usability and workload of 22 eMAPs (Table 1). For the validation of the clinician guide, we used qualitative research methods using focus groups.

**Ethical review**

This study received approval from the University of Waterloo Office of Research Ethics. All participants were informed of the study and provided consent prior to enrolling.

**Development of clinician guide**

The initial version of the clinician guide was developed by examining the results from the larger study, which tested the...
| Name of product                                             | Manufacturer                  | Purchased from     | Official web link (if available) or purchase link                                                                 |
|-------------------------------------------------------------|-------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------|
| GMS Med-e-lert Automatic Pill Dispenser                      | Group Medical Supply, LLC     | Amazon Canada      | https://groupmedicalsupply.com/product/gms-bluetooth-automatic-pill-dispenser-28-compartment-dosage-reminder-for-up-to-6-alarms-a-day-for-prenatal-care-for-women-medication-vitamins-supplements-for-adults-elderly/ |
| LiveFine Automatic Pill Dispenser and Reminder               | LiveFine                      | Amazon Canada      | https://www.livefineproducts.com/collections/main/products/ivpilldcgrp-automatic-pill-dispenser-28-day-electronic-medication-organizer-with-alarm-reminders |
| MedReady 1700 Automated Medication Dispenser                 | MedReady, Inc.                | Amazon Canada      | https://www.medreadyinc.net/products/medication-dispensers/medready-1700/                                    |
| MedSmart Med-Reminder and Dispensing System                  | e-pill                         | e-pill             | https://www.epill.com/medsmart.html                                                                           |
| e-pill MedTime Station Automatic Pill Dispenser with Tipper  | e-pill                         | e-pill             | https://www.epill.com/epillstation.html                                                                       |
| TimerCap Travel Size                                         | TimerCap, LLC                 | TimerCap, LLC      | https://www.timercap.com/product-page/travel-4-pack                                                           |
| TimerCap Universal Size                                      | TimerCap, LLC                 | TimerCap, LLC      | https://www.timercap.com/product-page/standard-4-pack                                                          |
| Jones Medication Adherence System                            | Jones Packaging, Inc.         | NA                 | NA                                                              |
| Reizen Vibrating Pill Box                                   | Reizen                        | Maxiaids           | https://www.maxiaids.com/reizen-vibrating-five-alarm-pill-box                                                  |
| VitaCarry Advanced Pill Case                                 | VitaCarry                     | Amazon USA         | http://www.vitacarry.com/?page_id = 9                                                                         |
| Nishiki Round Pill Box with Alarm                            | Nishiki                       | Amazon Canada      | https://www.amazon.ca/Arbor-Home-Automatic-Electronic-Medication/dp/B011X6YMYO                               |
| MedGlider System 1 with Talking Reminder                    | Medport                       | Amazon USA         | https://www.amazon.com/MEDport-MEDglider-Talking-Reminder-Medication/dp/B00804698A/ref = sr_1_2?               |
| Patterson Medical TabTime Super 8                           | Tabtime LTD                   | eBay Canada        | https://tabtime.com/products/tabtime-super-8                                                                  |
| 100-Hour Pill Reminder                                       | Aidapt                        | eBay Canada        | https://www.aidapt.co.uk/homepage.aspx?com = product&pg = 1035&productid = 1249                              |
| Med-Q Smart PillBox                                          | Med-Q                         | Med-Q              | https://medqpillbox.com/med-q-smart-pill-box/                                                                    |
| e-pill MedGlider Home Medication Management System           | e-pill                        | e-pill             | https://www.epill.com/medglider7x4.html                                                                         |

(continued)
### TABLE 1 (continued)

| Name of product                          | Manufacturer                  | Purchased from      | Official web link (if available) or purchase link                                                                 |
|------------------------------------------|-------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------|
| MedCentre System                         | MedCenter Systems, LLC        | Amazon Canada       | https://www.medcentersystems.com/MedCenter-System-Monthly-Pill-Organizer-Reminder-p/7026-5.htm                    |
| eNNOVEA Weekly Planner with Advanced Auto Reminder | eNNOVEA Medical, LLC         | e-pill              | https://www.epill.com/kitchenmedbox.html                                                                         |
| e-pill Multi-Alarm Pocket XL              | e-pill                        | e-pill              | https://www.epill.com/pilldispenserp.html                                                                       |
| 6 Grid Pill Storage Case with Alarm       | NR                            | Cesdeals.com        | https://www.cesdeals.com/product/portable-digital-lcd-alarm-medicine-box-pill-case-medical-kit-timer-reminder-6-compartmentsmedication-pills-health-care-device-183075 |
| Itzbeen Pocket Doctor                     | Itzbeen                       | Amazon Canada       | https://itzbeen.com/product/pocket-doctor-medication-reminder-device/                                           |
| e-pill Accutab Weekly Pill Dispenser      | e-pill                        | e-pill              | https://www.epill.com/accutab.html                                                                              |

NA, not applicable; NR, not reported.

Usability and workload required to use eMAPs. Twenty-two products were tested by a sample of older adults (n = 23), caregivers (n = 5) and health care professionals (n = 11) for usability, workload, time taken to set up and use the product and problems encountered while using the product. Each participant was asked to set up and use 5 products. Participants were provided with manufacturer instructions and a series of tasks that researchers requested they complete to use the product.13

We used the System Usability Scale (SUS)15,16 and the NASA–Task Load Index (NASA-TLX) questionnaire17,18 to determine and interpret usability and workload, respectively, and cognitive walkthrough19 to examine the problems encountered and time taken for setting up and using the product. We chose to report the following features in the clinician guide: mean unassisted task completion, mean efficiency, mean usability, mean workload and an overall eMAP score.

1. **Unassisted task completion**

Unassisted task completion was defined as the number of steps a participant completed without assistance from a research team member.20 When assistance was required, it included providing hints, explaining a step or physically assisting the participant to set up the product. Unassisted task completion was calculated by the following formula:20

\[
\text{Unassisted task completion (\%) = } \frac{\text{number of steps completed without assistance}}{\text{total number of steps required to use the product}} \times 100
\]

2. **Efficiency**

Efficiency was defined as the time spent on task completion.20 It is measured by dividing the proportion of steps completed successfully, whether assisted or unassisted, by each participant divided by the total time spent by the participant on all steps:20

\[
\text{Efficiency} = \frac{\text{number of steps completed successfully, unassisted or assisted}}{\text{total number of steps required to set up the product}} / \text{total time spent on completing steps (minutes)}
\]

3. **Usability**

Usability was determined by the SUS score of each product. SUS consists of 10 statements that assess an individual’s level of agreement with concepts such as complexity of the system, technical ability to use the system, integration of the functions and learnability of the system, among others. SUS scores range from 0 to 100, where higher scores indicate higher usability.15 Both SUS scores and a colour coding scale were used to display usability of each product in the clinician guide.15 SUS scores of 70.01 to 100.00, defined as “acceptable usability,” were colour coded green; SUS scores of 50.01 to 70.00 were defined as “marginally acceptable” and displayed in yellow; and SUS scores of <50.00 were defined as “not acceptable” and represented in red.

4. **Workload**

Workload was determined by the NASA-TLX score, where scores range from 0 to 100, with higher scores indicating more
work involved in using the product. Similar to SUS, both the scores and a colour coding scale were used to display NASA-TXL score ranges in the clinician guide.18 The colour green indicated NASA-TLX scores that were >75th quartile, yellow indicated between 50th and 75th quartile and red indicated <50th quartile.

5. eMAP score

Based on these 4 metrics, we determined an overall eMAP score. Each metric for each eMAP was given a score between 1 and 3, where 3 indicated that the eMAP for the particular metric fell within the highest quartile, or was coloured green. A score of 2 indicated that the eMAP fell within the 50th to 75th quartile or was coloured yellow, and a score of 1 indicated that it fell below the 50th quartile or was coloured red. The 4 metrics were then added up for each eMAP and divided by 1.2 to obtain a total score out of 10. Overall scores for the eMAPs ranged from 3.33 to 10. A corresponding image was used to showcase eMAP scores (see Table 2).

Focus group sample

Once the initial version of the tool was finalized with the 4 metrics identified above for each of the 22 eMAPs tested, the 11 health care professionals who completed the usability and workload testing for eMAPs in the larger study were invited to participate in a focus group.

Participants were provided with an explanation for the development of the tool, the definitions and formulas used to calculate the different metrics and how the overall score was determined. Participants were asked semistructured and probing questions regarding the use of the different metrics in the clinician guide, whether the tool accurately represented their experiences with the testing of the tool, whether the tool could be useful in clinical practice and whether additional factors could be reported (Appendix 1, available online at www.cpjournal.ca).

Data analysis

The focus group session was audio-recorded using a Sony Digital Voice Recorder ICD-PX470. Three research team members (AM, CL and JI) took detailed notes during the focus group meeting. The audio recording was then transcribed verbatim by one researcher (JI) into a Microsoft Word document (Microsoft Office 365 ProPlus Version 1907), and notes from the focus group were used to supplement the recording. The transcript was then independently verified by another member (AM). The transcripts were thematically coded to identify themes and subthemes. Transcripts were coded independently by 2 researchers (AM and JI). Any disagreement was resolved by discussion. The results of this analysis were used to develop a final version of the tool.

Results

Of the initial 11 health care professionals who participated in the larger study, 5 pharmacists agreed to participate in this

| Score range | Corresponding image |
|-------------|---------------------|
| ≥8.5        | ![Green](attachment:Green.png) |
| <8.5 and ≥7 | ![Yellow](attachment:Yellow.png) |
| <7 and ≥5.5 | ![Yellow](attachment:Yellow.png) |
| <5.5 and ≥4 | ![Red](attachment:Red.png)     |
| <4          | ![Red](attachment:Red.png)     |

| Variable | Pharmacists (N = 5) |
|----------|---------------------|
| Gender (n, %) |                  |
| Male      | 1 (20)             |
| Female    | 4 (80)             |
| Years of practice |       |
| Mean ± SD | 15.8 ± 12.7        |
| Mode      | 15                 |
| Median    | 15                 |
| Range     | 5-37               |

| Older adults worked with/dispensed prescriptions for (n, %) | |
|--------------------------------------------------------------|---|
| <10                                                          | 0 (0) |
| 10-20                                                        | 1 (20) |
| 20-30                                                        | 1 (20) |
| >30                                                          | 3 (60) |

| Assist older adults with medication-taking | |
|-------------------------------------------|---|
| Yes                                       | 5 (100) |

| Medication aids recommended to patients (n, %) | |
|-----------------------------------------------|---|
| Yes                                           | 5 (100) |
| Blister pack                                  | 5 (100) |
| Pill box/dosette                             | 1 (20) |

Table 2: Electronic medication adherence product grading scale

Table 3: Participant demographics
The focus group discussion consisted of 5 pharmacist participants and 6 research team members (Table 3).

**Qualitative analysis**

Thematic coding of the transcript generated 5 themes, including 1) interpretation, 2) appropriateness of the metrics, 3) independent scoring, 4) multiple product end-users and 5) further research (see Figure 1 for participant quotes associated with themes and subthemes).

**Interpretation.** Participants indicated difficulty with understanding the overall eMAP score, usability, workload, unassisted task completion and efficiency, as they were unfamiliar with these metrics.

They also indicated that users may require additional training to use the clinician guide and to revise the guide to allow those without any background knowledge to use it (Figure 1).

**Appropriateness of the metrics.** Several subthemes were identified within this theme. Participants discussed the appropriateness of the different metrics as factors by which to recommend products. For example, they felt comparing eMAPs based on the 5 metrics presented without a comparison of the number of compartments was not helpful in determining which product was appropriate for a patient with a complex medication regimen. Participants also indicated that all 4 metrics should not be weighted equally for every patient and found interpretation of the weighted scoring problematic. Participants also discussed the appropriateness of units representing the different metrics, cutoff values and colour coding and recommended other factors such as cost and portability to be included in the clinician guide.

**Independent scoring.** Participants noted that as clinicians, they would like to determine which product is best for their patient based on the metrics, instead of an overall score (Figure 1).

**Separation of metrics by product end-users.** Participants also reported that the guide should be used to help clinicians and caregivers determine which product may be usable by the end-user filling the product with medication as well as the person retrieving the medication for administration (Figure 1). In the study, usability was determined for both filling and using the product as one metric, but participants in this study reported that 2 separate usability metrics—one for filling the adherence product and one for retrieving the medication for administration—should have been determined.

**Further research.** Finally, participants noted further research needs to be conducted to measure other aspects of using
eMAPs that may guide selection of the product, such as product learnability.

General takeaways. Based on the discussions with the pharmacist participants and the qualitative analysis of the focus group, we determined participants wanted a tool that they, as clinicians, can use to aid them in independently determining which product is best for their patient, based on patient need and wants. Participants also wanted more information about the products, for example, whether the product is portable, the cost of the product, the number of compartments and number of days of supply each product can accommodate. Participants also wanted visual consistency in the formatting of the guide, for example, all values in percentages, all values colour coded and all values to the same number of decimal points. Participants did not appreciate the efficiency metric as...
well as the overall score, as these were not readily understood and could be easily misinterpreted.

**Final clinician guide**

The initial version of the clinician guide was modified with the feedback and suggestions received, and the final version is available as Figure 2. Of the original 5 metrics included in the initial version, the metrics of efficiency and the overall eMAP score were removed, and both SUS and NASA-TLX were modified by removing the scores. The colour coding used to represent degree of usability and workload was retained. Eight additional metrics were added: maximum number of alarms, number of days the product can accommodate for based on a daily dosing regimen, price, monthly subscription, portability, locking feature, average time and number of steps required to set the device. The metric unassisted task completion was recalculated to represent the proportion of individuals who were able to set, fill and remove medications from the device without any help from researchers. Additional instructions and patient case examples were included to guide the appropriate use of the tool (see Appendix 2, available online at www.cpjournal.ca).

**Discussion**

Our clinician guide is the first tool of its kind. There are no other guides that enable clinicians to recommend or assist patients with purchasing the most appropriate electronic medication adherence aid in medication-taking. By using this guide, clinicians, including pharmacists, physicians, nurses and occupational therapists, can compare the number of days a product can accommodate based on the frequency of dosing, the number of alarms that can be set as reminders, the cost of the product, whether a subscription fee is required for real-time electronic monitoring, a device’s portability and if the device can be locked, as well as average usability and average workload required to use the product. These features can be used by clinicians to recommend products based on the needs of the patient and by gauging whether the usability and workload required will affect independent use.

The features chosen to be represented in the clinician guide were also determined to be of importance in a qualitative analysis of interviews conducted with participants who tested the usability of the products.21 They indicated that the initial impression of simplicity or complexity in the setup affected the overall impression of the product. Participants found products that required repetitive reviews of instructions for setup unfavourable. Other product features that were discussed by participants were the availability of alarms, portability, storage capacity and affordability.

Many, if not all, community pharmacies offer the service of dispensing medications in blister packaging, also commonly known as compliance packaging. Blister packaging is useful for those patients on complex medication regimens, as the organization of the medications is completed by the pharmacy. This type of packaging addresses the errors a patient may make when filling their own multidose dispensing aid with medications from multiple prescription vials, each with its own set of instructions.22 It may improve efficiency in taking medications.22 Furthermore, it permits caregivers and health care providers to visually examine the packaging to determine whether doses are being taken on the days and times dispensed. However, older adults may not be able to peel the tabs or push medications through the blister packaging.3 In addition, while blister packaging reduces cognitive workload related to organizing medications, it does not address forgetfulness. It may be useful for patients with declining executive functioning23 but not declining memory.24 Older adults living within a fixed income may not be able to afford this service in every province.25 Patients who are unaware of the service or those who cannot afford the dispensing fees charged with each blister pack fill may opt to buy their own multidose dispensing aids, whether they have electronic features or not. Therefore, it is imperative that products be examined for appropriateness as they are not equally usable. Older adults and caregivers may struggle with setting up the product for use at home.13

While our guide compares 22 of the products tested, it is not comprehensive. Numerous other products are available for purchase.14 Many, if not all, of these products are marketed without an assessment of effectiveness in improving medication-taking or adherence.26 Furthermore, features of the products vary widely and can affect the usability of the products. Patients with impaired dexterity, impaired cognition and vision problems may find them difficult to use.24 Indeed, physical and cognitive capability was noted as crucial for the appropriate use of the products.21 Many products required good vision, hearing and dexterity to press small buttons, flip switches, rotate devices and respond to alarms, among others. Similarly, technology literacy and learnability may also drive the appropriate use of the product.

**Limitations**

While our guide offers some features to consider when determining which product is most suitable, more research is required to establish the effectiveness of the products in improving and sustaining adherence to medications. Furthermore, the guide is limited in its applicability as we tested our products with older adults who did not report any physical or cognitive challenges. We also did not test learnability. These user features have to be considered when recommending medication adherence devices, and future studies should investigate the usability of these products in patient populations with physical and cognitive limitations.

Another limitation of this study was the small sample size of 5 pharmacists. While we recruited 11 health care professionals to participate in the larger study, only 5 pharmacists agreed to participate in the focus group. The participation of the 5 pharmacists increases the robustness of the guide compared to one where the guide was developed solely by a research team; however, a larger
sample size and additional interprofessional participants would have increased the robustness even further and enabled other disciplines, such as occupational therapists, to use the tool.

**Conclusion**

Numerous electronic products are marketed to address medication-taking. However, there is significant variability in the features, cost, usability and workload among these products. This variability necessitates a comparison of features of the products so that an end-user, caregiver or clinician choose the right product for their use. Our Clinician Guide to Recommending Electronic Medication Adherence Products (eMAP Clinician Guide) provides a comparison of the features of 22 such products to guide clinicians in recommending the appropriate product based on the specific needs of the patient.

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**References**

1. Notenboom K, Beers E, van Riet-Nales DA, et al. Practical problems with medication use that older people experience: a qualitative study. *J Am Geriatr Soc* 2014;62:2339-44.

2. Maddigan SL, Farris KB, Keating N, Wiens CA, Johnson JA. Predictors of older adults’ capacity for medication management in a self-medication program. *J Aging Health* 2003;15:332-52.

3. Philbert D, Notenboom K, Boursy M, et al. Problems experienced by older people when opening medicine packaging. *Int J Pharm Pract* 2014;22:200-4.

4. Mullen RJ, Curtis LM, O’Connor R, et al. Visual acuity, literacy and unintentional misuse of nonprescription medications. *Am J Health-Syst Pharm* 2018;75:e213-20.

5. Sino CGM, Sietzema M, Egberts TCG, Schuurmans MJ. Medication management capacity in relation to cognition and self-management skills in older people on polypharmacy. *J Nutr Health Aging* 2014;18:44-9.

6. Edelberg HK, Shallenberger E, Wei Y. Medication management capacity in highly functioning community-living older adults: detection of early deficits. *J Amer Geriatr Soc* 1999;47:592-6.

7. Sumida CA, Vo TT, Van Etten EJ, Schmitter-Edgecombe M. Medication management performance and associated cognitive correlates in healthy older adults and older adults with MCI. *Arch Clin Neuropsych* 2019;34:290-300.

8. Yap AF, Thiru-moorthy T, Kwan YH. Medication adherence in the elderly. *J Clin Gerontol Geriatr* 2002;22:1239-48.

9. Palen L, Aalokke S. Of pill boxes and piano benches: “home-made” methods for managing medications. In: *Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work*. 2006:79-88. Available: https://dl.acm.org/doi/10.1145/1180875.1180888

10. O’Quin KE, Semahulu T, Orom H. Elder and caregiver solutions to improve medication adherence. *Health Educ Res* 2015;30:323-35.

11. O’Quin KE, Semalulu T, Orom H. Elder and caregiver solutions to improve medication adherence. *Health Educ Res* 2015;30:323-35.

12. O’Quin KE, Semahulu T, Orom H. Elder and caregiver solutions to improve medication adherence. *Health Educ Res* 2015;30:323-35.

13. Patel T, Ivo J, Faisal S, et al. A prospective study of usability and workload of electronic medication adherence products by older adults, caregivers and health care providers. *J Med Intern Res* 2020;22(6):e18073.

14. Farooqi M, Carter C, Patel T. Electronic medication adherence technologies: classification to guide use in older adults. *Can Pharm J (Ott)* 2017;159(S2):26.

15. Brook J, SUS—a quick and dirty usability scale. In: Jordan PW, Thomas B, McClelland IL, Weerdenmeer B, editors. *Usability evaluation in industry*. London (UK): CRC Press; 1996.

16. Bangor A, Staff T, Kortum P, Miller J, Staff T. Determining what individual SUS scores mean: adding an adjective rating scale. *J Usability Stud* 2009;4(3):114-23.

17. Hart SG, Staveland LE. Development of NASA-TLX (task load index): results of empirical and theoretical approach. *Adv Psychol* 1988;52:139-83.

18. Grier RA. How high is high? A meta-analysis of NASA-TLX global workload scores. *Proc Hum Factors Ergon Soc* 2015;59(1):1727-31.

19. Kushniruk AW, Patel VL. Cognitive and usability engineering methods for the evaluation of clinical information systems. *J Biomed Inform* 2004;37(1):56-76.

20. Albert W, Tullis T. Measuring the user experience: collecting, analyzing and presenting usability metrics. 2nd ed. Waltham (MA): Elsevier; 2013.

21. Faisal S, Ivo J, McDougall A, et al. Stakeholder feedback of electronic medication adherence products: qualitative analysis. *J Med Intern Res* 2020;22(12):e18074.

22. Lecouturier J, Cunningham B, Campbell D, et al. Medication compliance aids: a qualitative study of users’ views. *Br J General Pract* 2011;61:93-100.

23. Etty-Leal MG. The role of dose administration aids in medication management for older people. *J Pharm Pract Res* 2017;47:241-7.

24. Elliot RA. Appropriate use of dose administration aids. *Aust Prescriber* 2014;37:46-50.

25. Parminder MS. Compliance packaging: be aware of the hidden cost. *Can Med Assoc J* 2019;191:E1313.

26. Faisal S, Ivo J, Lee C, Carter C, Patel T. The usability, acceptability and functionality of smart oral multidose dispensing systems for medication adherence: a scoping review. *J Pharm Pract*. Epub 2020 Dec 17.