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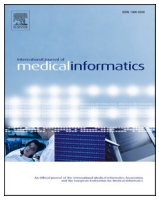

Usability of an app-based clinical decision support system to monitor psychotropic drug prescribing appropriateness in dementia

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ABSTRACT

Background: Guidelines recommend reluctant psychotropic drug (PD) prescribing in nursing home residents with dementia and neuropsychiatric symptoms (NPS), as efficacy of PDs is limited, and side effects are common. Nevertheless, PDs are commonly prescribed to reduce NPS. A smartphone application that evaluates appropriateness of PD prescriptions and provides recommendations from the revised Dutch guideline on problem behaviour in dementia may promote guideline adherence and increase appropriate prescribing.
Objective: This study aimed to assess user experiences, barriers and facilitators of the Dutch 'Psychotropic Drug Tool' smartphone application (PDT) in the context of appropriate prescribing of PDs to nursing home residents with dementia and NPS.
Methods/design: The PDT was developed according to the recommendations of the Dutch guideline for treatment of NPS in people with dementia. Feedback provided during usability testing with two end-users was applied to improve the PDT before implementation in day-to-day practice. Sixty-three prescribers were asked to use the PDT at their own convenience for four months. User expectations and experiences were assessed at baseline and after four months with the System Usability Scale and the Assessment of Barriers and Facilitators for Implementation.
Results: Expected usability (M = 72.59; SD = 11.84) was similar to experienced usability after four months (M = 69.13; SD = 16.48). Appreciation of the PDTs user-friendliness (on average 6.7 out of 10) and design (7.3) were moderately positive, in contrast to the global rating of the PDT (5.7). Perceived barriers for PDT use were time consumption and lack of integration with existing electronic systems. Perceived facilitators were ease of use and attractive lay out. For broader implementation, physicians suggested a change in direction of the PDT: start assessment of appropriateness based on the list of NPS instead of PD as primary input.
Conclusions: In this pragmatic prospective cohort study we found that the PDT was used by elderly care physicians, with mediocre user satisfaction. The PDT will be optimized based on user feedback regarding experienced usability, barriers and facilitators, after which broader implementation can be initialized.
The Medical Ethics Review Board of the University Medical Center Groningen declared this is a non-WMO study (UMCG RR Number: 201800284).

Abbreviations: PD, Psychotropic Drug; NPS, Neuropsychiatric Symptoms; PWD, People with dementia; NH, Nursing home; PDM, Psychotropic Drug Monitor; APID, Appropriate Psychotropic drugs use In Dementia index; PDT, Psychotropic Drug Tool; SUS, System Usability Scale; CDSS, Clinical Decision Support System.

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1. Introduction

Use of web-based applications to assess prescribing appropriateness is increasing, with mixed results. To illustrate, use of a computerized clinical decision support system (CDSS) to reduce inappropriate prescribing decreased the rate of new potentially inappropriate medications in general [1], although no effect on discontinuation of pre-existing inappropriate prescriptions was found. Use of the Tool to Reduce Inappropriate Medication (TRIM), which linked a CDSS to an electronic health record to evaluate appropriateness of medication, improved the decision-making process and reduced errors in medication reconciliation. However, TRIM use did not influence prescribing [2]. Use of the Systematic Tool to Reduce Inappropriate Prescribing (STRIP) Assistant, a CDSS for primary care physicians designed to optimize prescriptions of elderly patients with polypharmacy, increased decision appopriateness, although users spent significantly more time to optimize prescribed medication [3].

Use of web-based guidelines and prescription appropriateness assessments may be beneficial for implementation and uptake of new guidelines [4]. By giving physicians the opportunity to monitor their prescriptions, and providing targeted feedback, knowledge on the new guideline and appropriate prescribing are most likely to increase [5]. Previously developed web-based applications for guidelines in elderly care specifically targeted antipsychotics or polypharmacy and were intended for elderly in primary care or home/community-dwelling elderly [6–10]. However, a digital tool to assess appropriateness of psychotropic drugs (PDs) prescribed for neuropsychiatric symptoms (NPS) in people with dementia (PWD) living in nursing homes (NH) has not yet been developed.

PDs are commonly prescribed by physicians to reduce NPS in PWD, even though efficacy is limited, and side effects are common [11,12]. Guidelines recommend being reluctant in prescribing PDs [13–15], however, study results showed PDs are still prescribed regularly and often inappropriately [16,17]. Previous studies found that almost 63 to 75% of PWD living in NHs used at least one PD [18,19] and only 10% of PD prescriptions for NPS were prescribed fully appropriate [20].

The Dutch "Multidisciplinary guideline for problem behaviour in dementia" provides an overview of scientific evidence of efficacy and side effects of PDs [21]. Providing indications and recommendations in the guideline for physicians can contribute to thoughtful and appropriate prescribing of PDs in PWD [21]. Previous studies stressed that implementing and complying with guidelines is not always realized in practice [22,23]. Interventions that targeted appropriate prescribing of PDs aimed to increase physicians' awareness of the importance of regularly reviewing prescriptions and alerting them to the most recent guidelines [24,25]. Extensive paper-based guidelines or checklists are time-consuming and difficult to use in daily practice [26], whereas a handheld device such as a smartphone can provide prescribers with tailored, point-of-care information [27]. Indeed, a mobile application seemed to be a suitable medium to address inappropriate prescribing and to promote adoption of new guidelines in healthcare [28,29]. In light of the revised guideline, a smartphone application may be a convenient way for elderly care physicians to retrieve relevant guideline information about prescribing PDs for NPS in PWD residing in NHs.

In this paper, we describe the development and usability of the Psychotropic Drug Tool smartphone application (PDT) as a CDSS. The primary outcome is to assess the difference between expected and experienced usability in daily practice of the PDT, measured with the System Usability Scale (SUS) [30]. Secondary outcomes concern user experiences and barriers and facilitators for implementation of the PDT.

2. Methods

2.1. Design

First, a prototype of the PDT was developed. Second, prototype testing was performed to adapt the PDT to users' requirements. Then, user experiences, usability, and barriers and facilitators for implementation were assessed. Prescribers working at NHs in the Netherlands had access to the PDT for four months to monitor their own PD prescriptions for NPS in PWD.

2.2. Setting

The study was conducted in 13 NHs throughout the Netherlands. Sixty-three elderly care physicians (in training), specialized nurses and general practitioners working on a dementia special care unit were included. To prevent carry-over effects, physicians were excluded if they simultaneously participated in an intervention study targeting PDs. PWD and legal representatives did not have access to the PDT. Anonymity was guaranteed, as no personal data of prescribers nor residents were entered.

2.3. Materials

The PDT was derived from the Appropriate Psychotropic drugs use In Dementia (APID) index and the Psychotropic Drug Monitor (PDM) and was adjusted to the revised Dutch guideline for 'Problem behaviour in dementia' [21,31]. The APID index is a research tool with seven items to assess PD prescribing appropriateness [31]. The PDM is a paper-based self-assessment tool, derived from the APID [4]. The PDM consists of four items and includes a section to assess appropriateness of *pro re nata* (PRN) prescriptions. The items are *indication*, *dosage*, *duration*, and *evaluation* for continuous and *indication, evaluation*, and *instruction* for PRN prescriptions (Table 1). A score of 0 (*appropriate*), 1 (*not appropriate, not inappropriate*), or 2 (*inappropriate*) can be assigned to each item. The PDT is a mobile application, freely available in Dutch, in which both the Dutch guideline and the PDM can be consulted, developed to monitor PD prescriptions for NPS in PWD of 49 different PDs. The PDT is available for Android and iOS and can be downloaded in the App Store [32] and the Play Store [33]. The PDT is a CDSS in which appropriate prescribing of PDs for PWD and problem behavior can be evaluated. For the duration of the study, users received a personal login code to be able to access the PDT. After log-in with a personal code, the user selects what PD to evaluate and selects the most fitting answers to the multiple choice questions for the specific PD. In some cases, there is only one answer option. After answering the questions, for every question an explanation about appropriate prescribing of that PD according to the Dutch guideline can be read. External links are available to get more information on the specific recommendations. After the intervention period, the login procedure was removed, and the PDT became freely available.

2.4. Prototype development and testing

First, a paper prototype was developed based on the paper version of

Table 1
Items and related multiple-choice questions for continuous and pro re nata psychotropic drug prescriptions.

Prescription type	Item	Question
Continuous	Indication	*What is the indication for this prescription?*
	Dosage	*What is the prescribed daily dose?*
	Duration	*Is the therapy duration acceptable?*
	Evaluation	*Has recently been evaluated whether the prescribed drug still has the desired effect?*
Pro re nata	Indication	*What is the indication for this prescription?*
	Evaluation	*Has recently been evaluated whether the prescribed drug still has the desired effect?*
	Instruction	*Is it clearly defined at what time or in which situation this prescription may be used?*

the PDM and guideline [4,21]. The development team (consisting of a Professor of Elderly Care Medicine and Dementia (elderly care physician and chair of the guideline committee), a post-doc researcher/psychologist, and a junior researcher/psychologist, and three app developers) decided to omit the scores originally assigned to items, as the intervention was designed as an educational self-assessment tool. Emphasis was not on whether prescribing behaviour/policy is correct, but on raising awareness and being alert to medication review and adherence to current PD prescription guidelines [34]. App developers translated the paper prototype into the initial smartphone prototype. Important design factors were taken into account: language, colour and layout had to be consistent; clinical data had to be presented appropriately; and terminology had to be in line with daily practice [22,35].

Two elderly care physicians independently tested the PDT prototype once for fifteen minutes using the think aloud method, before it was implemented for the current study [36]. The PDT prototype was adapted according to physicians' feedback, which led to the version of the PDT deployed in the current study. The flowchart in Fig. 1 illustrates basic functionalities of the PDT.

The PDT is primarily designed for smartphone use but can also be accessed/used on a tablet. Users are guided through different steps to monitor the PD prescription (Fig. 1). First, the physician selects one of 49 included PDs from an alphabetical list for continuous or PRN use. For continuous use four multiple-choice questions are asked (Table 1), for PRN use three. Each answer option has a score of 0, 1 or 2, where a lower score indicates a more appropriate PD prescription. The answer options were developed for the paper-based psychotropic drug monitor and adapted in the PDT accordingly. 'Appropriate' would be when the answer is fully in line with the recommendation from the guideline. 'In between' would be when the answer is not 'wrong', but not preferred. 'Inappropriate' would be when the guideline would recommend against it or recommend something else. When selecting the answer options the prescriber did not see the options 'appropriate', 'in between', 'inappropriate'. Rather, the prescriber could select the best fitting answer from three options. To illustrate with an example: for dosage, the prescriber could select a) the dosage is between × and y mg. b) the dosage is lower than × mg, c) the dosage is higher than y mg. What factors to take into account when determining whether something was (in)appropriate was clarified only after filling out the answer options, in the evaluation/recommendation section of the app. These scores were not implemented in the PDT and are not presented in the current paper, as the aim was to increase awareness.

After selecting the answers, an overview of given and appropriate answers is shown. The physician can read a summarized guideline recommendation and click on a website link [37,38] for further information.

PDT use was at the user's own convenience; hence, physicians did not receive reminders. In order to measure actual, intrinsically motivated use, no push notifications were included in the PDTs functionalities. When encountering a problem with the PDT, physicians contacted the researcher. Physicians were advised to use the PDT preferably at least when prescribing a new PD, and when adjusting or evaluating PD prescriptions. The PDT was intended to be a standalone tool, not integrated with the physician's prescribing system.

2.5. Study procedures

Using convenience sampling, prescribers were recruited via three Dutch academic networks for NH organizations (University Network Elderly Care Groningen, UNO-UMCG; University Knowledge Network Old Age Care Nijmegen, UKON; University Network Elderly Care Amsterdam, UNO Amsterdam). Calls for participation were published in

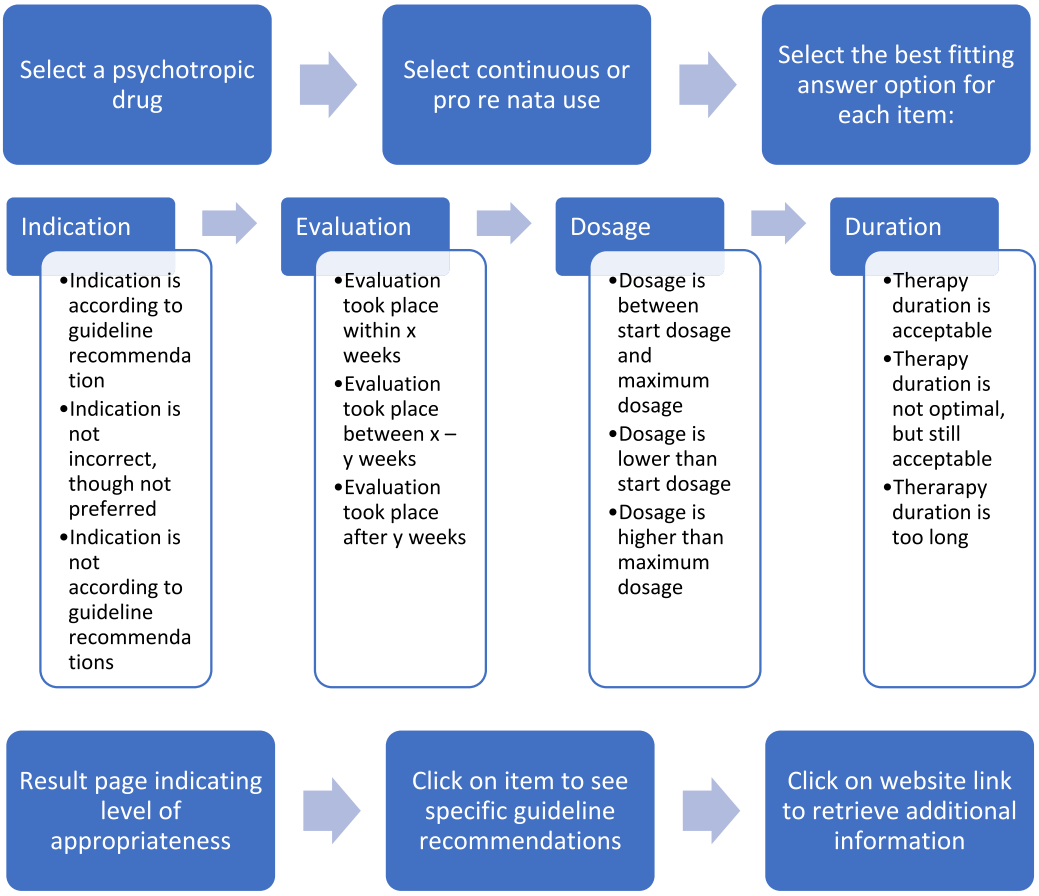

Fig. 1. Flowchart illustrating functionalities of the Psychotropic Drug Tool.

relevant newsletters and websites. Potential participants received an information letter about the study and a reminder after two weeks. Before the intervention started, prescribers attended an instruction session to get acquainted with the PDT and ask questions. Prescribers received personal login details and a printed manual to use the PDT. Requests to fill out the survey were sent via email, baseline and follow-up survey were administered via Qualtrics. The study was approved by the Medical Ethics Committee of the University Medical Center Groningen (UMCG 201800284).

2.6. Data collection

Prescribers filled out a baseline and follow-up survey reporting physician demographics (age, sex, years of work experience with the target group) and usability expectations and experiences using the System Usability Scale (SUS) [30]. The SUS is a reliable ($\alpha = 0.911$) [39] and valid measure ($r = 0.822$, $r = 0.985$) [40,41], which consists of ten statements (e.g. "I think that I would like to use this system frequently", "I thought there was too much inconsistency in this system", "I think that I would need the support of a technical person to be able to use this system") with which level of (dis)agreement is indicated on a 5-point Likert scale [42–44]. A higher score (range 0–100) at follow-up indicates that experienced usability was higher than expected usability. An average SUS score of 70 or higher can be interpreted as good, with better systems scoring between 80 and 90 and superior systems scoring >90. Systems with scores <70 require continued improvement [39]. Prescribers were also asked to rate on a scale from 1 (very poor) to 10 (excellent): the PDT in general; user-friendliness of the PDT; design of the PDT. For each of these ratings, there was an optional free text option, to elaborate on the given scores.

In the follow-up survey prescribers also filled out the Barriers and Facilitators Assessment Instrument, which has previously been used in the Netherlands to assess barriers and facilitators for implementation of innovations and guidelines. It consists of 27 general statements with which level of (dis)agreement is indicated on a 5-point Likert scale (1 = fully disagree, 2 = disagree, 3 = do not agree nor disagree, 4 = agree, 5 = fully agree). The Barriers and Facilitators Assessment Instrument [45] identifies barriers for introducing different types of innovations in patient care [45] and assesses factors that are likely to affect implementation outcomes on a context, healthcare professional, patient and innovation level [46], Cronbach's alpha's per category were 0.66, 0.63, 0.68 and 0.65, respectively. The authors of the instrument developed a manual with instructions to use the instrument [45]. Only questions deemed relevant to the PDT were administered, as the instructions of the Barriers and Facilitators Instrument indicated that general questions could be omitted depending on the type of innovation under investigation. For the PDT barriers and facilitators regarding innovation, healthcare professional and contextual characteristics were assessed, resulting in 18 statements. 9 Items on patient characteristics were not relevant for the current study and were omitted, as they focus on prevention. As suggested by Peters et al. [45], barriers were identified by counting the number of disagree and fully disagree responses to positive questions and counting the number of agree and fully agree responses to negative questions. The items 1–4, 7–9, and 11 are formulated negative, the items 5, 6, 10, 12, 13–18 are formulated positive. The higher the percentage for perceived barriers/facilitators, the more physicians felt like this statement could hinder/contribute to implementation. In an open text field, prescribers could comment on their experiences with and make suggestions for improvement of the PDT.

The baseline survey was filled out between November 2018–February 2019. The follow-up survey was filled out between April–June 2019. Incomplete surveys were included due to the low number of participants. Log data of physicians' actions performed in the PDT were registered automatically and anonymously. Log data were analysed to gain insight into frequency of application use and frequency of specific drug evaluations. User logs consisted of a user ID, timestamp, PD name and appropriateness scores (0, 1, 2) per item.

2.7. Data analysis

Descriptive statistics were used to analyse demographic data of physicians. For statistical analyses, SPSS 25.0 was used. Normality of data was assessed, after which mean and standard deviation or median and interquartile range were applied to report demographics. Differences between baseline and follow-up assessment were assessed with a non-parametric *t*-test. With Wilcoxon signed ranks test difference in SUS-scores between the group of prescribers who filled out baseline and follow-up assessment were assessed. Thematic analysis methods were applied to assess qualitative data.

3. Results

Initially, 63 prescribers of 14 NHs throughout the Netherlands agreed to participate. One NH (3 prescribers) refrained from participation after the instruction session due to lack of time. The vast majority of prescribers were elderly care physicians (in training) (≥80%) and female (≥73%) (Table 2). The response rate decreased by half from baseline to follow-up assessment.

After the instruction session, physicians (n = 53) reported a median of 75 [IQR = 63.75–80] on the SUS, whereas after the intervention period this slightly decreased with a median of 70 [IQR = 56.25–85] (n = 25) (Table 3). The median SUS-score at baseline in the subgroup of prescribers who only filled out baseline assessment (n = 27) was 75 [62.50–80]. In the subgroup of prescribers who completed both baseline and follow-up assessments, the median SUS-score was also 75 [63.75–82.50]. The Wilcoxon signed rank test showed no significant differences in SUS scores at baseline and follow-up ($z = -1.216$, $p = .224$) (n = 25) in this subgroup. Appreciation of the app scored sufficient with a mean grade of 5.7 out of 10 in general, a 6.7 for user-friendliness, and a 7.3 for design (Table 4).

Table 2
Demographics of prescribers at baseline and follow-up.

	Baseline	Subgroup baseline (follow-up)	Subgroup baseline: non-responders (no follow-up)	Follow-up
Characteristics of prescribers	*N = 52*	*N = 25*	*N = 27*	*N = 26***
Median age (years), [IQR]	49.50 [34–58.75]	53 [39–59]	47 [32–58]	52.5 [42–59.25]
Sex, female (N = 63) (%)	46 (73%)	20 (77%)	20 (74%)	20 (77%)
Work experience in long term care (years), median [IQR]	13 [5–22]	16 [7–22]	12 [3–23]	15 [7–22]
Work experience at current LTCU (years), median [IQR]	1.25 [0.50–3.75]	2.5 [0.63–6]	1 [0.50–3]	2.75 [0.69–7.75]
Current position, N (%)	N = 55	N = 25	N = 27	N = 26
Elderly care physician	39 (71%)	21 (84%)	19 (63%)	22 (85%)
Elderly care physician in training	5 (9%)	2 (8%)	2 (7%)	2 (8%)
General practitioner	4 (7%)	1 (4%)	3 (11%)	2 (8%)
Nurse practitioner	5 (9%)		1 (4%)	
Other	2 (4%)	1 (4%)	1 (4%)	

*IQR: interquartile range, LTCU: long-term care unit.
** The number of participants N differs per section, as physicians were not obligated to answer every question.

Table 3
Perceived usability of the PDT at baseline and follow-up.

	Baseline	Baseline (subgroup)	Non-responders (no follow-up)	Follow-up
Perceived PDT usability	*N = 53*	*N = 25*	*N = 27*	*N = 25***
Median System Usability Scale score (range 0–100), [IQR]				
	75 [63.75–80]	75 [63.75–82.50]	75 [62.50–80]	70 [56.25–85]
Median grade for PDT (scale 1 = very negative to 10 = very positive) [IQR]				
In general				6 [4–7.25]
User-friendliness				7 [5.75–8]
Design				8* [6.75–8]

* Due to small sample size median and interquartile range are reported in Table 3.
** The number of participants N differs per section, as physicians were not obligated to answer every question.

Table 4
Physicians' actual use of the Psychotropic Drug Tool.

		Frequency (n)	Valid %
Device type	Tablet	5	(19.2%)
	Smartphone	21	(80.8%)
Operating system	iOS	16	(61.5%)
	Android	10	(38.5%)
Technical difficulties	Never	24	(92.3%)
	Sometimes – less than once a week	2	(7.7%)
Clicked on the link to the guideline for additional information	Never	13	(50.0%)
	Sometimes – less than once a week	13	(50.0%)
Intended purpose for app use	To evaluate an existing psychotropic drug prescription	17	(65.4%)
	As a decision aid for prescribing a psychotropic drug	8	(30.8%)
	To consult information from the guideline	11	(42.3%)
	With a different purpose than mentioned above	5	(19.2%)
Frequency evaluation with the Psychotropic Drug Tool	Never	4	(15.4%)
	Sometimes – less than once a week	20	(76.9%)
	Regularly – about once a week	2	(7.7%)
Prescribing behaviour	Yes, I started prescribing differently by using the app	4	(15.5%)
Recommend to colleagues	Yes, I would recommend the use of the app to colleagues	13	(50.0%)
Most evaluated psychotropic drugs	Haloperidol	15	(13.9%)
	Citalopram	12	(11.1%)
	Risperidone	9	(8.3%)
	Buspirone	6	(5.6%)
	Aripiprazole	6	(5.6%)

Users' logs showed that the PDT was accessed 108 times by 29 unique users. However, due to a developmental error in the app, user logs of the first five weeks from the study start are missing. The PDT was more often accessed on a smartphone (n = 21, 81%) than on a tablet. Technical difficulties were barely encountered (n = 2, 8%). Half of the users (n = 13) clicked on the link to retrieve additional guideline information. Even though 20 (77%) users accessed the PDT less than once a week, half (n = 13) of the users would recommend the PDT to colleagues. Four (16%) users reported their prescribing behaviour changed after using the PDT. Their main goal for PDT use was to evaluate an existing PD prescription (n = 17, 65%) and to consult guideline information (n = 11, 42%). Eight prescribers (31%) used the PDT as a decision aid for prescribing a PD. Haloperidol, citalopram, and risperidone were viewed in the PDT most often (Table 4).

Facilitating innovation characteristics were complexity, attractiveness, and didactic benefit: three quarters of participating physicians deemed the PDT to be easy to use and almost two third were satisfied with the lay out, 13 (50%) physicians thought the PDT would be suitable for self-study (Table 5). Interestingly, 13 (50%) physicians did not find the PDT time consuming, whereas only five (20%) felt like PDT use was too time consuming. For other innovation characteristics experiences varied. A facilitating contextual characteristic for PDT-use was group norms, as most physicians expected fellow prescribers deem it important to apply innovations in daily practice. Interestingly, lack of time was scored both as a facilitator (n = 9, 34.6%) and a barrier (n = 9, 34.6%). Opportunity to take into account the wishes of the prescriber or the person with dementia himself, fit to day-to-day practice, and lack of clear added value of the PDT were considered barriers by a considerable number of prescribers.

Prescribers provided user feedback in the open text field. A frequently mentioned barrier was that the PDT is a standalone tool, not integrated with the electronic patient file or the prescribing system. In addition, multiple prescribers suggested having a text field for writing down motivated deviations from the guideline. Second, prescribers felt usability would improve with NPS as the primary input instead of PD type. Third, prescribers expressed the need for a search function to see only potentially appropriate or relevant treatment options and thereby increase efficiency of PDT use. Finally, several prescribers proposed to include non-pharmacological treatments in the PDT, which are also described in the guideline.

4. Discussion

This is the first study assessing usability of a smartphone application as a tool to increase PD prescribing awareness and appropriateness of prescribing PDs for NPS in PWD in NHs. In this study, we developed and tested the PDT. Prototype testing was applied to improve the prototype, before implementing the PDT in clinical practice. Only a minority of prescribers provided feedback concerning usability and feasibility of the PDT. Initial expectations expressed by prescribers were positive, as many physicians expressed interest in the PDT and recognized the importance and relevance of appropriate prescribing. Nevertheless, PDT use seemed infrequent in practice during the intervention period and only half (n = 25) of the prescribers filled out both baseline and follow-up assessment. Most users accessed the PDT less than once a week. This seems low, although it largely depends on a physician's number of patients and frequency of PD prescribing and (re)considering.

Integration in the physician's workflow might improve the PDTs usability, and reduce perceived workload, thereby enhancing impact on PD prescribing [47]. With this in mind, the PDT may also be integrated into an existing web-based system in the future.

New technologies such as the PDT have to be perceived as useful and easy to use, for prescribers to accept and adopt them in daily practice [48]. During the development and implementation of the PDT, design principles, previously identified barriers and facilitators on digitization of guidelines and evaluation of prescriptions' appropriateness were taken into account. Nevertheless, results indicated that user satisfaction and personal perceived need for the PDT were low, which may explain why the PDT was infrequently used and why little usability and feasibility feedback was received. Participants suggested to integrate motivated deviations in the PDT. Prescribers' considerations for deviating from guideline recommendations when they do not suffice was recently explored [49].

Table 5
Physicians' perceived barriers and facilitators for implementation of the PDT.

Categories with factors (n = 26)	Statement	n (% perceived barrier)*	n (%) do not agree nor disagree	n (% perceived) facilitator
Innovation characteristics				
Specificity, flexibility	The *PDT app* leaves enough room to weigh the wishes of the patient.	11 (42.3)	8 (30.8)	7 (26.9)
Specificity, flexibility	The *PDT app* leaves enough room for me to make my own conclusions.	10 (38.5)	8 (30.8)	8 (30.8)
Clarity/accuracy	I have clearly in mind what the added value of the *PDT app* can be in daily practice.	10 (38.5)	4 (15.4)	12 (46.1)
Feasibility/ applicability	I think using the *PDT app* fits well in my work in daily practice.	10 (38.4)	5 (19.2)	11 (42.3)
Compatibility	The *PDT app* does not fit into my ways of working at my practice.	7 (26.9)	8 (30.8)	11 (42.3)
Time investment	Working with the *PDT app* is too time consuming.	5 (19.2)	8 (30.8)	13 (50.0)
Didactive benefit	The *PDT app* is a good starting point for my self-study.	4 (15.4)	9 (34.6)	13 (50.0)
Attractiveness	The lay-out of the *PDT app* makes it handy for use.	2 (7.7)	8 (30.8)	16 (61.5)
Complexity	I think the *PDT app* is easy to use.	0 (0.0)	6 (23.1)	20 (76.9)
Contextual characteristics				
Legislation/ medical disciplinary law	I think the *PDT app* can easily be misused in medical disciplinary law/ inspection.	3 (11.5)	12 (46.2)	11 (42.3)
Group norms, socialization	Fellow geriatricians/ nursing home doctors deem it important to apply innovations in daily practice.	1 (3.8)	7 (26.9)	18 (69.2)
Reimbursement, insurance system	Working according to the *PDT app* requires financial compensation.	0 (0.0)	9 (34.6)	17 (65.4)
Healthcare professional characteristics				
Lack of time	I often forgot to use the *PDT app* due to lack of time.	9 (34.6)	8 (30.8)	9 (34.6)
Involvement	I did not thoroughly remember or apply information from the *PDT app*.	6 (23.1)	11 (42.3)	9 (34.6)
Lifestyle, working style	I have problems changing my old routines.	6 (23.0)	8 (30.8)	12 (46.2)
Knowledge, motivation	I wish to know more about the *PDT app* before I decide to apply it.	2 (7.7)	8 (30.8)	16 (61.6)
Doubts about the innovation	I think parts of the *PDT app* are incorrect.	2 (7.6)	10 (38.5)	14 (53.8)
Attitude, role perception	I have a general resistance to working according to protocols.	1 (3.8)	5 (19.2)	20 (76.9)

* In the % perceived barrier or % perceived facilitator column a higher percentage indicates that more physicians consider the statement to be a possible barrier or facilitator, respectively, for implementation.

Physicians acknowledged the PDTs relevance and the importance of guideline adherence and appropriate prescribing, though several barriers may hinder implementation of the PDT. A barrier for implementation might be the physicians' attitude and beliefs towards CDS tools and guidelines [44,50]. Even though not specifically assessed, physicians mentioned in the open fields and in personal conversations that the personal perceived need to use the PDT was low. Indeed, in the current study, we found physicians' perceived need to be a barrier. Most prescribers in this study were middle-aged with more than 10 years of professional experience. Multiple prescribers expressed their awareness of the revised guideline and that therefore the PDT is irrelevant for them. However, the results of appropriateness of PD prescriptions in line with the present study suggest otherwise[20]. Elderly care physicians may be aware of a new guideline but may not always act upon it. Many participating prescribers did not perceive themselves to be the appropriate intended PDT-user and expressed that the tool may be useful for physicians in training. Secondly, multiple prescribers mentioned at recruitment and at the instruction session that they are not prescribing that many PDs as is, not many of their residents use PDs, and that deprescribing already has a lot of attention in their NH. These believes may influence their motivation or perceived need to assess their own prescribing appropriateness [51]. These factors may partially explain why the PDT was infrequently used by prescribers.

Some limitations need to be addressed for this study. First, prototype testing with only two end-users might have been too minimal, as previous studies found at least five end-users are needed with prototype testing in medical and healthcare informatics to identify approximately 80% of usability issues [27,52]. With more end-users involved in the usability-testing phase, suggestions for optimization could have been identified earlier. Second, to prevent alert fatigue and to measure actual use of the PDT, we did not implement reminders or alerts. However, reminders might have led to more awareness for the use of the PDT. Finally, the response rate decreased with 50% from baseline to follow-up. These are self-reported data of prescribers who voluntarily agreed to participate in the study. Unfortunately, the perspectives of prescribers who did not agree to participate or who did not fill out the follow-up (and baseline) survey are unknown. Prescribers received the follow-up survey via e-mail and were reminded twice to fill out the survey. It is possible that prescribers did not fill out the survey because they did not or barely used the PDT. For some prescribers demographics data was partly missing. To prevent missing demographics data, a recommendation for future studies is to make survey sections containing demographic data obligatory to fill out. Due to a technical error safety measures of the PDT were too strict and users' logs were bounced and not registered in the first five weeks from the study start. Hence, it is impossible to draw conclusions based solely on these data. Despite these limitations, the PDT is a promising application, easily adaptable to prescribers needs and guideline revisions, which can stimulate guideline adherence.

Results of this study suggest that, after iterative adaptations based on

iterative user-testing, the PDT has the potential to aid prescribers in easily accessing specific guideline information on appropriate PD prescribing and thereby improve guideline adherence and prescribing appropriateness. Future research may further explore the feasibility of incorporating PDT features into an existing prescribing system. In the current study, four users experienced a change in their prescribing behaviour after PDT-use. It would be interesting to explore what changes were experienced. The PDT is currently freely available (in Dutch) [33] and features a search function, NPS as a starting point, and non-pharmacological interventions, added after user feedback received during the current study. Future research is needed to assess whether the adapted PDT leads to increased usability, feasibility, implementation in daily practice, guideline adherence, and ultimately to more appropriate PD prescribing for problem behaviour in PWD.

5. Conclusions

The study provided insight into experienced barriers of PDT app use for prescribers. Prescribers provided valuable user feedback, which will be leading in the further PDT development, after which broader implementation will take place. The adapted version of the PDT (*Psychofarmaca Tool*) is now freely available [32,33] and will be updated in the future. User feedback leading further PDT development concerned: NPS as a starting point instead of a PD; a search function, which also shows a pre-selection of potentially relevant PDs; non-pharmacological interventions mentioned in the guideline were added.

Authors' Contributions

The authors NR, SJ, and SZ designed the study. NR was responsible for the data acquisition. NR and SJ completed the initial data analysis. NR, SJ and SZ made significant contributions to the data interpretation. NR drafted the manuscript and all authors contributed to content and provided feedback. All authors approved the final version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijmedinf.2023.105132.

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