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Description of patient characteristics and medication adherence among medication access mobile application users and nonusers: a single-center questionnaire-based cross-sectional study

Ghadah Assiri[1,2*], Dalal Alabdulkarim[3,4], Asrar Alanazi[1], Sarah Altamimi[1], Nadin Lafi Alanazi[3] and Wael Khawagi[5]

Abstract

Background In this study, we aimed to describe patient characteristics and medication adherence among medication access mobile application users and nonusers.

Methods This was a cross-sectional study of a randomly selected sample of patients who refilled their medications either through the mobile application 'MNG-HA Care' or by phone call to a government-funded multispecialty hospital in Riyadh, Saudi Arabia. Data were collected through an online survey and filed either via WhatsApp or by phone call. Medication adherence was assessed using the five-item Medication Adherence Report Scale (MARS-5).

Results A total of 280 respondents were recruited, and their mean age was 48.8 years (standard deviation (SD): 17.8). More than 75% of application users and nonusers were younger (18–64 years) and lived in urban areas, 58% were male, 37.5% held a bachelor's degree, and 40% were unemployed. The number of respondents who accessed the mobile application (mobile application users) was 212, and 64.2% of them were adherent to their medications. Sixty-eight of the respondents used a phone call for refills (mobile application nonusers), and 77.9% of them were adherent to their medications. The most common self-reported reasons for using the application were to book an appointment and to request a medication refill. The most common self-reported reasons for not using the application were respondents' lack of knowledge about the availability of the application and preference for speaking directly to the health care provider. Adjusted multivariate logistic regression analysis revealed that medication adherence was not associated with application use (Odds Ratio (OR): 0.65; 95% CI: 0.33–1.29). However, male patients had significantly higher adherence than females (OR 2.68, 95% CI 1.31 to 5.51), and employed patients had significantly lower adherence than unemployed patients (OR 0.37, 95% CI 0.17 to 0.81).

Conclusions Providing patients with access to their medication list through a mobile application alone did not significantly impact medication adherence. Further research is needed to explore the potential benefits of incorporating

*Correspondence:
Ghadah Assiri
gassiri@ksu.edu.sa
Full list of author information is available at the end of the article

additional features, such as medication instructions and reminders within mobile applications, to improve medication adherence.

Keywords Patient access, MARS-5, Medication Adherence Report Scale, Medication adherence, Medication list, Mobile health care application

Background

Medication adherence is crucial for patients, as it ensures that they follow the prescribed medication dosing regimen accurately, including the timing, dosing, and intervals [1]. Nonadherence to medications has been associated with higher morbidity and mortality rates, as well as increasing health care costs [2, 3]. To evaluate medication adherence effectively, the National Institutes of Health (NIH) Adherence Network expert panel (2011) recommended the use of validated measures [4]. Some commonly used validated scales for medication adherence include the Morisky Medication Adherence Scale (MMAS), the General Medication Adherence Scale (GMAS) [5, 6], the Medication Adherence Report Scale (MARS) [7], and the Medication Adherence Rating Scale (MARS) [8]. However, despite the availability of these scales, adherence to medications remains a challenge, with reports indicating poor or unsatisfactory levels of adherence [9, 10].

In recent years, the accessibility of centralized medical record information has significantly improved through electronic health records (EHRs) [11]. This development presents an opportunity to enhance the quality of care and improve patient health outcomes by facilitating the flow of information between patients and health care professionals [12–16]. Patient portals and mobile applications have gained popularity as information technology platforms that provide patients with online access to their own medical records and foster engagement with their health care providers [17, 18]. In Saudi Arabia, a study focused on patient access to electronic records revealed that a majority of participants learned about their medicines by viewing the medication icons through a specific icon designed for medication education [19]. This icon allowed patients to access their medication list, learn about adverse drug reactions, read medication use instructions, request timing for medication intake, and understand their treatment plan [19].

Several studies conducted in the United States of America and Europe have assessed the impact of providing patients with online access to their medical records through patient portals or mobile applications on medication adherence, and factors related to patient adherence were studied [20–24]. A review of these studies, which included randomized controlled trials (RCTs), demonstrated statistically significant improvements in medication adherence rates among mobile application users compared to control groups [25, 26]. However, they were limited to a specific disease, and none of them were carried out in Saudi Arabia [25].

Understanding how these apps specifically affect medication adherence within the unique cultural and health care context of Saudi Arabia is important to tailor interventions and optimize health care outcomes. Saudi Arabia has a diverse population with varying health care needs and challenges. Factors such as cultural beliefs, language barriers, and access to health care services may influence medication adherence differently compared to other regions. While studies from other countries have demonstrated some positive effects [21–24], it is essential to explore the applicability and effectiveness of these interventions within the Saudi Arabian health care system. This knowledge can inform health care providers, policy-makers, and app developers to design and implement tailored interventions that address the specific needs and challenges faced by patients in Saudi Arabia, ultimately improving medication adherence and patient outcomes.

In 2016, a government-funded multispecialty hospital in Saudi Arabia introduced the 'MNG-HA Care' application, which allows patients to access their electronic medical records, refill their medications, and access electronic services [27, 28]. The application aims to promote positive health outcomes, increase health awareness, and provide reliable health information [28]. In this cross-sectional study, we aimed to describe patient characteristics and medication adherence among users and nonusers of the 'MNG-HA Care' mobile application. The research question was whether accessing medication through the 'MNG-HA Care' mobile application increased medication adherence. The following objectives were addressed:

a. To describe adherent and nonadherent patient characteristics;
b. To know the level of usage and reasons for using or not using the application;
c. To compare medication adherence using the Medication Adherence Report Scale (MARS-5) [29] between 'MNG-HA Care' mobile application users and nonusers; and

d. To evaluate the impact of patient access to their medication list through the 'MNG-HA Care' mobile application on medication adherence.

Methods

Study design

An online cross-sectional survey was conducted to describe adherent and nonadherent patient characteristics and to evaluate the impact of patient access to their medication list through the mobile application on medication adherence.

Study ethics

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of King Abdullah International Medical Research Center (protocol number: NRC21R/228/06; approval date: 27 June 2021). A written or oral informed consent was obtained electronically from participants before they answered the survey or at the beginning of the phone call. Privacy and confidentiality were assured, no identifiers were collected, and all data were kept in a secure place on password protected hard drives accessible only to the research team.

Setting

This study was conducted at a government-funded multispecialty hospital in Riyadh, Saudi Arabia, a tertiary academic medical center with approximately 1500 beds.

Participants and application features

Inclusion/exclusion criteria

The included participants were adults (≥18 years) who refilled their medications either through the 'MNG-HA Care' patient portal mobile application through the 'medication refill' option (considered 'mobile application users) or by using their phone number only (considered 'mobile application nonusers) [27]. It was the participant's preference to use or not use the application. For participants with disabilities and elderly individuals, a caregiver could refill the medications, and they were included in this study.

Individuals were excluded if they missed one or more answers on the MARS-5 questionnaire [29] because their total MARS-5 score would not be comparable with that of the rest of the study population.

The 'MNG-HA Care' platform was designed to meet the highest standards. The design and interface followed local and international standards and best practices, such as easy-to-use design, accessibility to people with special needs, and other features. This application is accessible via all platforms, including the desktop version, iOS platform, and Android platform. The platform is continuously monitored with a dedicated technical team to assure the continuity of the service. In addition, the platform is updated regularly to add new enhancement features.

An intensive promotion campaign was conducted to inform patients about the application, e.g., a Short Message Service (SMS) was sent to all patients, and brochures were distributed to patients while they were visiting outpatient clinics, being admitted, or visiting the emergency department. In addition, a promotion campaign was run on social media platforms.

Questionnaire development and administration

Medications at the government-funded multispecialty hospital can only be refilled via phone or through the 'MNG-HA Care' patient portal mobile application, which patients can use to view their medication list or medication dosing information.

A short, anonymous online survey was created. The survey consisted of multiple-choice questions in three sections. The first section assessed demographic characteristics. Respondents were asked about their age, sex, place of residence, education, employment, and chronic medical conditions. The second section was about the level of usage and purpose of using/not using the 'MNG-HA Care' application. The last section was related to any medication refilled by the patient and prescribed for any medical condition. We used a self-reported measure of medication-taking, the MARS, which was developed by Horne and Weinman [29, 30]. The MARS-5 questionnaire is a shorter version of the MARS questionnaire, comprising five items designed to address nonadherent behavior. An Arabic version of the English MARS-5 survey was previously validated, and the Cronbach's alpha was 0.71, indicating good internal reliability; this version was used since Arabic is the national language of Saudi Arabia [30]. Permission to use the MARS-5 questionnaire was obtained to ensure the lawful use of the questionnaire.

To decrease the social pressure on respondents to report high adherence, the MARS-5 questions were phrased in a nonthreatening manner, and respondents were assured that their responses would be confidential. The following statement prefaces the MARS-5 items: "*Many people find a way of using their medicines which suits them. This may differ from the instructions on the label or from what their doctor had said. Here are some ways in which people have said they use their medicines. For each statement, please tick the box which best applies to you*" (©Professor Rob Horne) [29].

The online survey was created in English and was then back-translated to Arabic by an experienced translator, except for the MARS-5 questions, which were translated

and validated previously as described above [30]. To ensure the clarity and relevance of the survey questions, the content validity was examined by four pharmacists. Then, the face validity was tested in a pilot survey of five respondents.

A list of all patients' phone numbers who used a phone call to order refills or used the 'MNG-HA Care' patient portal mobile application from 01 January 2021 to 13 June 2021 (six-month period) was requested. After removing duplicated patients, each patient was assigned a code number. Then, 800 patients were randomly selected using a random number table that was generated using the 'simple random sample without replacement' function in STATA (version 14) statistical software.

The survey link was sent out to the 800 patients using the 'medication refill' option by phone or via the mobile application, via WhatsApp or completed during the phone call. The online survey was completed through a Google form and exported to Excel spreadsheets for analysis. After two weeks, a reminder was made either by calling the patients or sending a message to the nonrespondents. Patients were contacted until we reached the required sample size of 280.

Variables

The following variables were collected: (a) demographic characteristics (age, sex, place of residence, education, employment, and chronic medical conditions), (b) level of usage and purpose of using or not using the 'MNG-HA Care' application, and (c) scores on the self-reported 5-item Medication Adherence Report Scale (MARS-5) [29]. The MARS-5 has two behavior nonadherence dimensions: nonintentional (forgetting) and intentional (stopping and skipping doses, changing the dose, and taking a lower dose than prescribed) [29]. All the questions were scored on a 5-point Likert scale (1 = always, 2 = often, 3 = sometimes, 4 = rarely, 5 = never). In line with previous research on Arabic-speaking populations [31, 32], a total score on the MARS-5 of 5–22 was considered nonadherent, and a score of 23–25 was considered adherent [29].

Users of the 'MNG-HA Care' application were divided into two groups: users and low users, who accessed the application one day a week or sometimes a month, and high users, who accessed the application daily or several days a week. Nonusers were participants who never used the application.

Bias

Nonresponse bias is common in survey research [33]. We tried several approaches to decrease nonresponse bias by making the survey short, clear, and easy to respond to; sending prenotification messages or calling the patients in case they were illiterate or did not speak Arabic; and following up with nonrespondents.

Sample size

The study sample size was based on statistical aspects. Therefore, we calculated the sample size based on the sample-to-item ratio, which calculates sample size based on the number of items in the study. The recommended ratio suggested by the literature was 1:5 up to 1:10 [34]. Considering a subject-item ratio of 5:1 plus 10% dropout, the required sample size was 275 participants.

Statistical methods

Categorical variables are presented as numbers and percentages. For continuous variables, the results are presented as the means ± standard deviations (SDs). The employment and education variables were changed from categorical to binary variables. Regarding the education variable, the respondent was considered employed if he or she answered yes. The participant was considered unemployed if he or she responded no or retired.

For the education variable, unschooled was considered uneducated. Respondents who attended elementary school, secondary school, high school, or had a bachelor's degree were considered educated. Regarding comorbidities, respondents with no comorbidities were considered to have none. Respondents with one or more comorbidities were considered to have 1–3 comorbidities and 4 or more comorbidities.

The association between medication adherence and application use and demographic characteristics such as age, sex, place of residence, education, and employment was assessed using univariate logistic regression analysis.

Variables that were found to be significant in the univariate analysis were entered into a multivariate logistic regression model to test for variables with a strong association with medication adherence.

The dependent variable was ordered (0: nonadherence; 1: adherence). The cutoff for nonadherence was a score of 22. The significance measure $P < 0.05$ and 95% CIs were used. The analysis was conducted using IBM SPSS (version 25) statistical software.

Data access and cleaning methods

The Excel datasheet was checked for errors in data, outliers, and missing data. All available data were collected. No missing information or outliers were found.

Results

A total of 1107 patients used a phone call for refills or the 'MNG-HA Care' patient portal mobile application from 01 January 2021 to 13 June 2021. The number of patients after removing duplicate mobile numbers was 1091.

Of them, 800 patients' mobile numbers were randomly selected by using a simple random sampling method.

From the 800 patients, we contacted all patients and kept either sending reminders or calling them until we reached the required sample size of 280 respondents, representing 35% of our target 800 patients.

Description of patient characteristics (medication adherent and nonadherent groups)

Overall, more than 75% of application users and nonusers were younger (18–64 years) and lived in urban areas, 58% were male, 37.5% held a bachelor's degree, and 40% were unemployed. The mean age was 48.8 years (standard deviation (SD): 17.8) (Table 1).

The most commonly reported chronic medical conditions among application users were dyslipidemia (30.2%), diabetes mellitus (28.8%) and essential hypertension (26.9%) (Fig. 1).

Level of usage and reasons for using or not using the application

The number of respondents who accessed their medication list using the 'MNG-HA Care' patient portal mobile application was 212 (75.7%). Only 68 of the respondents refilled their medications by phone call (MNG-HA Care application nonusers, 24.3%).

The three most common self-reported reasons for using the application were to book an appointment (81.1%), to request a medication refill (66.9%), and to view lab results (43.9%) (Table 2).

The three most common self-reported reasons for not using the application among the nonusers were that the patient did not know about the availability of the application (51.5%), preferred to speak directly to the health care provider (22.1%), and did not know how to use the application (17.6%).

Comparing medication adherence rates between 'MNG-HA Care' mobile application users and nonusers

Adherence scores ranged from 5 to 25 on the self-reported MARS-5 questionnaire. Based on the MARS-5 score, patients were categorized into two groups as described in the Methods section: nonadherent (MARS-5 score 5 to 22) and adherent (MARS-5 score 23 to 25).

Among the respondents who accessed their medication list through the 'MNG-HA Care' mobile application, 72% were adherent to their medications. Among the respondents who accessed their medication list through

Table 1 Description of adherent and nonadherent patient characteristics

Categories	Nonadherent ($n=91$) [MARS-5 score of 5 to 22]	Adherent ($n=189$) [MARS-5 score of 23 to 25]	Total ($N=280$)
Age			
Mean, SD (48.8, 17.8)			
18–64 years	82 (90.1%)	142 (75.1%)	224 (80%)
≥ 65 years	9 (9.9%)	47 (24.9%)	56 (20%)
Sex			
Female	49 (53.8%)	67 (35.4%)	116 (41.4%)
Male	42 (46.2%)	122 (64.6%)	164 (58.6%)
Place of residence			
Rural area	8 (8.8%)	38 (20.1%)	46 (16.4%)
Urban area	83 (91.2%)	151 (79.9%)	234 (83.6%)
Education			
Uneducated	13 (14.3%)	44 (23.3%)	57 (20.3%)
Educated	78 (85.7%)	145 (76.7%)	223 (79.7%)
Employment			
Unemployed	36 (39.6%)	76 (40.2%)	112 (40%)
Employed	55 (60.4%)	113 (59.8%)	168 (60%)
Presence of chronic medical conditions			
No	28 (30.8%)	34 (18%)	62 (22.1%)
Yes	63 (69.2%)	155 (82%)	218 (77.9%)
Application use			
Mobile application nonusers	15 (16.5%)	53 (28%)	68 (24.3%)
Mobile application users	76 (83.5%)	136 (72%)	212 (75.7%)

Abbreviations: MARS-5 5-item Medication Adherence Report Scale

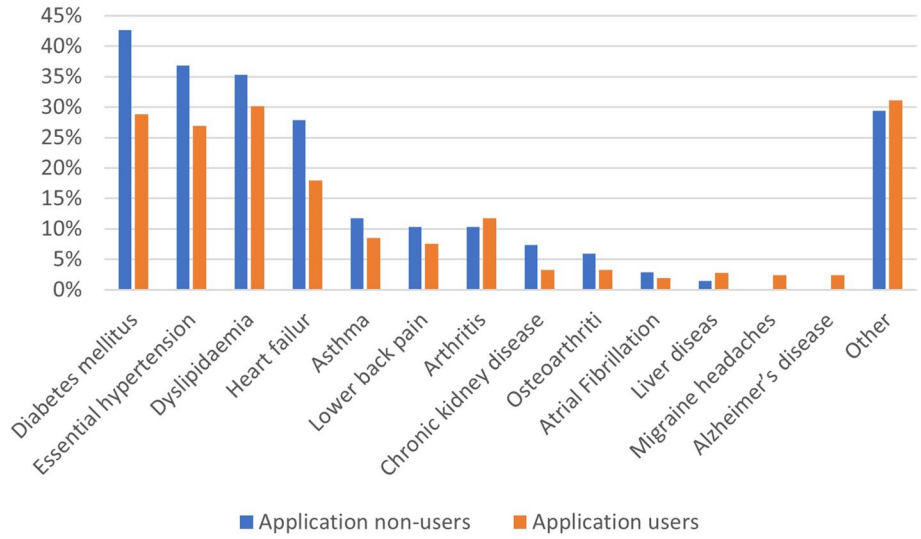

Fig. 1 Chronic medical conditions in application users and nonusers

Table 2 Amount of use and reasons for using or not using the application

Application nonusers (*n* = 68)		**Application users (*n* = 212)**		
		Amount of application use		
-		Sometimes a month or less	Low users 185 (87.3%)	166 (78.3%)
-		Once a week		19 (8.9%)
-		Several days a week	High users 27 (12.7%)	26 (12.3%)
-		Daily		1 (0.5%)
The purpose for application nonuse/use[a]				
Reasons		Reasons		
I do not know about the availability of the application	35 (51.5%)	Book appointments		172 (81.1%)
I do not know how to use the application	12 (17.6%)	View lab results		93 (43.9%)
The application is difficult to use	4 (5.9%)	Request a medication refill		142 (66.9%)
I prefer to speak to the health care provider directly	15 (22.1%)	Print medical reports		35 (16.5%)
I have concerns about the privacy/security of the application	0	View patient history		25 (11.8%)
The internet is not available at all or only sometimes	2 (2.9%)	Vaccination records		8 (3.8%)
-	-	Other		6 (2.8%)

[a] Does not sum up to the total number because the question could have more than one answer. Low users: those who used the application one day a week or sometimes in a month. High users: those who used the application daily or several days a week. Nonusers: those who never used the application

phone calls (mobile application nonusers), 28% were adherent to their medications. Eighty percent or more of the respondents never skipped a dose or took less than instructed. The responses to each question of the MARS-5 are summarized in Table 3.

Association between adherence and patient characteristics and patients using the 'MNG-HA care' application

Univariate logistic regression analysis revealed that medication adherence was associated with application use, age > 65 years, male sex, living in urban areas, holding a high school degree or university degree, employment or retirement, and one or more chronic diseases (Table 4).

Those patients who used the 'MNG-HA Care' application and accessed their medication list had significantly 49% lower odds of being adherent than nonusers (Table 4). However, this association was not significant in the multivariate regression (OR: 0.65; 95% CI: 0.33–1.29) (Table 4). Moreover, male patients had significantly higher adherence than female patients (OR 2.68, 95% CI 1.31 to 5.51). On the other hand, employed patients had significantly lower adherence than unemployed patients (OR 0.37, 95% CI 0.17 to 0.81).

Table 3 Responses for each question in the Medication Adherence Report Scale

	Items of the Medication Adherence Report Scale, © Professor Rob Horne. N = 280	Always	Often	Not sure	Rarely	Never
1	I forget to take my medicines	3 (1.1%)	14 (5%)	43 (15.4%)	88 (31.4%)	132 (47.1%)
2	I alter the dose of my medicines	2 (0.7%)	5 (1.8%)	26 (9.3%)	43 (15.4%)	204 (72.8%)
3	I stopped taking my medicines for a while	1 (0.4%)	6 (2.1%)	23 (8.2%)	41 (14.6%)	209 (74.7%)
4	I decided to skip a dose	3 (1.1%)	4 (1.4%)	16 (5.7%)	31 (11.1%)	226 (80.7%)
5	I take less than instructed	1 (0.4%)	5 (1.8%)	14 (5%)	24 (8.6%)	236 (84.3%)

Abbreviations: N Sample size. Note: The copyright of MARS and all its variants is owned by the originator Robert Horne, PhD, and permission to use it should be obtained by request to r.horne@ucl.ac.uk. [29]

Table 4 Univariate and multivariate associations between adherence and application use and patient characteristics

	Univariate		Multivariate	
	Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value
Do you use the app?				
No	1		1	
Yes	0.51 (0.27 to 0.96)	0.037*	0.65 (0.33 to 1.29)	0.217
Sex				
Female	1		1	
Male	2.12 (1.28 to 3.53)	0.004*	**2.68 (1.31 to 5.51)**	**0.007***
Age category				
18–64	1		1	
> = 65	3.02 (1.41 to 6.47)	0.005*	1.76 (0.73 to 4.25)	0.206
Place of residence				
Rural	1		1	
Urban	0.38 (0.17 to 0.86)	0.02*	0.57 (0.24 to 1.35)	0.202
Education				
Uneducated	1			
Primary School	1.08 (0.36 to 3.24)	0.886	-	
Middle School	0.8 (0.28 to 2.33)	0.685	-	
High School	0.46 (0.21 to 1.02)	0.057*	-	
University Degree	0.48 (0.23 to 1.00)	0.05*	-	
Employment				
Unemployed	1		1	
Employed	0.53 (0.30 to 0.95)	0.034*	**0.37 (0.17 to 0.81)**	**0.013***
Retired	2.15 (1.08 to 4.26)	0.029*	0.89 (0.37 to 2.15)	0.795
Comorbidities				
No comorbidities	1		1	
1–3 comorbidities	1.93 (1.06 to 3.51)	0.032*	1.46 (0.76 to 2.78)	0.254
4 or more comorbidities	2.41 (1.08 to 5.38)	0.032*	1.37 (0.54 to 3.48)	0.506

OR Odds ratio. **p* value significant if < 0.05

Discussion

Main results

The majority of the respondents accessed their medication list and refilled their medications through the 'MNG-HA Care' patient portal mobile application. Approximately one-quarter of the respondents refilled their medications through a phone call. Booking an appointment, requesting a medication refill, and viewing lab results were the most common self-reported reasons for using the 'MNG-HA Care' application. In addition, patients used the application to print medical reports and view their history. The most common self-reported reasons for not using the 'MNG-HA Care' application were patients' lack of knowledge about the availability of the

application, preference in speaking directly to the health care provider, and not knowing how to use the application. Another study carried out in the same setting found that being educationally/technologically illiterate was a major reason for not using the mobile application [35].

According to the results, our study population was younger with higher education levels and lived more often in urban areas. Most of our population (75.7%) used the mobile app more often. As supported by Alsalamah RK et al., this suggests that young patients are more likely to book an appointment through the mobile application [35]. This is probably because the younger, educated population is more technologically savvy than the elderly or less educated population.

More than 60% of patients were adherent, of whom 75.7% were 'MNG-HA Care' application users. Eighty percent or more of respondents never skipped a dose or took less than instructed. The odds of adherence were significantly 49% lower for patients who used the application and accessed their medication list than for nonuser patients (OR: 0.51; 95% CI: 0.27–0.96; p value: 0.037(. However, this association was not significant in the multivariate regression (OR: 0.65; 95% CI: 0.33–1.29; p value: 0.217). This result is contradictory to what has been found in some reviews that demonstrated statistically significant improvements in medication adherence rates among mobile application users compared to control groups [25, 26]. However, the results need to be interpreted with caution, as most of the studies were (a) small-scale studies, (b) feasibility studies, or (c) studies rated as having a high risk of bias due to insufficient reporting of information, no blinding of participants and personnel, or no allocation concealment [25].

Furthermore, while the MNG-HA Care application was launched in 2016, the medication refill function was implemented in 2020, during the COVID-19 pandemic, which was the time of our data collection, and patients may have only used the application to refill their medication without learning about their medications or remembering to take their medication at the right time by viewing the medication icon.

Comparison

Comparing our results to those of other studies is challenging for several reasons. One major factor is the discrepancies in study populations, settings, and adherence measures employed across different studies. Each study may have included a different group of participants with varying characteristics, such as age (e.g., elderly patients), medical conditions (e.g., congestive heart failure or rheumatoid arthritis), and demographic factors. The settings in which the studies were conducted also differ, such as different health care systems and geographical locations. Additionally, the adherence measures used to assess medication adherence have varied in their design and validation, such as the Morisky survey [22–24, 36, 37].

These variations in population, settings, and adherence measures make it difficult to directly compare the findings of different studies. It becomes challenging to determine whether differences in the results are due to the intervention being studied or to the differences in study design and population. To draw meaningful conclusions and make valid comparisons, it is crucial to consider the context and limitations of each study and carefully assess the similarities and differences in study design, population, and adherence measures employed. This result was in line with the result from a previous review that showed that there was inconsistency in the effectiveness of technology-mediated interventions for medication adherence and clinical outcomes [38].

Strengths and limitations

The first strength of this study was the use of MARS-5 to assess adherence, which is a valid measure and has good reliability [26]. The advantages of using the MARS-5 compared to other adherence scales are that it is quick, nonintrusive, and simple; all the items are applicable to our population; and it has been used for different disease conditions, such as hypertension, diabetes mellitus, chronic obstructive pulmonary disease, and coronary artery disease [39, 40]. The responses to the survey items are Likert-scaled responses, which are considered to offer further categorization of patients in terms of their positions along with adherence rather than a questionnaire with simple "yes" and "no" responses [30]. Second, selection bias was minimized by using a simple random sampling method. Third, it should be noted that our study did not specify any specific disease population or elderly age group. Fourth, nonresponse bias was minimized by making the survey short, clear, and easy to respond to; sending prenotification messages or calling the patients in case they were illiterate or did not speak Arabic; and following up with nonrespondents.

The main weakness of this study is that it was a single-center study, which limits the generalizability and power to detect an effect. Second, this study relied on self-reported responses, which may have overestimated the true rate of patient adherence, although a statement prefaces the MARS-5 items to decrease the social pressure on respondents to report high adherence. Third, the survey was online, so the population sample was likely to be younger, more highly educated, and more tech-savvy. However, some of the participants responded by their caregiver or answered the questionnaire by phone call. Fourth, we could not ascertain whether the patient's economic status or the number of current medications

contributed to patient access to their medication list because data on patient monthly income and average number of current medications were not collected.

Recommendations for practice and future research

Using the mobile application for medication refills itself did not appear to improve medication adherence. In addition, it is recommended that mobile applications be accompanied by interactive/customizable features such as medication reminders [41, 42], instructions regarding medication use and general information about the medications [43].

More randomized control research needs to be conducted on the impact of patient access to medication lists on medication management and, more specifically, on adherence. As no single method of adherence measurement is perfect, further studies combining subjective adherence measures (such as the survey) with less subjective measures such as patient interviews, pill-counting boxes, or the proportion of days covered (PDC) [44] are recommended to reveal whether patients are more adherent to medications [45]. Moreover, biochemical urine testing using liquid chromatography–tandem mass spectrometry is a promising new method to objectively assess medication adherence [46].

Although an intensive promotion campaign was conducted to inform patients about the application, half of the participants did not use the application because they did not know about the availability of the service. When providing patients with access to medical records through a website or mobile application, health care providers need to inform patients about this service. Some patients reported that they order their medicines by depending on the application icons; providing training and guidance on how to use the application, especially for elderly and less educated patients, in the clinic or by appointment is recommended. This will enable patients to receive the most benefit from accessing the service. After following these recommendations, the mobile application can be provided to patients in a form that is more complete, more helpful, and more likely to empower patients in self-care.

Conclusions

Three-quarters of the respondents in this study accessed their medication list using the 'MNG-HA Care' patient portal mobile application. Only one-quarter of the respondents were nonusers. Description of adherent and nonadherent patient characteristics and the impact of patient access to their medication list through the mobile application on medication adherence were evaluated. Overall, more than 60% of patients were adherent to their medications. Offering patients access to their medication through the mobile application did not appear to be a valuable addition to safe medication adherence. Further research is needed to explore the potential benefits of incorporating additional features, such as medication instructions and reminders within mobile applications, to improve medication adherence.

Abbreviations

EHRs	Electronic health records
IRB	Institutional Review Board
MARS	Medication Adherence Rating Scale
MARS-5	Medication Adherence Report Scale-5
MMAS	Morisky Medication Adherence Scale
NIH	National Institutes of Health
OR	Odds ratio
PDC	Proportion of days covered
RCT	Randomized controlled trial
SMS	Short Message Service
SD	Standard deviation
SPARO and GMAS	System Providing Access to Records Online General Medication Adherence Scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s44247-023-00039-8.

Additional file 1.

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Authors' contributions

Conceptualization, G.A. and D.A.; methodology, G.A.; software, G.A. and W.K.; validation, G.A and W.K.; formal analysis, G.A. and W.K.; investigation, A.A., S.A. and N.A.; resources, D.A. and N.A.; data curation, G.A.; writing—original draft preparation, G.A.; writing—review and editing, G.A., D.A. and W.K.; supervision, G.A.; project administration, G.A. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

All available data can be obtained by contacting the corresponding author.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the IRB at King Abdullah International Medical Research Center (protocol number: NRC21R/228/06; approval date: 27 June 2021). A written or oral informed consent was obtained electronically from participants before they answered the survey or at the beginning of the phone call. Privacy and confidentiality were assured, no identifiers were collected, and all data were kept in a secure place on password protected hard drives accessible only to the research team.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details
[1]Department of Clinical Pharmacy, College of Pharmacy, King Saud University, P.O. Box 2454, 11451 Riyadh, Saudi Arabia. [2]Department of Pediatrics, College of Medicine, Prince Abdullah Bin Khalid Celiac Disease Research Chair, King Saud University, Riyadh, Saudi Arabia. [3]Pharmaceutical Care Service, Ministry of the National Guard-Health Affairs, Riyadh, Saudi Arabia. [4]King Abdullah International Medical Research Center, Riyadh, Saudi Arabia. [5]Department of Clinical Pharmacy, College of Pharmacy, Taif University, Taif, Saudi Arabia.

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References

1. Vrijens B, De Geest S, Hughes DA, Przemyslaw K, Demonceau J, Ruppar T, et al. A new taxonomy for describing and defining adherence to medications. Br J Clin Pharmacol. 2012;73:691–705.
2. Chowdhury R, Khan H, Heydon E, Shroufi A, Fahimi S, Moore C, et al. Adherence to cardiovascular therapy: a meta-analysis of prevalence and clinical consequences. Eur Heart J. 2013;34:2940–8.
3. Roebuck MC, Liberman JN, Gemmill-Toyama M, Brennan TA. Medication adherence leads to lower health care use and costs despite increased drug spending. Health Aff. 2011;30:91–9.
4. Stirratt MJ, Dunbar-Jacob J, Crane HM, Simoni JM, Czajkowski S, Hilliard ME, et al. Self-report measures of medication adherence behavior: recommendations on optimal use. Transl Behav Med. 2015;5:470–82.
5. Naqvi AA, AlShayban DM, Ghori SA, Mahmoud MA, Haseeb A, Faidah HS, et al. Validation of the general medication adherence scale in Saudi patients with chronic diseases. Front Pharmacol. 2019;10:633.
6. Naqvi AA, Mahmoud MA, AlShayban DM, Alharbi FA, Alolayan SO, Althagfan S, et al. Translation and validation of the Arabic version of the General Medication Adherence Scale (GMAS) in Saudi patients with chronic illnesses. Saudi Pharm J. 2020;28:1055–61.
7. Chan AHY, Horne R, Hankins M, Chisari C. The medication adherence report scale: a measurement tool for eliciting patients' reports of nonadherence. Br J Clin Pharmacol. 2020;86:1281–8.
8. Lam WY, Fresco P. Medication adherence measures: an overview. Biomed Res Int. 2015;2015:1–12.
9. AlShayban DM, Naqvi AA, Alhumaid O, AlQahtani AS, Islam MA, Ghori SA, et al. Association of disease knowledge and medication adherence among out-patients with type 2 diabetes mellitus in Khobar. Saudi Arabia Front Pharmacol. 2020;11:60.
10. Balkhi B, Alwhaibi M, Alqahtani N, Alhawassi T, Alshammari TM, Mahmoud M, et al. Oral antidiabetic medication adherence and glycaemic control among patients with type 2 diabetes mellitus: a cross-sectional retrospective study in a tertiary hospital in Saudi Arabia. BMJ Open. 2019;9:e029280.
11. Vest JR. Health information exchange: national and international approaches. In: Menachemi N, Singh S, editors. Health information technology in the international context. Bingley: Emerald Group Publishing Limited; 2012. p. 3–24.
12. Gonçalves-Bradley DC, Buckley BS, Fønhus MS, Glenton C, Henschke N, Lewin S, et al. Mobile-based technologies to support healthcare provider to healthcare provider communication and management of care. Cochrane Database Syst Rev. 2018. https://doi.org/10.1002/14651858.cd012927.
13. Unertl KM, Weinger MB, Johnson KB, Lorenzi NM. Describing and Modeling Workflow and Information Flow in Chronic Disease Care. J Am Med Informatics Assoc [Internet]. 2009;16(6):826–36.
14. Or C. Pre-Implementation Case Studies Evaluating Workflow and Informatics Challenges in Private Primary Care Clinics for Electronic Medical Record Implementation. Int J Healthc Inf Syst Informatics [Internet]. 2015;10(4):56–64.
15. Keenan G, Yakel E, Dunn Lopez K, Tschannen D, Ford YB. Challenges to nurses' efforts of retrieving, documenting, and communicating patient care information. J Am Med Informatics Assoc. 2013;20(2):245–51.
16. Coiera E. When Conversation Is Better Than Computation. J Am Med Informatics Assoc. 2000;7(3):277–86.
17. Santo K, Richtering SS, Chalmers J, Thiagalingam A, Chow CK, Redfern J. Mobile phone apps to improve medication adherence: a systematic stepwise process to identify high-quality apps. JMIR Mhealth Uhealth. 2016;4: e132.
18. Xie Z, Nacioglu A, Or C. Prevalence, Demographic Correlates, and Perceived Impacts of Mobile Health App Use Amongst Chinese Adults: Cross-Sectional Survey Study. JMIR mHealth uHealth [Internet]. 2018;6(4):e103.
19. Alshoumr B, Yu P, Hailey D, Bindayel F, Alanazi S, Alshammary S. Understanding cancer patients' use and perceptions of inpatient portal: a case study at a tertiary hospital in Saudi Arabia. Int J Med Inform. 2021;148:104398.
20. Xie Z, Liu K, Or C, Chen J, Yan M, Wang H. An examination of the sociodemographic correlates of patient adherence to self-management behaviors and the mediating roles of health attitudes and self-efficacy among patients with coexisting type 2 diabetes and hypertension. BMC Public Health [Internet]. 2020;20(1):1227.
21. Assiri G. The impact of patient access to their electronic health record on medication management safety: a narrative review. Saudi Pharm J. 2022;30:185–94.
22. Chrischilles EA, Hourcade JP, Doucette W, Eichmann D, Gryzlak B, Lorentzen R, et al. Personal health records: a randomized trial of effects on elder medication safety. J Am Med Inform Assoc. 2014;21:679–86.
23. Ross SE, Moore LA, Earnest MA, Wittevrongel L, Lin C-T. Providing a web-based online medical record with electronic communication capabilities to patients with congestive heart failure: randomized trial. J Med Internet Res. 2004;6: e12.
24. van der Vaart R, Drossaert CHC, Taal E, Drossaers-Bakker KW, Vonkeman HE, van de Laar MAFJ. Impact of patient-accessible electronic medical records in rheumatology: use, satisfaction and effects on empowerment among patients. BMC Musculoskelet Disord. 2014;15:102.
25. Al-Arkee S, Mason J, Lane DA, Fabritz L, Chua W, Haque MS, et al. Mobile apps to improve medication adherence in cardiovascular disease: systematic review and meta-analysis. J Med Internet Res. 2021;23: e24190.
26. Ng R, Carter SR, El-Den S. The impact of mobile applications on medication adherence: a systematic review. Transl Behav Med. 2019;10:1419–35.
27. National Guard Health Affairs. MNG-HA launches "patient portal" mobile application. 2020. https://www.ngha.med.sa/English/MediaCenter/News/Pages/XVIMayXIV.aspx. Accessed 01 Mar 2021.
28. Yousef CC, Salgado TM, Farooq A, Burnett K, McClelland LE, Thomas A, et al. Predicting patients' intention to use a personal health record using an adapted unified theory of acceptance and use of technology model: secondary data analysis. JMIR Med Inform. 2021;9: e30214.
29. Horne R, Weinman J. Self-regulation and self-management in asthma: exploring the role of illness perceptions and treatment beliefs in explaining non-adherence to preventer medication. Psychol Health. 2002;17:17–32.
30. Alhalaiqa F, Masa 'Deh R, Batiha A-M, Deane K. Validity of Arabic version of beliefs about medication questionnaire. Clin Nurs Res. 2015;24:539–55.
31. Alsous M, Alhalaiqa F, Abu Farha R, Jalil MA, McElnay J, Horne R. Reliability and validity of arabic translation of medication adherence report scale (MARS) and beliefs about medication questionnaire (BMQ)–specific for use in children and their parents. PLoS ONE. 2017;12: e0171863.
32. Alyami M, Serlachius A, Mokhtar I, Broadbent E. Illness perceptions, HbA1c, and adherence in type 2 diabetes in Saudi Arabia. Patient Prefer Patient Prefer Adherence. 2019;13:1839–50.
33. Sedgwick P. Non-response bias versus response bias. BMJ. 2014;348:g2573.
34. Osborne JW, Costello AB. Sample size and subject to item ratio in principal components analysis. Pract Assess Res Evaluation. 2019;9:11.
35. Alsalamah R, Almasoud N, Alghtani J, Alrowaily M. The use of mobile application in primary health care in Saudi Arabia: a cross-sectional study. J Fam Med Prim Care. 2020;9:6068.
36. Or CK, Liu K, So MKP, Cheung B, Yam LYC, Tiwari A, et al. Improving Self-Care in Patients With Coexisting Type 2 Diabetes and Hypertension by Technological Surrogate Nursing: Randomized Controlled Trial. J Med Internet Res [Internet]. 2020;22(3): e16769.
37. Lyles CR, Sarkar U, Schillinger D, Ralston JD, Allen JY, Nguyen R, et al. Refilling medications through an online patient portal: consistent improvements in adherence across racial/ethnic groups. J Am Med Informatics Assoc [Internet]. 2016;23(e1):e28-33.

38. Mistry N, Keepanasseril A, Wilczynski NL, Nieuwlaat R, Ravall M, Haynes RB. Technology-mediated interventions for enhancing medication adherence. J Am Med Informatics Assoc [Internet]. 2015;22(e1):e177–93.
39. Lee CS, Tan JHM, Sankari U, Koh YLE, Tan NC. Assessing oral medication adherence among patients with type 2 diabetes mellitus treated with polytherapy in a developed Asian community: a cross-sectional study. BMJ Open. 2017;7: e016317.
40. Ramanath KV, Balaji DBSS, Nagakishore CH, Kumar SM, Bhanuprakash M. A study on impact of clinical pharmacist interventions on medication adherence and quality of life in rural hypertensive patients. J Young Pharm. 2012;4:95–100.
41. Tabi K, Randhawa AS, Choi F, Mithani Z, Albers F, Schnieder M, et al. Mobile apps for medication management: review and analysis. JMIR Mhealth Uhealth. 2019;7: e13608.
42. Vervloet M, Linn AJ, van Weert JCM, de Bakker DH, Bouvy ML, van Dijk L. The effectiveness of interventions using electronic reminders to improve adherence to chronic medication: a systematic review of the literature. J Am Med Informatics Assoc [Internet]. 2012;19(5):696–704.
43. Pérez-Jover V, Sala-González M, Guilabert M, Mira JJ. Mobile apps for increasing treatment adherence: systematic review. J Med Internet Res. 2019;21: e12505.
44. Wright E, Darer J, Tang X, Thompson J, Tusing L, Fossa A, et al. Sharing physician notes through an electronic portal is associated with improved medication adherence: quasi-experimental study. J Med Internet Res. 2015;17: e226.
45. Lehmann A, Aslani P, Ahmed R, Celio J, Gauchet A, Bedouch P, et al. Assessing medication adherence: options to consider. Int J Clin Pharm. 2014;36:55–69.
46. Beernink JM, Oosterwijk MM, Khunti K, Gupta P, Patel P, van Boven JFM, et al. Biochemical urine testing of medication adherence and its association with clinical markers in an outpatient population of type 2 diabetes patients: analysis in the diabetes and lifestyle cohort twente (DIALECT). Diabetes Care. 2021;44:1419–25.

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