Digital Applications Targeting Medication Safety in Ambulatory High-Risk CKD Patients

Randomized Controlled Clinical Trial

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Abstract

Background and objectives Patients with CKD are at risk for adverse drug reactions, but effective community-based preventive programs remain elusive. In this study, we compared the effectiveness of two digital applications designed to improve outpatient medication safety.

Design, setting, participants, & measurements In a 1-year randomized controlled trial, 182 outpatients with advanced CKD were randomly assigned to receive a smartphone preloaded with either eKidneyCare ($n=89$) or MyMedRec ($n=93$). The experimental intervention, eKidneyCare, includes a medication feature that prompted patients to review medications monthly and report changes, additions, or medication problems to clinicians for reconciliation and early intervention. The active comparator was MyMedRec, a commercially available, standalone application for storing medication and other health information that can be shared with patients' providers. The primary outcome was the rate of medication discrepancy, defined as differences between the patient's reported history and the clinic's medication record, at exit.

Results At exit, the eKidneyCare group had fewer total medication discrepancies compared with MyMedRec (median, 0.45; interquartile range, 0.33–0.63 versus 0.67; interquartile range, 0.40–1.00; $P=0.001$), and the change from baseline was 0.13 ± 0.27 in eKidneyCare and 0.30 ± 0.41 in MyMedRec ($P=0.007$). eKidneyCare use also reduced the severity of clinically relevant medication discrepancies in all categories, including those with the potential to cause serious harm (estimated rate ratio, 0.40; 95% confidence interval, 0.27 to 0.63). Usage data revealed that 72% of patients randomized to eKidneyCare completed one or more medication reviews per month, whereas only 30% of patients in the MyMedRec group (adjusted for dropouts) kept their medication profile on their phone.

Conclusions In patients who are high risk and have CKD, eKidneyCare significantly reduced the rate and severity of medication discrepancies, the proximal cause of medication errors, compared with the active comparator.

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Introduction

Adverse drug reactions (ADRs) are common in ambulatory patients with CKD, with a recent study reporting rates of 14.4 per 100 person-years overall and 2.7 per 100 person-years for serious ADRs (1). The economic consequences are immense, with increased health care utilization resulting from added outpatient visits and costly hospitalizations (2,3). Patients with CKD who have several comorbid conditions, take a large number of prescribed drugs, see multiple physicians, or have severely impaired kidney function are particularly at risk (1,4). Other contributing factors include prescribing errors, monitoring failures, and even the patients themselves, who often intentionally change or stop treatment without consulting their clinical team (1,5–7).

Improving medication safety and reducing the burden of ADRs are high priorities worldwide, as many instances are preventable (8). In patients with CKD, it is estimated that 32% of serious ADRs are likely or potentially preventable (1). However, past community-based preventive programs for patients with CKD showed little benefit (9,10), signaling the need for new approaches to optimize medication management (11). An important first step in improving medication safety is medication reconciliation, a process to identify and resolve medication discrepancies, the forerunner of serious ADRs (12,13). Although medication reconciliation is traditionally a clinician-driven endeavor, it is possible for patients who are ambulatory to become actively involved in

the process. This was shown in a study from Boston, Massachusetts, where patients were given online access to update medication data on an ambulatory electronic health record and report medication concerns to their physician before clinic visits (14,15). Poor communication between patients and clinicians is also an important major medication safety issue. In an ambulatory care study, 28% of adverse events classified as ameliorable were attributed to patients failing to notify their clinicians about medication-related problems, or the failure of physicians to address patient-reported symptoms (16). These communication failures can potentially be overcome by developing an integrated digital health platform that facilitates the bi-directional transfer of medication-related information between patients and clinicians in real time.

This study conflates a patient-centered approach to medication reconciliation with our experience in creating and evaluating mobile phone–based applications (apps) to support self-management for people with long-term health conditions (17,18). The apps' core features are algorithm-driven remote monitoring of key clinical parameters and the integration of the results into the workflow of the clinical team. We built the eKidneyCare app to enable patients with CKD to manage four self-care behaviors, including medications (19). The objective of this study was to evaluate in a randomized controlled trial the effectiveness of using the eKidneyCare app for medication reconciliation to reduce medication discrepancies. We hypothesized that its use by patients with CKD would decrease the rate and severity of medication discrepancies, the proximal cause of serious ADRs in this high-risk population, compared with the active comparator, MyMedRec, a standalone app for storing medication and other health information (20).

Materials and Methods

Study Design

This study is a 1-year, single-blind (investigators), randomized controlled trial comparing the use of eKidneyCare to MyMedRec for medication management in patients with CKD.

Setting and Study Participants

Clinic staff at each of six nephrology outpatient clinics at the University Health Network and Mount Sinai Hospital, academic medical centers in Toronto, Canada, screened English-speaking adults (≥18 years of age) with CKD stage 3b to stage 5d (eGFR <45 ml/min to dialysis) for eligibility. Those who had medically documented cognitive impairment, lived in a long-term care facility, were taking <2 prescription medications, were unavailable for extended periods of time, or were participating in other intervention trials were excluded. The institutional research ethics board approved the study (institutional research ethics board number: 16–5002), and all participants gave written informed consent.

Recruitment and Randomization

Eligible patients were mailed a study information sheet, and those interested in participating were asked to contact the study staff. Recruitment occurred over 4 months until the required sample size was reached. Enrollees were randomized in a 1:1 ratio using a secure web-based service (Randomize.net, Ottawa, Canada) to generate randomized block permutations stratified by dialysis status. Each randomization code was paired to a smartphone (Samsung Galaxy Grand Prime, Seoul, South Korea) preloaded with eKidneyCare or MyMedRec. All study participants received a smartphone containing the assigned mobile app and Bluetooth-enabled home BP monitor (Life Source UA-767; A&D Medical, San Jose, CA) with instructions on use from the Canadian Hypertension Education Program. They were advised to ask their physician about the frequency of home BP measurements. All participants received instructions on features and functionalities of their assigned mobile app. Each study subject completed the Rapid Estimate of Adult Literacy in Medicine test and questionnaires to determine familiarity with and use of technologic tools and home BP monitoring.

Intervention

The experimental intervention was eKidneyCare, and the system architecture is illustrated in Figure 1. Components included a smartphone app and a Bluetooth-enabled BP monitor for patients, a web-based dashboard for clinicians, data servers to execute algorithms, and interfaces with clinical repositories for medications and laboratory results. eKidneyCare targeted four self-care behaviors: managing medications, monitoring BP, assessing symptoms, and tracking key CKD laboratory tests (eGFR, hemoglobin, potassium, phosphate). For medication management, it prompted patients monthly to review their medication list on their smartphone and reported changes, additions, or medication problems to the clinical team for reconciliation and, if necessary, initiation of interventions. eKidneyCare automatically synchronized with the clinic pharmacy database to ensure patients had an updated medication list on their smartphone. Built-in algorithms reminded patients to take BP measurements, with contextualized results displayed immediately on the smartphone screen. It alerted nurses and physicians if BP thresholds were exceeded. Furthermore, each month, eKidneyCare prompted patients to assess for the presence and severity of CKD-related symptoms and alerted the clinical team should action be necessary. Finally, key CKD test results were automatically sent to the patients' smartphones, along with system-generated interpretive messages.

The control group received a smartphone preloaded with the MyMedRec app and home BP monitor. MyMedRec is a commercially available, standalone app specifically designed for users to manually enter and maintain a comprehensive health record such as a medication list, BP readings, and laboratory test results. Users have the option to share it with other individuals, including health care providers, *via* a built-in email feature.

All patients continued to receive usual care and followed standard clinic procedures. Given the nature of the intervention, it was not possible to conceal treatment assignments from patients, clinical staff, and study coordinators. Research staff involved in assessing outcomes, including adjudication of medication discrepancies and their clinical

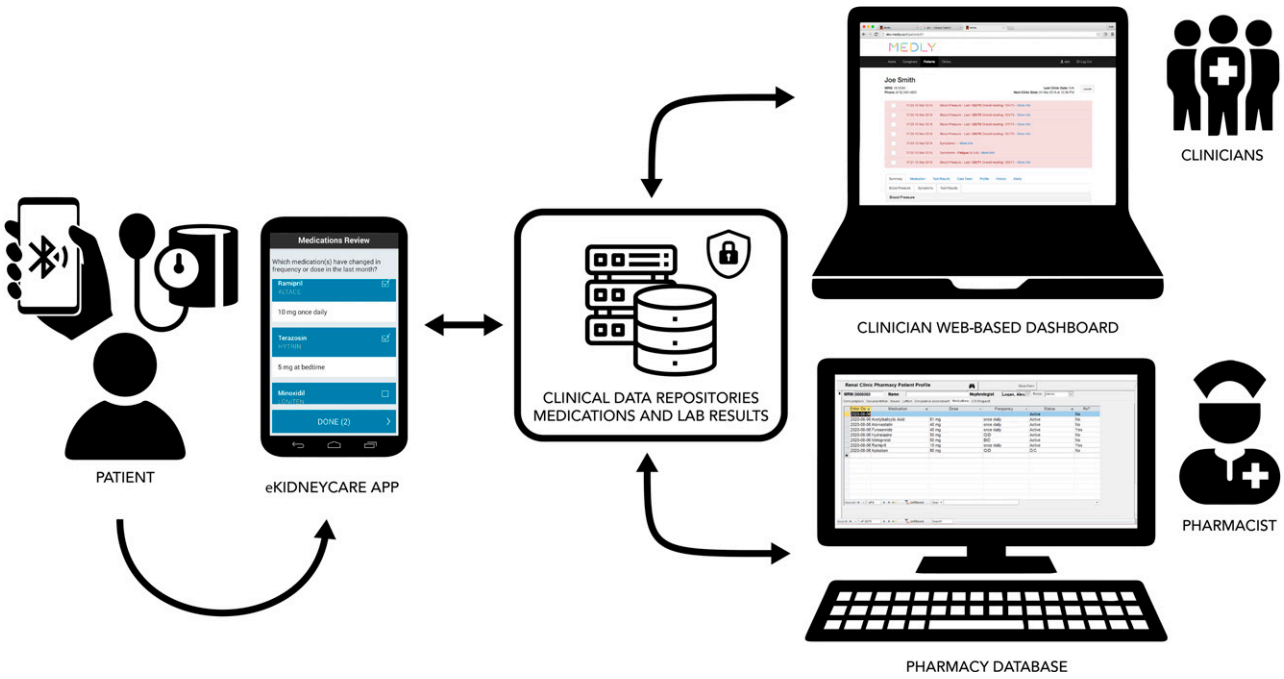


Figure 1. | System architecture. The components included a smartphone application and Bluetooth-enabled BP monitor for patients, web-based dashboard for clinicians, data servers to execute algorithms and store data, and live interfaces with clinical repositories for medications and laboratory results.

severity, and providing technical support were blinded to treatment assignment.

Assessments

The effectiveness of eKidneyCare was assessed by collecting data on key variables at baseline and study exit. Medication discrepancies were identified by having a pharmacist or certified pharmacy student take a comprehensive medication history from patients and comparing the information to the medical chart and retail pharmacy record. Differences in dose or frequency of all medications and unexplained presence or absence of medications were recorded as discrepancies (21). The total number of medication discrepancies for all medications and clinically relevant medications were determined, defining clinically relevant as any medication related to CKD treatment (antihypertensives, hypoglycemics, phosphate binders, anemia agents). All clinically relevant discrepancies were further categorized for their severity independently by four individuals using the National Coordinating Council for Medication Error Reporting and Prevention Index (22,23) (Supplemental Appendix 1). Agreement by three was required to designate a severity category for a discrepancy, and disagreements were resolved by a fifth adjudicator. Medications used for dialysis treatments (*e.g.*, heparin, antibiotics) were not included as part of the medication assessment.

BP was assessed in the clinic and at home using standardized protocols. Clinic measurements were taken with patients sitting alone in a quiet room by the BpTru BPM 200 sphygmomanometer, which automatically takes six readings and averages the last five. Home readings were taken in the sitting position, using an automated validated home BP monitor. Patients took two BP readings daily in the morning and evening for 7 days, and the second of the two paired readings was averaged to derive the summary measure.

Satisfaction with the mobile app was derived from usage data stored on the data servers and smartphones, and reported as the frequency and duration of app use. Data on patient-reported outcomes were obtained by having participants complete the Hospital Anxiety and Depression Scale, the Veterans Rand 12-item health survey, and the EuroQol-5 Dimension on entry and at exit. Patient characteristics, comorbidities, laboratory tests, and number of emergency room visits and hospitalizations during the study period were collected from electronic and clinic medical records.

Outcomes

The primary outcome was the medication discrepancy rate for all medications at exit, calculated as the total number of medication discrepancies standardized for the total number of medications (number of medication discrepancies per medication). Secondary outcomes included clinic (6 and 12 months) and home BP (12 months), CKD-specific (hemoglobin, potassium, and phosphate) laboratory test results, other medication outcomes including the clinical severity of medication discrepancies, satisfaction measured by mobile app usage, and quality of life scores from patient-reported outcome measures.

Sample Size

Sample size was based on reported medication discrepancy rates and changes observed in prior randomized controlled trials of hospital-based medication reconciliation interventions, given the paucity of comparable community-based intervention data (24). We calculated that 80 study

subjects per arm would give 80% power to detect an absolute reduction in the percentage of participants, with a medication discrepancy from 65% to 43%, and with a two-sided 5% significance level in a *z*-test for two proportions. Based on an anticipated attrition rate of 10%, we increased the number to 88 subjects per arm.

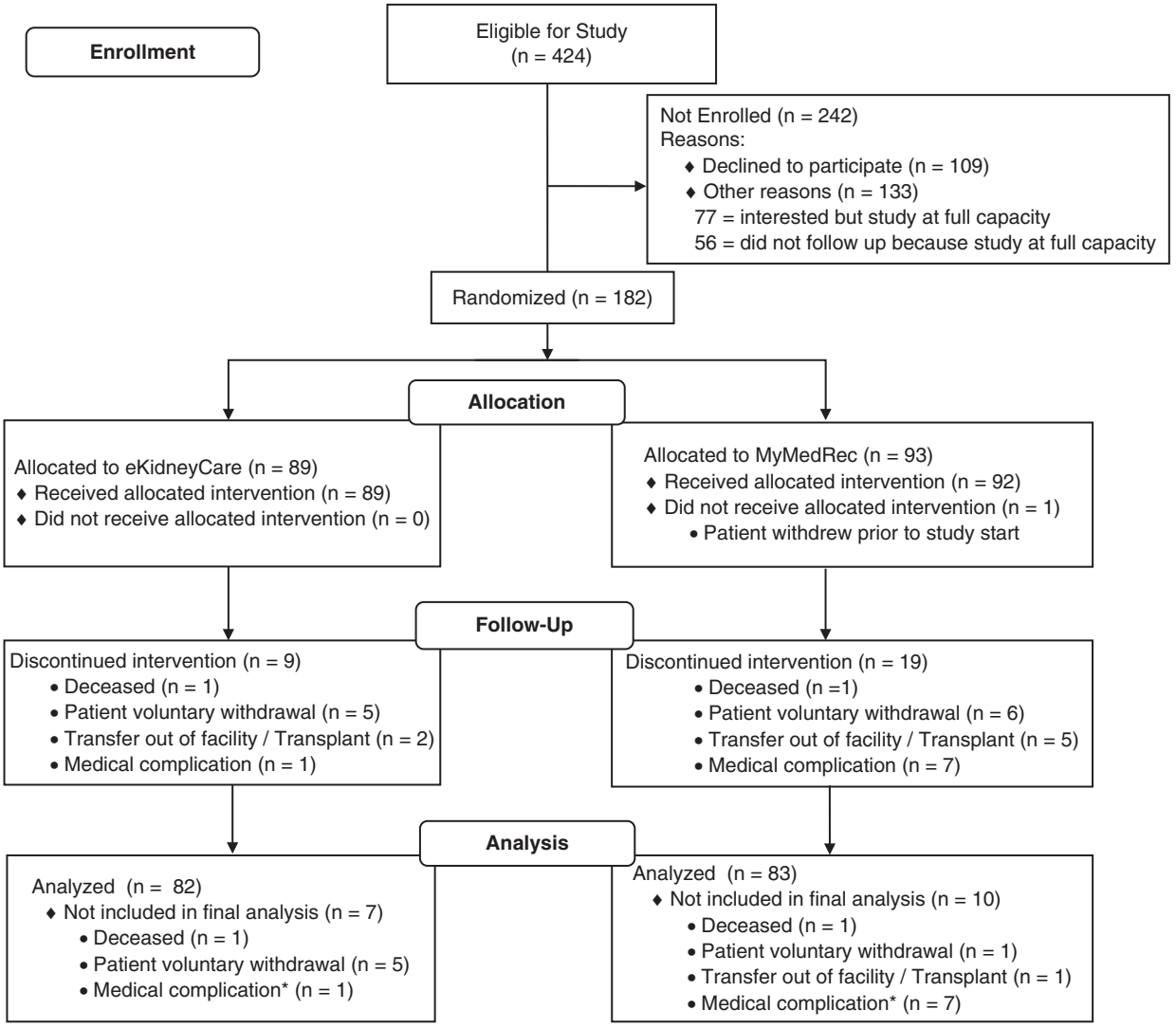
Data Analysis

Continuous variables were summarized as mean±SD or median and interquartile range (IQR), as appropriate, and categorical variables were summarized by counts and frequencies. The primary outcome (number of discrepancies per medication) was compared between groups using the Wilcoxon rank-sum test. Sensitivity of the primary analysis to missing data was assessed using a multiple imputation procedure, with the baseline value of the outcome predicting the 1-year value by predictive mean matching of the R package mice (25). Results for a two-sample comparison of means were pooled over 100 imputed datasets, and the Wilcoxon rank-sum *P* value was also computed on each dataset. Rate ratio and 95% confidence interval (95% CI) estimates for number of medication discrepancies per year were derived from Poisson regression, with per-subject random effects to account for overdispersion. Statistical tests of interaction were used to assess whether the effects of the intervention were consistent across prespecified subgroups. Statistical significance of changes in laboratory parameters was assessed using paired *t* tests for continuous variables or McNemar's test for binary variables. All tests used a two-tailed α of 0.05. Data were analyzed using R (version 4.0.2; R Foundation for Statistical Computing, Vienna, Austria).

Results

Patients

Of the 424 patients who were potentially eligible (Figure 2), 109 (26%) declined participation, and 133 (31%) were



* Medical complication indicates participants who had a serious clinical event and were unable to continue in the study; consequently, no endpoint data were collected.

Figure 2. | **CONSORT diagram.**

not further contacted as the required sample size was reached. In total, 182 (43%) were randomized to eKidneyCare ($n=89$) or MyMedRec ($n=93$). Overall, 154 (85%) completed the full study duration. Of those who discontinued early, 12 (7%) voluntarily withdrew, and of the remainder ($n=16$), 11 patients agreed to complete the endpoint assessment (total assessed=165%, 91%). Mean study duration of follow-up was 10.8±2.8 months.

The primary causes of CKD are summarized in Supplemental Appendix 2, and the baseline characteristics in Table 1. The majority of participants were White (56%) and male (65%), and the mean age was 57±15 years. Most (92%) had two or more comorbid conditions. The median number of medications in the two study groups at entry was similar, and 51% of all patients were prescribed ten or more medications. At entry, 70% of patients had at least one clinically relevant medication discrepancy. No group differences were seen in total medication discrepancies and clinically relevant medication discrepancies per patient. The proportion of all patients labeled as having hypertension at entry was 69%, and the majority (67%) had their BP under control (clinic BP ≤135/85 mm Hg). Baseline characteristics of patients, their use of technology and home BP monitoring devices, and other variables were well balanced, with no significant differences.

Medication Discrepancy Outcomes

The primary outcome of discrepancy rate for all medications was 0.45 (IQR, 0.33–0.63) in the eKidneyCare group and 0.67 (IQR, 0.40–1.00) for the MyMedRec group ($P=0.001$), and the change from baseline was 0.13±0.27 in the eKidneyCare group and 0.30±0.41 in the MyMedRec group ($P=0.007$). Sensitivity analysis using multiple imputations for missing primary outcome values did not change the results. For clinically relevant medications, the discrepancy rates were 0.33 (IQR, 0.20–0.46) for eKidneyCare and 0.50 (IQR, 0.32–0.72) for MyMedRec, respectively ($P<0.001$), with the change from baseline being significantly lower for eKidneyCare than MyMedRec (0.02±0.29 versus 0.18±0.43, $P=0.004$) (Table 2). Drug classification associated with clinically relevant medication discrepancies is outlined in Supplemental Appendix 3.

The total number of clinically relevant medication discrepancies per patient with the potential to cause patient harm overall and by severity category was significantly lower in the eKidneyCare than the MyMedRec group (Table 2). For discrepancies where the potential for harm is considered severe, the total number was 0.27±0.54 in the eKidneyCare group, compared with 0.63±0.91 in the MyMedRec group ($P=0.002$), with a rate ratio of 0.40 (95% CI, 0.24 to 0.66).

BP, Laboratory, and Other Secondary Outcomes

There were no significant within-group or between-group changes in BP, laboratory tests, and patient-reported outcome measures from baseline to exit (Table 3). Usage data revealed 72% of eKidneyCare users completed one or more medication reviews per month of study participants (Figure 3A). In contrast, only 28 MyMedRec users (30%, adjusted for dropouts) had a medication profile on their phone. Patients using eKidneyCare also took almost twice as many BP readings as those using MyMedRec (median, 194; IQR, 94–338 versus 102; IQR, 28–182, $P<0.0001$), in a sustained pattern over the 1-year study (Figure 3B).

Discussion

In this randomized controlled trial, we found that patients who used eKidneyCare, a fully integrated digital health app, had better outcomes than those using MyMedRec. Our results showed total and CKD clinically relevant medication discrepancies were significantly lower for the eKidneyCare group compared with the MyMedRec group at exit. The observed benefits were consistent across all categories of severity, and eKidneyCare users experienced nearly half the number of discrepancies that potentially can cause serious harm to patients with CKD and lead to hospitalization. Patients using eKidneyCare frequently used the medication feature throughout the study, and compared with MyMedRec participants, were more adherent with home BP monitoring and sustained that activity throughout. The study highlights the acceptability and sustainability of using eKidneyCare features and its effectiveness in reducing medication discrepancies, the forerunner of ADRs.

There are several reasons that might account for the better results with eKidneyCare on medication management. First, it recognizes the importance of patient participation in their own care and strengthens their role in maintaining an accurate medication list. Second, eKidneyCare extends medication management beyond the traditional medication reconciliation process by opening communication channels between patients and their clinical team between clinic visits, so that medication discrepancies and related problems can be addressed early to prevent ADRs. It has been posited that the lack of patient-clinician communication or the patient's inability to communicate medication-related concerns may account for more than half of preventable ADRs in ambulatory care (16,26,27). Although this study was not adequately powered to evaluate whether eKidneyCare can avert serious ADRs, we did observe a 60% rate reduction in discrepancies that could seriously harm patients and result in emergency room visits and hospitalization. The possibility of increased health care utilization is supported by recent evidence demonstrating an association between medication discrepancies and hospitalization in patients with CKD (28). Finally, eKidneyCare breaks down medication data silos, which studies have shown magnify medication errors (29,30), by allowing all users access to a common clinic pharmacy database and through secure communication channels, seamlessly connecting all stakeholders so that issues surrounding medication safety can be addressed quickly and efficiently. The integrated process of medication review and the synchronization of the patients' apps with the clinical pharmacy database also ensured that patients using eKidneyCare always had an updated medication list on their smartphone.

This study demonstrated for the first time that it is feasible to engage patients remotely in medication reconciliation and sustain their involvement over a year. The high rate of use of the medication feature in eKidneyCare throughout the study suggests patients perceived value in using it, and willingly accepted the responsibility of being involved in medication reconciliation. eKidneyCare also captures the trend toward increased home management of

Table 1. Baseline patient characteristics

Variable[a]	eKidneyCare	MyMedRec
N	89	93
Age, yr (SD)	56 (14)	58 (16)
Male, *n* (%)	54 (61)	64 (69)
CKD stage, *n* (%)		
3b	11 (12)	13 (14)
4	24 (27)	33 (36)
5	25 (28)	16 (17)
Dialysis	29 (33)	31 (33)
Home nocturnal hemodialysis	18 (20)	19 (20)
In-center hemodialysis	0 (0)	1 (1)
Peritoneal dialysis	11 (12)	11 (12)
Education, *n* (%)		
Graduate	10 (11)	24 (26)
College/University	53 (60)	51 (55)
High school	19 (21)	15 (16)
Primary school	5 (6)	2 (2)
Not stated	2 (2)	1 (1)
Health literacy REALM scores, *n* (%)		
Grade 3 or below	0 (0)	2 (2)
Grade 4–6	4 (5)	1 (1)
Grade 7–8	21 (24)	16 (18)
High school	62 (71)	71 (79)
Ethnicity, *n* (%)		
White	53 (60)	49 (53)
Black (Non-Hispanic)	10 (11)	17 (18)
Asian (Southeast Asian, Asian, South Asian)	22 (25)	26 (28)
First nations	1 (1)	0 (0)
Hispanic	2 (2)	1 (1)
Other or did not disclose	1 (1)	7 (8)
Comorbidity		
Number of comorbidities, median (IQR)	4 (3–6)	5 (3–7)
Number of comorbidities, *n* (%)		
0–1	5 (6)	10 (11)
2–3	29 (33)	17 (18)
4–5	27 (30)	29 (31)
≥6	28 (32)	37 (40)
Diabetes mellitus, *n* (%)	26 (29)	31 (33)
Hypertension, *n* (%)	65 (73)	60 (65)
Medications		
Total number of medications per patient, median (IQR)	10 (8–14)	11 (8–15)
Number with ten or more medications, *n* (%)	44 (49)	48 (52)
Antihypertensive medications, median (IQR)	2 (1–4)	2 (1–4)
Number with HTN medications, *n* (%)		
0	11 (12)	14 (15)
1	17 (19)	20 (21)
2	19 (21)	19 (20)
≥3	42 (47)	40 (43)
Total medication discrepancy rate, median (IQR)	0.38 (0.25–0.54)	0.38 (0.29–0.53)
Clinically relevant medication discrepancy rate, median (IQR)	0.33 (0.20–0.46)	0.30 (0.17–0.50)
BP, mm Hg, mean±SD, mm Hg		
Clinic systolic BP	125±23	122±20
Clinic diastolic BP	77±13	76±13
Home systolic BP	129±20	126±18
Home diastolic BP	77±13	76±12
Laboratory tests, *n* (%) in range		
Hemoglobin (10.0–12.0 g/dl)	47 (53)	53 (57)
Potassium (3.5–5.1 mEq/L)	77 (88)	80 (87)
Phosphate (<4.6 mg/dl)	29 (39)	27 (34)
Patient-reported outcome measures, mean±SD		
Hospital Anxiety and depression scale	8.7±5.8	9.0±6.3
Veterans Rand-12 physical component score	39.6±10.4	40.2±9.6
Veterans Rand-12 mental component score	50.2±9.2	49.8±10.7
EQ-5D	0.8±0.2	0.8±0.2
Use of technology, *n* (%)		
Personal computer	75 (84)	77 (83)
Smartphone	53 (60)	56 (60)
Cellphone	43 (48)	42 (45)
Tablet	49 (55)	53 (57)
Home BP monitor	66 (74)	63 (68)

Table 1. (Continued)

Variable[a]	eKidneyCare	MyMedRec
N	89	93
Use of medication management tools, *n* (%)		
Nothing	30 (34)	25 (27)
Blister package	9 (10)	9 (10)
Dosette box	31 (35)	35 (38)
Handwritten list	12 (14)	9 (10)
Self-generated computer list	8 (9)	7 (8)
Pharmacy-generated list	10 (11)	17 (18)

REALM, Rapid Estimate of Adult Literacy in Medicine; IQR, interquartile range; HTN, hypertension; EQ-5D, EuroQol-5 Dimension.
[a]There were no significant differences between the two groups for any variable.

chronic conditions, now spurred on by the COVID-19 pandemic, and demonstrates the feasibility of conducting medication reconciliation without the necessity of face-to-face interviews. The severe restrictions on in-person clinical visits have accelerated the adoption of technologies that enhance home care and integrate medical information. eKidneyCare is perfectly placed to take advantage of these changes, by offering patients an effective digital health tool that supports the self-management of many facets of kidney care. Finally, the study showed the limitations of standalone apps such as MyMedRec because only a minority of patients kept their medication profile on their phone.

This study has some limitations. We have no data on how frequently individuals randomized to MyMedRec actually performed medication reconciliation. Also, medication discrepancies were only categorized by their potential for patient harm, a process measure, and not actual ADRs. A study designed to relate ADRs to health-resource outcomes or clinical events would require a larger study of longer duration. There may be concerns about the generalizability of the study's findings, in that participants with higher education levels and considerable experience using a smartphone were overrepresented. More than likely, individuals on dialysis had more intensive medication

Table 2. Medication discrepancy outcomes at exit by study group

Outcome	eKidneyCare (*n*=82)	MyMedRec (*n*=83)	*P* value
Primary outcome			
All medications			
Discrepancy rate, median (IQR)	0.45 (0.33–0.63)	0.67 (0.40–1.00)	0.001
Change in discrepancies from entry, mean±SD	0.13±0.27	0.30±0.41	0.007
Number of discrepancies per patient, median (IQR)	5 (3–7)	6 (4–10)	0.01
Total number of medications per patient, median (IQR)	11 (8–14)	11 (8–13)	0.95
Secondary outcomes			
Proportion of patients with ≥1 clinically relevant medication discrepancies, *n* (%)	62 (70)	70 (75)	0.30
Clinically relevant medications			
Discrepancy rate, median (IQR)	0.33 (0.20–0.46)	0.50 (0.32–0.72)	<0.001
Change in discrepancies from entry, mean±SD.	0.02±0.29	0.18±0.43	0.004
Number of clinically relevant discrepancies per patient, median (IQR)	3 (2–4)	4 (2–6)	0.001
Number of clinically relevant medications per patient, median (IQR)	8 (6–11)	8 (6–11)	0.97
Severity of clinically relevant medication discrepancies[b], mean±SD			
All categories	2.66±2.19	4.16±3.70	0.004 0.61 (0.48–0.78)[a]
Category D or higher	1.66±1.88	3.08±3.31	<0.001 0.52 (0.38–0.70)[a]
Category E or higher	0.94±1.25	1.65±1.83	0.002 0.54 (0.39–0.76)[a]
Category E1 or higher	0.27±0.54	0.63±0.91	0.002 0.40 (0.24–0.66)[a]

IQR, interquartile range.
[a]Rate ratio (95% confidence interval).
[b]Severity on the basis of National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) Index.

Table 3. Secondary outcomes at exit by study group

Variable	eKidneyCare	*n*	MyMedRec	*N*	*P* Value
BP, mm Hg[a]					
Clinic BP, mean±SD					
6 mo systolic BP	−0.16±20.1	82	−1.21±18.9	77	0.78
Diastolic BP	−0.26±11.1	82	−1.78±9.9	77	0.24
12 mo systolic BP	−1.81±22.2	83	−2.61±19.4	82	0.78
Diastolic BP	−1.52±12.9	83	−1.49±10.3	82	0.91
Home BP, mean±SD					
12 mo systolic BP	−2.22±16.9	80	0.96±14.1	62	0.33
Diastolic BP	−0.26±8.9	80	0.10±7.1	62	0.92
Laboratory, mean±SD[a]					
Hemoglobin, g/dl	0.01±1.29	74	0.25±1.11	66	0.31
Potassium, mEq/L	−0.1±0.6	73	−0.1±0.7	67	0.71
Phosphate, mg/dl	0.03±1.36	61	−0.19±1.49	53	0.42
Patient-reported outcome, mean±SD[a]					
HADS	−0.1±4.6	81	0.5±5.8	70	0.33
VR12-PCS	−0.1±9.8	83	0.2±7.6	79	0.88
VR12-MCS	−1.1±8.9	83	−0.7±10.3	79	0.46
EQ-5D	0.8±0.1	82	0.8±0.2	77	0.41
Patient satisfaction: Mobile app data usage					
Per-person totals of BP measurements over study period, median (IQR)	194 (94–338)	89	102 (28–182)	93	<0.001
Number of patients with a gap >60 d between consecutive BP readings over follow-up, *n* (%)	13 (15)	89	63 (68)	93	<0.001

HADS, Hospital Anxiety and Depression Scale; VR12-PCS, Veterans Rand-12 Physical Component Score; VR12-MCS, Veterans Rand-12 Mental Component Score; EQ-5D, EuroQol-5 Dimension; IQR, interquartile range.

[a]Mean±SD change from baseline to exit, with positive numbers indicating an increase and negative a decrease.

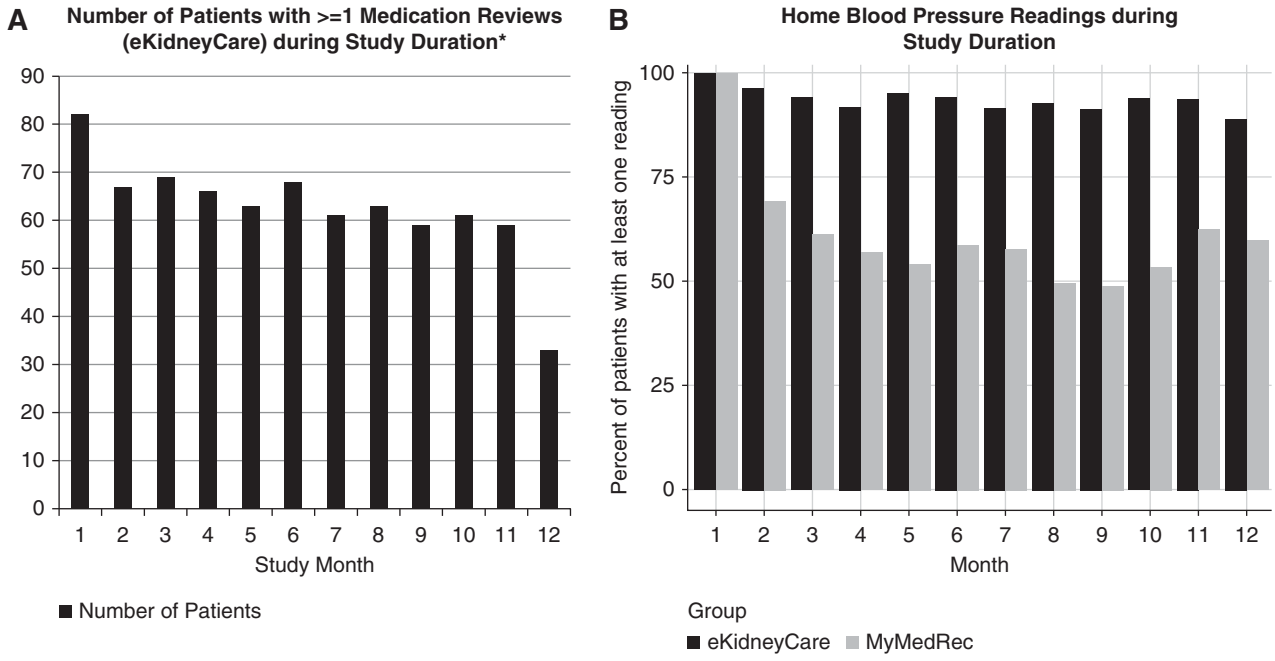


Figure 3. | **Mobile application usage data and sustainability.** (A) Number of patients using eKidneyCare with ≥ one patient-initiated medication review during the study duration. (B) Percentage of patients by group with at least one home BP reading per month. *The sharp reduction in the number of medication reviews in study month 12 is related to the large number of participants completing the study exit assessment in the 11th month. The mean study duration was 10.8 months.

oversight given their frequent provider interactions, which may have affected the number or severity of medication discrepancies. As patients were randomized, we anticipate any bias may have been present equally in both study arms and postulate that the frequent contact would reduce the observed effect size of the intervention. Criticism that there was no control group, representing the current standard of care, is mitigated by the observation that the majority of study participants did not use MyMedRec to add medication information, although it was downloaded on their phone and ready for use. Finally, although we followed the instructions on the use of MyMedRec, it is certainly possible that prepopulation of MyMedRec with medication information as we did for eKidneyCare might have affected the outcome of the study.

In summary, eKidneyCare offers patients who are high risk an effective digital tool to address the problem of medication safety from home. The study also demonstrated it is possible to actively integrate patients remotely in medication reconciliation and sustain their involvement over a year.

Disclosures

A. Logan reports employment with University of Toronto; and reports receiving research funding from Philips Respironics. E. Porter, G. Tomlinson, and S. Ong report employment with University Health Network. J. Cafazzo reports employment with University Health Network; reports serving as a member of the Medical Devices Advisory Committee Board of Novo Nordisk and chair of Scientific Advisory Committee, Digital Health Technologies, Health Canada; and served as a speaker for National Speakers Bureau. S. Jassal reports employment with University Health Network and University of Toronto and receiving honoraria from Otsaka (April 2020); Alexion, Janssen Ortho, and Sanofi provide unrestricted educational grants for educational meetings in which S. Jassal participates. All remaining authors have nothing to disclose.

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Data Sharing Statement

The individual deidentified participant data, including demographic information, the primary study outcome (medication discrepancies), the secondary outcomes, and other covariables, will be shared after the study results are published. Study documents including study protocol and clinical documents will also be available. To request access to this information, individuals should

contact Dr. A.G. Logan. Data access must be approved by the University Health Network Institutional Review Board.

Supplemental Material

This article contains the following supplemental material online at http://cjasn.asnjournals.org/lookup/suppl/doi:10.2215/CJN.15020920/-/DCSupplemental.

Supplemental Appendix 1. Medication discrepancy classification.

Supplemental Appendix 2. Primary CKD cause by study group.

Supplemental Appendix 3. Drug classification for clinically relevant medication discrepancies.

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