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The Patient-Held Active Record of Medication Status (PHARMS) study:

a mixed-methods feasibility analysis

Abstract

Background
Medication errors frequently occur as patients transition between hospital and the community, and may result in patient harm. Novel methods are required to address this issue.

Aim
To assess the feasibility of introducing an electronic patient-held active record of medication status device (PHARMS) at the primary–secondary care interface at the time of hospital discharge.

Design and setting
A mixed-methods study (non-randomised controlled intervention, and a process evaluation of qualitative interviews and non-participant observation) among patients >60 years in an urban hospital and general practices in Cork, Ireland.

Method
The number and clinical significance of errors were compared between discharge prescriptions of the intervention (issued with a PHARMS device) and control (usual care, handwritten discharge prescription) groups. Semi-structured interviews were conducted with patients, junior doctors, GPs, and IT professionals, in addition to direct observation of the implementation process.

Results
In all, 102 patients were included in the final analysis (intervention $n = 41$, control $n = 61$). Total error number was lower in the intervention group (median 1, interquartile range [IQR] 0–3) than in the control group (median 8, IQR (4–13.5, $P<0.001$), with the clinical significance score in the intervention group also being lower than the control group (median 2, IQR 0–4 versus median 11, IQR 5–20, $P<0.001$). The PHARMS device was found to be technically implementable using existing information technology infrastructure, and acceptable to all key stakeholders.

Conclusion
The results suggest that using PHARMS devices within existing systems in general practice and hospitals is feasible and acceptable to both patients and doctors, and may reduce medication error.

Keywords
electronic health records; general practice; medication errors; patient transfer; secondary care.

INTRODUCTION

Discharge from hospital to the community is associated with adverse events, with one in five patients experiencing an event within 3 weeks of hospital discharge.[1] Medication error is a major potentially preventable source of these adverse events.[1,2] Uncertainty surrounding what medications have been added, stopped, or altered in hospital is a common issue for GPs, and has the potential to lead to medication error.[3–5] Communication of discharge medication information to GPs is often not timely, resulting in an absence of up-to-date information when issuing a prescription.[6,7] The accuracy of medication information received is an additional concern, due to the high frequency of prescribing error in the hospital setting.[8–10]

Medication reconciliation, the formal process for identifying and correcting unintentional medication discrepancies during transitional care, is widely advocated.[11–13] The goal is to provide the patient and healthcare professionals with an up-to-date and accurate list of medications that is available in all settings and stages of care.[14] However, consensus has not been reached regarding the optimal method of generating and documenting accurate medication information during transitional care,[15] and the availability of such a list largely remains elusive in day-to-day practice.

In a consensus statement on medication reconciliation, Greenwald *et al* stated: *'A personal health record that is integrated and easily transferable between sites of care is needed to facilitate successful medication reconciliation.'*[14] In recent years, significant developments pertaining to eHealth — the use of information and communication technologies for health — have taken place.[16] Electronic patient health record systems are now used by >90% of GPs in Ireland and the UK.[17,18] Successful integration and transfer of electronic patient information between sites at a local, national, and international level remains a challenge, however.[18–22] Complete and universal electronic integration of patient information within and between primary and secondary care settings has yet to be achieved.

The patient represents the one constant in the transitional care process, and patient-held records may improve continuity of care and enhance patient empowerment.[23] Evidence suggests improved quality, completeness, and timeliness of delivery of electronic discharge information, with a subsequent reduction in medication error.[24–26] Hence, an electronic patient-held medication record may provide a solution

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How this fits in

Errors at hospital discharge are common and have negative clinical and economic consequences for patients, GPs, and hospital doctors. Establishing effective methods of reducing medication error as patients move between hospital and the community is a current priority in health care. With evidence suggesting improved quality of electronic discharge information, and the patient being the one constant in transitional care, a patient-held electronic medication record may be a solution. This study demonstrated that introducing a novel patient-held electronic medication record in existing primary and secondary care systems is technically and clinically feasible and acceptable, and may reduce medication error at hospital discharge.

to current issues arising at hospital discharge. GPs have a central role in overall patient care, and have been identified as accurate providers of patient medication information.[27] Giving a patient's GP overall responsibility for adjusting and updating an electronic patient-held medication record could potentially reduce errors arising from the involvement of multiple doctors in different stages and settings of care.[28,29]

Though potentially beneficial, the development of such a novel electronic intervention compatible with diverse and constantly evolving electronic healthcare systems presents challenges. Implementation of eHealth to date has not been straightforward.[20,30] Use of paper records within current healthcare systems may well be outdated, but the attributes of simplicity and universal applicability remain relevant. To this end, the authors sought to use a simple and commonly employed universal serial bus (USB) technology, and developed a novel electronic patient-held active record of medication status (PHARMS) device using this technology.[31] The device developed is key shaped and operates through the USB port of any computer where appropriate software has been installed. The device, once activated, provides a link to the patient's medication information in their electronic record in general practice (further details are available from the authors on request).

Successful development and implementation of a novel intervention within the healthcare setting requires a detailed understanding of the context in which it is being introduced, and the potential barriers to implementation. The overall aim of this study was to assess the feasibility of introducing an electronic patient-held medication record at the primary–secondary care interface at the time of hospital discharge, first by examining the performance of the device, and second by determining the acceptability of the initiative to key stakeholders (patients, doctors, information technology [IT] personnel), and identifying the barriers and facilitators to the process of its implementation.

METHOD

A mixed-methods study comprising a non-randomised controlled intervention, and a process evaluation comprising qualitative interviews and non-participant observation was conducted. A detailed account of study methodology is provided in the protocol for this study.[31]

The study was conducted in the five general medical and surgical wards of an urban 350-bed hospital and in general practices in County Cork, Ireland, between January and July 2016. Following admission to hospital, potentially eligible community-dwelling older adult patients (≥60 years) prescribed three or more medications were identified from a patient admission list generated on a daily basis. Patients who were resident in long-term care facilities, unable to provide written informed consent, or in receipt of end-of-life care were excluded. Written informed consent was obtained from patients.

Patients from four urban GP practices in which appropriate software had been installed were assigned to the intervention group and issued with a PHARMS, which was used at the time of discharge (further information is available from the authors on request). Eligible patients from GP practices, other than the four intervention practices, were assigned to the control group, and received usual care in the form of a handwritten discharge prescription.

Data on pre-admission and hospital discharge medication information, patient age, length of stay, medication number on admission, and functional status were collected for all patients. Functional status was assessed in terms of independence relating to continence, mobility, feeding, and dressing, as documented in the patient's notes. Medical card status (a means-tested national public health insurance system entitling the holder to free access to health care) was used as a proxy measure for socioeconomic status (SES).

Box 1. Errors on prescriptions

Patient demographic and legal requirements[32]

- Name and address
- Date
- Age or date of birth
- Prescriber's signature
- Irish Medical Council (IMC) registration number for the prescribing physician

Therapeutics

- Legibility/accuracy of spelling
- Presence of strength/dose/frequency
- Quantity
- Presence of drug–drug interactions as per Stockley's Drug Interactions (https://www.medicinescomplete.com)
- Omission of a pre-admission medication[2]

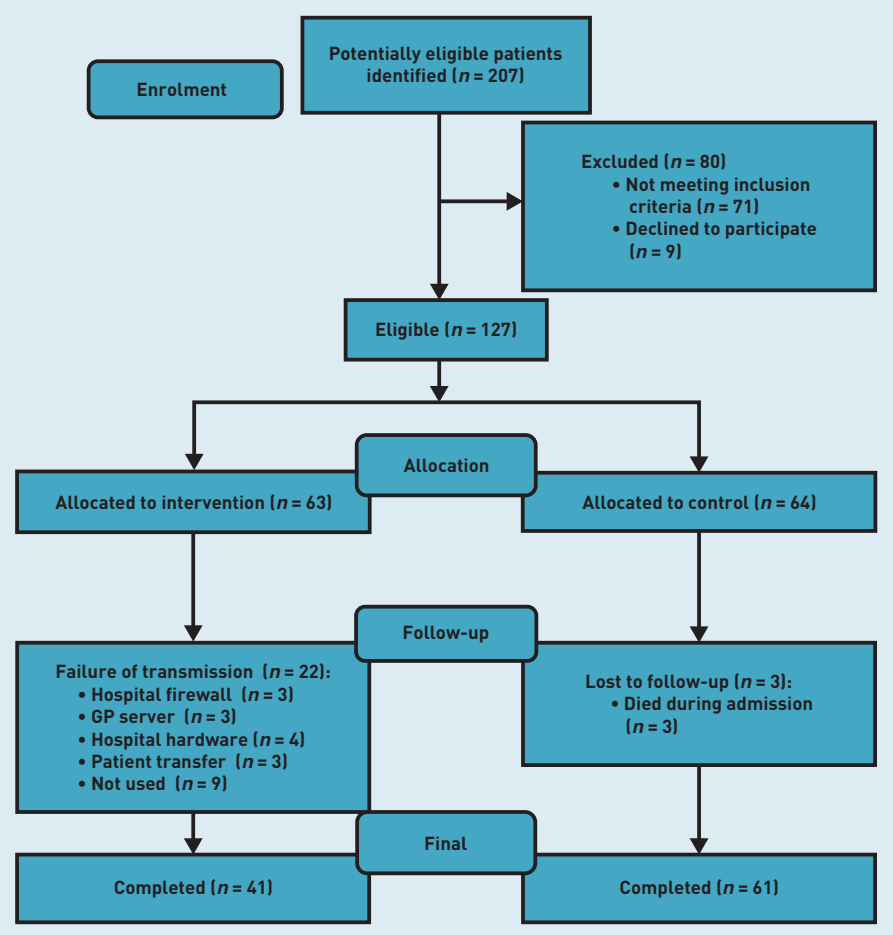
Clinical outcomes

Discharge prescriptions of intervention and control patients were examined for errors, and patients' doctors informed if errors posing clinical risk were detected. Box 1 gives a description of errors on prescriptions.

Errors were reviewed independently by a GP and a clinical pharmacist, and classified as significant, serious, or life threatening. Any discrepancies were resolved with the input of another GP. Error severity weights of $1^2 = 1$ (significant), $2^2 = 4$ (serious), and $3^2 = 9$ (life threatening), respectively, were assigned to reflect the relative potential of each error type to cause patient harm, and an error score was calculated for each patient (further information is available from the authors on request).[33]

Data were anonymised, coded, and entered into a Microsoft Excel (2010) spreadsheet on a password-protected computer. Statistical analysis was conducted using IBM SPSS version 24. Differences in baseline characteristics between groups were tested using the χ^2 test, *t*-test, and Mann–Whitney *U* test. Total error numbers and error scores were compared between groups using the Mann–Whitney *U* test. Occurrence of individual types of error between groups was compared using Fisher's exact text. Negative binomial regression models were used to analyse the association of group, sex, functional status, SES, age, and length of stay, with both error numbers and error scores. Statistical significance was determined using a *P*-value of <0.05.

Figure 1. Flow diagram of patient selection.



Process evaluation

Qualitative interviews. Semi-structured interviews were conducted with a census sample of the healthcare professionals involved in the study (junior doctors, GPs, and IT professionals). Suitability of a patient for interview was checked with the patient's GP before contacting the patient, and all intervention patients who were available to participate were contacted. Interviews were recorded, transcribed, and coded. Data were analysed iteratively using thematic analysis.[34] Dual independent coding of the first three transcripts of interviews with GPs, junior doctors, and patients ($n = 9$) was conducted by two members of the research team. Transcripts were read, and initial codes were generated and discussed at a research meeting, and a coding system agreed. All subsequent interviews were analysed by one of the researchers adhering to the principles of constant comparison,[35] and overseen by two others. Dual independent coding of all interviews with IT professionals ($n = 2$) was conducted by two researchers. Codes were discussed and a coding system agreed. NVivo Software Version 11 was used for data management (topic guides are available from the authors on request).

Non-participant observation. Direct observation of the implementation process was conducted[36] by one researcher, and observations recorded as field notes.

RESULTS

Patient selection is outlined in Figure 1. Characteristics of the intervention and control groups (Table 1) were broadly similar, with the exception of age.

Prescribing error

The total error number and clinical significance scores of errors were lower in the intervention group, and there were differences across a range of errors between groups, with a complete absence of error pertaining to patient information, date, legibility, quantity, and prescriber information among the intervention group (Table 2).

Table 1. Characteristics of study patients

	Intervention (*n* = 41)	Control (*n* = 61)	*P*-value
Sex, male, *n* (%)	22 (54)	38 (62)	0.51
Age, years, mean (SD)	72.6 (6.2)	77.4 (7.3)	0.01
Has medical card, *n* (%)	34 (83)	43 (71)	0.23
Medications on admission, median (IQR)	10 (8–15)	10 (7–13)	0.25
Independent mobility, *n* (%)	24 (59)	29 (48)	0.38
Independent dressing, *n* (%)	31 (76)	41 (67)	0.49
Continent, *n* (%)	32 (78)	56 (91)	0.09
Independent feeding, *n* (%)	38 (93)	51 (84)	0.30
Length of stay, median (IQR)	6 (3–10)	6 (5–13)	0.21

IQR = interquartile range. SD = standard deviation.

Predictors of error number and error score

The results of the univariable and multivariable analyses are shown in Table 3. In the multivariable analysis, after controlling for the other variables in the model, statistically significant lower rates of error numbers and error scores remained in the intervention group. Number of medications on admission was the only other statistically significant predictor of prescribing error number and error score. For an increase of one in pre-admission medication number, error count and the clinical significance score both increased by 9%.

Table 2. Types of errors on discharge prescriptions

	Intervention (*n* = 41)		Control (*n* = 61)		*P*-value
	Median (IQR)		**Median (IQR)**		
Total error number	1 (0 to 3)		8 (4 to 13.5)		<0.001
Clinical significance score	2 (0 to 4)		11 (5 to 20)		<0.001
Type of error	***n***	**%**	***n***	**%**	
Patient information	0	0	2	3.3	0.514
Date	0	0	5	8.2	0.08
Legibility and/or spelling	0	0	5	8.2	0.08
Quantity and/or duration	0	0	22	36.1	<0.001
Prescriber information	0	0	18	29.5	<0.001
Drug interaction	16	39	26	42.6	0.838
Frequency	3	7.3	2	3.3	1.0
Dose	4	9.8	7	11.5	1.0
Medication omission	17	41.5	46	75.4	0.001

IQR = interquartile range.

Qualitative interviews evaluating feasibility and acceptability

Interviews were conducted with a census sample of GPs (*n* = 8), junior doctors (*n* = 13), and IT professionals (*n* = 2). Interviews were conducted with 12 intervention patients (declined *n* = 2, died *n* = 6, unable to contact *n* = 4, current health issue as determined by GP *n* = 17)

Characteristics of interview participants are shown in Table 4. Interviews identified three main themes: clinical impact, intervention characteristics, and integration with usual care. Main themes, subthemes, and codes are outlined in Box 2. The main themes and the most significant subthemes are discussed.

Clinical impact. GPs, patients, and junior doctors all described the occurrence of and difficulties with medication error, and poor communication of medication information within the existing system:

'We forever have people coming in who are missing things for a week, until someone discovers they're missing whatever.' (Junior doctor 1)

'And, in some cases, then you have to follow up with the hospital, and following up with the hospital is incredibly time consuming. Like, really, incredibly time consuming and frustrating and annoying. I mean, I can't be strong enough on how, what a waste of time it is.' (GP1)

'I remember, like, one day coming out and the nurse had to ring the doctor to query something because the inhaler they had given me shouldn't be given with the medications I was on.' (Patient [P] 1)

Each stakeholder group embraced the PHARMS device as a potential method of reducing error and improving communication:

'It takes some of the inconsistency out of the traditional methods of finding out about patients' change of medication when they've been in hospital. If everyone was doing it we'd have, I suppose, solid prescriptions — we'd know what patients were really on coming out of hospital.' (GP7)

'One person I used it for was one who was in and out like a yo-yo and, in that instance, it provided continuity between the people ... so I thought it was very valid and useful.' (Junior doctor 4)

Table 3. Association of predictors and number of errors and error score

	Univariable			Multivariable		
Error number predictors	**IRR**	**95% CI**	***P*-value**	**IRR**	**95% CI**	***P*-value**
Group:						
Intervention (ref)	–					
Control	3.94	2.44 to 6.36	<0.001	4.88	3.35 to 7.13	<0.001
Sex:						
Female (ref)	–					
Male	1.19	0.80 to 1.78	0.39	1.20	0.79 to 1.82	0.39
Age	1.02	1.00 to 1.05	0.083	0.99	0.97 to 1.02	0.63
Medical card status:						
Yes (ref)	–					
No	0.96	0.64 to 1.45	0.85	0.92	0.64 to 1.31	0.63
Number of medications on admission	1.06	1.02 to 1.10	0.003	1.09	1.05 to 1.14	<0.001
Functional status:						
Not independent (ref)	–					
Independent	0.84	0.57 to 1.23	0.38	1.08	0.77 to 1.53	0.65
Length of stay	1.02	1.00 to 1.03	0.10	1.00	0.98 to 1.02	0.94

	Univariable			Multivariable		
Error score predictors	**IRR**	**95% CI**	***P*-value**	**IRR**	**95% CI**	***P*-value**
Group:						
Intervention (ref)	–					
Control	4.30	2.55 to 7.25	<0.001	5.71	3.66 to 8.91	<0.001
Sex:						
Female (ref)	–					
Male	1.44	0.90 to 2.29	0.13	1.36	0.86 to 2.17	0.19
Age	1.02	0.99 to 1.05	0.31	0.99	0.96 to 1.01	0.31
Medical card status:						
Yes (ref)	–					
No	0.77	0.49 to 1.21	0.26	0.74	0.49 to 1.12	0.15
Number of medications on admission	1.05	1.00 to 1.10	0.07	1.09	1.04 to 1.14	<0.001
Functional status:						
Not independent (ref)	–					
Independent	0.98	0.63 to 1.54	0.94	1.16	0.75 to 1.77	0.51
Length of stay	1.00	0.99 to 1.02	0.69	0.99	0.98 to 1.01	0.32

CI = confidence interval. IRR = incidence rate ratio. Ref = reference.

'Well, it's very handy, so your GP would have it and [you,] *when you go to hospital, all your information is on it. It's brilliant.'* (P3)

GPs found the electronic medication information beneficial at time of discharge:

'It was useful, because it was instant, and because I knew that's changed, and it's changed for a reason.' (GP1)

However, the quality of information received was noted to be variable by GPs, and to be dependent on the junior doctor generating the discharge medication information:

'I can remember having two different reactions, that it very much depended on who had filled in the [information] *from the hospital side. One* [junior doctor] *had made notes about what was stopped and what doses had increased, which was really helpful. And the other one was just a prescription'* (GP2)

The junior doctors felt overall that, although the device was useful for GPs and patients at discharge, it was not particularly useful for them when generating discharge information. They felt that it was not their role to reconcile medications at this point in care, and that it would be more relevant at admission:

'But it probably would be much [more] *helpful if you were doing an admission as, a lot of the time, I find that patients will come in and they won't have the list of medications with them, and you end up having to ring the GP anyway. So, I think that's when it would become more helpful — at admission rather than discharge.'* (Junior doctor 5)

Intervention characteristics. Patients found the key-shaped PHARMS device acceptable. A minority expressed a preference for an alternative shape to resemble a bank card. The majority expressed having difficulty with use of technology, and rejected alternative options such as an app:

'It's the likes of us that wouldn't really be tech savvy, it would be the ideal thing.' (P2)

'They tried to talk me into getting one of the touchphones, but I'm sure I have toes for fingers, because any time I tried to use it, I couldn't.' (P1)

Though enthusiastic about having the device to provide information to healthcare professionals, most patients did not want personal access to their medication information:

'I'd leave them [doctors] *do what they are doing. I just take my tablets and leave them* [doctors] *look after it.'* (P2)

'You know when a doctor's in front of you [you] *lose concentration and you can't remember the names … with the key* [device] *it would be better.'* (P4)

Table 4. Characteristics of participants in qualitative interviews (*n* = 35)

	Participants (*n*)
	GPs (*n* = 8)
Sex	
Male	5
Female	3
Type of practice	
Single handed	1
Group	7
Length qualified	
10–20 years	3
21–30 years	4
>30 years	1
	Junior doctors (*n* = 13)
Sex	
Male	6
Female	7
Age, years	
20–30 years	10
>30 years	3
Length qualified	
1 year	11
2 years	2
	IT professionals (*n* = 2)
Sex	
Male	2
Female	0
Length qualified	
10–20 years	1
>20 years	1
	Patients (*n* = 12)
Sex	
Male	5
Female	7
Age, years	
60–70 years	7
>70 years	5
Socioeconomic status	
Private health insurance	1
Medical card	11

USB technology and operation of the device was acceptable to healthcare and IT professionals alike, and regarded as a feasible option within the constraints of the current system:

'It did actually work. It could work in hospitals in Ireland. Technology in a public hospital may be behind the other technologies out there. When it comes to a great solution, for example, wireless technology, the problem is that technology is not available or accessible.' (IT professional [IT]1)

Integration with usual care. Though enhancing process efficiency for GPs, junior doctors found that using the device was an additional workload:

'On our end, it was probably less work than dealing with traditional prescriptions. So yeah, we're very happy.' (GP7)

'It's the duplication, the filling out of the discharge summary, and then you're filling out a prescription, and you're trying to find a computer.' (Junior doctor 9)

Infrequent use significantly impacted acceptability for junior doctors, and GPs highlighted full integration and widespread use as key for sustainability:

'I'm sure it would be fine if it were the primary method for every single patient, we might — that's the thing that we do. But when you're writing prescriptions all day, you just forget about it.' (Junior doctor 11)

'It would be no good for just a small portion of one hospital to use it. If it's the whole system, then great. Otherwise, it's just another system that's different. If it's just a small portion of people using it, then it's not going to be any good.' (GP7)

Uncertainty regarding the mechanism of device operation was an issue for GPs, patients, and junior doctors alike:

'The difficulty was, I was feeling vague about it [the device]. *So I couldn't really put her* [patient] *absolutely straight and say '"no, that's not how it's working, that's for the next time you're back", and so we* [patient and GPs in the practice] *all agreed that we didn't know how it worked.'* (GP2)

Issues of integration were regarded as minor from an IT perspective, and confidence in the safety and security of USB technology was expressed:

'We didn't really have any major technical problems. I would call them glitches and challenges.' (IT2)

'So, really, if the correct protection is in place, using USB technology is safe.' (IT1)

Non-participant observation

A number of issues pertaining to feasibility were identified through non-participant observation.

Uptake. Patients embraced the concept of the device and were keen to participate in the study, with only nine of the 136 patients approached declining to participate. All junior doctors were willing to participate, with a small number (*n* = 2) becoming 'champions', assisting and educating their peers regarding device use.

Fidelity and adherence. Of the 63 devices issued to patients, 41 were used successfully. Difficulty in communication between the product developer and hospital IT staff resulted in early-stage installation and implementation issues, with device failure due to unresolved hospital firewall and GP server issues (*n* = 6).

Basic hospital hardware issues negatively impacted successful device use:

- failure of use occurred due to simple printer malfunction (*n* = 4); and
- limited availability of computers on hospital wards resulted in junior doctors opting to issue a handwritten prescription rather than using the device (*n* = 2).

A number of devices were not used at discharge (*n* = 10). Three patients transferred to another hospital. Observed additional explanatory factors were:

- patients did not alert junior doctors to having the device;
- retaining the device was problematic during the inpatient stay, due to lack of a dedicated storage location; and
- nursing staff were key to successful use through alerting junior doctors to the presence of devices.

DISCUSSION

Summary

Introduction of a novel patient-held electronic medication record at hospital discharge was shown to be feasible,

Box 2. Themes, subthemes, and codes describing stakeholder views

Main theme	Subthemes	Codes
Clinical impact	Communication	Current communication barriers at primary–secondary care interface Discharge information accessibility for GPs Patient empowerment Clarity in transitional care
	Error reduction	Occurrence of error in current system Quality of discharge medication information Role of PHARMS device in error reduction
	Future use of PHARMS	Use at admission Use at discharge Use in community pharmacy Use during travel
Intervention characteristics	Physical attributes	Shape and structure of PHARMS device
	Technology	USB Mechanism of operation
Integration with usual care	Modification	Integration of information in GP software system Mandatory completion of fields in hospital system Use of hospital formulary Improving patient knowledge
	Workload	Process efficiency Time constraints
	Deviation from usual practice	Uncertainty regarding PHARMS device operation Infrequent use of PHARMS device Role of nursing staff in facilitating use of PHARMS device
	IT	Hospital hardware issues Mixed electronic and paper hospital record system Security Installation issues in hospital

PHARMS = patient-held active record of medication status. IT = information technology. USB = universal series bus.

being both technically implementable and acceptable to key stakeholders. The device was successfully integrated into existing electronic systems in primary and secondary care, and medication information successfully transferred between sites. GPs and patients felt it provided a potential solution to current issues of poor communication of medication information and the occurrence of medication error at the primary–secondary care interface. Not all devices were used, however, with lack of availability of hospital computers and printer malfunction negatively impacting use, and junior doctors reporting a perceived greater usefulness at time of hospital admission. The *ad hoc* nature of device use in the study led to issues of uncertainty and duplication of work. GPs and junior doctors advocated more widespread use. Patient education and involvement of nursing staff were also identified as facilitators to future implementation. Regarding device efficacy, lower total error number and clinical significance scores among intervention patients suggested potential to reduce the occurrence of medication error.

Strengths and limitations

To the authors' knowledge, this is the first study examining the introduction of a patient-held medication record using USB technology at the interface of primary and secondary care at time of hospital discharge. This study provides a detailed evaluation of the introduction of this novel electronic method to facilitate medication reconciliation in primary and secondary care from a quantitative and qualitative perspective. The study was conducted among community-dwelling older adult patients without significant exclusions, using basic technology and existing basic IT infrastructure, suggesting that the results may be applicable to a general population and other healthcare systems. The small scale of the study is a limitation, however. An additional limitation is the non-randomised study design. However, in terms of baseline characteristics, the groups were reasonably comparable. Though the control group had a chronological median age that was 5 years older than the intervention group, there was no apparent difference in biological age in terms of numbers of medications or functional status. In addition, the multivariable regression model controlled for age as a variable, and the difference in error score and error count remained between intervention and control groups. Younger age did not appear to enhance patients' ability to use the technology, based on the difficulties reported by the intervention patients during interviews. Use of specific GP practices may have been a source of selection bias, and a further larger-scale randomised study is warranted. Although the Hawthorne effect[37] may in part explain the reduction in prescribing error noted among intervention patients, quality of discharge information generated was reported by GPs as varying between junior doctors, suggesting this was not universally the case. The control group received handwritten discharge prescriptions. Thus, the impact on error reduction could be less if compared with discharge prescriptions in an existing electronic system. A final limitation is that all interviews were conducted by the principal investigator, a GP, potentially introducing a social desirability bias among interviewees. However, negative

opinions and experiences pertaining to the intervention were actively sought, and were reported by all stakeholder groups.

Comparison with existing literature

The study identified the occurrence of prescribing error at the interface of primary and secondary care at time of hospital discharge, a finding frequently reported in the literature.[10,38–40] Prescribing error among junior doctors is an important patient safety issue.[8,9] This study highlighted that lack of an accurate medication list at admission, in addition to a perceived lack of responsibility for medication review at hospital discharge among junior doctors, may be important contributory factors.

Use of the device varied between junior doctors. Previous research has shown that the rate at which an individual will adopt a new technology is variable, with the relative advantage of the technology over current practice being the strongest predictor of the rate of adoption.[41] Quality of discharge information generated varied between junior doctors. Nine devices issued to patients were not used at time of discharge. Lack of perceived relevance at hospital discharge, identified during interviews, may offer an explanation. Conversely, junior doctors promoting use of the device to their peers was noted to be an important facilitator.

Deviation from routine practice was noted to be an issue for both GPs and junior doctors, and negatively impacted device usefulness. In line with the findings from this study, a systematic review examining healthcare professionals' perceptions of implementation of electronic systems for medication prescription and/or use found that such systems positively impact patient safety, but that hardware problems and changes to routine work practice were significant barriers.[42]

Previous studies have highlighted that patients perceive difficulties with information transfer at the primary–secondary care interface.[43,44] A perception that their own lack of knowledge and difficulty in communicating with clinicians may contribute to the situation has been described.[45] Patients in this study universally embraced the device as a method of improving communication at this interface in care. The patients in the study felt empowered by carrying the device but, in general, did not want personal access to their medication information, and expressed having difficulties in using technology. This supports previous research where patients, though lacking familiarity with technology, perceived it to positively impact safety, trusted their healthcare providers, and expressed a willingness to embrace novel interventions.[46,47]

Prescribing error has been identified as particularly problematic among older adult patients taking multiple medications,[48,49] and this is confirmed by the authors' study, with increasing numbers of admission medications among study patients identified as a predictor of error occurrence. Employing electronic methods to generate and transfer discharge medication information has previously been shown to be beneficial in this population,[50] and this study demonstrated a statistically significant reduction in both total error number and the occurrence of clinically significant errors among intervention patients. This device, however, not only facilitates the electronic generation and transfer of discharge information, but also has the additional potential to promote medication reconciliation at the point of generating the discharge prescription, by providing the prescriber with a list of a patient's pre-admission medications, as documented in their GP record. This active electronic record of a patient's pre-admission medication may also have the potential to promote medication reconciliation at the point of hospital admission.

Implications for research and practice

Medication error at hospital discharge is an important issue for GPs, patients, hospital doctors, and pharmacists. Establishing effective methods of reducing medication error as patients move between hospital and the community is currently an international priority.[11,16] Previous research highlights, first, the importance of integration and communication of medication information between primary and secondary care,[5,51,52] second, the need for multidisciplinary and patient involvement,[45,51] and, third, the benefit associated with electronic systems.[24,25] In technology terms, a 'minimum viable product' is a basic product solving a core problem.[53] Perhaps with regard to medication error during transitional care, it is time to return to basics to meet the immediate clinical need. International implementation of eHealth strategies has not been straightforward, and a universal shared care record does not yet exist across healthcare systems. This study demonstrates that this device can be successfully used within existing systems without significant additional IT investment, and hence may be complementary to ongoing shared care record development.

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Ethical approval

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Provenance

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Competing interests

The authors have declared no competing interests.

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Though more advanced technologies than USB exist, such technologies may not be applicable to all healthcare systems, nor (as this study highlighted) acceptable to an older adult population. This feasibility study suggests that the PHARMS may provide a viable solution to the current issue of medication error at the interface of primary and secondary care. It has demonstrated that using a USB device is technically and clinically feasible and acceptable, and impacts positively on medication reconciliation at the point of hospital discharge. Findings from the study suggest that a larger-scale evaluation of the device, including deployment at the point of hospital admission, is now warranted.

REFERENCES

1. Williams H, Edwards A, Hibbert P, *et al*. Harms from discharge to primary care: mixed-methods analysis of incident reports. *Br J Gen Pract* 2015; DOI: https://doi.org/10.3399/bjgp15X687877.
2. Riordan CO, Delaney T, Grimes T. Exploring discharge prescribing errors and their propagation post-discharge: an observational study. *Int J Clin Pharm* 2016; **38(5):** 1172–1181.
3. O'Connor R, O'Callaghan C, McNamara R, Salim U. An audit of discharge summaries from secondary to primary care. *Ir J Med Sci* 2018; DOI: 10.1007/s11845-018-1862-6. [Epub ahead of print].
4. Uitvlugt EB, Siegert CE, Janssen MJ, *et al*. Completeness of medication-related information in discharge letters and post-discharge general practitioner overviews. *Int J Clin Pharm* 2015; **37(6):** 1206–1212.
5. Mastellos N, Car J, Majeed A, Aylin P. Using information to deliver safer care: a mixed-methods study exploring general practitioners' information needs in North West London primary care. *J Innov Health Inform* 2014; **22(1):** 207–213.
6. Robelia PM, Kashiwagi DT, Jenkins SM, *et al*. Information transfer and the hospital discharge summary: national primary care provider perspectives of challenges and opportunities. *J Am Board Fam Med* 2017; **30(6):** 758–765.
7. Belleli E, Naccarella L, Pirotta M. Communication at the interface between hospitals and primary care — a general practice audit of hospital discharge summaries. *Aust Fam Physician* 2013; **42(12):** 886–890.
8. Ryan C, Ross S, Davey P, *et al*. Prevalence and causes of prescribing errors: the PRescribing Outcomes for Trainee Doctors Engaged in Clinical Training (PROTECT) study. *PloS ONE* 2014; **9(1):** e79802.
9. Ross S, Bond C, Rothnie H, *et al*. What is the scale of prescribing errors committed by junior doctors? A systematic review. *Br J Clin Pharmacol* 2009; **67(6):** 629–640.
10. Michaelson M, Walsh E, Bradley CP, *et al*. Prescribing error at hospital discharge: a retrospective review of medication information in an Irish hospital. *Ir J Med Sci* 2017; **186(3):** 795–800.
11. National Institute for Health and Care Excellence. *Medicines optimisation: the safe and effective use of medicines to enable the best possible outcomes*. NICE guideline [NG5]. 2015. https://www.nice.org.uk/guidance/ng5 (accessed 11 Apr 2019).
12. World Health Organization. Essential medicines and health products. *Reporting and learning systems for medication errors: the role of pharmacovigilance centres*. Geneva: WHO, 2014. https://www.who.int/medicines/areas/quality_safety/safety_efficacy/emp_mes/en/ (accessed 11 Apr 2019).
13. Institute for Safe Medication Practices. *Targeted medication safety best practice for hospitals*. Horsham, PA: ISMP, 2017. https://www.ismp.org/guidelines/best-practices-hospitals (accessed 11 Apr 2019).
14. Greenwald JL, Halasyamani L, Greene J, *et al*. Making inpatient medication reconciliation patient centered, clinically relevant and implementable: a consensus statement on key principles and necessary first steps. *J Hosp Med* 2010; **5(8):** 477–485.
15. Campbell FKJ, Czoski-Murray C. Jones R. *A systematic review of the effectiveness and cost-effectiveness of interventions aimed at preventing medication error (medicines reconciliation) at hospital admission*. The University of Sheffield, School of Health and Related Research (ScHARR), 2007.
16. World Health Organization. *eHealth*. Global strategy on digital health. Geneva: WHO, 2016. http://www.who.int/ehealth/en/ (accessed 11 Apr 2019).
17. eHealth Ireland. https://www.ehealthireland.ie/ (accessed 11 Apr 2019).
18. Department of Health. *eHealth strategy for Ireland*. Dublin: Government of Ireland, 2013.
19. Ahmed Z, McLeod MC, Barber N, *et al*. The use and functionality of electronic prescribing systems in English acute NHS trusts: a cross-sectional survey. *PLoS ONE* 2013; **8(11):** e80378.
20. Ben-Assuli O. Electronic health records, adoption, quality of care, legal and privacy issues and their implementation in emergency departments. *Health Policy* 2015; **119(3):** 287–297.
21. Greenhalgh T, Stramer K, Bratan T, *et al*. Adoption and non-adoption of a shared electronic summary record in England: a mixed-method case study. *BMJ* 2010; **340:** c3111.
22. Mehta RL, Baxendale B, Roth K, *et al*. Assessing the impact of the introduction of an electronic hospital discharge system on the completeness and timeliness of discharge communication: a before and after study. *BMC Health Serv Res* 2017; **17:** 624.
23. Sartain SA, Stressing S, Prieto J. Patients' views on the effectiveness of patient-held records: a systematic review and thematic synthesis of qualitative studies. *Health Expect* 2015; **18(6):** 2666–2677.
24. Ehnbom EC, Raban MZ, Walter SR, *et al*. Do electronic discharge summaries contain more complete medication information? A retrospective analysis of paper versus electronic discharge summaries. *Health Inf Manag* 2014; **43(3):** 4–12.
25. Motamedi SM, Posadas-Calleja J, Straus S, *et al*. The efficacy of computer-enabled discharge communication interventions: a systematic review. *BMJ Qual Saf* 2011; **20(5):** 403–415.
26. Urban R, Armitage G, Morgan J, Marshall K. Is electronic discharge the answer? *Int J Pharm Pract* 2012; **20:** 40–41.
27. Fitzsimmons M, Grimes T, Galvin M. Sources of pre-admission medication information: observational study of accuracy and availability. *Int J Pharm Pract* 2011; **19(6):** 408–416.
28. Calderón-Larrañaga A, Poblador-Plou B, González-Rubio F, *et al*. Multimorbidity, polypharmacy, referrals, and adverse drug events: are we doing things well? *Br J Gen Pract* 2012; DOI: https://doi.org/10.3399/bjgp12X659295.
29. Green JL, Hawley JN, Rask KJ. Is the number of prescribing physicians an independent risk factor for adverse drug events in an elderly outpatient population? *Am Journal Geriatr Pharmacother* 2007; **5(1):** 31–39.
30. Mair FS, May C, O'Donnell C, *et al*. Factors that promote or inhibit the implementation of e-health systems: an explanatory systematic review. *Bull World Health Organ* 2012; **90(5):** 357–364.
31. Walsh E, Sahm LJ, Kearney PM, *et al*. The PHARMS (Patient Held Active Record of Medication Status) feasibility study: a research proposal. *BMC Res Notes* 2018; **11(1):** 6.
32. Irish Statute Book. *S.I. No. 540/2003 — Medicinal products (prescription and control of supply) regulations 2003*. http://www.irishstatutebook.ie/eli/2003/si/540/made/en/print (accessed 11 Apr 2019).
33. Pevnick JM, Nguyen C, Jackevicius CA, *et al*. Improving admission medication reconciliation with pharmacists or pharmacy technicians in the emergency department: a randomised controlled trial. *BMJ Qual Saf* 2018; **27(7):** 512–520.
34. Braun V, Clarke V. Using thematic analysis in Psychology. *Qual Res Psychol* 2006; **3:** 77–101.
35. Strauss A, Corbin J. *Basics of qualitative research: techniques and procedures for developing grounded theory*. 2nd edn. Thousand Oaks, CA: Sage Publications, 1998.
36. Patton MQ. Fieldwork strategies and observation methods. In: *Qualitative research and evaluation methods*. 3rd edn. Thousand Oaks, CA: Sage Publications, 2002: 259–338.
37. Adair JG. The Hawthorne effect: a reconsideration of the methodological artifact. *Int J Appl Psychol* 1984; **69(2):** 334–345.
38. Breuker C, Macioce V, Mura T, *et al*. Medication errors at hospital admission and discharge: risk factors and impact of medication reconciliation process to improve healthcare. *J Patient Saf* 2017; DOI: 10.1097/PTS.0000000000000420.
39. Roughead EE, Semple SJ, Rosenfeld E. The extent of medication errors and adverse drug reactions throughout the patient journey in acute care in Australia. *Int J Evid Based Healthc* 2016; **14(3):** 113–122.
40. Moore C, Wisnivesky J, Williams S, McGinn T. Medical errors related to discontinuity of care from an inpatient to an outpatient setting. *J Gen Intern Med* 2003; **18(8):** 646–651.
41. Sahin I. Detailed review of Rogers' diffusion of innovation theory and educational technology-related studies based on Rogers' theory. *Turkish Online J Educ Tech* 2006; **5(2):** 14–23.
42. Hogan-Murphy D, Tonna AP, Strath A, Cunningham ITS. Healthcare professionals' perceptions of the facilitators and barriers to implementing electronic systems for prescribing, dispensing and administration of medicines in hospitals: a systematic review. *Eur J Hosp Pharm* 2015; DOI:10.1136/ejhpharm-2015-000722.
43. Borgsteede SD, Karapinar-Carkit F, Hoffmann E, *et al*. Information needs about medication according to patients discharged from a general hospital. *Patient Educ Couns* 2011; **83(1):** 22–28.
44. Berendsen AJ, de Jong GM, Meyboom-de Jong B, *et al*. Transition of care: experiences and preferences of patients across the primary/secondary interface — a qualitative study. *BMC Health Serv Res* 2009; **9:** 62.
45. Sampson R, Cooper J, Barbour R, *et al*. Patients' perspectives on the medical primary–secondary care interface: systematic review and synthesis of qualitative research. *BMJ Open* 2015; **5(10):** e008708.

46. Frail CK, Kline M, Snyder ME. Patient perceptions of e-prescribing and its impact on their relationships with providers: a qualitative analysis. *J Am Pharm Assoc* 2014; **54(6):** 630–633.
47. Parker SJ, Jessel S, Richardson JE, Reid MC. Older adults are mobile too! Identifying the barriers and facilitators to older adults' use of mHealth for pain management. *BMC Geriatr* 2013; **13:** 43.
48. Picone DM, Titler MG, Dochterman J, *et al*. Predictors of medication errors among elderly hospitalized patients. *Am J Med Qual* 2008; **23(2):** 115–127.
49. Midlov P, Bergkvist A, Bondesson A, *et al*. Medication errors when transferring elderly patients between primary health care and hospital care. *Pharm World Sci* 2005; **27(2):** 116–120.
50. Moro Agud M, Menendez Colino R, del Coro Mauleon Ladrero M, Ruana Encina M. Analysis of an electronic medication reconciliation and information at discharge programme for frail elderly patients. *Int J Clin Pharm* 2016; **38(4):** 996–1001.
51. Kripalani S, Jackson AT, Schnipper JL, Coleman EA. Promoting effective transitions of care at hospital discharge: a review of key issues for hospitalists. *J Hosp Med* 2007; **2(5):** 314–323.
52. Spinewine A, Claeys C, Foulon V, Chevalier P. Approaches for improving continuity of care in medication management: a systematic review. *Int J Qual Health Care* 2013; **25(4):** 403–417.
53. Rancic Moogk D. Minimum viable product and the importance of experimentation in technology startups. *Technol Innov Manag Rev* 2012; **2(3):** 23–26.