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ORIGINAL RESEARCH ARTICLE

A Multi-method Exploratory Evaluation of a Service Designed to Improve Medication Safety for Patients with Monitored Dosage Systems Following Hospital Discharge

Fatema A. Alqenae[1] · Douglas Steinke[1] · Hilary Belither[2] · Peter Robertson[3] · Jennifer Bartlett[2] · Jack Wilkinson[4] · Steven D. Williams[1,5] · Lawrence Brad[5] · Mark Jeffries[1,6,8] · Darren M. Ashcroft[1,6] · Richard N. Keers[1,6,7]

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Abstract

Background and Objective Medication safety problems are common post-hospital discharge, and an important global healthcare improvement target. The Transfers of Care Around Medicines (TCAM) service was launched by a National Health Service Trust in the North-West of England, initially focusing on patients with new or existing Monitored Dosage Systems (MDS). The TCAM service is designed to enable the prompt transfer of medication information, with referrals made by hospitals at discharge to a named community pharmacy. This study aimed to explore the utilisation and impact of the TCAM service on medication safety.

Methods The evaluation included a descriptive analysis of 3033 anonymised patient referrals to 71 community pharmacies over a 1-year period alongside an assessment of the impact of the TCAM service on unintentional medication discrepancies and adverse drug events using a retrospective before-and-after study design. Impact data were collected across 18 general practices by 16 trained clinical pharmacists.

Results Most patient referrals (70%, 2126/3033) were marked as 'completed' by community pharmacies, with 15% of completed referrals delayed beyond 30 days. Screening of 411 patient records by clinical pharmacists yielded no statistically significant difference in unintentional medication discrepancies or adverse drug event rates following TCAM implementation using a multivariable regression analysis (unintentional medication discrepancies adjusted odds ratio = 0.79 [95% confidence interval 0.44–1.44, $p = 0.46$]; and adverse drug events adjusted odds ratio = 1.19 [95% confidence interval 0.57–2.45, $p = 0.63$]), although there remained considerable uncertainty.

Conclusions The TCAM service facilitated a number of community pharmacy services offered to patients with monitored dosage systems; but the impact of the intervention on unintentional medication discrepancies and adverse drug event rates post-hospital discharge for this patient group was uncertain. The results of this exploratory study can inform the ongoing implementation of the TCAM service at hospital discharge and highlight the need to understand service implementation in different contexts, which may influence its impact on medication safety.

Prior publication: This study has been presented as a poster at the Health Services Research and Pharmacy Practice (HSRPP) Conference, "Designing Healthcare: Stimulating Interdisciplinarity and Co-design for Quality Healthcare", (8–9 April, 2021, virtual conference), "Evaluating the Utilisation of a Service Designed to Enhance Care with Medicines Following Acute Hospital Discharge: A Retrospective Study". An abstract of this submission is published in the *International Journal of Pharmacy Practice*, Volume 29, Issue Supplement 1, pages i42–3.

Extended author information available on the last page of the article

Key Points

Most (70%) Transfers of Care Around Medicines (TCAM) service referrals for patients with monitored dosage systems over a 1 year between March 2019 and February 2020 were completed by community pharmacies, with 15% of referrals completed beyond 30 days.

No statistically significant changes in the rate of unintentional medication discrepancies and adverse drug events affecting patients on monitored dosage systems were detected after the implementation of the Transfers of Care Around Medicines (TCAM) service in 18 general practices, though there was uncertainty in the findings.

Drug classes most commonly reported with unintentional medication discrepancies and adverse drug event post-hospital discharge were cardiovascular and central nervous system drugs.

Following this exploratory study, further research is needed to explore how service context and implementation influence utilisation and impact.

1 Introduction

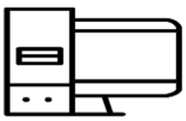
The period following hospital discharge is a disruptive and challenging time for patients, who may need to adjust their health routines and personal lives [1]. Not all patient care needs or risks are managed appropriately at and beyond discharge and as a consequence there is a risk of readmission to hospital or emergency department visits [2]. As healthcare providers may be poorly affiliated across care boundaries, miscommunication makes transition of care a fertile ground for medication errors and preventable harm [3]. Medication errors and medication-related harm (adverse drug events [ADEs]) are common after hospital discharge, being found to affect one in two and one in five patients, respectively, in one systematic review [4]. Healthcare providers report encountering recently discharged, confused patients who are uncertain about continuing medications prescribed before hospital admission or taking only the discharge medication regimen provided [5, 6]. Unjustified medication (prescribing a drug for which there is no indication), and medication-related harm at/post-hospital discharge affects patient safety and comes with an added financial burden [7, 8]. Medication non-adherence is also common, affecting between 40 and 55% of elderly patients 30 days post-hospital discharge [9–11]. Multi-compartment compliance aids (MCAs), commonly known as monitored dosage systems (MDS) or blister packs [12], have been suggested to improve patient adherence [13, 14]. In a recent survey in England, it was estimated that a median of 20 MDS were being prepared by community pharmacies per month [15], with an estimated 64 million MDS dispensed to around 1.2 million patients in England annually [16]. However, despite widespread use, there is a lack of evidence of the benefits of MDS [17, 18] alongside emerging reports of risk including incidents of patient confusion regarding changing MDS' brands post-hospital discharge [19]. Historically, hospitals may have sent the discharge letter for patients with MDS to the community pharmacy via fax, but this did not always occur and may have suffered from poor resolution of document images [20]. A survey conducted in 2005 in the UK found that information about patients' MDS were communicated in less than 50% of cases to patients' community pharmacies after hospital discharge, which raised medication safety concerns [21]. A recent national survey by Walters and colleagues (2022) in England reported that a shorter supply of medication was given on discharge for patients with MDS compared with other patients [22], which might cause pressure for the patients and their carers.

Technology has more recently received wider recognition as a tool to improve medication safety at care transfer [23–25]. Following hospital discharge, different 'Transfers of Care Around Medicines (TCAM)' services have been developed, that involve a dedicated e-referral tool within Information Technology (IT) systems to send timely discharge medication documentation and any follow-up tasks to the patient's nominated community pharmacy in order to improve medication safety and reduce waste. Following early work developing the TCAM intervention in England particularly around infrastructure and Information Technology (IT) platforms, it has undergone widespread adoption in hospital care as the Discharge Medicines Service and became an essential service in the community pharmacy contractual framework for England in February 2021 [26]. A TCAM service was implemented in February 2019 at an National Health Service (NHS) acute Trust in the North-West of England [27], which involves sharing discharge information from the hospital to 71 community pharmacies in the local area. Figure 1 provides details about the implementation of the TCAM service in the local area. The initial focus was to provide the TCAM service to patients with new or existing MDS.

There are a number of models of TCAM services in the UK [28, 29], with evidence of the effectiveness of such services now emerging. Available studies that have evaluated TCAM interventions focused on either service utilisation data or all-cause readmissions [30, 31]. Whilst all-cause readmissions may be used, there may be more sensitive measures to the intervention such as medication-related

The TCAM service initiative at the NHS acute Trust in North West of England consists of sending electronic admission and discharge notification, as well as the hospital discharge summary to the patients' nominated community pharmacy to enable referral (of discharge summary) via an encrypted platform, and an email alert instead of fax. After a referral from the hospital pharmacy, the nominated community pharmacies can accept, complete or reject the referral. If the referral is rejected, a follow-up call will be received from the hospital pharmacy team (to ask about reasons of referral rejection). Reasons for rejection might include that the patient is not/no longer a customer at this particular community pharmacy. The community pharmacy can also document medication side effects, any given care/service following discharge, and validate if a first repeat prescription is correct.

Four training events were organised for hospital and community pharmacy staff for the TCAM service, followed by a service launch in February 2019. Two training sessions were for hospital pharmacists and a further two sessions were for community pharmacy staff. Attendance at the training sessions was not mandatory. The first training session was planned by the Local Pharmaceutical committee in January 2019 and invited pharmacists via a newsletter, with the second taking place in July 2019. There was a demonstration of the TCAM system in the training session.



The encrypted platform facilitates services provided by community pharmacies such as medication reconciliation. At the base, before February 2019, the acute Trust had some problems with using faxes to send discharge related medication information with community pharmacies, such as delayed sending or poor-quality images, which risked medication safety.

The communication of the discharge letter to community pharmacies by the service delivery team was intended to reduce discrepancies in medication prescribing and dispensing between secondary and primary care, as both the community pharmacy and the general practice are quickly made aware of all details regarding patients' medication during and following the hospital episode. This project was also intended to improve monitoring and reporting of adverse drug reactions (via documenting in the system), improve communication between pharmacy teams across sectors, reduce medicines waste, improve the quality of information transfer and improve patient adherence (this study did not evaluate the impact on medicines waste or adherence).

Comparison between usual care and TCAM intervention steps

Process	Usual care	TCAM intervention
Clinical pharmacist at hospital sends admission notification to community pharmacy via:		
• Encrypted platform		✓
• Telephone call	✓	
Automatic discharge notification to community pharmacy via:		
• Encrypted platform		✓
Sends discharge letter (with up-to-date medication list) to community pharmacy via:		
• Encrypted platform (automatically system send whole discharge summary)		✓
• Fax (discharge prescription list)	✓	
Sends discharge letter to general practice via electronic system	✓	✓
Communication between healthcare providers at the primary care site and community pharmacies is via email or telephone.	✓	✓

Fig. 1 Description of the Transfers of Care Around Medicines (TCAM) service at the National Health Service (NHS) acute Trust in the North-West of England

admissions, which have been previously explored [32]. The TCAM service has been reported to decrease the hospital readmission rate and length of hospital stay [31]. A qualitative evaluation of the TCAM service 'Refer to Pharmacy' project by Ferguson and colleagues (2018) reported that pharmacists believed that the service had the potential to reduce human errors and improve communication with the general practitioner (GP) [33]. The available research however has yet to address the effect on medication safety of TCAM directly; one of the primary aims of the service. Thus, a targeted assessment of the impact of the TCAM intervention on medication safety outcome measures is needed alongside a service utilisation, and a process evaluation (published separately [20]) to explore how well the intervention was implemented and utilised and in doing so contextualise the evaluation of its impact [34]. This exploratory study therefore aimed to evaluate the utilisation and impact of the TCAM service on unintentional medication discrepancies (UMDs) and ADEs, for patients discharged with MDS from a National Health Service (NHS) acute Trust in the North-West of England.

2 Methods

The overall structure of this article follows the reporting criteria specified in "Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0)" [35], and "CONsolidated Standards Of Reporting Trials (CONSORT)" [36]. The protocol of the study is registered at the International Standard Randomised Controlled Trial Number (ISRCTN) registry (registration number 17094460, https://doi.org/10.1186/ISRCTN17094460). This study was part of a wider multi-methods evaluation of the TCAM service at the base Clinical Commissioning Group (CCG)/hospital, where a qualitative process evaluation has been published [20].

2.1 Study Design

This exploratory study consists of two parallel studies; a 'service utilisation' [what happened in the TCAM service (Fig. 1), using data from the encrypted community pharmacy platform] study and a 'service impact' [what was the TCAM service (Fig. 1) impact on UMD/ADE rates] study. The design of the 'service utilisation' study was a retrospective analysis of anonymised collected data from the community pharmacy encrypted platform. The design of the 'service impact' study was an uncontrolled, retrospective before-and-after study, where two cohorts of patients from the same general practice sites were investigated before and after the TCAM intervention was introduced.

2.2 Terminology

In this study, adverse drug events (ADEs) were defined as "'an injury resulting from medical intervention related to drug" [37], and unintentional medication discrepancies (UMDs) were defined as "unexplained differences in documented medication regimens across different sites of care." [38]. Any undocumented unexplained medication change was considered a UMD [39–44], unless it was documented as confirmed with the prescriber to be otherwise.

The study adopted the Institute for Healthcare Improvement (IHI) definition of medication reconciliation [45] to capture 'service impact' data. However, in order to reflect practice in the local area, the study also accepted any medical record entries sufficiently similar to medication reconciliation and conducted by a member of non-pharmacy general practice staff as 'medicine reconciliation' for data collection purposes. The methodology in this study assumed that medication reconciliation/identification of medication discrepancies completed and documented by practice staff (including the GP, nursing staff and administrative staff) was accurate. No independent conduct/verification of medication reconciliation was completed by the research team.

2.3 Study Setting

The 'service impact' data were collected from 18 general practices in the Clinical Commissioning Group (CCG) region of the base hospital in the North-West of England using their electronic health record systems. A CCG commissions NHS services in the local area [46]. An integrated healthcare record across primary and secondary care was available in the base CCG. All general practices involved in the study had access to a clinical pharmacist deployed to provide medicines optimisation services, including medicine reconciliation. Any changes in medications or other interventions brought about by the TCAM service were postulated to involve communication between community pharmacies, patients and general practices, and to then affect ongoing care, which would be captured in the medical record (e.g. as medication incidents, or through medicine reconciliation entries).

2.4 Data Collection

The 'service utilisation' study included TCAM electronic referral data covering 1 year between March 2019 and February 2020. The referrals were from the base NHS trust to all community pharmacies involved in the service ($n = 71$) in the CCG via the encrypted community pharmacy platform.

These data were extracted and anonymised retrospectively by a pharmacist in the acute hospital trust who routinely worked with these data. The data were then provided for the research team for analysis in one electronic sheet in Microsoft Excel®, 2010 (Microsoft, Redmond, WA, USA).

For the 'service impact' study, a required number of MDS patients ($n = 638$) was calculated based on the Dawson and Trapp calculations for the primary outcome of ADEs (the rate of ADEs for the calculation was based on a recent UK study of medication-related harm following discharge for older adults = 37% [8]). The pharmacy department at the base hospital identified patients; discharged with MDS; from their electronic patient record system. For patient selection, a random sample generator in Microsoft Excel®, 2010 (Microsoft, Redmond, WA, USA) was utilised to compile the sample. The 'service impact' study included all patients aged 18 years or older at the time of hospital discharge, who were discharged from an in-patient hospital stay at the base NHS hospital (staying at least 24 hours in the hospital) between August 2018 and August 2019 with a new or recurrent MDS. Eligible patient discharges between August 2018 and January 2019 for the retrospective data collection were identified for the TCAM pre-implementation stage and between March 2019 and August 2019 for the post-implementation stage. For the post-implementation phase of this study, this also included patients who were referred via the TCAM to a named community pharmacy. Patients with a planned admission (e.g. day-case surgery, or dialysis) or discharged from the emergency department were excluded. Patients who did not have a medicine reconciliation (or equivalent) entry in their general practice record, or those who died directly after hospital discharge (before medication reconciliation was completed) were excluded at the data collection stage. The data were collected by 16 trained clinical pharmacists attached to general practices in the CCG. These data collectors were routinely providing medication optimisation activity in the general practices involved. Each data collector received a 3-hour face-to-face group training session from the research team before data collection, where training included the identification and recording in sufficient detail of suspected ADEs and UMDs. Data collectors also received a data collection guide containing all information covered in the training session.

Medication safety data, including UMD and ADEs, were collected from general practice electronic record systems. Pharmacists reviewed medication reconciliation records (or equivalent) entries made within 30 days of hospital discharge to find UMDs. Alongside medicine reconciliation data, consultation data, laboratory data and prescribing data within a 90-day period post-hospital discharge were screened to identify ADEs. Each pharmacist data collector screened records over a 3-month period between September and December 2020. Data were extracted and pseudonymised (to preserve confidentiality) from medical records by pharmacists who had access as part of their routine clinical duties, using standardised data collection forms that were adapted from existing studies and transferred to the research team using a secure NHS e-mail [47, 48]. Pharmacist data collectors were advised that should they identify any malpractice incident that could have/did place patients at risk of harm, to report it to their line management (for follow-up investigation), the clinical team responsible for the care of the affected patient(s) and by using local incident reporting systems. Pharmacist data collectors were advised to use their professional judgement and experience to look for evidence that supported the presence of ADEs, and to use an adapted ADE trigger [49–51] list in the Data Collection Guide to help identify ADEs. During data collection, pharmacist data collectors assessed the severity of any identified UMD and categorised the severity based on the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) criteria [52]. Pharmacist data collectors were also instructed to use the ADE severity assessment tool in the Data Collection Guide to rate ADE harm severity. A summary of overall data collection steps across the 'service impact' and 'service utilisation' studies, and summary of data collection forms sections are provided in Appendix 1 and 2, respectively, of the Electronic Supplementary Material (ESM).

2.5 Data Validation

For the 'service impact' study, validation of UMD and ADE data was completed. Validation of UMDs was completed independently by three pharmacist researchers (FAA, RNK, DS), two of which had expertise in medication safety research (RNK, DS), followed by consensus meetings to confirm if the collected data were a UMD or intentional medication discrepancy based on the information supplied by data collectors. For ADEs, an expert panel consisting of a senior GP (LB) and two senior pharmacists (HB, SW) with a background in general practice, hospital and medication safety reviewed the data and reached a consensus on ratings. Panellists were blinded to the data collector, practice site, study phase and relevant dates. The expert panel met to confirm the causality, preventability and severity of identified ADEs by consensus, following a similar approach by previous ADE studies [47, 53]. The assessment was based on the amended Hallas criteria for causality of ADEs [54, 55], Helper criteria for preventability of ADEs [56] and National Patient Safety Agency criteria for severity of ADEs [57].

2.6 Data Classification

For the 'service utilisation' study, community pharmacies were coded as national multiple stores, independent

pharmacies (those who have a maximum two stores), regional multiple stores (with more than two stores in the region belonging to one particular company A) and regional stores (with more than two stores in the region belonging to one particular company B). For the 'service impact' study, medication classification was based on the British National Formulary (BNF) chapters [58]. Polypharmacy was defined as prescribed medication for a patient equalling five or more [59], while ten or more was coded as excessive polypharmacy [60–63].

2.7 Data Analysis

For the 'service utilisation' study, descriptive statistics were completed to summarise the data, including the percentage of completed referrals and the time to complete the referrals. For the 'service impact' study, Pearson's chi-squared test was completed to test the difference between two groups of included patients. For the data analysis (FA completed analysis, supported by JW), first, a descriptive analysis to characterise the study participants before and after service implementation was completed alongside an unadjusted analysis (without controlling confounding variables) comparing outcomes (UMDs and ADEs) before and after service implementation. This was followed by a logistic regression analysis, where a univariate analysis of the variable 'stage of service implementation' was first completed, followed by a multivariable logistic regression analysis for the outcome rate of UMDs and ADEs to determine the service impact after adjusting for possible confounders. A univariate regression analysis was performed to establish if the unadjusted odds ratio (uOR) and multivariable regression produced an adjusted odds ratio (aOR) to evaluate the effect of confounders on the relationship of the study period (pre-intervention and post-intervention) and UMDs or ADEs. The regression analysis included confounding variables that were chosen based on a literature review and clinical relevance including patient age, sex, number of medications and length of hospital stay [37, 40, 64–71]. Third, an adjusted analysis of baseline (pre-service implementation) UMD and ADE data, including potential predictors of outcomes was completed via a logistic regression analysis [72, 73]. All data analyses were carried out using Stata, version 14.0 (StataCorp LLC, College Station, Texas, USA).

3 Results

3.1 'Service Utilisation'

3.1.1 Patient Demographics

Between March 2019 and February 2020, there were 3033 TCAM service referrals from the base hospital to 71 community pharmacies across the CCG. Most of the referrals were for patients aged 70 years and above (72%, $n = 2195/3033$), with 14.5% ($n = 442/3033$) of referrals for patients aged 20–59 years. Sixty-five per cent ($n = 1713/3033$) of the referrals were for female patients.

3.1.2 Referrals Completed by Community Pharmacies

Overall, the majority of referrals (70%, 2126/3033) were marked as 'completed' by the community pharmacies, with 30% ($n = 907$) left uncompleted. A referral was considered complete if it was received from the hospital and acknowledged/reviewed/acted upon by the community pharmacy.

Table 1 shows that three-quarters of referrals for patients aged between 20 and 59 years were completed (75.5%, $n = 334/442$), while 69% of referrals for patients aged between 60 and 100 years were completed ($n = 1792/2591$). It also shows that an almost equal percentage of referrals were completed for female and male patients, which were 71% and 69%, respectively.

The number of referrals varied between 215 and 310 per month (median 246, interquartile range [IQR] 234–268). The completion rate varied between 63 and 85 % per month (median 69, interquartile range [IQR] 65.5–74). Table 1 shows that the majority of the referrals were sent to large national multiple community pharmacies (38.3%, $n = 1167/3040$), followed by independent pharmacies (37.6%, $n = 1145/3040$). However, the highest proportion of completed referrals were from local regional multiple community pharmacies (71%).

For the first 12 months of TCAM service implementation, community pharmacists acted on most referrals they received within the same month of referral, with 15% of referrals completed/or any activity saved after 30 days, over a median of 7.5 months (interquartile range [IQR] 4.2–11.7). The percentage of completed referrals recorded in the same month of the pharmacy receiving the referral was observed to show an increasing trend in the last 3 months of the evaluation (see Appendix 3 of the ESM).

Table 1 Number of all and completed transfers of care around medicines services by patient gender and age

Characteristics	Number of all referrals (n = 3033)	Number of completed referrals (n = 2126)	Percentage completion (%)
Age, years			
20–59	442 (14.6%)	334 (15.7%)	75
60–69	396 (13%)	279 (13.1%)	70
70–79	722 (23.8%)	510 (24%)	70
80–89	1091 (36%)	756 (35.6%)	70
90–100	382 (12.6%)	247 (11.6%)	64
Gender[a]			
Female	1713 (56.5%)	1217 (57.2%)	71
Male	1319 (43.5%)	909 (42.8%)	69
Month			
March 2019	215 (7.0%)	184 (8.6%)	85
April 2019	232 (7.6%)	171 (8.0%)	74
May 2019	265 (8.7%)	183 (8.6%)	69
June 2019	244 (8.0%)	169 (7.9%)	69
July 2019	269 (8.8%)	186 (8.7%)	69
August 2019	248 (8.1%)	187 (8.7%)	75
September 2019	233 (7.6%)	173 (8.1%)	74
October 2019	310 (10.2%)	201 (9.4%)	65
November 2019	239 (7.8%)	155 (7.2%)	65
December 2019	284 (9.3%)	179 (8.4%)	63
January 2020	252 (8.3%)	169 (7.9%)	67
February 2020	242 (7.9%)	169 (7.9%)	70
Total	**3033** (100%)	**2126** (100%)	**70**
Pharmacy type[b]			
Large national multiple	1167 (38.3%)	785 (37.1%)	67
Local regional multiple	728 (23.9%)	569 (26.9%)	71
Independent	1145 (37.6%)	759 (35.9%)	66
Total	**3040**[a] (100%)	**2113**[a] (100%)	**69**

Bold values indicate the total number for this category

[a]Missing data (n = 1)

[b]Because of a technical issue with extraction, the numbers are not identical to the remaining dataset

3.1.3 Community Pharmacy Activity and Services in Response to TCAM Service Referrals

Community pharmacists identified 45 referrals (20 female patients and 25 male patients) from the cohort of 2126 'completed' referrals (2%; n = 45/2126) as having issues that needed a referral to a GP. The most common reasons for referral to a GP were the identification of medication changes, incorrect repeat prescriptions following discharge or to request a new prescription or weekly MDS.

Different services were reported as being carried out in community pharmacies, once a referral was received, which then changed the referral status to 'completed'. Among the 2126 completed referrals, the five most common services commenced were: completed a medication reconciliation (n = 1004, 47.2%), information reviewed (n = 1004, 47.2%), offered home delivery of medication (n = 841, 39.5%), reviewed MDS arrangements (n = 503, 23.6%) and commenced MDS (n = 400, 18.8%) [see Appendix 4 of the ESM]. From the cohort of patients with completed referrals, 28.6% of patients received one service (n = 609/2126), 44.8% of patients received two services (n = 953/2126) and 26.5% of the patients received 3–14 services (n = 564/2126). There was a statistically significant difference (p = 0.01) in the age of patients between those receiving one, or more than one service with patients aged between 50 and 59 years having the highest proportion of people receiving more than one service (80.7%).

3.2 'Service Impact'

The number of completed data collection forms submitted to the research team was 594, including 242 data collection

forms pertaining to patients discharged in the pre-implementation stage, and 351 data collection forms to patients discharged in the post-implementation stage (one data collection form did not specify the phase of data collection, and was excluded as the patient was discharged from the emergency department). However, 183 (30.8%) data collection forms were excluded because of several reasons, the most common being the unavailability of medication reconciliation entry or related activity ($n = 93$); of the 93 data collection forms excluded because of the unavailability of medication reconciliation or (equivalent activity), 34 were from the pre-implementation phase and 59 were from the post-implementation phase, followed by the patient did not stay at least 24 h in the base hospital ($n = 21$), and the patient discharged from the emergency department ($n = 17$). Therefore, the total number of completed data collection forms included in the subsequent analysis was 411, where 41% of the data collected pertained to the TCAM service pre-implementation stage ($n = 168$), and 59% of the data collected represented the post-implementation stage ($n = 243$).

The two cohorts of patients were of similar age, and gender proportion. The majority of included patients were female (58%, $n = 241/411$). Almost one-quarter of the patients were aged less than 64 years ($n = 70/411$), with most aged 75–94 years (62%, $n = 254/411$), with a mean age of 77 years. Most of the included patients were of White ethnicity (92%, $n = 378/411$). Most of the included patients were discharged from medical wards (88%, $n = 362/411$), and the majority were discharged to home (90%, $n = 369/411$). The majority (88.5%, $n = 364/411$) of completed data collection forms indicated that patients were exposed to polypharmacy (prescribed more than five medications). In the post-implementation stage, data collectors recorded the reason(s) why a referral to the TCAM service was made. Most of the referrals were for recurrent MDS ($n = 204$), followed by new MDS ($n = 30$), and the need for additional service ($n = 5$). Four data collection forms did not state the reason for referral (see Appendix 5 of the ESM).

3.2.1 Unintentional Medication Discrepancies (UMDs)

Following review by the research team of the UMDs identified by the pharmacist data collectors, 52 data collection forms were assessed to have a total of 89 UMD. There were 36 data collection forms with one UMD, and 16 data collection forms with two or more UMDs. The majority of UMDs were assessed to have the capacity to cause an error (63%, $n = 56/89$), and/or cause potential harm (92%, $n = 82/89$). The crude rates of UMDs at baseline and after service implementation were 13.6% and 11.9%, respectively. The most common medication classes associated with UMD were medication for the cardiovascular system ($n = 39$, 43.8%), central nervous system ($n = 15$, 16.8%) and gastrointestinal system ($n = 9$, 10.1%) (see Table 2).

3.2.2 Adverse Drug Events (ADEs)

The number of data collection forms with ADEs associated with at least one medication was 72. However, after reviewing data collection forms by the expert panel, 18 data collection forms were excluded because of insufficient information or the patient having a hospital readmission that was not medication related. Thus, the number of data collection forms with ADEs associated with at least one medication confirmed by the expert panel was 54. Following a causality assessment, expert panel members assessed 18 ADEs to be possible ADEs ($n = 8$), or either not drug related or unevaluable ($n = 10$). Thus, a total of 36 ADEs were identified for further analysis and inclusion, including 23 probable ADEs (64%) and 13 definite ADEs (36%). The majority of the included 'confirmed' ADEs occurred in the post-implementation stage (64%, $n = 23/36$), with 36% ($n = 13/36$) of ADEs occurring in the pre-implementation stage. Table 3 shows that the crude rates of ADEs at baseline and after service implementation were 7.7% and 9.4%, respectively.

Following an expert panel assessment, almost half of the 'confirmed' ADEs were considered preventable (55.5%, $n = 20/36$). Most preventable ADEs occurred in the post-implementation stage ($n = 13/20$). It was found that six data collection forms included more than one ADE. Most confirmed ADEs were rated by the expert panel to be of mild clinical severity (70%, $n = 25/36$), with the remaining 30% of ADEs of moderate severity ($n = 11/36$). Most mild and moderate severity ADEs occurred in the post-implementation stage (60%, $n = 15/25$ and 73%, $n = 8/11$, respectively). The common medication classes implicated in harm were cardiovascular ($n = 22$, commonly diuretics), central nervous system ($n = 7$) and gastrointestinal ($n = 3$). The most common consequences of ADEs were reduced renal function or acute kidney injury (AKI) ($n = 5$), followed by oedema, or swelling ($n = 5$). The majority of patients affected by ADEs were female (75%, $n = 27/36$), and aged between 75 and 84 years (69%, $n = 25/36$). Table 3 shows summary statistics for ADE data, including a breakdown of patients affected by ADEs according to the stage of TCAM service implementation. As shown in Table 3, the crude rates of preventable ADEs at baseline and after service implementation were 3.5% and 4.1%, respectively.

The majority of patients affected by ADEs or UMDs had hospital stays between 1 and 7 days. However, a higher proportion of patients who had a longer hospital stay (more than 30 days) were affected by UMDs, or ADEs (see Appendix 6 of the ESM).

Table 2 Description of unintentional medication discrepancies (UMDs)

	Stage of service implementation		Total frequency
	Pre-stage	Post-stage	
Patient affected by UMDs	23 (13.6%)	29 (11.9%)	52 (12.7%)
Gender			
Male	11 (6.5%)	11 (4.5%)	22 (5.3%)
Female	12 (7.1%)	18 (7.4%)	30 (7.2%)
Age, years			
> 65	5 (2.9%)	7 (2.8%)	12 (2.9%)
≤ 65	18 (10.7%)	21(8.6%)	39 (9.4%)
Total number of included patients in the stage	168 (100%)	243 (100%)	411 (100%)
Nature of the UMD			
Medication affected by UMDs	41	48	89
Medication discrepancy severity (NCC MERP criteria)			
A: Circumstances or events that have the capacity to cause error	26 (63.4%)	30 (62.5%)	56 (63%)
B: An error occurred but the error did not reach the patient	6 (14.6%)	7 (14.5%)	13 (14.6%)
C: An error occurred that reached the patient but did not cause patient harm	2 (4.8%)	9 (18.7%)	11 (12.3%)
D: An error occurred that reached the patient and required monitoring to confirm that it resulted in no harm to the patient and/or required intervention to preclude harm	6 (14.6%)	1 (2%)	7 (7.8%)
E: An error occurred that may have contributed to or resulted in temporary harm to the patient and required intervention	1 (2.4%)	0	1 (1.1%)
Missing data	0	1 (2%)	1 (1.1%)
Medication discrepancy harm[a]			
Potential harm	37 (90.2%)	45 (94%)	82 (92.1%)
No harm	3 (7.3%)	1 (2%)	4 (4.4%)
Actual harm	1 (2.4%)	0	1 (1.1%)
Missing data	0	2 (4%)	2 (2.2%)
Total medications affected by UMDs	41 (100%)	48 (100%)	89 (100%)
Medication class based on British National Formulary chapters			
Cardiovascular system	20	19	39 (43.8%)
Angiotensin-converting enzyme (ACE) inhibitors	4	6	
Diuretics	5	3	
Central nervous system	6	9	15 (16.8%)
Opioids	4	1	
Gastrointestinal system	4	5	9 (10.1%)
Laxatives	3	4	
Endocrine system	2	3	5 (5.6%)
Respiratory system	2	3	5 (5.6%)
Blood and blood-forming organs	1	3	4 (4.4%)
Musculoskeletal system	1	2	3 (3.3%)
Skin	1	2	3 (3.3%)
Genito-urinary system	1	1	2 (2.2%)
Nutrition and metabolic disorders	1	1	2 (2.2%)
Anti-infective system	1	0	1 (1.1%)
Eye	0	1	1 (1.1%)

NCC MERP National Coordinating Council for Medication Error Reporting and Prevention, *UMDs* unintentional medication discrepancies

[a]Categorised based on the NCC MERP

Table 3 Quantitative description of adverse drug events (ADEs)

	Pre-stage ($n = 168$)	Post-stage ($n = 243$)	Total ($n = 411$)
Patients affected by ADEs	13 (7.7%)	23 (9.4%)	36
Gender			
Male	1 (0.6%)	8 (3.3%)	9
Female	12 (7%)	15 (6.1%)	27
Age, years			
> 65	1 (0.6%)	2 (0.8%)	3
≤ 65	12 (7%)	21 (8.6%)	33
Clinical severity of ADEs			
Low	10 (5.9%)	15 (6.1%)	25
Moderate	3 (1.7%)	8 (3.2%)	11
Preventability of ADEs			
Preventable	6 (3.5%)	10 (4.1%)	16
Non-preventable	7 (4.1%)	13 (5.3%)	20
Medication classes associated with ADEs			
Anti-infective	0	1	**1**
Blood and blood-forming organs	0	1	**1**
Skin	0	1	**1**
Respiratory system	1	0	**1**
Gastrointestinal system (laxative)	2	1	**3**
Nervous system	1	6	**7**
Antiepileptics	1	1	2
Analgesics, opioid	0	2	2
Analgesics, non-opioid	0	1	1
Antipsychotics	0	1	1
Antidepressants	0	1	1
Cardiovascular system	9	13	**22**
Diuretics	3	8	11
Angiotensin-converting enzyme inhibitors	3	0	3
Antithrombotic, antiplatelet drugs	2	1	3
Calcium-channel blockers	0	2	2
Beta-adrenoceptor blockers	0	1	1
Angiotensin receptor antagonists	0	1	1
Antithrombotic, factor Xa inhibitor	1	0	1
Most common symptoms of ADEs			
Reduced renal function, or acute kidney injury	2	3	5
Oedema or swelling	2	3	5
Diarrhoea	2	2	4
Uncontrolled blood pressure (high or low)	2	2	4
Drowsiness or dizziness	1	2	3

Bold values indicate the total number for this category

ADEs adverse drug events

3.2.3 Regression Analysis

Table 4 presents the results of a logistic regression analysis exploring the impact of TCAM services on UMD and ADE rates. The unadjusted odds (uOR) ratio for UMDs was 0.85 (95% confidence interval [CI] 0.47–1.53, $p = 0.59$) and for ADEs was 1.24 (95% CI 0.61–2.53, $p = 0.54$). Adjusting for possible confounding variables did not change the risk significantly; the adjusted odds ratio (aOR) for UMDs was

Table 4 Logistic regression analysis of unintentional medication discrepancies and adverse drug events

	Unintentional medication discrepancies				Adverse drug events			
	Odds ratio	95% CI		*p* value	Odds ratio	95% CI		*p* value
Univariate logistic regression								
Stage (0 pre, 1 post)	0.85[a]	0.47	1.53	0.59	1.24[a]	0.61	2.53	0.54
Multivariable logistic regression								
Stage (0 pre, 1 post)	0.79[b]	0.44	1.44	0.46	1.19[b]	0.57	2.45	0.63

CI confidence interval

[a]Unadjusted odds ratio

[b]Adjusted odds ratio

0.79 (95% CI 0.44–1.44, $p = 0.46$), and for ADEs was 1.19 (95% CI 0.57–2.45, $p = 0.63$).

The baseline rates (pre-implementation stages) of UMDs and ADEs in this study were 14% ($n = 23/168$) and 7.7% ($n = 13/168$) of patients, respectively. In the analysis of the predictors of outcome in the pre-intervention stage, there was no observed statistically significant risk factor predicting the occurrence of UMD. However, there was a significant positive correlation in the univariate regression analysis between patient gender (female) and the risk of experiencing one or more ADEs (odds ratio 9.5, 95% CI 1.21–75.68, $p = 0.03$) [for the results obtained from the baseline univariate and multivariable regression analyses, see Appendix 7 of the ESM].

4 Discussion

4.1 Main Findings and Interpretation

This study explores both the TCAM intervention utilisation and impact on medication safety outcomes for patients using MDS post-hospital discharge. Thus, this study informs the continuing implementation of this intervention in the UK as well as internationally and in doing so aligns with the goals of the WHO Third Global Patient Safety Challenge: Medication Without Harm, which has made improving medication safety at the transfer of care a priority [74].

The descriptive 'service utilisation' analysis of TCAM patient referrals over 1 year provided insight into the nature and breadth of responses to referrals by community pharmacies. The proportion of completed referrals in our study was higher than in the previous literature [30, 31, 75]. There was an observed increasing percentage of completed referrals being made in the same month of receiving referrals in the later months of the evaluation period, indicating that community pharmacies may have developed greater awareness and experience in the use of TCAM over time. This highlights that user feedback could be sought on the use of the encrypted platform to help guide improvement in real time. However, 30% of referrals were not completed at all and 15% were delayed longer than 1 month, which indicates that further research is needed to better understand the causes of referral rejections and delays in completing referrals. It has been reported by Jeffries et al., who conducted qualitative interviews with healthcare providers regarding their feedback on the TCAM implementation in the same site as this project, that the TCAM requires a "interdependent, collaborative network of different stakeholders" [20]. Perhaps a possible future approach is implementation-science based research, which understands the context that impacts the implementation of the innovation (how healthcare professionals work together to deliver TCAM), to help inform implementation and sustainability strategy for this service [76].

We have revealed that the TCAM service was utilised for both young and older patients with MDS, with 14% of patients being referred aged 59 years and younger. Corresponding referral 'completion' rates were found to be lower for those aged 90+ years (64%, $n = 247/382$) and higher for those aged < 60 years (75%, $n = 334/442$), which prompts the need for further investigation to understand these differences. These findings may reflect the need for pharmacy professionals to recognise and address inequalities and adopt alternative approaches to medicine optimisation for different patient groups.

The recorded services provided by community pharmacies to patients referred by the TCAM service following hospital discharge were diverse. The three most common services provided were medication reconciliation and review information (47.2%), home delivery (39.5%) and review MDS arrangements (23.6%). The breadth of services observed in this study, including easy open tops (6%), large print labels (3.5%) and talking labels (1.5%) reflect the vulnerable nature of the included patients on MDS. This study broadly supports the findings by Jeffries et al. [20], who in a process evaluation of the TCAM service highlighted how the service facilitated communication with patients and their

families, where the 'service utilisation' data confirm that the receipt of referrals by community pharmacy initiated opportunities to contact patients to follow up on the discharge.

The 'service impact' analysis found that the majority of patients affected by ADEs or UMDs were female (this comparison did not take into account the number of medicines prescribed) and aged 75 years and older. This study supports previous observations that female patients may be more affected by ADEs [77], with potential contributing factors including biological gender influencing medication pharmacokinetics [78–80]. The evaluation also found that the most common medication classes implicated in incidents were medications for cardiovascular and central nervous system body systems. These results further support the observations of others that these medication groups are implicated in medication errors and patient harm across stages of the patient healthcare journey, and are an important target for intervention [81–87].

This study has also found that in the pre-implementation phase (baseline data) ADE and UMD rates were 7.7% (n = 13/168), and 14% (n = 23/168), respectively, which is lower than in the previous literature [8, 88, 89], though earlier studies did not exclusively focus on those patients with MDS. The retrospective data collection method used in this study could be attributed to the low baseline rate of UMDs and ADEs. Where other studies utilised prospective approaches [90, 91], however, it may be argued that retrospective methods reflect clinical practice without the interference of the research team.

The earlier observation coupled with the fact that no evidence on impact was found on the rates of UMD and ADEs following a multivariable analysis may be attributed to a number of factors requiring further exploration. For example, in the study region, medication safety initiatives and performance metrics have been used for a number of years. The CCG area also benefits from the use of an integrated healthcare record across primary and secondary care, where evidence highlights its impact on medication safety. In addition, the area has also benefited from sustained implementation of a general practice-based clinical pharmacy team who may have supported a positive local medicines safety culture. Finally, it could be attributed to the lack of infrastructure (integrated health records with community pharmacies) that supports the intervention. As medication reconciliation alone by community pharmacists may not translate into a better clinical assessment of patients to prevent ADEs without access to the complete medical record and understanding of the patient's clinical condition.

4.2 Strengths and Limitations

This study is the first investigation of TCAM service utilisation and the impact on medication safety over a 1-year period to explore the extent, speed and impact of service embedding. To support consistency and accuracy in 'impact' data collection, pharmacist data collectors were trained, provided a standardised data collection guide and were sent regular e-mails with frequently asked questions about data collection. Assessment of ADEs causality, preventability and severity criteria was completed using an established validated framework by an expert panel who reached a consensus on ratings, the method was adapted from existing studies [47, 48].

However, this study has a number of limitations. Firstly, the retrospective nature of data collection [92] meant that the quality of the collected data was dependent on the quality of the documentation in patient records [93], which are known to be variable [94]. Secondly, whilst the research team were unaware of any other interventions to changes in the study CCG/hospital during the evaluation, a before-and-after study design cannot rule out the possible influence of temporal changes that may otherwise have been minimised through use of a control group [95] (although this was not feasible as the TCAM intervention was rolled out across the whole CCG at the same time, outside the influence of the research team). In addition, other study designs employing the use of control groups and randomisation may more robustly assess the effect of TCAM. Thirdly, data were not collected about the level of expertise or education of the person who completed medication reconciliation for each included patient in clinical practice, and this was not factored in the analysis. Evidence from Jordan suggests that pharmacist education level may be associated with positive perceptions toward the value of medicines reconciliation [96]. Fourthly, to capture 'service impact' data, the study also accepted any medical record entries sufficiently similar to medication reconciliation and conducted by a member of non-pharmacy general practice staff as 'medicine reconciliation' for data collection purposes. Fifthly, the generalisability of the study was limited in terms of including patients from one geographical area (though data were collected from 18 primary care sites in eight local areas, and a regression analysis controlled this variable). Sixthly, the study did not reach statistical power calculations for the ADE sample size (n = 638), and identified a low number of ADEs. Therefore, there is more uncertainty around the results and further evaluation is required on a larger scale to make informed decisions about the implementation and optimisation of this service. Seventhly, the pharmacist data collectors knowledge about the study might have impacted the quality of recorded data in medical records post-service implementation.

4.3 Implications of Findings

Based on findings from this study, the Discharge Medicines Service (DMS) could be used to target patient and

medication groups most at risk of errors and patient harm. This study highlights emerging targets for intervention, including the pronounced role of cardiovascular, central nervous system and gastrointestinal medications in both ADEs and UMDs. For example, a greater emphasis on reassessing patient kidney function, monitoring indicators after discharge and checking acute kidney injury (AKI) risk with the use of diuretics, as diuretics were the most common groups implicated in harm post-hospital discharge in this study. There has been a national effort to optimise medication in patients with acute kidney injury "Think Kidney" [97], where there has been an emphasis on diuretics and advice on patient counselling before discharge, and the availability of complete information in the discharge summary regarding drug restart and monitoring timing. In addition, this study highlighted the need for integrated electronic health and care records (e.g. community pharmacies could have access to GP summary records).

Medication reconciliation was the most common service provided in community pharmacies (47.2%) in this study following referral via the TCAM service. Medicine reconciliation has been added as a standard service in a community pharmacy within the new Community Pharmacy Contractual Framework (CPCF) in England for 2019/20 to 2023/2024 [98], and this study both highlights its importance but also that attention must be drawn to better understanding the current conduct of the service and how it may be optimised in the future.

More research is needed to explore in depth how the service is implemented and used in different contexts, and with wider patient groups beyond those utilising MDS to evaluate more fully how the TCAM service impacts upon medication safety. In addition, further study with more focus on the influence of context on intended outcome measures is suggested, given that the TCAM service is currently nationally implemented in England in diverse regions and healthcare settings as the Discharge Medicines Service. This research may determine whether amendments to this service might be needed to adapt implementation in different contexts. In addition, this work will be an important foundation for future efforts to evaluate the service impact at scale using multi-site studies with adequate statistical power and concurrent process evaluation. Utilising implementation science for this research to inform an ongoing implementation and sustainability strategy for this service as it is rolled out across the NHS in England could also be helpful [76]. A future study should identify context-related characteristics that might have impacted the utilisation of the service, including community pharmacy types (high street, supermarket, multiples, independents), number/nature of staff in community pharmacy who interact with the service, reasons of referral rejections, reasons of completing referrals beyond 2 weeks and methods adopted to prioritise referrals.

5 Conclusions

This is the first exploratory study evaluating the utilisation and impact on medication safety of the Transfers of Care Around Medicines (TCAM) service post-hospital discharge. Whilst the TCAM service facilitated a number of community pharmacy services being promptly offered to patients with MDS; the impact of the intervention on UMD and ADE rates for these patients following hospital discharge was uncertain. Further research should explore the implementation and impact of this service in other contexts using larger study samples. This research has identified patient-level and medication-level targets for future optimisation of the TCAM service or the development of other interventions such as medication indicators.

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Declarations

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Conflict of interest Fatema A. Alqenae, Douglas Steinke, Peter Robertson, Hilary Belither, Jennifer Bartlett, Jack Wilkinson, Steven D. Williams, Lawrence Brad, Mark Jeffries, Darren M. Ashcroft and Richard N. Keers have declared no conflicts of interest in undertaking the proposed research.

Ethics approval The research was exempt from the University Research Ethics Committee review as a decision by the University of Manchester University Research Ethics Committee (2019-7048-10983). Health Research Authority (IRAS project ID 262688) and host organisation (Research & Development—Capacity and Capability, and data sharing agreement with each primary care site) approvals were obtained before the start of the study.

Consent to participate Not applicable.

Consent for publication Not applicable.

Availability of data and material The datasets for this article are not publicly available as this was not approved by the Health Research Authority.

Code availability Not applicable.

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Authors and Affiliations

Fatema A. Alqenae[1] · Douglas Steinke[1] · Hilary Belither[2] · Peter Robertson[3] · Jennifer Bartlett[2] · Jack Wilkinson[4] · Steven D. Williams[1,5] · Lawrence Brad[5] · Mark Jeffries[1,6,8] · Darren M. Ashcroft[1,6] · Richard N. Keers[1,6,7]

✉ Fatema A. Alqenae
Fatemaalqenae@hotmail.com

1 Division of Pharmacy and Optometry, School of Health Sciences, Centre for Pharmacoepidemiology and Drug Safety, University of Manchester, Oxford Road, Manchester M13 9PT, UK

2 Pharmacy Department, Salford Royal Hospital, Northern Care Alliance NHS Foundation Trust, Salford, Greater Manchester, UK

3 Primary Care Practice, Salford, Manchester, UK

4 Centre for Biostatistics, Division of Population Health, Health Service Research and Primary Care, School of Health Sciences, University of Manchester, Manchester, UK

5 Westbourne Medical Centre, Bournemouth, UK

6 NIHR Greater Manchester Patient Safety Translational Research Centre, Manchester, UK

7 Suicide, Risk and Safety Research Unit, Greater Manchester Mental Health NHS Foundation Trust, Manchester, UK

8 Division of Population Health, Health Service Research & Primary Care, School of Health Sciences, University of Manchester, Manchester, UK