Title: A mixed-method study of community pharmacy staff's use, perceptions and acceptance of barcode scanning technology

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ABSTRACT

Introduction

Increasing technology is a strategic goal within pharmacy to facilitate medicines' dispensing. Barcode scanning technology (BST) is considered low cost and reliable with potential safety benefits. A barrier to BST implementation within hospital pharmacy includes staff resistance; however, few studies explore BST within community pharmacy. To address this, pharmacy staff's use, perceptions and acceptance of BST within Scottish community pharmacies were examined.

Methods

Community pharmacies within Scotland using BST to scan medicines were identified using Twitter, eNewsletters and snowball sampling; 57 pharmacies were identified. Between May-Aug 2019, managers/owners participated in semi-structured interviews to explore BST use, and staff operating BST completed an online questionnaire to examine perceptions and acceptance. Interview data underwent content analysis and questionnaire data presented as medians (IQR).

Results

BST was used for various purposes, most commonly for dispensed item verification (n=43 pharmacies) and to identify falsified medicines (n=10 pharmacies). Twenty pharmacy managers/owners were interviewed which revealed multiple scanners and BST functionalities. Thirty-five participants from 16 pharmacies participated in the questionnaire. Staff considered BST as easy to use. There were positive perceptions and acceptance of BST for dispensed item verification, and negative perceptions and less acceptance of BST for identifying falsified medicines.

Discussion

BST implementation was identified in a minority of Scotland's 1,254 community pharmacies, and greater effort may be needed to increase technology utilisation. The variation of BST use may affect safety due to increased complexity. BST's purpose may underpin staff perceptions and acceptance. Future studies should explore barriers and observe BST use in practice.

PUBLIC INTEREST SUMMARY

Barcode scanning technology (BST) may help pharmacy staff to dispense medicines safely. Hospital pharmacy staff have reported disliking using BST to scan medicines; however, no similar research has been carried out within community pharmacy. This study examined Scottish community pharmacies' use of BST to scan medicines, and the pharmacy staff's views. Fifty-seven pharmacies were identified. BST was most commonly used to verify that the correct medicine was selected during dispensing (n=43 pharmacies) and to identify 'falsified medicines' which were not safe to dispense (n=10 pharmacies). Staff considered BST as easy to use, but were more positive and accepting of BST for verifying the correct medicine than for identifying falsified medicines. This suggests BST's purpose may underpin pharmacy staff perceptions and acceptance. A small number of pharmacies in Scotland used BST for this purpose, therefore more efforts may be needed to promote technology use.

MANUSCRIPT

Introduction

The use of technology is increasing within all sectors to create “smart products, smart processes and smart procedures” [1]. Within healthcare, various technologies have been adopted to deliver high quality care, such as electronic health records [2]. Increasing the utilisation of technology is a long-term strategic goal within pharmacy to facilitate the safe and effective dispensing of medicines [3,4]. One method of achieving this may be through the adoption of barcode scanning technology (BST). This technology is regarded as easy to use, low cost, and reliable [5-7] in industries such as car manufacturing and retail [6-8]. These attributes are appealing within pharmacy settings compared to other technologies such as automation [9,10], which are more expensive and may require re-fitting of pharmacy premises [11].

Barcodes are ‘data carriers’, and within pharmacy BST uses a light-emitting or laser source to detect and scan these in order to transfer the data onto electronic systems or link to other datasets [6]. Traditionally, BST can be used to scan 1D linear barcodes which are rectangular in shape with dark bars interspersed with spaces of varying thickness [6]. These barcodes can be scanned on medicines to verify correct medicine selection during dispensing [12]; for stock inventory management [13,14]; to log expiry dates [14]; and for remuneration purposes [15]. These applications of BST have been introduced within primary and secondary care settings; various community pharmacies in Europe - including France, Denmark and Sweden - are known to routinely scan 1D medicine barcodes for remuneration [15], and a 2017 survey revealed that 61.9% of hospital pharmacies in the United States used BST for scanning 1D medicine barcodes [16].

Advances in bar-coding technology have resulted in the development of 2D matrix barcodes, which are typically square in appearance and are commonly termed ‘QR codes’ [6]. 2D matrix barcodes have greater data storage capacity that 1D linear barcodes with capability to store medicinal details, batch numbers and expiry dates [6,15]. Widespread application of 2D barcodes on medicinal products was introduced by the European Union’s Falsified Medicines Directive (FMD) in 2019, which introduced measures to prevent the supply of falsified medicines throughout the European Union. This includes the introduction of anti-tamper devices on medicines and pharmacy staff scanning the

2D matrix barcode during dispensing to identify falsified medicines [17,18]. This was legislated in February 2019, although reports indicate that some pharmacies have been conducting FMD scanning as early as December 2018 [19].

Thus far, exploratory studies on BST implementation within pharmacy practice have focused on the scanning of 1D medicine barcodes within hospital pharmacy settings, where it has been identified that BST can positively affect the incidence of dispensing errors [5,20-22] and improve financial returns [23]. However, there are also instances of BST not achieving intended outcomes in relation to error prevention [22], and some hospital pharmacy staff have perceived BST as not useful for patient care or job performance [24]. For technology to achieve intended outcomes it must be successfully used in practice, and the widely used Technology Acceptance Model (TAM) proposes that technology will not be successfully used in instances of negative staff perceptions and low acceptance of technology (Figure 1). The implementation of BST in hospital pharmacy has been met with low pharmacy staff satisfaction [24], negative perceptions [25,26], and fear of change [27]. A study by Alharti et al in 2015 concluded that staff resistance had the greatest impact on successful implementation of BST in the hospital pharmacy setting [27], which offers a potential explanation as to why BST does not always achieve intended outcomes. Furthermore, FMD scanning may also be encountered with negative staff perceptions, as prior to its introduction English community pharmacy staff predicted it would be disruptive and negatively impact workload [28].

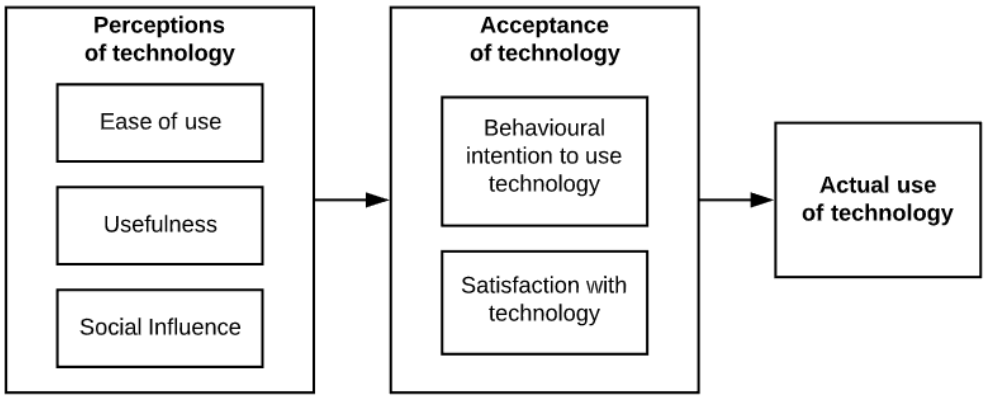

Figure 1. Technology Acceptance Model [24]

Although many studies have explored BST in hospital pharmacy settings [5, 20-27], there is little research on the implementation of BST within community pharmacy, and no studies were identified on the use of BST for scanning 2D medicine barcodes. Such studies are required considering the

potential implementation challenges with BST and technology in general [29], and it is plausible that staff resistance identified within hospital pharmacy may also be apparent within community pharmacy. There are approximately 1,250 community pharmacies within Scotland which have a contract with the National Health Service (NHS) to provide prescribed medicines with no monetary charge at the point-of-care [30]. These pharmacies have routinely used BST since 2007 for the purpose of scanning 1D barcodes on prescriptions. This allows for electronic transfer of prescription data to the pharmacy's patient medication record (PMR) system and facilitates remuneration as data is transferred to a centralised electronic system to process payments [31]. However, within Scottish community pharmacies there is now the possibility for BST to be used to scan medicines rather than prescriptions. It is unclear to what extent – and for what purpose – this is being carried out. The aim of this study was to explore the use of BST when scanning 1D and/or 2D medicine barcodes within community pharmacies in Scotland, followed by an examination of community pharmacy staff's perceptions and acceptance.

Methods

This was a mixed-method study of sequential design with qualitative semi-structured telephone interviews with pharmacy managers/owners, followed by an online questionnaire with various pharmacy staff members. This was conducted in a convergent manner with the results offering an overall interpretation of the use, perceptions and acceptability of the BST [32]. Initial qualitative interviews were necessary due to the sparse knowledge of BST use within community pharmacies, and the questionnaires allowed for a wide range of pharmacy staffs' perceptions and acceptance of BST to be identified. The study was conducted between March 2019 and September 2019. Advice was sought from the University of Strathclyde Ethics Committee who advised that this study was Service Evaluation and did not required ethical approval.

Recruitment of pharmacies

Community pharmacies within Scotland which implemented BST to scan medicines were eligible for inclusion in the semi-structured interviews and questionnaire. Representatives from the Scottish Government, the Scottish NHS, Community Pharmacy Scotland (CPS), NHS Education for Scotland, the University of Strathclyde and Robert Gordon University were asked to identify eligible pharmacies.

The project was briefly advertised through Twitter, and a CPS eNewsletter emailed to Scottish pharmacies by CPS also advertised the initial qualitative component (see Appendix 1 for advertisements). The advertisements had information of the study and provided contact details of the research team for those interested. Snowball sampling was also employed whereby pharmacy staff from identified pharmacies were asked to identify other eligible pharmacies. Snowball sampling was considered necessary as there is no established database of pharmacies using BST within Scotland. Recruitment of pharmacies occurred throughout March 2019 -May 2019 and ceased once no new pharmacies were identified. This recruitment strategy identified 57 community pharmacies using BST to scan medicines in Scotland, representing 12 separate pharmacy businesses. Pharmacy representatives who participated in the interviews were thereafter recruited to participate with the online questionnaire.

Data collection

In May 2019, pharmacy managers, owners, or superintendent pharmacists of the pharmacies identified were contacted by telephone to confirm if they used BST to scan medicines and for what purpose. The sites whose representatives were agreeable to participate in further evaluation activities were then invited by a researcher (NW) to participate in a semi-structured, telephone interview in May 2019. An email address of the representative was sought for the purpose of emailing them a Participant Information Sheet. These telephone interviews were conducted with the pharmacy manages/owners and focused on the adoption, application and functionalities of BST. The format of the interviews necessitated that fully informed consent was sought verbally to ensure that it was contemporaneous to the interview (see Appendix 2 for the verbal consent script). Additionally, asking participants to print and return a consent form was viewed as an imposition. The interviews were audio-recorded. From June to August 2019, representatives of the pharmacy sites who participated in the interviews were contacted and asked if willing for their pharmacy staff who operate BST to be invited to participate with an online questionnaire to identify perceptions and acceptance of BST. On agreement, a link to the questionnaire was disseminated via email; one pharmacy site requested paper questionnaires which were disseminated alongside individual return envelopes. The questionnaire was preceded with a Participant Information Sheet, and participants provided informed

consent prior to completing the questionnaire. All Participant Information Sheets explained that participation was voluntary.

Research team and reflexivity

The semi-structured interviews were conducted by NW (PhD; Research Assistant), KP (MSc; Research Assistant) and RN (PhD; Research Fellow) who identify as female. Both NW and RN have experience of conducting research interviews, and KP was trained to conduct the interviews for the purpose of this study. One researcher (NW) had an established relationship with a participant prior to the study; this participant was not contacted by this researcher (NW) and instead all communication was with KP or RN. For all other participants, the researchers did not have an established relationship with any of the other participants prior to the study, and participants were aware of the reasons for conducting the research. KP and RN work solely as researchers, and NW also works as a community pharmacist. Therefore, NW may have had biases/assumptions about the research topic.

Development of data collection tools

(i) Semi-structured interview schedule

The semi-structured interview schedule was developed with open and closed-ended questions by members of the research team to explore the adoption, application and functionality of BST (see Appendix 2). This was reviewed by an expert group knowledgeable about community pharmacy technology and the project's reference group, comprising of academic staff and NHS strategists. The authors piloted the interview guide with a pharmacist who was in the process of adopting BST and the schedule was amended, and the first 5 interview participants were asked for comments on the questions asked at the end of the interview, although this resulted in no changes. The duration of the interviews were between 10-36 minutes.

(ii) Questionnaire

A questionnaire by Holden et al based upon the TAM was adapted for use to identify pharmacy staff's perceptions and acceptance of BST [24,33], as presented in Appendix 3. The adaptations focused on using terminology familiar to Scottish pharmacy staff (for example substituting "bar-coding system" with "barcode scanning system") and were deemed superficial and would not impact the original questionnaire's reliability or validity. The questionnaire was developed as a Qualtrics online survey

with a 7-point Likert scale response option (ranging from 1 = not at all to 7 = to a very great extent), and demographic characteristics were sought of participants including age, gender, and job role (see Appendix 3 for all demographics sought). The questionnaire was reviewed by members of the research team and by an expert group knowledgeable about community pharmacy technology (representative from CPS and community pharmacy staff members) and the project's reference group (comprising academic staff and NHS strategists). The authors piloted the questionnaire with 8 pharmacy staff from 2 pharmacies which had implemented BST.

Data analysis

The interview data were transcribed by NW and KP; transcripts were not returned to participants for comment and/or correction. The data underwent a content analysis within NVivo v12.0, which is a method that can be applied to qualitative and quantitative data to facilitate the description and quantification of data [34]. Within NVivo, participant's quotes which represented similar content were group together within categories [34]. The number of pharmacies with data within each category was calculated and presented as a percentage of the total number of pharmacies. Data analysis was conducted for all interview data obtained; as the data underwent a content analysis and was not conceptually rich, there was no cessation of data analysis based on data saturation. Ten percent of data entry and analysis was validated by a second researcher.

The questionnaire data were inputted into SPSS v26.0, with analysis conducted separately for the different functionalities of BST as they were considered discrete innovations. The questionnaire sections which represented a scale were tested for internal consistency using Cronbach's alpha coefficient [35], with a score of >0.7 indicative of adequate reliability [36]. Median responses with interquartile range (IQR) were used to present responses. Demographic characteristics were presented as frequencies and percentages.

Results

The scope of this study was to understand BST use within Scottish community pharmacies when used to scan medicines. The results are presented by first reporting on the (1) BST use, followed by (2) BST adoption and application, and lastly (3) staff perceptions and acceptance of BST.

1. BST use

Of the 57 pharmacies, BST was used for 4 applications, as presented in Table 1. This included: verification that the correct medicine has been selected during dispensing - hereon referred to as verification scanning; FMD scanning; stock inventory management; and label generation. Two pharmacies used BST for both verification and stock inventory management, and one pharmacy used BST for both stock inventory management and label generation.

Table 1. Application of barcode scanning technology (n=57 pharmacies)

Application of BST	**Description of application**	**Number of pharmacies (n, %)***
Verification scanning	1D medicine barcodes are scanned to verify the dispensed medicine is what was prescribed.	43, 75.4%
FMD scanning	2D medicine barcodes are scanned to ensure it is not a falsified medication as per the European Union Falsified Medicines Directive.	10, 17.5%
Stock inventory management	1D medicine barcodes are scanned to record or check pharmacy stock levels.	3, 5.3%
Label generation	1D medicine barcodes are scanned into the PMR system as opposed to 'free-typing' the medicines name.	1, 1.8%%

FMD = Falsified Medicines Directive, PMR = Patient Medication Record, *The percentages do not add up to 100% as some pharmacies used BST for more than one purpose

2. Adoption and application of BST

(i) Respondents

Thirty-seven of the 57 eligible pharmacies were owned by a single pharmacy business; four of these pharmacies were nominated by the owner to participate in the semi-structured interview. Therefore, representatives of 24 pharmacies were invited to participate in the semi-structured interview, with representatives from 21 (91.3%) pharmacies agreeing. Overall, 20 individuals participated in the interviews comprising pharmacists, owners, and superintendent pharmacists. Some participants represented more than one pharmacy, and sometimes both an owner and pharmacist were interviewed regarding a single pharmacy site (e.g. if the first participant could not answer all questions).

(ii) Pharmacy characteristics

The characteristics of the 21 pharmacies are presented in Table 2. Seven of the 14 NHS Scotland Health Boards were represented, alongside a range of pharmacy business sizes including independent (n=2, 9.5%) and large chain (n=5, 23.8%) pharmacies. The most common number of medicine items dispensed per month was 8,000-9,999 items (n=7, 33.3%). Overall, 141 pharmacy staff were employed within the 21 pharmacies, and the total number of staff which used BST was 121.

Table 2. Pharmacy site characteristics (n=21)

Pharmacy site characteristics		**Number of pharmacies (n)**	**Percentage of pharmacies (%)**
NHS Scotland Health Board location	Ayrshire and Arran	1	4.8%
	Greater Glasgow and Clyde	6	28.6%
	Forth Valley	4	19.0%
	Lanarkshire	3	14.3%
	Lothian	2	9.5%
	Shetland	1	4.8%
	Tayside	4	19.0%
Pharmacy business size	Single, independent pharmacy	2	9.5%
	Small pharmacy business (2-4 pharmacies)	5	23.8%

	Medium pharmacy business (5-30 pharmacies)	9	42.9%
	Large pharmacy business (>30 pharmacies)	5	23.8%
Number of items dispensed per month	<4,000	0	0%
	4,000-5,999	2	9.5%
	6,000-7,999	4	19.0%
	8,000-9,999	7	33.3%
	Didn't know	3	14.3%
	Did not wish to disclose	5	23.8%

NHS = National Health Service

The application and functionalities of BST of the 21 pharmacies is presented in Table 3, with most pharmacies conducting verification scanning (n=10, 47.6%) or FMD scanning (n=10, 47.6%). 'Honeywell' (n=13, 61.9%) and 'Newland' (n=6, 28.6%) scanners were most commonly used, and these were used for different purposes (Table 3). The majority of pharmacies had used BST for less than one year (n=17, 80.5%), with the remaining pharmacies using BST for 1-5 years (n=3, 14.2%) or 15-20 years (n=1, 4.8%). Additionally, for the majority of pharmacies the BST was not wireless (n=20, 95.2%), was positioned on a stand (n=19, 90.5%), was integrated with the PMR system (n=16, 76.2%), and did not require a button to be pressed in order to scan (n=20, 95.2%).

Table 3. Application and functionalities of BST and scanners used (n=21 pharmacies)

Application of BST*	**Pharmacy Site Number**	**Scanner(s) used**	**PMR system**	**BST is integrated into PMR**	**BST is wireless**	**BST is used handheld**	**Need to press a button on BST to scan**
Verification scanning (n=10, 47.6%)	1	Honeywell	Analyst	✔	×	×	×
	2	Honeywell	Analyst	✔	×	×	×
	3	Honeywell	Analyst	✔	×	×	×

	5	Honeywell	Analyst	✔	×	✔	×
	6	Honeywell	Analyst	✔	×	✔	×
	14	Metrologic orbit	Analyst	✔	×	×	×
	15	Honeywell	Analyst	✔	×	×	×
	17	Honeywell	Analyst	✔	×	×	×
	18	Honeywell	Analyst	✔	×	×	×
	20	Honeywell	Analyst	✔	×	×	×
FMD scanning (n=10, 47.6%)	7	Newland	Proscript	×	×	×	×
	8	Honeywell, DMD Ready Zenon	Analyst	✔	×	†	×
	9	Newland	Proscript	×	×	×	×
	10	Newland	Proscript	×	×	†	×
	11	Honeywell, DMD Ready Zenon	Analyst	✔	×	†	×
	12	Honeywell, DMD Ready Zenon	Analyst	✔	×	×	×
	13	Symbol DS4308	Nexphase	✔	×	×	×
	16	Newland	Proscript	×	×	×	×
	19	Newland NLS-HR22	Proscript	✔	×	×	×
	21	Newland	Proscript	✔	×	×	×
Stock inventory management	4	Data Logic, Gryphone, MIO	Analyst	×	✔	✔	✔

	14	Metrologic orbit	Analyst	✔	×	×	×
(n=3, 12.3%)	18	Honeywell	Analyst	✔	×	×	×
Label generation (n=1, 4.8%)	4	Honeywell	Analyst	✔	×	×	×

FMD = Falsified Medicines Directive; † The scanner is used both handheld and propped up on a stand; *The percentages do not add up to 100% as some pharmacies used BST for more than one purpose

(iii) Reasons for adopting BST

The content analysis of the reasons pharmacies adopted BST is presented in Table 4. For FMD scanning, the decision was mostly due to EU-wide legislative change (n=9, 90%), with it reported that: *"we have to do it, it's not something that's optional" (S11, P9).* Half of participants (n=5, 50%) reported pressure: *"to be honest we kind of felt pressured into doing it"* (S19, P18). Some participants (n=3, 30%) also adopted it because they believed it would improve safety and patient care: *"I would understand from a safety point of view why we are doing it, it's to stop counterfeit getting into the supply chain*." (S8, P7)

For verification scanning, the decision to adopt this technology mostly centred on its scope to improve patient care (n=9, 90.0%) and safety (n=8, 80.0%): "*it was really more of the error side of things, to try and reduce and improve on safety really" (S17, P16).* Some pharmacies adopted this technology secondary to the FMD legislative change as they were having to implement barcode scanning technology anyway (n=4, 40.0%), and half of the pharmacies (n=5, 50.0%) conducting verification scanning also believed it would free up pharmacists time. For stock inventory management, the decision to adopt the technology varied, which included the scope of improved safety and patient care (n=2, 66.7%) due to its potential to *"minimise errors" (S4, P3*).

Table 4. Reasons for adopting BST (n, %)

Reasons for adoption	Verification scanning (n=10)	FMD scanning (n=10)	Stock inventory management (n=3)	Label generation (n=1)
Improve safety	8, 80.0%	3, 30.0%	2, 66.7%	1, 100.0%
Business benefits	3, 30.0%	1, 10.0%	0, 0.0%	1, 100.0%
Improve patient care	9, 90.0%	3, 30.0%	2, 66.7%	1, 100.0%
Free up pharmacist time	5, 50.0%	0, 0.0%	1, 33.3%	0, 0.0%
Legislative change	4, 40.0%	9, 90.0%	0, 0.0%	0, 0.0%
Maintain reputation as innovator	3, 30.0%	1, 10.0%	1, 33.3%	0, 0.0%
Peer pressure	0, 0.0%	5, 50.0%	0, 0.0%	0, 0.0%

BST = barcode scanning technology, FMD = Falsified Medicines directive

(i) Response rate and demographics

This data collection focused on verification and FMD scanning due to the small number of pharmacies applying BST for stock inventory management and label generation. Representatives from 19 of the 20 verification and FMD scanning pharmacies who participated in the semi-structured interviews agreed to participate with the questionnaire, and representatives from 16 pharmacies responded (84.2%). Of these, 7 pharmacies applied BST for FMD scanning and 9 applied BST for verification scanning. 35 usable responses (33.7%) were obtained out of the approximated maximum of 104 pharmacy staff, as identified form the scoping interviews. Twenty-six participants (74.3%) were from verification scanning pharmacies, and 9 participants (25.7%) were from FMD scanning pharmacies. Table 5 presents the demographic characteristics of the respondents. The majority of respondents from verification scanning pharmacies were Dispensers/Dispensing Assistants (n=14, 53.8%), whereas the majority from FMD scanning respondents were Pharmacists/Pharmacy Managers (n=8, 88.9%).

Table 5. Demographic characteristics of participants (n=, %)

Demographic characteristics	All questionnaire responses (n=35)	Verification scanning participants (n=26)	FMD scanning participants (n=9)
Gender			
Male	20, 57.1%	13, 50.0%	7, 77.8%
Female	15, 42.9%	13, 50.0%	2, 22.2%
Main role in pharmacy			
Accredited Checking Technician	1, 2.9%	1, 3.8%	0, 0.0%
Dispenser/Dispensing Assistant	15, 42.9%	14, 53.8%	1, 11.1%
Locum pharmacist (i.e. self-employed)	1, 2.9%	1, 3.8%	0, 0.0%
Medicines counter assistant	1, 2.9%	1, 3.8%	0, 0.0%
Pharmacist	6, 17.1%	1, 3.8%	5, 55.6%
Pharmacist manager	8, 22.9%	5, 19.2%	3, 33.3%
Pharmacist proprietor/owner	1, 2.9%	1, 3.8%	0, 0.0%
Pre-registration pharmacy graduate	2, 5.7%	2, 7.7%	0, 0.0%
Years worked in main role			
0-10	27, 77.1%	23, 88.5%	4, 44.4%
11-20	5, 14.3%	2, 7.7%	3, 33.3%
21-30	2, 5.7%	0, 0.0%	2, 22.2%
31-40	1, 2.9%	1, 3.8%	0, 0.0%
Hours worked per week			
0-20	6, 17.1%	6, 23.1%	0, 0.00%
21-40	21, 60.0%	16, 61.5%	5, 55.6%
41-60	8, 22.9%	4, 15.4%	4, 44.4%

FMD = Falsified Medicines directive

(ii) Overall perceptions and acceptance of BST

An overview of participants' perceptions and acceptance of BST is presented in Table 6. The questionnaire scales each had Cronbach's alpha coefficient of >0.7 (Appendix 4). Overall, BST was

regarded as easy to use by FMD and verification scanning participants. The median responses indicate that participants held more positive perceptions and acceptance of BST if it was used for verification scanning, rather than when used for FMD scanning (Table 4). When compared with FMD scanning participants, verification scanning participants were more likely to consider BST as useful for themselves and patients, were more satisfied with BST, and had greater intentions to use BST before and after its implementation.

Table 6. Responses to perceptions and acceptance of technology questions

Questionnaire domains		**Verification scanning participants**		**FMD scanning participants**	
		median	IQR	median	IQR
Perceptions measures	Ease of use	6.00	5.50-6.50	5.00	3.50-5.50
	Usefulness for self	5.00	4.50-6.00	1.00	1.00-2.50
	Usefulness for patients	5.00	4.00-6.00	3.00	1.00-4.00
	Social influence	5.75	4.875 - 6.50	3.50	1.00-4.375
Acceptance measures	Behavioural intention to use - before implemented	5.00	2.00-6.00	4.00	2.50-4.25
	Behavioural intention to use - after implemented	6.00	5.00-7.00	4.00	1.00-4.00
	Satisfaction	6.00	5.125-6.00	2.75	1.75-4.25

FMD = falsified medicines directive, BST = barcode scanning technology

1 = not at all, 2 = to a very limited extent, 3 = to a limited extent, 4 = to a moderate extent, 5 = to a considerable extent, 6 = to a great extent, 7 = to a very great extent

NB. Cronbach's alpha indicated reliability of the questionnaire's sections (Cronbach alpha >0.7), presented in Appendix 4

Discussion

This study was the first to explore the use of BST within the community pharmacy setting, and also pharmacy staff's perceptions and acceptance of this. The findings indicated sparse implementation of BST to scan medicines in Scotland; only 57 community pharmacies were identified out of a national cohort of 1,254 [30, 37], with most using BST to scan medicines for <1 year. Within pharmacies where BST was implemented there was a notable degree of heterogeneity: BST was used for various purposes; there were multiple scanner types; and the functionality varied (e.g. whether BST integrated with PMR systems). Overall, the pharmacy staff considered BST as easy to use. When used for verification scanning the pharmacy staff positively perceived and accepted BST, in contrast with negative perceptions and less acceptance of BST when used for FMD scanning.

Sparse implementation of BST for scanning medicines was identified in Scotland. A greater adoption rate was anticipated as Scottish pharmacy staff routinely use BST for prescription barcode scanning [30]. For verification scanning, various facilitators hinted towards a greater adoption rate, including safety benefits and Scottish Government support for verification scanning [4,5,20-22]. For FMD scanning, EU-wide legislation mandated BST use for FMD scanning [17,18], and FMD scanning was anticipated within most pharmacies. The low compliance with FMD legislation could be due to various barriers, such as insufficient awareness of FMD legislation [28,38], lack of implementation readiness [28]; the UK's imminent withdrawal from the EU [39]; or the financial burden associated with upgrading pharmacy systems, at an approximated cost of $50-200/pharmacy [15,28]. Our findings indicate that current facilitators are not sufficient to drive widespread implementation of BST in Scotland, and highlights the disparity in BST implementation within different settings - with U.S. hospital settings in particular exhibiting greater adoption rates [16,40]. This could be secondary to the various studies in hospital contexts evidencing positive impacts of BST which may facilitate implementation [15, 20-22, 40], and such positive findings have not been identified in community pharmacy which may hinder its adoption. An important next stage would be to identify the barriers and facilitators to the adoption and implementation of BST, which could offer insights into how this sector can evolve to strategically increase the utilisation of technology to facilitate medicines management [3,4].

BST was applied for 4 different purposes and variation in terms of scanner models and functionality was identified. This exemplifies that there is no unified approach to using BST within Scottish community pharmacies. This heterogeneity may increase the complexity of the dispensing setting with implications on patient safety considering the high-risk nature of pharmacy work activities [41,42]. The World Health Organisation acknowledges that healthcare technology can increase complexity, and postulate that a standardised approach to technology application may prevent erroneous use and facilitate a technology's integration within practice [43]. In terms of BST, a possible unified approach may be for a single scan of a medicines barcode to be able to perform several purposes. The introduction of 2D barcodes on medicines makes this possible due to greater data storage capabilities, and some PMR systems have begun to launch 'plugins' which allow the FMD scanning process to also perform an verification check and expiry date check [44,45]. This unified approach could increase the benefits associated with BST which may facilitate implementation, and would aid the development of standardised national resources to engage pharmacy staff [46].

Exploring staff perceptions using the TAM identified that BST is considered easy to use, regardless of whether it was used for verification or FMD scanning. This is understandable as the same scanners can be used for both purposes. The ease of use of BST indicates that technological re-design is unnecessary, which is positive as poor usability and design flaws are challenges with other pharmacy technologies [24,26,47-53], including BST-use in hospital settings [24]. Interestingly, the usability of BST was the only domain of the TAM whereby the results were comparable between the FMD and verification scanning participants. Participant's positively perceived and accepted BST for verification scanning, whereas FMD scanning participants were less positive and accepting. This tentatively supports previous work which suggests that the usability of technology is not the sole factor influencing its acceptance in practice and suggests that the reason for using the technology may be of greater significance [46]. Negative acceptance of BST in hospital settings has also been identified [24-27], and as the TAM postulates a relationship between acceptance and the actual use of technology in practice (Figure 1), such findings may indicate problematic BST-use in practice and challenging work processes [24,31, 40]. Therefore an important follow-on study to be undertaken by the authors will involve observing the actual use of BST for FMD scanning to understand the potential implications of these results on community pharmacy practice.

Different reasons for adopting verification and FMD scanning technology were identified, which may explain why BST was perceived as useful when used for verification scanning and not so for FMD scanning. Verification scanning was adopted to improve safety and patient care, which are both integral within the role of pharmacy practice [54], thus it is understandable that BST for verification scanning was perceived as useful for staff and patients. For FMD scanning, the decision to adopt BST centred on legislative change, and participants generally did not implement it to improve safety or patient care, which offers an explanation as to why it was not perceived as useful. This finding is pertinent as a recent systematic review identified that if an innovation aligns with the integral roles of pharmacy practice it may be more likely to be positively perceived and implemented in practice [55]. This indicates the importance of identifying reasons for adopting technological innovations, and the authors suggest that during pre-implementation of pharmacy technology there should be consideration if its function aligns with the roles or values of pharmacy practice. Overall, these findings and ongoing research could help inform the development of implementation strategies to support technology adoption within community pharmacy.

Strengths and limitations

This study offers important contributions to the literature as previous studies focused solely on BST use within hospital settings to scan 1D medicine barcodes. A study strength was the multiple recruitment strategies adopted to identify pharmacies, which was necessary as no database of pharmacies using BST exists. Resource constraints meant that contacting all community pharmacies in Scotland was not an option, therefor it is possible that the pharmacies that participated may be an under-estimation and that ‘early adopters’ or ‘technically oriented’ pharmacies have been recruited who may be more accepting of technology [56,57]. The application of the validated TAM model within the questionnaire ensured that key parameters known to influence the perceptions and acceptance of technology were examined [33]. However, due to the low questionnaire response rate it was not possible to identify significant differences between the verification and FMD scanning participant or statistically model the TAM relationship. Further to this, there was low engagement of pharmacy support staff from FMD scanning pharmacies, thus their perceptions and acceptance of BST is

unknown. Better engagement with the evaluation by verification scanning participants is possibly reflective of the overall positive perceptions of BST for this use. Another limitation was that a pharmacy owner nominated representatives to participate in the semi-structured interviews which could have introduced selection bias. Lastly, a potential limitation is that NW additionally works as a community pharmacist and may have had biases/assumptions about the research topic; however, the research team do not believe this had any effect on the study and its findings.

Conclusion

Sparse implementation of BST for scanning medicines was identified in Scotland despite a number of facilitators, which indicates that greater efforts are needed to strategically increase the utilisation of technology in this setting. The variation associated with BST use may pose safety concerns, and promoting a unified approach may facilitate wider implementation and development of national resources to engage pharmacy staff. The data suggests that the purpose for which BST is used may underpin technology acceptance. Future studies are needed to identify: barriers to BST adoption and how these can be overcome, the actual use of BST in practice, and how pharmacy technology aligns with the roles and values of pharmacy practice. The current findings alongside future research could inform the development of implementation strategies to support technology adoption in this context.

References

1. Alcácer V, Cruz-Machado V. Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems. Eng Sci Technol Int J. 2019;22:899-919. doi: 10.1007/s10845-018-1433-8

2. Chaudhry B, Wang J, Wu S, et al. Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care. Ann Intern Med. 2006;144:742-52. doi: 10.7326/0003-4819-144-10-200605160-00125

3. Westerling AM, Haikala V, Airaksinen M. The role of information technology in the development of community pharmacy services: visions and strategic views of international experts. Res Social Adm Pharm. 2011;7:430-7. doi: 10.1016/j.sapharm.2010.09.004

4. Scottish Government. Achieving excellence in pharmaceutical care: a strategy for Scotland.

https://www.gov.scot/publications/achieving-excellence-pharmaceutical-care-strategy-scotland/; 2017 Accessed 28.03.2020

5. Poon EG, Cina JL, Churchill W, et al. Medication dispensing errors and potential adverse drug events before and after implementing bar code technology in the pharmacy. Ann Intern Med. 2006;145:426-34. doi: 10.7326/0003-4819-145-6-200609190-00006

6. Furness A. Machine-readable data carriers – a brief introduction to automatic identification and data capture. Assembly Autom. 2000;20:28-34. doi: 10.1108/01445150010311699

7. Madakam S, Ramaswamy R, Tripathi S. Internet of Things (IoT): A Literature Review. Int J Comput Commun. 2015;3:164-73. doi: 10.4236/jcc.2015.35021

8. Dodge M, Kitchin R. Codes of Life: Identification Codes and the Machine-Readable World. Environ Plan D. 2004;23:851-81. doi:10.1068/d378t

9. Spinks J, Jackson J, Kirkpatrick CM, Wheeler AJ. Disruptive innovation in community pharmacy - Impact of automation on the pharmacist workforce. Res Social Adm Pharm. 2017;13:394-7. doi: 10.1016/j.sapharm.2016.04.009

10. Walsh KE, Chui MA, Kieser MA, Williams SM, Sutter SL, Sutter JG. Exploring the impact of an automated prescription-filling device on community pharmacy technician workflow. J Am Pharm Assoc. 2003;51:613-8. doi: 10.1331/JAPhA.2011.09166

11. Pharmacy Magazine. The robots are coming... https://www.pharmacymagazine.co.uk/the-robots-are-coming...; 2017 Accessed 28.03.2020

12. Oldland AR, Golightly LK, May SK, Barber GR, Stolpman NM. Electronic inventory systems and barcode technology: impact on pharmacy technical accuracy and error liability. Hosp Pharm. 2015;50:34-41. doi: 10.1310/hjp5001-034

13. GSM Barcoding. HOW BARCODING IS ESSENTIAL FOR THE HEALTHCARE INDUSTRY. https://www.barcoding.co.uk/how-barcoding-is-essential-for-the-healthcare-industry/; 2019 Accessed 28.03.2020

14. Nold EG, Williams TC. Bar codes and their potential applications in hospital pharmacy. Am J Hosp Pharm. 1985;42:2722-32. doi: 10.1093/ajhp/42.12.2722

15. European Commission. Impact Assessment on the Directive 2001/83/EC of the European Parliament and of the Council by laying down detailed rules for the safety features appearing on the packaging of medicinal products for human use; 2015. https://ec.europa.eu/smart-

regulation/impact/ia_carried_out/docs/ia_2015/swd_2015_0189_en.pdf; 2015 Accessed 28.03.2020
16. Schneider PJ, Pedersen CA, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: Dispensing and administration-2017. Am J Health Syst Pharm. 2018;75:1203-26. doi: 10.2146/ajhp180151
17. Royal Pharmaceutical Society. Falsified Medicines Directive. Available from: https://www.rpharms.com/resources/ultimate-guides-and-hubs/fmd; 2018 Accessed 28.03.2020
18. The Scottish Government. Implementing the Falsified Medicines Directive: Safety Features. https://www.gov.uk/guidance/implementing-the-falsified-medicines-directive-safety-features; 2018 Accessed 18.08.2020
19. The Pharmaceutical Journal. Bolton pharmacy claims to be first in UK to become FMD compliant. https://www.pharmaceutical-journal.com/news-and-analysis/news/bolton-pharmacy-claims-to-be-first-in-uk-to-become-fmd-compliant/20205862.article; 2018 Accessed 28.03.2020
20. Wang BN, Brummond P, Stevenson JG. Comparison of barcode scanning by pharmacy technicians and pharmacists' visual checks for final product verification. Am J Health Syst Pharm. 2016;73:69-75. doi: 10.2146/ajhp150135
21. Galbraith W, Shadid J. Compounding & dispensing errors before and after implementing barcode technology in a nuclear pharmacy. Int J Pharm Compd. 2012;16:253-6.
22. Oldland AR, Golightly LK, May SK, Barber GR, Stolpman NM. Electronic inventory systems and barcode technology: impact on pharmacy technical accuracy and error liability. Hosp Pharm. 2015;50:34-41. doi: 10.1310/hjp5001-034
23. Maviglia SM, Yoo JY, Franz C, et al. Cost-benefit analysis of a hospital pharmacy bar code solution. Arch Intern Med. 2007;167:788-94. doi: 10.1001/archinte.167.8.788
24. Holden RJ, Brown RL, Scanlon MC, Karsh B-T. Pharmacy workers' perceptions and acceptance of bar-coded medication technology in a pediatric hospital. Res Social Adm Pharm. 2012;8:509-22. doi: 10.1016/j.sapharm.2012.01.004
25. Samaranayake NR, Cheung ST, Cheng K, Lai K, Chui WC, Cheung BM. Implementing a bar-code assisted medication administration system: effects on the dispensing process and user perceptions. Int J Med Inform. 2014;83:450-8. doi: 10.1016/j.ijmedinf.2014.03.001
26. Nanji KC, Cina J, Patel N, Churchill W, Gandhi TK, Poon EG. Overcoming barriers to the implementation of a pharmacy bar code scanning system for medication dispensing: a case study. J

Am Med Inform Assoc. 2009;16:645-50. doi: 10.1197/jamia.M3107

27. Alharthi H, Sultana N, Al-Amoudi A, Basudan A. An Analytic Hierarchy Process-based Method to Rank the Critical Success Factors of Implementing a Pharmacy Barcode System. Perspect Health Inf Manag. 2015;12:1g

28. Barrett R. Evaluation of community pharmacists' readiness to implement the Falsified Medicines Directive (Directive 2011/62/EC): an English cross-sectional survey with geospatial analysis. BMJ open. 2020;10:e033405. doi: 10.1136/bmjopen-2019-033405

29. Karsh B-T, Weinger MB, Abbott PA, Wears RL. Health information technology: fallacies and sober realities. Am Med Inform Assoc. 2010;17:617-23. doi: 10.1136/jamia.2010.005637

30. House of Commons Library. NHS charges: Briefing paper No 07227. https://commonslibrary.parliament.uk/research-briefings/cbp-7227/; 2020 Accessed 28.03.2020

31. The Pharmaceutical Journal. Scotland's acute medication service to start in July. https://www.pharmaceutical-journal.com/news-and-analysis/scotlands-acute-medication-service-to-start-in-july/10003133.article?firstPass=false; 2019 Accessed 28.03.2020

32. Schoonenboom J, Johnson Burke. How to Construct a Mixed Methods Research Design. Kolner Z Soz Sozpsychol. 2017;69(Suppl 2):107-31. doi: 10.1007/s11577-017-0454-1

33. Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quart. 1989;13:319-40. doi: 10.2307/249008

34. Elo S, Kyngäs H. The qualitative content analysis process. J Adv Nurs. 2008;62:105-15. Doi: 10.1111/j.1365-2648.2007.04569.x

35. Tavakol M, Dennick R. Making sense of Cronbach's alpha. Int J Med Educ. 2011;2:53-5. doi: 10.5116/ijme.4dfb.8dfd

36. Boone H, Boone D. Analyzing Likert Data. J Ext. 2012;50

37. Community Pharmacy Scotland. Our Aims. https://www.cps.scot/what-we-do/our-aims/; 2019 Accessed 28.03.2020

38. WŁodarczak U, Swieczkowski D, Religioni U, Jaguszewski M, Krysinski J, Merks P. Awareness of the implementation of the Falsified Medicines Directive among pharmaceutical companies' professionals in the European Economic Area. Pharm Pract. 2017;15:1031. doi: 0.18549/PharmPract.2017.04.1031

39. The Pharmaceutical Journal. Falsified Medicines Directive is yet another casualty of Brexit.

https://www.pharmaceutical-journal.com/opinion/editorial/falsified-medicines-directive-is-yet-another-casualty-of-brexit/20206122.article?firstPass=false; 2019 Accessed 28.03.2020

40. Lawler E, Hedge A, Pavlovic-Veselinovic S. Cognitive ergonomics, socio-technical systems, and the impact of healthcare information technologies. Int J Ind Ergon. 2011;41:336-44. doi: 10.1016/j.ergon.2011.02.006

41. Weir NM, Newham R, Bennie M. A literature review of human factors and ergonomics within the pharmacy dispensing process. Res Social Adm Pharm. 2019. doi: 10.1016/j.sapharm.2019.08.029

42. Al Juffali L, Al-Aqeel S, Knapp P, Mearns K, Family H, Watson M. Using the Human Factors Framework to understand the origins of medication safety problems in community pharmacy in Saudi Arabia: A qualitative study. Res Social Adm Pharm. 2018;15:558-67. doi: 10.1016/j.sapharm.2018.07.010

43. World Health Organization. Increasing complexity of medical technology and consequences for training and outcome of care: background paper 4. https://apps.who.int/iris/handle/10665/70455. 2010 Accessed 28.03.2020

44. CegeximRx. Launching Our New FMD Integrated Plugin. https://www.cegedimrx.co.uk/blog/fmd-integrated-plugin; 2019 Accessed 28.03.2020

45. CegeximRx. Falsified Medicines Directive: Plugin Details. https://www.cegedimrx.co.uk/falsified-medicines-directive-resources. 2019 Accessed 28.03.2020

46. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. 2009;4:50. doi: 10.1186/1748-5908-4-50

47. Malone DC, Abarca J, Skrepnek GH, et al. Pharmacist workload and pharmacy characteristics associated with the dispensing of potentially clinically important drug-drug interactions. Med Care. 2007;45:456-62. doi: 10.1097/01.mlr.0000257839.83765.07

48. Szeinbach S, Seoane-Vazquez E, Parekh A, Herderick M. Dispensing errors in community pharmacy: perceived influence of sociotechnical factors. Int J Qual Health Care. 2007;19:203-9. doi: 10.1093/intqhc/mzm018

49. James KL, Barlow D, Hiom S, Roberts D, Whittlesea C. Development and use of the critical incident technique in evaluating causes of dispensing incidents. Int J Pharm Pract. 2008;16:239-49. doi: 10.1211/ijpp.16.4.0006

560 50. Odukoya O, Chui MA. Retail pharmacy staff perceptions of design strengths and weaknesses of
561 electronic prescribing. J Am Med Inform Assoc. 2012;19:1059-65. doi: 10.1136/amiajnl-2011-000779
562 51. Odukoya OK, Chui MA. e-Prescribing: characterisation of patient safety hazards in community
563 pharmacies using a sociotechnical systems approach. BMJ Qual Saf. 2013;22:816-25. doi:
564 10.1136/bmjqs-2013-001834
565 52. Odukoya OK, Stone JA, Chui MA. E-prescribing errors in community pharmacies: exploring
566 consequences and contributing factors. Int J Med Inform. 2014;83:427-37. doi:
567 10.1016/j.ijmedinf.2014.02.004
568 53. Odukoya OK, Stone JA, Chui MA. Barriers and facilitators to recovering from e-prescribing errors
569 in community pharmacies. J Am Pharm Assoc. 2015;55:52-8. doi: 10.1331/JAPhA.2015.13239
570 54. World Health Organization. The Role of the Pharmacist in the Health Care System: Community
571 pharmacy. https://apps.who.int/medicinedocs/en/d/Jh2995e/1.6.2.html. 1993 Accessed 28.03.2020
572 55. Weir NM, Newham R, Dunlop E, Bennie M. Factors influencing national implementation of
573 innovations within community pharmacy: a systematic review applying the Consolidated Framework
574 for Implementation Research. Implement Sci. 2019;14:21. doi: 10.1186/s13012-019-0867-5
575 56. Rogers EM. Innovativeness and Adopter Categories. Diffusion of Innovations, 5th Edition: Free
576 Press; 2003. p. 283
577 57. Harvey J, Avery AJ, Waring J, Barber N. The socio-technical organisation of community
578 pharmacies as a factor in the Electronic Prescription Service Release Two implementation: a
579 qualitative study. BMC Health Serv Res. 2012;12:471. doi: 10.1186/1472-6963-12-471
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APPENDICES

Appendix 1: Advertisement

Advertisement via Twitter:

The University of Strathclyde are looking for pharmacies using barcode scanning technology in novel ways (e.g. for accuracy checking/FMD) to explore its use and pharmacy staff opinions of it. If interested/want more information in this study, contact natalie.m.weir@strath.ac.uk.

Advertisement via CPS eNeswletter:

Pharmacies using barcode scanning technology

The University of Strathclyde has been commissioned by NHS Education for Scotland to evaluate the use of barcode scanning technology within community pharmacies. While pharmacies have used scanners for some time for scanning GP10 prescriptions within PMR systems, the evaluation will focus on new uses of the scanning technology to aid medicine-related processes within the pharmacy (e.g. for accuracy checking, stock control, or for the Falsified Medicines Directive).

Researchers at the University would like to talk to pharmacies which use barcode scanning technology in one of these new ways. The evaluation will focus on how the technology is used and pharmacy staff opinions of it. The project will initially involve a short telephone interview with pharmacy managers or owners.

If you are interested in participating in this study or would like more information, please contact Natalie Weir at natalie.m.weir@strath.ac.uk.

Appendix 2: Verbal Consent Script and Interview schedule

Verbal Consent Script

Hi, my name is [insert name] and I am a researcher at the University of Strathclyde. I'm looking to speak with [name of pharmacist].

I previously spoke with you about a study I am involved in about barcode scanning technology within pharmacies, and have emailed you the information sheet about this. Can I just check that you have read this?

If yes continue, if not ask them to read it/briefly go over it

I would like to ask you some questions about your pharmacy/pharmacies and the use of the barcode scanning technology. It should take about 15 minutes, is now still a good time?

If yes continue, if not, try to re-arrange for another time.

I will need to audio record this conversation for the study, is that okay?

If yes, start recording, if not, ask if okay to make notes

Thank you, I am now recording our conversation. You don't need to answer any of the questions I will ask and you can decide at any point during our conversation if you no longer wish to speak with me, and before the end of our conversation you are free to withdraw participation. After this interview I will type up what we have said. As it said in the information sheet, nobody will be able to identify you from this and any copies of the recording will be kept on a password protected system. All copies of your interview will be deleted at the end of the study period.

Before we start, do you have any questions?

Thank the interviewee for their question (e.g. Glad you asked that/that's a good questions) and answer any questions

You can also ask questions during the interview process. Do you understand all the information I've given you?

If yes, continue

Do you consent to taking part in this interview?

If yes continue, if not thank the participant for their time

Thank you. I am aware that you might be working right now, so I can pause the interview if something comes up in your pharmacy and restart again once you've dealt with it. That's perfectly fine.

Interview Schedule

Section 1: Use of barcode scanning technology

Currently, our knowledge of barcode scanning technology is limited as we have only just started this project. So, please answer the questions assuming that we know nothing about barcode scanning technology.

We believe prescription barcodes have been scanned in pharmacies for some time; however, this study is interested in newer uses of barcode scanning technology used to scan medicines.

Purpose

1. What do you use barcode scanning technology for when scanning medicines?
   - *PROMPTS:* *To verify that dispensed items match those on a prescription (i.e. accuracy check)?*
   - *For stock control purposes?*
   - *For storing expiry dates/date checking?*
   - *To check if a medicine is counterfeit (i.e. FMD)?*
   - *Any other reasons?*

If the barcode scanner is used for more than one purpose when scanning medicines, ask the following questions separately for each purpose.

2. When did you start using it for [that purpose]?
3. Why did your pharmacy decide to start using barcode scanning technology for [that purpose]?
   - *PROMPTS:* *Improve safety?*
   - *Improve patient care?*
   - *Free up pharmacists time?*
   - *Business benefits?*
   - *Legislative change (i.e. FMD, barcodes added to prescriptions)?*
   - *Peer pressure?*
   - *Maintain reputation as an innovator?*
4. Has barcode scanning technology used for [that purpose] influenced safety in your pharmacy?
   - *PROMPTS:* *Increased / reduced / no effect on error rates*
   - *Increased / reduced / no effect on near misses?*
   - *Increased / reduced / no effect on risk of litigation?*

Technology

If the pharmacy uses barcode scanning technology for more than one of these purposes stated above:

5. Is the same scanner used for all of these purposes?

6. Is the scanner you use for scanning medicines the same scanner you use to scan in prescriptions?

7. What Patient Medication Record (PMR) system is used?

NB. If more than one type of scanner is used to scan medicines, ask the following questions 6 and 7 separately for each.

8. Can you describe the type(s) of barcode scanning technology you use for [that purpose]?
   PROMPTS: *Standalone device or integrated with PMR (patient medication record)?*
   Name, model?
   Supplier?
   Can it scan 1 dimensional barcode (linear barcode) or 2 dimensional barcodes (QR code)
   Wireless?
   Do you use it handheld, or propped up on stands?
   Do you need to press a button for it to scan, or just pass the barcode pass it?

9. Why did you choose that type of scanner?
   PROMPTS: *Cost?*
   Usability?
   Design features?
   Reputation of the product? (e.g. if known to be reliable)
   To integrate within the workflow?
   Recommended?
   Peer pressure? (e.g. other pharmacies using it)
   Only option from supplier?

In general…

10. Has barcode scanning technology in general had an influence on your business?

PROMPTS: *Workload*

Process

Stock management

Staffing profile

Skill mix

Security

Patient satisfaction

Section 2: About you and your pharmacy

NB. This will be completed by the interviewer as part of the telephone interview.

1. What is your job role in the pharmacy?

□ Pharmacist proprietor/owner

□ Locum pharmacist

□ Pharmacy manager

□ Pharmacy technician

□ Other_____

2. What is the name of the pharmacy chain? _____

3. How many pharmacies does your pharmacy chain have? *(to state in numbers)*

_____

4. What NHS Health Board are the pharmacy/pharmacies which use the scanning technology located in?

□ NHS Ayrshire and Arran □ NHS Borders □ NHS Dumfries and Galloway

□ NHS Fife □ NHS Forth Valley □ NHS Grampian

□ NHS Greater Glasgow and Clyde □ NHS Highland □ NHS Lanarkshire

□ NHS Lothian □ NHS Orkney □ NHS Shetland

□ NHS Tayside □ NHS Western Isles

5. What is the name and address of the pharmacy/pharmacies that uses the scanning technology?

NB. State that this will only be used if we wish to invite you to participant in further evaluation activities

_____

_____

_____

6. How many pharmacy staff members, including yourself if you use it, use the barcode scanning technology [for stated purpose]?

NB. Ensure a number is provided and not undefined amount such as "a few", "quite a lot"

_____

How many pharmacy staff members are routinely employed in the pharmacy section of your store, including counter assistants?

NB. Ensure a number is provided and not undefined amount such as "a few", "quite a lot"

_____

7. Do pharmacy technicians work in your pharmacy?

□ Yes □ No

If yes, are they accuracy checking technicians?

□ Yes □ No

8. What is the number of items dispensed per month in your pharmacy?

NB. State that this will not be made publically available, but is only used as an indicator of how busy your pharmacy is.

□ 0-1,999

□ 2,000-3,999

□ 4,000-5,999

□ 6,000-7,999

□ 8,000-9,999

□ 10,000-11,999

□ >12,000

Section 3: Services offered by your pharmacy

9. Does your pharmacy have a medication delivery service?
   □ Yes □ No
10. Does your pharmacy have a care home medication service?
   □ Yes □ No
11. Does you pharmacy dispense Multi-compartment Compliance Aides (MCA's) (i.e. dosette boxes/trays)
   □ Yes □ No
12. Does your pharmacy have a spoke and hub dispensing model?
   □ Yes □ No
13. Does your pharmacy have robotic dispensing technology?
   □ Yes □ No

Debriefing

Thank you, we are now at the end of the interview and I appreciate the time you have taken to speak with me. Before we finish, do you have any additional comments? The next part of the study will involve the pharmacy staff who use the barcode scanning technology completing an online questionnaire. Would you be happy for the pharmacy staff in your pharmacy/pharmacies doing that?

If yes, arrange for the online questionnaire to be sent.

[Snow ball sampling: ask if know of other pharmacies using barcode scanning technology]

[End of interview: Thank participant]

799 **Appendix 3: Questionnaire items**

Ease of use	**not at all**	**to a very limited extent**	**to a limited extent**	**to a moderate extent**	**to a considerable extent**	**to a great extent**	**to a very great extent**		I do not know
In actual practice, to what extent...									
…is the barcode scanning system clear and understandable?	1	2	3	4	5	6	7		8
…do you find the barcode scanning system to be easy to use?	1	2	3	4	5	6	7		8
…does interacting with the barcode scanning system require a lot of your mental effort?	1	2	3	4	5	6	7		8
…do you find it easy to get the barcode scanning system to do what you want it to do?	1	2	3	4	5	6	7		8
Please offer any comments you may have regarding the ease of use of the barcode scanning technology in the box below:									

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Usefulness for yourself	**not at all**	**to a very limited extent**	**to a limited extent**	**to a moderate extent**	**to a considerable extent**	**to a great extent**	**to a very great extent**		I do not know
In actual practice, to what extent...									
…does using the barcode scanning system improve your performance in your job?	1	2	3	4	5	6	7		8
…does using the barcode scanning system in your job increase your productivity?	1	2	3	4	5	6	7		8
…does using the barcode scanning system enhance your effectiveness on the job?	1	2	3	4	5	6	7		8
…do you find the barcode scanning system to be useful in your job?	1	2	3	4	5	6	7		8
Please offer any comments you may have regarding the usefulness of the barcode scanning technology for yourself in the box below:									

803

804

Usefulness for patients	**not at all**	**to a very limited extent**	**to a limited extent**	**to a moderate extent**	**to a considerable extent**	**to a great extent**	**to a very great extent**		I do not know
In actual practice, to what extent...									
…do you think the barcode scanning system improves patient care?	1	2	3	4	5	6	7		8
…do you think the barcode scanning system reduces the likelihood of medication errors?	1	2	3	4	5	6	7		8
…do you think the barcode scanning system facilitates better patient care decision making?	1	2	3	4	5	6	7		8
…do you think the barcode scanning system makes caring for patients easier?	1	2	3	4	5	6	7		8
Please offer any comments you may have regarding the usefulness of the barcode scanning technology for patients in the box below:									

805

806

Influence from others	**not at all**	**to a very limited extent**	**to a limited extent**	**to a moderate extent**	**to a considerable extent**	**to a great extent**	**to a very great extent**		I do not know
To what extent...									
…do people who influence your behaviour think that you should use the barcode scanning system?	1	2	3	4	5	6	7		8
…do people who are important to you think that you should use the barcode scanning system?	1	2	3	4	5	6	7		8
Please offer any comments you may have regarding those who influence you to use the barcode scanning technology in the box below:									

807

808

Your intention to use the barcode scanning system	**not at all**	**to a very limited extent**	**to a limited extent**	**to a moderate extent**	**to a considerable extent**	**to a great extent**	**to a very great extent**		I do not know
Before you had access to the barcode scanning system, to what extent...									
…did you intend to use it?	1	2	3	4	5	6	7		8
…did you predict that you would use it?	1	2	3	4	5	6	7		8
…did you want to use the new barcode scanning system?	1	2	3	4	5	6	7		8
Now that you have access to the barcode scanning system...									
…how much do you want to use the barcode scanning system?	1	2	3	4	5	6	7		8
Please offer any comments you may have regarding your intention to use the barcode scanning technology in the box below:									

809

810

Satisfaction with the barcode scanning system	**not at all**	**to a very limited extent**	**to a limited extent**	**to a moderate extent**	**to a considerable extent**	**to a great extent**	**to a very great extent**		I do not know
To what extent are you satisfied with the barcode scanning system?	1	2	3	4	5	6	7		8
How much better do you like the new method of working compared with the old way?	1	2	3	4	5	6	7		8
To what extent are you dissatisfied with the barcode scanning system?	1	2	3	4	5	6	7		8
To what extent would you recommend the barcode scanning system to colleagues?	1	2	3	4	5	6	7		8
Please offer any comments you may have regarding your satisfaction with the barcode scanning technology in the box below.									

Has anything else not mentioned within this questionnaire affected your decision to use/not use the barcode scanning system?

Demographic questions

1. Are you: *(Tick one box only)*

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Prefer not to say

2. How old are you? *(Tick one box only)*

- ☐ 16 – 24 years old
- ☐ 25 – 34 years old
- ☐ 35 – 44 years old
- ☐ 45 – 54 years old
- ☐ 55 – 64 years old
- ☐ 65 years or older

3. How long have you personally been using the barcode scanning technology?
(Please state in months AND/OR years)

Number of months:_____

Number of years:_____

4. How often do you use the barcode scanning technology *(Tick one box only)*

- ☐ I use it on an hourly basis
- ☐ I use it on a daily basis
- ☐ I use it on a weekly basis
- ☐ I use it on a monthly basis
- ☐ Other (please state:_____)

5. Which of the following categories best describes your MAIN role in your community pharmacy?
(Tick one box only)

- ☐ Accredited Checking Technician
- ☐ Dispenser/Dispensing Assistant (trainee)
- ☐ Locum pharmacist (i.e. self-employed)
- ☐ Medicines counter assistant
- ☐ Pharmacist
- ☐ Pharmacist manager
- ☐ Pharmacist proprietor/owner
- ☐ Pre-registration pharmacy graduate
- ☐ Registered Pharmacy Technician
- ☐ Relief pharmacist (i.e. employee)
- ☐ Other (please state:_____)

6. How long have you worked in this main role?

Please state to the nearest year: _____

7. How many hours a week do you work in the pharmacy which uses the barcode scanning system?
Please state in hours: _____

Appendix 4: Cronbach's Alpha of questionnaire sections

Questionnaire Section	Cronbach's Alpha
(i) ease of use	0.901
(ii) usefulness for self	0.923
(iii) usefulness for patients	0.845
(iv) social influence	0.904
(v) behavioural intention to use - before implemented	0.728
(vi) behavioural intention to use - after implemented	N/A*
(vii) satisfaction with the barcode scanning system.	0.898

*This questionnaire section was a single measure and not a scale