

Preventing medication administration errors using pharmacy-managed barcode medication management systems in long-term residential care

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Abstract

Background

Older people in long-term residential care are at increased risk of medication errors. The purpose of this study was to evaluate a computerised barcode medication management system designed to improve drug administrations in residential and nursing homes, including comparison of error rates and staff awareness in both settings.

Methods

All medication administrations were recorded prospectively for 345 older residents in thirteen care homes during a 3-month period using the computerised system. Staff were surveyed to identify their awareness of administration errors prior to system introduction. Overall, 188,249 attempts to administer medication were analysed to determine the prevalence of potential medication administration errors (MAEs). Error classifications included attempts to administer medication at the wrong time, to the wrong person or discontinued medication. Analysis compared data at residential and nursing home level and care and nursing staff groups.

Results

Typically each resident was exposed to 206 medication administration episodes every month and received nine different drugs. Administration episodes were more numerous ($p < 0.01$) in nursing homes (226.7 per resident) than in residential homes (198.7). Prior to technology introduction, only 12% of staff administering drugs reported they were aware of administration errors being averted in their care home. Following technology introduction, 2,289 potential MAEs were recorded over three months. The most common MAE was attempting to give medication at the wrong time. On average each resident was exposed to 6.6 potential errors. In total, 90% of residents were exposed to at least one MAE with over half (52%) exposed to serious errors such as attempts to give medication to the wrong resident. MAEs rates were significantly lower ($p < 0.01$) in residential homes than nursing homes. The level of non-compliance with system alerts was low in

both settings (0.075% of administrations) demonstrating virtually complete error avoidance.

Conclusion

Potentially inappropriate administration of medication is a serious problem in long-term residential care. A computerised barcode system can accurately and automatically detect inappropriate attempts to administer drugs to residents. This tool can reliably be used by care staff as well as nurses to improve quality of care and patient safety.

Background

The care home sector is an increasingly important provider of long-term care for older people. A recent review of the literature has identified that research in the area of quality and safety of long-term care is lacking, especially for residential homes which have limited access to nursing skills [1]. Furthermore, a number of authors have identified management of medication in care homes as a key area for improved patient safety [2-9]. In England, over 18,000 homes currently provide beds for more than 453,000 people, compared to 167,000 beds in hospitals. The majority of these individuals are older people with complex health needs. Six out of ten are cared for in a residential home with no on-site nursing staff. In such homes the management of prescribed medication is undertaken by social care staff who may have had no formal training in safe practice [10]. In nursing homes, which must have a registered nurse (RN) on site 24 hours per day to meet regulation requirements, medicine administration is one of the many tasks carried out by busy RNs. In both settings, prescribing the medication is the responsibility of the general practitioner (GP) or a hospital physician.

It is known that in England 45% of all care homes in 2005 failed to meet the minimum standard for medication management [4]. Also, a more recent UK study in 55 care homes found that 70% of residents had experienced one or more medication errors [11]; these included mistakes made by GPs in prescribing, dispensing errors by pharmacies, and administration errors made by care home staff. To guard against errors, electronic medication administration recording (eMAR) has been widely implemented in US emergency and hospital care settings [12]. Similar systems are now beginning to be marketed for use in long term care and nursing home environments. In hospitals safety is being further improved by the introduction of barcode verification technology integrated with the eMAR [13].

We have undertaken the first evaluation of a barcode medication management system specifically developed for use in residential and nursing homes. The pharmacy-managed system is designed to provide bar-coded dispensing, controlled administration, clinical

readings, communication, and stock management. The aims of the study were to assess the use of the system to control medication administration errors in care homes, examine differences in the number and types of error averted and consider staff awareness of the potential for such errors to occur prior to introduction of the system.

Methods

Design of the study

The Proactive Care System (PCS) was introduced into a cross-section of nursing and residential homes. Prior to introduction of the system, staff completed a baseline questionnaire exploring their awareness of inappropriate administration of medicines and their perceptions of likely administration errors. Following formal training by the company and a 4 week period to allow staff to familiarise themselves with the new technology, data were collected on all medication administrations over a 3-month observation period. Every attempted inappropriate administration of medicines was identified prospectively over this period.

Setting

The study was undertaken in 13 care homes (9 residential and 4 nursing) representing a geographical spread covering the South West, Midlands and North West of England. Study sites included small and large independent care providers from both commercial and not for profit sectors. All homes were rated as being of a good or higher standard by national regulator inspection. Staff who administered medication were all trained in use of the new technology.

All 345 residents in receipt of medication during the study period were included in the study; 254 in the residential homes and 91 in the nursing homes. A convenience sample of 45 staff responsible for the management and administration of medications was identified to complete the baseline questionnaire.

Technology

The pharmacy-managed, barcode medication management system differs from a simple eMAR system in its design and functionality (See **Additional file 1**). During a medication round, the user scans each recipient's barcode identifier using a hand-held device to ensure the correct resident's drug file is recalled. The system then carries out a number of checks to ensure the following are correct (i) resident, (ii) medication, (iii) time, (iv) dose, (v) quantity and (vi) in date. If administration is outside any parameter, the system alerts the user immediately. At the end of each week a report is sent to the care home manager with details of the 'near misses' and the members of staff involved. Where administration of a medicine within the correct time window becomes lapsed, the system enters this as a 'missing record'. This lack of compliance with barcode administration is confirmed at the next available opportunity by requiring the user to enter further details.

Data collection and analysis

Medication administrations

Anonymised data on every barcode medication administration taking place 24 hours per day over a 3-month period were extracted from the system. Data were downloaded as Excel files and subsequently transferred for analysis into the SPSS statistical package. Initial analysis provided information on the numbers of residents receiving medication, the number of medications per resident, and the number of administrations given (with or without scanning of barcodes). Mean values were calculated separately for residential and nursing homes and compared using the independent samples t test.

Pattern of medication administration errors

The definition adopted for medication administration errors was "any deviation between the medication as prescribed and that administered" [11]. If the system recorded the same type of error repeatedly within a short time period (i.e. attempts to administer medication incorrectly after initial alert), this was counted as a single potential error.

The number of potential medication administration errors (MAEs) averted and the types of error were recorded. Potential MAEs were placed in broad thematic categories related to incorrect timing, attempts to give medication to the wrong person and administration of medication that had been discontinued. If analysis indicated that a user alert was triggered by a slightly early attempt to administer medication (i.e. within 10 minutes of the prescribed time) this was excluded since it was judged likely to have only minor consequences. Mean MAR rates were compared for residential and nursing homes using the independent samples t test. More detailed analysis was undertaken of records in each broad category to identify any patterns which might be indicative of an explanation for errors occurring.

Staff awareness of medication administration errors in their care home

A baseline staff questionnaire (see **Additional file 2**) collected information prior to technology introduction on: (i) general awareness of medication administration errors; (ii) most common types of administration error experienced with current paper-based system; (iii) common reasons for these errors; and (iv) level of confidence (Likert scale) when undertaking medicine round as sole administrator. The questionnaire was piloted in a care home that was not part of the study. Responses were analysed globally and separately for residential home staff and RNs in nursing homes. Levels of self-confidence in undertaking medicine rounds were compared using the Man-Whitney *U* test.

Results

Medication administrations

A total of 345 residents in the 13 care homes were receiving medication throughout the period of data collection; 245 in residential homes and 91 in the nursing homes. Residents received a mean of 8.9 different medications each; 9.0 medications per resident in the nursing homes and 8.8 in residential homes.

During the observation period, residents were exposed to a total of 213,220 separate medication administration episodes, equivalent to an average 206 administrations per resident each month. For nursing home residents, the monthly average number was higher (226.7) than for those in residential homes (198.7); an independent samples t test showed that this difference was significant ($t(22) = -7.64; p < 0.01$).

Pattern of medication administration errors

The barcode hand-held device recorded 88% (n=188,249) of all administrations. These formed the basis of the analysis of averted medication errors. Table 1 shows that, as a percentage of total administrations, the proportion was significantly lower in nursing homes; 84% of nursing home administrations were barcode scanned versus 90% of residential homes ones ($t(22) = 8.61; p < 0.01$). Likely reasons for failure of staff to use barcode scanning are described in **Additional file 1**.

Table 1 - Number of potential medication administration errors (MAEs)

	No. potential MAEs in 3 month observation period		
	All Homes	Residential Homes	Nursing Homes
Total barcode medication administration episodes	188,249	136,340	51,909
Number of residents receiving medication	345	254	91
Av. number bar-coded administrations per resident	545.6	536.8	570.4
Number averted MAEs	2,289	1,481	808
Frequency averted MAEs	1.2%	1.0%	1.2%
Av. number averted MAEs per resident	6.6	5.8	8.9
Av. number averted MAEs per 100 resident months	221.2	194.4	296.0

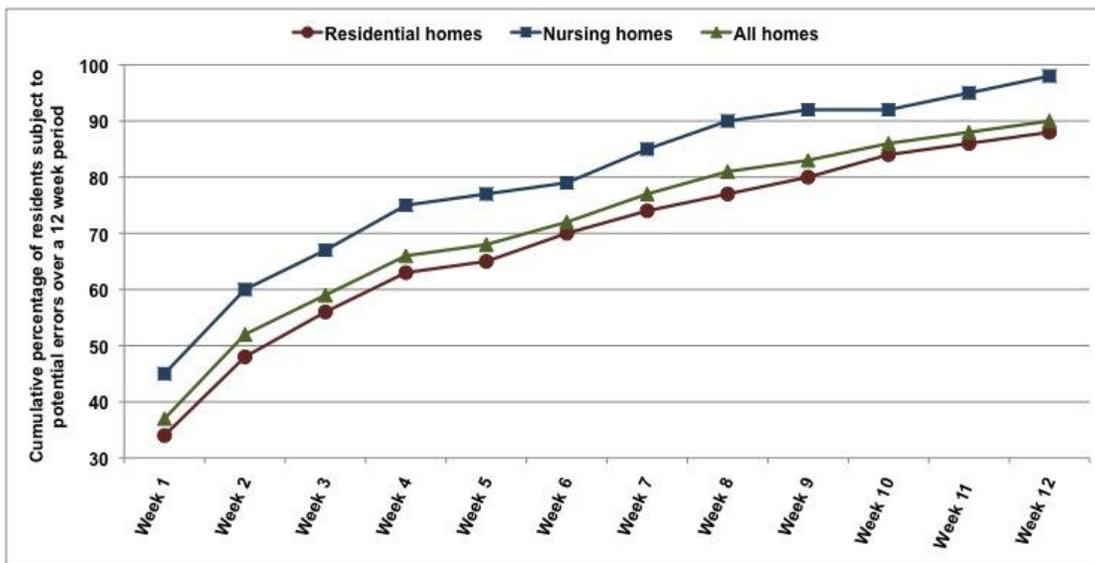
(i) Frequency of averted medication administration errors

We identified 2,289 user alerts for potential medication administration errors during the 3-month observation period. This represented 1.2% of all the barcode episodes analysed. Table 1 shows that the frequency was significantly higher in nursing homes than in residential homes ($t(22) = -4.70; p < 0.01$). Administrations where the system registered

a ‘missing record’, indicative of a lack of compliance with a user alert, were extremely infrequent. Over the study period, there were a total of only 142 such occasions (75 in the nursing homes and 67 in the residential homes). This equated to 0.075% of administrations.

In any one week, the percentage of residents for whom the risk of a medication administration error was averted ranged from 30% to 39%. Over a period of three months the cumulative risk for a patient of exposure to at least one potential error rose to 90%. Figure 1 indicates that the risk was 10% higher for residents in a nursing home (98%) than for those in residential care (88%).

Figure 1 - Cumulative percentages of residents exposed to potential medication administration errors (MAEs)



(ii) Types of error averted

Table 2 provides details of the medication administration errors averted, broken down by type of error and type of home. Overall, nursing home residents were significantly more likely ($t(22) = -5.35; p < 0.01$) to be exposed to an administration error than those in residential homes. These figures translate into 296 vs. 194 averted administration errors per 100 resident months respectively.

This Table shows that the most frequently recorded error of attempting to give a 4-hourly medication too early was significantly more likely to occur for individuals in nursing homes than those in residential care ($t(22) = -4.96; p < 0.01$). When these records were examined in more depth they indicated attempts to give medications such as paracetamol prematurely which had been given in the last 4 hours.

Table 2 - Types of potential medication administration errors (MAEs) averted

Type of error	No. potential MAEs averted in 3 month observation period					
	All Homes		Residential Homes		Nursing Homes	
	Total No.	Av. No/ Resident ¹	Total No.	Av. No/ Resident ¹	Total No.	Av. No/ Resident ¹
Attempted to give a 4-hourly medication too early (< 3.50 hrs)	1,021	3.0	604	2.4**	417	4.6**
Attempted to give other medication at wrong time	586	1.7	412	1.6 [†]	174	1.9 [†]
Attempted to give medication on the wrong day	359	1.0	231	0.9**	128	1.4**
Attempted to give medication to the wrong resident	233	0.7	164	0.6 [†]	69	0.8 [†]
Attempted to give a medication that has been discontinued	90	0.3	70	0.3 [†]	20	0.2 [†]
<i>Total</i>	<i>2,289</i>	<i>6.6</i>	<i>1,481</i>	<i>5.8**</i>	<i>808</i>	<i>8.9**</i>

¹ Excludes residents not receiving any medication

[†] Non-significant $p > 0.05$ difference between nursing and residential homes

** Significant at $p < 0.01$ difference between nursing and residential homes

The second most frequently recorded error was attempting to give other medications later or earlier than the prescribed time. A quarter of all averted administration errors fell into this category. For these cases, the difference between residential care homes and nursing homes was not significant ($p > 0.05$). Examination of records suggested that staff, who have set times for medication rounds, try to fit as many medication administrations as possible into a round, rather than following prescribed times. An associated, potentially more serious error-type was attempting to give medication on the wrong day. Closer

analysis of records indicated that these errors were often linked to one day's dose having been given and a different administrator, who was unaware of this, trying to give the same dose again in the same 24 hour period. Examples included agency staff unfamiliar with the resident and their regime. This type of near miss was more likely to occur in nursing homes than residential homes ($t(22) = -3.12; p < 0.01$).

The final two error-types listed in Table 2 are potentially the most serious. The first, which involved staff attempting to give medication to the wrong resident, represented one in ten near misses in both settings. The second, which involved staff attempting to give a medication that has been discontinued, represented one in twenty five near misses. There was no significant difference between residential and nursing homes. Over the 3-month observation period, the likelihood that a resident would be exposed to one or both of these more serious errors was 52% overall; 48% and 63% for residential and nursing home residents respectively.

Staff awareness of medication administration errors in their care home

A total of 45 staff responsible for management and/or administration of medications completed the baseline survey. These included 31 staff from the residential homes (7 home managers and 24 social care staff); and 14 nursing home staff (3 RN managers and 11 RNs). In nursing homes, all the RNs held a level 1 registered nurse qualification. In the residential homes, 5 social care staff held the National Vocational Qualification (NVQ) at level 4, 18 staff held NVQ at level 3, and 7 staff the basic social care level 2 qualification [14].

(i) General awareness of medication administration errors

Table 3 shows that nearly one third of staff (all social care staff in residential homes) reported that they were aware of potential medication administration errors being averted in their care home, commonly referred to as 'near misses'. No nursing home RNs reported a similar awareness of administration errors.

Table 3 - Staff awareness of potential medication administration errors

Response	All Care Home Staff No. (%)	Residential Home Care Staff No. (%)	Nursing Home RNs No. (%)
Yes	12 (29)	12 (41)	0 (0)
No	29 (71)	17 (59)	12 (100)
<i>Total</i>	<i>41 (100)</i>	<i>29¹ (100)</i>	<i>12¹ (100)</i>

¹Two missing values in each setting

(ii) Common types of administration error observed with current paper-based system

Table 4 indicates that when using their existing paper-based system, missed medication was the error that staff were most likely to think was occurring in their home (69% of all staff). Nearly half (44%) of staff in both types of home also agreed that sometimes medication was given at the wrong time. Only residential home staff reported that they were aware of more serious errors such as medication being given to the wrong person (44%) or of the wrong medication being given (29%). Both staff agreed that the two remaining errors (wrong dosage given, discontinued medication given) occurred, but a higher percentage of care staff than RNs agreed with this statement.

Table 4 - Types of actual medication administration errors observed by staff

Type of error observed	Number of staff agreeing they had observed type of error		
	Staff in All Care Homes No. (%)	Staff in Residential Homes No. (%)	Staff in Nursing Homes No. (%)
Medication missed	31 (69)	23 (74)	8 (57)
Medication given at wrong time	20 (44)	14 (45)	6 (43)
Medication given to wrong person	15 (33)	15 (48)	0 (0)
Wrong medication given	13 (29)	13 (42)	0 (0)
Wrong dosage given	12 (27)	10 (32)	2 (14)
Discontinued medication given	8 (18)	7 (23)	1 (7)

(iii) Perceived most common reason contributing to administration errors

Table 5 shows that nearly all staff in both settings identified ‘interruptions during round’ as a contributory reason for errors when using the paper-based system; and around half also agreed that being ‘stressed’ or ‘under pressure to complete the round’ contributed, with the first more frequently identified in residential homes and the second in nursing homes. No respondent identified ‘lack of training’ as a contributory cause. RNs also did not agree with reasons such as ‘insufficient knowledge of medication’ or ‘present system confusing and open to error’, although a small number of care staff did. Analysis showed that errors were linked to a combination of distractions and work pressures.

Table 5 - Staff agreement with postulated reasons for medication errors

Reason for error	Number of staff agreeing with stated reason		
	Staff in All Care Homes No. (%)	Staff in Residential Homes No. (%)	Staff in Nursing Homes No. (%)
Interruptions during round	43 (96)	31 (100)	12 (86)
Staff stressed	23 (51)	20 (65)	3 (21)
Under pressure to complete round	21 (47)	12 (39)	9 (64)
Shortage of staff	6 (13)	5 (16)	1 (7)
Current system confusing and open to error	4 (9)	4 (13)	0 (0)
Insufficient knowledge of medication	2 (4)	2 (7)	0 (0)
Lack of training	0 (0)	0 (0)	0 (0)

(iv) Level of confidence when undertaking medicine rounds alone

Staff responsible for administering medication appeared to be at ease with carrying out medicine rounds on their own. Based on a Likert scale of 1-7 (1= *not at all at ease*, and 7 = *extremely at ease*), there was no significant difference between staff in residential homes (mean score 6.0) and nursing homes (mean score 6.5) in this respect (Mann-Whitney *U* test, $p > 0.05$). There was also no significant association between mean scores for level of confidence and the qualification level a member of staff had achieved; RNs (mean score = 6.5), NVQ4 (7.0), NVQ3 (5.9) and NVQ2 (6.1).

Discussion

Medication management covers the whole process through prescribing, to dispensing and then administration of medicines. Errors in any one of these steps can have serious consequences for the patient. Although errors are acknowledged to be preventable [10], currently they still result in significant morbidity, mortality and healthcare utilisation by older people [2-6]. According to the United States (US) Food and Drug Administration, over 770,000 patients are injured because of medication errors every year [15]. Administration errors account for 38% of these events. In the US, it is reported that up to 35% of older people in the community may experience some form of adverse medication event each year [16]; the incidence is thought to be even higher amongst nursing home residents [17]. In Italy, up to 30% of hospital admissions in older people are related to such events [18]. In the UK, 9% of hospital admissions for people aged 60 and over are as a result of 'poisonings by drugs, medicaments and bio substances' [19]. There were 76,692 hospital admissions associated with adverse drug reactions in English hospitals in 2005 and this number had increased by 45% over the period 1998 to 2005; 59% of all cases involved patients aged over 60 years [20].

Older people are at increased risk of medication-related adverse events due to a combination of multiple medication (polypharmacy) and age-related changes in the body's response to medicines [21]. Polypharmacy is extremely common in care homes, with residents reported to regularly receive seven or more items each [22]. In such a situation, the risk of incorrect administration of a prescribed medication is high and can lead to a significant number of adverse events [23]. To date, most studies on medication safety in care homes have focused on prescribing; relatively little research has examined administration of prescribed medicines and how the safety of this might be improved. A recent comprehensive literature review has drawn attention to a general absence of research on this area of safety and quality improvement in care homes, in particular residential homes [1].

With the number of people aged 75 and over in the UK projected to nearly double by 2033, increasing from 4.8 to 8.7 million [24], the quality of clinical care provided to older people will increasingly affect patient safety. The care sector in the UK relies heavily on residential homes with no on-site nursing and, as older people's care needs increase, innovative ways of providing clinical expertise will be required [25]. New technology may also have a part to play in improving quality of care, especially in areas such as management of medication. Suggested interventions for preventing medication errors include manual medication reviews, checks of prescription requests, checks of authorised prescriptions, stock checks, checks of dispensed items and audit of medication administration charts [26]. Two recent systematic reviews of the literature found evidence that computerised support systems can improve prescribing and dispensing practices for older people, although there is limited research on administration of medication [27, 28].

Electronic medication administration recording (eMAR) systems introduced to replace paper-based MAR charts have been shown to be effective in reducing errors in settings such as nursing homes as well as hospitals [29-31]. However, barcode medication management systems, which have a broader functionality than simple eMAR systems, have only been assessed in hospitals to date [12, 13]. The present study is the first to evaluate such a system in a long-term care setting.

In agreement with research in other settings, our study found a high level of potential medication administration errors ('near misses') in care homes [32-34]. Our findings indicate that, over a three month observation period, 98% of residents in the nursing home setting and 88% in residential care homes were exposed to at least one potential administration error. The findings mirror those reported in a recent study of care homes in England although, because a smaller number of administrations was examined and sampling methods differed (See **Additional file 3**), rates cannot be directly compared [11]. In the present study, the majority of residents were exposed to a potential administration error during the observation period although there was a difference

between settings. Rates for the most serious errors were 48% in residential care and 63% in the nursing homes where RNs undertake medication rounds.

The near misses identified above seem to be linked to system and behaviour effects rather than a lack of education or training. Staff in both settings identified interruptions to medicine rounds as a major cause of errors, as supported by several other authors [35-42]. Neither staff group associated errors in medication administration with lack of training. The fact that recorded level of confidence was not linked to qualification levels would appear to support this. Instead, it appears that the necessary concentration required for safe administration of medicines is interrupted by competing demands upon staff time. However, our survey findings also indicated that, before introduction of the new technology, RNs in nursing homes appeared to be generally less aware of potential administration errors than their residential home social care staff counterparts.

Some explanation for these observed differences may lie in the complexity of decision-making underpinning the process of medication administration for RNs as opposed to care staff [43-45]. Whitman *et al* [46] suggest that for the RN, increased activity and time pressures associated with patients who are more seriously ill and have more complex medication regimes will inevitably raise the risk of medication errors. RNs with their higher level knowledge and responsibility are also more likely to have to multitask when undertaking medication rounds [47]. Furthermore, in some cases RNs may employ critical thinking and clinical judgement, using their knowledge of the patient to make decisions regarding the timing and dosage of medications, which may counter what is prescribed [44]. In contrast, it has also been suggested that the conduct of routine tasks can lead staff who administer medication into complacency and a diminished sensitivity towards the potential for harm resulting from a medication error [48, 49]. In other contexts, higher grade nurses have been reported to be more prone to making medication errors than those of a lower grade [50]. Factors such as these could explain why some research has found that RNs have a tendency to report errors that have actually occurred more so than ones that have been averted [51]. Among social care staff, who do not have a robust professional or educational framework to support them [52], the sense of ‘stress’

produced could act as a motivator to increase rather than diminish their awareness of potential medication errors and improve compliance with what is prescribed.

The technology evaluated in the present study was implemented in an institutional care home setting and provided automatic, system-initiated, real-time alerts to highlight safety issues and improve the administration of medication, which may partly explain its effectiveness. A recent review of the evidence on computerised prescribing decision support systems concludes that these perform better in institutional rather than ambulatory settings, and when decision support is initiated automatically by the system as opposed to user initiation [53]. In a context in which communication between shifts is imperfect, or there is a high level of agency use, a system with built-in safeguards may also be expected to be more effective. For some systems, there is evidence that staff in nursing homes adopt unsafe work-around practices [54]. Interestingly, there was no evidence of this in the present study. Presumably, this is because the system by its very nature is more difficult to circumvent, with all data management undertaken outside the care home setting and feedback provided on all alerts to the care home manager. At the same time, there was a high level of acceptability for this system among nursing and social care staff.

The main limitations associated with the present study include: the relatively small number of care homes studied, the disparity in numbers between nurses in nursing homes and care staff in residential homes, and the absence of agreed criteria for valuing the different types of medication administration error observed. Although a number of approaches have been attempted to categorising medication errors for older people in hospital, the community, or general practice [55-57], it is only very recently that this debate has extended to care homes [58]. However, existing criteria concentrate almost exclusively on identifying errors in prescribing, and only rarely errors in administration [59]. There is therefore no consensus on the relative importance of different types of administration errors in care homes. Even so, certain errors observed (such as attempting to give medication to the wrong resident or to give a medication that has been discontinued) could clearly be considered as more serious. A further limitation is the

assumption that introduction of the system did not alter behaviour and make staff more careful. Any Hawthorne effect would mean that administration error levels prior to system introduction could be higher than those reported in this paper.

Finally, our findings suggest that care staff in nursing homes might also be trained to administer basic medication using such a system. This would leave registered nurses free to focus on more complex medication regimes and also free up valuable nurse time for other tasks in these homes. The potential also exists for data from the system studied to be used to assess other aspects of medication management, such as prescribing. A preliminary analysis of prescribing of antipsychotics in a large number of care homes and comparison against national guidelines has demonstrated various short-comings [60]. Further research is required to examine prescribing patterns for other medications and bench-mark these across care homes or GP practices. More research is also be required into the decision-making of nurses during medication rounds in nursing homes before delegation to care staff in this setting can be recommended.

Conclusions

The use of a barcode medication management system tailored for use in care homes has been shown to successfully avert a significant number of potential medication administration errors. The system has high acceptability and little evidence of staff adopting unsafe work-around practices. We conclude that patient safety is supported by this system. The finding that non-nursing staff in residential homes and RNs in nursing homes can be alerted to potential error-prone situations means the system can be reliably disseminated in both settings.

List of abbreviations

eMAR	Electronic Medication Administration Recording
GP	General Practitioner
MAR	Medication Administration Record

NVQ	National Vocational Qualification
PCS	Proactive Care System
PIN	Personal Identification Number
MAEs	Medication Administration Errors
RN	Registered Nurse (RN)
US	United States

Competing interests

The authors declare that have no competing interests. AS has had no relationship with Pharmacy Plus Ltd that might have an interest in the submitted work; DW and SN received support through an educational grant given to the University of the West of England by Pharmacy Plus Ltd for the study; AS, DW, SN have no non-financial interests that may be relevant to the submitted work; and their spouses, partners, or children have no financial relationships that may be relevant to the submitted work.

Authors' contributions

DW, AS and SN conceived the idea for the study. SN obtained the data, undertook the surveys and completed the statistical analysis. AS and DW wrote the manuscript which was reviewed by all authors. All authors had full access to all data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

Ethics Approval

The study obtained ethics approval from the University of the West of England Ethics Committee HSC (Health and Social Care) on 25th July 2008 Ref HSC/08/07/47. Prior to this, confirmation was received via email that the research did not need NHS or COREC approval (June 2008).

All participants received project written information prior to request for written consent. All participants' questionnaires were anonymous; participants were identifiable by codes known only to the researcher (SN). No resident was capable of identification in computer-related data files.

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Additional files

Additional file 1

Title: Comparison of characteristics of eMAR and pharmacy-managed, barcode medication management systems

Description: This file provides a more comprehensive description of:

- eMAR (Electronic Medication Administration Recording) systems and
- PCS (Proactive Care System using pharmacy-managed, barcode medication management).

Additional file 2

Title: The Pro-active Care System and Medicines Management in Care Homes: An Exploratory Study of its Impact: **Pre-Introduction Questionnaire**

Description: This file contains the questionnaire used prior to introduction of the technology. Questions covered a large number of areas, including:

- demographics, job role, qualifications, work experience;
- experiences of medication supply, administration and storage
- personal use of computers in the home and at work and mobile phone use;
- pre-PCS introduction SWOT analysis of current system of medication ordering, supply, storage, administration;
- sources of job pressure.

Additional file 3

Title: Comparison of current research and Barber *et al.* study (2009)

Description: This file provides a comparison of the present research and the only other large scale study of medication administration errors in UK care homes, including details of:

- study sites
- site selection process
- resident sample studied
- medication administrations observed
- administration errors recorded

Additional file 1 – Comparison of characteristics of eMAR and pharmacy-managed, barcode medication management systems

1.1 Electronic Medication Administration Record (eMAR) systems

Over the last decade different parts of the world have seen the introduction of eMAR (Electronic Medication Administration Recording) systems to help provide safety checks and stock management in hospitals and, increasingly, in long term care facilities.

An eMAR system allows an electronic version of the patient's Medication Administration Record (MAR) chart to be displayed on the computer screen which is usually attached to a drugs trolley. The records are updated via a web interface by the nurse/ carer or a designated person such as a pharmacist.

Whilst there are benefits in moving from a paper based system to an electronic solution in the recording of information, the process of ensuring that the correct patient receives the correct drug remains entirely manual. An eMAR system can usually identify the correct patient and bring the correct record up on the screen. However, the ability to validate the drug being given with the correct one on the screen can only occur if the eMAR system has the ability to recognise the packet concerned. Usually, the drugs being administered either have no barcodes or do not have sufficient information on their barcodes to perform an absolute check. In this respect, a basic eMAR system continues to carry the risk of giving a patient the wrong drug.

1.2 Pharmacy-managed, barcode medication management systems

A comprehensive barcode medication management system is designed for administering medication, stock management, clinical readings and communication. In this approach, the pharmacy manages the data on the system which includes information on the patient, their drugs, doses, timings and other prescribed information. The Proactive Care System (PCS) evaluated in this study was developed by Pharmacy Plus Ltd specifically for use in care homes. In this system information is presented on a hand-held device which is synchronised with the pharmacy's data in real-time. The functionality uniquely allows the system to reconcile the drug being administered with the prescribing information held on file that provides an absolute check at the point of administration.

The core function is delivered with the use of specific barcode identifiers:

The “**Patient Barcode**” is an identifier unique to the patient. This is provided by the pharmacy and printed onto a label. It is recommended the label is attached in close proximity to the patient (e.g. their bedroom door, or medication cupboard). However, depending on the procedures within the care home the Patient Barcode could be on the drugs trolley, although this is not ideal.

The **Dispensing Barcode** is an identifier unique to the dispensed item. It is printed on every dispensing label from the pharmacy and holds the entire transaction details. The

Dispensing Barcode identifies the patient, drug, dose, date, quantity and can link the dispensing transaction back to the prescription from which that medication was dispensed.

In terms of process, care home staff log onto the administration system using a Personal Identification Number (PIN) code. During the medication round, the user scans the Patient Barcode using the device which then shows a picture of the resident to give initial visual confirmation. On confirmation of correct patient, the system computes the drugs that need to be given for this patient and displays this on screen in red. The user is required to read the items on the screen and find the physical medicine in the usual way. However on finding the medicine, the user must now scan the Dispensing Barcode. The system then performs a number of checks to ensure the medicine selected is for: (i) the correct resident; (ii) the correct medication; (iii) the correct time; (iv) the correct dose; (v) the correct quantity; and (vi) in date. If administration is outside any of these parameters, the system alerts the administrator by both displaying a red warning screen with details of the error message and sounding an alarm simultaneously. A successful scan will allow the user to proceed to prepare and administer the medication. The system has also been designed, after initial site testing, to mimic exactly what members of staff do in real practice, thus reducing the likelihood of work-around or non-adherence to the system by busy staff.

The system does allow the user to perform the key processes without barcode scanning. For example, instead of scanning the Patient Barcode, the user can simply select them from a list (but still retain visual confirmation). Also the user can select the drug by reading it from the screen and confirm they have the correct one. In this way, Non-Barcode functionality has been allowed to accommodate those occasions where the medicines are not supplied by Pharmacy Plus or where the barcode was unreadable. However our research showed that whilst allowing for this, the occasions were limited as 88% barcoding was achieved on average. Furthermore, the percentage barcoding by a user is a performance indicator presented to management within the reports.

Because the administration system has the ability to validate the medicine being selected against the prescribed information held on the electronic file the system can capture all events which fail to meet the appropriate criteria and generate a 'near miss' event record. This registers the member of staff, the resident, the medication and the error itself. A summary of each near miss is provided to the care home manager for future action. In this respect, the Proactive Care System differs significantly in its design and functionality from other technologies such as eMAR charts.

Additional file 2 – The Pro-active Care System and Medicines Management in Care Homes: An Exploratory Study of its Impact: Pre-Introduction Questionnaire

Date:

Participant Code:

Home Code:

Age:

Gender: Male Female

Job Role:

Care Home Manager Care Worker

Senior RGN Senior Care Worker

Other RGN Other (please state) _____

Grade:

Qualifications:

RGN Level 1 NVQ 2 NVQ 3 NVQ 4 No Qualification

Other (please specify) _____

Are you currently in training for NVQ3? Yes No

Job title:

How long working in residential care (months): _____

How long working in nursing home care (months) _____

Are you: (a) Full-time (b) Part-time

If part-time, how many hours/days per week do you work? _____

Are you: employed by: The home Nurse Bank Agency

The following questions will ask you about your experiences of medication supply, administration and storage. All of your answers are completely confidential and only the research team will see individual questionnaires. You will be identified only by a study code.

1. Where are residents' medications dispensed from?

(a) A trolley that is taken directly to the residents

(b) A locked cupboard within the resident's own room

(c) The nurse's office/treatment room (i.e. trolley stays in treatment room and medication is taken out to the resident by nurse/carer)

(d) Other (please state) _____

(e) Any combination of (a), (b), (c) and (d) please state _____

2. Do you have a recognised medication policy in the home? Yes No Not sure

3. If yes, how often are you required to read this policy?

Only when starting at the home Every 6 months Yearly No specified time period

Other (please state) _____

(Explore at interview: *How does your policy say you should administer meds, do you comply with this policy? How about if you were busy and under pressure? Is there anything to detect or prevent people from not complying? Have you come across anyone who does not do it this way?*)

4. Where in the home is this policy kept? _____

5. Which do you think are the most common reasons for drug errors? (Please tick any that apply).

Staff are overworked

Staff are under stress

Poor/insufficient knowledge of the action of medications and their side effects

Under pressure to complete drug round in a certain amount of time

Interruptions to the round from other staff and residents

Current system of drug administration is confusing and open to error

Lack of training

Shortage of appropriately qualified staff

Other (please state) _____

6. Which, if any, of the following errors have you seen in your home? Please tick any that apply.

Wrong dosage being given Medication given to the wrong resident

Wrong medication given Medication given at the wrong time

Medication missed altogether I have not seen any of these errors in my home

Administering medications that have been discontinued

Other type of error (please give examples) _____

7. Which do you think are the most common errors of medication accountability? Please rate from 1 – 7 with 1 being the 'most common' and 7 being the 'least common'. (Interview question: which if any of these errors have you seen in your home?)

Not signing for medication given

- Not recording reasons for non-administration
- Not recording actual amount given for variable dose prescriptions (e.g. "1 or 2 to be given")
- Not recording time given for PRN medications
- Not booking in supplies
- Not having a witness sign for changed made to the MAR
- Other type of error (please specify)_____
- I have not seen any of these errors

8. How long ago did you last attend drug administration training?_____months/years

9. Did your training involve looking at the side effects of common medications?

Yes No

10. Did your training involve looking at what some common medications do?

Yes No

11. Do you know the purpose for of all of the drugs that you give out?

Always Almost always Sometimes Almost never Never

12. In a normal week, how often would you administer drugs?_____times per/week

13. How confident are you that your current drug administration system is:

(a) Safe: residents get correct medication at correct time (Please tick the answer that best matches how you feel).

- 1. Very confident
- 2. Fairly confident
- 3. Neither confident nor lacking confidence
- 4. Fairly lacking confidence
- 5. No confidence

(b) Time efficient re: duration of medication round (Please tick the answer that best matches how you feel).

- 1. Very confident
- 2. Fairly confident
- 3. Neither confident nor lacking confidence
- 4. Fairly lacking confidence
- 5. No confidence

(c) How confident are you that your current system is the best given the number of staff available to dispense medicines? (Please tick the answer that best matches how you feel).

- 1. Very confident
- 2. Fairly confident
- 3. Neither confident nor lacking confidence
- 4. Fairly lacking confidence
- 5. No confidence

14. Approximately how long does a drug round take at present? (Observation: rounds will be observed for shortcuts, adherence to policy, etc. and timed to gather data on actual times before and after PCS introduction this will then be compared to the actual times)

- (a) Early morning _____ mins _____
- (b) Lunchtime _____ mins _____
- (c) Teatime _____ mins _____
- (d) Bedtime _____ mins _____

15. Are you aware of incidences of any 'near misses' (i.e. times where an error has almost occurred but the administrator has noticed just in time) in the home? Yes No

(Interview: Please give examples.) _____

16. Do you generally carry out the drug round: (a) Alone or (b) With another person

17. How at ease are you with carrying out a drug round on your own? (please circle the number that best fits your level of ease)

1 2 3 4 5 6 7
Not at all *At ease* *Extremely at ease*

18. What are the pitfalls/problems associated with your current method of stock control? (please tick any that apply).

- (a) Time consuming
- (b) Easy to make a mistake
- (c) Run out of stock before next order
- (d) Order too much stock
(i.e. potential for stock to go out of date – stock wastage)
- (e) Involves too many staff members
- (f) Uses too much storage space

- (g) No problem
- (h) Don't know how much we have in stock at any one time

19. If you ticked any of the answers at 16 above, which of these is the most frequent problem and which is the least frequent problem? (please choose a letter from (a) – (g))

Most frequent problem is _____

Least frequent problem is _____

Alterations to MARs

20. Who is allowed to make changes to MAR sheets (e.g. dosage changes, discontinuation of meds etc)?

- | | | | | | |
|--------------------------------|--------------------------|------------|--------------------------|-----------------|--------------------------|
| Care Home Manager | <input type="checkbox"/> | Senior RGN | <input type="checkbox"/> | Senior Managers | <input type="checkbox"/> |
| Care Staff (with med training) | <input type="checkbox"/> | Other RGNs | <input type="checkbox"/> | | |
| Other care staff | <input type="checkbox"/> | GP | <input type="checkbox"/> | | |
| Other (please state) | <input type="checkbox"/> | _____ | | | |

21. Is a signature required when alterations are made to MARs? Yes No

22. Is a witness signature required when amendments are made to MARs? Yes No

Special Circumstances

23. Some meds normally require some form of checking action prior to administration. In your home do you undertake any of the following:

- | | | | | |
|---|-----|--------------------------|----|--------------------------|
| (a) Pre-issue Pulse recording for digoxin | Yes | <input type="checkbox"/> | No | <input type="checkbox"/> |
| (b) Regular BP monitoring for those on blood pressure medications | Yes | <input type="checkbox"/> | No | <input type="checkbox"/> |
| (c) Glucose monitoring for insulin | Yes | <input type="checkbox"/> | No | <input type="checkbox"/> |

If you answered 'yes' to any of a, b or c above, please complete questions 22-25. (Interview: If you answered no to any of these, who is responsible for the giving of these medications? Staff in home, district nurse, self-med etc.)

24. Thinking about medications that require some checking action to prior to administration e.g. pulse recording for digoxin, blood glucose monitoring for insulin, etc. have you received training in order to carry out these resident checks?

(Interview: If you have NOT received training to carry out these tasks, what happens if a resident is prescribed a drug that requires pulse/BP/blood sugar monitoring before administration.)

- Yes, I have received training
- No, I have NOT received training

25. If you HAVE received training from whom/where did you receive this training?

- RGN training In-house training course (i.e. arranged by company)
RGN in my home GP
District/community nurse Other (please state)_____

26. Where are checks (e.g. pulse/blood sugar recordings) noted?

- On the MAR sheet only On MAR **and** care plan/notes
In residents care/nursing notes plan **only** Other (please specify)

27. Please read the following statements and answer the questions below:

(a) Statement 1: ‘Staff administering medications assume that the content of the blisters is correct and therefore do not need checking thoroughly.’

- Do you think that this statement is true or untrue? True Untrue
Have you ever come across a situation where the blisters were wrong? Yes No
Do you think that with Blisters, some people do not make thorough checks: Yes No
I have found no problems with this Agree disagree

(interview question : Can you give me any examples of this?)

(b) Statement 2: ‘Staff assume that the blisters on the racks are up-to-date (i.e. no one has taken any off or added any on).’

- Do you think that this statement is true or untrue? True Untrue
Have you ever come across a situation where the blisters were wrong? Yes No
Do you think that with Blisters, some people do not make thorough checks: Yes No
I have found no problems with this Agree Disagree

(Interview question : Can you give me any examples of this?)

(c) Statement 3: Staff assume that the blisters on the racks are placed in the correct residents section.

(Interview question : Can you give me any examples of this?)

- Do you think that this statement is true or untrue? True Untrue
Have you ever come across a situation where the blisters were wrong? Yes No
Do you think that with Blisters, some people do not make thorough checks: Yes No
I have found no problems with this Agree Disagree

(d) Statement 4: Interim medicines can be supplied in the middle of the month. Because they are supplied in the middle, blisters may not be placed on the racks in the correct position. Thus, there is a risk of them getting missed out of the normal drug administration system.

(Interview question: Can you give me any examples of this?)

Is this a real risk? Yes No

Have you ever seen medicines being missed under this circumstance? Yes No

Have you ever come across blisters placed on the racks in the incorrect position Yes No

(e) Statement 5: 'Interim medicines, can be supplied in the middle of the month. Because they are supplied in the middle, there is a risk of some medications that are not blistered (because they are not able to go on the racks e.g. may be in the fridge) being missed.'

(Interview question: Can you give me any examples of this?)

Is this a real risk? Yes No

Have you ever seen medicines being missed under this circumstance? Yes No

(f) Statement 6: 'Because everything is supplied in blisters, dose changes during the month would have to be added to, or removed from the racks, thus there is risk of medicines not being administered properly.'

Do you think that this statement is true or untrue for your home? True Untrue
(Interview: Prompt if busy, if forgetful, if new member of staff)

Have you ever come across situations where the changes were not made? Yes No

Are there other risks? Yes No
(Explore in interview if yes)

(g) Statement 7: 'The racking system presents some difficulties.'

Do you think that this statement is true or untrue for your home? True Untrue
(If true explore through interview)

Is the system bulky? Yes No

Is it a pain to have to swap the different racks round? Yes No

Do you think it is easy to pop out the tablets from the racks? Yes No

Do you ever find that the blisters are not on the right racks? Yes No

Do you ever find that the blisters are not in the right order? Yes No

Do you ever find someone's blisters in the wrong section of the rack? Yes No

Does opening blisters ever injure your fingers? Yes No
I do not find any problems with the racking system Agree Disagree

(h) Statement 8: 'Blisters are on the racks in the order that the patients usually have their medicines, but sometimes residents are not there when it is their turn and could risk getting missed.'

Do you think that this statement is true or untrue for your home? True Untrue

Have you ever known it to happen? Yes No

What method is used to prevent this happening? (Please tick all that apply)

MAR Check Blisters at end of round Notepad No prompt required

Other (please specify)

(i) Statement 9: MAR charts are easier to use when additional identifiers are used (colour coding or other similar) to show you which medicines are due and at which time.

Is this statement true or untrue? True Untrue

Interview: If true what types of identifiers are used and what difficulties do these present

Do you think there is a greater risk of medicines being missed when MAR charts do not have additional identifiers e.g. colour coding? Yes No

Have you ever come across an instance when the colour coding was wrong? Yes No

(interview: please give examples if answered yes)

(interview: Who is responsible for colour coding? Is it always the same person/different person?)

(j) Statement 10: One thing that CSCI inspectors look for on MAR sheets is missing entries.

Were you aware of this? Yes No

Why do you think missing entries are not recorded?

Time pressure Not enough space on MAR charts I have found no Problem with this

Other reasons (please specify)

(k) Statement 11: 'CSCI inspectors also look for recorded reasons why medications have not been given.'

Were you aware of this? Yes No

Why do you think reasons for non-administration are not recorded?

Time pressure Not enough space on MAR charts I have found no Problem with this

Other reasons (please specify)

(l) Statement 12: 'CSCI inspectors look to see whether the number/dose of PRN medication is recorded on the MAR sheets.'

Were you aware of this? Yes No

Why do you think the number/dosage of PRN medications is sometimes not recorded?

Time pressure Not enough space on MAR charts
I have found no Problem with this Other reasons (please specify)

(m) Statement 13: 'Sharing of some resident medicines, e.g. Lactulose and Movicol is unavoidable.'

Do you think that this statement is true or untrue for your home? True Untrue

Why do you think this happens? (please tick any that apply)

Not enough room on trolley Residents own stock has run out

New medication has been prescribed, so no stock available for that resident

Other (please state)

Have you ever seen this practice of sharing?

Frequently Fairly frequently Rarely Never

Was it to do with storing and finding the medicines within the trolley Yes No

Do you think being able to store this type of medication within the trolley, would reduce the incidence of sharing medicines?

Yes No

(n) Statement 14: 'New entries indicating any medication changes are usually made as new entries and countersigned.'

Do you think that this statement is true or untrue for your home? True Untrue

Do you come across occasions where the MAR chart has been changed rather than a new entry made? Yes No

Do you come across occasions where the changes are not signed by two people? Yes No

Do you sometimes find it difficult to decipher other people's handwriting? Yes No

(o) Statement 15: 'Some residents may have a number of MAR sheets plus an interim MAR sheet which may be placed at the back of existing sheets. This increases the risk of medications being missed.'

Do you think that this statement is true or untrue for your home? True Untrue

Have you seen this happen?

Frequently Fairly frequently Rarely Never

28. When you are off for a few days how do you inform yourself of medication changes? Please tick any that apply.

Study MAR charts Discuss with colleagues Ask residents Other (Please specify)

29. When do you usually sign the MAR sheets

Sign before potting sign after potting Use both practices equally

Other (please specify) _____

Have you ever seen or suspected that MAR charts have been signed on mass?
Yes No

(Explore at interview: Why sign when you sign? How do you know which medicines have been potted if you're interrupted? How do you ensure that you remember to go back and sign the MAR chart, if you were interrupted?)

30. What is your opinion of the MAR chart folder?

I have no problems with the MAR chart folder Yes No

Do you find it too bulky? Yes No

Is it easy to find patients MAR charts in the folder? Yes No

Do the MAR chart holes get damaged and slide out? Yes No

Other (please state) _____

31. What is your attitude towards the introduction of a new medication system to replace the one you are using?

Very keen Fairly keen Neither keen nor reluctant Fairly reluctant
Very reluctant

32. Of the following, who do you think holds a positive attitude towards changing to a new medication system? (Tick all that apply)

Care Home Manager Senior RGN Senior Managers

Care Staff Other RGNs Residents/Relatives

Senior Care staff GP

Other (please specify) _____

Who is the most positive and who is the least positive? _____

33. Who of the following do you think holds a negative attitude towards changing to a new medication system? (tick all that apply)

Care Home Manager Senior RGN Senior Managers

Care Staff Other RGNs Residents/Relatives
 Senior Care staff GP
 Other (please specify) _____

Who is the most negative and who is the least negative? _____

Computer use

This section will ask you a series of questions regarding your use of computers in the home and at work.

34. How often do you use a computer at home? (Please tick the most appropriate answer)

Never Daily Weekly Monthly

35. What do you use a home computer for? (Please tick all that apply)

Playing games Spreadsheets

Word processing Email

Internet for information gathering Internet for finance

Internet for chat/discussion rooms Internet for shopping

Other (please give details) _____

36. How often do you use a computer at work? (please tick the most appropriate answer)

Never Daily Weekly Monthly

37. What do you use a work computer for? (Please circle all that apply)

Patient data/records (e.g. blood results, x-rays, etc) Email

Ordering/stock control Word processing

Management (e.g. off duty, bed status) Playing games

Internet for information gathering Spreadsheets

Internet for chat/discussion rooms Internet for shopping

Other (please give details) _____

38. Do you have any formal training in computer use (e.g. CLAIT, RSA, ECDL)? (Please circle the appropriate answer)

Yes No

39. How would you rate your experience in terms of computer use? (Please circle the appropriate answer)

Inexperienced 0 1 2 3 4 5 6 7 8 9 10 Experienced

40. How would you rate your confidence in terms of computer use? (Please circle the appropriate answer)

Confident 0 1 2 3 4 5 6 7 8 9 10 Low confidence

Mobile Phones

The following section asks you about your mobile phone use.

41. Do you own a mobile phone? Yes No

42. Do you own a PDA or smartphone? (E.g. iPhone, Blackberry, Palm etc) Yes No

43. What kind of things do you regularly do with your mobile phone/smartphone? (Tick all that apply)

- | | | | |
|------------------|--------------------------|------------------------|--------------------------------|
| Make calls | <input type="checkbox"/> | Text people | <input type="checkbox"/> |
| Listen to music | <input type="checkbox"/> | Take photographs | <input type="checkbox"/> |
| Check emails | <input type="checkbox"/> | Surf the internet | <input type="checkbox"/> |
| Create documents | <input type="checkbox"/> | Instant messaging | <input type="checkbox"/> |
| Play games | <input type="checkbox"/> | Other (please specify) | <input type="checkbox"/> _____ |

The Pro-active Care System and Medicines Management in Care Homes: An Exploratory Study of its Impact

Pre-PCS Introduction SWOT ANALYSIS; Think about your current system of medication ordering, supply, storage, administration before answering the following questions 44-47

44. Please identify up to 5 strengths for your current system of medication ordering, supply, storage and administration. Explain briefly why for each, then rate them on a scale of 1-5, with 1 = *unimportant*, 2 = *fairly unimportant* 3 = *neither unimportant nor important*, 4 = *fairly important* 5 = *very important*

Strengths	Why?	Rate

45. Please identify up to 5 weaknesses for your current system of medication ordering, supply, storage and administration. Explain briefly why for each, then rate them on a scale of 1-5, with 1 = *unimportant*, 2 = *fairly unimportant* 3 = *neither unimportant nor important*, 4 = *fairly important* 5 = *very important*

Weaknesses	Why?	Rate

46. Please identify up to 5 opportunities to strengthen your current system of medication ordering, supply, storage and administration. Explain briefly why for each, then rate them on a scale of 1-5, with 1 = *unimportant*, 2 = *fairly unimportant* 3 = *neither unimportant nor important*, 4 = *fairly important* 5 = *very important*

Opportunities	Why?	Rate

47. Please identify up to 5 threats to your current system of medication ordering, supply, storage and administration. Explain briefly why for each, then rate them on a scale of 1-5, with 1 = *unimportant*, 2 = *fairly unimportant* 3 = *neither unimportant nor important*, 4 = *fairly important* 5 = *very important*

Threats	Why?	Rate

Sources of Job Pressure

The following section asks you questions about the pressures that you may come across as part of your work.

Using one of the following numbers, please indicate against each of the following items A-Z, your level of job pressure.

- 1 = no pressure
- 2 = slight pressure
- 3 = moderate pressure
- 4 = considerable pressure
- 5 = high pressure

Number

- | | |
|---|-------|
| A. Increased demands from residents. | _____ |
| B. Inappropriate demands from residents. | _____ |
| C. Dealing with problem residents. | _____ |
| D. Dealing with very ill residents and their relatives. | _____ |
| E. Dealing with earlier discharges from hospital. | _____ |
| F. Worry about complaints/litigation. | _____ |
| G. 24-hour responsibility for residents. | _____ |
| H. Working environment and home set-up. | _____ |
| I. Insufficient time to do justice to the job. | _____ |
| J. Fear of assault at work. | _____ |
| K. Disturbance of home/family life by work. | _____ |
| L. Dividing time between work and spouse/family. | _____ |
| M. Unsociable hours. | _____ |
| N. Unrealistic high expectations of role by others. | _____ |
| O. Insufficient resources within the home. | _____ |
| P. Dealing with conflict within the home. | _____ |
| Q. Long working hours. | _____ |
| R. Paperwork. | _____ |
| S. Organisational changes in the homes | _____ |
| T. Adverse publicity by media. | _____ |
| U. Lack of support within home. | _____ |
| V. Emphasis on resource issues in the home. | _____ |
| W. The pace of change within homes. | _____ |

- X. Professional isolation. _____
- Y. Increased workloads. _____
- Z. Lack of appreciation from residents. _____

Additional file 3 – Comparison of current research and Barber *et al.* study (2009)

Characteristic	Barber <i>et al</i> [17]	Current study
Study sites	<ul style="list-style-type: none"> - 55 care homes - Breakdown: 5 nursing, 12 residential, 38 residential & nursing homes 	<ul style="list-style-type: none"> - 13 care homes - Breakdown: 4 nursing, 9 residential homes
Site selection process	<ul style="list-style-type: none"> - Homes selected via Bradford, London, Cambridgeshire PCTs - Large and small chains; single owner; voluntary sector; LA homes. - Size 20-29 places most common 	<ul style="list-style-type: none"> - Homes selected based on technology (PCS¹) Availability in North West, South West, South. - Large and small chains; single owner; independent sector homes. - Size 25-68 places (30-50 places most common)
Resident sample studied	<ul style="list-style-type: none"> - 256 residents sampled - Random sample - 256/ 399 (total residents approached) - Breakdown: 117 nursing, 139 residential - Mean number medications/ resident = 8.0 	<ul style="list-style-type: none"> - 345 residents included - All residents in receipt of medication - 345/ 463 (total resident places) - Breakdown: 91 nursing, 254 residential - Mean number medications/ resident = 8.8
Medication administrations observed	<p>Information collected by observing medication rounds and using MARS²:</p> <ul style="list-style-type: none"> - observation of two medication rounds per resident - morning & tea-time rounds only - 1 or 2 (max) days data on each resident - total 512 resident medication rounds. 	<p>Information collected by downloading data from system:</p> <ul style="list-style-type: none"> - data collected on ~336 medication rounds per resident. - morning, lunch-time, tea-time & night time rounds - 84 days data on each resident - total 188,249 medication administrations
Administration errors recorded	<p><i>If found that:</i></p> <ul style="list-style-type: none"> - medication incorrect - un-prescribed medication - timing error if has clinical significance - extra dose - wrong dose³ - omissions³ - other: deteriorated medication, different formula, route error³ 	<p><i>If recorded attempt to:</i></p> <ul style="list-style-type: none"> - give medication to wrong person - give discontinued medication - give medication at wrong time (including too early, already given, wrong day) - N/A - N/A - N/A

¹ PCS = Proactive Care System which includes pharmacy-managed barcode medication administration system

² MARS = Medication Administration Recording System (paper-based)

³ PBAS technology does not allow this type of medication administration error