



# The implementation of a Technician Enhanced Administration of Medications [TEAM] model: An evaluative study of impact on working practices in a children's hospital

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## ABSTRACT

**Background:** Children are frequently prescribed unlicensed and off-label medicines meaning dosing and administration of medicines to children is often based on poor quality guidance. In UK hospitals, nursing staff are often responsible for administering medications. Medication Errors [MEs] are problematic for health services, though are poorly reported and therefore difficult to quantify with confidence. In the UK, children's medicines require administration by at least two members of ward staff, known as a 'second check' system, thought to reduce Medication Administration Errors [MAEs].

**Objectives:** To assess the impact on working practices of the introduction of a new way of working, using Technician Enhanced Administration of Medications [TEAM] on two specialist wards within a children's hospital. To evidence any potential impact of a TEAM ward-based pharmacy technician [PhT] on the reporting of MEs.

**Methods:** A TEAM PhT was employed on two wards within the children's hospital and trained in medicines administration. Firstly, an observational pre-and-post cohort design was used to identify the effect of TEAM on MEs. We analysed the hospital's official reporting system for incidents and 'near misses', as well as the personal incident log of the TEAM PhT. Secondly, after implementation, we interviewed staff about their perceptions of TEAM and its impact on working practices.

**Results:** We affirm MEs are considerably under-reported in hospital settings, but TEAM PhTs can readily identify them. Further, placing TEAM PhTs on wards may create opportunities for inter-professional knowledge exchange and increase nurses' awareness of potential MAEs, although this requires facilitation.

**Conclusions:** TEAM PhT roles may be beneficial for pharmacy technicians' motivation, job satisfaction, and career development. Hospitals will need to consider the balance between resources invested in TEAM PhTs and the level of impact on reporting MEs. Health economic analyses could provide evidence to fully endorse integration of TEAM PhTs for all hospital settings.

## Introduction

Administering medicines to children remains a concern for health-care providers. Incidences of Medication Errors [MEs], in particular Medication Administration Errors [MAEs], continue to be problematic for health services, especially in paediatrics<sup>1</sup> where children are three

times more likely than adults to experience MEs. It has been theorised<sup>2</sup> that "learning to prescribe occurs as a dynamic series of socially negotiated interactions within and between individuals, communities and environments." MEs are known to occur more frequently during the prescribing and administration of medicines compared to any other stage in the medicines management process.<sup>3–7</sup>

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Epidemiological studies estimate the relative percentages of MEs in paediatric settings to be as high as 72–75% when administering medication, compared to 37% when prescribing medication.<sup>8</sup> The majority of MAEs are reportedly attributed to nurses (in the form of the wrong time, rate, or dose); not surprisingly, since administration by a nurse is usually the last step in the medication process.<sup>7,9</sup> Furthermore, it is important to note across all hospital settings, MEs are frequently under- or mis-reported.<sup>10–14</sup>

Several definitions exist for the term ME, but the most frequently used is that cited by the National Coordinating Council for Medication Error Reporting and Prevention<sup>15</sup> [NCC MERP; an independent body composed of 27 national organisations]: “*any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer*”. The definition for a MAEs can be defined as per the American Society of Health-System Pharmacists<sup>16</sup> [ASHP]: “*deviation from the prescriber's medication order as written on the patient's chart, manufacturers' preparation/administration instructions, or relevant institutional policies*”. The higher incidence of MEs in children results from the need for complex treatment regimens to accommodate individualised dosing based on age, weight, and physiological immaturity. Children are frequently prescribed unlicensed and off-label medicines. This means the product may not be designed for use in children and that good quality paediatric dosing and administration details may not be available at the point of prescribing and administration.<sup>6,17–19</sup>

In addition to pharmacists, hospital pharmacy teams are primarily made up of pharmacy technicians [PhTs], increasingly assigned to ward-based activities. Pharmacists are also supported by a wide range of allied staff, such as pharmacy assistants. Pharmacists and PhTs working in Great Britain, unlike pharmacy assistants, are required to be registered with the General Pharmaceutical Council [GPhC].<sup>20</sup> Pharmacy technicians contribute to the wider healthcare team by supporting nursing staff at ward level with the optimisation and rationalisation of patients' medication.<sup>21</sup>

A report on the productivity and performance of National Health Service [NHS] hospitals in England, recommended PhTs spend more time in face-to-face roles with healthcare staff on wards.<sup>22</sup> Pharmacy technicians have since continued to develop their ward-based roles<sup>23,24</sup> which have been reported to have a positive impact on the use of medicines.<sup>25</sup> More recently, the PhT role has developed further, in the form of medicines reconciliation for patients on admission to, and discharge from hospital.<sup>26–28</sup>

Within the United Kingdom [UK], it has become increasingly accepted practice to employ PhTs and pharmacy assistants to support nurses with demanding medication administration workloads.<sup>24,29–31</sup> Two older studies reported the increased effectiveness of wards and pharmacy departments after the introduction of ward-based PhTs.<sup>32,33</sup> Furthermore, more recent studies in the context of the general ward,<sup>34</sup> and in the context of an oncology ward,<sup>24</sup> where PhTs worked alongside nurses to prepare and administer medication, showed that PhTs led to a reduction in adverse events, nurses' work-related stress and freed-up nurses' time. Further evidence comes from a study involving the use of pharmacy assistants which showed a reduction in the rate of MAEs in the form of omitted doses.<sup>29</sup> Pharmacy assistants working in ward-based environments have also demonstrated there is potential for their contribution to mitigate dose omission and save nursing time.<sup>35</sup> However, new evidence indicates nurse-led medication administration ward rounds supported by PhTs had no impact on reducing omitted doses.<sup>30,31</sup>

To date, all studies evaluating the effects of ward-based pharmacy technicians have been in the context of adult medicine. In contrast, the aim of this study was to assess the impact of a new working practice called: Technician Enhanced Administration of Medications [TEAM] on two specialist wards within a children's hospital in the North West of England, and to define evidence of any potential impact of a ward-based PhT on the reporting of MEs.

## Methods

A mixed methods approach was used to explore the potential impact of TEAM. First, an observational pre-and-post cohort design was adopted to identify any effects of TEAM on MEs on two wards. This meant the research team did not intervene in the study setting or its participants, but rather followed the participants (as a cohort) over time with, in our case, data collected at two different points, before the change in practice occurred and after the change has occurred. Each ward was observed for three months and ME reports were analysed for the number of reported medication incidents logged on the Ulysses risk management system.<sup>36</sup> This system is used to report incidents and ‘near misses’ (any medication error which does not result in patient harm or error with potential for harm that does not reach the patient) in hospitals. Subsequently, the personal incident log of the PhT was analysed. Second, a qualitative semi-structured interview study was employed to obtain the perceptions of staff on both wards about TEAM after its implementation. Collecting both ‘near misses’ data and interview data enabled the team to triangulate our results providing stronger evidence for our conclusions.

### Context and intervention

TEAM was introduced consecutively onto two specialist wards in a children's hospital in the North West of England, for a period of three months per ward. In the UK, paediatric medicines are checked by two clinicians (usually two nurses), before being administered to the child in a process called ‘second checking’. This is to avoid fatal dosing errors which can occur from miscalculation of medicines which are often designed for adults and are used off-label or unlicensed in children's medicine. The pharmacy department within the hospital was responsible for the appointment and upskilling of the ward-based PhT employed to fulfil the TEAM role. This person will be referred to throughout this study as the ‘TEAM PhT’, and was the same for both wards. The TEAM PhT role was a single, self-standing, temporary addition to the staff, created as an entirely new role for the hospital. The person fulfilling this role was expected to be ward-based and provide medicines administration support (in the form of ‘second checking’); order and re-stock medications to the ward; and support nursing staff with their duties on the ward (including offering medicines advice, readying medications for patient discharges, and keeping the ward tidy and timely). The TEAM PhT held the necessary qualifications, was employed full-time, held relevant registrations for pharmacy technicians in the UK,<sup>20</sup> and had completed an Accredited Checking Pharmacy Technician Course.<sup>37</sup> The TEAM PhT also received in-house training on a variety of skills which included: Medicines Administration Record [MAR] charts; MEDITECH 6, an electronic medical record system,<sup>38</sup> the Ulysses Safeguard System,<sup>36</sup> the Trust's integrated risk management system, undertaking an intravenous therapy training course in addition to successfully completing a nurse administration competency booklet.

### Ethics

The study was reviewed and deemed a service evaluation by the University's Faculty of Health and Social Care Research Ethics Committee, with the hospital site granting research governance approval.

### Mixed methods analysis: ME data

Ulysses data were obtained and analysed through descriptive statistics. The personal incident log of the TEAM PhT was analysed. The log contained observed MEs relating to medication administration, storage of medicines, and medication supply and documented relevant actions and interventions taken by the TEAM PhT.

**Table 1**  
Qualitative interview participant details.

Professional Title	Hospital Base	Interview Type
Ward-based Pharmacy Technician [TEAM PhT] <sup>a</sup>	Ward 1	Face-to-Face
Ward-based Pharmacy Technician [TEAM PhT] <sup>a</sup>	Ward 2	Face-to-Face
Strategic Staff Member	Pharmacy	Face-to-Face
Strategic Staff Member	Nursing	Face-to-Face
Ward Manager	Ward 2	Telephone
Sister	Ward 2	Telephone
Staff Nurse 1	Ward 1	Telephone
Staff Nurse 2	Ward 2	Telephone
Staff Nurse 3	Ward 1	Telephone
Staff Nurse 4	Ward 1	Telephone
Pharmacist 1	Ward 1	Telephone
Pharmacist 2	Ward 2	Telephone
Pharmacist 3	Ward 2	Telephone
Near-Patient Pharmacy Technician [NPPhT]	Ward 2	Telephone

<sup>a</sup> **N.B.:** TEAM PhT is the same individual who was interviewed twice, once after each Ward on which they worked.

The TEAM PhT's personal log was independently analysed by two researchers [SAS, LCC] using a content analysis approach,<sup>39</sup> in a similar vein to previous research.<sup>40</sup> After each ME was identified using the content analysis approach, it was then scored for severity using the NCC MERP Index for Categorizing MEs Algorithm,<sup>15,41</sup> again independently by two researchers [SAS, LCC]. The NCC MERP Index was chosen over the National Reporting and Learning System [NRLS],<sup>42</sup> as the NCC MERP index focusses specifically on ME reporting rather than patient safety incidents overall, and is one of the most comprehensive tools for evaluating medication errors,<sup>15</sup> and has been used successfully in a number of studies previously to grade the severity of MEs.<sup>43–47</sup>

#### Qualitative analysis: Interview data

Fourteen semi-structured interviews (face-to-face or telephone) were held with purposively selected key stakeholders who worked with the TEAM PhT in a strategic or operational way (see Table 1). Interviewees included strategic staff members for pharmacy and nursing within the hospital, one ward manager, one nurse sister, four staff nurses, three pharmacists, and one near-patient pharmacy technician [NPPhT]. Two interviews were also undertaken with the TEAM PhT (one after the completion of their time on each ward). An interview schedule was designed to support the understanding of the impact of the newly introduced TEAM on the wards, and how it may affect working practices. Respondents were asked to consent at the start of the interview, which was arranged at a time convenient to them. Interviews

**Table 2**  
Types of MEs recorded, and number of actions taken, by the TEAM PhT.

Type of Medication Error Recorded <sup>a</sup>	Actions taken by the TEAM PhT	
	Ward 1 <sup>b</sup>	Ward 2 <sup>c</sup>
<b>Supply</b> (e.g. where a medication was unavailable at the time required; replacements were required; or there was going to be an imminent shortage of a particular medication, etc.)	58	23
<b>Storage Issues</b> (e.g. where a medication requiring refrigeration had been stored outside of the refrigerator, etc.)	15	14
<b>Communications &amp; Linking-up</b> (e.g. between the ward and pharmacy, or between health professionals and parents, etc.)	43	19
<b>Medication Administration/Dosing Issues</b> (e.g. where the wrong medication, delivery method, or dose was set to be administered, etc.)	30	25
<b>Information</b> (e.g. where the TEAM PhT was the source of knowledge or advice to ward staff about medications, to pharmacy about ward issues or patients, or to parents about the effects of their children's medications, etc.)	25	6
<b>Expiry Date Issue</b> (e.g. where the medication was or about to become out of date, or where the date it was opened had not been recorded, etc.)	55	39
<b>Total Actions Taken</b>	<b>226</b>	<b>126</b>

<sup>a</sup> **N.B.:** One incident recorded as a medication error may have prompted multiple actions.

<sup>b</sup> 152 Recorded Incidents.

<sup>c</sup> 88 Recorded Incidents.

lasted between 30 and 70 min, were transcribed verbatim and anonymised during this process.

A thematic analysis approach<sup>48,49</sup> was utilised as it is known to be complementary to content analysis approaches in mixed methods studies where data are generated from multiple sources.<sup>50–52</sup> In our case, data were derived from staff interviews and from the TEAM PhT's log.

Qualitative data were independently analysed by two researchers [SAS, AK] who then cross-checked themes.<sup>53</sup> Disagreements were discussed and resolved by consensus. To uphold confidentiality, detailed descriptors of the wards and the staff have not been used in this paper.

## Results

### Mixed methods results

Ulysses data sets contained six incidents in the pre-intervention period, and no incidents reported by nurses during the intervention period. This discrepancy meant the project relied on the analysis of the personal incidents log.

Over the initial three-month period, the TEAM PhT's personal log of incidents for the first ward contained 152 recorded incidents, triggering 226 actions by the TEAM PhT. The subsequent three months on the second ward saw 88 incidents reported, with 126 associated actions taken by the TEAM PhT. The categories of ME recorded, and the frequency of actions taken by the TEAM PhT (see Table 2).

Analysis of the data suggests there were many MEs which were unreported, and that a discrepancy existed between the number of MEs reported on each ward, to those identified by the TEAM PhT. This suggests MEs are widely under-reported or simply go un-reported in these contexts and that there is currently insufficient evidence to suggest TEAM PhTs could reduce MEs altogether, but may be somewhat effective in reducing the overall number of severe MEs from occurring. The severity of these MEs were scored using the NCC MERP Index for Categorizing MEs Algorithm<sup>15,41</sup> (see Table 3). These ME 'near misses' were not categorized by the TEAM PhT, but rather only logged by them. They were categorized according to the NCC MERP by two researchers [SAS, LCC] once the log was submitted to the research team after the TEAM PhT left each ward.

### Qualitative results

Four themes were generated around a central organising concept of 'Impact of Changing Working Practices'. These themes were: 'Knowledge Exchange'; 'Medication Error Reduction and Safety'; 'Reallocation of Resources'; and 'Role Development'.

**Table 3**  
Frequency of ME severity across wards.

Medication Error Severity <sup>a</sup>	Ward 1	Ward 2
No patient involvement (i.e. action recorded, but not in relation to patient so could not use algorithm)	28	15
No error actually occurred (A)	17	0
Error, but did not reach patient (B)	81	64
Patient was not harmed, and no intervention required (C)	14	8
Patient was not harmed, but intervention or extra monitoring was required (D)	2	1
Error led to temporary harm of patient, but patient did not require further hospitalisation (E)	0	0
Error led to temporary harm of patient, and patient required further hospitalisation (F)	0	0
Error led to permanent harm of patient (G)	0	0
Error did not lead to permanent harm of patient (H)	0	0
Error led to patient death (I)	0	0

<sup>a</sup> NCC MERP Index for Categorizing MEs Algorithm (based on Hartwig, Denger, & Schneider<sup>41</sup>, 1991).

### Knowledge Exchange

Respondents commented that the TEAM PhT themselves, and the TEAM model appeared to encourage better, more efficient, and more collaborative working practices for ward staff facilitating knowledge exchange. It appears that TEAM improved the transfer of knowledge to nursing staff not only about safe medicines management and administration, but other aspects such as patient requirements, and variations of medications to suit patients' needs. Also evident from our analysis is how the implementation of TEAM has assisted in 'upskilling' other members of the staff who work on, and in parallel to, the ward.

*...the interaction was doing medications together, oral and IV... and I would ask [TEAM PhT] sometimes about medications if I wasn't sure about something, and [TEAM PhT] could then find out for me if they themselves wasn't [sic] sure, which again saved time. (Sister – Ward 2)*

*You had that 'go-to person' [TEAM PhT]... you could check medications, but you could also ask something about pharmacy, and they could go off to pharmacy and communicate with them – so it was a really good, positive thing I think. (Staff Nurse 2 – Ward 2)*

TEAM also enabled a better transfer of patient information between the ward-based nursing staff and their colleagues in pharmacy as noted by ward-based and pharmacy-based staff:

*[TEAM PhT] would give us a brief of who was going home, who had started new medications, if any patients had any problems with medications, more so than what nurses would, because [TEAM PhT] had that relationship with us and that sort of knowledge-base and appreciation of pharmacy... (Pharmacist 1 – Ward 1)*

*...it is quite a complexed ward, and you did feel when [TEAM PhT] was there you had that extra link between, so it felt like a more complete circle if that makes sense – you could note [TEAM PhT] was there as the go-between... (Pharmacist 2 – Ward 2)*

*I think when [TEAM PhT] came onto the ward it was, well I'm guessing they found it and even myself found it a lot better as well, because [TEAM PhT] had more of the drug information about what was going on with each individual patient. (NPPHT – Ward 2)*

Overall, through this theme, we see that TEAM improved the transfer and exchange of knowledge not only about safe medicines management and administration to nursing staff, but also contributed to pharmacy having a better understanding of the patients who were receiving the various medications on the ward. In doing so, participants indicated TEAM may have improved efficiencies around medication decision making, ensuring that patients were being treated with the

correct medications, at the correct doses, and administered in the correct way.

### Medication Error Reduction and Safety

Medication Error Reduction and Safety was the second theme. It covered aspects of ward-based practices which were thought to be improved by the implementation of TEAM. It was suggested that having a TEAM PhT on the ward supporting the preparation and checking of medications enabled increased identification of errors.

*...it's just been like a revolution in medicines..... I've asked [TEAM PhT] to be my eyes and ears at 'medicine times', in checking that we are following policies... trying to improve how we manage medicines and eliminate errors and problems. (Ward Manager – Ward 2)*

*...[TEAM PhT] was able to tell me the drug doses that were maybe incorrect or asking me to review doses before they gave them. [TEAM PhT] was more clued in that aspect, and it helped my role in that they would alert me to think they [doses] might not have been right, so I could prioritise myself better..... I'm a Medication Safety Pharmacist. (Pharmacist 2 – Ward 2)*

The TEAM PhT was able to assist in educating nursing staff members on the safe storage, methods of administration, calculations of dosages, side effects, and potential problematic effects resulting from drug interaction.

*...[TEAM PhT] was a lot more knowledgeable on medications, prescriptions, on the contra-indications and side-effects of each drug... (Staff Nurse 4 – Ward 1)*

*[TEAM PhT] is also a great port of call for nursing staff with expiry dates, and utilising medication properly rather than excessively opening everything, so [TEAM PhT] keeps a good eye on stock levels... They've also been very good at giving advice to the nursing team about medication and what medication to give together and understanding doses and querying doses. (Pharmacist 3 – Ward 2)*

These data suggest staff of all levels were appreciative of TEAM, and recognised its role in enhancing the safe calculation and administration of medication doses.

### Reallocation of Resources

Staff across all levels and professions commented that TEAM PhT was useful in undertaking routine tasks which otherwise distract nursing staff from delivering care to patients. Similarly, the ability of the TEAM PhT to 'second check' medications prior to administration to patients meant that nursing staff were more available to attend to patient needs.

*I really do think this is working. I think there is improvement in practice. I think the [TEAM PhT] role does bring something different, and I think it does release time to care. (Strategic Staff Member – Nursing)*

*I try and sort of help others out when I'm not as busy just like [TEAM PhT] would've done. You know, if [TEAM PhT] was sort of not busy doing something else, they were there to help people, and it made me realise how important that actually is... (Staff Nurse 3 – Ward 1)*

Analysis showed that members of nursing staff on both wards were able to administer medications more efficiently, improve admissions and discharge processes, as well as increase patient safety.

*...when I was on the ward, there has been a number of occasions where they've had staff phone in sick, so they've said it doesn't matter, we won't need bank cover or shift cover, or moving from another ward..... you could argue it saves the trust money in one way, without compromising safety... (TEAM PhT – Ward 1)*

*When [TEAM PhT] came on the ward, I felt my shifts ran much more smoothly because all my patients were cared for by nursing staff, and the*



*healthcare assistants and the medicines were [administered] within 10 minutes of the time they were prescribed – give or take – and the parents were much happier. (Staff Nurse 1 – Ward 1)*

When established, both wards had confidence that patient safety was being enhanced by TEAM. Even so far as to suggest that should there be a member of nursing staff on leave or off due to illness, there was enough staff on the ward with the TEAM PhT to not require bank staff.

### Role Development

Participants commented that TEAM may lead to role alteration and changes in the composition and numbers of different healthcare professionals [HCPs] on a ward as well as workload practices for all staff involved in medication administration. Staff were aware that TEAM could be developed further to become an integral part of the staff based on the ward should it become a permanent feature of the rostered staff:

*...I think it would be a really interesting role... I think we've become a bit stuck at the moment once we've qualified... Whereas the job that [TEAM PhT] was trialling out... it looked like there'd be good opportunities to expand your knowledge and work alongside other professionals. (NPPHT – Ward 2)*

*I would like to see the role as not part of the non-medical prescribing service, but actually a standalone service in its own right, with its own team, where you've got a team leader that will do all the training and then you've got various technicians that will cover various wards, and again the needs and the times that the technician was on that ward was determined by the ward needs. (TEAM PhT – Ward 2)*

There was a recognition that TEAM had affected professional roles and practices at service delivery level requiring wider changes to staff and ward management.

*I'd certainly like to see an extension of what we call our medicines management technicians to be medicines management optimisation technicians and fulfilling this sort of remit at a ward level as well. That will require some rethinking of roles that they're currently doing... (Strategic Staff Member – Pharmacy)*

*Ultimately, this [TEAM PhT] role could replace a nurse role on the wards, and instead of having six nurses on a shift, you've only got five and a pharmacy technician. (Strategic Staff Member – Nursing)*

This theme further questions how TEAM may be developed, and how PhTs in the future may be deployed differently in hospitals.

### Discussion

The aim of this study was to assess the impact of TEAM on two specialist wards in a children's hospital. TEAM was designed to increase ME reporting by nurses, and ultimately, to contribute to an overall reduction of MEs. The study aimed to understand how inter-professional work between ward based PhTs and nurses could maximise opportunities for shared learning and knowledge exchange, leading to improved awareness of issues involving medicine storage and administration. In addition, there was an expectation that additional staff supporting medicine administration would allow nurses to complete medication rounds quicker and more efficiently, potentially releasing nursing staff for other ward-based duties.

The study's premise on ME reporting was challenged, and we found no evidence that, in this context, placing a pharmacy technician on the wards alongside nurses led to increased ME reporting, or indeed a decrease in ME rates *per se*. In line with other reports,<sup>10–14</sup> we observed a low rate of ME reporting. With the scale of this study, the ME signal was too low to conclude any meaningful data on the impact of TEAM on ME reporting. However, the use of the TEAM PhT's personal log was a

suitable surrogate in the context of this study. This echoes a long-standing concern in the literature regarding the low reporting rates of MEs by HCPs, and the debate around how to motivate nurses to improve reporting.<sup>40,54–56</sup>

Given the lack of data on ME as the primary study outcome, the TEAM PhT's personal log was examined as to whether the TEAM PhT had witnessed any potential MEs. We found no evidence that PhTs influence nurses' ME reporting. This may change if knowledge exchange opportunities between nurses and PhTs can be maximised. All the incidents recorded in the TEAM PhT's log were included in the analysis which clearly showed there were a considerable number of incidents which met reporting criteria in-line with the NCC MERP severity algorithm.<sup>15,41</sup> This clearly indicates many incidences (a total of 240 recorded on the TEAM PhT's log for the duration of this study) which warranted reporting on the Ulysses risk management system, but that were not. Furthermore, all incidents reported on the TEAM PhT's log were able to be categorized using the NCC MERP, meaning that these MEs would have occurred and gone unidentified had the TEAM PhT not been there to record them.

The study demonstrated two important aspects of the presence of a TEAM PhT on specialist wards within a paediatric hospital. First, it confirmed considerable under-reporting of MEs in hospital settings.<sup>7,10,12–14</sup> It demonstrated that incidents could be identified by a TEAM PhT, as confirmed by analysis of the TEAM PhT's log. Second, placing TEAM PhTs on wards in an inter-professional environment may create opportunities for an exchange of knowledge, and increase nurses' awareness of pharmacological aspects of medication. However, placing PhTs with nurses on a ward is unlikely to facilitate diffusion of knowledge on its own.

Existing research on the processes of inter-professional knowledge exchange points to the need for additional support to bring about cross-professional shared learning.<sup>57–61</sup> Perceptions of different status and competencies between HCPs may impede collegial sharing of knowledge,<sup>62,63</sup> and in this setting, increased awareness of medication storage and administration requirements.<sup>61,64–68</sup>

Improved patient care was reported as a possible benefit to the presence of the TEAM PhT on the ward by some respondents. However, future research is needed to explore how additional TEAM PhT resources might impact on nurse capacity. In particular, whether nursing staff make best use of the time freed-up through TEAM needs to be examined. This issue is linked with wider concerns about the efficiency of the TEAM PhT resource.<sup>30,31</sup>

Although the additional help with medication administration rounds and guidance on medication storage was appreciated, there was a sense among some respondents that the current duties and work tasks of a TEAM PhT would not amount to a full-time position across one ward. There was a concern that, at 'down times', the TEAM PhT would engage in conventional pharmacy related tasks, liaising between the ward and the hospital pharmacy, which fell outside the job description of the TEAM PhT.

This points to an additional issue. In this study, the TEAM PhT was located alongside nurses on the ward. However, on one of the wards, a NPPHT was already at hand to assist nurses with routine medication issues such as re-stocking and taking drug histories from patients. Whilst there are clear differences in job descriptions between the ward-based TEAM PhT, and the existing NPPHT,<sup>20,22</sup> there is a question as to whether or not NPPHT roles could be expanded and transformed to incorporate some of the tasks that the TEAM PhT role was designed to undertake, rather than creating a singular, self-standing, new position of a designated TEAM PhT. Consideration of this overlap in PhT roles echoes the concern above as to whether TEAM PhTs on wards would be the most effective use of resources, given that single wards may not offer sufficient work for a full-time position. However, the main question is to sufficiently evidence why a TEAM PhT would be a more cost-effective use of resources rather than providing additional nursing hours.<sup>22</sup>

### Strengths, limitations, and future research

This was a relatively small exploratory study of the impact of a new working practice involving TEAM. Our cross-disciplinary evaluation drawing on both clinical and academic pharmacy professionals, and social scientists has enabled us to interrogate these data – especially the qualitative – in a thorough and rigorous manner. This has allowed us to present findings with both academic meaning and clinical application, something which has more recently been raised as important for health service evaluation and healthcare research,<sup>69</sup> and which may be used as foundational evidence to challenge and improve policy for patient safety. Furthermore, our mixed methods, triangulated approach has added both rigour and depth to our analyses, meaning results can be interpreted with confidence and be used to inform clinically relevant policy.<sup>70,71</sup> However, the fact that only one TEAM PhT was used makes it difficult to fully assess the potential impact of the role, and how much the effect of the project depended on personal characteristics of the individual. Future studies should use comparative designs involving several appointees and control wards (i.e. standard ward staffing without the introduction of a TEAM PhT) to cross-verify the effects of a TEAM PhT.

Furthermore, this evaluation was undertaken over two consecutive three-month periods. This is a relatively short period of time for a new role to be established, and to demonstrate effective change. Nonetheless, our results suggest TEAM PhTs have the potential to, and in this case, did make some changes to working practices on specialist children's wards. We would expect future studies to include a longer period of the TEAM PhT role within the ward setting, and for the TEAM PhT role to be subject to indicators which would need to be devised and tested in order to evaluate quality improvement reporting excellence.

Additionally, the present study did not capture the voices of the patients, parents and carers present on the wards at the time the TEAM PhT was *in situ*. Whilst it may be difficult for patients, parents and carers to differentiate between different staff and their roles or, in fact, detect role changes amongst staff, their views ought to be heard in any future research. Listening to their perspectives may evidence the impact that the pharmacy technician role could have on patients.

Finally, the TEAM PhT role contained no structured shared learning component, but was built on the assumption that proximity in the workplace between nurses and the TEAM PhT would stimulate and sustain professional knowledge exchange. As pointed out in literature concerning inter-professional knowledge diffusion, good practice requires supporting processes for knowledge to spread.<sup>58,72</sup>

### Conclusions

The role of a ward-based PhT to aid the administration of medicines within children's hospitals (or TEAM PhT) requires careful consideration and design if there is to be any expected effects in terms of inter-professional learning, knowledge exchange, and structured upskilling from the TEAM PhT to the rest of the ward staff administering medicines. Gains in available nursing time may be used to maximise the potential impact of the TEAM PhT on inter-professional education.

In undertaking this research, we have laid the foundations for future evidence-based practice studies to build upon. There may be good reasons to institute a TEAM regime in hospitals when viewed from the perspective of PhTs' motivation, job satisfaction and career development. This study has provided insight which suggests the surveillance performed by a TEAM PhT may provide a vehicle for improved reporting of MEs, thus may act as an important policy driver for quality improvement, incident reporting excellence, and ultimately improving patient safety. However, in order to make a more informed decision for the strategic healthcare staff, management, and policy makers within the NHS and local Trusts, cost analyses; healthcare economics; and patient outcome data could potentially provide some of the evidence required about the future role of ward-based pharmacy technicians and the adoption of TEAM models.

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### Declaration of competing interest

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### References

- Bannan D, Tully MP. Bundle interventions used to reduce prescribing and administration errors in hospitalized children: a systematic review. *J Clin Pharm Therapeut*. 2016;41:246–255.
- McLellan L, Yardley S, Norris B, de Bruin A, Tully MP, Dornan T. Preparing to prescribe: how do clerkship students learn in the midst of complexity? *Adv Health Sci Educ*. 2015;20:1339–1354.
- Kaushal R, Bates DW, Landrigan C, et al. Medication errors and adverse drug events in pediatric inpatients. *J Am Med Assoc*. 2001;285:2114–2120.
- Krahenbühl-Melcher A, Schlienger R, Lampert M, Haschke M, Drewe J, Krahenbühl S. Drug-related problems in hospitals: a review of the recent literature. *Drug Saf*. 2007;30:379–407.
- Leape LL, Bates DW, Cullen DJ, et al. Systems analysis of adverse drug events. *J Am Med Assoc*. 1995;274:35–43.
- Lindell-Osuagwu L, Korhonen MJ, Saano S, Helin-Tanninen M, Naaranlahti T, Kokki H. Off-label and unlicensed drug prescribing in three paediatric wards in Finland and review of the international literature. *J Clin Pharm Therapeut*. 2009;34:277–287.
- Ross L, Wallace J, Paton J, Stephenson T. Medication errors in a paediatric teaching hospital in the UK: five years operational experience. *Arch Dis Child*. 2000;83:492–497.
- Miller MR, Robinson KA, Lubomski LH, Rinke ML, Pronovost PJ. Medication errors in paediatric care: a systematic review of epidemiology and an evaluation of evidence supporting reduction strategy recommendations. *Qual Saf Health Care*. 2007;16:116–126.
- Raju TN, Kecskes S, Thornton JP, Perry M, Feldman S. Medication errors in neonatal and paediatric intensive-care units. *Lancet*. 1989;12:374–376.
- Härkänen M, Vehviläinen-Julkunen K, Murrells T, Rafferty AM, Franklin BD. Medication administration errors and mortality: incidents reported in England and Wales between 2007–2016. *Res Soc Adm Pharm*. 2019;15:858–863.
- Holmström A-R, Järvinen R, Laaksonen R, Keistinen T, Doupi P, Airaksinen M. Inter-rater reliability of medication error classification in a voluntary patient safety incident reporting system HaiPro in Finland. *Res Soc Adm Pharm*. 2019;15:864–872.
- Kingston MJ, Evans SM, Smooth BJ, Berry JG. Attitudes of doctors and nurses towards incident reporting: a qualitative analysis. *Med J Aust*. 2004;181:36–39.
- Kmietowicz Z. A fifth of acute trusts may be under-reporting medical errors. *BMJ*. 2014;348:1.
- Morrison M, Cope V, Murray M. The underreporting of medication errors: a retrospective and comparative root cause analysis in an acute mental health unit over a 3-year period. *Int J Ment Health Nurs*. 2018;27:1719–1728.
- National Coordinating Council for Medication Error Reporting and Prevention. *Types of Medication Errors*. 2001; 2001 <https://www.nccmerp.org/types-medication-errors> Accessed 04.09.19.
- American Society of Health-System Pharmacists. ASHP standard definition of a medication error. *Am J Hosp Pharm*. 1982;39:321.
- Chedoe I, Molendijk H, Hospes W, van den Heuvel ER, Taxis K. The effect of a multifaceted educational intervention on medication preparation and administration errors in neonatal intensive care. *Arch Dis Child Fetal Neonatal Ed*. 2012;97:F449–F455.
- Lo A, Co M, Lo C, Chua D, Soltesz D. Specialized pharmacy oncology technician: experience at the ridge meadows hospital. *Can J Hosp Pharm*. 2010;63:138–141.
- Nunn AJ. Making medicines that children can take. *Arch Dis Child*. 2003;88:369–371.
- General Pharmaceutical Council. *Registering as a Pharmacy Technician*. 2017; 2017 <https://www.pharmacyregulation.org/registration/registering-pharmacy-technician> Accessed 04.09.19.
- Care Quality Commission. *Medicines in Health and Adult Social Care*. Newcastle upon

- Tyne, United Kingdom: Care Quality Commission; 2019.
22. Carter P. *Operational Productivity and Performance in English NHS Acute Hospitals: Unwarranted Variations*. London, United Kingdom: UK Government Department of Health and Social Care; 2016.
  23. Mattingly AN, Mattingly II TJ. Advancing the role of the pharmacy technician: a systematic review. *J Am Pharmaceut Assoc*. 2018;58:94–108.
  24. Sinclair A, Eyre C, Petts H, Shuard R, Correa J, Guerin A. Introduction of pharmacy technicians onto a busy oncology ward as part of the nursing team. *Eur J Hosp Pharm*. 2018;25:92–95.
  25. Roland C, Guérin A, Bussi res J. GM-009 Role and impact of hospital pharmacy technician: a literature review. *Eur J Hosp Pharm*. 2017;24:A161.
  26. Gernant SA, Nguyen MO, Siddiqui S, Schneller M. Use of pharmacy technicians in elements of medication therapy management delivery: a systematic review. *Res Soc Adm Pharm*. 2018;14:883–890.
  27. Koehler T, Brown A. A global picture of pharmacy technician and other pharmacy support workforce cadres. *Res Soc Adm Pharm*. 2017;13:271–279.
  28. van den Bemt PM, van den Broek S, van Nunen AK, Harbers JB, Lenderink AW. Medication reconciliation performed by pharmacy technicians at the time of pre-operative screening. *Ann Pharmacother*. 2009;43:868–874.
  29. Baqir W, Jones K, Horsley W, et al. Reducing unacceptable missed doses: pharmacy assistant-supported medicine administration. *Int J Pharm Pract*. 2015;23:327–332.
  30. Keers RN, Seston EM, Kontopantelis E, et al. *Evaluation of Pharmacy Technician Supported Medication Administration Rounds (TECHMED) on Reducing Omitted Doses: A Pilot Randomised Controlled Trial and Process Evaluation in a University Teaching Hospital*. Manchester, United Kingdom: University of Manchester; 2017.
  31. Seston EM, Ashcroft DM, Lamerton E, Harper L, Keers RN. Evaluating the implementation and impact of a pharmacy technician-supported medicines administration service designed to reduce omitted doses in hospitals: a qualitative study. *BMC Health Serv Res*. 2019;19:1–10.
  32. Conroy C, Cattell R, Nicholls M. Contribution of ward-based technician service to delivering effective patient health care and reducing dispensary workload. *Int J Pharm Pract*. 2002;10:171–175.
  33. Langham JM, Boggs KS. The effect of a ward-based pharmacy technician service. *Pharm J*. 2000;264:961–963.
  34. van de Plas A, Smits C, Mens V, van Leeuwen R, Frankfort E, Neef C. Parenteral medication preparation by pharmacy technicians on the ward improves medication safety. *Eur J Hosp Pharm*. 2012;19:135–136.
  35. Rathbone AP, Jamie K, Blackburn J, et al. Exploring an extended role for pharmacy assistants on inpatient wards in UK hospitals: using mixed methods to develop the role of medicines assistants. *Eur J Hosp Pharm*. 2018.
  36. Ulysses. The Ulysses risk management systems. <https://www.ulysses.co.uk/>; 2018 Accessed 04.09.19.
  37. Health Education England. Training courses for pharmacy technicians. <https://www.hee.nhs.uk/our-work/pharmacy/pharmacy-integration-fund/pharmacy-technician-training>; 2017 Accessed 04.09.19.
  38. Medical Information Technology, Inc. MEDITECH electronic health record solutions. <https://ehr.meditech.com/>; 2017 Accessed 04.09.19.
  39. Hsieh H-F, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. 2005;15:1277–1288.
  40. Bj rkst n KS, Bergqvist M, Anders n-Karlsson E, Benson L, Ulfvarson J. Medication errors as malpractice – a qualitative content analysis of 585 medication errors by nurses in Sweden. *BMC Health Serv Res*. 2016;16:1–8.
  41. Hartwig SC, Denger SD, Schneider PJ. Severity-indexed, incident report-based medication error-reporting program. *Am J Hosp Pharm*. 1991;48:2611–2616.
  42. National Reporting and Learning System. NRLS reporting. <https://report.nrls.nhs.uk/nrlsreporting/Default.aspx>; 2018 Accessed 04.09.19.
  43. Dalmolin GRS, Rotta ET, Goldim JR. Medication errors: classification of seriousness, type, and of medications involved in the reports from a University Teaching Hospital. *Braz J Pharm Sci*. 2013;49:793–802.
  44. Dos Santos L, Winkler N, Dos Santos MA, Martinbiancho JK. Description of medication errors detected at a drug information centre in Southern Brazil. *Pharm Pract*. 2015;13:1–7.
  45. Gleason KM, McDaniel MR, Feinglass J, et al. Results of the medications at transitions and clinical handoffs (MATCH) Study: an analysis of medication reconciliation errors and risk factors at hospital admission. *J Gen Intern Med*. 2010;25:441–447.
  46. Husch M, Sullivan C, Rooney D, et al. Insights from the sharp end of intravenous medication errors: implications for infusion pump technology. *BMJ Qual Saf*. 2005;14:80–86.
  47. Wolf ZR, Hicks R, Serembus JF. Characteristics of medication errors made by students during the administration phase: a descriptive study. *J Prof Nurs*. 2006;22:39–51.
  48. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3:77–101.
  49. Braun V, Clarke V. *Successful Qualitative Research: A Practical Guide for Beginners*. London, United Kingdom: SAGE; 2013.
  50. Crowe M, Inder M, Porter R. Conducting qualitative research in mental health: thematic and content analyses. *Aust N Z J Psychiatr*. 2015;49:616–623.
  51. Schwappach DL, Gehring K. Trade-offs between voice and silence: a qualitative exploration of oncology staff's decisions to speak up about safety concerns. *BMC Health Serv Res*. 2014;14:1–10.
  52. Vaismoradi M, Turunen H, Bondas T. Content analysis and thematic analysis: implications for conducting a qualitative descriptive study. *Nurs Health Sci*. 2013;15:398–405.
  53. Campbell JL, Quincy C, Osserman J, Pedersen OK. Coding in-depth semistructured interviews: problems of unitization and intercoder reliability and agreement. *Socio Methods Res*. 2013;42:294–320.
  54. Flynn L, Liang Y, Dickson GL, Xie M, Suh DC. Nurses' practice environments, error interception practices, and inpatient medication errors. *J Nurs Scholarsh*. 2012;44:180–186.
  55. Hung CC, Chu TP, Lee BO, Hsiao CC. Nurses' attitude and intention of medication administration error reporting. *J Clin Nurs*. 2016;25:445–453.
  56. Parry AM, Barriball KL, While AE. Factors contributing to registered nurse medication administration error: a narrative review. *Int J Nurs Stud*. 2015;52:403–420.
  57. Baillie L. We need to talk about the 6Cs: perspectives on a recent debate. *J Res Nurs*. 2015;20:331–336.
  58. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations norms in interprofessional teams: systematic review and recommendations. *Milbank Q*. 2004;82:581–629.
  59. Hewitt G, Sims S, Harris R. Evidence of communication, influence and behavioural norms in interprofessional teams: a realist synthesis. *J Interprof Care*. 2015;29:100–105.
  60. Pype P, Mertens F, Helewaert F, Krystallidou D. Healthcare teams as complex adaptive systems: understanding team behaviour through team members' perception of interpersonal interaction. *BMC Health Serv Res*. 2018;18:1–13.
  61. Petit Dit Dariel O, Cristofalo P. A meta-ethnographic review of interprofessional teamwork in hospitals: what it is and why it doesn't happen more often. *J Health Serv Res Pol*. 2018;23:272–279.
  62. Brown JM, Sandars JE, Nwoliwe C, et al. Multi-disciplinary training hubs in North West England: the training hub lead perspective. *Educ Prim Care*. 2019.
  63. Zubairu K, Lievesley K, Silverio SA, et al. A process evaluation of the first year of Leading Change, Adding Value. *Br J Nurs*. 2018;27:817–824.
  64. Betancourt JC, Valmocina M, Grossman D. Physicians' knowledge and perceptions of the roles and functions of nurse practitioners. *Nurs Pract*. 1996;21:13–15.
  65. Edwards S, Axe S. The 10 'R's of safe multidisciplinary drug administration. *NursePrescribing*. 2015;13:398–406.
  66. Hussaini SY, Box M, Scholes S. Piloting the role of a pharmacist in a community palliative care multidisciplinary team: an Australian experience. *BMC Palliat Care*. 2011;10:1–12.
  67. Longpr  C, Dubois C-A. Fostering development of nursing practices to support integrated care when implementing integrated care pathways: what levers to use? *BMC Health Serv Res*. 2017;17:1–16.
  68. Manias E. Effects of interdisciplinary collaboration in hospitals on medication errors: an integrative review. *Expet Opin Drug Saf*. 2018;17:259–275.
  69. Silverio SA, Gauntlett W, Wallace H, Brown JM. (Re)discovering grounded theory for cross-disciplinary qualitative health research. In: Clift BC, Gore J, Bekker S, Costas Batlle I, Chudzikowski K, Hatchard J, eds. *Myths, Methods, and Messiness: Insights for Qualitative Research Analysis*. Bath, United Kingdom: University of Bath; 2019:41–59.
  70. Farmer T, Robinson K, Elliott SJ, Eyles J. Developing and implementing a triangulation protocol for qualitative health research. *Qual Health Res*. 2006;16:377–394.
  71. Shneerson CL, Gale NK. Using mixed methods to identify and answer clinically relevant research questions. *Qual Health Res*. 2015;25:845–856.
  72. Woo BFY, Lee JXY, Tam WWS. The impact of the advanced practice nursing role on quality of care, clinical outcomes, patient satisfaction, and cost in the emergency and critical care settings: a systematic review. *Hum Resour Health*. 2017;15:1–22.