Evaluation of automation on the Gold Coast University Hospital Pharmacy department

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Evaluation of automation on the Gold Coast University Hospital Pharmacy department

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Abstract

Background

Pharmacy robotics have been implemented globally to create medication management efficiencies. However, translation to the Australian public hospital environment has not been evaluated. It is also not known what factors influence pharmacy staff to use new technologies that could guide future automation implementation strategies.

Aim

The primary aim of this research is to evaluate the introduction of a Pharmacy Robotic Dispensing System (PRDS) in an Australian public hospital pharmacy and the impact it had on pharmacy staff medication supply activities in both the dispensary and imprest management.

Secondly, this research aims to identify factors that influence hospital pharmacy staff acceptance of robotics during implementation and over time.

Method

This study was conducted in a tertiary public hospital on the Gold Coast, Australia and took place in two phases, each phase consisting of a staff survey and a time in motion study.

Phase one: May 2016; an initial assessment prior to the PRDS becoming operational for baseline data. Data for the staff survey and time and motion study were collected and analysed in this phase.

Phase two: August 2017; PRDS had been operational for 15 months and the study was repeated. Data for the staff survey and time in motion study were remeasured in this phase for comparative analysis

Staff survey: A single centred, prospective, longitudinal cohort quantitative study. Pharmacy staff were surveyed using the Extended Technology

Acceptance Model (ETAM). Fischers exact test and correlation analysis of paired responses was used to identify significant factors influencing usage of the PRDS between the two time points.

Time in motion study: A single centred, prospective, longitudinal time in motion study. Time stamped video footage was collected tracking medication orders in numbered containers throughout the pharmacy dispensary. Activities observed and recorded comprised of dispensing, labelling, assembly of items, number of items and time waiting to be actioned. Data was analysed and compared overall turnaround times; time waiting to be actioned; dispensing, assembly and labelling times; plus dispensing rates (items/person/hours). Fitbit Zip® used to anonymously track pharmacy assistant steps per day in the dispensary. Dispensing software (iPharmacy ®) supplied the location of stocked medication and electronic tracking databases provided data for imprest medication supply turnaround time, picking and waiting for action times. Median turnaround times and Mann Whitney U test used to examine relationships between phases, plus mean steps per day and two tailed t-test used to analyse changes in movement.

Results

Sixty four respondents completed surveys during phase one (70%: 64/91) and 34 paired surveys were collected fifteen months later in phase two (53%: 34/64). Respondents were predominantly young, female with a tertiary qualification. Initial perceptions of the pharmacy robot did not change over time, with the exception of 'reliability'. Participants found the robot less reliable than expected after working with it for fifteen months. Departmental leaders had greatest influence on technology acceptance during implementation and over time. Other key factors correlating with pharmacy staff acceptance included: how useful the robot was perceived to be; ease of use; and how relevant the robot was for an individual role. Higher levels of education had a negative association with usage during implementation and age was not a factor.

Medication stored in the robot was limited to 46% (n=20,771 full packs) of total pharmacy holdings (n= 45,437 full packs). At baseline, 774 orders were received in the dispensary over five days increasing by 13% to 887 in phase two ($p<0.01$). Dispensary workload increased, staff levels remained constant and pharmacy assistant movement significantly reduced ($p<0.05$). However, there were no significant changes to dispensing rates and turnaround times.

Conclusion

This study identified critical insights influencing staff acceptance of pharmacy robots that will help inform future implementation. The influence of pharmacy leaders emerged as key influence on technology acceptance. Leveraging on this influence a communication strategy prior to implementation should include information on useful functions and known benefits of the system customised for individual roles. In addition, pharmacy robotics has the potential to absorb increased workload and reduce staff movement in the dispensary when staffing levels remained constant. However, turnaround times alone are too simplistic as a sole measure of benefits for robotics in Australian public hospital pharmacy.

Statement of Originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Jane Hogan

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List of abbreviations and terms

Abbreviation	Name
ACSQHC	Australian Commission on Safety and Quality in Health Care
AHPRA	Australian Health Practitioner Regulation Agency
BAU	Business As Usual
BD™	Bectin, Dickinson and company
eMM	Electronic Medicines Management
ETAM	Extended Technology Acceptance Model
Flow	Pharmacy assistant position within the Pharmacy department that picks stock prior to dispensing, prioritises workload in the Pharmacy and receives phone calls
GCHHS	Gold Coast Hospital and Health Service
GCUH	Gold Coast University Hospital
HHS	Hospital and Health Service
HIT	Health Information Technology
i/p/h	Items per person per hour
IA	Inventory Assistant
Imprest	An inventory of drugs obtained for use at a hospital or issued for treatment of the hospitals patients (1)
IT	Information Technology
LAM	List of Approved Medication
NHS	National Health Service
PA	Pharmacy Assistant
PBS	Pharmaceutical Benefits Scheme
PDE	Portable Data Entry
PICF	Participant Information and Consent Form
PRDS	Pharmacy Robotic Dispensing System
RBH	Robina Hospital
Robot	BD Rowa™ automated dispensing robot

Rowa® Box System	Automated imprest picking system. Storage totes automatically loaded for Vmax® to supply ordered medication for imprest.
Rowa® ProLog	Automatic stock loading system. Automatically load medication into the storage unit of the Vmax®
Rowa® Vmax®	PRDS medication storage unit with input and output controls
Support staff	Non-pharmacist, pharmacy staff working in the GCHHS Pharmacy department including pharmacy assistants, pharmacy technicians, Stores staff and administration staff
TAM	Technology Acceptance Model
WHO	World Health Organisation

Thesis organisation

Chapter 1	Provides a general introduction to the study, outlines the literature gap, aims and hypotheses of the thesis
Chapter 2	Factors influencing acceptance of robotics in hospital pharmacy: a longitudinal study using the Extended Technology Acceptance Model
Chapter 3	A time in motion study of impact of robotics on medication supply in an Australian hospital pharmacy
Chapter 4	Key findings, future direction, limitations and conclusion.

Publications included in this thesis

Peer reviewed publications

Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2020), Factors influencing acceptance of robotics in hospital pharmacy: a longitudinal study using the Extended Technology Acceptance Model. Int J Pharm Pract, 28: 483-490. https://doi.org/10.1111/ijpp.12637

Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2021), A time in motion study of impact of robotics on medication supply in an Australian hospital pharmacy. J Pharm Pract Res,51: 129-136. https://doi.org/10.1002/jppr.1708

Conference presentations

Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2018), Newlyweds: pharmacy and robots. Society of Hospital Pharmacists of Australia National Conference 24-25 November 2018, Brisbane, Australia.

Conference posters

Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2018), Where's WALL·E™: Where do robots really impact hospital Pharmacy dispensaries? Society of Hospital Pharmacists of Australia National Conference 24-25 November 2018, Brisbane, Australia.

Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2016) The challenges and triumphs of implementing a pharmacy robotic system in a hospital. Gold Coast University Hospital Research Showcase

Contribution by others to the thesis

ALL PAPERS INCLUDED ARE CO-AUTHORED

Included in this thesis are papers in *Chapters two and three* which are co-authored with other researchers. My contribution to each co-authored paper is outlined at the front of the relevant chapter.

The bibliographic details/status for these papers including all authors, are:

Chapter Two

Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2020), Factors influencing acceptance of robotics in hospital pharmacy: a longitudinal study using the Extended Technology Acceptance Model. Int J Pharm Pract, 28: 483-490. https://doi.org/10.1111/ijpp.12637

Submitted to the International Journal of Pharmacy Practice as an original research manuscript. I, the primary author, retain the right to include under Personal Use copyrights.

Chapter Three

Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2021), A time in motion study of impact of robotics on medication supply in an Australian hospital pharmacy. J Pharm Pract Res, 51: 129-136. https://doi.org/10.1002/jppr.1708

Submitted to the Journal of Pharmacy Practice and Research as an original research manuscript. I, the primary author, retain the right to include under Personal Use copyrights.

Candidate: Jane Hogan 29.06.2021

Supervisor: Associate Professor Gary Grant 29.06.2021

Supervisor: Dr Fiona Kelly 29.06.2021

Chapter 1. Introduction

This research aims to evaluate the impact of introducing a Pharmacy Robotic Dispensing System (PRDS) into an Australian tertiary public hospital pharmacy imprest and dispensary tasks and processes. Including the impact on pharmacy staff workload, productivity and turnaround times of medication supply. There is an absence of studies evaluating the impact of PRDS in Australian Hospital Pharmacies. International literature has been applied to the Australian setting that may not necessarily translate given the differing funding models, part pack management, imprest medication supply, storage limitations, and workflow models that vary from the literature

Secondly, this research aims to identify factors that influence hospital pharmacy staff acceptance of PRDS technology during “implementation” and again over time when work returned to “business as usual” (BAU). Limited information is available to guide pharmacy leaders in developing appropriate implementation strategies that maximise pharmacy staff usage and acceptance of the PRDS.

1.1 Health care costs

Globally, health care and pharmacy are experiencing increased demand to reduce costs yet increase efficiency, accuracy, and safety (2-4). Approximately half of the increase in Australian health care costs are a result of long-term health care of the elderly and this increase is expected to continue (5). Australians aged over 65 are expected to triple from 3.4 million to 9.6 million by 2050 (6). As the Australian population ages the World Health Organisation (7) reports that Australia should expect increased use of hospital and health care services in the future, including higher demands on pharmacy, prompting innovative strategies to deliver health care in the future (7).

1.2 Queensland Health Care and medication funding

Public hospitals in Queensland, Australia rely on both state and federal government funding to provide hospital services (8, 9). The dual funding of health care in Queensland is managed by each Hospital and Health Service (HHS) to maintain budgets, benchmarks, save on costs and manage revenue (9). As part of the National Medicines Policy the federal government subsidises medications via the Pharmaceutical Benefits Scheme (PBS) which outlines the formulary restrictions that a person can access medication (10). In addition, the Queensland Government utilises a state-wide formulary of medications available for use in Queensland health hospitals known as the List of Approved Medications (LAM) (11). The medications received by inpatients of public hospitals are not eligible for reimbursement by the PBS, and the HHS incurres the cost of the medication (10). In an effort to minimise expense to the hospital, Queensland Health hospitals dispense partial-pack medications, enough medication supply for the inpatient's expected duration of stay e.g. 10 tablets from a box of 30 tablets. This results in partially used boxes of medication to be manually stored and managed in the pharmacy (part-pack management). When a patient is discharged from hospital or seen as an outpatient, they are eligible for PBS reimbursement, as such are prescribed full PBS quantities if clinically appropriate for ongoing supply to have dispensed at either their local community pharmacy or hospital pharmacy (10).

1.3 Workplace pressures in pharmacy

As health care demands increase so too does the pressure on the health care workers that support and care for patients (7, 12). The Pharmacy Board of Australia (3) recommend Australian Pharmacists dispensing workloads in the range of 150-200 items per day or no more than 16 to 20 prescription items per hour (3, 13). However daily prescription numbers are reported in excess of 300 to 400 scripts per day, increasing the risk of dispensing errors and reduce pharmacist's time for patient safety services (3, 12, 14). Should workloads exceed the recommended limits, additional pharmacists, pharmacy assistants or strategies such as automation may be required (3). Utilising dispensing technologies such as PRDS are one strategy that could assist Pharmacists in maintaining a safe workloads with an ever increasing demand on medication supply (3, 15).

1.4 Pharmacy Robotic Dispensing System (PRDS)

The first pharmacy robot was developed as part of a master's program project in the 1980's, which used bar code technology to dispense medication (15). As technology advanced over time, PRDS was used extensively in community pharmacies throughout the US and Europe by 1997 (16, 17). These early PRDS were automated storage systems with greater storage capacity to replace conventional systems such as pull-out draws and shelving (17). Five years later, the Welsh Assembly Government (18) and the Audit Commission (19) advocated for pharmacies to utilise new Health Information Technologies (HIT) to improve medication safety, as a result PRDS were widely incorporated throughout many National Health Service (NHS) hospitals in the United Kingdom (18-20). The first community pharmacy to introduce PRDS in Australia occurred in 2004, and it was not until 2010 that the first PRDS was embedded in a public hospital at the Princess Alexandra Hospital, Brisbane, Queensland (21, 22). The global pharmacy robot market now extends throughout North America, Latin America, Asia Pacific, Europe, Middle East and Africa. The widespread increase of PRDS in the past decades along with the fast pace of technological advancement was not accompanied with an increase in research or documentation (23, 24).

Volpe *et al.* (15) states that pharmacy *robotic* technology has continued to evolve into key categories: a) Large, "robotic arm" PRDS that store and dispense medication, such as the one in this study; b) robotic delivery devices that can travel through hallways, sense obstructions, enter and exit escalators to deliver medication; c) automated sterile compounding *robots* that prepare intravenous preparations such as chemotherapy (15). Currently, PRDS advancements in Australia are focused on streamlining PRDS implementation strategies plus improving PRDS integration with other HIT such as electronic prescribing, in an effort to close the loop in medication management and improve future medication safety (25).

PRDS are large machines that can store and dispense packaged medications (15). Programmed for repetitive medication distribution actions, PRDS mimic human behaviour without requiring continuous input from the operator at a speed faster than human handling (15). International experience had shown that PRDS improve pharmacy efficiencies with increased productivity, greater storage capacity, and faster turnaround time of medication supply and reduced costs (15, 17, 26-28). Automation has also been found to improve staff satisfaction, workplace experience and reduce overall stress on the staff who use them (26, 27). The benefits of PRDS are summarised in Table 1.1.

However, Boyde *et al.* (24) found the reported benefits may be favourably biased, setting overly optimistic expectations of PRDS performance [9]. Negative results and challenges associated with the implementation were potentially under reported and not well understood (24). In addition the introduction of new technology could create new, unexpected tasks and unintended problems for the pharmacy to manage such as fault resolution, support and maintenance tasks, and staff training requirements (2, 24, 27). Staff could feel their role is devalued post implementation and the additional tasks increase workplace stress (27). In addition there were new stressors related to trouble shooting problems with the robot and fewer staff in the dispensary (27). The challenges of PRDS are summarised in Table 1.1. Due to conflicting information pharmacy leaders must rely on anecdotal information and manufacturer marketing information to review and evaluate the impact of PRDS implementation (24).

The Extended Technology Acceptance Model (ETAM) had been widely used in health care settings to understand factors influencing acceptance of newly introduced technology (29-31). Not yet applied to PRDS, studies exploring user technology acceptance in health care had focussed on the period of time when users are working with and familiar with the system (32-35). Limited information is available about acceptance and use of the technology during implementation, prior to the system becoming operational (32). Few studies had explored what factors during implementation had long lasting impact on acceptance and use of systems beyond the implementation phase as users became more familiar and proficient using a system (32).

Table 1.1 Advantages and challenges of PRDS

Advantages	**Challenges**
Perform high speed repetitive functions Available 24 hours a day Remote operation Redeploy staff time Workflow efficiencies Increase accuracy Reduce dispensing errors Improve storage capacity Improve stock control Reduce picking times Increased staff satisfaction	High cost Size and weight of machine Remodelling requirements to accommodate PRDS Service and maintenance costs Unintended Consequences Technical issues Downtime planning Complexity of workflow Increased locations for stock Appropriate packaging limitations Lack of research

1.5 PRDS and hospital pharmacy

At the time of this study Queensland Health had implemented PRDS at three public hospitals in the state: the Princess Alexandra Hospital, Robina Hospital (RBH) and the Gold Coast University Hospital (GCUH). It was not known if the benefits of PRDS reported internationally was transferable to the Australian hospital pharmacy environment. Funded by both state and federal governments, public hospitals in Australia had a unique funding model and experience medication management issues not considered in other PRDS research (9). It was routine practice to supply medication to hospital inpatients via an imprest model; the systematic review and replenishment of a ward based inventory by the pharmacy (1). The pharmacy also supplies partial packs of medication to individual inpatients, discharge and outpatients e.g. 10 tablets from a box of 30 tablets. This resulted in partially used boxes of medication to be manually stored and managed in the pharmacy i.e. part pack management, which has not been evaluated in prior studies

In addition, the PRDS imposes physical limits and restrictions on total pharmacy stock holdings that could be stored within. Packaging may not be appropriately proportioned or sized and unsuitable for PRDS storage e.g. large items (36). In addition legislative restrictions prevent the storage of controlled drugs and flammable items; refrigerated items must be stored in a fridge plus pharmacy management may choose to exclude items according to operational need (1). Large limitations on stock suitable for storage in the PRDS could impact expected benefits.

1.6 GCHHS: Gold Coast Hospital and Health Service

The Gold Coast Hospital and Health Service (GCHHS) provide pharmacy services to two public hospitals and community clinical services on the Gold Coast, Queensland, Australia. The Gold Coast University Hospital (GCUH) and Robina Hospital (RBH), a 750 bed and 403 bed hospital respectively operate outpatient clinics and 24 hour emergency departments (37). Both hospitals have centrally located pharmacies that operate under a single management and considered to be one department across two sites. Staff rotate between sites based on individual preference and operational need, with one third of staff working at RBH. The RBH had already installed and were operating a PRDS eight months prior to the study. GCUH was the site of this study. Dispensaries supply mostly original full packs of medication to hospital wards (imprest), discharge and outpatient prescriptions plus small quantities of part pack medication to hospital inpatients to cover the expected duration of stay, e.g. three days.

1.7 GCUH PRDS

The PRDS was a ROWA® Vmax® with sufficient capacity to meet the needs of the expanding health service.

The PRDS installation has three key components:

1. **The Rowa**® **Box System** – provides automated bulk medication supply into totes ready for delivery, use for imprest medication supply. Figure 1.1 PRDS: Rowa® Box System;
2. **Rowa**® **Vmax**® – the largest part of the system which store and retrieve packs of medications. GCUH has two Vmax storage units. Figure 1.2 PRDS: inside Rowa® Vmax; and
3. **Rowa**® **ProLog**– this component allows the system to automatically load the stock into the Rowa Vmax®. The user places stock onto the conveyor belt and the autoloader sorts, identifies and inputs the stock. Figure 1.3 PRDS: Rowa® ProLog.

Figure 1.1 PRDS: Rowa® Box System

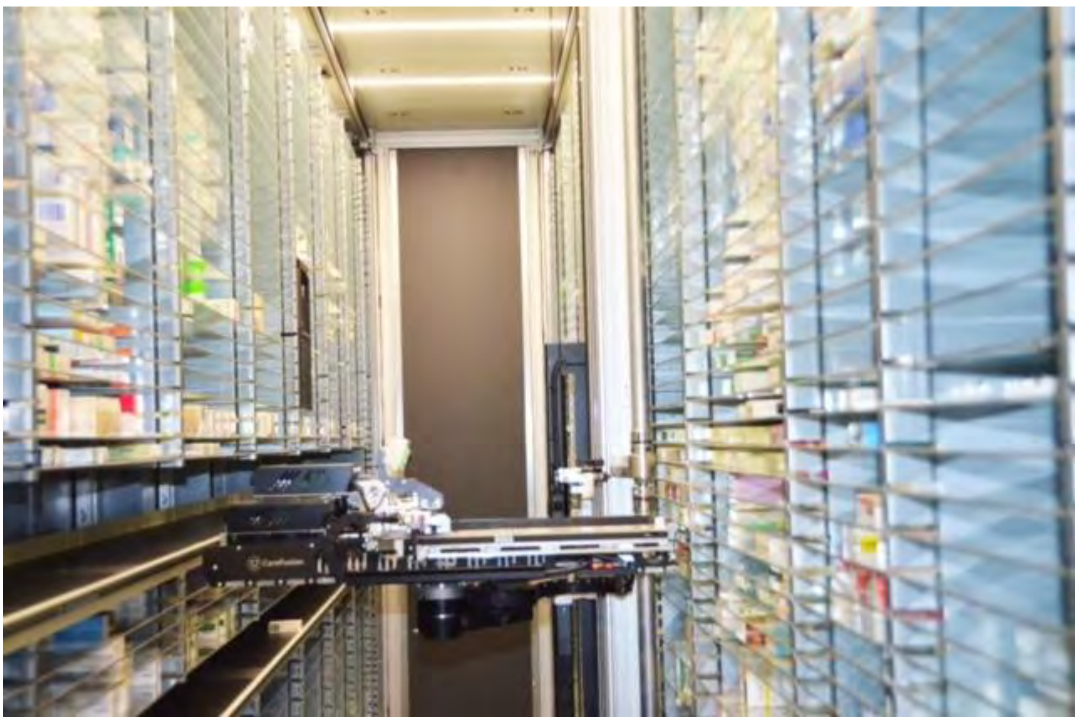

Figure 1.2 PRDS: inside Rowa® Vmax®

Figure 1.3 PRDS: Rowa® ProLog

1.8 Research aims and objectives

1.8.1 Hypothesis

The addition of a PRDS in an Australian public hospital pharmacy will improve pharmacy turnaround times, productivity and processes.

1.8.2 Aims

The primary aim of this research is to evaluate the impact of introducing a pharmacy robotic dispensing system into an Australian tertiary public hospital pharmacy imprest and dispensary tasks and processes. Including the impact on pharmacy staff workload, productivity and medication supply turnaround times.

Secondly this research aims to identify factors that influence hospital pharmacy staff acceptance of PRDS technology during “implementation” and again over time when work returned to “business as usual” (BAU).

1.8.3 Objectives

The objectives of the research are as follows:

1. Evaluate the impact of introducing a PRDS into an Australian tertiary public hospital pharmacy imprest and dispensary tasks and processes.
    a) Dispensary order turnaround times: Measured by observing the time taken to dispense various orders in the dispensary including time orders wait for dispensing action to occur, time taken to process, overall turnaround time plus time taken to label and assemble items.
    b) Imprest supply turnaround times: Measured by recording the time taken to perform imprest medication supply activities ready for delivery to clinical areas. Including total turnaround times, time spent waiting for picking to occur, and time taken to pick an imprest order.
    c) Dispensing productivity: Measured by comparing the average workload output of ‘item per person per hour’ with and without the

PRDS in the pharmacy compared to professional workload standards.

d) Pharmacy staff movement: Measured by electronically tracking dispensary-based pharmacy assistant steps per day in both phases.

2. Identify factors that influence hospital pharmacy staff acceptance of PRDS
    a) Measured by surveying hospital pharmacy staff attitudes and perceptions of PRDS and what influences their usage.

1.9 Ethics statement

The project received ethics approval from the Gold Coast Hospital and Health Service Human Research Ethics Committee (ethics application HREC/16/QGC/66, approved 27 April 2016) and Gold Coast Hospital and Health Service Human Research Ethics Committee (ethics application HREC/17/QGC/18, approved 19 April 2017).

Chapter 2. Factors influencing acceptance of robotics in hospital pharmacy: a longitudinal study using the Extended Technology Acceptance Model

2.1 Statement of contribution to co-authored published paper

This chapter includes a co-authored paper. Article accepted 16 April 2020 to International Journal of Pharmacy Practice

Citation: Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2020), Factors influencing acceptance of robotics in hospital pharmacy: a longitudinal study using the Extended Technology Acceptance Model. Int J Pharm Pract, 28: 483-490. https://doi.org/10.1111/ijpp.12637

Professor of Biostatics Robert Ware also provided advice, identifying the most appropriate statistical analysis for the data collected.

My contribution to the paper involved:

- Concept and design of study (80%)
- Designed data collection tool (80%)
- Designed database (100%)
- Data collection and entry (100%)
- Data analysis and interpretation of results (80%)
- Drafted paper (100%)
- Finalised manuscript (100%)

Candidate: Jane Hogan 29.06.2021

29.06.2021

Supervisor: Associate Professor Gary Grant (Corresponding author)

Supervisor: Dr Fiona Kelly 29.06.2021

2.2 Abstract

Objectives

To explore factors influencing hospital pharmacy staff acceptance of a pharmacy robotic dispensing system during implementation and over time.

Methods

A single centred, prospective, longitudinal cohort quantitative study was conducted in an Australian tertiary public hospital using the Extended Technology Acceptance Model (ETAM). Staff were surveyed during the implementation of a pharmacy dispensing robot (May 2016) and again after working with the system for fifteen months (August 2017). Fishers exact test and correlation analysis of paired responses were used to identify significant factors influencing use of the system between the two time points.

Key findings

Sixty four respondents completed surveys during implementation (n=64) and 34-paired surveys were collected fifteen months later. Respondents were predominantly young, female with a tertiary qualification. Initial perceptions did not change over time, with the exception of reliability. Departmental leaders had greatest influence on technology acceptance during implementation and over time. Other key factors correlating with acceptance included: how useful the robot was perceived to be; ease of use and how relevant the robot was for an individual role. Higher levels of education had a negative association with usage during implementation and age was not a factor.

Conclusion

This study identified critical insights influencing staff acceptance of pharmacy robots that will help inform future implementation. The influence of pharmacy leaders emerged as key influence on technology acceptance. Leveraging on this influence a communication strategy prior to implementation should include information on useful functions and known benefits of the system customised for individual roles.

Keywords

Robot, Pharmacy, Hospital, dispensing

2.3 Introduction

Globally, health care and pharmacy are experiencing increased demand to reduce costs yet increase efficiency, accuracy and safety (2-4). Automation tools such as pharmacy robot dispensing systems (PRDS) are one strategy used to improve medication management efficiencies (26, 38). PRDS are large, automated robotic machines in pharmacies that store and dispense packaged medications (15). Programmed for repetitive medication distribution actions, PRDS mimic human behaviour without requiring continuous input from the operator at a speed faster than human handling (2, 15).

Widely implemented in pharmacies globally, PRDS have been reported to result in pharmacy efficiencies. PRDS increase the storage capacity of the pharmacy, improve turnaround time of medication supply and reduce costs (15, 17, 26, 27). Automation has also been found to improve staff satisfaction, workplace experience and reduce overall stress on the staff who use them (26, 27) .

Boyde *et al* (24) challenge the reported benefits, suggesting the available literature may be favourably biased, setting overly optimistic expectations of PRDS performance (24). Negative results and challenges associated with the implementation are potentially under reported and not well- understood (24). The introduction of new technology can create new, unexpected tasks and problems for the pharmacy to manage such as fault resolution, support and maintenance tasks, and staff training requirements (2, 24, 27). Staff can feel their role is devalued postimplementation and the additional tasks increase workplace stress (27). Due to conflicting information, pharmacy leaders must rely on anecdotal information and manufacturer marketing information to review and evaluate the impact of PRDS implementation (24).

The Extended Technology Acceptance Model (ETAM) has been widely used in health care settings to understand factors influencing acceptance of newly introduced technology (29-31). Not yet applied to PRDS, studies exploring user technology acceptance in health care have focussed on the period of time when users are working with and familiar with the system (32, 35). Limited information is available about acceptance and use of the technology during implementation, prior to the system becoming operational (32). Few studies have explored what factors during implementation have long-lasting impact on acceptance and use of systems beyond the implementation phase as users become more familiar and proficient using a system (32).

Two major ETAM factors that influence an individual's intention to use technology are (i) *Perceived ease of use* – extent to which a person believes that using the system will be free of effort; and (ii) *perceived usefulness* – extent to which a person believes that using the system will enhance his or her job performance (29, 30, 34). *Intention to use* is defined by Wu *et al* (39) as the '*individuals interest in using the system for future work'* (30, 39).

The ETAM tool can also identify the influence of social and cognitive factors impacting *perceived usefulness* such as *subjective norm* (the effect of people in a position of influence e.g. departmental leaders (30, 31, 33, 37, 40), *job relevance* (how applicable the system is to the user's role and helping to get the job done (30, 33) and *results demonstrability* (30, 32, 33) how a user understands the benefits of the system (30, 33, 40).

This study aimed to explore factors influencing hospital pharmacy staff acceptance of PRDS technology during 'implementation' and again when work had returned to 'business as usual' (BAU). It also aimed to explore factors during implementation that had a sustained impact on technology acceptance during BAU.

2.4 Method

2.4.1 Design

A single centred, prospective, longitudinal cohort quantitative study was conducted at a tertiary public hospital pharmacy in Queensland, Australia.

2.4.2 Setting

The Gold Coast Hospital and Health Service (GCHHS) provides a pharmacy service to two public hospitals on the Gold Coast. Gold Coast

University Hospital (GCUH) and Robina Hospital (RBH), a 750 bed and 403-bed hospital, respectively, operate outpatient clinics and 24-hour emergency departments (37). Both hospitals have centrally located pharmacies that operate under a single management and are considered to be one department across two sites. Staff rotate between sites based on individual preference and operational need, with one-third of staff working at RBH. The RBH had already installed and were operating a PRDS eight months prior to the study. GCUH was the site of this study.

The GCHHS pharmacy was supported by 131 staff across both hospital sites including 83 pharmacists, five Intern pharmacists, and 43 support staff consisting of pharmacy assistants (n=33), stores staff (n=5) and administration officers (n=5). The GCUH PRDS was a Becton Dickinson (BD) Rowa Vmax tandem with Prolog autoloader and Box system integrated with iPharmacy dispensing system. The dispensary was manned by three to four pharmacists, and a minimum of four support staff at any one time which is rotated among staff during both time points.

The management team supported PRDS operator training, releasing staff from daily duties via a rostering system and communicating an expectation of attendance in meetings and email. Staff were also rostered at RBH for short periods to gain basic training and experience with the PRDS which was operational for eight months prior to the GCUH PRDS

2.4.3 Data collection and analysis

The ETAM survey was adapted to the PRDS and circulated to hospital pharmacy staff at two time points, preimplementation 11th–17th May 2016 (Implementation phase) and postimplementation 14th–18th August 2017 (BAU phase). The study explored individual perceptions of the PRDS and changes over time using paired data.

The ETAM survey used by Venkatesh and Davies (30) was adapted to PRDS use in this context. The ETAM survey was circulated to two clinical and two non-clinical staff to test face and content validity resulting in minor changes to the wording, replaced the terminology of 'results demonstrability' with ‘usefulness assessment’ and the addition of 14 operational questions on the request of the senior manager (41, 42). The final survey consisted of a demographics section comprising age, gender, education level and operational questions; and 41 statements across ten domains of the ETAM. Each statement sought participant agreement along a five-point Likert scale rating (1, strongly agree, to 5, strongly disagree) with a neutral point as used by Dasgupta *et al.* (33) (see Appendix 10 and Appendix 11). The operational questions were included to meet site needs at the time and have not been included in reporting. Participants were not asked for their individual position to ensure anonymity and maximise participation. A self-nominated code was used to pair data and maintain confidentiality.

The sample comprised 91 staff. Staff on extended leave or not employed at either hospital at baseline data collection were excluded (n=40). Staff that participated in the implementation phase were subsequently invited to participate in the BAU phase. The survey was circulated at two time points: preimplementation 11th–17th May 2016 (Implementation phase) and postimplementation 14th– 18th August 2017 (BAU phase). Only staff that participated at implementation were eligible to participate in the BAU phase, the survey was promoted to all staff to maintain anonymity.

After presentation of research to staff, the survey was circulated to participants via pharmacy staff email and as hard copies of the survey if they preferred this format (see Appendix 10 and Appendix 11). Hard copies were available at a central point accessible for self-selection and were returned via sealed box at both RBH and GCUH over two weeks. Reminders were sent via email containing a link to the survey. The *implementation phase* was conducted when daily pharmacy operations did not include the use of PRDS. The PRDS was under construction in the pharmacy but not in use at GCUH. Most staff had received experiential operator training ready to use the PRDS in the near future. Guided by prior studies, the *BAU phase* was conducted after working with the PRDS for fifteen months, and workflow changes had been implemented to accommodate the new automation (27, 32). The tool was used to identify factors influencing acceptance during implementation that have a sustained influence over time which will be referred to as the *sustained impact*.

2.4.4 Data management and analysis

Responses were coded in SPSS v24 (43), and analysis of ordinal data limited to demographic and ETAM questions, excluding additional operational questions. If reliability tests revealed Cronbach α less than 0.7, analysis was limited to the least ambiguous question. Descriptive analyses, Fishers exact test, Spearman's rank correlation coefficient and McNemars test were used to explore significant correlations in each phase and between the two time points. Data analysis was informed by prior research. Ethics approval was granted for both phases: implementation HREC/16/QGC/66 and BAU HREC/17/QGC/18.

2.5 Results

2.5.1 Response rate and demography

A total of 64 surveys were returned during the implementation phase providing a response rate of 70% (n=91). In the BAU phase, 34 surveys were completed (53%; 34/64).

Participants were predominantly young, female and held a tertiary qualification (Table 2.1). During implementation, two-thirds of the participants (n=42) had received training on the functions of the robot and a similar proportion (n=43) had worked with a pharmacy robot elsewhere. A significant number of staff who had received PRDS training had also previously worked at RBH during the implementation phase (Fishers exact test $p<0.001$, n=39).

Table 2.1 Demographic characteristics of GCHHS pharmacy staff participating study during implementation and business as usual (BAU)

Phase	Implementation (n=64)	BAU (n=34)
Characteristics	n (%)	n (%)
Age (years)		
<35	40 (62.5)	22 (64.7)
35–54	19 (29.7)	12 (35.3)
55+	5 (7.8)	0 (0)
Gender		
Female	51 (79.7)	27 (79.4)
Education		
Completed secondary schooling	3 (4.7)	1 (2.9)
Tertiary diploma	14 (21.9)	3 (8.8)
Bachelor or above	47 (73.4)	30 (88.2)
Prior experience with robot	43 (67.2)	NA
Received basic robot training	42 (65.6)	NA
Worked at RBH since August 2015	42 (65.6)	NA

2.5.2 Staff perceptions over time

All observed changes between the implementation phase and BAU were analysed using McNemars. No significant difference in perceptions was observed over this time period ($p > 0.05$) with the exception of reliability ($p < 0.01$, $n = 33$). Staff perceived the system output quality was reliable during implementation yet confidence significantly declined during BAU.

2.5.3 Factors influencing intention to use

At the implementation stage *intention to use* was positively influenced by *perceived ease of use*, *perceived usefulness*, *job relevance* and *subjective norm*, with moderate correlation reported (r= 0.38 to 0.58, p<0.05). At BAU, there was continued association with all of these factors, more with *perceived usefulness* (r=0.64, p<0.01) than *job relevance* (r = 0.63, p<0.01), *ease of use* (r = 0.51, p<0.01) or *subjective norm* (0.37, p<0.05) (see Table 2.2).

The potential influence of age and education was explored, during implementation *higher education* showed a low negative correlation *with intention to use* (r = -0.25, p<0.05) which was not sustained at BAU. Age was not a significant factor and there was a low negative correlation between *education* and *job relevance* during implementation (r= -0.31, p<0.05).

Table 2.2 Spearman´s rank correlation coefficient of factors influencing intention to use PRDS during implementation and business as usual (BAU)

	Implementation n=64			BAU n=33		Impact over time n=34
	Q1	Q2		Q1	Q2	Q1
Demographics			Demographics			
Age	0.22	0.18	Age	0.40*	0.17	0.39*
Gender	0.10	0.03	Gender	0.33	0.16	0.44*
Education	0.14	0.25*	Education	0.07	0.16	0.26
Perceived usefulness			Perceived usefulness			
Using the robot will improve my job performance	0.47**	0.49**	Using the robot improves my performance in my job	064**	0.28	0.22
Using the robot will increase my productivity	0.44**	0.48**	Using the robot in my job increases my productivity	0.33	0.17	0.39*
Using the robot would enhance my efficiency	0.38**	0.39**	Using the robot has increased my efficiency in my job	0.46*	0.22	0.19
The robot will be a useful addition to my job	0.48**	0.51**	The robot has been a useful addition to my job	0.35*	0.28	0.17
Perceived ease of use			Perceived ease of use			
How I will interact with the robot is clear and understandable	0.24	0.17	I clearly understand how to interact with and use the robot	0.58**	0.54**	018
I think the robot will be easy to use	0.33**	0.29*	I think the robot is difficult to use	0.48**	0.42*	0.15
Learning to use the robot will be easy for me	0.44**	0.36**	Interacting with the robot requires a lot of mental effort	0.51**	0.07	0.18
It will be easy for me to become skilled at using the robot	0.18	0.10	I find it easy to get the robot to do what I want it to do	0.35*	0.09	0.34
Subjective norm			Subjective norm			
People who are important to me think I should use the robot	0.58**	0.52**	People who are important to me think I should use the robot	0.37*	0.42*	0.37*
People at work that influence my behaviour think I will like the robot	0.51**	0.45**	People at work that influence my behaviour think I will like the robot	0.30	0.05	0.43*
Job relevance			Job relevance			
Using the robot will be important for my job	0.54**	0.57**	Using the robot is important for my job	0.39*	0.63**	0.23
Using the robot is relevant to my job	0.53**	0.55**	Using the robot is relevant to my job	0.50**	0.44**	0.08

Question one (Q1) = Assuming I have access to the robot I intend to use it.

Question two (Q2) = I predict I will use the robot (Implementation), I use the robot frequently (BAU).

*p<0.05.

**p<0.01.

***p<0.001.

2.5.4 Factors influencing perceived usefulness

At the implementation stage factors that significantly influenced *perceived usefulness* included a moderate correlation with *subjective norm* (r= 0.39 to 0.55, p<0.01), and *job relevance* (r= 0.40 to 0.65, p<0.01), and low correlation with *usefulness assessment* (results demonstrability) (r= 0.26 to 0.46, p<0.05) (**Table 2.3**). These correlations were strengthened at BAU for *usefulness assessment* (results demonstrability) (r = 0.44 to 0.75, p<0.05), maintained for *subjective norm* (r = 0.37 to 0.62, p<0.05), and weakened for *job relevance* (r= 0.37 to 0.57, p<0.05) with non-significant values reported for this factor. The sustained impact of usefulness assessment (results demonstrability) during implementation on *perceived usefulness* during BAU also showed moderate positive correlations (r = 0.4 to 0.62, p<0.05). However, *subjective norm* had the strongest overall influence on *perceived usefulness* during BAU.

Table 2.3 Spearman´s rank correlation coefficient of factors influencing perceived usefulness during implementation and business as usual (BAU)

	Q1			Q2			Q3			Q4		
	Implementation	BAU	Sustained impact	Implementation	BAU	Sustained impact	Implementation	BAU	Sustained impact	Implementation	BAU	Sustained impact
Subjective norm												
People who are important to me think I should use the robot	0.39**	0.44*	0.13	0.50**	0.38*	0.39*	0.49**	0.55**	0.19*	0.46**	0.42*	0.38*
People at work that influence my behaviour think I will like the robot	0.37**	0.43*	0.27	0.47**	0.40*	0.37*	0.49**	0.62**	0.26	0.38**	0.52**	0.36*
Job relevance												
Using the robot will be important for my job	0.55**	0.37*	0.18	0.64**	0.30	0.39*	0.64**	0.40*	0.36*	0.65**	0.30	0.29
Using the robot is relevant to my job	0.4**	0.57**	0.16	0.53**	0.42*	0.26	0.57**	0.53**	0.23	0.54**	0.28	0.39*
Usefulness assessment (results demonstrability)												
I have no difficulty telling others about the benefits of using/having a robot in the Pharmacy	0.18	0.60**	0.27	0.42**	0.68**	0.62**	0.28*	0.68**	0.40*	0.29*	0.67**	0.33
The benefits of the robot are clear to me	0.26*	0.44*	0.28	0.46**	0.64**	0.56**	0.38**	0.54**	0.53**	0.40**	0.75**	0.48**

Factors with lower significance and smaller changes over time were not included in the table: Image, Voluntariness, attitude, output quality.
Question one (Q1) = Using the robot will improve my job performance (Implementation), Using the robot improves my performance in my job (BAU).
Question two (Q2) = Using the robot will increase my productivity (Implementation), Using the robot in my job increases my productivity (BAU).
Question three (Q3) = Using the robot would enhance my efficiency (Implementation), Using the robot has increased my efficiency in my job (BAU).
Question four (Q4) = The robot will be a useful addition to my job (Implementation), The robot has been a useful addition to my job (BAU).
*p<0.05.
**p<0.01.
***p<0.001.

2.6 Discussion

Key factors influencing hospital pharmacy staff acceptance of significant new technology (i.e. PRDS) were highlighted in this prospective longitudinal study using a theoretically informed framework (ETAM). It is of note that the significant influence of the pharmacy management team and the factors *perceived usefulness* and *subjective norm* were sustained over time. Other factors of influence at BAU included *perceived ease of use*, and *job relevance* yet age of staff did not demonstrate any influence.

This study reflects a novel longitudinal approach to assessing technology in a pharmacy setting using a theoretically informed framework. Prior studies have restricted focus to immediately after the system is implemented and operational (30, 32, 33), whilst this study explored factors influencing acceptance of PRDS and unique insight into associated changes over two time points. Other key strengths include the use of paired, anonymous survey data pre and postimplementation, and a high initial response rate (70%). Strategies used to achieve this included limiting length of survey, introducing the research to staff in person, support from management and allocating work time to complete it (44-46). However, use of anonymous paired data also limited eligible participants postimplementation and study findings do not reflect the views of all staff, particularly staff aged 55 years or older and the finding of age not having influence would require further confirmation. This was compounded by recreational and sick leave during winter. Other limitations include study setting of a single hospital and robot type; timing of data collection; and distribution age of participants during BAU.

The BAU survey did not meet the ideal minimum for *intention to use*, *output quality, usefulness assessment* (results demonstrability) or *subjective norm* which may reflect question clarity and results should be interpreted with caution. This was mitigated by limiting analysis to one of the two ETAM questions used to measure *intention to use*. The least ambiguous question ‘assuming I have access to the robot I intend to use it’ was used as a key measure of technology acceptance.

2.6.1 Staff perceptions over time

Initial staff perceptions towards the PRDS did not change over time. Staff perceptions of the PRDS immediately prior to live operation remained consistent after 15 months of working with the technology. This highlights the importance of positively influencing staff early in the implementation phase as attitudes are unlikely to change.

2.6.2 Factors influencing intention to use

Identification of *perceived usefulness* and *subjective norm* as key factors influencing staff *intention to use* the PRDS is consistent with prior literature (29-31, 39). Participants are driven to use the system based on the social influence of leaders and by how useful and relevant the system is to their role (30, 39). This is supported by the study finding of sustained influence of leaders on intended usage from implementation to BAU. These insights highlight the importance of pharmacy leaders developing a united communication strategy prior to implementing a PRDS that will have long-lasting influence on staff acceptance. Communications should include tailored information about the benefits of the PRDS and how it will impact individual roles.

Pharmacy staff with a tertiary education mistakenly perceived PRDS would not be relevant to their role and underestimated expected use. This perception was held despite two thirds of participants reported to have received training and/or worked with a PRDS elsewhere prior to implementation. During BAU perceptions changed, education levels did not influence intended usage or perceived relevance to role.

Perceived ease of use had the greatest sustained impact on technology acceptance over time. Concurrently, user confidence in PRDS reliability declined during BAU, which may reflect operational system issues experienced at the time of data collection. Davies (29) explains that users are willing to cope with some difficulty when using a new system, so long as it provides a useful and relevant benefit (29). Increased usage and familiarity over time, could have resulted in participants becoming more positive (32). In addition, the influence of leaders declined over time as participants gained experience with the system. Participants relied less on social influences and continued to judge the system based on how easy and reliable it is to use.

2.6.3 Factors influencing perceived usefulness

Consistent with prior literature, the study showed that if an individual perceived the PRDS to be relevant to their role this influenced how useful they perceived the system to be and ultimately their intention to use it (30, 33). This study further revealed the influence was strongest during implementation and weakened over time. Leaders should consider customising information about how the PRDS will impact specific roles to have a greatest influence on perceived usefulness and usage, especially during implementation. Strategic communication postimplementation highlighting the benefits of PRDS and achievement of and/or relevance to specific roles as a result of PRDS may support this further.

Staff knowledge of the benefits of a system influenced how useful the PRDS was perceived to be and ultimately their intention to use the system (33). This relationship was strongest after working with the PRDS during BAU, probably because staff had a better understanding of the benefits of the PRDS (33).

Insights into key drivers of staff acceptance of significant new technology can effectively inform strategies to implement future pharmacy technology, both PRDS and beyond. This becomes increasingly critical as technology rapidly evolves, yet human resources may remain stagnant, and a strategic approach is essential to maintaining relevance. The evidence of drivers provided here can be integrated into change management plans for other sites introducing PRDS or other technology and tested to determine whether drivers remain consistent. The study has also successfully implemented a theoretically informed framework of technology acceptance that can be used to inform an evidence driven approach to future advancement.

2.7 Conclusion

Study findings provide critical insights that could inform future PRDS implementation. It is apparent that a clear and planned communication strategy from pharmacy management is key to effective implementation, particularly if it includes core messages about usefulness and benefits at and beyond initial implementation. Leaders should also tailor messages to different roles and target pharmacists who underestimate their use of the PRDS and have potential influence on other staff members.

Chapter 3. A time in motion study of impact of robotics on medication supply in an Australian hospital pharmacy

3.1 Statement of contribution to co-authored published paper

This chapter includes a co-authored paper.

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Citation: Hogan, J., Grant, G., Kelly, F. and O'Hare, J. (2021), A time in motion study of impact of robotics on medication supply in an Australian hospital pharmacy. J Pharm Pract Res, 51: 129-136. https://doi.org/10.1002/jppr.1708

My contribution to the paper involved:

- Concept and design of study (80%)
- Designed data collection tool (80%)
- Designed database (100%)
- Data collection and entry (100%)
- Data analysis and interpretation of results (80%)
- Drafted paper (100%)
- Finalised manuscript (100%)

Candidate: Jane Hogan 29.06.2021

Supervisor: Associate Professor Gary Grant* 29.06.2021

Supervisor: Dr Fiona Kelly 29.06.2021

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3.2 Abstract

Background

Pharmacy robotics have been implemented globally to create medication management efficiencies. However, translation to the Australian public hospital environment has not been evaluated.

Aim

To evaluate the impact of introducing robotics in an Australian public hospital on pharmacy imprest and dispensary tasks.

Method

A single centred, prospective, longitudinal time in motion study was conducted in an Australian tertiary public hospital using mixed methods during robot implementation (Phase 1, May 2016) and fifteen months later (Phase 2, August 2017). Time stamped video footage of dispensary activities was collected, observed and analysed; Fitbit Zip® anonymously tracked pharmacy assistant movement. Dispensing software (iPharmacy ®) provided the location of stocked medication and electronic tracking databases provided imprest turnaround times. Ethics approval: HREC/16/QGC/66, HREC/17/QGC/18.

Results

Medication stored in the robot was limited to 46% (n=20,771 full packs) of total pharmacy holdings (n= 45,437 full packs). At baseline, 774 orders were received in the dispensary over five days increasing by 13% to 887 in phase two ($p<0.01$). Dispensary workload increased, staff levels remained constant and movement was reduced. However, there were no significant changes to dispensing rates and turnaround times.

Conclusion

Pharmacy robotics has the potential to absorb increased workload and reduce staff movement in the dispensary when staffing levels remained constant. However, turnaround times alone are too simplistic as a sole measure of benefits for robotics in Australian public hospital pharmacy.

Key words: Pharmacy; Hospital; Dispensing; Utilisation Evaluation; E-health

Ethics statement

The project received ethics approval from the Gold Coast Hospital and Health Service Human Research Ethics Committee (ethics application HREC/16/QGC/66, approved 27 April 2016) and Gold Coast Hospital and Health Service Human Research Ethics Committee (ethics application HREC/17/QGC/18, approved 19 April 2017).

3.3 Introduction

Pharmacy Robotic Dispensing Systems (PRDS) are widely used globally to improve medication management efficiencies (26, 38). Pharmacy Robotic Dispensing Systems are large, automated robotic machines that store and dispense packaged medications (15). International experience has shown that PRDS improve productivity, increase storage capacity and improve turnaround time of medication supply (15, 17, 26-28).

The Pharmacy Board of Australia recommend a maximum dispensing rate of 16 to 20 prescription items per hour per pharmacist (3, 13). Should workloads exceed these limits, additional pharmacists, pharmacy assistants (PA) or strategies such as automation may be required (3). Automation has been found to improve dispensing efficiency by absorbing increased workloads, reduce staff and significantly increase the number of items processed per person per hour (20, 47).

However, studies are scarce with conflicting results and reported benefits are overly biased, with positive outcomes widely published and negative results under reported (24, 47). The introduction of new technology is known to create new tasks and unintended problems for the pharmacy to manage such as fault resolution, maintenance and continued staff training (2, 24, 27). Automation also increases the complexity of the dispensing process and ideal workflow changes are not well understood in the literature (24, 48).

Further, it is not known if the benefits of PRDS reported internationally translates to the Australian hospital pharmacy environment that experience medication management issues not considered in other PRDS research (9). Medication is routinely supplied to hospital inpatients via an imprest model; the systematic review and replenishment of a ward-based inventory by the pharmacy (1). The pharmacy also dispenses partial packs of medication to individual patients e.g. 10 tablets from a box of 30. This requires part pack management and storage in the pharmacy, which has not been evaluated in prior studies. In addition, items may be unsuitable for storage in PRDS due to packaging shape or legislative restrictions e.g. controlled drugs and flammable items. Pharmacy management may also choose to exclude items according to operational need (1, 36).

This study aimed to evaluate the impact of introducing PRDS in an Australian tertiary public hospital pharmacy on imprest and dispensary tasks.

3.4 Method

3.4.1 Design

A single centred, prospective longitudinal time in motion study was conducted at a tertiary public hospital pharmacy in Queensland, Australia.

3.4.2 Setting and participants

The Gold Coast Hospital and Health Service (GCHHS) provide pharmacy services to two public hospitals and community clinical services on the Gold Coast. The Gold Coast University Hospital (GCUH) is a 750 bed public tertiary hospital operating outpatient clinics and a 24 hour emergency department (37). It has a centrally located pharmacy dispensary, supplying mostly original packs of medication to hospital wards and by dispensed prescription plus small quantities of part pack medication to hospital inpatients to cover the expected duration of stay, e.g. three days. All forms of medication supply requests managed within the pharmacy dispensary will be referred to as *orders*.

Participants included the 121 GCHHS pharmacy staff potentially fulfilling dispensary or imprest duties, 83 pharmacists, five intern pharmacists, and 33 PA's. The study excluded participants on extended leave, not working at GCUH at the time of the study, or not involved these duties. The GCUH PRDS was a Becton Dickinson (BD) Rowa® Vmax tandem with Prolog® autoloader and Box system® integrated with iPharmacy® dispensing system.

3.4.2.1 Imprest

PA's order medication to replenish hospital ward stock on rostered days, up to three times a week. PA's attend multiple allocated clinical wards at the beginning of the working day to order imprest medication via Portable Data Entry (PDE) device, which is then uploaded into dispensing software. Orders are printed and placed in a queue to be actioned by the Inventory Assistant (IA). The IA is a pharmacy assistant, who manually picks medications for imprest orders. An electronic tracking database is used by staff to track the progress and location of imprest orders.

3.4.2.2 Dispensary

The dispensary receives medication supply requests two ways: via written order received in the pharmacy e.g. prescription; or by remote dispensing of non-imprest inpatient medication by ward-based pharmacists. All written orders are first received and confirmed by front reception, logged in a tracking database and placed inside a coloured container, which indicates the order type and urgency to staff. Containers are moved to the dispensary for pharmacist clinical review and passed on to *Flow,* a pharmacy assistant position, who prioritises work in the dispensary for PA's to action.

Non-imprest, inpatient medication supply requests generated by ward pharmacists appear in the dispensary as printed labels at the *Flow* workstation. *Flow* groups labels by relevant ward, place in a container awaiting picking and assembly by a PA. *Flow* prioritises all orders received in the dispensary and is the starting point of the measurement for this study. *Flow* minimises disruptions to the dispensary by managing non-dispensing responsibilities such as phone calls, stock availability and *ad hoc* imprest requests, limiting *flow's* capacity to perform dispensing actions.

PA's select the next prioritised container in line and manually pick the required medication. Using dispensing software orders are processed, items labelled and assembled to pass on to the pharmacist for final accuracy and clinical check which is also the stop point of the study. The dispensary routinely maintains two four-hour shifts; morning and afternoon with a change of pharmacists and PA's at 12.30pm. PA workstation hot desks are not always manned and can be used by different staff throughout the day.

3.4.3 Data collection and analysis

Data collection adopted a multifaceted approach to capture the complexities of a hospital pharmacy dispensary via videotaping, electronic tracking, dispensing software and departmental databases.

Data was collected over ten days as two time points of five working days between 11th - 17th May 2016 (Phase 1) and the 14th – 18th August 2017 (Phase 2) informed by prior studies (23, 26, 48). Phase one was conducted pre-implementation during the physical construction of the PRDS. At Phase two the PRDS had been functional for fifteen months. Pharmacy staff were informed of study details prior to data collection including visual demonstration of footage that would be collected.

3.4.3.1 *Imprest*

Data was extracted from the time stamped, electronic tracking data base routinely used to track progress of regular and *ad hoc* imprest medication orders. Further, the IA wore an electronic tracking device (Fitbit Zip®) recording steps per day.

3.4.3.2 *Dispensary*

The design used by Lin *et al* (23) was adapted, time stamped video footage was collected from six small, movement sensitive cameras fixed to two work-stations from multiple perspectives in the dispensary. Another six cameras were affixed to three more stations however time limitations prevented inclusion. Cameras were set up one week prior to data collection periods to familiarise staff and minimise the Hawthorn effect (49). Staff not wishing to participate in the study could work at clearly marked stations free of cameras. The field of view was limited to the working bench so individuals were not identifiable, footage tracked numbered containers moving through the dispensary. Footage was observed and recorded in an electronic database by two observers. Observers attended training and followed written instructions. Regular meetings and communication ensured consistency of data. Interrater reliability was assessed by repeating a sample of measured recordings and analysed by Cronbach α.

Not previously used in this setting, electronic tracking (Fitbit Zip®) was used to triangulate key findings relating to changes in turnaround times and workload (50, 51). Four Fitbit Zip® were worn by PA's to track steps per day. Trackers did not identify individual staff and were transferred between staff during shift changes.

Based on workload analysis undertaken by Hiom *et al,* data collection was limited to the actual time staff were physically present and working at the observed station for greater accuracy evaluating productivity (items/person/hour) (28). Turnaround times greater than eight hours were excluded from the time study and productivity data was limited to one PA workstation due to the varied responsibilities of *Flow*.

All data was entered into SPSS v26 (52). Turnaround times and workload (i/p/h), median and interquartile ranges were calculated and Mann Whitney U test to examine the relationship between phases (20, 26). Fitbit Zip® data was normally distributed, and two tail t-tests were used for analysis. Ethics approval was granted for both phases (HREC/16/QGC/66 and HREC/17/QGC/18).

3.5 Results

3.5.1 Operational impacts on workflow

All eligible participants working in the pharmacy dispensary agreed to participate (n= 72). Daily dispensary staff numbers remained constant between phases: there was no significant change to the total number of pharmacists [Phase 1: M=5.8 (SD 0.84), Phase 2: M=6.0 (SD 0.00), $p>0.05$] or PA's [Phase 1: M=7.4 (SD 0.89), Phase 2: M=7.2 (0.84), $p>0.05$] manning the dispensary. The number of PA's conducting imprest ordering duties did not change [Phase 1: M=2.6 (SD 0.55), Phase 2: M=2.0 (SD 0.71) $p>0.05$]. Only 46% (n=20,771 packs) of total GCUH pharmacy stock (n=45437 packs) was stored and managed within the PRDS.

Several workflow changes were noted in phase two. Laptops replaced PDE's for PA's to directly process imprest orders from clinical areas, which would remotely trigger PRDS to begin picking. The pharmacy-based IA manually picked 'non-robot stock' and then reconciled with robot picked medication. Staggered imprest ordering throughout the day replaced morning only imprest ordering and the number of planned ‘next day’ imprest deliveries increased (Phase 1: n=2; Phase 2: n=13). The impact of workflow changes was not specifically measured in this study.

New tasks and additional responsibilities introduced all staff include reconciling robot and non-robot picked medication and investigate the cause of omitted stock from imprest and dispensary orders create unintended consequences (24). All staff must address technical malfunctions, blockages and faults causing unintended delay and frustrations.

3.5.2 Activity tracking - Fitbit Zip®-(Steps/position/day)

IA took significantly more steps per day in phase two (Phase 1: M=6338 (SD 409); Phase 2: M=8933 (SD 1272), $p<0.01$). Fitbit® data for the IA was not recorded on the 13/5/16, the device was mistakenly removed from the site. In contrast, dispensary PA’s took significantly fewer steps each day (Phase 1: M=6137 (SD 913); Phase 2: M=4089 (SD 703), $p<0.05$). No significant change in steps per day was observed for *Flow* (Phase 1: M= 9037 (SD 1607); Phase 2: M=9067 (SD 1117)).

3.5.3 Video footage

A total of 1649 containers entered the dispensary over 10 days (Phase 1: n=774; Phase 2: n = 875), and 73% of all containers were observed waiting for dispensing action to occur (Phase 1: n=546; Phase 2: n= 657). Thirty three percent of containers were processed at the two observed dispensing stations: *Flow* (Phase 1: n=136; Phase 2: n=143) and PA (Phase 1: 128; Phase 2: n=131). Each position was observed for 9 days in total, one day of footage lost in phase two due to visual obstructions.

Total observed dispensary workload significantly increased by 13% in phase 2 (Phase 1: n=774; phase 2: n=875, $p<0.01$). Changes to the type of orders received in the dispensary include: 48% increase in urgent items (Phase 1: 167, Phase 2: 247), 4% more non-urgent orders (Phase 1: n=167, Phase 2: n=565) and 8% less discharge prescriptions (Phase 1: n=68, Phase 2: n=63). Approximately half of work received was dedicated to inpatient supply which did not significantly change over time (Phase 1: n= 367, 46.5%; Phase 2: n= 422, 53.5%). When 7.5% of results (n=123) were analysed for inter-rater reliability, Cronbach α = 1.

3.5.4 Turnaround times

3.5.4.1 *Imprest*

Impress medication supply overall median turnaround times did not significantly change (Phase 1: 1hr 21min 58sec; Phase 2: 1 hr 22min 50sec, p>0.05) as summarised in Table 3.1. The median ‘time awaiting picking to start’ reduced by 19min 16sec in phase 2 however the change was not significant (Phase 1: 1hr 8 min 20sec; Phase 2: 49min 4 sec, p>0.05). The median picking time took three times longer with the PRDS (Phase 1: 10min 29sec; Phase 2: 30min 13sec, p<0.001). The number of next day delivery imprest orders increased in phase two (Phase 1: n=2, Phase 2: n=13). No significant change in median turnaround time was observed for *ad hoc* imprest orders between phases (Phase 1: 24min; Phase 2: 17min, p>0.05).

Table 3.1 Turnaround times for imprest medication supply

		Overall turnaround				Time taken to pick stock				Time awaiting picking to start			
	Phase	Number assessed	Median turnaround time	range	Mann whitney U test	Number assessed	Median turnaround time	range	Mann whitney U test	Number assessed	Median turnaround time	range	Mann whitney U test
Imprest (Routine)	Phase 1	80	1 hour 21 min 58 sec	2 min 28 sec to 3 hours 55min 35 sec	p>0.05	82	10 min 29 sec	1 sec to 1 hr 8 min 12 sec	P<0.001	80	1 hr 8 min 20sec	6 sec to 3 hours 37 min 33 sec	P >0.05
	Phase 2	72	1 hour 22 min 50 sec	2 min 30 sec to 7 hr 19 min 34 sec		85	30min 13 sec	1 sec to 6 hr 2 min 37 sec		72	49 min 4sec	15 sec to 5 hr 58 min 51sec	
Imprest (*AdHoc*)	Phase 1	101	24 min	1 min to 3 hr 53min	p>0.05	Not assessed				Not assessed			
	Phase 2	110	17 min	1 min to 4 hr 45 min									

3.5.4.2 *Dispensary*

Table 3.2 summarises the impact of the PRDS on the turnaround times of orders through the GCUH pharmacy dispensary. Overall turnaround times consist of the sum of two parts: ‘time awaiting dispensing to start’ plus the ‘time taken to dispense'. Overall turnaround, waiting and dispensing times did not significantly change for any urgent orders. Non urgent inpatient orders took significantly longer to turnaround (Phase 1: 13min 43sec; Phase 2: 23min 25 sec, $p<0.01$) and waited twice as long to be actioned (Phase 1: 9min 58sec; Phase 2: 22min 22 sec, $p<0.001$). Discharge prescriptions were processed significantly faster in phase two (Phase 1: 24min 20sec; 13 min 47 sec, $p<0.05$), although this did not significantly improve overall turnaround times which remained constant (Phase 1: 43min 8 sec; Phase 2: 37min 6 sec, $p>0.05$). In addition, the number of 'next day' orders in the dispensary almost tripled in phase two (Phase 1: n=5, phase 2: n=13).

'Time taken to dispense' consists of three parts: picking stock, processing the order in the dispensing software, and assembling the items ready for final pharmacist check. Picking times were not specifically measured in this study as PRDS has been shown to reduce picking times for dispensing prescriptions (26, 48).The time taken to process and assemble items did not significantly change the processing time per item (Phase 1: 70 sec, n=52; Phase 2: 69 sec, n=56, $p>0.05$) and assembly time per item (Phase 1: 65 sec (n=59); Phase 2: 56 sec n=63, $p>0.05$). Figure 3.1 summarises containers excluded from analyses.

Table 3.2 Turnaround times for dispensed orders.

Order type		Overall turnaround				Time awaiting dispensing to start				Time taken to dispense			
		Number assessed	Median overall turnaround time	Interquartile range	Mann whitney U test	Number assessed	Median time awaiting action	range	Mann whitney U test	Number assessed	Median time awaiting dispensing action	Interquartile range	Mann whitney U test
Overall	Phase 1	264	14 min 22 sec	30 sec to 7 hr 24min 16 sec	p >0.05	546	10 min 5 sec	2 sec to 7 hr 13 min 47 sec	P<0.05	196	6 min 5 sec	48 sec to 1hr 21 min 51 sec	p>0.05
	Phase 2	274	16min 0sec	8 sec to 5hr 37min 29 sec		657	13 min 54 sec	2 sec to 7 hr 44min 48 sec		225	5min 43 sec	1 sec to 43 min 58sec	
URGENT	All												
	Phase1	82	11 min 22 sec	30 sec to 48min 38 sec	P >0.05	100	3 min 18 sec	6 sec to 31 min 31 sec	p>0.05	52	6 min 51 sec	1 min to 41 min 8 sec	P >0.05
	Phase 2	92	9 min 24 sec	8 sec to 48 min 25 sec		180	3 min 14 sec	3 sec to 30 min 23 sec		65	6min 32 sec	13 sec to 43 min 58 sec	
	Inpatient												
	Phase 1	15	5 min 19 sec	30 sec to 23 min 26 sec	p>0.05	18	1 min 30 sec	6 sec to 17 min 16 sec	P > 0.05	11	2 min 50 sec	1 min to 11 min 50 sec	p> 0.05
	Phase 2	25	3 min 46 sec	8 sec to 13 min 16 sec		49	1 min 51 sec	3 sec to 13 min 59 sec		17	1 min 48 sec	13 sec to 8 min 22 sec	
	Non inpatient												
	Phase 1	67	12 min 13 sec	2 min 23 sec to 48 min 38 sec	P >0.05	82	4 min 20 sec	14 sec to 31 min 31 sec	P > 0.05	41	7 min 26 sec	1min 51 sec to 41 min 8 sec	P > 0.05
	Phase 2	67	10 min 53 sec	3 min 35 sec to 48 min 25 sec		131	3 min 47 sec	17 sec to 30 min 23 sec		48	8 min 28 sec	1 min 57 sec to 43 min 58 sec	
DISCHARGE	Phase 1	22	43 min 8 sec	5 min 49 sec to 1hr 49 min 3 sec	P >0.05	36	14 min 18 sec	4 sec to 1 hr 32 min 57 sec	P > 0.05	13	24 min 20 sec	59 sec to 1 hr 4min 36 sec	P <0.05
	Phase 2	24	37min 6 sec	4 min 47 sec to 2hr 17 min 48 sec		47	22min 5 sec	1 min 15 sec to 2hr 51 min 16 sec		20	13 min 47 sec	1 min 30 sec to 38 min 22 sec	
NON-URGENT	All												
	Phase 1	160	15 min 45 sec	42 sec to 7hr 24 min 16 sec	P < 0.05	410	13 min 1 sec	2 sec to 7 hr 13min 47 sec	P< 0.001	131	4min 52 sec	48 sec to 1 hr 21min 51 sec	p>0.05
	Phase 2	158	24 min 25 sec	11 sec to 5 hr 37 min 29 sec		430	24 min 39 sec	2 sec to 7 hr 44 min 48 sec		140	4 min 43 sec	1 sec to 41 min 48 sec	
	Inpatient												
	Phase 1	120	13 min 43 sec	42 sec to 2hr 1min 55sec	P <0.01	296	9 min 58 sec	2 sec to 2 hr 19 min 8 sec	P <0.001	96	4 min 8 sec	48sec to 49 min 58 sec	p>0.05
	Phase 2	131	23 min 25 sec	11 sec to 4hr 14min 39 sec		320	22min 22 sec	2 sec to 4 hr 27 min 57 sec		106	3min 40 sec	1 sec to 28min 58 sec	

	Non inpatient												
	Phase 1	40	29 min 27 sec	1 min 54 sec to 7hr 24min 16 sec	P > 0.05	114	39 min 31 sec	4 sec to 7 hr 13 min 47 sec	P >0.05	35	8 min 29 sec	1 min 8 sec to 1 hr 21 min 51 sec	p>0.05
	Phase 2	27	43 min 30 sec	36 sec to 5 hr 37 min 29 sec		110	39 min 30 sec	5 sec to 7 hr 44 min 48 sec		34	7min 32 sec	1min 25 sec to 41min 48 sec	

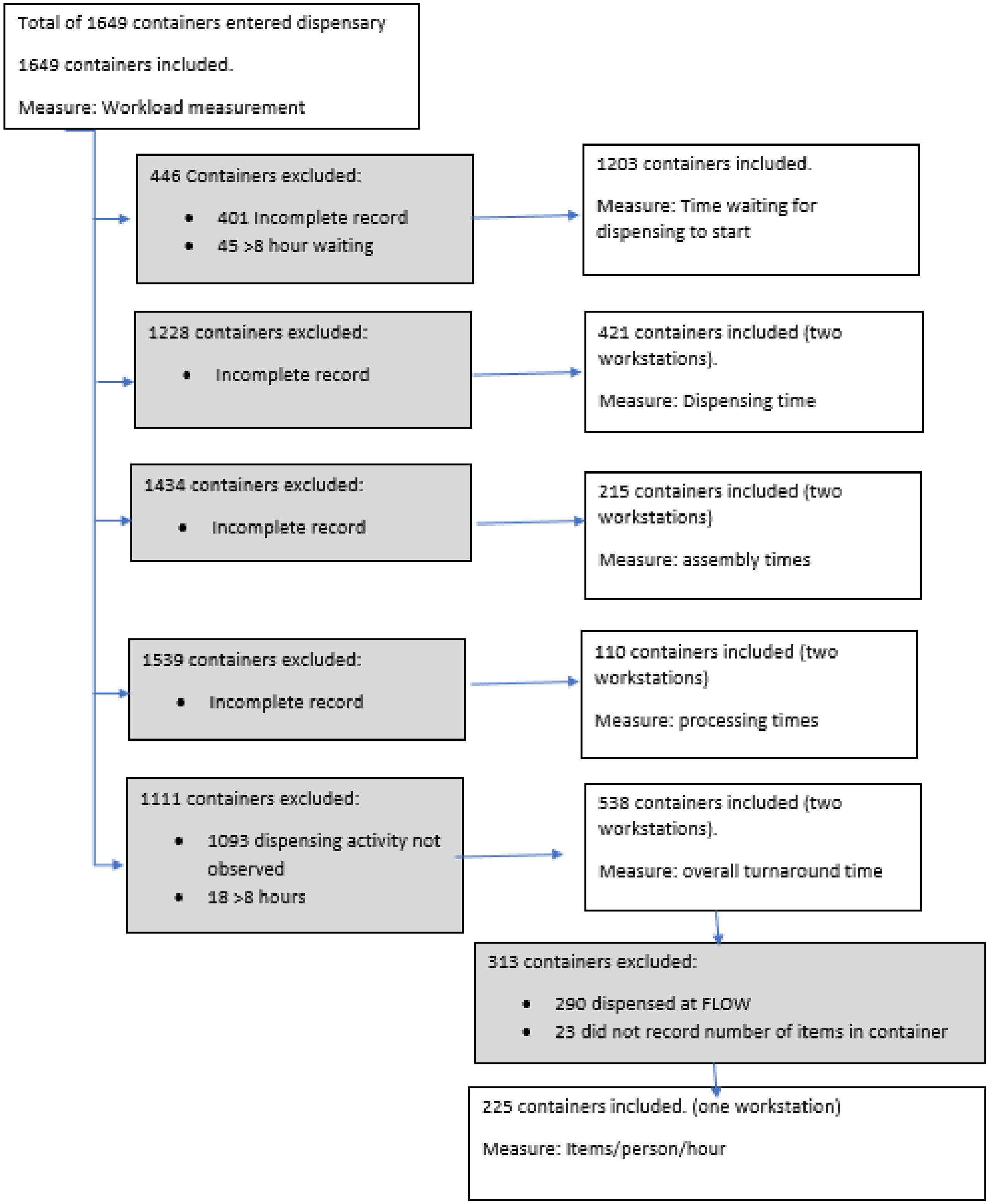

Figure 3.1 Observed video footage inclusion and exclusion criteria.

3.5.5 Productivity

Two PA positions were observed completing detailed dispensing actions: *Flow* and one PA. The PA activity was exclusively analysed for items/position/hour due to the varied responsibilities of the *flow* position. Productivity is summarised in Table 3.3, analysing actual time spent at the workstation for accurate and detailed analysis. Although mean dispensing rates (items/position/hour) decreased for inpatient dispensing and increased for non-inpatient dispensing, the results were not significant. Inpatient (Phase 1: 49.37 i/p/h; Phase 2: 46.38 i/p/h, p>0.05), non-inpatient orders (Phase 1: 24.2 i/p/h; Phase 2: 27.0 i/p/h, p>0.05).

Table 3.3 Items/position/hour (i/p/h) for a pharmacy assistant position (n=1)

	Phase	Total items dispensed	Total time observed	i/p/h Mean (SD)	t-test p value
All (n=225 containers)	Phase 1	466	18:22:01	27.91 (14.63)	p>0.05
	Phase 2	650	19:04:27	34.93 (12.07)	
Inpatient (n=99 containers)	Phase 1	188	5:00:40	49.37 (23.21)	p>0.05
	Phase 2	310	6:19:44	46.38 (19.50)	
Non inpatient (n=126 containers)	Phase 1	278	13:21:21	24.2 (15.1)	p>0.05
	Phase 2	340	12:44:43	27.0(8.38)	

3.6 Discussion

This study aimed to investigate if the benefits of PRDS reported in the literature were replicated in an Australian tertiary public hospital pharmacy. The study found an increased work volume and a greater number of urgent items were managed by the same number of staff, yet turnaround times and dispensing rates were unremarkable. Turnaround times are too simplistic as a sole measure of benefit for the complex pharmacy environment.

3.6.1 Imprest

Literature shows that PRDS picking times improve when filling prescriptions, however little is known about the impact on hospital imprest supply (26, 48). Although overall imprest turnaround times remained unchanged and picking times increased, PRDS enabled operational flexibility reflected in associated workflow changes such as remote processing, staggered imprest ordering, and increased next day deliveries. Associated times saved from increased operational flexibility were not captured in this study.

Workflow changes combined with new tasks and unintended consequences may have contributed to unremarkable turnaround times (24, 48). Additional tasks of reconciling PRDS items with manually picked stock, identifying and actioning discrepancies and fault resolution became routine tasks for imprest supply contributing to overall picking time, potentially explaining the considerable increase. The complex workflow and unintended consequences encountered from PRDS mask potential time and productivity benefits (26, 48). Findings suggest that turnaround times are too simplistic a measure when evaluating the impact of PRDS on imprest management. Efficiencies gained may relate to operational flexibility, stock control and time spent handling stock and should be further evaluated (26, 47).

3.6.2 Dispensary

Reported turnaround time benefits are conflicting or inconclusive due to the complexity of the pharmacy environment (23, 24, 26, 48, 53). Consistent with other studies, overall turnaround times, dispensing rates, labelling and assembly times were not significantly impacted by PRDS (20, 26, 28, 54). Despite this, a higher workload and an increased number of urgent items were managed by the same number of staff. The reduction in dispensary staff movement suggests staff spend less time away from the workstation to focus on dispensing. The considerable workload increase without significant time savings can be explained by the complex nature of the pharmacy environment and PRDS.

Consistent with literature, limits were imposed on items suitable for storage in the PRDS and a considerable volume of partial packs could not be managed via the PRDS (36). The significant increase in non-urgent order turnaround and waiting times may be due to the large increase in prioritised urgent items which imposed further delays. Further, delays from unintended consequences and increased complexity of dispensing steps may mask efficiencies gained (2, 24, 27, 48). Expected time savings are not achieved if turnaround times are sensitive to factors other than picking stock and are too simplistic a measure for evaluating PRDS implementation in the complex Australian hospital pharmacy (26, 36, 55).

This study provides further evidence PRDS efficiencies relate to absorbing higher workloads with a static workforce, greater workflow flexibility and improved capacity to prioritise work (20, 23, 28, 36). Multiple operational workflow changes were implemented to maximise PRDS benefits but not specifically measured in this study. Workflow redesign is key to the pharmacy maximising PRDS efficiencies and this requires thorough and ongoing evaluation (23, 48).

Strengths and limitations

Key strengths of this study include multifaceted data collection and anonymous time analysis of dispensary activities from multiple perspectives to limit the Hawthorne effect (20, 49). Key limitations include restricting analysis to activities performed at two workstations, data loss through visual obstructions and any impact of workflow changes on service delivery as these were not measured in this study. The study setting is limited to a single hospital and robot type and accuracy of self-reported tracking databases. Future studies should consider including multiple sites and types of PRDS focusing on stock handling activities and evaluation of ideal workflow redesign.

3.7 Conclusion

This study revealed significant insights that could inform future PRDS implementation in Australian public hospital pharmacies. Turnaround times and dispensing rates did not change yet more work was done with the same number of staff. Reduced staff movement and flexible workflow may contribute to benefits however, further evaluation is required. This study revealed that reliance on turnaround times as a sole measure of benefit when evaluating the impact of PRDS is an overly simplistic measure due to the complexity of the medication supply process in Australian public hospital pharmacy.

Chapter 4. Discussion and concluding remarks

4.1 Chapter introduction

This chapter summarises key learnings of the previous chapters. It will describe how the study addressed the research objectives. The chapter will conclude with suggestions for future research, future direction and limitations.

4.2 Key learnings and future research

The primary aim of this research was to investigate the impact of introducing a PRDS into an Australian hospital pharmacy imprest and dispensary tasks. To investigate if the benefits of PRDS reported in the literature were comparable in an Australian tertiary public hospital pharmacy. Secondly, this research aimed to identify factors that influence hospital pharmacy staff acceptance of robotics during implementation and over time.

4.2.1 State government

Consistent with prior research, this study identified that the PRDS introduced new unintended consequences such as technical malfunctions, blockages and faults influencing potential efficacies (24, 56). This study also found that pharmacy staff perceived the reliability of the PRDS declined over time which has not previously been identified in literature. Queensland Health utilise a state-wide, centrally supported information technology (IT) infrastructure including internet, bespoke viaduct systems, and interfacing dispensing software. These systems are utilised to send messaging from the pharmacy dispensing software to the PRDS to direct an action. State-wide IT systems influence robot functionality and reliability yet was not measured in this study. The source of reduced reliability and unintended consequences may have been due to the PRDS itself or potentially the complex data pathways of the interfacing software that were unable to be measured in this study (24, 56). In addition, PRDS have been implemented on an *ad hoc* basis by individual hospitals with the financial means to purchase and implement the system, each with limited insight into potential state-wide impact on IT systems. Further, there is an absence of long-term strategic planning for state-wide digital health implementation, maintenance, and support to guide future implementations (56).

The Australian Commission on Safety and Quality in Health Care (ACSQHC) provide national guidance on implementing electronic medication management (eMM) systems such as automated dispensing cabinets, electronic prescribing, smart pumps, robotics and other digital health technologies (25). These could impose increased pressure on state-wide IT infrastructure, crucial in delivering optimal function to all digital health systems for Queensland Health. In order to address identified limitations, health departments should establish a state-wide eMM strategic plan to maximise the capacity of the digital health technology, reduce confounding factors impacting potential benefits and return on investment (25). This strategy should include planning IT infrastructure, timely and effective technical support, establishing working groups, site implementation requirements, testing strategies with co-ordinated feedback and communication to the PRDS Company to ensure ongoing development to suit hospital needs.

4.2.2 Hospital pharmacy managers

Workflow

This study found the PRDS enabled greater operational flexibility in staff time and workflow. During the study, GCUH pharmacy implemented novel approaches to manage workload to utilise PRDS functions such as remote dispensing and imprest supply to trigger PRDS picking. Medication supply was no longer reliant on staff returning to the pharmacy to action orders as electronic approaches to communication were deployed for greater flexibility to staffing. Staggered imprest ordering permitted the IA to act on orders throughout the full day, supported by the significant increase in IA daily movement. The combination of staggered imprest management, online and ward-based medication ordering and increasing 'next day' imprest deliveries resulted in more dispensary pharmacy assistants available in the morning, a greater window of time for imprest management activities and manageable increase in workload with static staffing numbers.

This study did not specifically measure the impact of workflow changes implemented with PRDS, yet findings support prior studies that identified adapting workflows and redeploying staff time is key to gaining full advantage of potential efficiencies (23, 48). Prior to PRDS implementation, pharmacy managers should review current operational workflow, identify inefficiencies, and operational workarounds. Establish a strategy for all pharmacy staff to easily feedback workflow issues at baseline, pre and post implementation which should be regularly reviewed and workflow strategies addressed. Ongoing workflow review beyond implementation could help liberate staff time to redeploy into other pharmacy activities, facilitate operational flexibility and maximise benefits as technology evolves. The ideal changes recommended to maximise the benefit of new technologies is not well understood in the literature and requires further evaluation (24).

Turnaround time

Consistent with prior research, this study found overall dispensing and imprest supply turnaround times, dispensing rates, labelling and assembly times did not significantly change with the introduction of PRDS (20, 26, 28, 54). Despite this, a higher workload and an increased number of urgent items were managed by the same number of staff. The considerable workload increase without significant time savings can be explained by the complex nature of the pharmacy environment and PRDS. Large variability in items/person/hour found in this study indicate each prescription varies in number and complexity, plus PRDS increase the complexity of workflow steps to supply medication (48). Expected time savings are not achieved if turnaround times are sensitive to factors other than picking stock and are too simplistic a measure for evaluating PRDS implementation in the complex Australian hospital pharmacy (26, 36, 55).

Automation increases the number of locations to gather medications and increase the complexity of the dispensing process (24, 48). Reported turnaround time benefits are conflicting or inconclusive due to the complexity of the pharmacy environment (23, 24, 26, 48, 53). As a result pharmacy leaders must rely on vague and conflicting evidence along with manufacturer marketing information to guide expectations of PRDS in hospital pharmacy (24). These findings suggest that pharmacy managers should not rely solely on generic measures such as turnaround times to measure the impact of PRDS in hospital pharmacy. Future evaluation should identify other measures that also align with the hospital strategic objectives and focus on stock handling activities, role changes and redeploying staff time, workflow changes, medication error reduction and storage capacity (24, 26, 48). Pharmacy managers should also use caution when applying study findings to hospitals that are not tertiary level public hospital located in metropolitan areas. Demonstrated results of absorbing increased workload and improved responsiveness to urgent requests may translate to hospitals supporting growing populations or responding to surges in workload e.g. redirection from another hospital, however, these benefits may not translate in rural or remote areas with static growth.

Pharmacy assistant dispensing rates

The recommended dispensing workload for Australian hospital pharmacists is in the range of 16 to 20 prescription items per hour to maintain medication safety (3, 13). This study found that dispensing rates did not significantly change with the introduction of PRDS. However, although unchanged, dispensing rates (items/person/hour) in this study were twice as high as the recommended rate for Australian hospital pharmacists. Observed dispensing activities in this study were conducted by pharmacy assistants and intern pharmacist who did not have clinical review and checking responsibilities. The exclusion of clinical review may indicate that dispensary assistants are capable of dispensing at a much higher rate than pharmacists and the current workload recommendations underestimate the possible workload capabilities of the hospital pharmacy. To better guide workforce planning and future role redesign, a workload capacity recommendation for hospital pharmacy assistants should be developed.

Communication

Consistent with prior literature this study found that pharmacy staff are driven to use the PRDS based on the influence of pharmacy leaders and by how useful and relevant the system is to their role (29-31, 39). This is supported by the study finding the influence of leaders during implementation continues to impact pharmacy staff PRDS usage over time. This highlights that pharmacy leadership and communication is key to PRDS and can be leveraged for successful PRDS implementations. A clear, planned and united communication strategy from pharmacy management is key to effective implementation, particularly if it includes core messages about usefulness and benefits at and beyond initial implementation. Communications should include core messages about benefits and impact on each role tailored to individual roles. This study also revealed that pharmacy staff with tertiary education such as pharmacists, underestimate their use of the PRDS during implementation. In a position of influence, pharmacy leaders should target pharmacists with tailored communication of expected benefits and impact on the pharmacist role.

Training

This study identified that perceived ease of use had the greatest influence on PRDS technology acceptance over time. In addition, this study found the influence of leaders declined over time as participants gained further experience with the system. Over time, participants relied less on social influences and continued to judge the system based on how easy it was to use. To maximise staff usage of the PRDS long term, pharmacy managers should develop a clear and effective PRDS training plan ready for implementation and to support suitable induction of new staff thereafter. Also, ongoing training plans will be required *ad hoc*, for required refresher training and to train existing staff on new evolving PRDS functions to be utilised.

4.2.3 Pharmacy staff

Efficient operations of a PRDS in a hospital pharmacy are reliant on adapting workflows and redeploying staff time, however ideal changes are not well understood in the literature (24). Pharmacy staff should expect frequent and ongoing review of workflow steps for their position to identify inefficiencies and potential improvements. Pharmacy staff participating in workflow review with help managers provide processes that are role specific and potentially more efficient for the role. Pharmacy staff should be prepared to participate in workflow review prior to implementation and continue to provide feedback over time.

This study also found that pharmacy staff that have a clear understanding of the benefits of the PRDS and how it will impact their role are more likely to use the PRDS. Considering the influence of pharmacy leaders found in this study, pharmacy staff should engage with a team leader who can tailor messages of expected benefits of the PRDS and the expected relevance to their role. This includes targeting pharmacists, who were found to mistakenly perceive that PRDS would not be relevant to their role, underestimating their use.

4.2.4 Researchers

This study revealed that due to the complex nature of hospital pharmacy, effective evaluation of PRDS implementation cannot rely solely on generic measures such as turnaround times. Future studies need to identify other measures that align with hospital strategic objectives. Potential areas for future evaluation should be targeted toward stock handling, storage capacity, operational flexibility, workflow adaptation and the redirection of staff time. Such benefits may be more transferable to public hospital pharmacy districts beyond metropolitan areas that may not experience the same fluctuation in workload as reported in this study. In addition, this study was time limited to evaluate the impact of PRDS after 15 months, future research could repeat this study to understand long term influences and impacts of PRDS beyond 15 months.

Direct observation is the gold standard method for measuring workload (12). This study utilised video recording to address the reported limitations with direct observation and provide detailed time analysis of pharmacy activities (12, 49). Video observation permitted the observer to stop, review, zoom in and collect detailed accurate data. However, this study found observing detailed video footage was time consuming and imposed limitations in data collection. Further, to address ethical concerns and limit the impact of the Hawthorn effect, cameras recorded a restricted area which limited data collection of activities beyond the dispensing station (49). Technological advancements in digital tracking have since been developed as a viable alternative to direct observation for future time in motion studies. Digital tracking programs and devices can collect real time detailed data and minimise time burden experienced in this study (57). Future research should review available digital tracking alternatives to record detailed time studies of the complex pharmacy environment without the time limitations of video observation.

Electronic tracking (Fitbit Zip®) was used to triangulate key findings relating to changes in turnaround times and workload (50, 51). At the time of the study, electronic trackers had not been used in this setting with little evidence available to guide application, data collection and analysis. New electronic tracking devices have since emerged providing a greater range of monitoring capability. Current wearable electronic trackers can now be used to track activity levels, cognitive load and haemodynamic changes such as body temperature, heart rate and skin conductance in real time (58-61). Electronic activity tracking devices such as the MOX® by Maastrict instruments™ can track Step count, dynamic, standing and sedentary time with a light weight, water proof device and would be ideal for future studies (61). Such devices could track not only PRDS impact on activity and potentially cognitive load and stress response in the future. Future research should consider utilising advanced wearable electronic tracking devices to further understand the impact of PRDS of pharmacy staff.

This study did not measure the impact of workflow changes implemented along with PRDS, yet findings support prior studies that have identified workflow redesign is key to gaining full advantage of the potential PRDS efficiencies (23, 48). Efficient operations of a PRDS in a hospital pharmacy dispensary are reliant on adapting workflows and redeploying staff time, however recommended ideal changes are not well understood in the literature (24). Hospital pharmacy PRDS workflow requires thorough and ongoing evaluation. Future research should measure the impact of workflow adaptation and identify most efficient workflows to maximise PRDS efficiencies in Australian hospital pharmacy.

Australian hospitals are working towards increasing electronic medicines management (eMM) to improve medication safety by incorporating interfacing electronic prescribing, automated dispensing cabinets and PRDS (25). The evolving complexity or increasing digital health systems was not evaluated in this study. Further research is required to investigate the impact of incorporating future integrated eMM systems, workflow requirements, unintended consequences and overall impact on pharmacy activities. Furthermore as digital solutions emerge with machine learning and clinical decision making, some pharmacist roles and responsibilities may be modified or replaced by eMM (62, 63). Evaluation of emerging future roles of hospital pharmacist with digital health solutions could assist shape health care in the future (63).

4.3 Future Direction

PRDS are capable of a large number of operational functions to support pharmacy workflow. However, the operational capacity of the PRDS in this study was limited by the available technology of PRDS in 2016, the state managed internet and software systems previously discussed and limiting change fatigue on time poor staff. These factors directed pharmacy manager decisions relating to workflow and the PRDS functions utilised during implementation. However, pharmacy automation and the systems that support them continue to be developed at a fast pace requiring users to maintain ongoing learning and consider future application to the pharmacy (24). Underutilisation of evolving PRDS capacity may limit potential reported benefits.

Pharmacy managers could mitigate PRDS underutilisation by establishing several long-term strategies in conjunction with PRDS implementation. Include eMM within the departmental strategic plan to ensure digital health implementation is in line with both state and local hospital targets. Establish a pharmacy staff position responsible for managing automation. Pharmacy automation responsibilities would include establishing and reviewing an effective feedback system for pharmacy staff to easily report PRDS issues. Feedback should be regularly reviewed to influence workflow improvements, minimise workarounds and prompt required servicing of the PRDS. In addition, with limited research on the impact of PRDS on Australian hospital pharmacy, key feedback issues should be collated and prioritised to report to the PRDS Company and IT stakeholders. This could be done as an individual hospital or collaboratively as a state health system in line with the eMM strategic plan. This feedback to PRDS Company is done with view to influence future PRDS product development to suit hospital pharmacy operational functions. With ongoing collaboration, PRDS may improve storage limitations identified in this study such as part pack management, storage functions that can accommodate legislative restrictions of schedule 8 medications and pack size, and ultimately improve efficiency.

The pharmacy automation role should remain updated on new and emerging PRDS functions and consider the possible application in the pharmacy workflow, aligning with the local eMM strategic plan. Introducing more complex workflow steps should be considered with caution as increased complexity can result in unintended consequences and impact efficiency (24, 48). The automation role should also contribute to state-wide eMM working groups to develop an effective test strategy to ensure evolving digital health technologies do not impair optimal function and introduce further unintended consequences to PRDS operations. In summary, workflow review efforts far exceed the initial PRDS implementation and need ongoing review and management to optimise future hospital pharmacy digital efficiencies. Pharmacy managers should consider the long-term operational management requirements of PRDS and eMM strategic plan when considering PRDS implementation in Australian hospital pharmacy.

4.4 Limitations

Limitations specific to the research have been addressed in earlier chapters. The main overall limitations of this research include:

1. This study represents one type of robot in one large public hospital pharmacy and may not reflect the experience of other Australian hospitals. However, results are transferable for hospital pharmacies using different robot companies.

2. Modifications in workflow and lay out of the pharmacy were necessary prior to data collection to provide space for PRDS construction which may have impacted the authenticity of the baseline data. Future studies should plan to collect baseline data before modification to the work environment occurs.

3. The use of anonymous paired data for the ETAM survey limited eligible participants post-implementation and study findings do not reflect the views of all staff, particularly staff aged 55 years or older and the finding of age not having influence would require further confirmation. This was compounded by recreational and sick leave during winter.

4. The ETAM BAU survey did not meet the ideal minimum for *intention to use, output quality, usefulness assessment (results demonstrability)* or *subjective norm* which may reflect question clarity and results should be interpreted with caution. This

was mitigated by limiting analysis to one of the two ETAM questions used to measure *intention to use*. The least ambiguous question ‘assuming I have access to the robot I intend to use it’ was used as a key measure of technology acceptance.

5. Video footage was time consuming to observe, and data had to be limited to two workstations in place of six. A large volume of work was processed at a station not observed in this study. The stations selected for observation are the most frequently manned to maximise results. Video footage also encountered visual obstructions, power outages and limited to activities performed at the workstation. Video footage provided detail and accuracy in recording as outlined as a limitation in previous studies. However, incorporating barcode scanning for digital recording or electronic tracking of orders would alleviate the time burden on data collection.

6. Tracking databases relied on staff to utilise the database at the time the activity was undertaken. This was not an additional task for staff, who were expected to use the database as part of daily workflow prior to the study. However, accuracy of the database usage was not analysed.

7. The second phase of this study was repeated fifteen months after PRDS implementation, failing to provide longer term evidence of staff acceptance and continued efficiencies. Future studies could repeat a third phase for comparative analysis beyond fifteen months.

8. This study was unable to measure the impact of the state-wide IT system influence on individual robot functionality and reliability. Technical issues encountered during the study may have been due to the PRDS or potentially the complex interfacing systems. Future studies could mitigate the limitation by examining the types and origin of the faults experienced.

9. Several workflow changes were implemented to accommodate the PRDS. The impact of workflow changes was not specifically measured. Future studies could include identifying the influence of operational flexibility and workflow changes on pharmacy efficiencies.

10. This study did not measure the gap between PRDS functions utilised by the hospital pharmacy against the full capacity of the PRDS. Future studies could examine the prevalence and cause of underutilising PRDS functions.

4.5 Conclusion

This study revealed critical insights to help inform future PRDS implementation strategies in Australian hospital pharmacies. The influence of pharmacy leaders, benefits, and how easy the PRDS was perceived to use, emerged as key influencers on pharmacy staff technology acceptance during implementation and over time. Pharmacy managers can leverage this influence with a clear planned communication strategy delivered by pharmacy leaders including core messages such as useful functions and known benefits of the system customised for individual roles.

Turnaround times and dispensing rates did not change with PRDS yet more work was done with the same number of staff. Operational flexibility, reduced dispensary pharmacy assistant movement, and workflow changes may have contributed to benefits however further evaluation is required. This study revealed that reliance on generic measures such as turnaround times is overly simplistic due to the complexity of the medication supply process in Australian public hospital pharmacy and more suitable measures should be identified in line with pharmacy operational goals. Workflow review efforts far exceed the initial PRDS implementation and need ongoing review and management to optimise future hospital pharmacy digital efficiencies. In addition, existing state-wide IT services and support provide unique limitations when evaluating PRDS reliability and utilising full potential capacity. This presents opportunities to refine future PRDS implementations and development through eMM strategic planning, supported by a pharmacy automation role.

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Appendices

Appendix 1 GCHHS HREC approval – phase one

30 March 2016

Enquiries to: HREC Coordinator
Phone: 07 5687 3879
HREC Ref HREC/16/QGC/66
E-mail: GCHEthics@health.qld.gov.au

Mrs Jane Hogan Robina Hospital
2 Bayberry Lane
Suburb QLD XXXX

Dear Mrs Hogan

HREC Reference: HREC/16/QGC/66
Project title: Evaluate the impact of an Automated Robotic system on the GCHHS Pharmacy Department

Thank you for submitting the above project for ethical and scientific review, which has been undertaken by the Gold Coast Hospital and Health Service Human Research Ethics Committee (HREC).

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)-Updated May 2015, NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007)* and the *CPMP/ICH Note for Guidance on Good Clinical Practice*. Attached is the HREC Composition with specialty and affiliation with the Hospital and Health Service (HHS) (Attachment I).

This research project meets the requirements of the *National Statement on Ethical Conduct in Human Research (2007)-Updated May 2015*.

HREC approval is valid for **3 years**. Expiry 30 March 2019 The documents reviewed and approved include:

Document	Version	Date
Application (AU/10/0444426)		
Data collection tool		
Flow Chart		
Letter of Support		25 February 2016
Response to request for further information		29 March 2016
Protocol	2	25 March 2016

Participant Information and Consent Form	2	25 March 2016
Researcher CV		

Please note the following conditions of approval:

1. **This letter constitutes ethical approval only.** A copy of this approval must be submitted to the HHS Research Governance Officer/(RGO) along with a completed Site Specific Assessment (SSA) Form and applicable documents for authorisation from the CE to conduct this research within the HHS

    a. Once authorisation to conduct the research has been granted, please complete the
    Commencement Form (Attachment II) and return to the office of the Human Research Ethics Committee GCHEthics@health.qld.gov.au

2. **Reporting to the HREC:** The following reports are required to be submitted to the HREC. Failure to fulfill these reporting requirements may result in withdrawal or suspension of HREC approval:
    a. **Progress Reports:** The Coordinating/Principal Investigator will provide a progress report annually to the HREC and at completion of the project. Progress reports are due on the anniversary of the HREC approval date.

    b. **Safety Reporting**: The Coordinating/Principal Investigator will immediately report, in the specified format, anything which might warrant review of ethical approval of the project, including:
        i. Serious Adverse Events which impact on the ethical or scientific validity of the project must be notified to the HREC as soon as possible. In the case of Serious Adverse Events occurring at the local site, a full report is required from the Principal Investigator, including duration of treatment and outcome of event.
        ii. If required, the Investigator must provide a summary of the adverse events, in the specified format, including a comment as to suspected causality and whether changes are required to the Patient Information and Consent Form.
        iii. Unforeseen events that might affect continued ethical acceptability of the project.

    c. **Other monitoring:** The HHS administration and/or the HREC may inquire into the conduct of any research or purported research, whether approved or not and regardless of the source of funding, being conducted on HHS premises or claiming any association with the HHS; or which the Committee has approved if conducted outside its HHS.

3. **Amendments to this project**:
    Amendments for review by an HREC:

a. Amendments to the research project which may affect the ongoing ethical acceptability of a project must be submitted to the HREC for review.
b. Amendments should be reflected in a cover letter from the Principal Investigator, providing a brief description and rationale for the changes, and their implications for the ongoing conduct of the study. All relevant updated documentation should also be provided. Further advice on submitting amendments is available from http://www.health.qld.gov.au/ohmr/documents/researcher_userguide.pdf

Amendments for review by an RGO:

c. Amendments to the research project which affect only the ongoing site acceptability of the project are not required to be submitted to the HREC for review. These amendment requests should be submitted directly to the Research Governance Office/r (by-passing the HREC).

Amendments for review by an HREC Coordinator:

d. Amendments which do not affect either the ethical acceptability or site acceptability of the project (e.g. typographical errors) should be submitted in hard copy to the HREC Coordinator. These should include a cover letter from the Principal Investigator providing a brief description of the changes and the rationale for the changes, and accompanied by all relevant updated documents with tracked changes.

4. **Early termination or routine completion of the project:**
   a. The HREC must be notified if the project is discontinued at a site before the expected date of completion. Notification should be in the form of a cover letter from the Principal Investigator, providing a rationale for the early termination.
   b. For projects that are completed, the HREC must be notified by submission of a progress report, along with a copy of any research summaries or intended publications.

Should you have any queries about the HREC's consideration of your project please contact the HREC Coordinator on ph. 07 5687 3879. The HREC Terms of Reference, Standard Operating
Procedures, membership and standard forms are available from
http://www.health.qld.gov.au/ohmr/html/regu/regu_home.asp

The HREC wishes you every success in your research.

Yours sincerely

Vanessa Druett
HREC Coordinator
On behalf of
Emeritus Professor Drew Nesdale
Chair
Gold Coast Hospital and Health Service
Human Research Ethics Committee (EC00160)

Sites Approved

Site	**Site Investigator/'s**
Gold Coast Hospital and Health Service	Mrs Jane Hogan

Appendix 2 GCHHS HREC amendment – phase one

Gold Coast Health
Building a healthier community

Queensland Government

Office of the Human Research Ethics Committee

31 August 2016

Enquiries to: HREC coordinator
Phone: 07 5687 3879
HREC Ref HREC/16/QGC/66
E-mail:: GCHEthics@health.qld.gov.au

Mrs Jane Hogan
Robina Hospital
2 Bayberry Lane
ROBINA QLD 4226

Dear Mrs Hogan

HREC Reference: **HREC/16/QGC/66**
Project title: Evaluate the impact of an Automated Robotic system on the GCHHS Pharmacy Department
Amendment number: **AM02**

The following documentation was reviewed and approved at the meeting of the Chair of the Gold Coast Hospital and Health Service Human Research Ethics Committee (HREC) held on 31 August 2016

The amendment will be ratified at the HREC meeting to be held on 28 September 2016.

Document	Version	Date
Notification of Amendment		19 August 2016
Survey Data Collection Tool		
Flow Chart		
PowerPoint Data Collection Tools: • Activity: Flow • Activity: Dispensing • Activity: Pharmacist Checking		

The HREC is constituted and operates in accordance with the National Health and Medical Research Council's *"National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007)* and the *"CPMP/ICH Note for Guidance on Good Clinical Practice"*.

A copy of this letter must be forwarded to the GCHHS Research Governance Office/r.

It should be noted that all requirements of the original approval still apply.

If you have any queries please do not hesitate to contact the HREC Coordinator on 07 5687 3879 or via GCHEthics@health.qld.gov.au

Yours sincerely

Carine Hoye
A/HREC Coordinator
On behalf of
E/Prof Drew Nesdale
Chair HREC
Gold Coast Hospital and Health Service
Human Research Ethics Committee (EC00160)

Office
Research Directorate
Level 2, Pathology and Education Building
1 Hospital Boulevard
Southport QLD 4215

Phone
61 7 5687 3879

Page 1

Appendix 3 GCHHS HREC Approval – phase two

19 April 2014

Enquiries to: HREC Coordinator
Phone: 07 5687 3879
HREC Ref: HREC/17/QGC/18
E-mail: GCHEthics@health.qld.gov.au

Mrs Jane Hogan
Robina Hospital Pharmacy
2 Bayberry Lane
ROBINA QLD 4226

Dear Mrs Hogan

HREC Reference: HREC/17/QGC/18
Project title: Evaluation of the impact of a Pharmacy Robotic Dispensing System on the GCHHS Pharmacy department

Thank you for submitting the above project for ethical and scientific review, which has been undertaken by the Gold Coast Hospital and Health Service Human Research Ethics Committee (HREC).

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)-Updated May 2015, NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007)* and the *CPMP/ICH Note for Guidance on Good Clinical Practice*. Attached is the HREC Composition with specialty and affiliation with the Hospital and Health Service (HHS) (Attachment I).

This research project meets the requirements of the *National Statement on Ethical Conduct in Human Research (2007)-Updated May 2015*.

HREC approval is valid for **3 years**. Expiry 19 April 2020

The documents reviewed and approved include:

Document	Version	Date
Application (AU/10/66FA216)		22 December 2016
Protocol		
Participant Information and Consent Form	2	22 February 2017
Flow Chart		
Extended Technology Acceptance Survey		
Filming in Progress Sign		

Letter of Support from Elizabeth Coombes, Director of Pharmacy		27 January 2017
Response to Request for Further Information		15 March 2017

Please note the following conditions of approval:

1. **This letter constitutes ethical approval only.** A copy of this approval must be submitted to the HHS Research Governance Officer/(RGO) along with a completed Site Specific Assessment (SSA) Form and applicable documents for authorisation from the CE to conduct this research within the HHS

    a. Once authorisation to conduct the research has been granted, please complete the Commencement Form (Attachment II) and return to the office of the Human Research Ethics Committee GCHEthics@health.qld.gov.au

2. **Reporting to the HREC:** The following reports are required to be submitted to the HREC. Failure to fulfill these reporting requirements may result in withdrawal or suspension of HREC approval:
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    b. **Safety Reporting**: The Coordinating/Principal Investigator will immediately report, in the specified format, anything which might warrant review of ethical approval of the project, including:
        i. Serious Adverse Events which impact on the ethical or scientific validity of the project must be notified to the HREC as soon as possible. In the case of Serious Adverse Events occurring at the local site, a full report is required from the Principal Investigator, including duration of treatment and outcome of event.
        ii. If required, the Investigator must provide a summary of the adverse events, in the specified format, including a comment as to suspected causality and whether changes are required to the Patient Information and Consent Form.
        iii. Unforeseen events that might affect continued ethical acceptability of the project.

    c. **Other monitoring:** The HHS administration and/or the HREC may inquire into the conduct of any research or purported research, whether approved or not and regardless of the source of funding, being conducted on HHS premises or claiming any association with the HHS; or which the Committee has approved if conducted outside its HHS.

3. **Amendments to this project**:
    Amendments for review by an HREC:
    a. Amendments to the research project which may affect the ongoing ethical acceptability of a project must be submitted to the HREC for review.

b. Amendments should be reflected in a cover letter from the Principal Investigator, providing a brief description and rationale for the changes, and their implications for the ongoing conduct of the study. All relevant updated documentation should also be provided. Further advice on submitting amendments is available from
http://www.health.qld.gov.au/ohmr/documents/researcher_userguide.pdf

Amendments for review by an RGO:

c. Amendments to the research project which affect only the ongoing site acceptability of the project are not required to be submitted to the HREC for review. These amendment requests should be submitted directly to the Research Governance Office/r (by-passing the HREC).

Amendments for review by an HREC Coordinator:

d. Amendments which do not affect either the ethical acceptability or site acceptability of the project (e.g. typographical errors) should be submitted in hard copy to the HREC Coordinator. These should include a cover letter from the Principal Investigator providing a brief description of the changes and the rationale for the changes, and accompanied by all relevant updated documents with tracked changes.

4. **Early termination or routine completion of the project:**
    a. The HREC must be notified if the project is discontinued at a site before the expected date of completion. Notification should be in the form of a cover letter from the Principal Investigator, providing a rationale for the early termination.
    b. For projects that are completed, the HREC must be notified by submission of a progress report, along with a copy of any research summaries or intended publications.

Should you have any queries about the HREC's consideration of your project please contact the HREC Coordinator on ph. 07 5687 3879. The HREC Terms of Reference, Standard Operating
Procedures, membership and standard forms are available from
http://www.health.qld.gov.au/ohmr/html/regu/regu_home.asp

The HREC wishes you every success in your research.

Yours sincerely

Carine Hoye
HREC Coordinator
On behalf of
Emeritus Professor Drew Nesdale
Chair
Gold Coast Hospital and Health Service
Human Research Ethics Committee (EC00160)

Sites Approved

Site	**Site Investigator/'s**
Gold Coast Hospital and Health Service	

Appendix 4 Pharmacy staff research education – slide content phase one

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1


Pharmacy Department
What are we doing now?
Working hard
Picking own stock
Answering lots of calls
Helping out the front
Fixing inventory discrepancies
A lot of walking
Studying
Dispensing/supplying
KEEP
CALM
PHARMACY
TECHNICIAN

7


Methods: How are we going to track it?
Time in motion study - 5 days
Tracks the time it takes to perform medication supply tasks within the department
1. Videorecording
2. Electronic tracking
3. Scriptraker
4. Inventory management records
5. Phone records
6. Imprest tracking system

8


1. Video recording
Video cameras set up at dispensing stations
No sound recorded
Tracking the movement of the bucket, not tracking the person
Track activities performed eg labelling, collecting missing stock
Anonymous
Filmed off line onto a lap top in the Pharmacy
Clearly mark areas in dispensary being filmed
Not tracking staff, not to be used for performance review

9


Video recording

10


Video recording

11


Video recording

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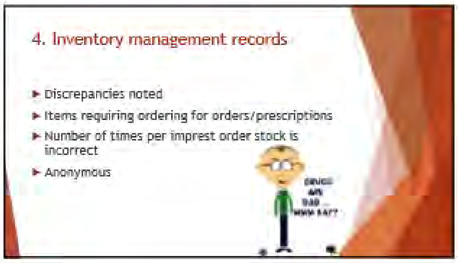

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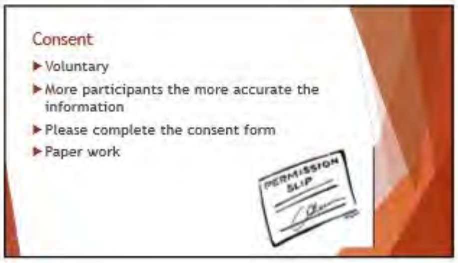

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Appendix 5 Participant Information Consent Form (PICF) – phase one

Gold Coast Health
Building a healthier community

Research Participant Information Statement

Evaluate the impact of an automated robotic system on the GCHHS Pharmacy department	
Jane Hogan	

(1) What is the study about?

An automated dispensing robot is scheduled for construction in the Pharmacy department April 2016. This study aim to track the current work processes prior to any physical change to the dispensary so that the impact of the robot can be measured in the future.
Currently there is limited research on robotic implementation in Hospital pharmacy environments, certainly no data from Australia.

You're invited to participate in a study evaluating the impact of the robot on the Pharmacy department. The study will collect this baseline data so that we can learn about the impact of introducing this technology on Pharmacy staff and where the robot has created improvements or hindrances. I am hoping to answer the question "Did the robot do what we hoped it would do?" You were selected as a possible participant in this study as a team member of the GCHHS Pharmacy department who's work environment will be impacted by the introduction of the robot in the Pharmacy.

As part of the study selected workspaces and dispensing activities will be filmed and/or electronically tracked within the Pharmacy department for five days between the 7th March and the 11th March. Videotaping and electronic tracking have been chosen to minimise impact on staff and capture the most accurate record of dispensing in the pharmacy. The area being filmed will be clearly marked in the dispensary so you are aware if you are in the area being filmed. The footage will focus on dispensing tasks rather than filming people and tracking data will not be recording sound. By participating in this study you will help us to review in the future how the robot has impacted the Pharmacy department, both positively and negatively, and consider the impact new technology has on staff.

(2) Who is carrying out the study?

The research is being conducted by Jane Hogan, Senior Pharmacist at GCHHS under the supervision of Jennie O'Hare, Assistant Director of Pharmacy, Dr Gary Grant and Dr Fiona Kelly from the School of Pharmacy, Griffith University, Gold Coast.
The research studies contribute to Jane Hogan's studies for the award of the Masters of Medical Research being undertaken at Griffith University.

(3) What does the study involve?

As a participant in this study, you will be involved in activities such as:
Videotaping: The 'Flow' position and dispensing areas in the Pharmacy will be videotaped to track normal work activities. Please note the video footage will not record sound. The area being recorded hopes to track the journey of the medication bucket and the time it takes to transition from each area in normal working conditions. Tracking system: An electronic tracking system will be used to track the movement of the dispensary positons. This will track transition of this position in key areas throughout the dispensary. This tracking system will be in the form of either a wrist band worn, phone application or tracking button kept in your pocket.

Methods: A time in motion study will be conducted to track the key tasks in the Pharmacy likely to be impacted by the introduction of robot. It also aims to quantify how long it takes to do these tasks. Some tasks include the time taken to pick stock for dispensing, imprest picking, and correcting inventory.
Video recording and electronic tracking were chosen to minimise disruption to the dispensary and work place.
The data collected will track the time it takes to complete a task eg picking stock. The study will not track your individual activity as several staff members can complete a positon throughout the day eg flow. The item being tracked is the bucket. There will be no audio recording on the video, we will not be able to hear you.

(4) How much time will the study take?

The videotaping and tracking system should not impact on your working time. There may be some minor inconvenience setting up the video equipment and ensuring the tracking system is with the positon of Flow when shifts change over. The study aims not to impact normal working process as much as possible.
The study will track dispensary processes for 5 working days in April 2016.

(5) Will I incur any costs by participating in the study?

There will be no costs incurred as a result of participation in this study.

(6) Can I tell other people about the study?

Yes. This is not a confidential study.

(7) Will I receive the results of the study?

Results of the study will be distributed shared with the Pharmacy department. Initially the results will be presented to the Pharmacy Management Group and then distributed to the wider Pharmacy staff by presentation and email circulation.

(8) Confidentiality and disclosure of information

Video cameras will be positioned to focus filming on dispensing related tasks and not people so that collection of identifying information is minimal. Any information that is obtained in connection with this study able to be identified as you will remain confidential and will be disclosed only with your permission, except as required by law. The data collected in the study will be used for the purposes of the time in motion study to review the impact of the robot on the Pharmacy work place. It will not be used for performance review of individual staff.

Video footage obtained in the dispensary will be recorded offline, so no external parties are able to view the footage while it is recording. The footage will only be observed by the research team.

If you consent to participating in this study, I plan to discuss the results with Griffith University academic supervisors Dr Gary Grant, Dr Fiona Kelly and Jennie O'Hare as part of my Masters program. In any publication, information will be provided in such a way that you cannot be identified.

(9) Can I withdraw from the study?

Participation in this study is voluntary - you are not under any obligation to consent and - if you do consent - you can withdraw at any stage without affecting your relationship with the GCHHS Pharmacy, Jane Hogan, Jennie O'Hare or Griffith University. You can withdraw your consent by advising the researcher either verbally, via email, or by completing and returning the 'Participant Withdrawal of Consent Form' that is supplied herein.

If you take part in the videorecording in the dispensary and wish to withdraw, as this is a focus group it will not be possible to exclude individual data once the videorecording has commenced. However you will no longer be rostered in the focus area being filmed.

(10) How can I obtain further information?

When you have read this information, Jane Hogan will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact either the researcher Jane Hogan or research supervisor Jennie O'Hare, Assistant Director of Pharmacy 56357191.

(11) What can I do if I have a complaint or a concern?

Any concerns or complaints about the conduct of this study should be directed to the:

HREC Secretary
Gold Coast University Hospital
1 Hospital Boulevard
SOUTHPORT QLD 4215
Email: GCHEthics@health.qld.gov.au

Any complaint will be investigated promptly and you will be informed of the outcome.

This information sheet is for you to keep.

Research Participant Consent Form

Evaluate the impact of an Automated Robotic system on the GCHHS Pharmacy Department	
Jane Hogan	

Participant Consent

I __________________________, agree to participate in this research which involves videotaping the dispensary area, electronic tracking of staff movement and review of Pharmacy data bases. I have read the Research Participant Information Statement and had any question I have about the research answered for me by the researcher.

Please complete, placing a ✓ in applicable boxes

____

Name of Research Participant (First name and Surname)(Print)

Are you 18 years of age or older? ☐ Yes

☐ No - A parental consent form is required to be completed.

____

Research Participant Signature Date

____

Name of Witness Relationship of Witness to Research Participant *(e.g., friend,* sibling, parent, partner)

____

Witness Signature Date

____ _______________________
Researcher's Signature Date

Research Participant Withdrawal of Consent Form

You can withdraw your participation consent by advising the researcher verbally, via email to jane.hogan2@health.qld.gov.au or by returning this completed form to Jane Hogan, Robina Hospital Pharmacy, 2 Bayberry Lane, ROBINA 4226.
Please note: It will not be possible to remove any individual data previously recorded, however you will no longer be required to work in the specified areas filmed.

Evaluate the impact of an Automated Robotic system on the GCHHS Pharmacy Department	
Jane Hogan	

I hereby wish to WITHDRAW my consent to participate in the research proposal described above and understand that such withdrawal WILL NOT jeopardise any treatment or my relationship with the Gold Coast Hospital and Health Service, Pharmacy department, Jane Hogan or Jennie O'Hare.

____
Research Participant Name *(Print)*

_____________________________________ _____________________________
Research Participant Signature Date

Appendix 6 Pharmacy staff research education – slide content phase two

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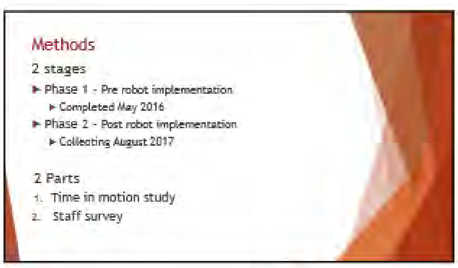

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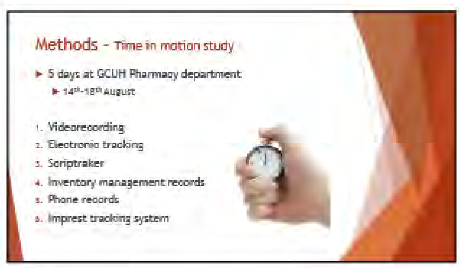

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1


Methods - Time in motion study
1. Video recording
Video cameras set up at dispensing stations
No sound recorded
Tracking the movement of the bucket, not tracking the person
Anonymous
Filmed off line onto a lap top in the Pharmacy
Clearly mark areas in dispensary being filmed
Set up one week ahead of time
Not tracking staff, not to be used for performance review

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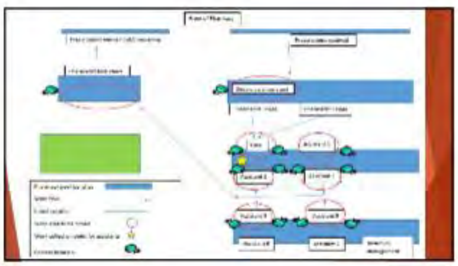

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Video recording

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Video recording

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Video recording

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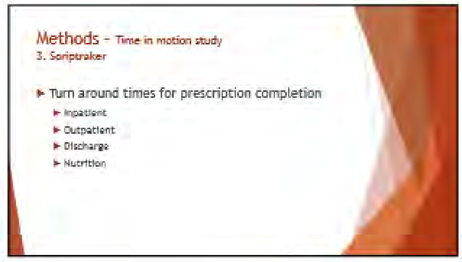

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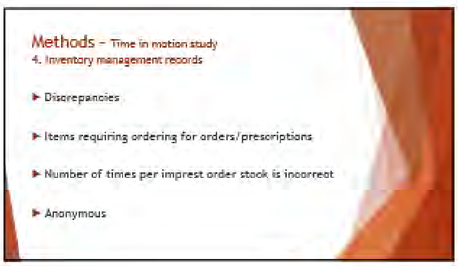

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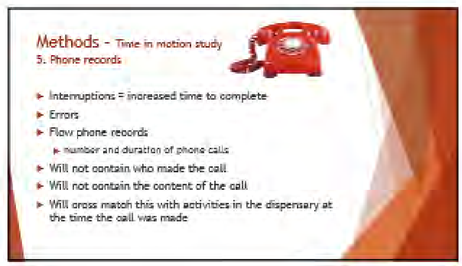

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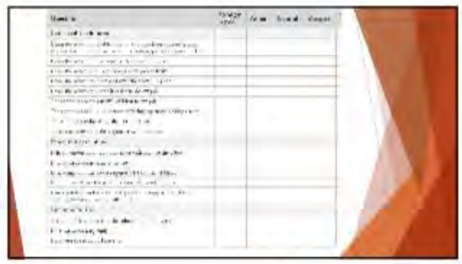

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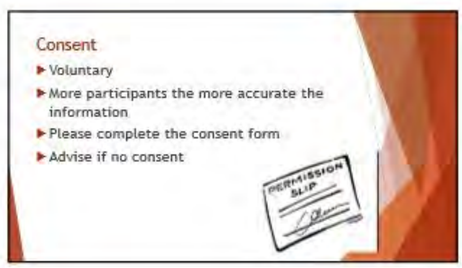

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Withdrawal

- Research is Voluntary
- Withdrawal of consent
  - Verbally, email, withdrawal form
- No penalty for non-participation
- Time in motion focus group - unable to remove footage once collected
- Survey is anonymous - need to advise unique code to withdraw

25

Where will the results go?

- After the time on motion study is repeated and the results compared
  - PMG
  - Wider GCHHS Pharmacy department
  - Thesis of Masters of Medical research
  - Pharmacy conferences
  - Assist other Hospitals planning to implement robotics

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ETHICS

- GCHHS Human Research Ethics committee
- Griffith University Human Research Ethics Committee
  - HREC/16/QGC/86, SSA/16/QGC/87
  - HREC/17/QGC/18, SSA/17/QGC/154

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Limitations

- One hospital experience
- One type of robot

28

What now

- Consent form
  - Only 7 days to complete
  - Yes - complete form, No - advise Jane or Jennie
  - Keep information sheet and withdrawal form
  - You are the "research participant"
  - Due date: 10th August 2017
- Survey
  - Hard copy or online
- Camera set up 7th August
- Filming from 14th-18th August

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Questions?

Griffith UNIVERSITY

30

5

Appendix 7 Participant Information Consent Form (PICF) – phase two

Gold Coast Health
Building a healthier community

Research Participant Information Statement

Evaluation of the impact of a Pharmacy Robotic Dispensing System on the GCHHS Pharmacy department

Jane Hogan

(1) What is the study about?

A Pharmacy Robotic Dispensing System (PRDS) is an automated dispensing robot that was installed in the GCUH Pharmacy department in May 2016. This study aims to track how dispensary work flow and tasks have changed since the implementation of the robot by comparing our current work practise with the robot to work flow and work tasks prior to the introduction of the robot.

Currently there is limited research available on the impact of robotics in Hospital pharmacy environments, and certainly no data from Australia.

To evaluate the impact of the Robot on the GCHHS Pharmacy department the study will be carried out in two phases.

Phase 1: Pre-implementation of the robot (completed)

Phase 2: Post- implementation of the robot

Data was collected for Phase one of the study in May 2016 prior to the robot implementation. With the robot now operational and established in daily work tasks, phase 2 of the study will soon commence.

You're invited to participate in phase 2 of a study evaluating the impact of the robot on the Pharmacy department. The study will collect this data to compare the work environment both before and after the introduction of the robot. To learn about the impact of introducing this technology on Pharmacy staff and where the robot has created improvements or hindrances. I am hoping to answer the question "Did the robot do what we hoped it would do?" You were selected as a possible participant in this study as a team member of the GCHHS Pharmacy department who's work environment has been impacted by the introduction of the robot in the Pharmacy.

As part of the study, selected workspaces and dispensing activities will be filmed and/or electronically tracked within the Pharmacy department for five days. Videotaping and electronic tracking have been chosen to minimise impact on staff and capture the most accurate record of dispensing in the pharmacy. The area being filmed will be clearly marked in the dispensary so you are aware if you are in the area being filmed. The footage will focus on dispensing tasks rather than filming people and tracking data will not be recording sound. By participating in this study you will help in understanding how the robot has impacted the Pharmacy department, both positively and negatively, and consider the impact new technology has on staff.

(2) Who is carrying out the study?

The research is being conducted by Jane Hogan, Senior Pharmacist at GCHHS under the supervision of Jennie O'Hare, Assistant Director of Pharmacy, Dr Gary Grant and Dr Fiona Kelly from the School of Pharmacy, Griffith University, Gold Coast.
The research studies contribute to Jane Hogan's studies for the award of the Masters of Medical Research being undertaken at Griffith University.

(3) What does the study involve?

As a participant in this study, you will be involved in activities such as:
Videotaping: The work benches within the dispensary will be videotaped to track normal work activities. Please note the video footage will not record sound. The area being recorded hopes to track the journey of a numbered medication bucket and the time it takes to transition from each area in normal working conditions.
Tracking system: An electronic tracking system will be used to track the movement of staff in the dispensary. This will track the frequency and distance travelled throughout the dispensary. This tracking system will be in the form of either a wrist band worn, or fitbit to be worn. The data collected is anonymous.
Staff Survey: a 2 page anonymous survey exploring how you perceive the robot has impacted you and your workplace. For staff to be eligible for this part of the study they must have participated in the pre-implementation staff survey in May 2016. If you did not participate in this part of the study you will not be required to complete the survey. The survey is anonymous, with only a unique identifying code nominated by you. This allows us to track changes in attitudes toward the robot.

Methods: A time in motion study will be conducted to track the key tasks in the Pharmacy dispensary and how long it takes to do them. Some tasks include the time taken to pick stock for dispensing, imprest picking, and the distance travelled to complete dispensing tasks.
Video recording and electronic tracking were chosen to minimise disruption to the dispensary and work place.
The data collected will track the time it takes to complete a task eg picking stock. The study will not track your individual activity as several staff members can complete a positon throughout the day eg flow. The item being tracked is the bucket. There will be no audio recording on the video, we will not be able to hear you.

The staff survey will investigate how staff felt about the robot and compare responses before the robot was introduced to after the robot has been implemented.

(4) How much time will the study take?

The videotaping and tracking system should not impact on your working time. There may be some minor inconvenience setting up the video equipment and ensuring the tracking system is with the positon of Flow when shifts change over. The study aims not to impact normal working process as much as possible.
The study will track dispensary processes for 5 working days.

(5) Will I incur any costs by participating in the study?

There will be no costs incurred as a result of participation in this study.

(6) Can I tell other people about the study?

Yes. This is not a confidential study.

(7) Will I receive the results of the study?

Results of the study will be distributed shared with the Pharmacy department. Initially the results will be presented to the Pharmacy Management Group and then distributed to the wider Pharmacy staff by presentation and email circulation.

(8) Confidentiality and disclosure of information

Video cameras will be positioned to focus filming on dispensing related tasks and not people so that collection of identifying information is minimal. Any information that is obtained in connection with this study able to be identified as you will remain confidential and will be disclosed only with your permission, except as required by law.
The data collected in the study will be used for the purposes of the time in motion study to review the impact of the robot on the Pharmacy work place. It will not be used for performance review of individual staff.

Video footage obtained in the dispensary will be recorded offline, so no external parties are able to view the footage while it is recording. The footage will only be observed by the research team.

If you consent to participating in this study, I plan to discuss the results with Griffith University academic supervisors Dr Gary Grant, Dr Fiona Kelly and Jennie O'Hare as part of my Masters program. In any publication, information will be provided in such a way that you cannot be identified.

(9) Can I withdraw from the study?

Participation in this study is voluntary - you are not under any obligation to consent and - if you do consent - you can withdraw at any stage without affecting your relationship with the GCHHS Pharmacy, Jane Hogan, Jennie O'Hare or Griffith University. You can withdraw your consent by advising the researcher either verbally, via email, or by completing and returning the 'Participant Withdrawal of Consent Form' that is supplied herein.

If you take part in the videorecording in the dispensary and wish to withdraw, as this is a focus group it will not be possible to exclude individual data once the videorecording has commenced. However you will no longer be rostered in the focus area being filmed. Similarly, if you wish to withdraw from the survey, you do not have to complete the post implementation study survey. However as the surveys are anonymous it will not be possible to identify and withdraw your survey after it has been completed and submitted.

(10) How can I obtain further information?

When you have read this information, Jane Hogan will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact either the researcher Jane Hogan or research supervisor Jennie O'Hare, Assistant Director of Pharmacy 56357191.

(11) What can I do if I have a complaint or a concern?

Any concerns or complaints about the conduct of this study should be directed to the:

HREC Secretary
Gold Coast University Hospital
1 Hospital Boulevard
SOUTHPORT QLD 4215
Email: GCHEthics@health.qld.gov.au

Any complaint will be investigated promptly and you will be informed of the outcome.

This information sheet is for you to keep.

Research Participant Consent Form

Evaluation of the impact of a Pharmacy Robotic Dispensing System on the GCHHS Pharmacy department	
Jane Hogan	

Participant Consent

I ___________________________, agree to participate in this research which involves videotaping the dispensary area, electronic tracking of staff movement, review of Pharmacy data bases and anonymous staff survey. I have read the Research Participant Information Statement and had any question I have about the research answered for me by the researcher.

Please complete, placing a ✓ in applicable boxes

____
Name of Research Participant *(First name and Surname)(Print)*

Are you 18 years of age or older? ☐ Yes
☐ No - A parental consent form is required to be completed.

____ __________________________
Research Participant Signature Date

____ __________________________
Name of Witness Relationship of Witness to Research Participant *(e.g., friend, sibling, parent, partner)*

____ __________________________
Witness Signature Date

____ _________________________
Researcher's Signature Date

Research Participant
Withdrawal of Consent Form

You can withdraw your participation consent by advising the researcher verbally, via email to jane.hogan2@health.qld.gov.au or by returning this completed form to Jane Hogan, Robina Hospital Pharmacy, 2 Bayberry Lane, ROBINA 4226.
Please note: It will not be possible to remove any individual data previously recorded, however you will no longer be required to work in the specified areas filmed.

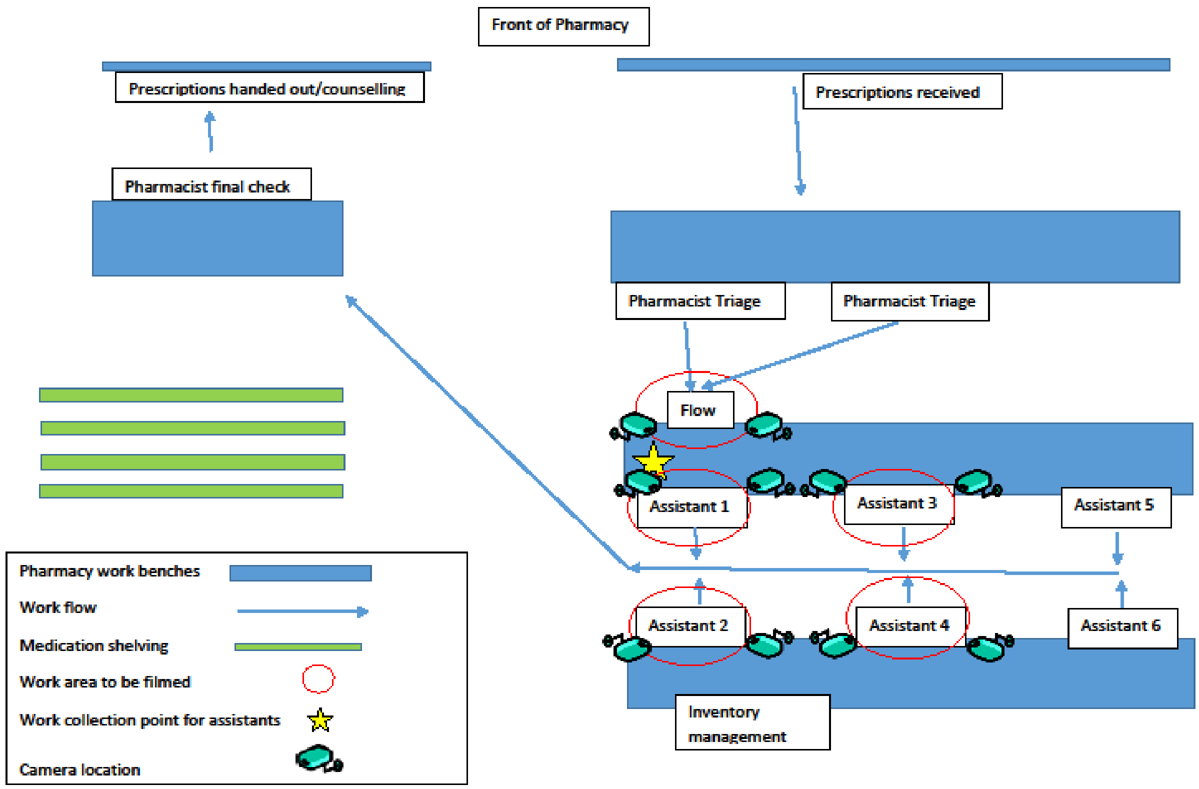
Evaluation of the impact of a Pharmacy Robotic Dispensing System on the GCHHS Pharmacy department	
Jane Hogan	

I hereby wish to WITHDRAW my consent to participate in the research proposal described above and understand that such withdrawal WILL NOT jeopardise any treatment or my relationship with the Gold Coast Hospital and Health Service, Pharmacy department, Jane Hogan or Jennie O'Hare.

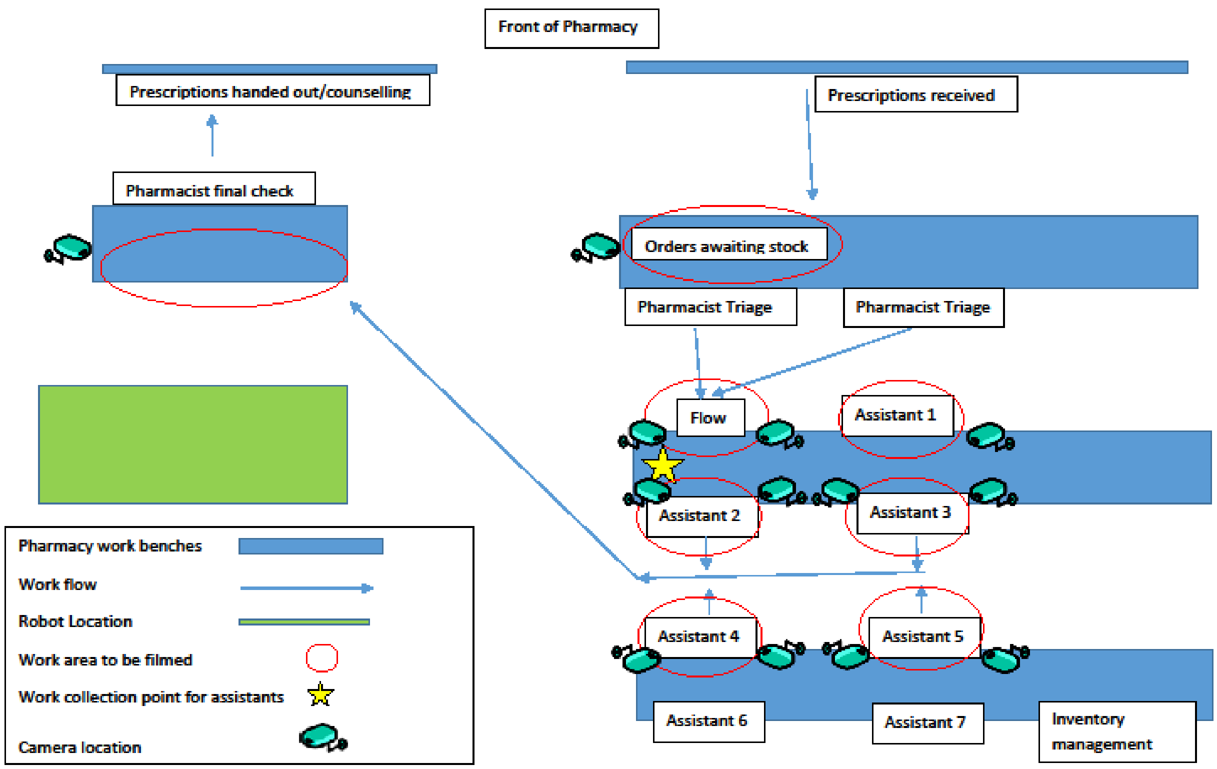
____
Research Participant Name *(Print)*

____
Research Participant Signature Date

Appendix 8 Work flow and Camera Placement in Pharmacy department – phase one



Appendix 9 Work flow and Camera Placement in Pharmacy department – phase two



Appendix 10 ETAM Staff Survey – phase one

Griffith University

School of Pharmacy
Parklands Drive
Southport Qld 4215

Evaluation of the Imapct of Automation in the GCHHS Pharmacy Department
Ethics Number: **HREC/16/QGC/66**

Please enter your unique ID Code | See front sheet for code

Please indicate your age (in years)

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65-74
- ☐ 75 +

Gender

- ☐ Male
- ☐ Female

What is the highest degree or level of school you have completed? *If currently enrolled, highest degree received.*

- ☐ Less than Year 12 or equivalent
- ☐ Year 12 or equivalent eg HSC/leaving certificate
- ☐ Tafe/Trade/technical/vocational training
- ☐ Associate diploma
- ☐ Undergraduate diploma
- ☐ Bachelor degree (including honors)
- ☐ Postgraduate diploma (includes graduate diploma/certificate)
- ☐ Masters degree
- ☐ PhD

Have you worked at Robina Hospital since the robot has been operational? Since Aug 2015

- ☐ Yes
- ☐ No

Have you received basic robot training at Robina Hospital?

- ☐ Yes
- ☐ No

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Perceived Usefulness					
Using the robot will enable me to accomplish tasks more quickly (eg take less time to dispense a prescription/process imprest orders)					
Using the robot will improve my job performance					
Using the robot will increase my productivity					
Using the robot would enhance my effectiveness on the job					
Using the robot will make it easier to do my job					
The robot will be a useful addition to my job					
The robot will have no impact on reducing my stock picking errors					
The robot will reduce my dispensing errors					
There will be more stock discrepancies with the robot					
Perceived ease of use					
Learning to use the robot will be easy for me					
I will find the robot easy to do what I want it to do					
It will be easy for me to become skillful at using the Robot					
I think the robot will be easy to use					
I think the robot will have enough support in place to assist me if anything goes wrong					
How I will interact with the robot is clear and understandable					
I am concerned I will not be able to use the robot					
Intension to Use					
Assuming I have access to the robot, I intend to use it					
I predict I will use the robot					
I will only use the robot if I have to					
Attitude					
Robots improve patient care by reducing medication errors					
Robots can improve patient care by improving efficacy					
The Robot will create a barrier to work flow by restricting the access to medication					
The robot makes me feel less valuable as an employee					
Job Relevance					
Using the robot will be important for my job					
Using the robot is relevant to my job					
The work in the dispensary is currently completed in a reasonable timeframe (with no robot)					
The build-up of work in the dispensary at peak times is stressful					

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Output Quality					
The actions and functions of the robot will be of high quality					
The robot is unreliable and will form barriers to smooth workflow					
The robot will break down often and cause delays					
Results Demonstrability					
I have no difficulty telling others about the benefits of using/having a robot in the Pharmacy					
The benefits of the robot are clear to me					
I would have difficulty explaining why using the robot may or may not be beneficial					
Subjective Norm					
People at work that influence may behavior think I will like/use the robot					
People who are important to me think I should use the robot					
The people I work closely with think the robot is a positive addition to the workplace					
Image					
Pharmacies with robots have more prestige than those who do not have a robot					
Having a robot in the Pharmacy will make others want to work here					
Having a robot at the GCUH Pharmacy will increase the status of the Pharmacy					
The people in my organisation who use robots have more prestige than those who do not					
Voluntariness					
Whether I use the robot or not is up to me (it is voluntary)					
My supervisor will not require me to use the robot					
Although it might be helpful, using the system is certainly not compulsory in my job					
I will avoid using the robot as much as possible					

Unique ID Code

Please enter the letters & numbers as asked below

1. 1st Initial of your middle name (if no middle name use surname)
2. Month you were born as a 2 digit number (eg March = 03, September = 09)
3. Last letter of your middle name (if no middle name use surname)

For example, Mary Rose Janson, born in February would have the code R02E

This code will be used to match to your survey after the robot has been installed

Appendix 11 ETAM Staff Survey – phase two

Griffith University
School of Pharmacy
Parklands Drive
Southport Qld 4215

Gold Coast Health
Building a healthier community

Evaluation of the impact of a Pharmacy Robotic Dispensing System on the GCHHS Pharmacy department

Ethics Number: HREC/17/QGC/18

Please enter your unique ID Code | See front sheet for code

Please indicate your age (in years)

☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65-74 ☐ 75 +

Gender

☐ Male ☐ Female

What is the highest degree or level of school you have completed? *If currently enrolled, highest degree received.*

☐ Less than Year 12 or equivalent
☐ Year 12 or equivalent eg HSC/leaving certificate
☐ Tafe/Trade/technical/vocational training
☐ Associate diploma
☐ Undergraduate diploma
☐ Bachelors degree (including honors)
☐ Postgraduate diploma (includes graduate diploma/certificate)
☐ Masters degree
☐ PhD

Did you participate in the first staff survey prior to the installation of the robot in May 2016?

☐ Yes ☐ No

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Perceived Usefulness					
Using the robot has enabled me to accomplish tasks more quickly (eg take less time to dispense a prescription/process imprest orders)					
Using the robot improves my performance in my job					
Using the robot in my job increases my productivity					
Using the robot has increased my efficiency in my job					
Using the robot has made it easier to do my job					
The robot has been a useful addition to my job					
The robot has had no impact on reducing my stock picking errors					
The robot has reduced my dispensing errors					
There are more stock discrepancies with the robot					
Perceived ease of use					
I clearly understand how to interact with and use the robot					
I think the robot is difficult to use					
Interacting with the robot requires a lot of mental effort					
I find it easy to get the robot to do what I want it to do					
I am confident on the actions required and support available if anything should go wrong with the robot					
Intention to Use					
Assuming I have access to the robot, I intend to use it					
I use the robot frequently					
I only use the robot if I have to					
Attitude					
Robots improve patient care by reducing medication errors					
Robots can improve patient care by improving efficiency					
I can easily access information on the robot					
The robot has created a barrier to work flow					
The robot makes me feel less valuable as an employee					
Job Relevance					
Using the robot is important in my job/duties					
Using the robot is relevant to my job/duties					
The work in the dispensary is completed in a reasonable timeframe					

The build-up of work in the dispensary at peak times is stressful					
Output Quality					
The actions and functions of the robot are of high quality					
The robot is unreliable					
The robot often breaks down and causes delays					
Usefulness Assessment					
I have no difficulty telling others about the benefits of using/having a robot in the Pharmacy					
The benefits of the robot are clear to me					
Subjective Norm					
The people I work closely with think the robot is a positive addition to the workplace					
People who are important to me think I should use the robot					
People at work that influence my behavior think I will like the robot					
Image					
Pharmacies with robots have more prestige than those who do not have a robot					
Having a robot in the Pharmacy will make others want to work here					
Having the robot at the GCUH Pharmacy will increase the status of the Pharmacy					
Voluntariness					
Whether I use the robot or not is up to me (it is voluntary)					
My supervisor will not require me to use the robot					
Although it might be helpful, using the system is certainly not compulsory in my job					
I will avoid using the robot as much as possible					

Unique ID Code

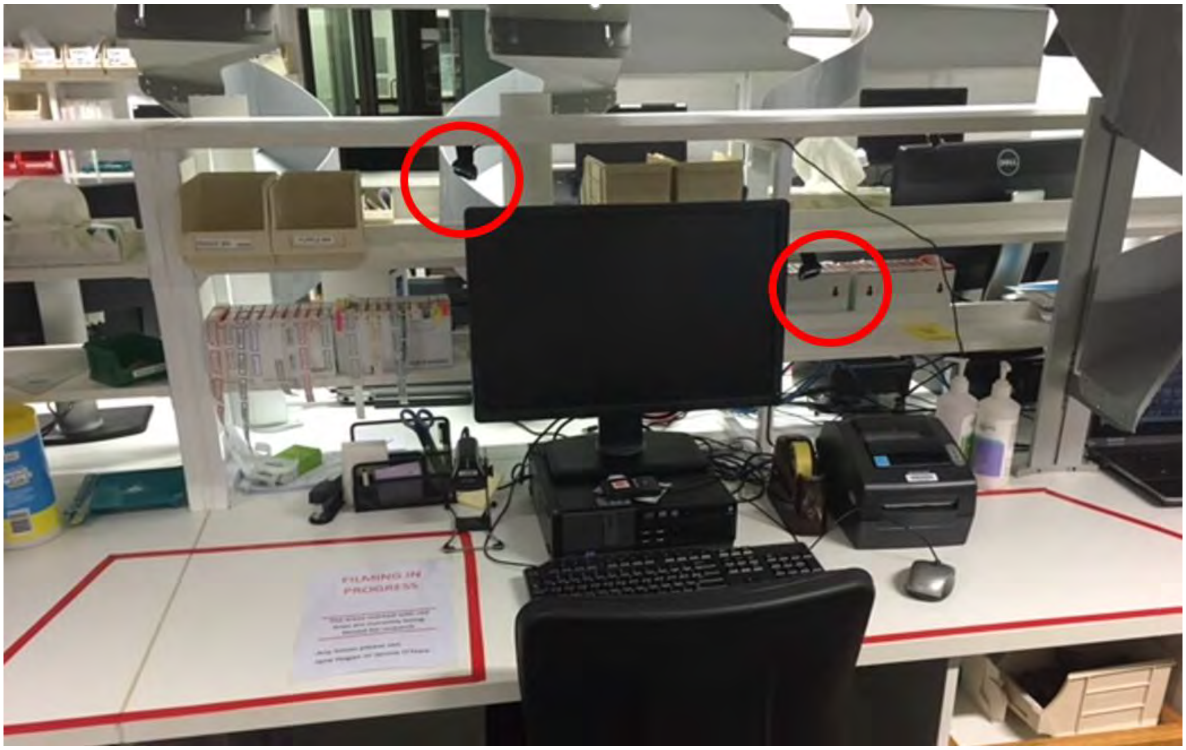
Please enter the letters & numbers as asked below

4. 1st Initial of your middle name (if no middle name use surname)
5. Month you were born as a 2 digit number (eg March = 03, September = 09)
6. Last letter of your middle name (if no middle name use surname)

For example, Mary Rose Janson, born in February would have the code R02E

This code will be used to match to your survey after the robot has been installed

Appendix 12 Camera placement at dispensing station and marked filmed working area



Appendix 13 Training sheet for research assistant data collection

Log into Database:
Login details to be sent eventually in the upcoming days
Desktop, Dropbox (doubleclick), Open 'Final Release' (not .zip), Open 'Date_input.accdb'

General information

- This is a time in motion study – trying to capture the journey of the bucket, what is in it and what happens to it. Recording the time of the day even down to seconds
- Start at top with bucket number and work your way down. Additional information can be added in other fields as they are seen
- Press F5 to refresh the home screen if you can't see the bucket you entered
- Follow the journey of the bucket in and out of fields
- It is a 24 hour clock eg 2pm = 14:00
- Time field – click on the field to enter the date, click elsewhere to reveal the time to populate. Utilise copy and paste for time fields to save this step each time
- Can skip back and forth in video by Playback-'jump forward' or 'Jump backward'. If needing to move greater amount of time utilise the 'Jump to specific time' however note the time you are leaving so you can easily return
- There are 2 staff being trained during this time – a bucket can be removed from a shelf and then return with no action
- Pressing the spacebar with pause and play the video
- The cameras have only captured footage when there was movement in front of them. SO time can jump forward quicly

Flow

Record bucket number	if you can see the bucket number record other details, the bucket may become available later When starting a new bucket – self check it is not already on home screen and needs to be marked off flow Exclude yellow bucket 82 unless it is placed on top shelf
Changed bucket number	Please update the original bucket number to the new number and colour If bucket split into 2 buckets, please start a new bucket number and retain the details of the first bucket
Record bucket colour	Options are beige, blue, red, yellow
Camera number	This has to be added each time
# Items in bucket	Indicate all number of items in the bucket. If part packs are used (not original packaging) please tick the part pack box This may not be clear at flow – this may be clearer at 'dispensing'
Date/time arrived	Time you first see the bucket in view – must be recorded Force function: will not allow times earlier than this in other fields
Date/time left	Time the bucket leaves the view of flow and doesn't return

	This could be the same number as 'removed from top shelf' or 'picked up from low shelf' Must be recorded Force function: will not allow times later than this in other fields Buckets recirculate quickly, important to mark out of field
Staff member leaves station	Each time someone leaves the work station for more than 3 seconds please record that they left. It will ask for a return time and why they left. If you are not sure why – unknown is available
View/edit existing date	You may wish to change the information entered about the staff member leaving. Note if multiple entries there will be more than one page to scroll through at bottom of pop up
Inpatient label put into bucket	For inpatient buckets only (ie book or just labels in bucket) It is assumed there are labels in the bucket when it is placed on the shelf This is when new labels are added Note: this can be very difficult to see at flow. Exclude if you can't see the bucket number
Inpatient book put into bucket	When a bucket only has labels and no inpatient book. Record when the bucket receives a book You will not often use this function as inpatient buckets usually have books in them
Bucket moved to low shelf	The time the bucket touches the low shelf
Bucket picked up from low shelf	When collected Record time and what happened eg collected stock. Unknown if not sure Note: Not all buckets will start here
Edit data	If you need to change the information recorded for "bucket picked up from low shelf" Eg recorded unknown, later see if was to collect stock
Bucket moved to top shelf	Record time bucket first placed on shelf
Bucket removed from top shelf	Time bucket first removed from shelf Remember: record the time the bucket leaves view of the camera in the 'date/time left'
Repeats Invoice Fridge Green sticker DMR IMAR	Recording what is in the bucket/script Please tick when you see any of these item during the journey Can be added to or edited throughout the dispensing/checking process where a clearer view is available See examples provided for guidance on what these look like Inpatient book = book in bucket or labels only in bucket
Dispensing occurred at flow	If the labelling and assemble occurred at flow, please tick this box to open up the dispensing field

When top shelf gets 'crowded' (eg end of day)	Write down order of buckets to better keep track and cross them off as they leave

Dispensing

Record bucket number	Record the bucket number if not entered
Changed bucket number	Please update the original bucket number to the new number and colour If bucket split into 2 buckets, please start a new bucket number and retain the details of the first bucket
Camera number	This has to be added each time
# Items in bucket	Indicate or update all number of items in the bucket. If part packs are used (not original packaging) please tick the part pack box
Date/time arrived	Time you first see the bucket in view – must be recorded Force function: will not allow times earlier than this in other fields
Date/time left	Time the bucket leaves the view of dispensing and doesn't return Must be recorded Force function: will not allow times later than this in other fields
Staff member leaves station	Each time someone leaves the work station for more than 3 seconds please record that they left. It will ask for a return time and why they left. If you are not sure why – unknown is available
View/edit existing date	You may wish to change the information entered about the staff member leaving. Note if multiple entries there will be more than one page to scroll through at bottom of pop up
Activities in field of view	
Labels were pre-printed	Please tick if labels are already available eg inpatient and nutriton
Start processing Rx	When barcode is scanned on script If no barcode scanned - enter when script picked up from bucket
Labels finish printing	Record time when the last label is printed
Start labelling/assembling	When 1st label removed from strip to add to book/item
Finish labelling assembling	All items labelled and added to bucket with paper work and script Remember: enter the time the bucket leaves view in the 'date/time left'
Additional labels printed during assembly	If further labels are required after final label print please tick this box This does not include blank labels
Pharmacist check occurred at station	If the product is barcode scanned or placed in a bag then pharmacist is checking at the station

	Record that this has happened here and it will open the pharmacist check option

Pharmacist Check

This is effectively the end of the journey, recording only when the bucket arrives for checking

Date/time arrived	Record when the bucket has arrived at the checking station If pharmacist checking at flow/dispensing please record when the first product gets scanned or placed in brown bag