Kimber, Michael B. (2007) ***The application of telepharmacy as an enabling technology to facilitate the provision of quality pharmaceutical services to rural and remote areas of Australia.*** **PhD thesis, James Cook University.**

Chapter 6 Development of a telepharmacy system

6.1 Introduction

Whilst the surveys described in the previous chapter found that there was limited support for automated dispensing of medicines outside of pharmacies, other aspects of telepharmacy found support. These included the provision of medication information via telepharmacy and the possibilities of remote medication reviews. Alongside the study of the receptiveness of telepharmacy applications among healthcare professionals was an examination of the applicability of available automated dispensing machines to the Australian context. This chapter discusses design requirements needed for suitable automated dispensing, existing equipment available, and provides schematics of test machines suitable for the local context. The results of this study provide prototype equipment which would enable pharmaceutical professionals to adapt telepharmacy to an area of particular need: Medication Reviews in rural and remote areas.

In March 1999, R.W. Manning, then Senior Policy and Planning Officer for Territory Health Services (Northern Territory Australia), wrote the following requirements for a system to allow technology to provide pharmaceuticals to remote communities:[155]

- transmit online prescriptions;
- combine prescribing and dispensing programs;
- allow supply at time of prescribing;
- use inventory control with portable data entry;
- have visual and oral communications between remote health clinic and pharmacy;
- develop Consumer Medical Information (CMI) to be electronically produced for local community;
- use “telepharmacy” to allow pharmacist to monitor procedures in distant locations;
- communications directly with clinic staff;
- have patient medication profiles available to pharmacist for online viewing;
- allow clinic staff to link up with District Medical Officer (DMO) at all locations.

In order to achieve this, Manning stated that it would be necessary to make use of existing commercially available software and to integrate this into a program such as the Rural Health Information System, (now called Primary Care Information System or PClS). Manning further claimed that this would provide technical expertise, reduce time for implementation, assist in training and provide economies of scale. Furthermore to achieve this aim it would be necessary to establish an appropriate body to manage the change process. The results expected would be:

- a reduction in the high staff turnover in remote health clinics now being experienced
- an overall satisfaction from all stakeholders in the process
- a high degree of uniformity in actions across all clinics and their operations

Unfortunately these recommendations were not accepted by the Territory Health Services, but some elements were subsequently incorporated into the Nguiu Pharmacy project in the Tiwi Islands (see Chapter 4).

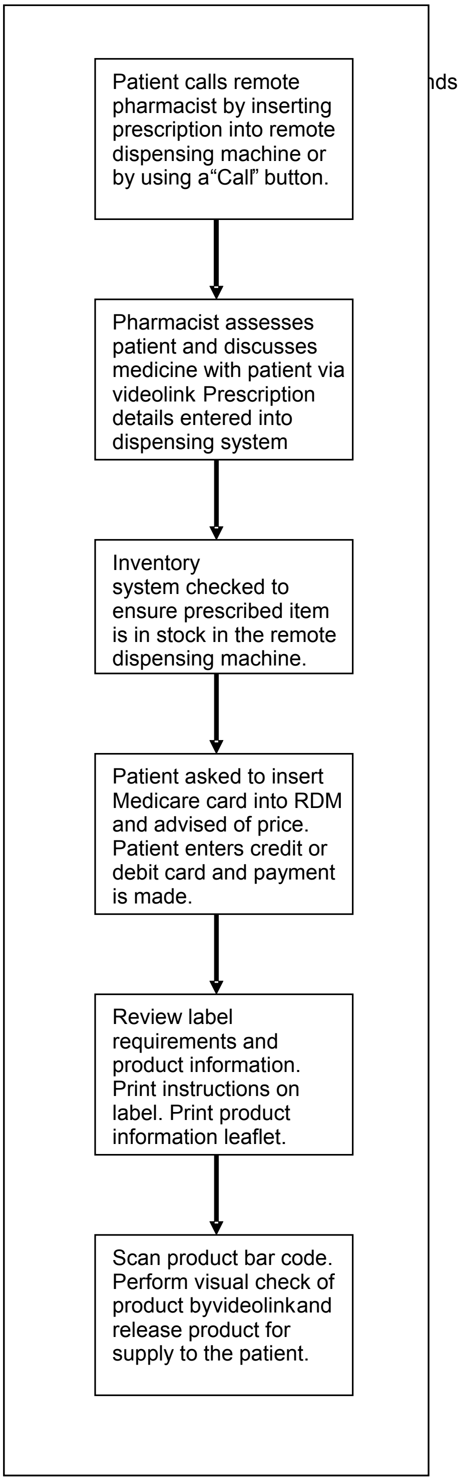
The introduction of simple quality control measures is a further example of how technology can provide a quality pharmaceutical service. Peterson et al. stated that one of the main factors identified as being important in reducing the risk of dispensing errors was having mechanisms for checking dispensing procedures.[156] This is even more important in areas where pharmacists are not available and the responsibility for medication supply has been delegated to nurses. Rich in her article on "How we think about medication errors: A model and a charge for nurses"[157] stated that "Utilization of simple prescription technologies, like bar codes and onscreen drug images, can reduce medication dispensing errors by one full percentage point."

The requirements for a videolink were further defined in the Victoria Department of Human Services Remote Pharmacy Pilot Project Evaluation which stated "The overall finding of the evaluation was that the pilot pharmacy videophone project has been successful in demonstrating that pharmacy advice and consultations can be delivered effectively by videophone. The videophone service has been highly valued and has facilitated improved access to primary health care service in a remote community in Victoria".[158] This study therefore entrenched the requirement for a video conferencing capability to be incorporated in a remote dispensing machine.

A draft outline specification prepared by Australian Vending Innovations further defined a telepharmacy system suitable for Australian conditions.[159] This outline specification included a flow chart of the required processes, including the ability to accept credit card and EFTPOS card payments.

Whilst there is no record of such a machine being built the specifications are very comprehensive. However, the draft specification did not include a description of the dispensing software and therefore it is likely that the software was to be custom written for the application.

Figure 46: Australian Vending Innovations Flow Chart



Particular issues identified in the preliminary studies and Manning's requirements for telepharmacy applications in Australia provide a foundation for adapting existing automated dispensing systems to suit local requirements.

In July 2005, Manning further refined these requirements to provide pharmaceuticals to remote communities in an unpublished report entitled "Remote controlled robotic dispensing machine".[160] The requirements were defined as follows:

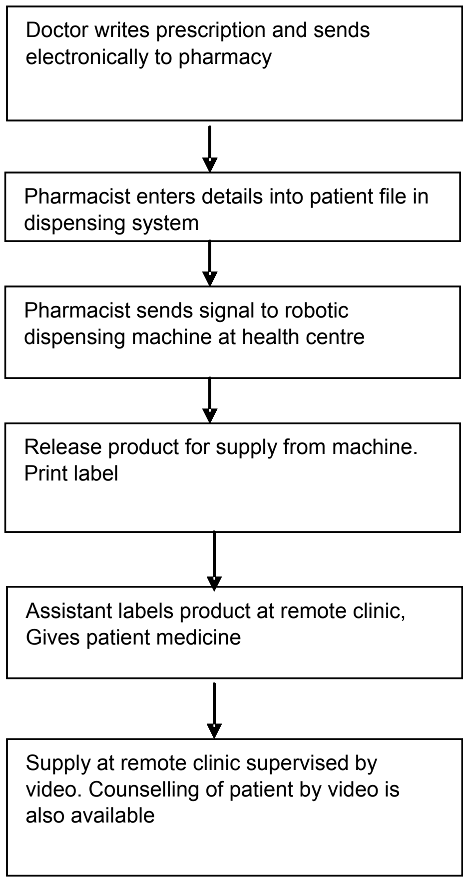
- Doctor prescribes on IT system chosen by clinic as its preferred Patient Information Recall System.
- Prescription is transmitted electronically to central pharmacy which has the contract to supply and dispense for the nominated health centre where the doctor is practicing.
- Pharmacist enters prescription data into database for patient to check that all is okay and there are no adverse reactions likely with other prescribed medicines or previously diagnosed treatments.
- Pharmacist sends electronic signal to remote dispensing machine at the health centre and instructs machine to drop a packet of drug out of compartment in which it is stored.
- Pharmacist instructs printer at remote health centre to print the label for the prescribed medication.
- Pharmacy technician at remote health centre matches up the packet and the label in view of the pharmacist at the central point through web video camera.
- Dispensing is complete and labelled medicine is handed to patient with appropriate counselling by either the pharmacy technician or the supervising pharmacist by video link.
- Machine is refilled on a regular basis from the central location of the host pharmacy.

In addition, in the Manning[160] report he concluded that the number of medicines to be held by the machine at a clinic need only be less than 100. In the Tiwi Pharmacy Upgrade Project it was found that for a population of 2,500 people the number of medicines dispensed in a three month period in total was 12,000 and of these 4,300 were for chronic disease management. A further analysis showed that the top 50 represented 3,592 (83%). A good case could be made for a machine to hold just 50 products although if one existed with a capacity of up to 100 products this could be utilised. The high prescribing of perindopril erbumine (Coversyl) tablets on the Tiwi Islands is due to the work on prevention of renal disease. In Minnesota in the U.S.A., Mendota Healthcare has installed an automatic dispensing machine named InstyMeds which has a limited but comprehensive stock level of 80 individual products for after hours medical centre use where no physical pharmacy is available.[161]

Other conclusions from the Manning report were:

- Machine refill would ideally be done along the same lines as say the catering modules on airlines. A full cartridge replacing a partly used cartridge on a regular basis. The replacement would come from the central location.
- Speed is not a factor – the degree of speed does not matter as it is the convenience to the patient to receive their medicines that is the motivation for this device. The volume of usage is not great – the quality use of medicine is a key improvement sought.
- Connectivity by Broadband should be assumed.

Figure 47: Remote controlled dispensing machine (Manning)



The above specifications whilst comprehensive do not include the provision for bar code reading.

A search of the United States and European Patent Office databases revealed a number of issued Patents in the U.S.A., European Patent Office and World Patents. The search criteria used were "pharmaceutical dispensing systems", "telepharmacy" and "automated pharmaceutical".

Table 34: Automated Dispensing and Telepharmacy - Relevant Patents

S#	Ref	Description	Publication Details	Comments
6	A	Automated dispensing system[162]	1974-01-15 US3786421 –	Atlantic Richfield Co
23	B	Prescription drug-dispensing apparatus[163]	1977-10-18 US4054343	
13	C	Pharmaceutical dispensing cabinet[164]	1981-05-19 US4267942 –	
22	D	Drug dispensing apparatus[165]	1987-05-12 US4664289	Sanyo Electric
20	E	A dispenser for use with a drug dispensing device[166]	1993-10-14 AU4439693	Baxter
12	F	System, method and device for remote data capture[167].	1993-10-20: EP0566441 –	Euro CP Sarl
21	G	Drug dispensing system[168]	1994-08-17 GB2275123	
5	H	Automated dispensing system for pharmaceutical products[169]	1995-08-18: NL1000542C –	Consumer Health Entrepreneurs
18	I	Drug storing apparatus for automatic drug dispensing machines[170]	1997-01-23 AU4447496	King Sheng Wu
19	J	Processing apparatus for dispensing[171]	1997-05-06 JP9117492	Tokyo Shokai
11	K	Pharmaceutical dispensing device and methods [172]	1998-04-28 US5745366 –	Omnicell.com
9	L	Pharmaceutical dispensing system[173]	1999-05-25: US5907493 –	SmartCabinet RDS Robot System Innovat.com
10	M	Pharmaceutical dispensing arrangement[174]	2001-02-20 US6189727 –	S&S XRay
17	N	Drug dispensing apparatus[175]	2001-03-01 JP2000103401	Sanyo Electric
4	O	Integrated system and method of vending prescription medications using a network of remotely distributed, automated dispensing units[176]	2001-12-11 US6330491 –	Lion Nicholas
3	P	Integrated system and method of vending prescription medications using a network of remotely distributed, automated dispensing units[177]	2002-05-23: US2002062175 –	Lion Nicholas
8	Q	Medical pharmaceutical dispensing and selling system and pharmaceutical dispensary supporting system [178]	2002-10-25 JP2002312482 –	Mitsui Bussan
16	R	Systems and methods for drug dispensing[179]	2003-07-03 US2003125837	Telepharmacy-solutions.com
15	S	Drug dispensing cabinet having a drawer interlink, counterbalance and locking system[180]	2004-02-19 WO2004014285	McKesson Automation Robot Rx System
2	T	System and apparatus for the dispensing of drugs[181]	2004-06-10 US2004111179 –	Pyxis® Corp
7	U	Automated dispensing system[182]	2004-10-07 WO2004085262	ARX Rowa Speed Case Arxinter.net
14	V	Method for controlling a drug dispensing system[183]	2005-03-24 US2005065645	ADDS Telepharmacy-solutions.com
1	W	Automated dispensing system[184]	2006-02-01: EP1620319	ARX Ltd

Twenty-three Patents with some relevance to the above requirements were examined. The most relevant Patents were those issued to Telepharmacy Solutions (ADDS machine, used in the Washington State project[115]), McKesson Automation's Robot Rx System, ARX Ltd's Rowa Speed Case installed in hospitals in the United Kingdom and the Pyxis® Corporation MedStation (units installed in a number of hospitals in Australia) and Omnicell's Medication Dispensing System.

Examples of commercial automated dispensing equipment:

Figure 48: ADDS machine - Telepharmacy Solutions (www.telepharmacysolutions.com)

Figure 49: RobotRx McKesson Automation (www.mckesson.com)

Figure 50: ROWA Speed Case ARX Ltd (www.arxinter.net)

Figure 51: MedStation Pyxis® Corporation (www.pyxis.com)

Whilst all of the above patents had some key elements of the ideal requirements for a remote dispensing machine suitable for use in Australia, none had all the necessary elements. Most of the automated equipment installed in the U.S.A. is used for automated counting from bulk containers.

Based upon the Manning Tiwi Island Pharmacy requirements and the Australian Vending Innovations[159] draft specifications, the essential requirements for an automatic dispensing system suitable for rural Australia are summarised as follows:

6.1.1.1 Requirements:

1. A unit capable of storing a range of 80-100 individual medications, with multiple pack storage for high volume products.
2. Entry of patient details into a standard dispensing system, preferably employing a touch screen type entry.
3. An automated method of removing, preferably, an individual product from the storage unit.
4. An image acquisition capability to store a picture of the dispensed product pack and the expiry date and batch number if required.
5. Bar code reading of the dispensed product.
6. Video supervision of the dispensing unit.
7. For remote operation, all the above features a method of reliably taking control of the automatic dispensing unit and operating it remotely, along with a method of viewing the patient's prescription if an online prescribing system is not available.
8. A video conferencing capability to enable the remote pharmacist to provide counselling services to the patient. This video conferencing capability could also then be used to provide medication reviews for patients in rural and remote areas who do not have easy access to a medication review pharmacist.

6.2 Development of a pilot automatic dispensing machine.

In order to test the hypothesis that a remote dispensing machine could dispense a limited range of products, and since a commercial remote dispensing machine was not available, it was proposed to develop two styles of pilot machines with the capability of dispensing demonstration products. The equipment was also to be capable of reading product barcodes and take images of the final pack prior to supply from the machine. It was proposed to use commercially available software and hardware wherever possible to reduce development costs. A trial was proposed comparing the operation of the pilot dispensing machine locally and then remotely.

6.2.1 Specifications

The purpose of this section is to describe the development of a pilot telepharmacy system to demonstrate that it is feasible such equipment could meet the requirements of a rural or remote clinic with no pharmacist. As stated by Lopes et al. in a paper delivered at the Intelligent Robots and Systems International Conference in 2004, the usage of standard components, whenever possible, has an important impact on the overall cost of actually producing a robotic system and this is an important constraint for many research groups.[(185)] In the construction of the systems described below, whenever possible, standard hardware and software components were incorporated into the design. There are two basic equipment designs.

The first design employs a variety of automation techniques from vending equipment (InstyMeds) to advanced robotics (RobotRx). The feature of this design is that individual product packs are selected and supplied. In most designs quality control features such as barcode scanning, video supervision and image acquisition are employed.

The second design consists of a cabinet design where individual compartments are filled with product. Each compartment may be configured to hold an individual pack or a stock of packs. The pharmacist releases the product for supply and an individual compartment is then opened. An example of this type of equipment is the Pyxis® MedStation. In ward use, typically a patient medication profile will be prepared by a clinical pharmacist and then a patient code is supplied to the ward nursing staff to allow the product to be removed from the MedStation as required. In some instances, for example a refrigerator, the door of the unit is opened by code number entry and the entire contents are available for selection. Dispensing safeguards such as barcode reading and, to a lesser extent, video supervision are employed. The design of demonstration pilot equipment will be discussed in four sections:

1. System layout
2. Design principles and process flow chart
3. Individual Design Elements mapped to requirements
4. The software required to meet the requirements

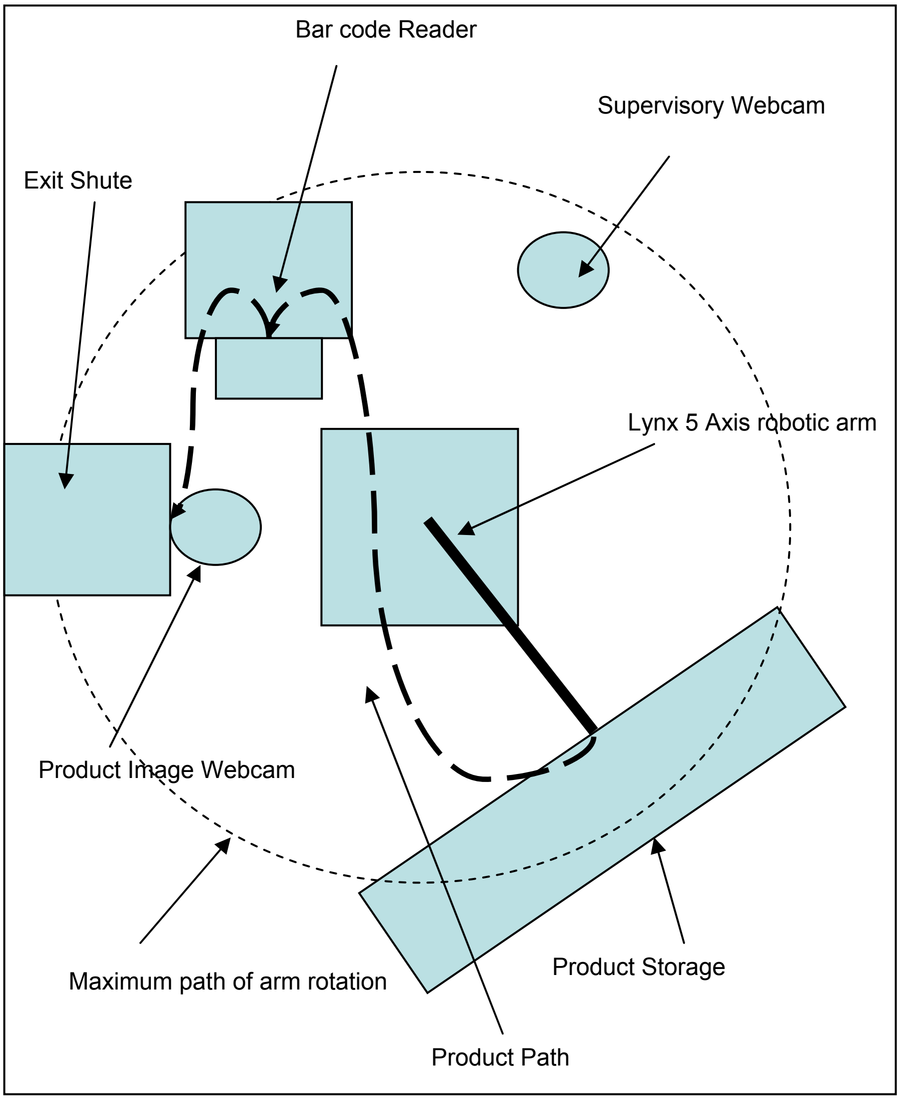
The requirements discussed in the Manning specifications and the Australian Vending Innovations draft specifications in the Introduction will be listed to highlight how these requirements were incorporated into the design specifications.

6.2.1.1 System layout.

6.2.1.1.1 Design A – Robotic version

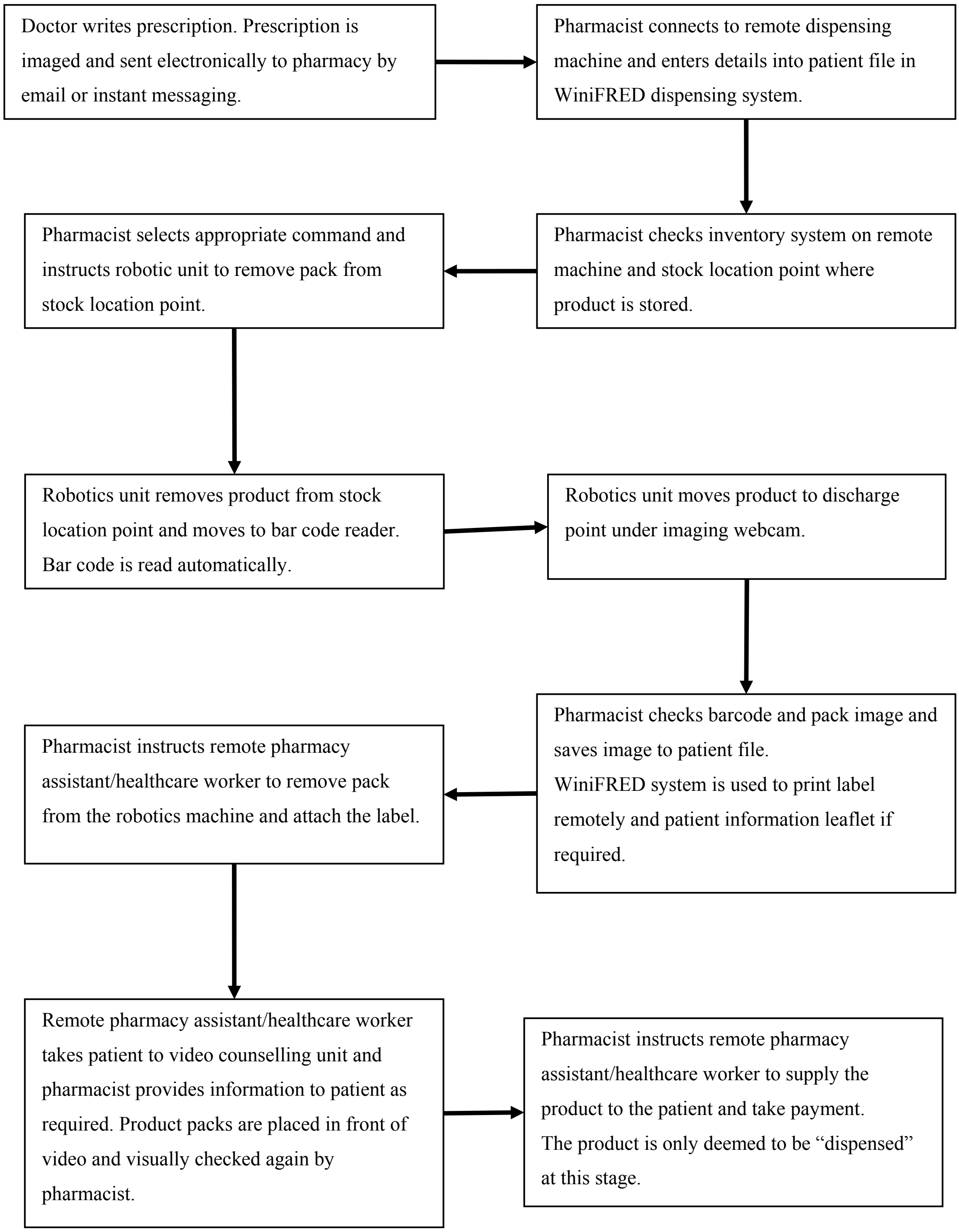
Design Principles

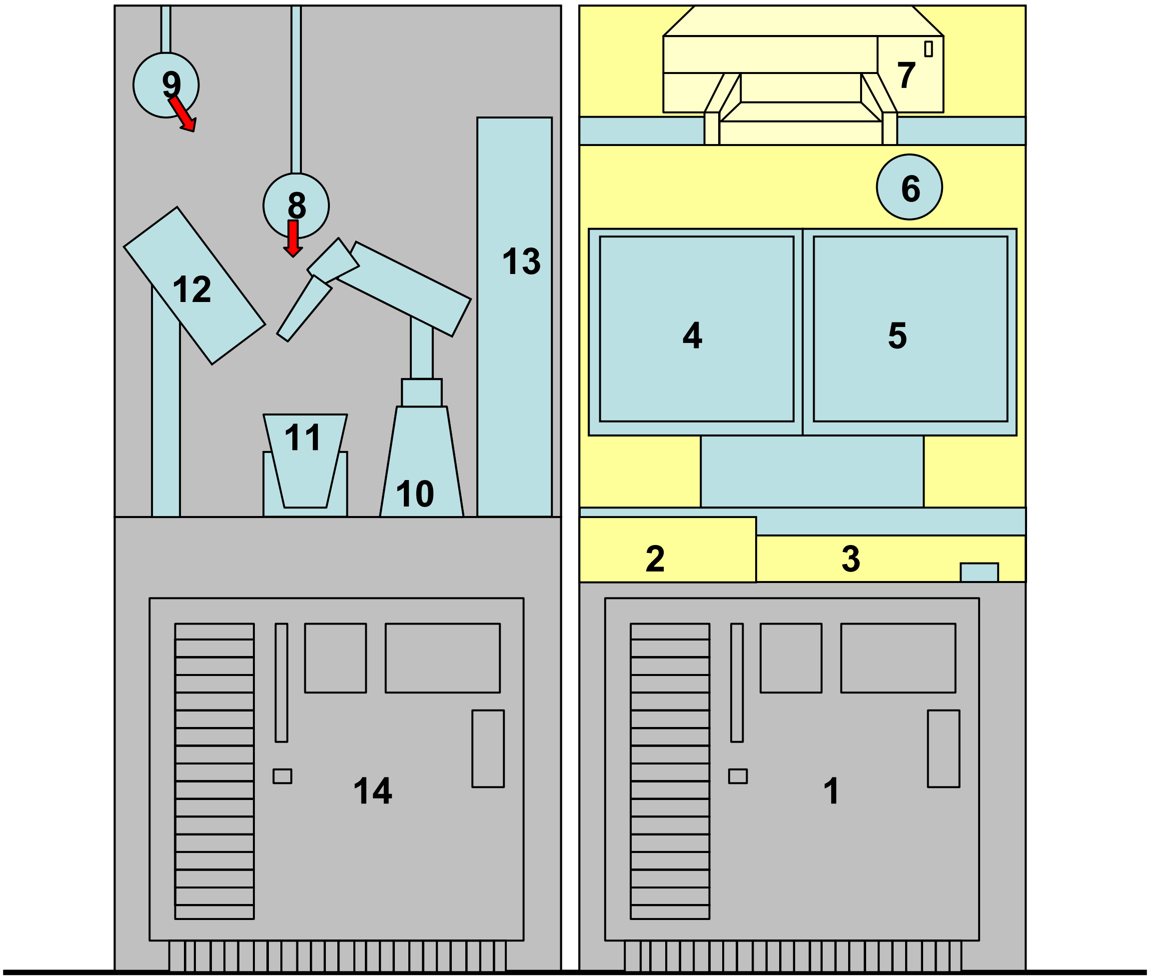
Figure 52: Plan Layout Drawing Design A – Robotic version



6.2.1.2 Design Principles and process flow chart

Figure 53: Process Flow chart - Design A – Robotic Version





Legend

Number	Description	Number	Description
1	Videoconferencing computer	8	Product imaging webcam
2	Scanner or imaging unit	9	Supervisory webcam
3	Keyboard & mouse(shared via KVM switch)	10	Robotic arm
4	Screen 1 – robotic unit	11	Discharge shute
5	Screen 2 - videoconferencing	12	Bar code reader
6	Videoconferencing webcam	13	Product storage area
7	Printer	14	Robotic unit computer

Figure 54: Design A – Robotic Version

6.2.1.3 Individual Design Elements mapped to requirements

Requirement 1. A unit capable of storing a range of 80-100 individual medications, with multiple pack storage for high volume products.

For the purpose of a pilot machine demonstration, a unit capable of supplying individual products from 10–12 storage locations, being approximately 10 per cent of the commercial unit requirements and suitable for demonstrating reproducibility and programming.

A honeycomb of 12 storage locations was constructed, each compartment holding one product pack.

Figure 55: Pilot dispensing machine storage compartments

Requirement 2. Entry of patient details into a standard dispensing system, preferably employing a touch screen type entry.

A national survey of pharmacists in 2005 by Lee[(123)] included a question about the use of dispensing systems in Australia. The WiniFRED seemed to be the most widely used dispensing system with 34.1

per cent respondents using it. Other dispensing systems, which were still being commonly used, include Locke (19.5%), Amfac (15.2%), Aquarius/Simple (12.0%) and MINFOS (8.5%).

An add on touch screen attachment was also incorporated into the final design (Magic Touch, Keytec Inc, Richardson, TX 75081).

The WiniFRED dispensing system (PCA NU Systems) was installed on the controlling PC, together with a printer to print labels.

Requirement 3. An automated method of removing, preferably, an individual product from the storage unit.

A micro robotic arm was constructed (Lynx 5 Axis Robotic Arrm, (Lynxmotion, Inc.
Pekin, IL 61555-0818).

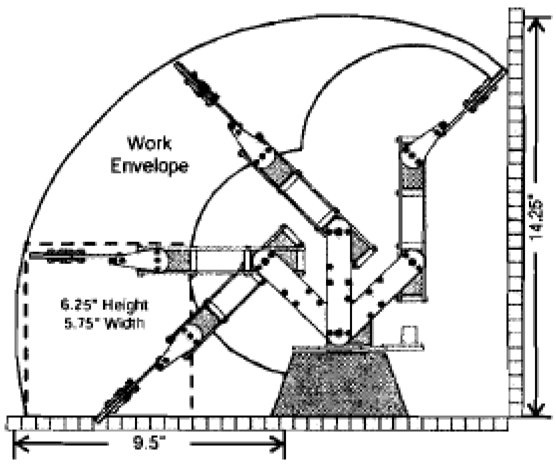


Figure 56: Vertical elevation - operating envelope Lynx 5 Axis Arm

The initial model constructed (Version 1) had rotational problems and consistently caught on the microprocessor wiring.

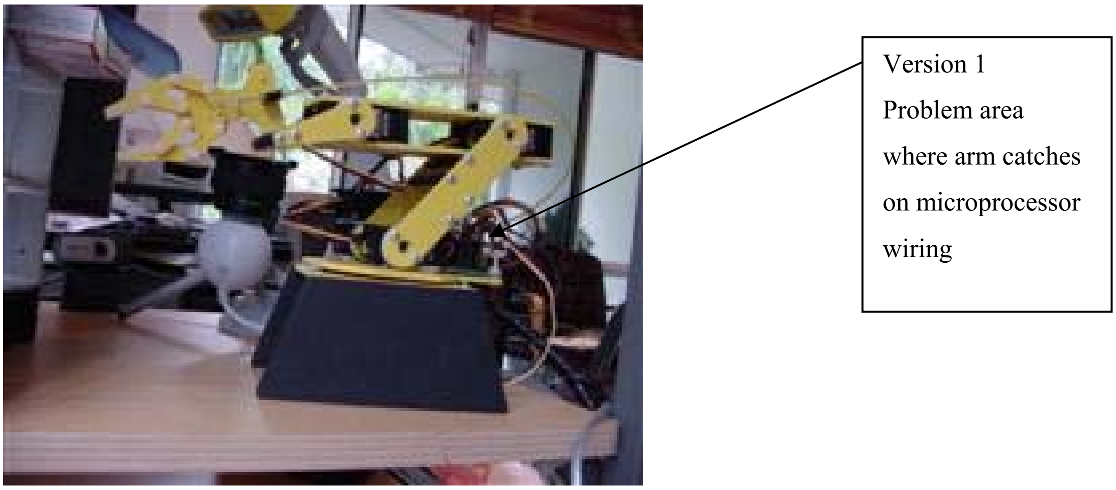


Figure 57: Lynx 5 Axis Arm- Version 1

A second version (Version 2) was constructed from scratch using larger servo motors and a rotating gripper. This version also had mechanical problems as the gripper servo was too heavy for the arm and severely limited the operating envelope and the base rotation was inconsistent.

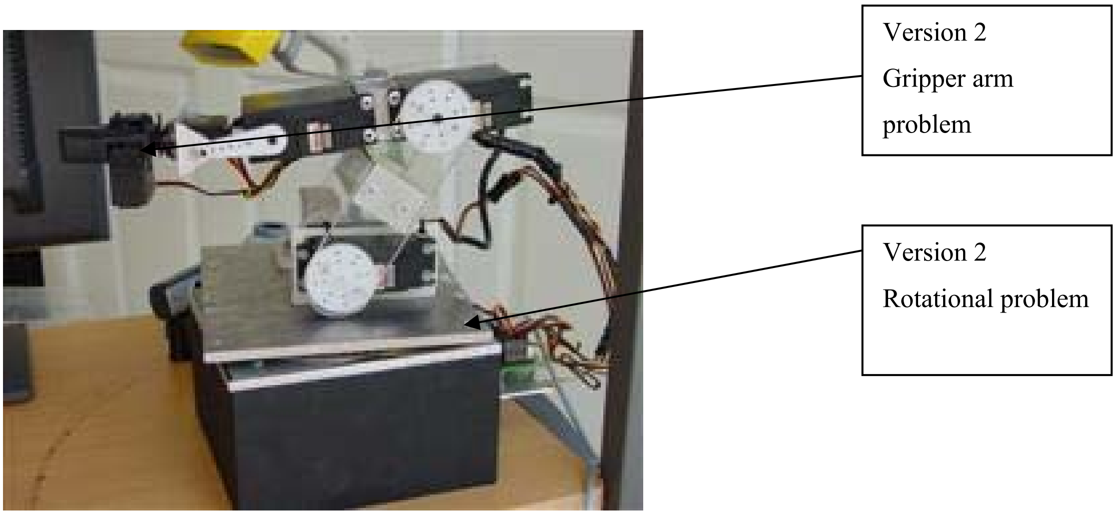


Figure 58: Modified Lynx 5 Axis Arm- Version 2

A third version was constructed using an updated base from Lynx which proved reliable in operation.

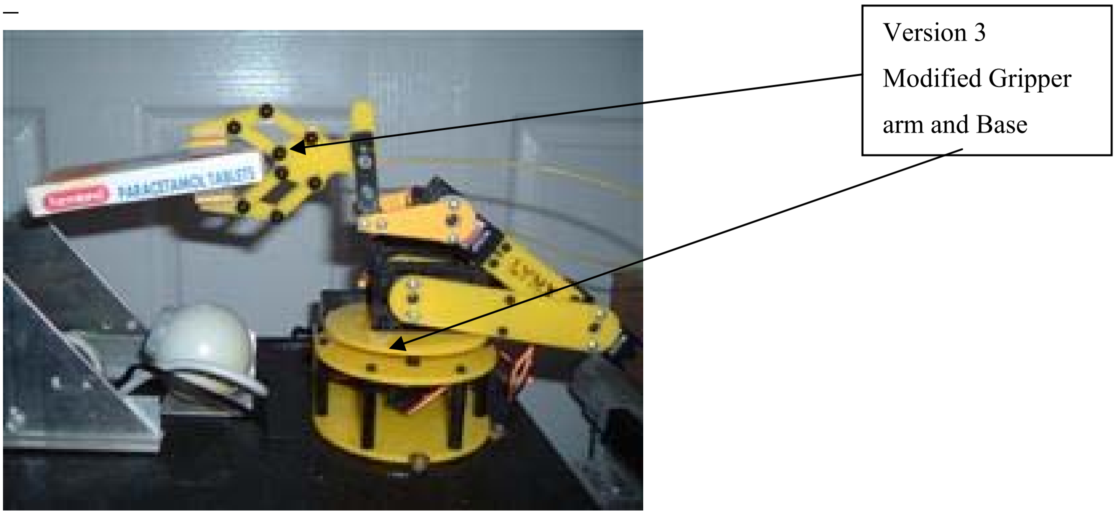


Figure 59: Modified Lynx 5 Axis Arm- Version 3

The version 3 arm can successfully remove an individual pack from one of the storage locations and place it in the delivery slot. The successful robotic arm (Version 3) was incorporated into the pilot dispensing machine.

Requirements 4&5. An image acquisition capability to store a picture of the dispensed product pack and the expiry date and batch number if required and bar code reading of the dispensed product.

Various designs were trialled, the final unit is shown in Figure 60. This unit incorporated two webcams to capture images of both sides of the pack and a barcode reader.

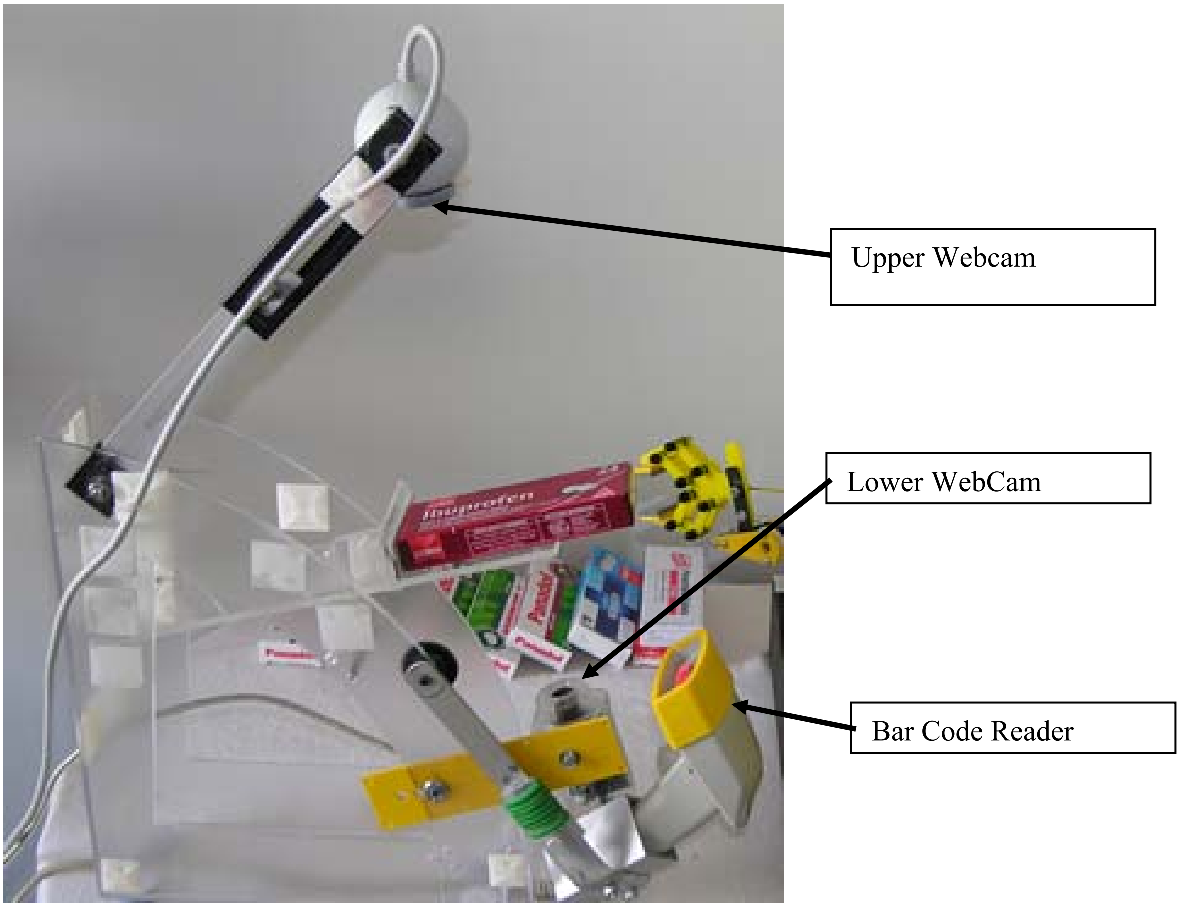


Figure 60: Data acquisition and barcode reading

Equipment specifications:

Various webcams were trialled, the main issue being to find a webcam capable of focussing within 150 mm, this being the average distance required to fill the frame with a product pack.

Of the many cameras trialled, the most successful were the Swann (Swann Corp), DLink300 (D-Link Corporation, Fountain Valley, CA 92708), QuickCam (Logitech Corporation, Romanel-Sur-Morges, Switzerland) and iSight (Apple Corporation, Cupertino, CA). The barcode reader installed was a Wasp CCD keyboard wedge scanner (Wasp Bar Code Technologies, Plano, TX, 75074).

Requirement 6. Video supervision of the dispensing unit.

Of the many webcams trialled and described above, the most suitable for in cabinet installation for viewing the dispensing operation was the Logitech QuickCam

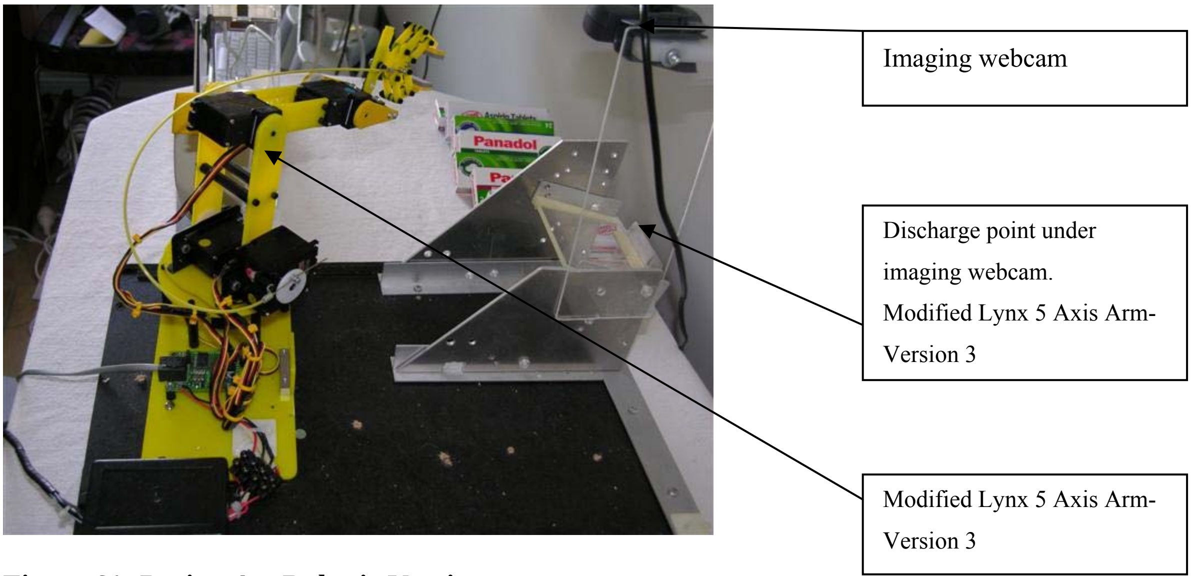


Figure 61: Design A – Robotic Version

Requirement 7. For remote operation, all the above features plus a method of reliably taking control of the automatic dispensing unit and operating it remotely, plus a method of viewing the patient's prescription if an online prescribing system is not available.

Trials done used two commercially available software products PCAnywhere (Symantec Corporation) and Microsoft Remote Desktop (Microsoft Corporation). These software programs allow a local computer to take control of a remote computer over a LAN, the Internet, or direct dialup. Early trials used PCAnywhere, but this was changed to Microsoft Remote Desktop when the iChat video conferencing program (Apple Corporation) was used. The Apple iSight camera and iChat combination provided a superior video conferencing platform because iChat uses the H264 video codec (see Chapter 3) and encryption.

Requirement 8. A video conferencing capability to enable the remote pharmacist to provide counselling services to the patient. This video conferencing capability could also then be used to provide medication reviews for patients in rural and remote areas who do not have easy access to a medication review pharmacist.

Initial trials of video conferencing used Microsoft NetMeeting and PC equipment with various webcams. Whilst acceptable, the video conferencing images and sound were often problematic, as reported by Peterson and Anderson.[117] With the release of the Apple iChat video conferencing software and iSight webcam, this equipment was trialled and proved to be a superior video conferencing system with the additional advantage of encryption. The remote connection software was therefore changed to Microsoft Remote Desktop as this program allows Apple equipment to connect to PC type equipment using the Windows XP operating system.

6.2.1.3.1 Design B – Storage Cabinet version

Requirement 1. A unit capable of storing a range of 80-100 individual medications, with multiple pack storage for high volume products.

For the purpose of a pilot machine demonstration, a unit capable of supplying individual products from 10-12 storage locations, being approximately 10 per cent of the commercial unit requirements and suitable for demonstrating reproducibility and programming.

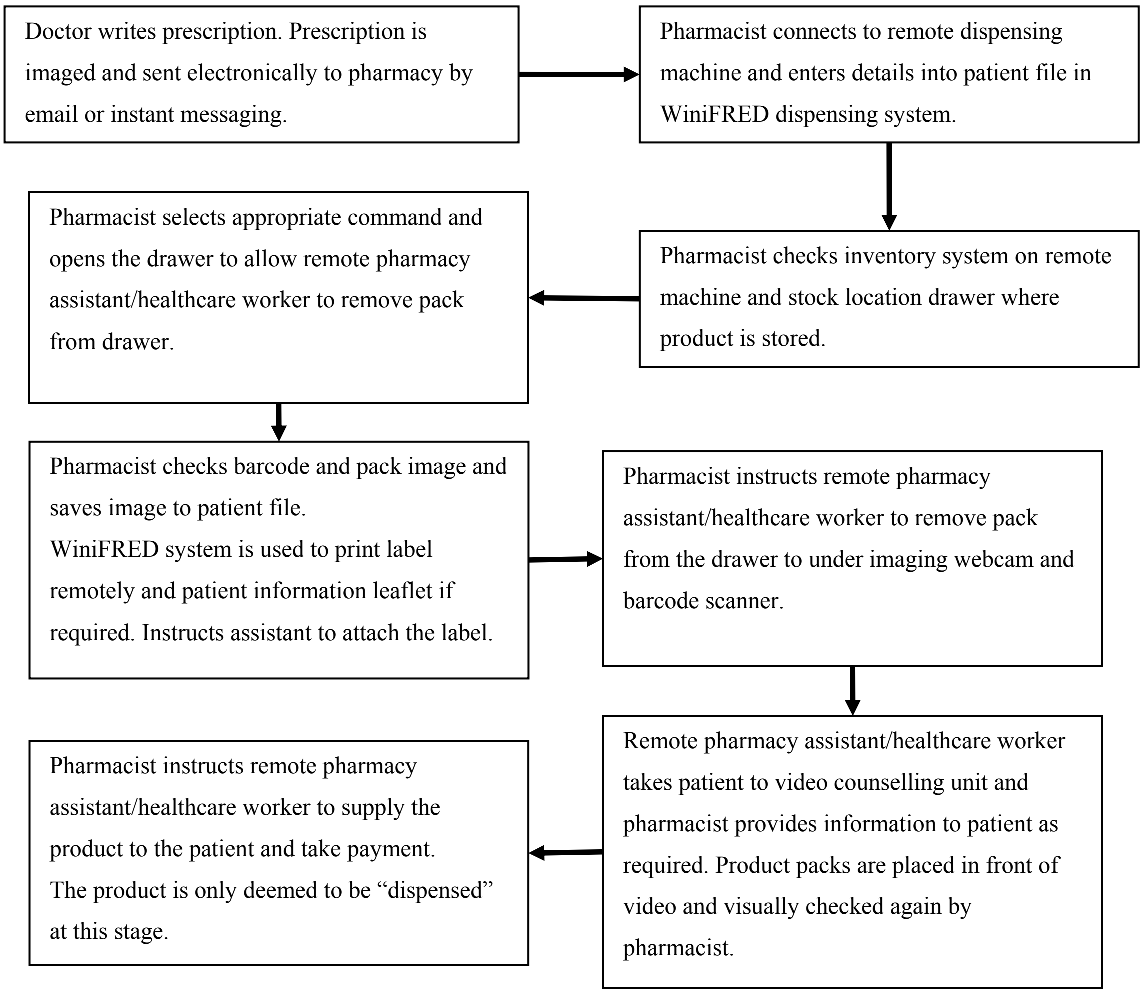


Figure 62: Flow chart - Design B – Cabinet Version

A storage cabinet version was constructed with three drawers. The top drawer had a rotary carousel with 4 compartments installed to allow individual packs to be supplied. The second and third drawers were constructed to allow a product pack to be removed from a reduced selection of products. This design mimics the Pyxis® MedStation.

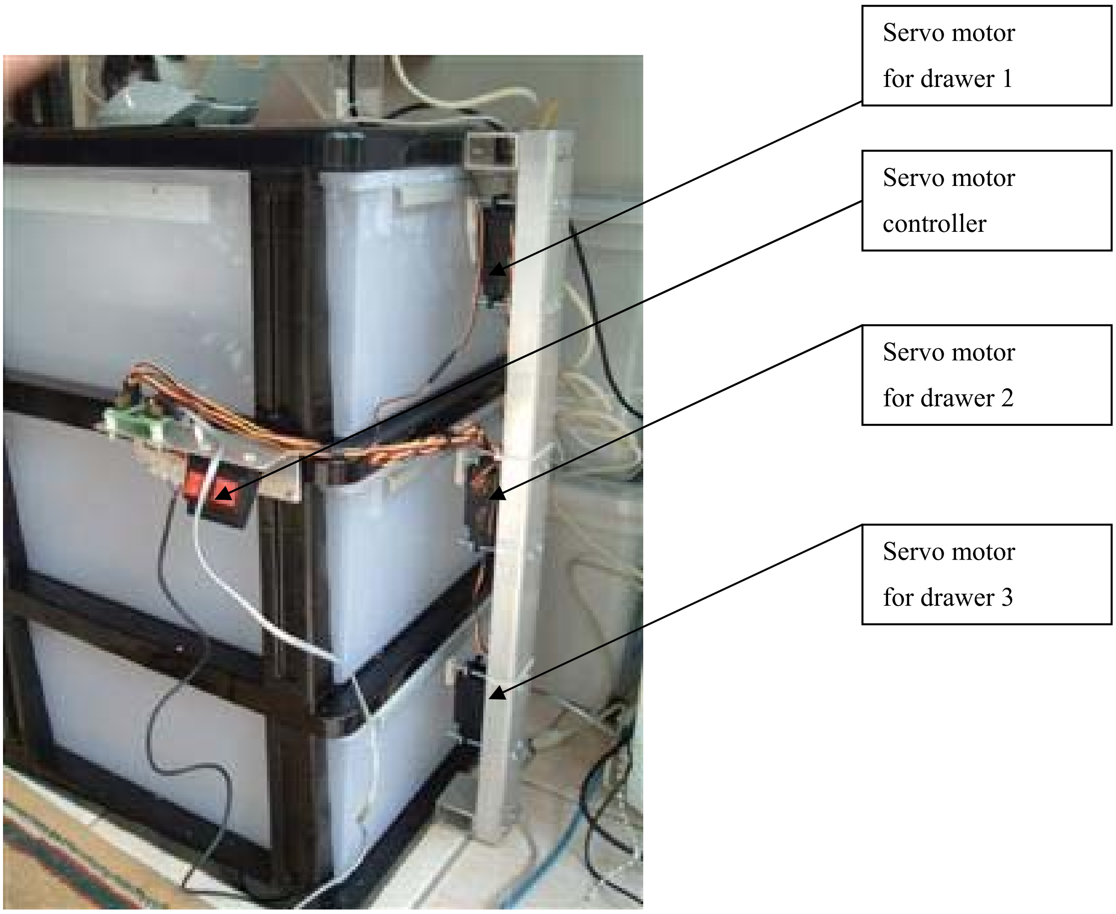


Figure 63: Cabinet style storage drawers

Figure 64: Cabinet style storage drawers, showing top drawer carousel.

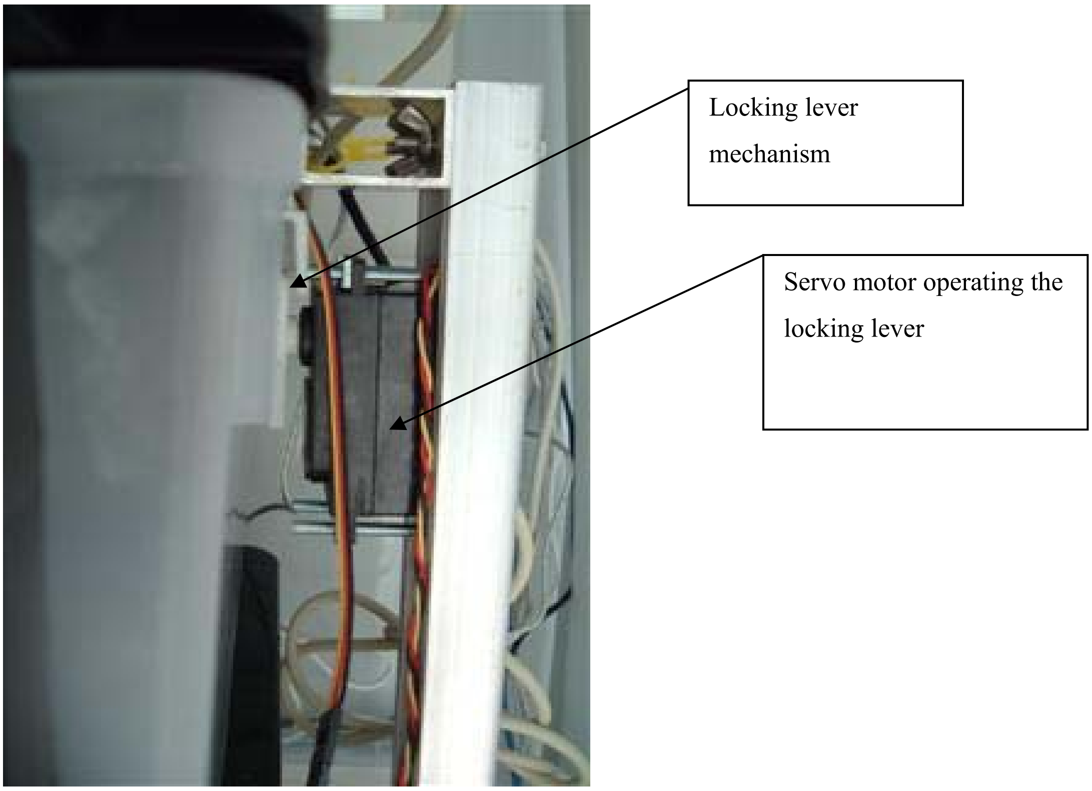


Figure 65: Cabinet style storage drawers, showing opening mechanism.

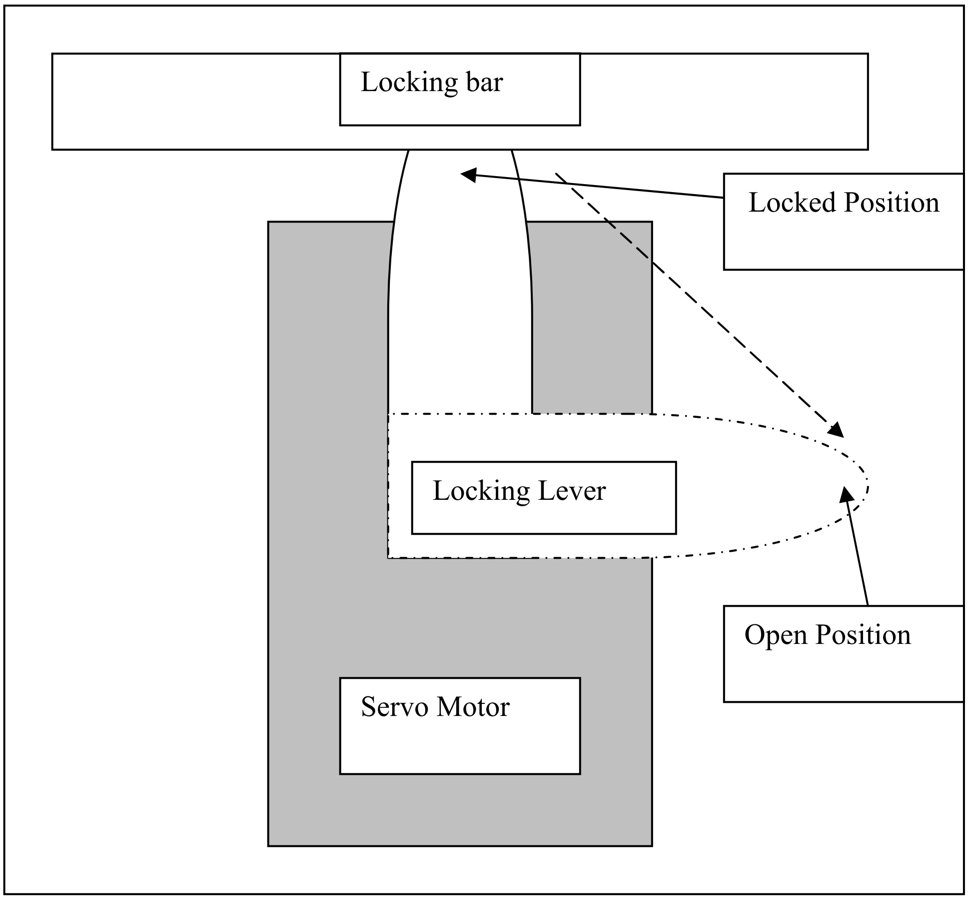


Figure 66: Cabinet style storage drawers, diagram of opening mechanism.

All the other requirements were the same as for the first design, therefore only the operation of the release of the locking catches to allow access to the drawers was trialled.

6.2.1.4 The software required to meet the requirements.

In order to operate the remote dispensing unit, the pharmacist uses Microsoft Remote Desktop software to connect to the remote computer. This setup automatically accepts a connection from the controlling computer. Diagrammatically this is represented as follows:

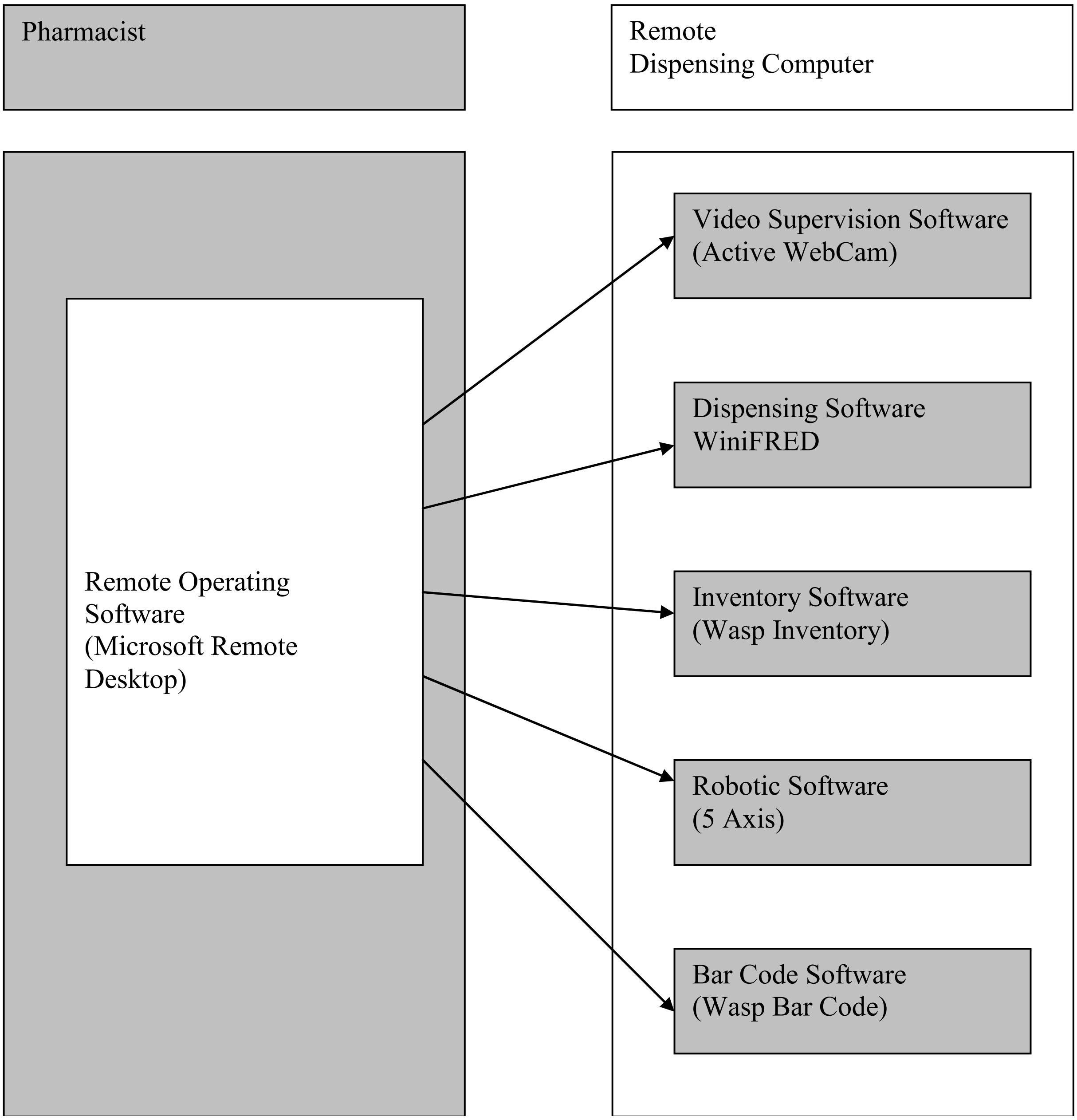


Figure 67: Software Components

6.2.1.4.1 Video Supervision Software

The software used for video supervision was either ProQ or Active WebCam. This program allows multiple webcams to be connected to the remote computer. The webcam outputs can be adjusted from full motion video (30 frames per second (fps)) to a single frame every minute. The frames can be recorded to disk and stored on the remote computer. For the purposes of remote supervision and to save on disk space, the software was set to record at one frame per 10 seconds.

6.2.1.4.2 Dispensing System Software

WiniFRED dispensing software was installed on the remote PC and interfaced to the printer.

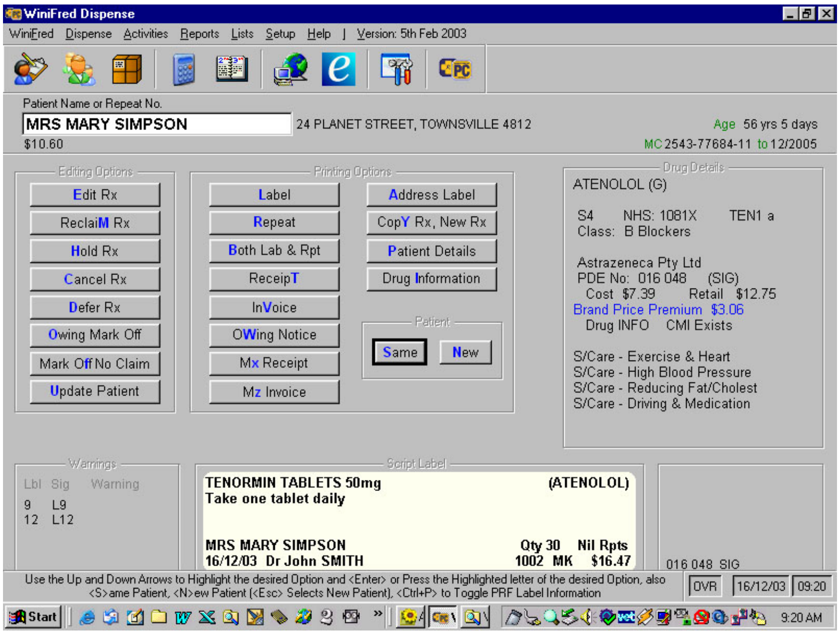


Figure 68: WiniFRED program interface

6.2.1.4.3 Inventory Software

The trial software used was Wasp Inventory, a basic inventory control software program. The software was setup with the 12 location storage points detailed below.

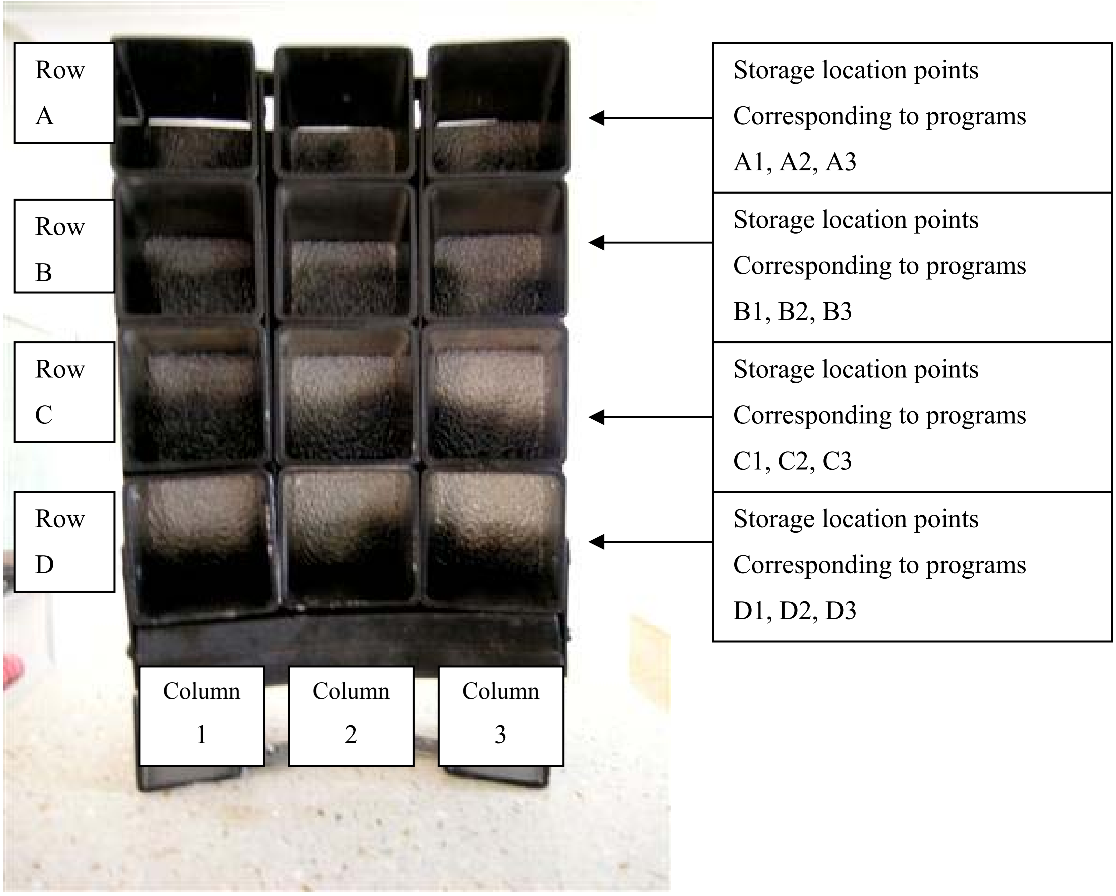


Figure 69: Location storage points corresponding to location storage and program routines

6.2.1.4.4 Robotics Unit Software

The robotics unit was controlled by 5 Axis ROBOT software (Beyond Technologies). This software allows the robotic arm to be programmed to follow a complex series of moves in three dimensions. The simplest way to program the robotic arm is to set the software in record mode and use the individual component sliders to record each segment. A complete sequence is then saved as a file. Each file has a location name and corresponds to the program needed to move a product pack from one of the defined storage locations to the bar code reading position, pause to allow the code to be read and then to move the product on to the discharge point under the imaging camera as shown in the layout drawing. The twelve product storage location points in the pilot unit were each programmed with a routine to instruct the robotic arm to remove the pack from that specific location point to the discharge point, via the barcode reader.

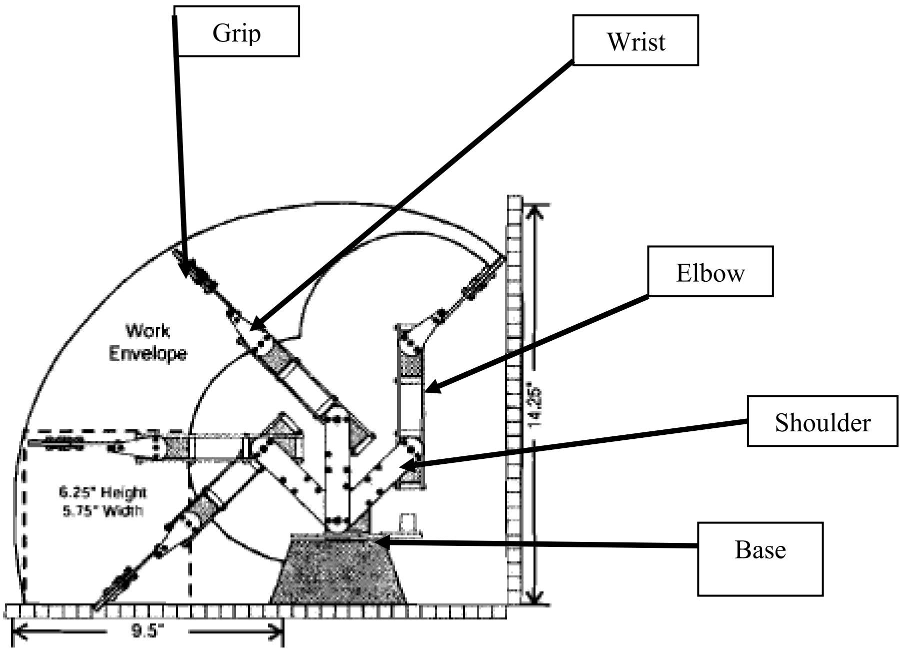


Figure 70: 5 Axes item descriptions

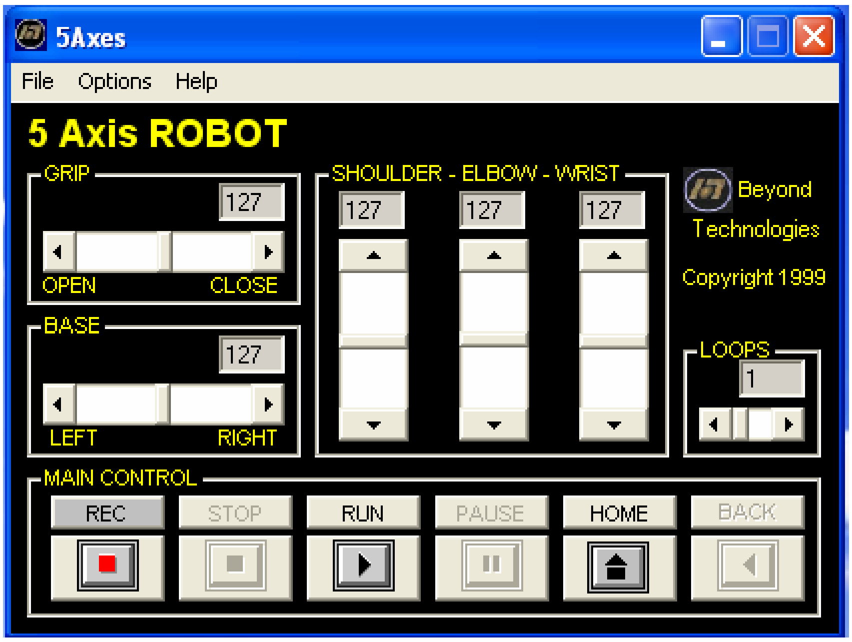


Figure 71: 5 Axes program interface

Range of movements possible: 0 – 255, corresponding to a movement of the robotic arm of 180^{0}.

Table 35: Example of program routine to move a product pack from location A1(Fig 69)

Comments	Commands	Position
Start	Reset	Home
Start of sequence to move to location point A1	Base	229
	Shoulder	160
	Elbow	160
	Grip	50
	Shoulder	119
	Elbow	150
	Shoulder	108
	Elbow	142
	Wrist	114
	Elbow	135
	Shoulder	100
	Elbow	128
	Shoulder	92
	Elbow	122
	Wrist	108
	Shoulder	92
	Elbow	122
	Wrist	108
End of sequence to move to location point	Shoulder	95
Start of pick up product sequence	Grip	250
	Base	50
	Shoulder	102
	Base	32
	Elbow	170
	Shoulder	250
	Elbow	234
	Wrist	102
End of pick up product sequence	Grip	50
Start of sequence to move to barcode reader	Base	127
	Shoulder	200
	Elbow	176
	Shoulder	250
End of sequence to move to barcode reader	Elbow	234
Start of sequence to move to discharge point	Base	32
	Wrist	102
	Grip	250
	Elbow	170
	Shoulder	127
	Elbow	204
	Base	230
	Shoulder	170
	Elbow	122
End of sequence to move to discharge point	Shoulder	100
	Wrist	108
	Shoulder	92
Drop product at discharge point	Grip	50
Start of sequence to move to resting point	Shoulder	96
	Elbow	133
	Shoulder	110
	Elbow	142
	Shoulder	170
End of sequence to move to resting point	Base	127
End	Reset	Home

6.2.1.4.5 Barcode reading software

The bar code reading software used for the trial was the Wasp Inventory software. The bar code reader used for the trial is a keyboard wedge design and therefore the bar code read by the unit can be recorded by most text reading programs on the local computer such as Microsoft Excel.

6.2.2 Calibration of the equipment

In order to determine the accuracy of the robotic arm to withdraw a pack from a specific point and move the pack 180^0, a series of cycles were completed in local operation mode and the variation calculated.

6.2.2.1 Method

The robotic arm was set up and connected to the local computer via the serial port connection. A pick up point was set at the beginning of the cycle. A mark was drawn on the support section of the pick up point and the pack was aligned to this line (see below).

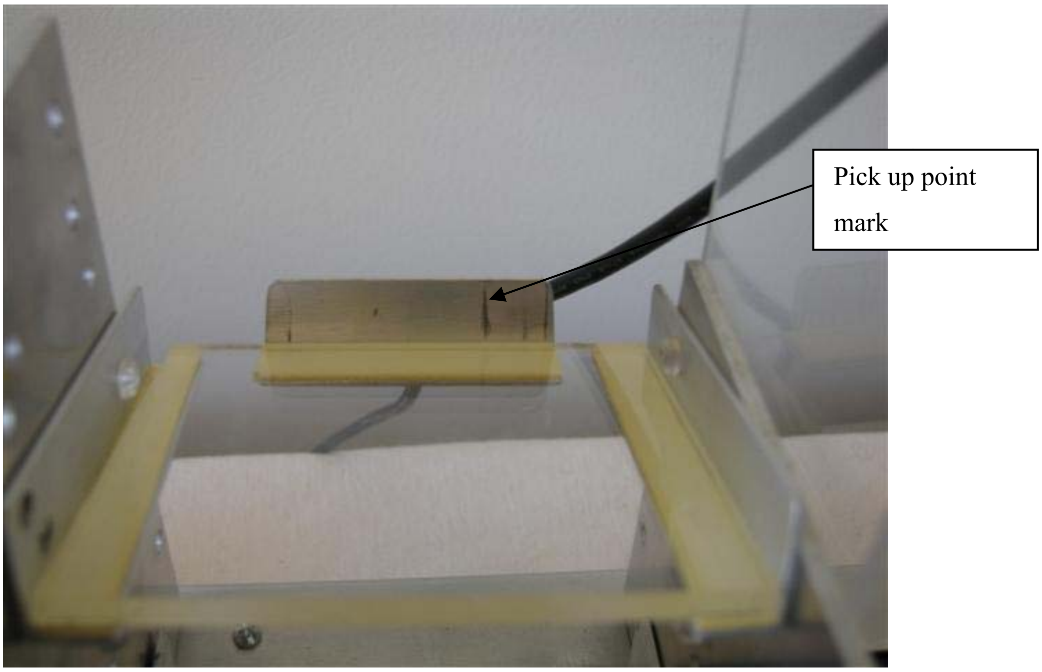


Figure 72: (a) Pick up Point

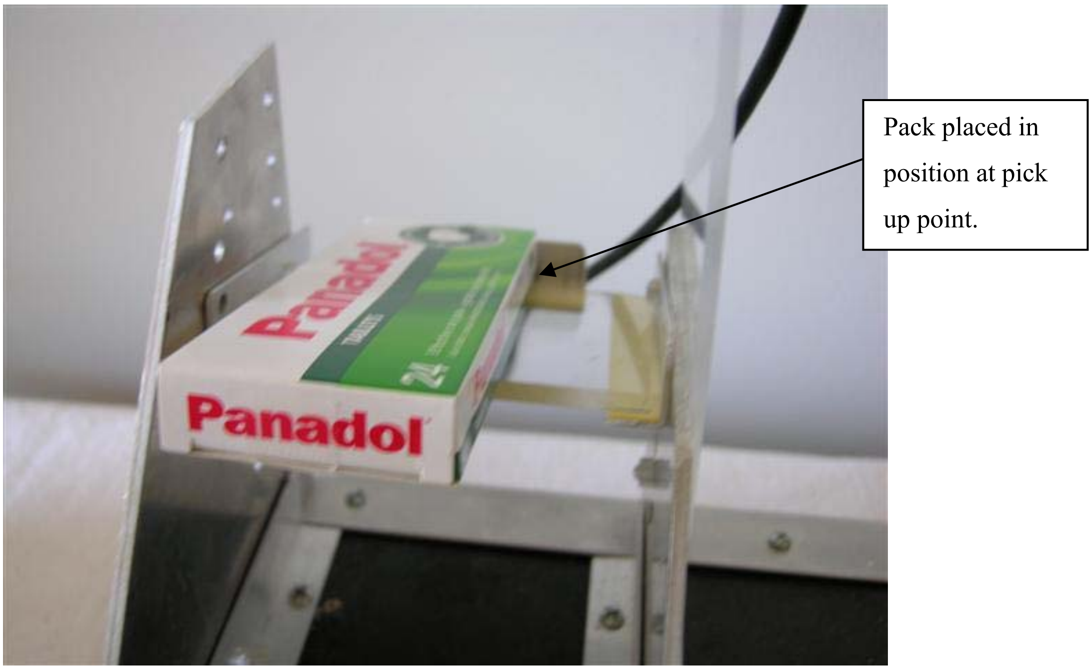


Figure 73: (b) Pick up Point

A cycle was then instigated via the 5 axis software to pick up the pack and move it 180^0 to the discharge point. The discharge point had a calibrated rule attached to the support section. Each cycle was timed and recorded. The left hand position of the pack was read from the calibrated rule after the robotic cycle had discharged the pack (see below).

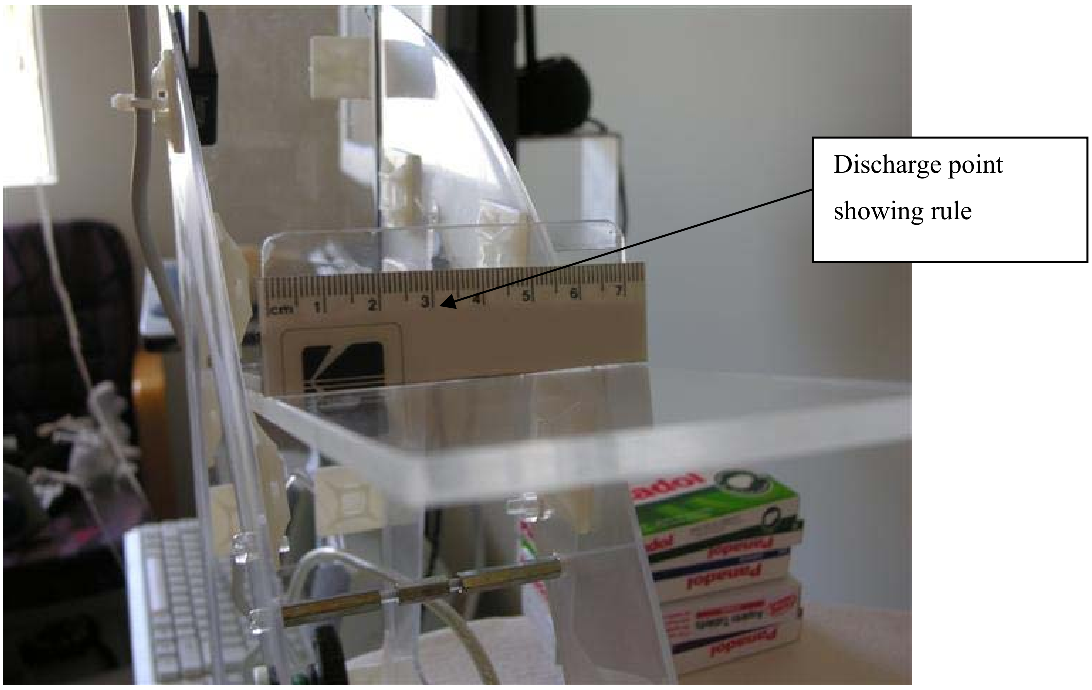


Figure 74: (a) Discharge Point

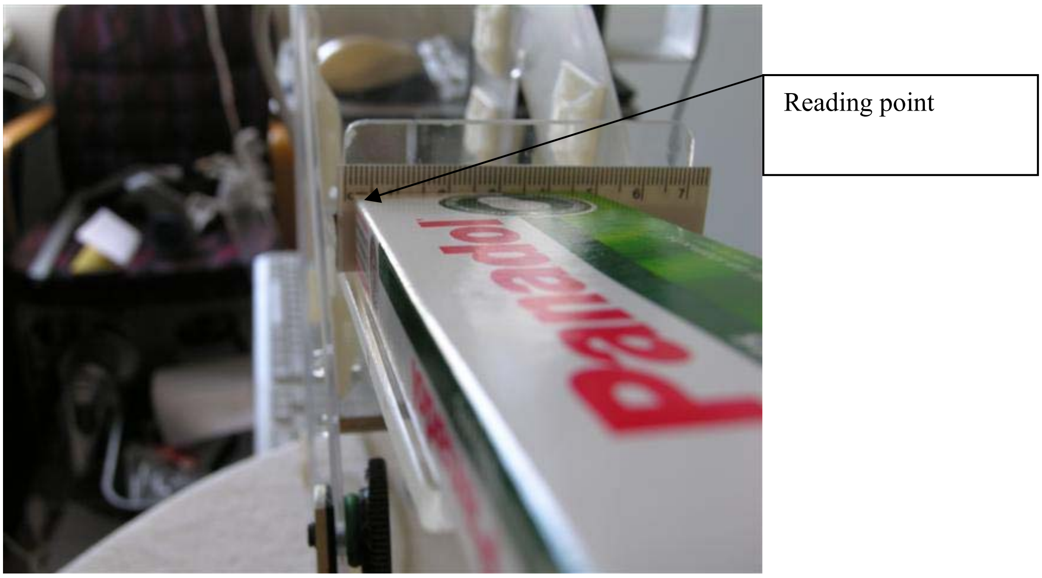


Figure 75: (b) Discharge Point with pack.

Top and bottom images of the pack were recorded at the discharge point. The bar code reader was also set up at the discharge point and the robotic cycle adjusted to allow the bar code on the pack to be passed through the reading beam and read immediately prior to being delivered to the discharge point. Each bar code reading result was recorded using an Excel spreadsheet. Ten separate packs were cycled through the system and this series was repeated three times to give 30 individual measurements.

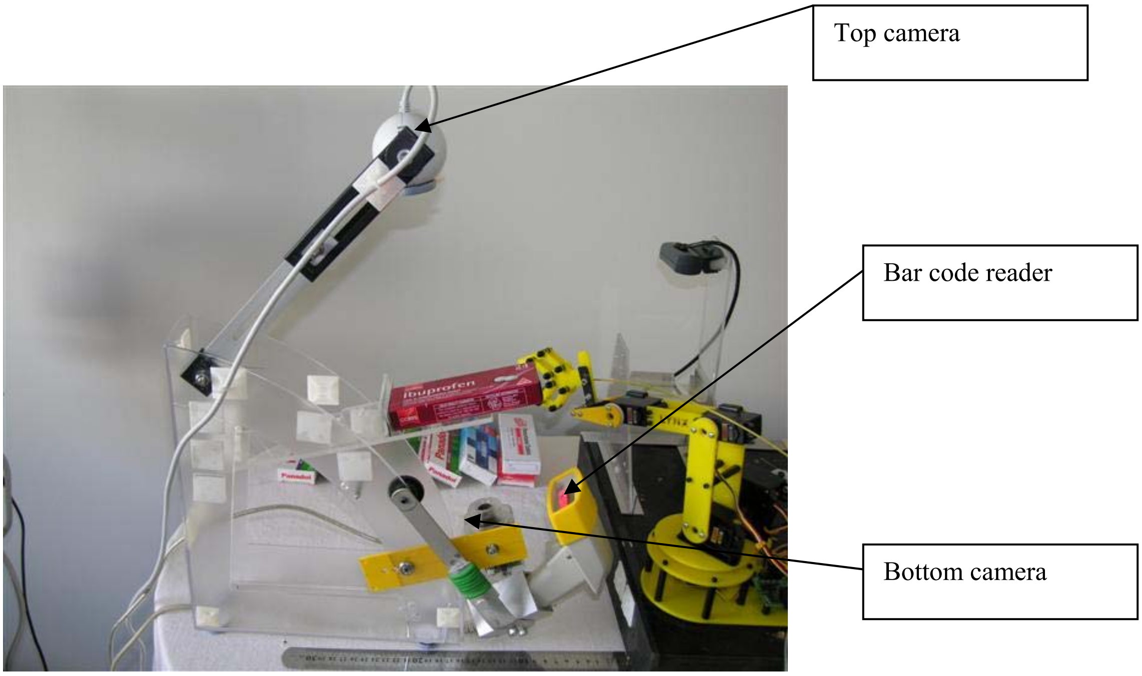


Figure 76: Calibration set up

6.2.2.1.1 Results

The cycle times and final pack positions were statistically analysed. The mean and standard deviations are presented in the Table below.

Table 36: Robotic Calibration cycle times and final pack positions

Statistics		Placement Accuracy	Cycle Time
N	Valid	30	30
	Missing	0	0
Mean		6.0870	4.3453
Std. Deviation		.27806	.50540
Range		.97	1.66
Minimum		5.65	3.66
Maximum		6.62	5.32
Coefficient of Variation		11.6%	4.6%

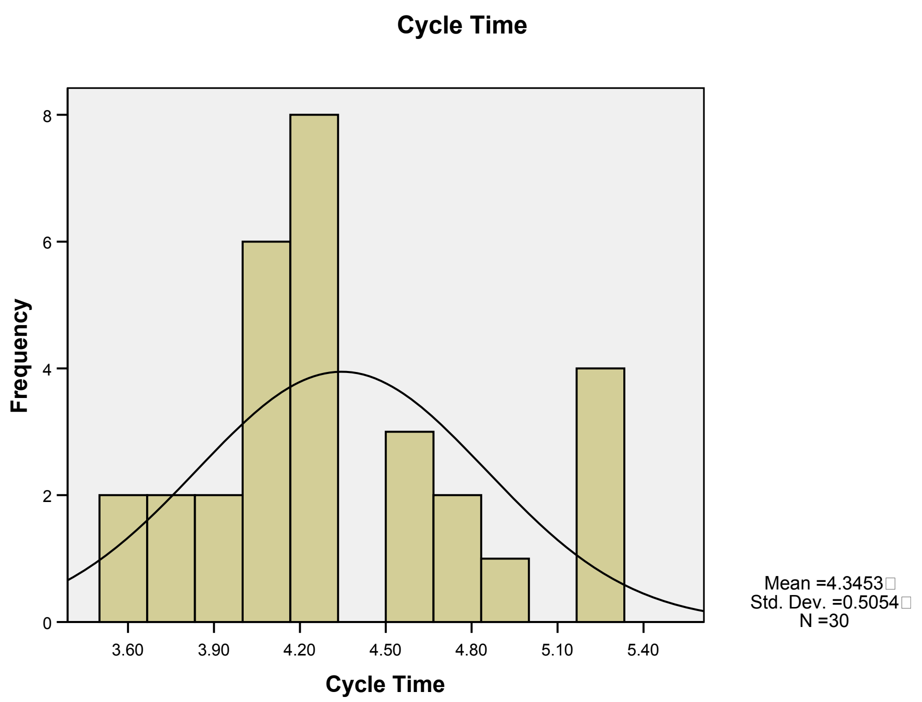


Figure 77: Robotic Calibration cycle times

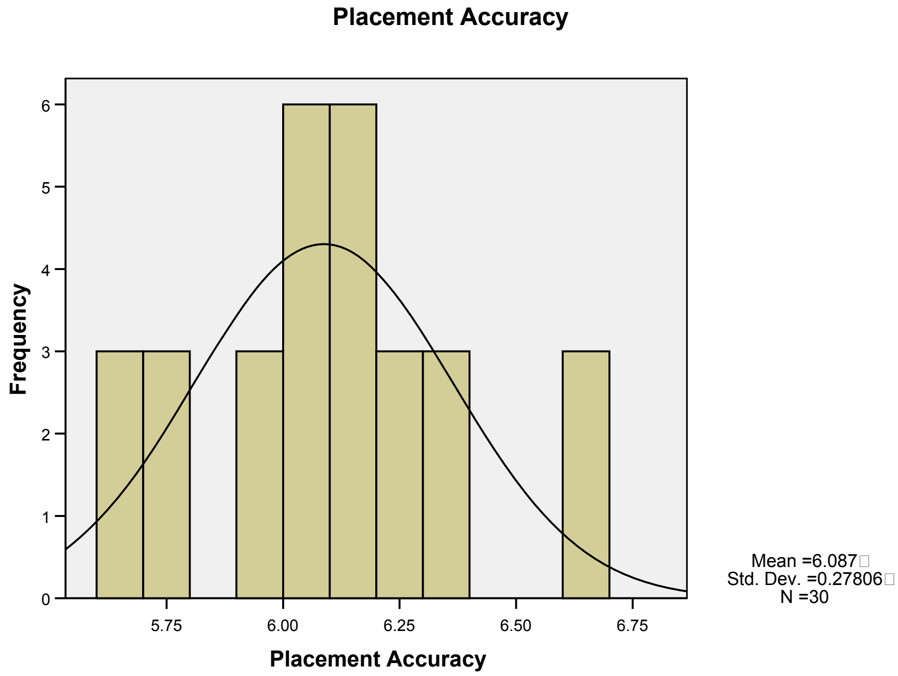


Figure 78: Robotic Calibration final pack positions

The spreadsheet recordings of the bar codes were inspected and compared to the actual bar codes on the pack to determine the accuracy of the readings. All readings corresponded to the pack bar codes.

Each of the images at the discharge point were subjectively inspected to determine if the images were sufficiently clear to enable identification of the pack. The top images were satisfactory and allowed identification of the product, although the images were not clear enough to read all the fine print on the pack. The bottom images were not satisfactory as the clear plastic shelf distorted the text.

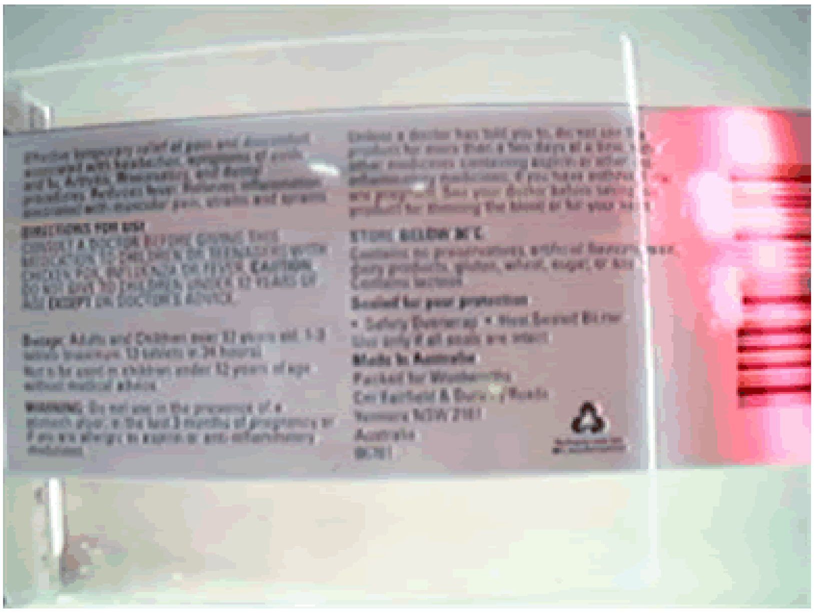


Figure 79: Image of bottom of the pack

Figure 80: Image of the top of the pack

6.2.2.1.2 Discussion

The results indicated that the imaging procedure would require some modification if fine details such as pharmacy labels, batch numbers and expiry dates were to be visible, as in the situation of a medication review. The lower camera images whilst probably suitable for video supervisory purposes, were not clear enough to read and indicated that the clear plastic shelf was not a satisfactory solution for the image acquisition. A single bar code reading was missed during the first cycle. The missed bar code was probably due to the incorrect pressure of the robot jaws and the cellulose packing film on the pack. The pressure of the jaws was adjusted by 10 points and the further two cycles were satisfactory.

6.2.2.1.3 Conclusion

The robotic cycles were consistent and the variation in placement accuracy within the operating needs of the equipment. No packs were placed outside of the measurement rule. The bar codes were read consistently except for one reading. However, this indicates that a second bar code reader, located at a different point in the machine, would probably be necessary in a production.

The images from the top camera were satisfactory from a video supervision point of view. However, for fine print reading such as expiry date or batch number, as required in medication reviews, a higher quality image would be required. This issue is addressed in Chapter 7.

To investigate the performance of the pilot dispensing machine, the equipment was operated on a local basis and a complete cycle of withdrawing a pack from each of the storage locations and discharging the product after an image was taken at the exit point. This same cycle was then repeated after connecting the equipment via the remote software and a wireless LAN.

6.2.3 Study 1. Investigation of the operation of the pilot robotic dispensing machine

6.2.3.1 Introduction

To investigate the performance of the pilot dispensing machine, the equipment was first assembled according to the user requirements described in Chapter 5 and calibrated as described in the previous section. The equipment was then operated on a local basis. The aim of this study was to investigate the performance of the equipment when operated by the local controlling computer.

6.2.3.2 Methods

6.2.3.2.1 Equipment and procedure

The equipment described in Section 6.2.1.1.1 - robotic version was used for this study.

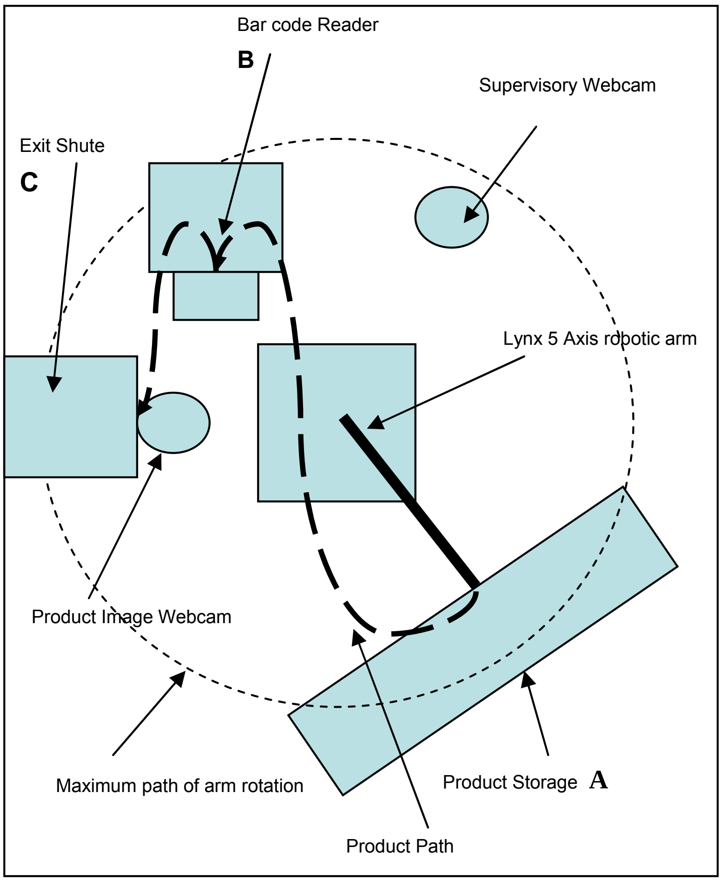


Figure 81: Layout of Robotic Dispensing Equipment

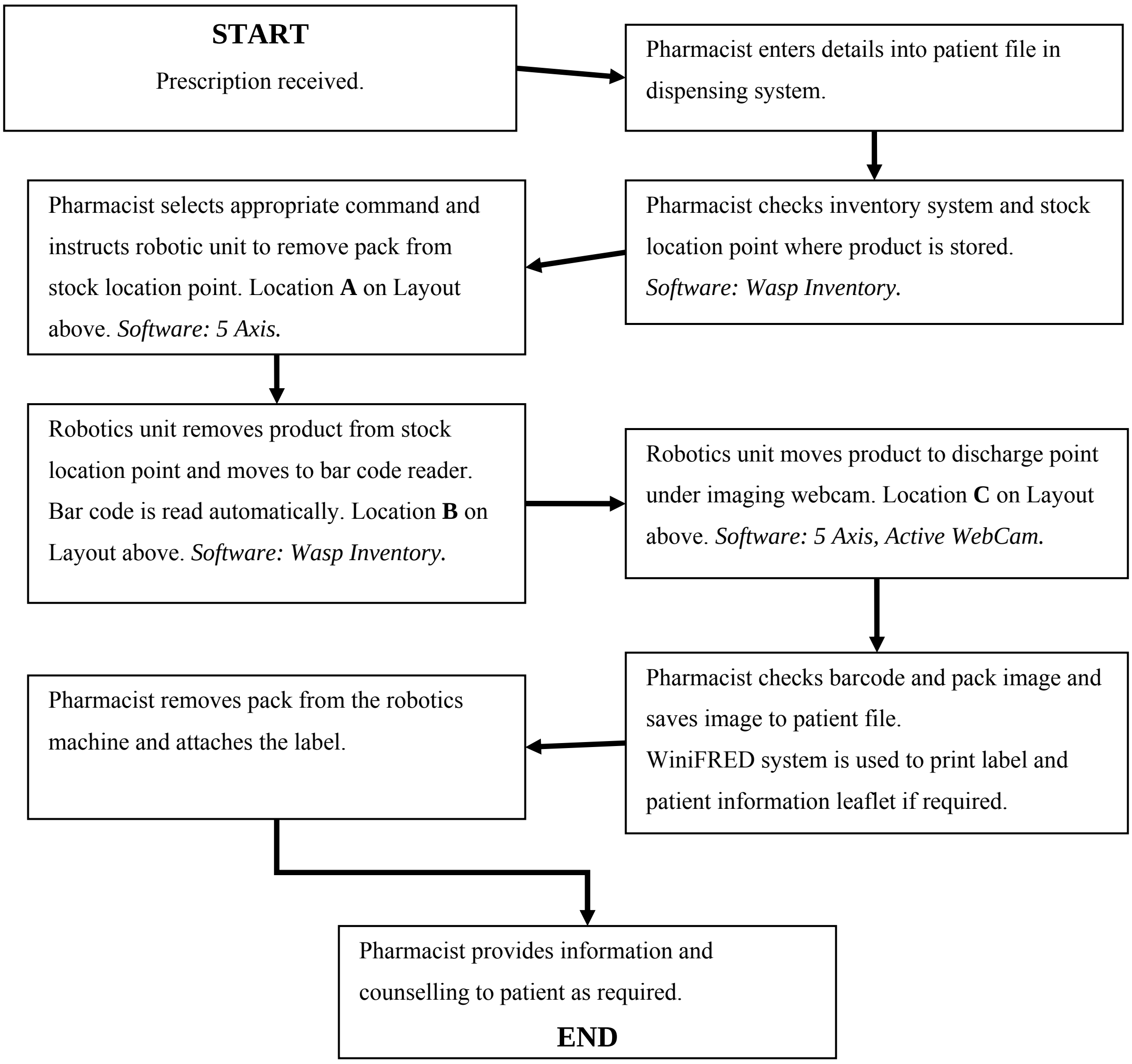


Figure 82: Flow Chart of the Process – Local operation of the robotic dispensing machine

Three full cycles were completed, each cycle comprised:

- withdrawing a pack with the robotic arm from each of 10 storage locations,
- reading the bar code,
- taking an image at the exit point, and
- discharging the product.

6.2.3.2.2 Measurements

The position of each pack was measured after the robotic operation using the rule method as described in the calibration section above. Each cycle was also timed.

6.2.3.3 Results

The cycle times and final pack positions were statistically analysed. The mean and standard deviations are presented in the Table below.

Table 37: Robotic local run cycle times and final pack positions

Statistics

Robotic Local Cycle Time

N	Valid	30
	Missing	0
Mean		13.11
Std. Deviation		.65
Range		2.69
Minimum		11.68
Maximum		14.37
Coefficient of Variation		4.8%

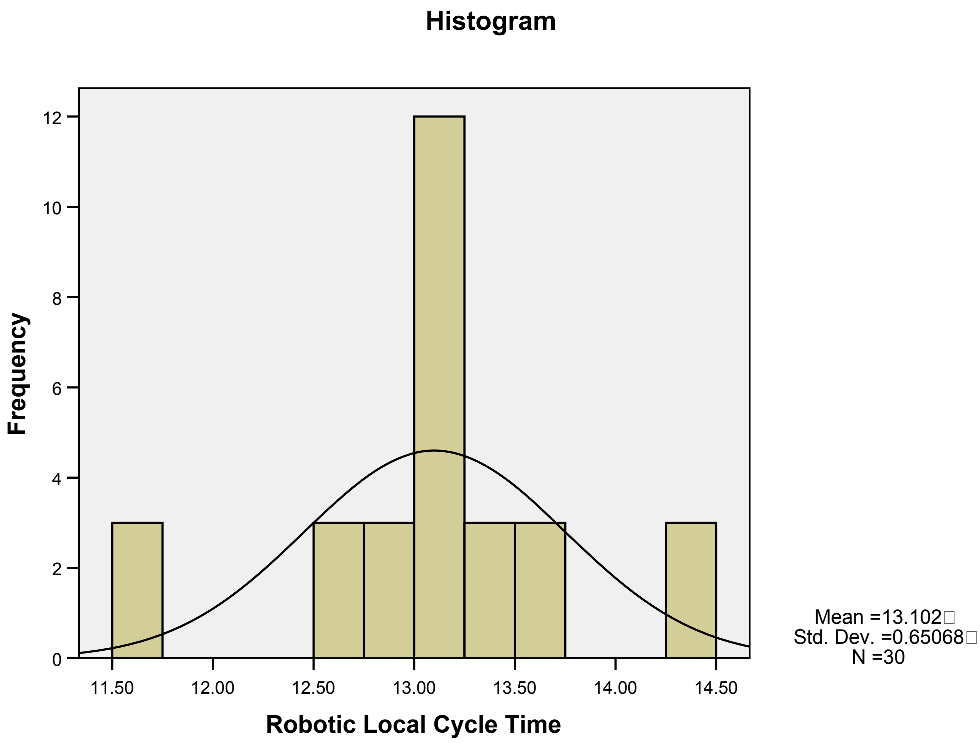


Figure 83: Robotic local run cycle times

Table 38: Robotic local run, cycle times and final pack positions

Statistics

Robotic Local Place Precision

N	Valid	30
	Missing	0
Mean		8.17
Std. Deviation		2.41
Range		10
Minimum		3
Maximum		13
Coefficient of Variation		30.1%

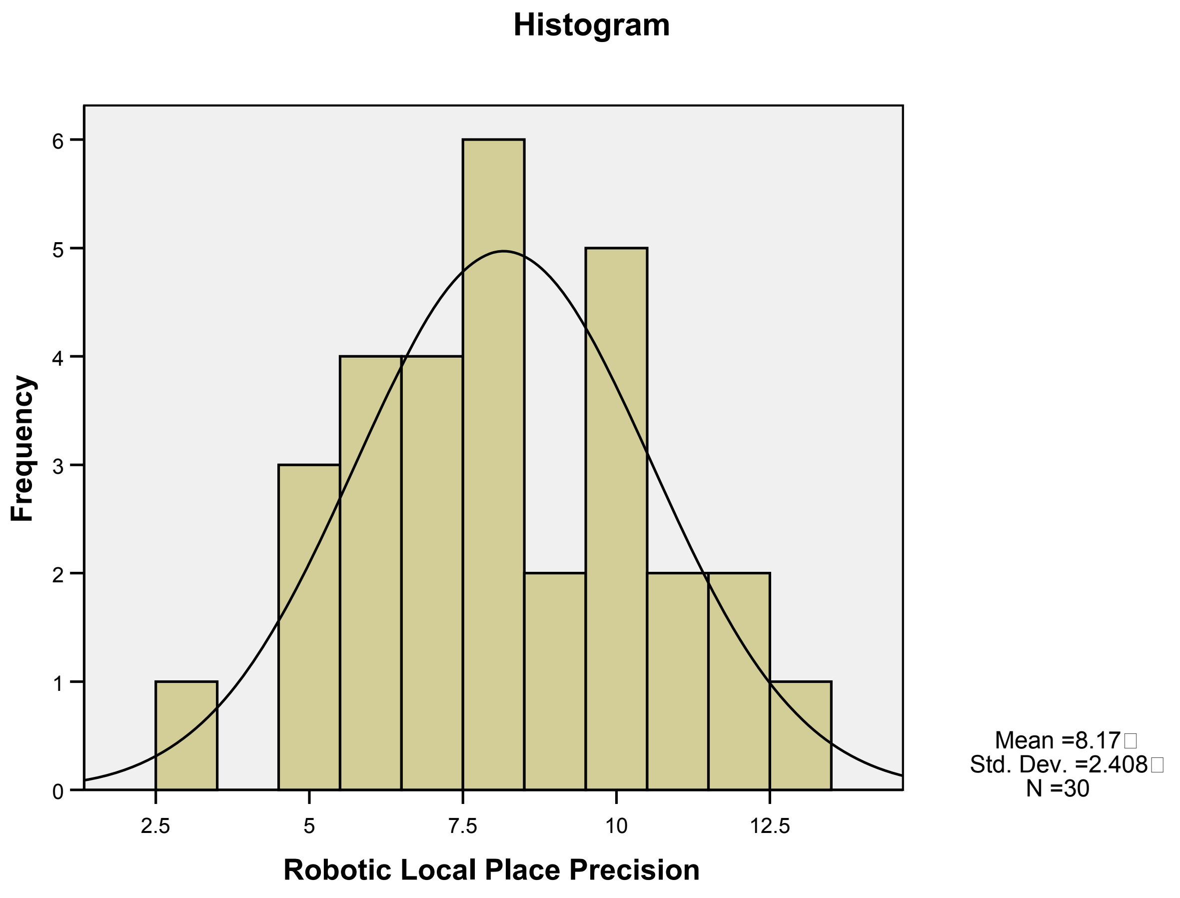


Figure 84: Robotic local run, final pack placement positions

The Wasp Inventory recordings of the bar codes were inspected and compared to the actual bar codes on the pack to determine the accuracy of the readings. All readings corresponded to the pack bar codes.

6.2.3.4 Discussion

As found in the calibration trial above, the results indicated that the imaging procedure would require some modification if fine details such as pharmacy labels, batch numbers and expiry dates were to be visible, as in the situation of a medication review. The lower camera images whilst probably suitable for video supervisory purposes, were not clear enough to read and indicated that the clear plastic shelf was not a satisfactory solution for the image acquisition.

The robotic arm placed all the packs in the discharge position, although the accuracy was not as precise as in the trial.

The cycle times during the calibration trial showed Coefficient of Variation 11.6% compared to 4.8% during the above trial. The maximum cycle time for the trial was 14.4 seconds. This is suitable for local operations in a small dispensary.

The placement accuracy during the calibration trial showed Coefficient of Variation 4.6% compared to 30.1% during the above trial. This was probably due to the initial positions of the pack in the storage locations as the packs were placed in the rack position and not aligned to any particular point as was done during the calibration trials.

6.2.3.5 Conclusion

The robotic equipment operated as per the design requirements when operated in local mode. The placing accuracy of the packs, whilst indicating a larger variation than the calibration trial, was within the tolerances of the discharge shute.

6.2.4 Study 2. Investigation of the operation of the pilot robotic dispensing machine when operated remotely.

6.2.4.1 Introduction

To investigate the performance of the pilot dispensing machine, after connecting the equipment via the remote software and a wireless LAN, the equipment used for Study 1 above was assembled according to the user requirements described in Chapter 5. The equipment was then operated remotely. The aim of this study was to investigate the performance of the equipment when operated by the remotely situated pharmacist.

6.2.4.2 Methods

6.2.4.2.1 Equipment and procedure

The robotic dispensing equipment is set up as per Study 1. Using Windows Remote Desktop a laptop (to simulate the remotely situated pharmacist) was then connected to the dispensing equipment. The dispensing equipment was set to automatically receive the remote computer. At this point the laptop displayed the screen of the dispensing machine and was able to operate the equipment in the same way as in Study 1.

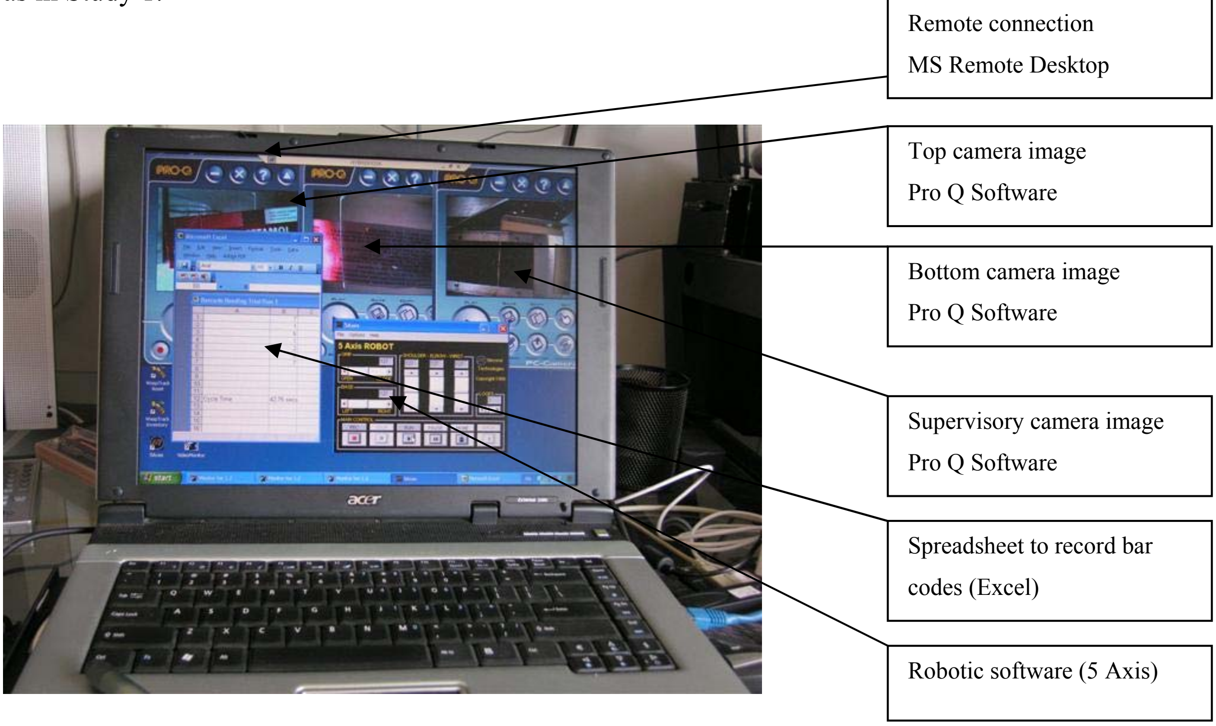


Figure 85: Laptop operating remote computer

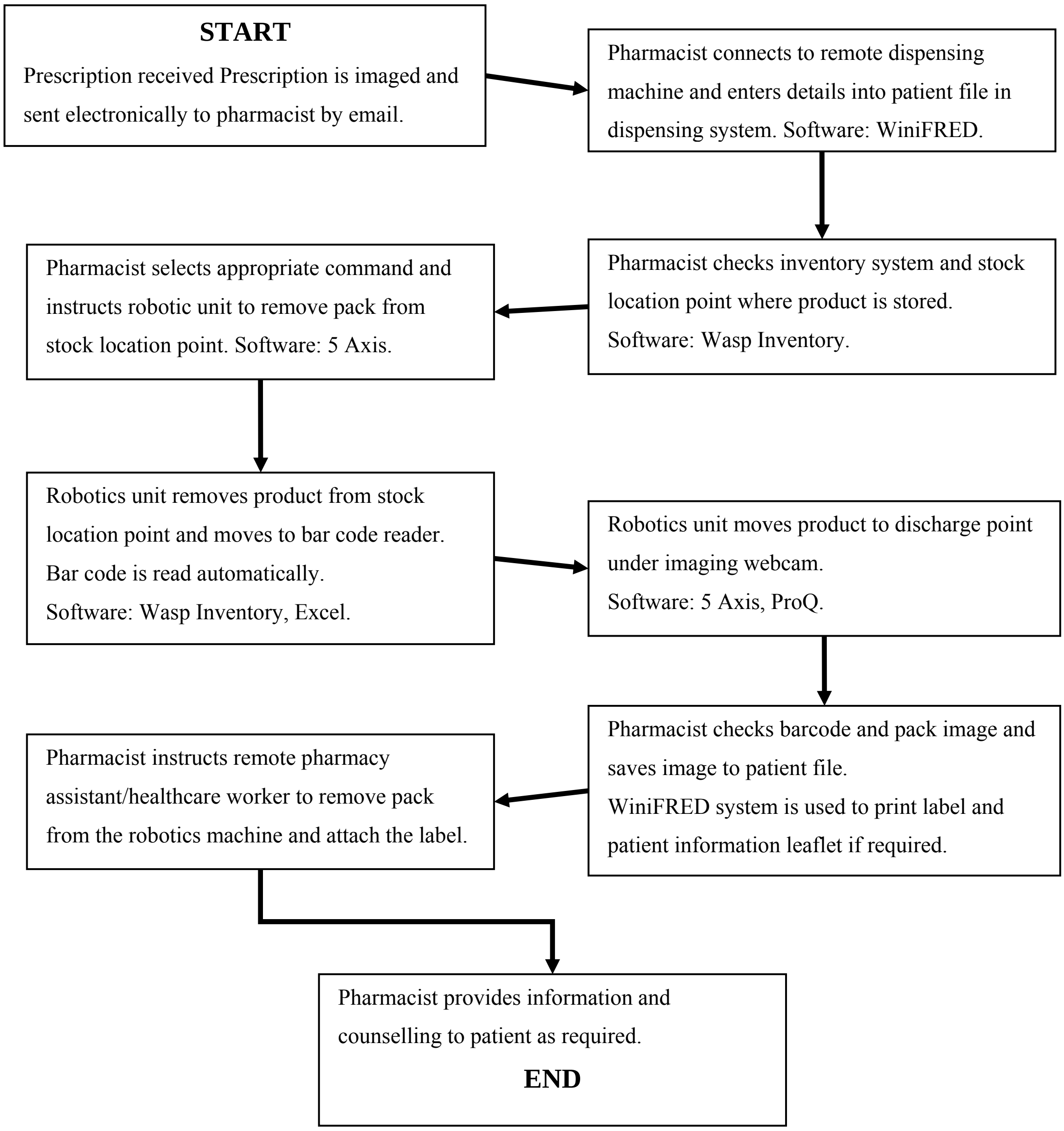


Figure 86: Flow Chart of the Process – Remote operation of the robotic dispensing machine

Operating the equipment remotely, three full cycles were completed, each cycle comprised:

- withdrawing a pack with the robotic arm from each of the 12 storage locations,
- reading the bar code,
- taking an image at the exit point,
- printing the label, and
- discharging the product.

6.2.4.2.2 Measurements

The position of each pack was measured after the robotic operation using the rule method as described in the calibration section above. Each cycle was also timed.

6.2.4.3 Results

The cycle times and final pack positions were statistically analysed. The mean, range and standard deviations are presented in the Table below.

Table 39: Robotic Remote Run Cycle times

Statistics

N	Valid	30
	Missing	0
Mean		32.05
Std. Deviation		7.51
Range		21.40
Minimum		25.91
Maximum		47.31
Coefficient of Variation		26.3%

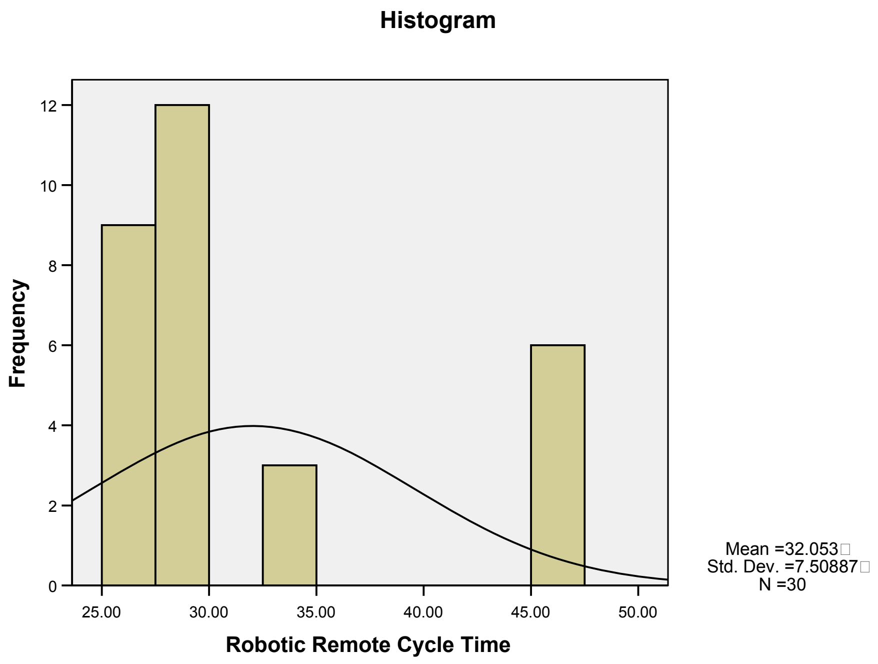


Figure 87: Robotic Remote Run Cycle times

It was not possible to record the bar codes when connecting remotely as the bar code reader did not recognise the command when the software was operated via Microsoft Remote Desktop.

Statistics

Table 40: Robotic Remote Place Precision

N	Valid	30
	Missing	0
Mean		6.30
Std. Deviation		4.84
Range		23
Minimum		-3
Maximum		20
Coefficient of Variation		76.8%

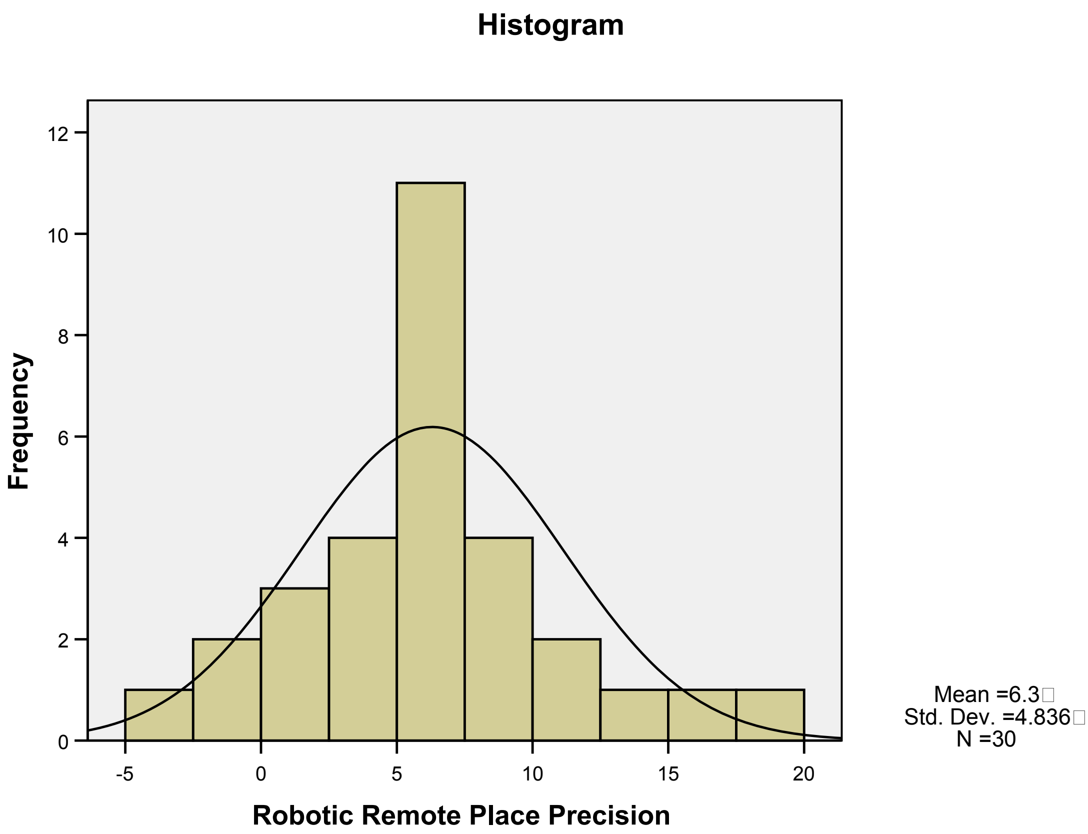


Figure 88: Robotic Remote Run Placement Precision

The cycle times were also significantly different to those recorded when operating the equipment locally as in Study 1, however, the precision of pack placement showed a more normal distribution.

6.2.4.4 Discussion

As found in the Study 1 above, the results indicated that the imaging procedure would require some modification if fine details such as pharmacy labels, batch numbers and expiry dates were to be visible, as in the situation of a medication review. The quality of the images had also degraded. The upper camera images were still suitable for video supervisory purposes, but were not clear enough to read. The lower camera images were unsuitable. The supervisory camera images were suitable for the purpose.

Whilst the robotic arm placed all the packs in the discharge position, the accuracy was not as precise as in the trial, but was closer to a normal distribution than Study 1. The slower cycle time is an expected result in remote operation. This delay is due to latency in the signal transmission and the load on the local PC processor due to the remote software. Latency is not an issue in this application, since the slower cycle times are not critical and the equipment operated satisfactorily in remote operation. This is not the case in other time critical telemedicine applications, such as telesurgery, where a latency of greater than 500 milliseconds can impact upon the ability of the surgeon to complete a task and on the accuracy with which the task is completed.(186)

When connected remotely, the bar code reader did not recognise the bar codes. This was determined to be a factor of the bar code reader design. The particular bar code reader installed was in the form of a “wedge decoder” and acted as a keyboard substitute. Wedge decoders are the easiest to integrate and are supported with nearly all terminals.(187) However, because the bar code reader was acting as a proxy keyboard, when the remote laptop assumed control of the robotic computer this control was software based and did not operate the remote keyboard. As a result the bar code reader was not able to be controlled by the remote computer.

6.2.4.5 Conclusion

The robotic equipment operated as per the design requirements when operated in remote mode, except for the bar code reading and the lower camera images. The placing accuracy of the robotic arm, whilst indicating a larger variation than the calibration trial, was more precise than in Study 1 and within the tolerances of the discharge shute.

The failure of the bar code reader in remote operation indicates that a different design of bar code reader, rather than the "keyboard wedge design" will be required for more advanced trials.

The degraded image of the lower camera also indicates that a different approach is required where higher quality images are required such as in the case of medication reviews. This degraded image from the cameras also indicated that the bandwidth capability of the equipment was at its limits. The addition of full motion video capability to enable video conferencing to the equipment would be unrealistic.

It was therefore decided to add a second computer to the pilot equipment, dedicated to video conferencing. A single screen was maintained by the installation of a KVM switch (OmniView 4 Port, Belkin Corporation) which allows one monitor to be shared between other computers. The operation of the telepharmacy equipment in video conferencing mode will be discussed in Chapter 7.

Peterson and Anderson[114] in their article "The North Dakota Telepharmacy Project: Restoring and Retaining Pharmacy Services in Rural Communities", have noted the import of separating audio and video functionality. They stated:

> "It is not recommended to integrate the audio/video conferencing system with the pharmacy operations software system. One site attempted to do this and experienced significant problems in that, if one system went down, the other system was also affected, producing complete system failure (ie, prescription operations and video). Keeping the systems separate allows the prescription operations to continue if there is a video system failure".

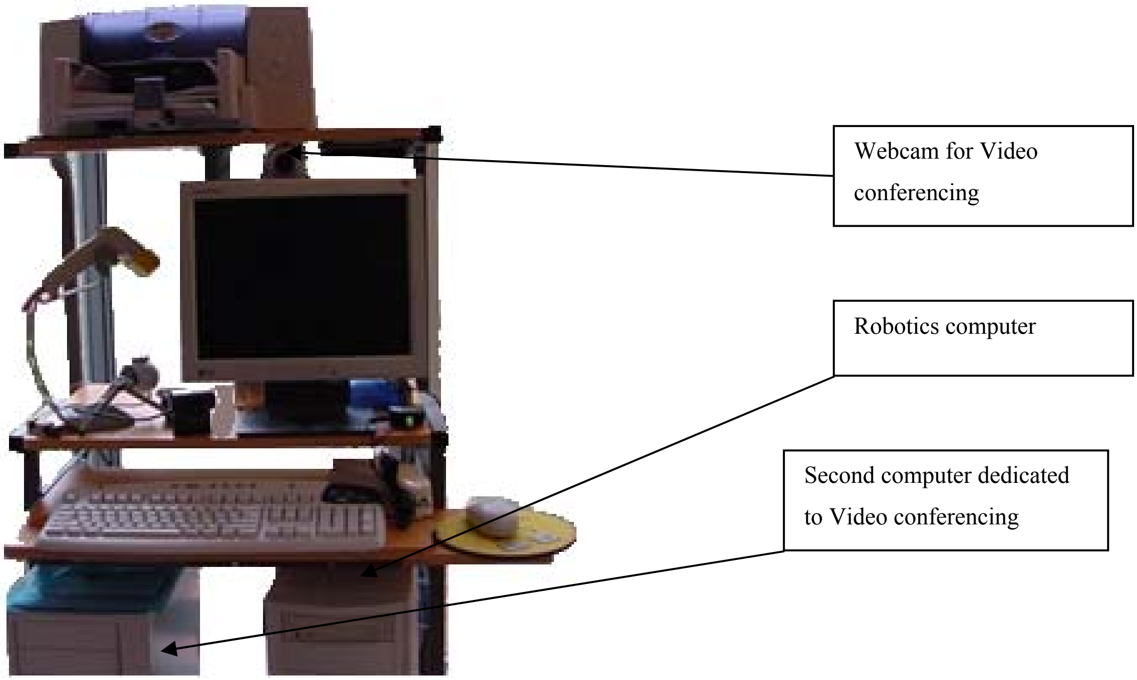


Figure 89: Robotic Dispensing Equipment with Video Conferencing capability via a second dedicated PC

Study 3. Investigation of the operation of the pilot cabinet dispensing equipment.

6.2.4.6 Introduction

To investigate the performance of the pilot cabinet dispensing equipment, the equipment was first assembled according to the user requirements described in Chapter 5 and Section 6.2.1.3.1. The equipment was then operated on a local basis. The aim of this study was to investigate the performance of the equipment when operated by the local controlling computer.

6.2.4.7 Methods

6.2.4.7.1 Equipment and procedure

The equipment described in Chapter 5, Specifications and Section 6.2.1.3.1 - cabinet version was used for this study.

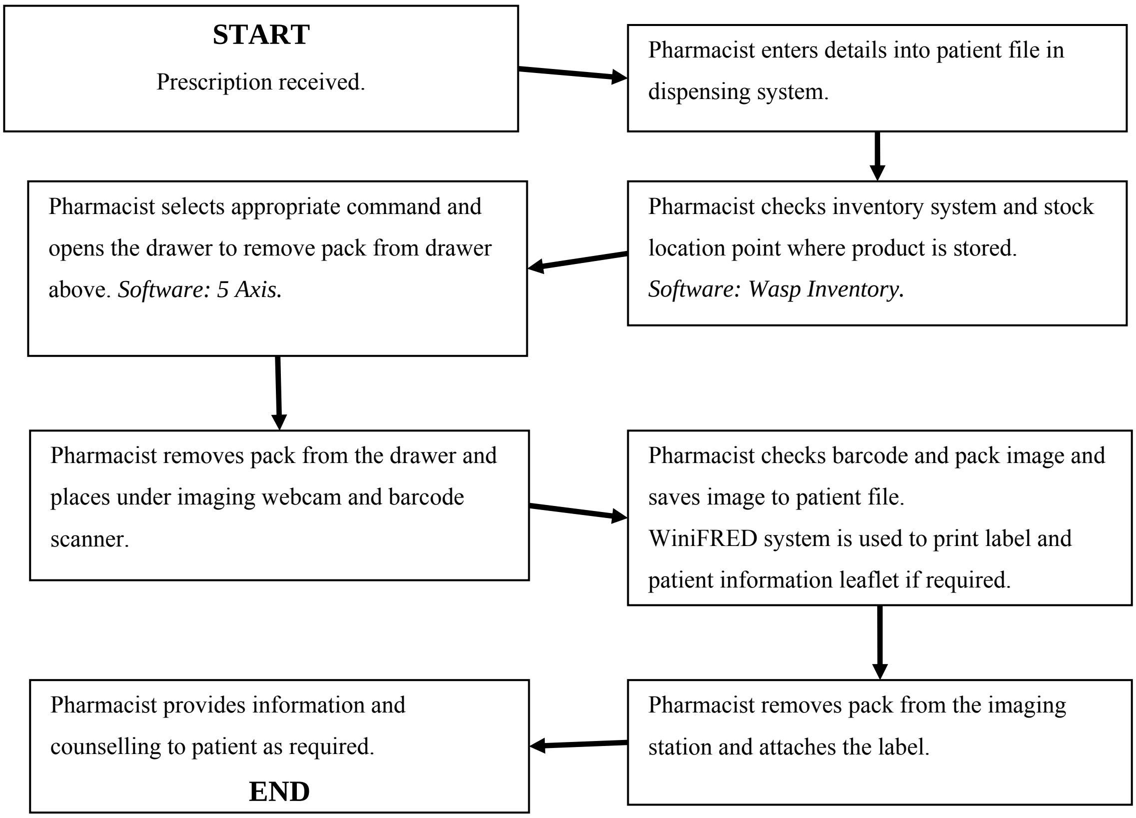


Figure 90: Flow Chart of the Process – Local operation of the cabinet dispensing equipment

Three full cycles were completed (6 packs in total per cycle), each cycle comprised:

- withdrawing a pack from each of the 4 compartments in the top drawer,
- withdrawing a pack from the middle drawer,
- withdrawing a pack from the lower drawer,
- reading the bar code of each pack,
- taking an image of each pack, and
- labelling the product.

There are only 6 possible stock location points in the cabinet dispensing equipment:

- Top drawer: Locations 1-4
- Middle drawer: Location 5
- Lower drawer: Location 6

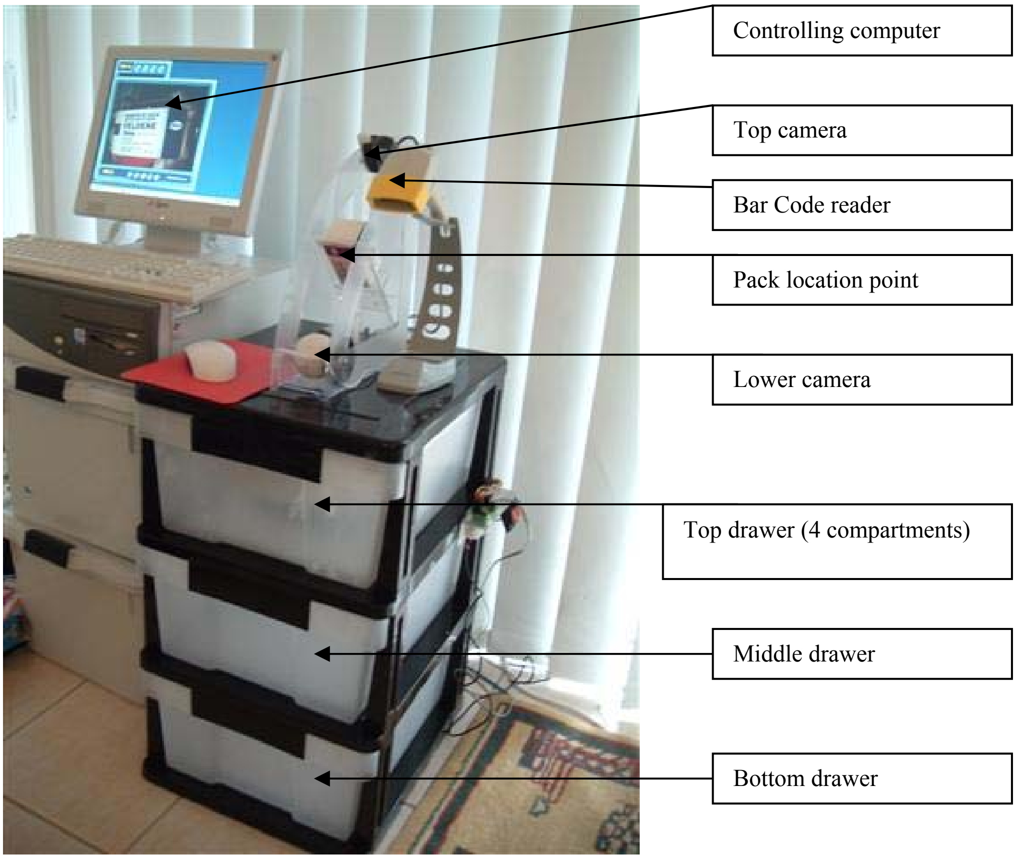


Figure 91: Cabinet dispensing unit

6.2.4.8 Results

The cycle times were recorded. The mean and standard deviations are presented in the Table below.

Table 41: Cabinet version cycle times

Statistics

N	Valid	30
	Missing	0
Mean		4.1
Std. Deviation		.73
Range		2.7
Coefficient of Variance		18.0%

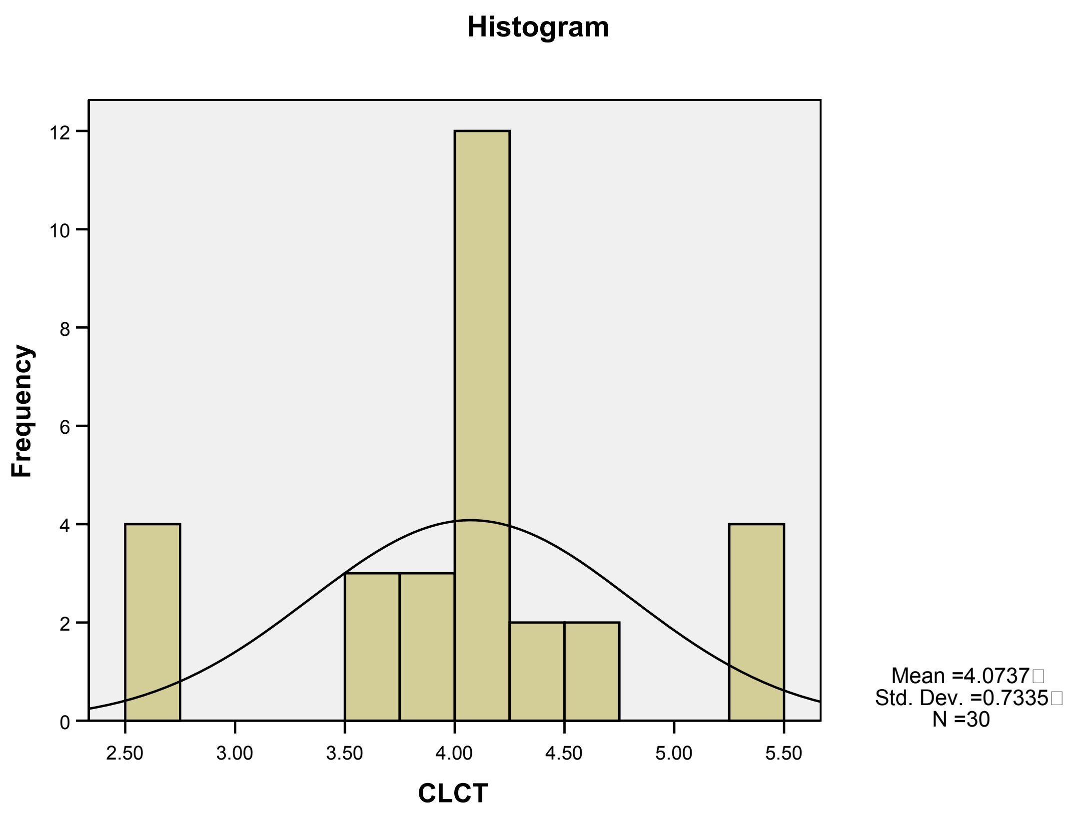


Figure 92: Cabinet version cycle times

The recordings of the bar codes were inspected and compared to the actual bar codes on the pack to determine the accuracy of the readings. All readings corresponded to the pack bar codes.

6.2.4.9 Discussion

The quality of the pack images were of the same resolution as those in Study 1. As found in the calibration trial, the results indicated that the imaging procedure would require some modification if fine details such as pharmacy labels, batch numbers and expiry dates were to be visible, as in the situation of a medication review. The lower camera images whilst probably suitable for video supervisory purposes, were not clear enough to read and indicated that the clear plastic shelf was not a satisfactory solution for the image acquisition.

In this study, the operator manually placed the pack in the imaging station and the accuracy of placement was not measured. The pharmacist also placed the packs under the bar code reader and waited for the audio signal from the reader indicating that the bar code had been read.

6.2.4.10 Conclusion

The cabinet equipment operated as per the design requirements when operated in local mode. The operation of the equipment was simpler than the robotics unit since the product could only be in one of six locations.

6.2.5 Study 4. Investigation of the operation of the pilot cabinet dispensing equipment when operated remotely.

6.2.5.1 Introduction

To investigate the performance of the pilot dispensing machine the equipment was connected via the remote software and a wireless LAN. The equipment used for Study 3 above was assembled according to the user requirements described in Chapter 5 and Section 6.2.1.3.1. The equipment was then operated remotely. The aim of this study was to investigate the performance of the equipment when operated by the remotely situated pharmacist.

6.2.5.2 Methods

6.2.5.2.1 Equipment and procedure

The cabinet dispensing equipment was set up as per Study 3. Using Windows Remote Desktop a laptop (to simulate the remotely situated pharmacist) was then connected to the dispensing equipment. The dispensing equipment was set to automatically receive the remote computer. At this point the laptop displayed the screen of the dispensing machine and was able to operate the equipment in the same way as in Study 3.

Figure 93: Image and Bar Code acquisition- remote operation of the cabinet dispensing equipment

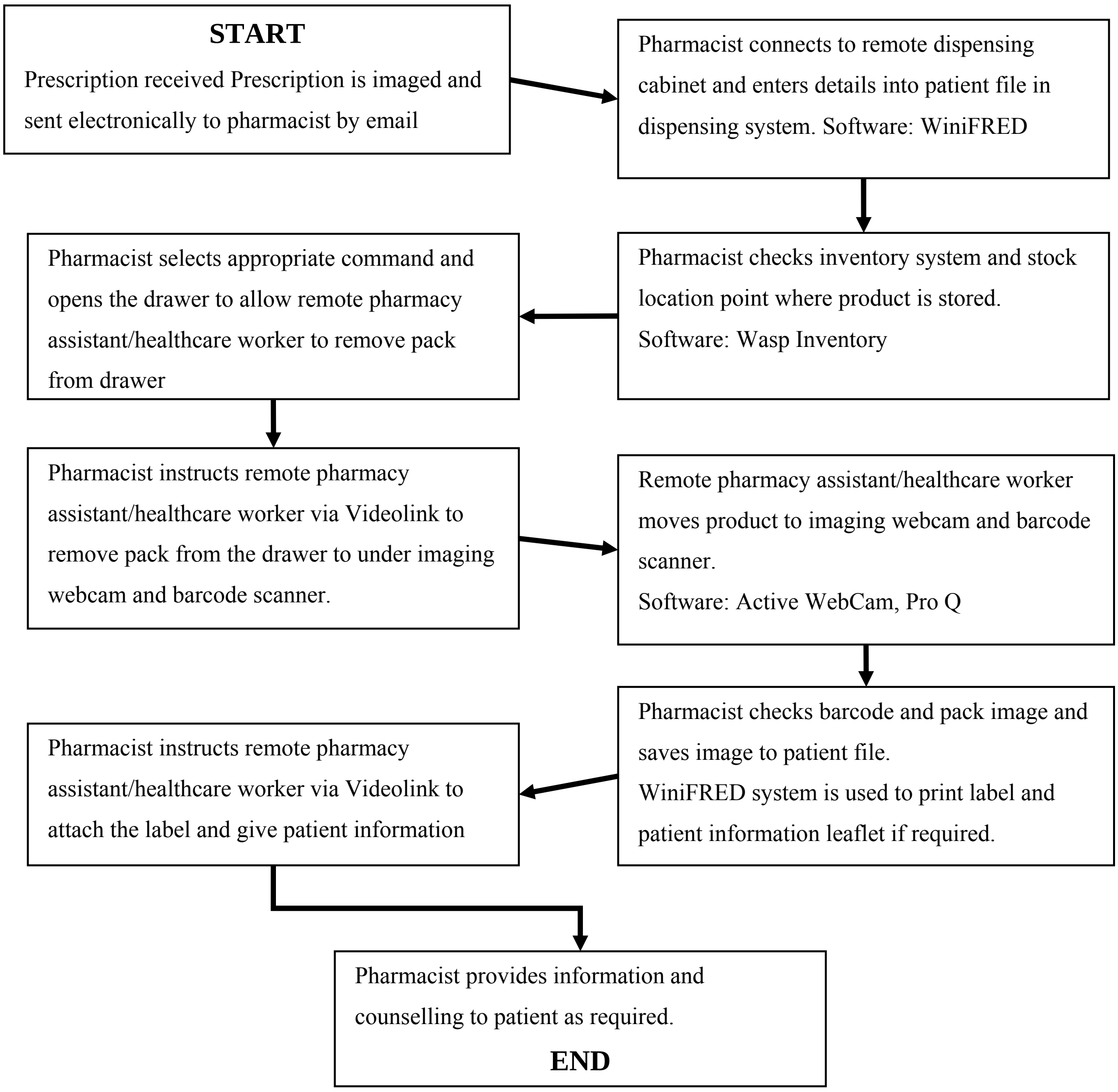


Figure 94: Flow Chart of the Process – Remote operation of the cabinet dispensing equipment

Operating the equipment remotely, three full cycles were completed (6 packs in total per cycle), each cycle comprised:

- withdrawing a pack from each of the 4 compartments in the top drawer,
- withdrawing a pack from the middle drawer,
- withdrawing a pack from the lower drawer,
- reading the bar code of each pack,
- taking an image of each pack, and
- labelling the product.

6.2.5.3 Results

The cycle times were recorded. The mean and standard deviations are presented in Table 43.

Table 42: Cabinet version remote operation - cycle times

Statistics

N	Valid	30
	Missing	0
Mean		6.1
Std. Deviation		.65
Range		2.7
Minimum		4.7
Maximum		7.4
Coefficient of Variation		10.7%

The recordings of the bar codes were inspected and compared to the actual bar codes on the pack to determine the accuracy of the readings. All readings corresponded to the pack bar codes.

6.2.5.4 Discussion

The quality of the pack images were of the same resolution as those in Study 2. As found in Study 2 above, the results indicated that the imaging procedure would require some modification if fine details such as pharmacy labels, batch numbers and expiry dates were to be visible, as in the situation of a medication review. The lower camera images whilst probably suitable for video supervisory purposes, were not clear enough to read and indicated that the clear plastic shelf was not a satisfactory solution for the image acquisition.

In this study, the remote assistant manually placed the pack in the imaging station and the accuracy of placement was not measured. The assistant also placed the packs under the bar code reader and waited for the audio signal from the reader indicating that the bar code had been read.

6.2.5.5 Conclusion

The cabinet dispensing equipment operated as per the design requirements when operated in remote mode, except for the lower camera images. As found in Study 2, the cycle times were longer than in local mode. In the cabinet model this was barely noticeable because of the short cycle time to open the selected drawer.

Because the assistant in the remote location placed the packs under the bar code reader, there were no bar code reading issues as found in Study 2.

As in Study 2, the degraded image of the lower camera also indicates that a different approach is required where higher quality images are required such as in the case of medication reviews. This degraded image from the cameras also indicated that the bandwidth capability of the equipment was at its limits. The addition of full motion video capability to enable video conferencing to the equipment would be unrealistic and a second computer dedicated to this application is required.

The following section details further experimentation to improve upon the videoconferencing and image acquisition capability of the telepharmacy system.

6.2.6 Development of Video Conferencing and Imaging units.

The initial video conferencing units were constructed by the researcher to simulate the functionality of the SPARC type video kiosk similar to those units that were intended for the aborted Tasmania West Coast project.

Figure 95: LHS-SPARC type video kiosk and RHS-Pilot videoconferencing trial unit (Mk 2)

Image acquisition devices (webcams) connected to the video conferencing unit are used, where appropriate, to take images of the patient's medication and transmit these to the pharmacist.

The above four studies all indicated that the quality of the images as acquired by the webcams was suboptimum. Although the video images were suitable for supervision of the remote assistants, they were not suitable for video conferencing.

Various Internet video conferencing systems were trialled, both Windows based systems and Apple systems.

6.2.6.1 Method

Two computers were set up with the appropriate software and then connected via a wireless LAN at a speed of 500 – 700 kbits/sec. The minimum required bandwidth or speed for Video Conferencing is 128 KBPS, the recommend bandwidth for video conferencing data transfer is 384 KBPS or greater.[188]

A standard passage consisting of 114 words was read by two people on either side of the video conference. A male and a female were used in each video conference to evaluate the difference in voice pitch and clarity. Each side of the video conference was recorded using a video camera (recording A and B). The recordings, unedited, were then played back on a television and the quality of each side of the video conference was evaluated on a 1-10 scale where 1 was very poor and 10 was excellent. The ratings by the two people (designated A and B) on either side of the video conference were summed and a total ranking calculated.

The results are summarised below:

Table 43: Webcam and Video Conference Software Evaluation.

Computers	Video conferencing Software	Webcam	Recording A Rating Sound	Recording A Rating Video	Recording B Rating Sound	Recording B Rating Video	Rank Total
PC/PC	NetMeeting/NetMeeting	Swan/ QuickCam	4	5	5	5	19
PC/PC	NetMeeting/Trillian	Swan/ QuickCamSphere	4	4	6	6	20
PC/iMac	Trillian/iChat	QuickCam Sphere/iSight	6	6	8	8	28
iMac/iMac	iChat/iChat	iSight/iSight	8	9	9	9	35

6.2.6.2 Results

Whilst based upon an assessment of only two people and therefore subjective, the iMac/iMac video conference was clearly superior in both sound and video with a score of 35. The other system that was suitable for video conferencing was the PC/iMac combination using Trillian software on the PC and iChat on the iMac. The two other systems trialled were considered not suitable. It should be noted that the first two systems trialled used older style USB 1 type webcams and NetMeeting, which is also an older protocol based upon the H320 protocol, whilst the iChat software uses the superior H264 protocol.

Based upon these results the image capture device was rebuilt to use the iChat software and the iSight camera. The two systems are shown below, the PC webcam system (A) and the iSight/iMac system (B).

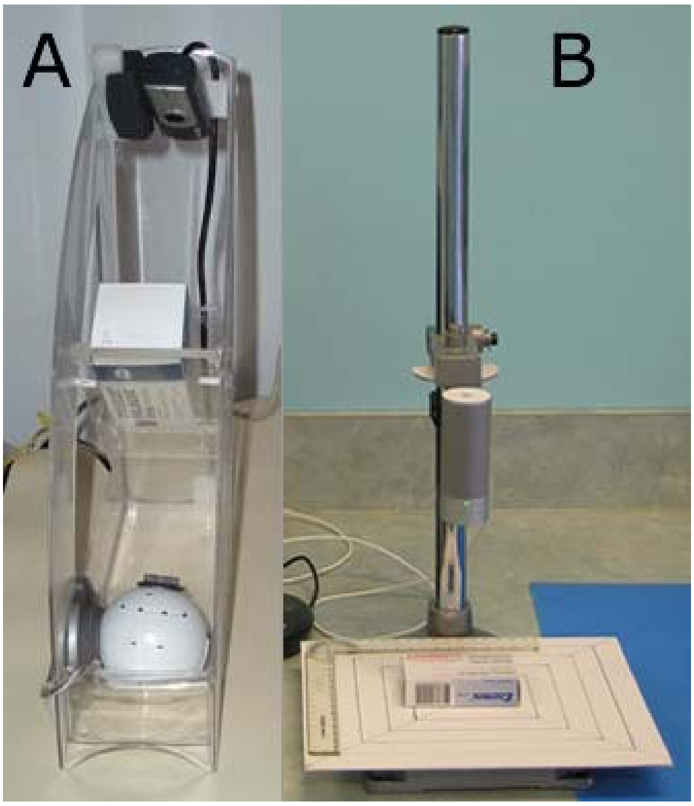


Figure 96: Image Capture Devices

The quality of the images from the two image capture systems were evaluated and the iSight (B) was considered to be of higher quality. An example image from each of the two systems is shown below, with the PC/Swan webcam image (C) and the iMac/iSight webcam (D).

Figure 97: Images from webcams - C = PC, D = iMac

6.3 Hypothesis Testing

Hypothesis 2 (Chapter 1) states that:

2. The application of telepharmacy applications can be demonstrated by pilot studies.

   Specifically this can be stated as:

   a. Pilot studies using automated dispensing equipment can demonstrate the application of such equipment in a simulated environment.

The studies described in this Chapter demonstrate that the two versions of pilot dispensing equipment developed can satisfactorily dispense products in a simulated dispensary environment. The equipment was then operated in a simulated remote environment using a wireless LAN adjusted to Broadband Internet speeds. The remote trials demonstrated that the pilot equipment could be also satisfactorily operated under such conditions, with the comment that the bar coding equipment in the robotic version of the pilot equipment requires a different design when operated under remote conditions. The results of the studies therefore provide a basis for the support of the hypothesis that pilot studies using automated dispensing equipment can demonstrate the application of such equipment in a simulated environment. The main issues identified in the studies were the limitations of the pilot equipment to dispense more than 10–12 products at a time and therefore future trials will require the development of storage and retrieval systems for a range (80–100) of product lines suitable for rural conditions. Such commercial equipment is available overseas and could potentially be modified (with appropriate funding) to Australian rural conditions for use in future trials. An Australian developed system (Bluepoint) is reported to be undergoing trials in Victoria.(136) Preliminary examination of the details provided on the website (www.expressrx.com.au) indicate that this equipment could potentially be modified to suit rural conditions.

6.3.1.1 Conclusion

The image capture device using the iSight webcam was the superior system and this equipment should be used in the Medication Review trial described in Chapter 7.

Similar equipment would be suitable for use in a stand-alone situation, in combination with a barcode reader to provide a low cost effective quality control unit for all dispensing operations. When such equipment is used in conjunction with a dispensing system such as WiniFred, a robust and reliable system of quality control is possible. WiniFred currently supports bar code entry via a reader so the addition of imaging capture to the dispensary system is a relatively minor expense.

In a survey of pharmacists' attitudes towards dispensing errors conducted by Peterson et al.[156] the respondent pharmacists reported that they thought that the risk of dispensing errors was increasing and most were aware of dispensing errors that had left their pharmacy undetected during the past 6 months prior to the survey (1999). The results of the survey also indicated that in order to reduce the occurrence of errors, methods must be devised to identify the sources of errors and to implement strategies to correct them and quality assurance and quality systems should be an integral part of pharmacy dispensing practice.

The following image (Figure 78) illustrates how a pack image could be simply integrated into the current WiniFred dispensing system by entering the image details into the dispensing record for the patient under the Note section of the software using a simple standard file convention of:

{patient name}_date_ product dispensed.

Any other standard file naming convention would be suitable.

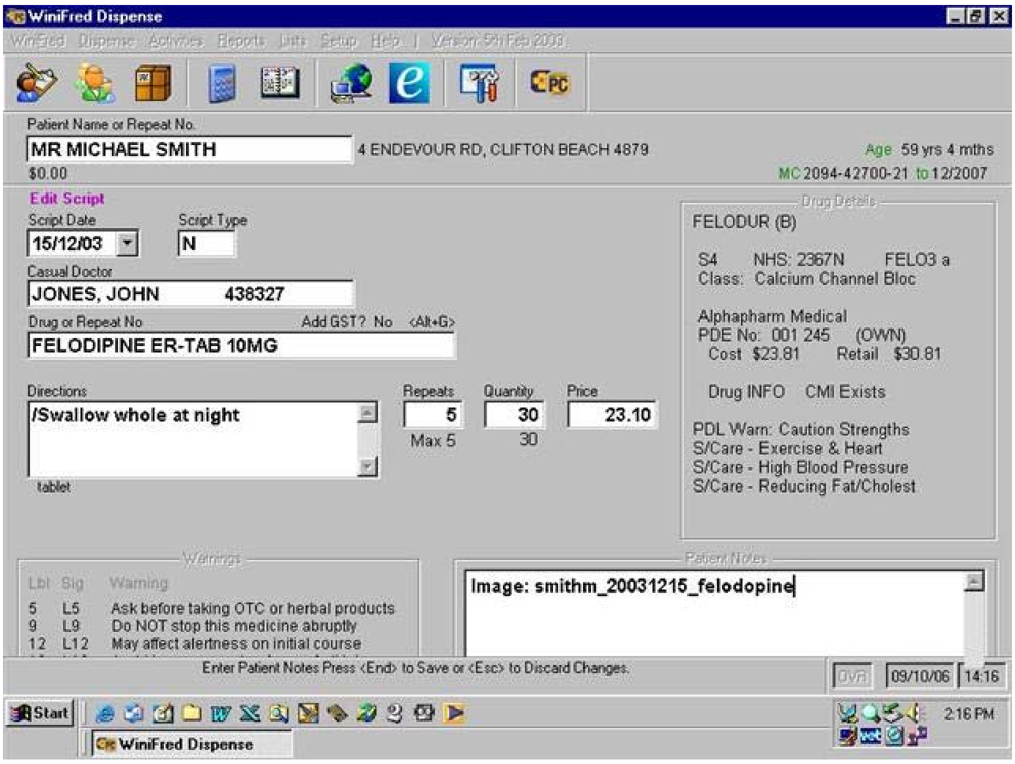


Figure 98: WiniFred Note section with pack image file details.

6.4 Chapter Summary

The definition of the requirements by the Senior Policy and Planning Officer for Territory Health Services (Northern Territory, Australia) to allow technology to provide pharmaceuticals to remote communities provided an excellent grounding for the development of a telepharmacy system aimed at rural and remote communities in Australia. Further investigation of specifications (Australian Vending Solutions) and a search of patents on telepharmacy systems also provided much useful information on the possible design of such systems.

Further and more detailed specifications were provided by the Tiwi Health Board project group and this eventuated in a set of eight key requirements for a telepharmacy system, designed for use in rural and remote Australia. These requirements were defined as follows:

(i) A unit capable of storing a range of 80–100 individual medications, with multiple pack storage for high volume products.

(ii) Entry of patient details into a standard dispensing system, preferably employing a touch screen type entry.

(iii) An automated method of removing, preferably, an individual product from the storage unit.

(iv) An image acquisition capability to store a picture of the dispensed product pack and the expiry date and batch number if required.

(v) Bar code reading of the dispensed product.

(vi) Video supervision of the dispensing unit.

(vii) For remote operation, all the above features plus a method of reliably taking control of the automatic dispensing unit and operating it remotely, plus a method of viewing the patient's prescription if an online prescribing system is not available.

(viii) A video conferencing capability to enable the remote pharmacist to provide counselling services to the patient. This video conferencing capability could also then be used to provide medication reviews for patients in rural and remote areas who do not have easy access to a medication review pharmacist.

Using the above requirements, two versions of pilot telepharmacy systems were developed. The first version was a fully automatic robotic version, with a limited capacity of products, but with all the other requirements above. The second version was a simplified cabinet version, also with a limited supply of products, but otherwise meeting the requirements. Both these versions were trialled firstly by local operation and then by remote operation using a wireless LAN tuned to simulate a broadband Internet connection. These trials indicated three issues that required further development.

The first of these was that, in remote operation of the robotic version of the automatic dispensing system, the system was not capable of reading the bar code. This was identified as being due to the style of the bar code reader, since it acted as an auxiliary to the keyboard when operated in remote mode, the remote keyboard was not part of the remote equipment operation. It was determined that this could easily be solved by a different bar code reader in future designs.

The second issue was the quality of the product image when viewed by the remote pharmacist, particularly in the application of the system to medication reviews. This issue was solved by the development of an imaging acquisition device, with a more precisely calibrated stand and adjustment capability.

The final issue was that of the quality of the image and sound during video conferencing. This issue was solved by experimentation of various personal computer based equipment and setups. The use of a second computer to provide the video conferencing capability was found to be the most suitable solution, as was the change of equipment to that which was designed to use the ITU telecommunication H264 protocol rather than the H320 protocol.

This change of equipment resulted in a superior video conferencing experience and image acquisition capability and was therefore the equipment used for the medication review patient trial described in Chapter 7.

Chapter 7 Medication Reviews

7.1 Medication Reviews, a clinical area of pharmacy that is amenable to telepharmacy

The national survey of pharmacists conducted by Lee in 2005 indicated that 51 per cent of respondent pharmacists servicing outlying communities were interested in using telepharmacy capabilities to conduct Medication Reviews (eg HMR's). The surveys of healthcare professionals, pharmacists, medical practitioners, nurses and nurses/healthcare workers described in Chapter 5 indicated an even higher support for the concept of conducting medication reviews via telepharmacy.

The survey of pharmacists, restricted to the geographical areas of northern Queensland, Northern Territory and northern Western Australia, indicated that 61 per cent of pharmacists surveyed thought that medication reviews could be carried out by using telepharmacy (Chapter 5, Survey 1, Section 2 question 4). The survey of medical practitioners, restricted to the geographical areas of northern Queensland, indicated that 86 per cent of medical practitioners surveyed thought that medication reviews could be carried out by using telepharmacy (Chapter 5, Survey 2, Section 2 question 3). Furthermore 97 per cent of nurses surveyed at the Royal College of Nursing Annual Conference, Cairns July 2006 also supported the use of telepharmacy to conduct Medication Reviews (Chapter 5, Survey 3, Section 2 question 3).

During the course of this study, Medication Reviews became a priority under the Third Pharmacy Agreement and in the latest Fourth Pharmacy Agreement (in force until 2010). Currently funding arrangements are in place to remunerate pharmacists for the conduct of Medication Reviews (currently $180 per review). A successful pilot study would provide the basis for lobbying the Health Insurance Commission (HIC) to expand the current remuneration to include telepharmacy as a method of conducting Medication Reviews for patients in rural and remote areas who would not otherwise be able to have their medications comprehensively reviewed.

The existing Queensland Health videoconferencing network represents an ideal infrastructure to introduce medication reviews to the public health sector. Queensland Health has established a Safe

Medications Practice Unit and one of their first priorities is to trial medication reviews in rural south east Queensland in 2007.[g]

The clinical area of Medication Reviews therefore represents an ideal area to study on the effectiveness of telepharmacy in offering professional pharmacy services. In this chapter a method of conducting Medication Reviews using the type of equipment described in Chapter 6 is discussed. Thereafter, a Medication Review patient trial is introduced and the results of the trial are described.

7.2 The Medication Review trial

It was proposed to recruit a group of 8–12 patients to participate in the trial using video conferencing to conduct Medication Reviews. Information provided by the Cairns Division of General Practice indicates that 72 HMRs were conducted in Cairns in 2004 and 106 in 2005.

The patients were recruited by advertising for volunteers to participate in the trial. The advertisement was displayed, with copies of the Patient Information and Informed Consent Form (Appendix C), in the waiting room of the QML facilities adjacent to the Clifton Beach Medical Centre. The patients were selected with the approval and assistance, where possible, of their medical practitioner. The medical practitioners at the Clifton Beach Medical Centre agreed to assist in this regard.

Pharmacists' Professional Practice Standards allow the HMR to be conducted in an appropriate location other than the home. The proposed trial was planned to take place in the QML facilities adjacent to the Clifton Beach Medical Centre, Cairns, Queensland. At present HMR's are conducted on a face to face basis, although some accredited pharmacists will use the information collected by community pharmacists to compile their reports, checking information with the patient as required.

[g] Personal communication, Christine Mac Lean, Queensland Health, December 2006.

7.3 Design of the Medication Review Trial

The purpose of this trial was to determine if the use of telepharmacy techniques are appropriate for the conduct of Medication Reviews by simulating a Broadband ADSL Internet connection between the accredited pharmacist conducting the Medication Review and the patient. This is particularly applicable for patients in rural and remote areas where it is difficult for a pharmacist to personally visit the patient's home. The trial was in the form of a pilot study in order to collect information and develop appropriate procedures for the conduct of medication reviews via telepharmacy. Pilot studies play an important role in providing information for the planning and justification of future large trials.[189]

The aims and hypotheses relevant to this trial were:

Aims:

To investigate, through video conferencing, whether Medication Reviews can be effectively and efficiently conducted in an environment simulating a Broadband ADSL Internet connection between the accredited pharmacist conducting the Medication Review and the patient.

Hypothesis:

In Chapter 1 the following hypothesis was proposed

2. The application of telepharmacy applications can be demonstrated by pilot studies.

Specifically this can be stated as:

a. Pilot studies using automated dispensing equipment can demonstrate the application of such equipment in a simulated environment.

b. Pilot studies in a simulated environment can demonstrate the feasibility of conducting medication reviews using telepharmacy techniques such as video conferencing.

This study is concerned with hypothesis 2b.

The QML facility was used to simulate a remote environment. The accredited medication review pharmacist was situated in one room and the patient in another. The patient was not able to see or hear the pharmacist except through the video link. QML approved the after hours use of their facilities in the Clifton Beach shopping centre for the trial. The medication review pharmacist had a computer with video conferencing facilities and the area where the patient was situated also had such facilities. In addition to the video conferencing units, an image acquisition device, connected to the video conferencing unit was used, where appropriate, to take images of the patient's medication and transmit these to the pharmacist.

A helper was on hand to assist the patient with the technology and the interview. The use of a helper in this situation was supported by the healthcare professional surveys described in Chapter 5. The survey of pharmacists indicated that 86 per cent of pharmacists surveyed thought that medication reviews, carried out by using telepharmacy, would require the help of a trained person or healthcare worker in the remote location to assist the patient during the review. (Chapter 5, Survey 1, Section 2 question 5). The survey of medical practitioners indicated that 67 per cent of medical practitioners surveyed thought that the help of a trained person or healthcare worker would be necessary (Chapter 5, Survey 2, Section 2 question 4). Furthermore all of nurses surveyed at the Royal College of Nursing Annual Conference, Cairns July 2006 also thought that the help of a trained person or healthcare worker would be necessary (Chapter 5, Survey 3, Section 2 question 4).

The medication review pharmacist participating in the trial was a lecturer from the James Cook University School of Pharmacy accredited to conduct medication reviews.

7.3.1 Methodology and patient recruitment

The patients were recruited by advertising for volunteers to participate in the trial. The advertisements were displayed, with copies of the Patient Information and Informed Consent Form (See Appendix C), in the waiting room of the QML facilities adjacent to the Clifton Beach Medical Centre and the QML Smithfield rooms. Where possible the patients were selected with the approval and assistance of their medical practitioner(s). All patients were asked to carefully read Patient Information and sign the Informed Consent form prior to participating in the trial.

All volunteers who wished to participate in the trial were considered.

7.3.1.1 Inclusion criteria

- The patient currently takes 5 or more regular medications; these medications may be either prescription, over the counter, complementary or herbal medications, or
- The patient currently takes more than 12 doses of medication/day, or
- Significant changes have been made to the patient's medications in the last 3 months, or

- The patient takes medications with a narrow therapeutic index or medications requiring therapeutic monitoring – for example, Warfarin, or
- The patient has any symptoms suggestive of an adverse drug reaction, or
- The patient is attending a number of different doctors, both general practitioners and specialists, or
- The patient has recently been discharged from a hospital (in the last 4 weeks).

7.3.1.2 Exclusion criteria

For the purposes of this trial:

- Children under the age of 18 years;
- Inability to speak or write in English;
- Symptoms of Dementia.

7.3.2 Selecting a system

Taking into account the issues that arose during the development of the telepharmacy system described in Chapter 6, the system selected for the Medication Review trial was the iChat videoconferencing system and three Apple computers (Apple mini 1.6 GHz , iMac G5 2.33 GHz, iMac G3 700MHz - Apple Computer Inc.).

7.4 Procedure

An appointment was made for the telepharmacy conference. The patient collected all the medications he/she currently was currently taking and brought them to the telepharmacy conference. The trial took place over three separate days (Thursday evening, Friday evening and Saturday afternoon). After the official working day was over, the QML rooms at Clifton Beach were set up with the equipment for the trial as shown in the layout (refer to the following diagram). This arrangement provided appropriate privacy for the patient during the conduct of the Medication Review.

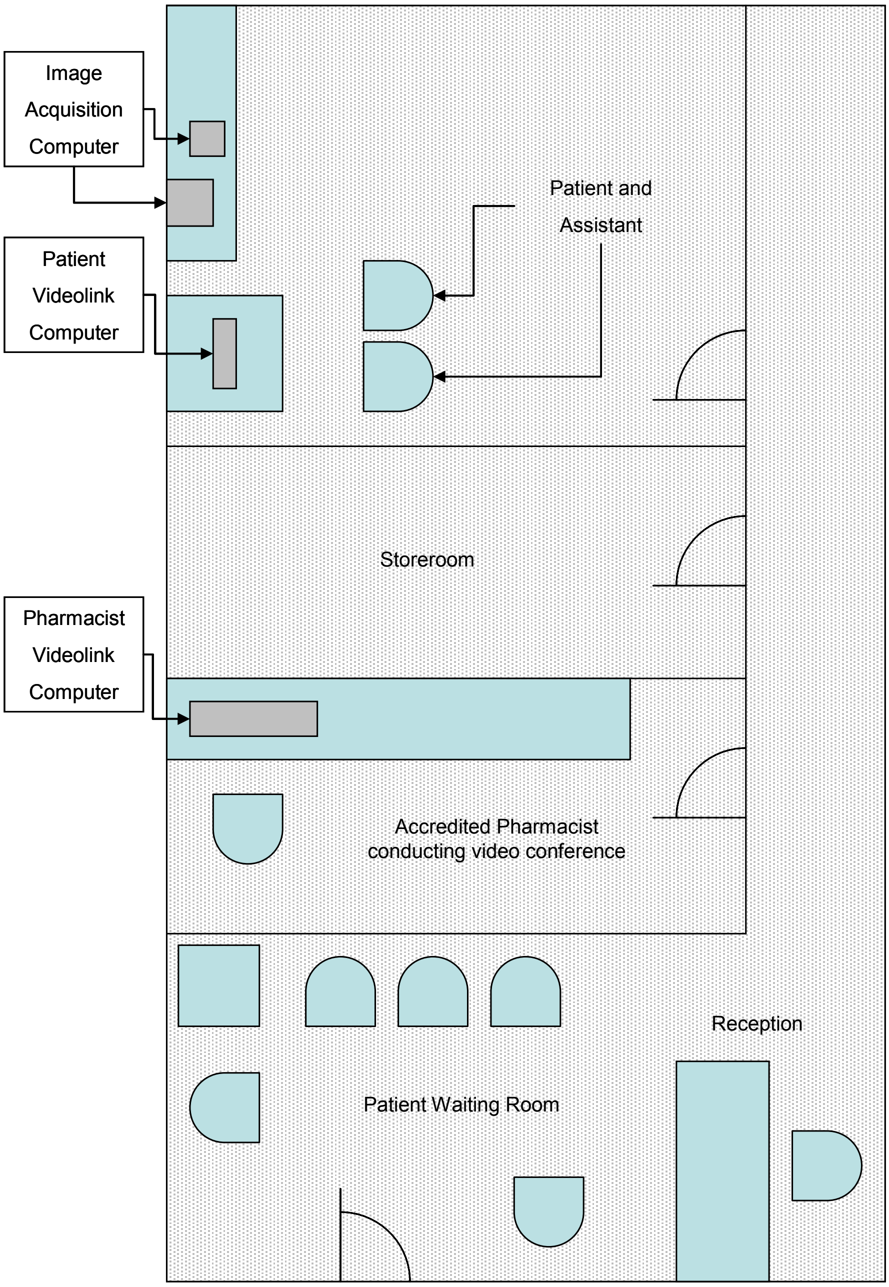


Figure 99: Room Layout for Medication Review Trial

The patients arrived in the waiting room at the appropriate appointment times, were offered coffee and asked if they were still happy to participate in the videoconference. The Informed Consent forms were reviewed. All patients agreed to participate.

When the accredited medication review pharmacist was ready for the videoconference, the patient was taken to the patient interview room. The pharmacist was already in the other interview room.

An IP computer to computer link (Bonjour, Apple Computer Inc) was established between the three computers using an encrypted wireless network, (Airport Extreme, Apple Computer Inc). Two of the computers, the pharmacist unit and the patient unit (see layout above for room layout), were then connected via video conferencing. The videoconference link was established at approximately 680 kbits/sec.

Figure 100: Videoconference, Pharmacist View, Interview Room 2

A helper was on hand to assist the patient with the technology and the interview. The image acquisition device, connected to the video conferencing unit, was also used, where appropriate, to take images of the patient's medication and transmit these to the pharmacist. The researcher was also on hand to assist the pharmacist with the technology and video tape the video conference for future reference. The following is an example of the product images captured during the video conference and transmitted to the interviewing pharmacist (patient names have been edited).

Figure 101: Medication Review Trial product images

The patient was requested to have all his/her medications available and preferably, where space permitted, to place them on the table between the patient and the videoconferencing monitor (see Figure 102).

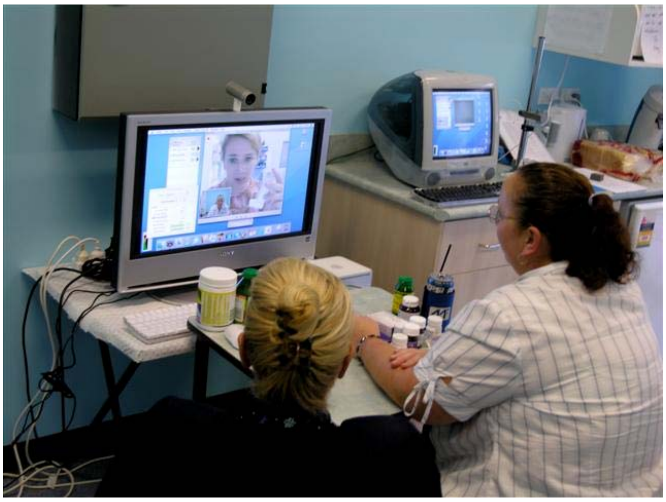


Figure 102: Videoconference, Patient View, Interview Room 1

The accredited medication review pharmacist conducted the review using a standard medication review check list.

A question and answer format was used after an appropriate greeting and settling in period. Each medication the patient was currently taking was discussed and was held up to the videoconference camera for the pharmacist to view. Where the image was not clear enough for the pharmacist to view, the pack was taken by the helper to the third computer which had an imaging device attached. Images were then taken and sent to the pharmacist by instant messaging via the Bonjour network.

Figure 103: Third computer with imaging device attached Interview Room 1

All the videoconferences were recorded (recorder.xhead, version 4, www.xheadsoftware.com) and saved to file. At the end of the conference, the videolink was terminated and the patient was asked to complete an assessment form on their videoconference experience (see Appendix C for a copy of this form). The medication review pharmacist, using the checklist and notes taken during the conference together with the saved videoconference recordings, prepared a report which was sent to the patient's general practitioner.

7.5 Results

The saved videoconferences were reviewed at the end of the trial and the quality of the sound and the clarity of the image were graded by the researcher and the assistant, using a scale of 1 to 5, where 1 was very poor, 2 was poor, 3 was acceptable, 4 was very good and 5 was excellent). The results of the grading by the two viewers were summed and a median grading calculated as shown in the Table below.

Table 44: Medication Review Trial - Audio and Video Quality

Patient	Audio Quality Scale 1 - 5	Video Quality Scale 1 - 5
A	3	4
B	4	4
C	3	4
D	3	4
E	4	4
F	4	4
G	3	4
H	3	4
I	4	4

The results from the completed patient satisfaction forms were tabulated and appear in the Table below.

Gender	Female	Female	Male	Female	Female	Male	Female	Female	Male
Year of Birth	1937	1952	1947	1965	1958	1946	1957	1946	1952
How do you rate the quality of the video image?	Excellent	Excellent	Excellent	Very Good	Excellent	Very Good	Excellent	Excellent	Very Good
How do you rate the quality of the sound?	Very Good	Excellent	Good	Good	Excellent	Very Good	Good	Good	Excellent
How do you rate the time taken to organise the video conference?	Excellent	Excellent	Excellent	Very Good	Excellent	Very Good	Very Good	Excellent	Excellent
How would you rate the privacy of your conversation with the pharmacist?	Excellent	Excellent	NA	Excellent	Excellent	Very Good	Very Good	Excellent	Excellent
How would you rate how well the pharmacist answered your questions?	NA	Excellent	Excellent	Excellent	Excellent	Very Good	Very Good	Excellent	Excellent
How would you rate the professionalism of the Staff assisting the telepharmacy experience?	Excellent	Excellent	Excellent	Excellent	Excellent	Very Good	Very Good	Excellent	Excellent
How would you rate your telepharmacy experience overall?	Excellent	Excellent	Excellent	Very Good	Excellent	Very Good	Very Good	Excellent	Excellent
If the Telepharmacy service was only available as a telephone call, rather than a video conference, do you believe that this would be an effective way of conducting a review of your medications?	Yes	Yes	Yes	Yes	No	Somewhat	No	No	No
If you were not able to travel to a pharmacy would you use the Telepharmacy facility to seek advice from the pharmacist on a *minor illness*?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If you were not able to travel to a pharmacy would you use the Telepharmacy facility to seek advice from the pharmacist on *non-prescription* medicines?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If you were not able to travel to a pharmacy would you use the Telepharmacy facility to seek advice from the pharmacist on *prescription medicines*?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If you were not able to travel to a pharmacy would you use the Telepharmacy facility in the future if it was available	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 45: Patient Telepharmacy Experience Survey Responses

7.5.1 Patient Telepharmacy Experience Survey

Questions 1 and 2 were Gender and Date of Birth. Two thirds of the patients were female. The range of birth years was 1937 to 1965.

Table 46: Gender and Birth Year of Telepharmacy Medicine Review Trial Participants

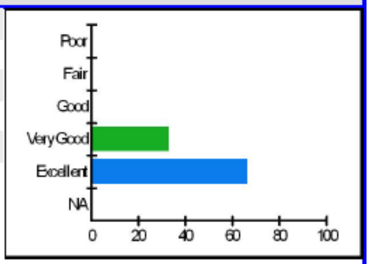
Gender	Birth Year
Female	1937
Male	1946
Female	1946
Male	1947
Female	1952
Male	1952
Female	1957
Female	1958
Female	1965

The next series of questions required responses of “Poor”, “Fair”, “Good”, “Very Good”, “Excellent” and “Not Applicable”. The issues canvassed included the patient’s opinions of the telepharmacy experience. Question Three asked the patient to rank the quality of the video. Of the respondents, six rated the video quality as “Excellent”.

Table 47: Patient Telepharmacy Medicine Review Trial Opinions on Quality of Video

Quality of Video — Mean: 4.7

Response	Value	Freq.	Percent	Cum. Percent	Valid Percent	Cum. Val. Percent	Graph
Poor	1.0	0	0.0	0.0	0.0	0.0	
Fair	2.0	0	0.0	0.0	0.0	0.0	
Good	3.0	0	0.0	0.0	0.0	0.0	
Very Good	4.0	3	33.3	33.3	33.3	33.3	
Excellent	5.0	6	66.7	100.0	66.7	100.0	
NA	6.0	0	0.0	100.0	0.0	100.0	
Total Valid		9	100.0		100.0		

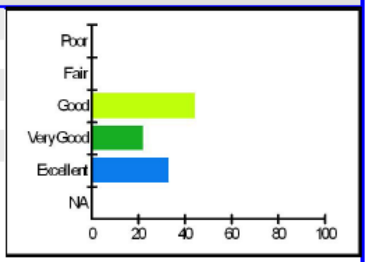


Question Four asked the patient to rank the quality of the sound. Of the respondents, four rated the sound quality as “Good”, two rated the sound as “Very Good” and three rated the sound as “Excellent”.

Table 48: Patient Telepharmacy Medicine Review Trial Opinions on Quality of Sound

Quality of Sound — Mean: 3.9

Response	Value	Freq.	Percent	Cum. Percent	Valid Percent	Cum. Val. Percent	Graph
Poor	1.0	0	0.0	0.0	0.0	0.0	
Fair	2.0	0	0.0	0.0	0.0	0.0	
Good	3.0	4	44.4	44.4	44.4	44.4	
Very Good	4.0	2	22.2	66.7	22.2	66.7	
Excellent	5.0	3	33.3	100.0	33.3	100.0	
NA	6.0	0	0.0	100.0	0.0	100.0	
Total Valid		9	100.0		100.0		

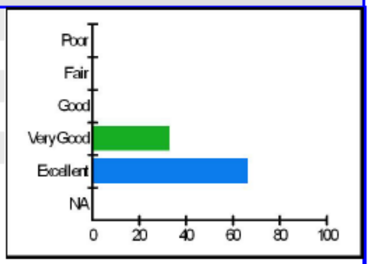


Question five, asked the patient to rate the time taken to organise the video conference. Of the respondents, six rated this as “Very Good” and three rated it as “Excellent”.

Table 49: Patient Telepharmacy Medicine Review Trial Opinions on the time taken to organise the video conference.

Time to organise? — Mean: 4.7

Response	Value	Freq.	Percent	Cum. Percent	Valid Percent	Cum. Val. Percent	Graph
Poor	1.0	0	0.0	0.0	0.0	0.0	
Fair	2.0	0	0.0	0.0	0.0	0.0	
Good	3.0	0	0.0	0.0	0.0	0.0	
Very Good	4.0	3	33.3	33.3	33.3	33.3	
Excellent	5.0	6	66.7	100.0	66.7	100.0	
NA	6.0	0	0.0	100.0	0.0	100.0	
Total Valid		9	100.0		100.0		

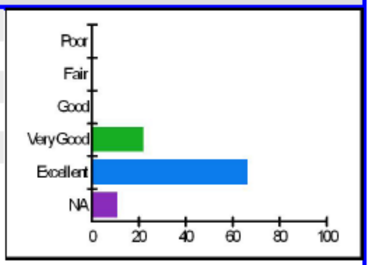


Question six, asked the patient to rate the privacy of the video conference. Of the respondents, two rated this as “Very Good” and six rated it as “Excellent”, and one thought the question was “Not Applicable”.

Table 50: Patient Telepharmacy Medicine Review Trial Opinions on the privacy of the video conference.

Privacy — Mean: 4.9

Response	Value	Freq.	Percent	Cum. Percent	Valid Percent	Cum. Val. Percent	Graph
Poor	1.0	0	0.0	0.0	0.0	0.0	
Fair	2.0	0	0.0	0.0	0.0	0.0	
Good	3.0	0	0.0	0.0	0.0	0.0	
Very Good	4.0	2	22.2	22.2	22.2	22.2	
Excellent	5.0	6	66.7	88.9	66.7	88.9	
NA	6.0	1	11.1	100.0	11.1	100.0	
Total Valid		9	100.0		100.0		

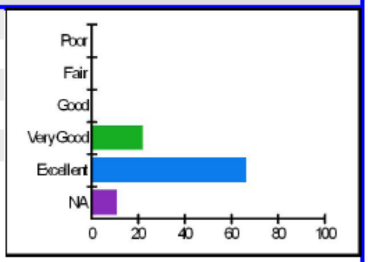


Question seven, asked the patient to rate how well the pharmacist answered his/her questions during the video conference. Of the respondents, two rated this as “Very Good” and six rated it as “Excellent”, and one thought the question was “Not Applicable”.

Table 51: Patient Telepharmacy Medicine Review Trial Opinions on how well the pharmacist answered his/her questions during the video conference.

Questions answered? — Mean: 4.9

Response	Value	Freq.	Percent	Cum. Percent	Valid Percent	Cum. Val. Percent	Graph
Poor	1.0	0	0.0	0.0	0.0	0.0	
Fair	2.0	0	0.0	0.0	0.0	0.0	
Good	3.0	0	0.0	0.0	0.0	0.0	
Very Good	4.0	2	22.2	22.2	22.2	22.2	
Excellent	5.0	6	66.7	88.9	66.7	88.9	
NA	6.0	1	11.1	100.0	11.1	100.0	
Total Valid		9	100.0		100.0		



Question eight, asked the patient to rate the professionalism of the Staff assisting the telepharmacy experience. Of the respondents, two rated the staff as “Very Good” and seven rated the staff as “Excellent”.

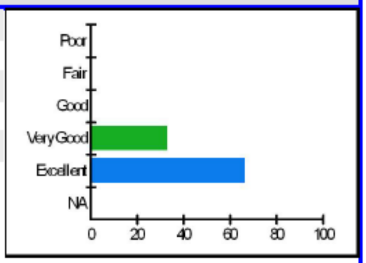
Question nine, asked the patient to rate the overall telepharmacy experience. Of the respondents, three rated the experience as “Very Good” and six rated the experience as “Excellent”.

Table 52: Patient Telepharmacy Medicine Review Trial Opinions on the overall telepharmacy experience.

Overall experience? Mean: 4.7

Response	Value	Freq.	Percent	Cum. Percent	Valid Percent	Cum. Val. Percent
Poor	1.0	0	0.0	0.0	0.0	0.0
Fair	2.0	0	0.0	0.0	0.0	0.0
Good	3.0	0	0.0	0.0	0.0	0.0
Very Good	4.0	3	33.3	33.3	33.3	33.3
Excellent	5.0	6	66.7	100.0	66.7	100.0
NA	6.0	0	0.0	100.0	0.0	100.0
Total Valid		9	100.0		100.0	

Graph



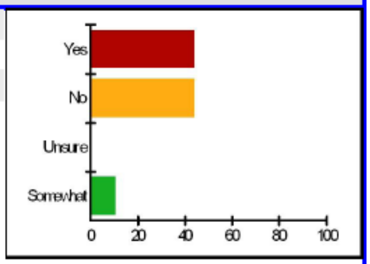
Question ten required responses of “Yes”, “No”, “Not Sure”, and “Somewhat”, and asked the patient if the Telepharmacy service was only available as a telephone call, rather than a video conference, did he/she believe that this would be an effective way of conducting a Medication Review. Of the respondents, four answered “Yes” and four answered “No”, and one thought a telephone review would be “Somewhat” suitable.

Table 53: Patient Telepharmacy Medicine Review Trial Opinions if telephone could be used for a Medication Review if videoconferencing was not available.

Telephone? Mean: 1.8

Response	Value	Freq.	Percent	Cum. Percent	Valid Percent	Cum. Val. Percent
Yes	1.0	4	44.4	44.4	44.4	44.4
No	2.0	4	44.4	88.9	44.4	88.9
Unsure	3.0	0	0.0	88.9	0.0	88.9
Somewhat	4.0	1	11.1	100.0	11.1	100.0
Total Valid		9	100.0		100.0	

Graph



The next group of questions related to the patient’s opinion of the applicability of telepharmacy and required responses of “Yes”, “No”, and “Not Applicable”.

Questions eleven, twelve, thirteen and fourteen asked if the patient were not able to travel to a pharmacy would he/she use the telepharmacy facility to seek advice from the pharmacist on

- a minor illness?
- non-prescription medicines?
- on prescription medicines?

Of the respondents, all answered “Yes” that they would use telepharmacy in these circumstances.

The final question asked if the patient were not able to travel to a pharmacy would he/she use a telepharmacy facility in the future if it was available. Of the respondents, all answered “Yes” that they would use telepharmacy in this circumstance.

7.6 Discussion

When using the iChat software operating over a LAN at simulated broadband speeds of between 500-700 kbits/second, the interview process and the collection of data to produce a Medication Review report were highly satisfactory. The rating by the patients of the quality of the video images was in the range of very good to excellent and the sound was in the range of good to excellent. The use of videoconferencing to conduct a Medication Review was considered by all the participants to be in the range of Very Good to Excellent. The use of telephony only to conduct a Medication Review was, however, considered to be an unsatisfactory method by four of the participants, with one not certain. All the patients agreed that they would be prepared to use telepharmacy, if they were not able to travel to a pharmacy, and would use telepharmacy in such a situation to seek advice on minor illnesses, non-prescription and prescription medicines.

This study on the use of videoconferencing for conducting a Medication Review was accomplished using a LAN at speeds of 500 – 700 kbits/sec. The purpose of the study was to determine if it is feasible to conduct Medication Reviews using videoconferencing. Based upon previous work by Nissen and Tett,[(75)] where telecommunications problems marred their study, it was felt that the process of conducting the reviews was the important issue, rather than introducing a further variable. With the increase in speed and reliability of telecommunication platforms, Broadband speeds of 500-700 kbits/sec are quite feasible in most rural areas within a few years. Current ADSL speeds available from Telstra (Table 5) range from 256/64 kbps to 1500/256 kbps. Telstra claim that the third generation (3G) mobile broadband network (NextG) introduced in Australia in October 2006 will have average speeds of 550Kbps to 1.5Mbps and peak network downlink speeds of 3.6 Mbps.[h]

[h] www.bigpond.com

This pilot study therefore represents a "baseline", indicating that Medication Reviews can feasibly be accomplished via telepharmacy. The reports prepared as a result of the medication reviews appear in Appendix C. Patient details have been removed from the reports to protect patient privacy.

This approach is supported by Russell in his Thesis entitled "Establishing the Efficacy of Telemedicine as a Clinical Tool for Physiotherapists: From systems design to randomised controlled trial", where he states that "Ideally, a public telephone system connection should be used when evaluating a telemedicine system designed to run via the standard telephone system. However, this study has demonstrated that an experimental LAN communications platform can adequately emulate a public telephone system connection". This approach was therefore adopted for the Medication Review trial.

The video recordings from the patient video conferencing interviews were edited to conform with Internet viewing requirements (320X240 pixel resolution)[190] (Apple QuickTime Pro). These videos are suitable for store and forward applications and were tested on a local intranet. Two full patient interviews, one from the patient's perspective and one from the pharmacist's perspective are available for review (see Appendix G). The patient involved has given specific Informed Consent for the interview to be made available for the purposes of reviewing this thesis.

The pharmacist did have some difficulty with the sound quality. This was due to the interview room, where the patient was situated, being a large open room with hard sound reflecting surfaces. The pharmacist, however, was still able to successfully conduct the interviews. The sound, from the patient's perspective, was graded as good to excellent (Table 48). The reason for this difference in sound quality was that the pharmacist was situated in a much smaller room with less sound reflecting surfaces. In telepharmacy implementation it will be necessary to situate the equipment accordingly to avoid large open spaces with hard sound reflecting surfaces.

The images of the medication packs were transmitted at a resolution of 352 by 288 pixels. The images were easy to read and all details on the label legible (see Figure 101 above). Resolutions of 768 by 512 pixels have been found to be adequate in dermatology telemedicine applications for the evaluation of burns care and image quality greater than 1024 by 768 pixels are probably unnecessary for burn interpretation.[191] Given the resolution requirements for label verification are not as critical as those of a skin burn verification, resolutions higher than 352 by 288 pixels are probably unnecessary for verification of pack images, however, the equipment used for the trial is capable of delivering the resolutions up to 1024 by 768 pixels if required.

7.7 Hypothesis Testing

2. The application of telepharmacy applications can be demonstrated by pilot studies.

   Specifically this can be stated as:

   a. Pilot studies using automated dispensing equipment can demonstrate the application of such equipment in a simulated environment.

   b. Pilot studies in a simulated environment can demonstrate the feasibility of conducting medication reviews using telepharmacy techniques such as video conferencing.

Hypothesis 2 a. was discussed in Chapter 6.

In accepting the hypothesis that a pilot study can demonstrate the feasibility of conducting medication reviews using telepharmacy techniques such as video conferencing, the results from Tables 45 to 51 were examined.

The results from the pilot study demonstrate that there is sufficient patient acceptability and information to justify the next step, which would consist of the planning and justifying a randomised controlled medication review trial using patients domiciled in remote areas. Such an enlarged study would involve the recruiting of patients in suitable remote areas, where broadband telecommunications were available. Ideally a minimum of 60 patients should be recruited to allow for two groups of at least 30 patients. A general rule of thumb for such a study has been stated at 30 patients or greater to estimate a parameter.[189] The patient group would be randomly divided into two groups. The first group would have medication reviews conducted using the conventional HMR procedure. A medication review pharmacist would visit the remote location in person and conduct the review face to face. The second group would have the medication reviews conducted using telepharmacy techniques as described in this Chapter. A patient satisfaction questionnaire would be administered to both patient groups and to the medical practitioners, pharmacists and helpers involved in the trial.

The information from such a trial would provide an excellent basis for estimating the suitability and costs of using telepharmacy techniques for medication reviews in comparison with conventional HMR procedures. If successful, the information gained from such a study would provide a basis for approaching the HIC to fund medication reviews using telepharmacy techniques for remotely situated patients who may not normally be able to have such reviews conducted because of time, cost or resource reasons.

7.8 Chapter summary

The purpose of the trial was to clearly establish if medication reviews were feasible using telepharmacy techniques under controlled conditions and to provide information for the planning and justifying of a randomised controlled medication review trial involving patients domiciled in remote areas.

Under controlled network situations and acknowledging the limited composition of the volunteer patient group, the trial was a clear success. The patients participating in the trial were unanimous in their support for the concept and expressed a clear opinion that telepharmacy is a practical alternative in the situation where distance makes it difficult to conduct a medication review in the conventional face-to-face format in the home. There were some limitations in the trial. There were no patients aged over 70 years, and therefore the trial did not investigate older age groups and their acceptance (or otherwise) of the technology. The trial selection criteria excluded patients with English as a second language, those with obvious signs of dementia, and also excluded children.

A respondent to the survey of pharmacists on telepharmacy stated in the free format section:

"I would only consider telepharmacy if there was absolutely no alternative".

This is perhaps an unfortunate conclusion from the pharmacy profession as is at odds with the expressions of support for the concept by the medical profession respondents to the survey on telepharmacy.

A more pragmatic opinion, expressed by a medical practitioner in the free format section of the survey, sums up the approach to medication reviews by telepharmacy, which stated

"The whole point of a HMR is that it is 'face to face'. However, better a 'screen' than NO review".

Chapter 8 Discussion, Recommendations and Conclusion

8.1 Discussion

The continent of Australia with its vast distances and majority of people clustered along the seaboards makes it extremely difficult to provide quality pharmaceutical services in rural and remote areas. As telecommunications increase in speed and reliability, the use of information technology has the potential to greatly reduce the isolation that many rural populations experience. To date, however, the uptake of telepharmacy in Australia is virtually non-existent.

Partly this is due to the apathy of the pharmacy profession in addressing the issues of pharmaceutical services in rural and remote areas and also partly due to the cost containment efforts by the State and Territory governments. Australia was, arguably, one of the pioneers of telepharmacy with the introduction, and continued use, of the RFDS medicine chest. Unfortunately, this pioneering spirit did not extend to the application of the medicine chest program by involving the pharmacist in the prescribing process. The entire RFDS medicine chest system is administered by medical practitioners and healthcare workers. This same attitude also extends to the rural and remote clinics. Whilst some States, such as Queensland, have included a District Pharmacist as a resource that a nurse or healthcare worker can utilise as necessary, there is no data available to indicate that such resources are regularly consulted. The result is a rural and remote health system that has few pharmacists, other than those in private practise in rural towns, and pharmaceutical services have been delegated to other healthcare professionals. There are no data that can be analysed to identify medication adverse events in rural and remote areas arising from such causes as incorrect dosage, dispensing of the wrong medicine and drug interactions. Hamrosi et al.[(6)], reported “Aboriginal health workers reported a general lack of access to medications and frequent inappropriate use of medications due to limited understanding, literacy and information all of which lead to non-compliance with instructions”.

The implications of a failed high technology project should also be carefully considered. There will be considerable expenditure on such a project, both in human effort and capital expenditure. Therefore it is of utmost importance that such a project is well resourced and project managed by experienced personnel. The implementation of a high technology project is only the first step; the staff at the remote clinics will need to manage the system on a daily basis and therefore it is imperative that full and comprehensive training and ongoing personnel development is a fundamental part of any telepharmacy system.

8.2 Recommendations

8.2.1 Training

There are no pharmacy assistant training courses for healthcare workers working in rural and remote communities. The courses that are available are either directed at community[192] or hospital pharmacy assistant training.[193]

8.2.1.1 Recommendation 1

Develop a training course for AHWs working in rural and remote areas to prepare Dose Administration Aids (DAAs).

The issues confronting medication compliance are well known, particularly for elderly patients.[6, 69, 70] These issues take on an extra dimension when the patient resides in a rural or remote community. As discussed in Section 2.1.7, DAAs are a method of improving medication adherence for patients with multiple chronic medical conditions. Current legislation in the States and Territories of Australia do not permit the preparation of DAAs, except under the direct supervision of a pharmacist, since this is classed as a dispensing operation. The logistical complications inherent in providing DAAs to rural and remote communities has resulted in either the withholding of DAAs, and supplying multiple medication packs to the patient, or the clinic staff preparing the DAAs "illegally".[9]

It is recommended that a training course for AHWs be created that focuses on the proper preparation of DAAs in rural and remote clinics, including supervision, quality and legal issues. This course should be incorporated into the VET system and be nationally accredited at a Certificate II level, incorporating a number of the units already in the Certificate III in Health Service Assistance (Hospital and Community Health Pharmacy Assistance) HLT31402, and including a new unit covering DAAs, as described below.

State and Territory governments and other stakeholders will need to be consulted to change the current pharmacy laws to permit AHWs holding this proposed qualification to legally prepare DAAs in rural and remote clinics.

8.2.1.2 Recommendation 2

Develop a training course for pharmacy assistants working in rural and remote areas.

The Certificate III in Health Service Assistance (Hospital and Community Health Pharmacy Assistance) HLT31402 could form a suitable basis for this course. As discussed in Chapter 4, HLT31402 is divided essentially into three sections. Section 1 prepares the student for working effectively in a workplace and includes business and communication units. Section 2 comprises three introductory level courses in health sciences such as basic medical terminology and complying with infection control procedures. There are then seven pharmacy oriented units in Section 3 that are directly applicable to pharmacy practice. Of these units two are not suitable for rural and remote clinics in that they involve the training of the assistant to help with the preparation of extemporaneous products and small scale pharmaceutical manufacture. Both of these activities are unnecessary in rural and remote clinics.

These units should therefore be replaced by two telepharmacy units; the first aimed at the medication review process conducted by video conferencing and the supply of Scheduled medicines under video supervision. The second unit required would be aimed at the dispensing of imprest and S100 products, under video supervision and the preparation of DAAs (Webster, Dosett packs). In addition, a basic pharmacology unit will be required, similar in content to that of the RIPRN course.

At present there are no course materials available for the pharmacy component of the Certificate III HLT31402 course, although Performance Criteria have been developed. In order for a nationally accredited Certificate to be awarded, the training must be delivered by a Registered Training Organisation, with the Course approved by the appropriate State or Territory Training Authority.

Individual Statements of Attainment in the pharmacy units could be made available in order to address the current lack of appropriate formal pharmacy assistant training courses for rural and remote healthcare workers handling and supplying medications.

8.2.2 Telepharmacy Systems Implementation

In order to provide an improvement in the quality of pharmaceutical services to rural and remote communities, it is recommended that the introduction of information technology be implemented in a step-wise manner.

The implementation pyramid shows the stepwise implementation of telepharmacy from the simple introduction of imaging and bar code reading to the full installation of a remote dispensing machine.

Once a telepharmacy project has been identified, the first step should be to develop an appropriate training course for AHWs and other professional staff involved, followed by a comprehensive training programme. This will avoid the project being compromised because the key personnel are not familiar with the proposed system. This is shown in Step 1 of the Implementation Pyramid in Figure 104.

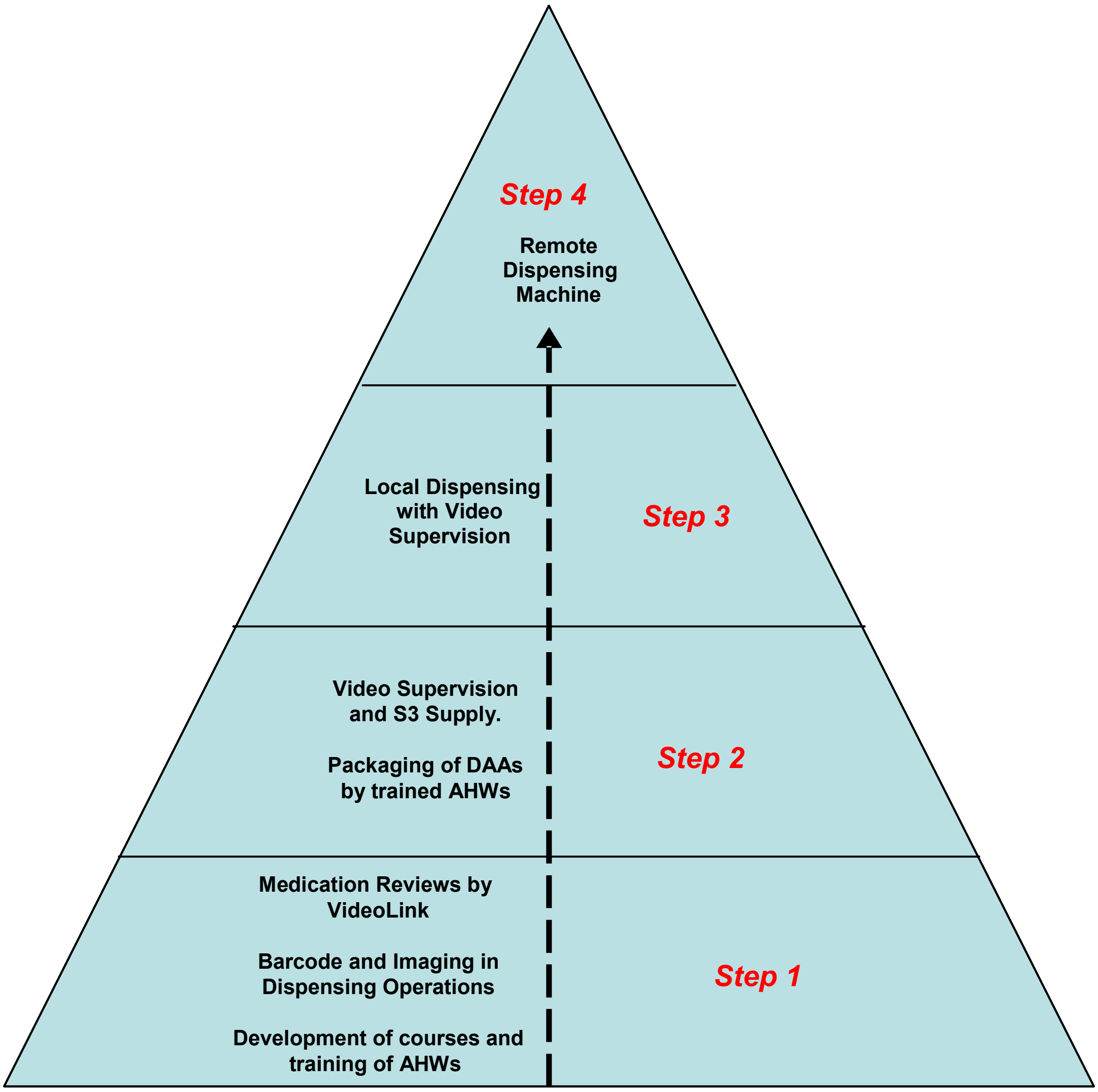


Figure 104: Implementation progression pyramid

8.2.2.1 Recommendation 3

Introduce bar code readers and imaging devices for all dispensing systems.

Initially, all installations where medications are supplied, should be equipped with a bar code reader connected to an appropriate dispensing or inventory control system, which recognises the bar code and displays the name of the product on a screen for the remote healthcare worker to accept.

This is a relatively low cost and simple implementation and could use existing software such as that used in the Tiwi Island Pharmacy project. The image below shows the implementation of a dispensing system, with touch screen which also is connected to a bar code reader.

Figure 105: Tiwi Island Pharmacy Project touch screen dispensing system demonstrated by an AHW at Nguiu Pharmacy, Tiwi Islands.[(71)]

A simple imaging device of the design below could also be added at low cost:

Figure 106: Imaging device

This unit comprises a webcam (iSight, Apple Computer Inc.) mounted on a modified drill press at a cost of less than $200 for camera and stand.

The low cost of both the bar code reader and the imaging unit is such that all pharmacies and clinics should have such an installation, regardless of whether they practise in a city, town or rural area because of the quality assurance function they provide. Flynn et al. noted in the Journal of the American Pharmaceutical Association that the "utilization of simple technologies, like bar codes and onscreen drug images, can reduce medication dispensing errors by one full percentage point".[(194)]

Recommendation 3 is represented by Step 1 in the implementation pyramid.

8.2.2.2 Recommendation 4

Introduce medication reviews via telepharmacy.

Once video conferencing is available at Broadband speeds, the opportunity arises to implement medication reviews via videolink. The staff in the remote area will need special training in this regard and the first telepharmacy unit described in Recommendation 1 should be completed before such an operation commences. This area is unique and the important finding to come out of this thesis is that medication reviews conducted by video conferencing are feasible and, provided there are no communication issues and a competent helper is on hand to assist the patient, the outcome is quite acceptable to the patient.

In the Queensland Health environment, the existing videoconferencing network represents an ideal infrastructure to introduce medication reviews to the public health sector. Queensland Health has established a Safe Medications Practice Unit and one of their first priorities is to trial medication reviews in rural south east Queensland in 2007.

Since medication reviews and eHealth initiatives are priority areas in the Fourth Pharmacy Agreement and the implementation does not require changes to legislation, medication reviews by telepharmacy should be considered a high priority project where considerable benefits are possible with only modest investment.

Recommendation 4 is represented by Step 1 in the implementation pyramid.

8.2.2.3 Recommendation 5

Introduce video supervision for the supply of S3 products by rural licensed premises.

When Broadband is available in a rural area, the next step in the implementation triangle can be implemented, the introduction of video supervision to enable Schedule 3 products to be supplied by operations with the appropriate Poison License. An example of this implementation is the supply of salbutamol inhalers in rural areas without a pharmacy, or when the pharmacy is closed. At present Poison Regulations and Pharmacy Board Rules in States and Territories do not permit this type of transaction. Overseas experience suggests that, with appropriate regulation, there is no reason why this restriction should remain. Remote supervision is already common in the USA[114, 115] and underway in the UK.[120]

Recommendation 5 is represented by Step 2 in the implementation pyramid.

8.2.2.4 Recommendation 6

Introduce local dispensing by a delegated trained pharmacy assistant at a remote location, under video supervision.

Step 3 in the implementation pyramid described above, involves local dispensing by a delegated trained pharmacy assistant, under video supervision. This implementation is similar to that described by Peterson and Anderson in the North Dakota Telepharmacy Project.(114) However, this step could also include the installation of a remote cabinet unit, as described in Chapter 6, remotely operated by a pharmacist, either in a Call Centre or a delegated pharmacy. This installation is similar to those described by Clifton et al.(115) in the Washington State Project. Steps 1 to 3 require minimal technical support other than for telecommunications and some minor engineering expertise for the remote cabinet installation.

The implementation of Step 4, full installation of a remote dispensing machine, whilst technically feasible as demonstrated in Chapter 6, is not recommended for rural and remote areas due to unknown reliability and support issues. Another important consideration is that, whilst there was support from three of professional groups surveyed, medical practitioners, nurses and healthcare workers, for the concept of remote dispensing machines, the pharmacist group were not in favour of such an approach. Since the pharmacist group should be the key drivers of such an initiative it is unlikely to succeed until the reasons for the lack of support from the pharmacist group are ascertained.

8.3 Further studies

This study has identified that further research is needed to ascertain the reasons for the lack of support shown for remote automated dispensing equipment in rural areas when the local pharmacy is closed and in remote areas without pharmacies.

The medication review study has shown that the use of information technology to conduct medication reviews is feasible. Further studies would include larger randomised trials using the Internet. These trials will require both substantial funding and a change in the current remuneration rules to allow medication reviews to be conducted via videoconferencing. However, the information from the pilot study will provide important input into the planning and justification of future medication review trials using telepharmacy techniques.

The automation studies have shown that a quality control device consisting of a bar code reader and an imaging device to capture dispensed packs is a simple and effective way to reduce the potential of dispensing errors. Further studies would involve the recruiting of a pharmacist group prepared to participate in the implementation of imaging and bar code reading as a quality control measure after the dispensing process.

The introduction of remote dispensing equipment will require a series of trials to determine the optimum type of equipment that would be suitable for rural Australia. Initial trials would probably be undertaken using the cabinet type unit, since this is mechanically simple and requires the least amount of technical support, whilst at the same time providing a substantial improvement over the existing situation where pharmacists are essentially excluded from the dispensing process in remote areas. In combination with video supervision, a simple and robust system is possible of providing rural and remote communities with pharmaceutical services that they currently do not have access to today.

8.4 Conclusion

It is unrealistic to expect that all communities will have personal access to a pharmacist; distances are too vast and the costs prohibitive. However, telepharmacy has the potential to improve the quality of pharmaceutical services in rural and remote areas. The targeted surveys of pharmacists, medical practitioners and nurses discussed in Chapter 4 indicated that that there is an appreciation and willingness to improve pharmacy services through the use of telepharmacy. Whilst the more technology intensive applications, such as automated, remotely controlled dispensing were not thought to be a suitable embodiment of telepharmacy at present, the use of telepharmacy in medication reviews, patient counselling and remote video supervision was widely supported by the professions surveyed.

The first part of this study was involved with identifying the opinions of relevant health professionals who would be directly involved in telepharmacy systems and identifying the characteristics of a telepharmacy system for use in rural Australia. The field trips to northern Queensland, the Tiwi Islands in the Northern Territory and the west coast of Tasmania provided a basis for the formulation of the surveys of professionals on telepharmacy and the focus group discussions with the Tiwi Island Health Board representatives identified a number of key factors that should comprise a telepharmacy system.

These key factors identified are summarised as follows:

1. A unit capable of storing a range of 80–100 individual medications, with multiple pack storage for high volume products.
2. Entry of patient details into a standard dispensing system, preferably employing a touch screen type entry.
3. An automated method of removing, preferably, an individual product from the storage unit.
4. An image acquisition capability to store a picture of the dispensed product pack and the expiry date and batch number if required.
5. Bar code reading of the dispensed product.
6. Video supervision of the dispensing unit.
7. For remote operation incorporating all the above features plus a method of reliably taking control of the automatic dispensing unit for remote operation, and a method of viewing the patient's prescription if an online prescribing system is not available.
8. A video conferencing capability to enable the remote pharmacist to provide counselling services to the patient. This video conferencing capability could also then be used to provide medication reviews for patients in rural and remote areas who do not have easy access to a medication review pharmacist.

An analysis of the systems commercially available indicated that these were not suitable for rural Australian requirements. They were either too complex, or had features which were not applicable to stated requirements. This work did not have the funding to produce or purchase a commercial unit, however, two embodiments of an automatic dispensing equipment design, were produced in pilot plant format. The features included in both embodiments of the design included:

1. A unit capable of storing a range of 80–100 individual medications, with multiple pack storage for high volume products.

   The pilot unit constructed was capable of storing 10-12 individual product packs. Scale up of the unit to one capable of storing 80-100 individual packs is relatively straight forward due to use of the robotic pick and place arm. The cabinet unit is simpler to scale-up since only additional drawers fitted with servo motors are required.

2. Entry of patient details into a standard dispensing system, preferably employing a touch screen type entry.
   The WiniFRED dispensing system was installed with the capability of entering the data via a touch screen being incorporated in the design.

3. An automated method of removing, preferably, an individual product from the storage unit.

   The robotic version of the design provided this functionality, and the top drawer of the cabinet dispensing model also included this capability.

4. An image acquisition capability to store a picture of the dispensed product pack and the expiry date and batch number if required.

   This functionality was incorporated into the equipment designs via the use of webcams.

5. Bar code reading of the dispensed product.

   This functionality was included into the robotic version to automatically read the barcode of the product pack as it was dispensed.

6. Video supervision of the dispensing unit.

   This functionality was also incorporated into the equipment designs via the use of a webcam.

7. For remote operation incorporating all the above features plus a method of reliably taking control of the automatic dispensing unit for remote operation, and a method of viewing the patient's prescription if an online prescribing system is not available.

   This functionality was incorporated by the use of remote desktop software.

8. A video conferencing capability to enable the remote pharmacist to provide counselling services to the patient. This video conferencing capability could also then be used to provide medication reviews for patients in rural and remote areas who do not have easy access to a medication review pharmacist.

   This functionality was also incorporated, via a separate video conferencing unit.

Important findings from this work were:

- Standard bar code readers do not record data when operated in remote mode. This is because the equipment acts in the form of an auxiliary keyboard and therefore requires the use of the local keyboard. Remote reading of bar codes will require the incorporation of a different style of reader. This was not an issue with the cabinet unit design since the reading of the bar code was accomplished by the remote assistant.
- More than two webcams installed in the dispensing unit caused a degradation of the video image. Various software solutions were trialled, the one that proved the most

successful was Active Webcam, a surveillance software program which supported multi webcams and allowed adjustment of the frame rate to optimise the image quality. For remote operation, bandwidth could be reduced to 50 -100 kbits/sec if the webcams were set to take individual frames at 1 second intervals, however, this setting was not suitable for video conferencing applications. As identified by Clifton et al. the trials also showed that the use of video conferencing on the same equipment resulted in poor performance.(115)

- A separate computer was therefore used for the video conferencing application of the unit. As stated above, the image quality of the webcams in video mode was satisfactory for remote supervision, however, for an application such as a medication review, which would require the reading of full label and expiry date details, an image capture device was necessary to capture high quality pictures of the pack details.
- The final telepharmacy design therefore had two components:
    1. The dispensing unit, with appropriate software installed and two webcams in the robotic embodiment, and
    2. A videoconferencing unit with a separate image capture device.

The equipment was trialled in local format and then satisfactorily operated (except for the bar code issue identified above), via a wireless LAN, tuned to broadband speeds of 500 – 700 kbits/s, using remote desktop software. The work therefore supports the applicability and ability of remote dispensing equipment, using standard software, to dispense medications under the remote supervision of a pharmacist.

The video conferencing unit developed was then used via a wireless LAN, tuned to bandwidth speeds of 500 – 700 kbits/s, for the medication review study of nine volunteer patients. This study was important since there is an increasing focus on evidence-based practice in health care and therefore the study provides the pharmacy profession with a firm scientific base upon which to justify the use of telepharmacy for medication reviews where it is not possible or economic for a pharmacist to travel to the patient to conduct a HMR, or where the patient is not able to travel to a pharmacy.(99)

The work therefore supports the six primary aims of this thesis which were:

1. To ascertain the opinions of relevant healthcare professionals on the concepts of telepharmacy.
2. To identify the requirements of a telepharmacy system suitable for use in rural Australia, by examination of the literature and discussion with key stakeholders.

3. To develop a pilot telepharmacy system based upon the identified requirements.
4. To demonstrate the validity, accuracy and reliability of the telepharmacy system in dispensing a limited range of products locally and then remotely via telecommunications.
5. To identify an area of telepharmacy where there is a clinical need and which has broad support of the key professional stakeholders.
6. To demonstrate the applicability of telepharmacy to the identified area of clinical need by means of a trial involving volunteer patients.

The incorporation of the quality control applications identified during the study; that of bar code reading and image capture of the dispensed products, are relatively simple and low-cost implementations which could provide a high degree of assurance that the patient has not been given the wrong medication.

The studies also identified that medication review studies conducted via telepharmacy are practical and feasible. This therefore supports the provision, via information technology, of patient counselling on their medications, either for prescription items or over the counter products, when the patient is remotely situated or has difficulty in travelling to a pharmacy.

The results of the studies undertaken have important implications for pharmacy practice.

The provision of telepharmacy services to rural and remote areas has the potential to provide quality pharmaceutical services such as the dispensing, supply and distribution of medicines; the provision of knowledge and information about drugs, with the primary objective being the promotion and assurance of quality use of medicines. The use of information technology can also assist in the provision of pharmaceutical care, where pharmacists respond to patients' drug-related needs to assist them achieve their desired health outcomes.