Beyond the Essential Medicines List
Improving access to essential medicines at the primary healthcare level in Solomon Islands through the implementation of mobile electronic inventory

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PhD Thesis

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This thesis is submitted in total fulfilment of the degree
Final submission: January 2018
Abstract

Background
Access to essential medicines in low and middle-income countries remains limited, due in part to weaknesses in national and local supply chains. Emerging technologies present an opportunity to strengthen supply chains by improving stock management and providing real-time data to health planners but there has been a paucity of published data on the effectiveness of these approaches.

Aim
To improve the availability, staff comprehension and usage of priority medicines for mothers and children in the Solomon Islands through the implementation of mobile electronic inventory systems at the provincial medical supply level.
To explore the relationship between medicines availability, staff comprehension and medicines usage.

Primary Hypothesis
That the implementation of mobile electronic inventory at provincial Second Level Medical Stores (SLMS) in Solomon Islands will improve the availability of priority medicines for mothers and children at the primary healthcare level.

Method
A before-and-after intervention effectiveness field study, conducted over 12 months in Solomon Islands. Individual SLMS were purposely selected to be either in the intervention or control group – for operational reasons, these were not randomly allocated. Primary healthcare clinics across Solomon Islands were then part of the intervention or control arm, depending on which SLMS they were supplied from. Six SLMS, servicing 121 clinics, comprised the intervention group. Six SLMS, servicing 104 clinics, comprised the control group.
Mobile electronic inventory systems were installed in the six SLMS supplying the intervention group. The six SLMS supplying the control group continued using the established paper-based ordering systems.
A series of educational interventions was also implemented across all clinics.

Baseline data collection commenced in April 2013 in 80 randomly selected clinics (control n = 40; intervention n = 40), assessing the:

i) Availability;

ii) Comprehension and;

iii) Usage

of 31 Priority Medicines for Mothers and Children.

Follow-up data collection was conducted 12 months after the implementation of the intervention.

The primary outcome measure was the mean percentage availability of 17 medicines, out of the 31 WHO priority medicines, that are mandated to be available at the clinic level. The mean was taken as the average percentage from all surveyed clinics in the intervention and control arms.

**Results**

**Availability**

**Overall**

Medicines availability increased by 9.9% [6.4, 13.4] from baseline (n = 68, mean = 64.2%, s.d. = 14.5) to follow-up (mean = 74.0%, s.d. = 14.1); t=5.61, p<0.001

**Control group**

In the control group, medicines availability increased by 12.4% [6.8, 18.1] from baseline (n = 36, mean = 59.5%, s.d. = 16.0) to follow-up (mean = 71.9%, s.d. = 16.1); t=3.28, p=0.002

**Intervention group**

In the intervention group, medicines availability increased by 7.0% [3.0, 11.0] from baseline (n = 32, mean = 69.5%, s.d. = 10.5) to follow-up (mean = 76.5%, s.d. = 11.2); t=2.58, p=0.012

**Primary outcome**

The overall mean availability of medicines at baseline was 64.2% (SD = 14.5). Medicines availability increased by 9.9% overall from baseline to follow-up (p<0.001). The results for each group are shown in Table 2. There was strong evidence of a difference in medicines availability between the 2 groups.
at baseline, with the intervention group having 10.0% (95% CI: 3.4 - 16.7%) higher availability
(p=0.004) at baseline than the control group. Follow-up availability was not different (95% CI: -6.6%
to 6.3%, p=0.957) in the intervention group than the control group, adjusting for baseline availability.
This analytical model did not show any evidence for a difference in the magnitude of change between
the control and intervention groups.

Comprehension

Overall, staff comprehension increased by 13.7% from baseline (mean = 58.5%) to follow-up (mean =
72.2%); t=6.83, p<0.001

In the control group, comprehension increased by 13.5% from baseline (mean = 58.6%, n = 50, s.d. =
13.0) to follow-up (mean = 72.1%, n = 43, s.d. = 13.2); t=4.94, p<0.001

In the intervention group, comprehension increased by 14.0% from baseline (mean = 58.4%, n = 51,
s.d. = 14.6) to follow-up (mean = 72.4%, n = 40, s.d. = 13.5); t=4.68, p<0.001

Usage

The proportion of episodes of care where medicines usage was rational increased by 6.5% over the
life of the study: from baseline (mean = 55.4%, 3404/6147 episodes of care) to follow-up, (mean =
61.9%, 3962/6400); χ² = 55.1, p<0.005.

In the control group, rational use of medicines (RUM) improved from 54.2% (1128/2083 episodes of
care) to 63.4% (2184/3444); χ² = 46.4, p<0.005.

In the intervention group, RUM improved from 56.0% (2276/4064 episodes of care) to 60.1%
(1778/2956); χ² = 12.0, p<0.005

For every 1% improvement in comprehension, a corresponding 0.4% increase was observed in the
rational use of medicines. There was insufficient evidence to show a strong correlation between
medicines availability and usage.
Discussion

The findings of this study did not support the primary hypothesis; there was no difference in the magnitude of change in medicines availability between the clinics serviced by medical stores which used electronic inventory compared with those that did not. There were significant improvements in both the control and intervention groups.

In the first year of implementation however, there had been a possibility that availability would actually decline in the intervention group and this was not the case – medicines availability improved in the intervention group.

Many factors influence the availability of medicines at the primary healthcare level in low and middle-income countries, including geography, funding, transport and storage infrastructure and staff training – more research is required to determine the extent to which each of these play a role.

Staff comprehension and medicines usage increased in both groups. Availability of essential medicines remains a prerequisite for rational usage of medicines but this study suggests that improvements in availability do not lead to improvements in usage, unless comprehension also improves.

There was no difference in staff comprehension between the control and intervention groups. This met expectations as all educational interventions were applied equally to both groups.

Electronic inventory systems may have other benefits, including workload efficiencies, shorter lead times, reduced data entry duplication, real-time provision of data and less errors.

Conclusions

Emerging technologies have the potential to improve supply chains in low and middle-income countries and to this end, this study has provided a model for the implementation of mobile electronic inventory systems that may be applicable across other Pacific island country settings.

There is insufficient evidence from the current study however, to support the primary hypothesis that mobile electronic inventory systems improve the availability of essential medicines.
Further research over longer time periods is required to determine the extent to which various factors influence availability. This would help to determine priority-setting and funding allocations.
Declaration

This is to certify that this thesis comprises only my original work towards the PhD, except where indicated in the Preface and Statement of Contribution. Due acknowledgement has been made in the text to all other material used. The thesis is fewer than 100,000 words, exclusive of tables, figures, maps, bibliographies and appendices.

Michael James Nunan

Date: 16th September, 2017
Preface and statement of contribution

Unless otherwise stated, I managed the entire project and conducted all work presented in this thesis including conceiving the original idea, developing and testing the data collection tools, submitting both ethics applications, managing annual ethics reports, coordinating data collection, entering and cleaning data, analysing data and writing this body of work.

A number of other people contributed to the conception of this work, the development of the methodology, data collection, the implementation of interventions, data cleaning and analysis, reviewing manuscript drafts and proof-reading of the thesis. The major contributors are listed here.

Timmy Manea and Willie Horoto (Solomon Islands Ministry of Health and Medical Services) helped to conceive the idea of mobile electronic inventory systems in the Solomon Islands and contributed substantially to the design and implementation of the project.

Erica Reeve (WHO) supervised the random selection of clinics for data collection.

Suzanna Vidmar and Michelle Wiest provided advice on data entry, cleaning and analysis.

Erin Nunan, Jane Hawtin, Eleanor Neal, Dr Sarah McNab, Dr Emily Reeve, Dr Louise Vella and Dr Gerard Kelly very generously helped with proof-reading of this thesis.

Erin Nunan helped undertake data verification for the medicines usage chapter.

Sustainable Solutions© wrote original software and provided technical support to the project.

Most importantly, my supervisors Prof Trevor Duke, Prof Andrew McLachlan, Mr Greg Duncan and Dr Divinal Ogaoga provided support at every step, including and especially during the development of the methodology and thesis drafting.

A/Prof Noel Cranswick chaired my Advisory Panel, and A/Prof Andrew Steer sat as a Panel Member for the entirety of my PhD. Both provided extremely strong advice, particularly in the area of data analysis and I am extremely grateful for their support and encouragement.
A truly special thank-you to all Solomon Islands pharmacy officers and nurses involved.

Data collection team members:
Jayms Faneagalo, Solomon Bosa, Rollina Nunu, Mary Elliot, Mieke Kern, Julie Zinihite, Jessie Larui, Gabriel Spencer, John Gela

The project was funded by the Solomon Islands Government’s Ministry of Health and Medical Services and the Australian Government’s Department of Foreign Affairs and Trade (DFAT) Aid Program.
Publications and presentations in support of this work

Publications related to but not directly arising from this work


Publications


Presentations

Australia / Solomon Islands Bilateral Aid Talks (Solomon Islands - Australia Partnership for Development), Heritage Park Hotel, Honiara Solomon Islands, 1st May, 2013
Presentation: mSupply Mobile Electronic Inventory – improving medicines supply at the primary healthcare level
Speakers: Michael Nunan, Willie Horoto

Presentation: Provincial distribution to primary healthcare level (Electronic Inventory)
Speakers: Michael Nunan, Willie Horoto, Timmy Manea
3 Minute Thesis Competition, University of Melbourne

Heats: Ella Latham Theatre, Royal Children’s Hospital, Melbourne: 3rd June, 2015

Finalist, Department of Paediatrics: Ella Latham Theatre, Royal Children’s Hospital, Melbourne: 9th October, 2015

Presentation: *Improving access to essential medicines in Solomon Islands using mobile electronic inventory*

Speaker: Michael Nunan

PSA15 (Pharmaceutical Society of Australia’s Annual Conference), Sofitel Sydney Wentworth Hotel, Sydney Australia, 31st July – 2nd August, 2015

Presentation: *The implementation of mobile technologies for medical supply chains in developing countries: from the Pacific Islands to an Ebola outbreak*

Speaker: Michael Nunan


Keynote Presentation: *Pharmacists without borders: International roles for pharmacists*

Speaker: Michael Nunan
## Acronyms and abbreviations

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<tr>
<td>ACTs</td>
<td>Artemisinin Combination Therapies (anti-malarials used in Solomon Islands)</td>
</tr>
<tr>
<td>AL</td>
<td>Artemether-Lumefantrine (specific ACT in use in Solomon Islands)</td>
</tr>
<tr>
<td>Alma Ata</td>
<td>Site of International Conference on Primary Health Care in 1978</td>
</tr>
<tr>
<td>ARVs</td>
<td>Anti-retroviral drugs, used in the treatment of HIV</td>
</tr>
<tr>
<td>AVI</td>
<td>Australian Volunteers International</td>
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<tr>
<td>Bin Cards</td>
<td>Another term for ‘stock cards’, a hard-copy (paper) method used in clinics for monitoring stock usage and levels.</td>
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<tr>
<td>CICH</td>
<td>Centre for International Child Health (University of Melbourne)</td>
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<tr>
<td>DDD</td>
<td>Defined Daily Dose</td>
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<tr>
<td>DFAT</td>
<td>Department of Foreign Affairs and Trade (Australian Government)</td>
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<tr>
<td>EML</td>
<td>Essential Medicines List</td>
</tr>
<tr>
<td>EpiData®</td>
<td>Data entry software program</td>
</tr>
<tr>
<td>FDA</td>
<td>US Food and Drug Administration</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GNI</td>
<td>Gross National Income</td>
</tr>
<tr>
<td>GRADE</td>
<td>Grading of Recommendations, Assessment, Development and Evaluation (mechanism for systematic appraisal of published literature)</td>
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<tr>
<td>HAI</td>
<td>Health Action International</td>
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<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
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<tr>
<td>HR</td>
<td>Human Resources</td>
</tr>
<tr>
<td>IFPMA</td>
<td>International Federation of Pharmaceutical Manufacturers &amp; Associations</td>
</tr>
<tr>
<td>INRUD</td>
<td>International Network for Rational Use of Drugs</td>
</tr>
<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
</tr>
<tr>
<td>MDGs</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>MHMS</td>
<td>Solomon Islands Ministry of Health and Medical Services</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>mSupply©</td>
<td>Stock management software provided by Sustainable Solutions</td>
</tr>
<tr>
<td>NMP</td>
<td>National Medicines Policy</td>
</tr>
<tr>
<td>NMS</td>
<td>Solomon Islands National Medical Stores</td>
</tr>
<tr>
<td>NMTC</td>
<td>Solomon Islands National Medicines and Therapeutics Committee</td>
</tr>
<tr>
<td>NPSD</td>
<td>Solomon Islands National Pharmacy Services Division (MHMS)</td>
</tr>
<tr>
<td>NRH</td>
<td>National Referral Hospital (Honiara, Solomon Islands)</td>
</tr>
<tr>
<td>ORS</td>
<td>Oral Rehydration Solution or Oral Rehydration Salts</td>
</tr>
<tr>
<td>PACTAM</td>
<td>Pacific Technical Assistance Mechanism (formerly administered by AVI)</td>
</tr>
<tr>
<td>PHF</td>
<td>Primary Healthcare Facility</td>
</tr>
<tr>
<td>PIC</td>
<td>Pacific Island Country (referring to the island nations of the western and south Pacific, generally encompassing Melanesia, Polynesia and Micronesia)</td>
</tr>
<tr>
<td>PNG</td>
<td>Papua New Guinea, the largest and most populous PIC.</td>
</tr>
<tr>
<td>RAMSI</td>
<td>Regional Assistance Mission to the Solomon Islands</td>
</tr>
<tr>
<td>RDT</td>
<td>Rapid Diagnostic Test</td>
</tr>
<tr>
<td>RUM</td>
<td>Rational Use of Medicines</td>
</tr>
<tr>
<td>Septrin</td>
<td>Trade name for Cotrimoxazole: Trimethoprim and Sulfamethoxazole</td>
</tr>
<tr>
<td>SIG</td>
<td>Solomon Islands Government</td>
</tr>
<tr>
<td>SLMS</td>
<td>Second Level Medical Store</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Messaging Service</td>
</tr>
<tr>
<td>STATA©</td>
<td>Statistical analysis software program (StataCorp)</td>
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<tr>
<td>STGs</td>
<td>Standard Treatment Guidelines</td>
</tr>
<tr>
<td>STI</td>
<td>Sexually transmitted infection</td>
</tr>
<tr>
<td>TRIPS</td>
<td>Agreement on Trade Related Aspects of Intellectual Property Rights</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations International Children’s Fund</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency (radio network in health facilities in Solomon Islands)</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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Chapter 1: Introduction and thesis overview

Background

The concept of ‘essential medicines’ was first articulated in the mid-1970s and it basically held that a limited selection of evidence-based medicines, chosen to treat and manage priority health needs would result in better health outcomes, improved medicines management, more efficient use of financial resources and improved access to care. Later, it would also come to encompass the development of contextually appropriate treatment guidelines, procurement, financing and distribution of medicines. The first WHO Model Essential Medicines List was published in 1977 and the Declaration of Alma Ata in 1978 recognised the provision of essential medicines as one of eight elements of primary health care.

The availability of essential medicines at the primary health care level is a pre-requisite for ensuring access to medicines in low and middle-income countries. Despite the emergence of the concept of essential medicines in the late 1970s and the presence of a National Medicines Policy in the majority of lower and middle-income countries, the availability of essential medicines at the point of care remains inadequate globally.

One key reason for this is the failure of local, regional and international medicines supply chains. It is hypothesised that emerging technologies may have a role in helping to address the challenges in achieving access to medicines in low and middle-income countries but there is a paucity of evidence to guide practice, including aspects of implementation and the utility of such technologies.

Medicines supply and access in the Solomon Islands

The Solomon Islands, a Pacific island country of 560,000 people located east of Papua New Guinea (PNG), typifies the experience of many low income countries. Despite the existence of a National Medicines Policy, encompassing the principles of essential medicines, the availability of medicines at the primary level remained inadequate.

In Solomon Islands, medicines are supplied free to patients through clinics, via the National Pharmacy Services Division (NPSD), which sits within the Ministry of Health and Medical Services of the
Solomon Islands’ Government. The country has a National Medicines Policy, incorporating the principles of Essential Medicines.⁶

NPSD procures all medical supplies, including pharmaceuticals, through the National Medical Stores (NMS) and distributes these to clinics via a national network of twelve Second Level Medical Stores (SLMS).

SLMS are staffed by Pharmacy Officers and are positioned in strategic locations across the provinces. Pharmacy Officers are responsible for ordering supplies from NMS (located in the capital, Honiara), and distributing them on to clinics in their respective ‘catchment areas’. Under the pre-existing stock management system prior to this study, the twelve SLMS carried out all tasks manually, using hard copy paper order forms to request supplies from NMS and to make records of orders arriving from clinics. This medical supply system is cumbersome, provides little data back to the central level, duplicates data entry and contributes to long lead times on all orders from NMS.

The country has successfully used electronic stock management at the central level (NMS) since 2005 and a roll-out of a mobile version of this software to SLMS was proposed as early as 2011, to improve efficiencies, reduce lead times and improve the quality of data pertaining to medicines supply.

The NPSD developed a mobile version of their existing stock management software, mSupply®, in partnership with a private software provider (Sustainable Solutions©) and implemented this system in six SLMS in April 2013. Solomon Islands is believed to be the first Pacific Island Country (PIC) to implement a mobile electronic inventory system for the supply of medicines in their public health system.

Simultaneously, NPSD rolled out a series of educational interventions to all health facilities in the country, focussing on the World Health Organisation’s Priority Medicines for Mothers and Children. These educational initiatives were based in part on a pilot project undertaken in 2011 and developed further in conjunction with the Reproductive and Child Health Division within the Ministry of Health.⁷

Given the potential opportunity to draw lessons from this experience that might be applied across similar settings in the region, the Solomon Islands Ministry of Health partnered with the Centre for
International Child Health (University of Melbourne) to develop and carry out research to systematically assess the impact of this new program.

Solomon Islands is possibly the first country in the world to systematically assess the impact of mobile electronic inventory across a national medical supply system, using a controlled study methodology examining the availability, comprehension and usage of priority medicines at the primary healthcare level.

This thesis contextualises the Solomon Islands’ experience of the global concept of essential medicines, presents the background to the project, the results of this research and proposes a model for the implementation of this novel mobile electronic inventory system in other PICs.

The project was funded by the Solomon Islands Government and the Australian Government’s Department of Foreign Affairs and Trade (DFAT) Aid Program.

Hypothesis

That the provision of mobile electronic inventory systems at provincial SLMS, coupled with educational initiatives at the primary healthcare level, will improve the availability of priority medicines for mothers and children.

Description of research

A controlled pre- and post-intervention effectiveness study, undertaken over a 12 month period in Solomon Islands.

Every primary healthcare clinic in the country (n ≈ 320) was separated into either a control or intervention arm, based on which SLMS supplied the clinic. Approximately 100 clinics were excluded. Baseline data were collected across 80 randomly selected clinics from the two groups (control n = 40, intervention n = 40) looking at three indicators: medicines availability (primary indicator), staff comprehension and medicines usage (secondary indicators). A series of educational interventions were then implemented across all 320 clinics in the country, focussing on the 31 WHO
Priority Medicines for Mothers and Children. Finally, mobile electronic inventory systems were installed on iPads in the six SLMS supplying intervention group clinics. The six remaining SLMS, supplying the control group clinics, continued to use the established paper-based inventory systems. Twelve months after the baseline assessment and data collection, follow-up data were gathered from the same clinics (control n = 40, intervention n = 40) using identical data collection tools.

Objectives

Primary Objective

To evaluate whether mobile electronic inventory systems can improve the availability of the WHO Priority Medicines for Mothers and Children in primary healthcare facilities in Solomon Islands.

Secondary Objectives

- To evaluate whether a series of educational interventions would improve health worker comprehension around the use of the WHO Priority Medicines in Solomon Islands.
- To evaluate whether the usage of the WHO Priority Medicines in primary healthcare facilities in Solomon Islands could be improved by these multi-faceted interventions aimed at improving medicines availability and health worker comprehension.
- To explore the relationship between availability, comprehension and use of medicines. Also to demonstrate a model for implementation of mobile electronic inventory in similar settings and to propose a methodology for assessment of these systems.

Structure of this thesis

Chapter 2 provides a background to global essential medicines policy, providing a historical basis for the WHO Model Essential Medicines List and a discussion of the strategy’s shortfalls.

Chapter 3 is a Literature Review looking at previous studies into the effect of emerging technologies on the availability of medicines in low and middle-income countries.
Chapter 4 continues the discussion of essential medicines policy, framing it in the Solomon Islands context, with a history of the country’s health system from the 1990s onwards and a detailed description of the practical aspects of the country’s National Medicines Policy.

Chapter 5 describes the established, paper-based medicines supply system used in Solomon Islands and then the new mobile system, introduced in April 2013. This includes a brief description of the development of both systems.

Chapter 6 explores various methods measuring medicines availability in primary healthcare facilities and provides evidence for the methodology used in this study.

Chapter 7 presents the methodology and results for the primary outcome measure of medicines availability.

Chapter 8 presents the methodology and results for the secondary outcome of staff comprehension.

Chapter 9 presents the methodology and results for the secondary outcome of medicines usage.

Chapter 10 summarises the findings of Chapters 7 – 9 and explores the relationship between availability, comprehension and the usage of medicines. Chapter 10 also contains verification of the extent to which the interventions were implemented. It concludes by providing a discussion of key confounders of this study.

Chapter 11 is a brief case study focusing on one disease area and one treatment. This chapter looks at the effect of the interventions on the availability and usage of zinc sulphate for childhood diarrhoea. This case study provides important but comprehensible points for discussion and lessons which apply across the spectrum of child and maternal health.

Chapter 12 provides an overall summary of the results and a model for implementation in similar contexts, as well as proposing a methodology for future research in this area.

Chapter 13 places this research in its broader context, using existing literature and interviews with experts in this field. It presents an overview of current medical supply chain innovations, with a focus on mobile electronic inventory in low-resource settings over the last 20 years, outlining the current enablers, challenges and innovations in the field.
Chapter 2: The global essential medicines situation

Introduction

Improving the availability of essential medicines at primary healthcare facilities is a fundamental element to strengthening access to medicines in low and middle-income countries. Whether people have access to essential medicines when they are unwell depends on many factors, including care-seeking behaviours, health literacy, dosage forms, cost, geography and social class. Availability at the point of service delivery remains a pre-requisite to access however. Despite many theories for improving medical supply chains, the availability of medicines at the primary level in low and middle-income countries remains inadequate.

This chapter presents the history of essential medicines policy in a global context and frames the current situation in relation to medicines availability across the developing world.

Essential Medicines and Drug Supply

The emergence of essential medicines policy

The concept of ‘essential medicines’ emerged in the 1970s in response to the proliferation of therapeutic agents that had occurred from the late 1940s onwards. Highlighting this, one half of all antibiotics in use today were developed between 1950 and 1960. This had put an unusual strain on health services, particularly in low and middle-income countries, with a poor evidence base to support local formularies and large variation in the drugs used between facilities. This proliferation of medicines resulted in both financial and clinical risks. Clinicians had little information to guide prescribing and this was acutely felt in low and middle-income countries where limited access to continuing professional education further hindered decision making. In the 1950s and 60s, individual facilities were often responsible for their own procurement and were thus unable to create economies of scale, so that costs had begun to increase unsustainably. The Drugs and Therapeutics Committees that were created within individual hospitals had little guidance on the most
cost-effective therapies available for each condition and low and middle-income countries – many of which were emerging from the colonial era with weak public services – had limited resources with which to conduct economic analyses. Low and middle-income countries are far less likely to have clinical pharmacologists, testing laboratories and the health sector infrastructure to support research. The impact on patient populations was acute; in 1966, the USA’s Food and Drug Administration (FDA) contracted with the National Academy of Sciences and National Research Council to investigate the safety and efficacy of four thousand drugs approved for use between 1938 and 1962, all released with no evidence as to whether these medicines were safe and effective. This retrospective analysis occurred simultaneously with massive research into new agents. By 1965 for example, the National Cancer Institute in America was testing 15,000 agents every year for potential effectiveness against cancer alone.

At the time, prescribers had limited information on which of an innumerable number of medicine options might be most effective and the availability of any one item across multiple facilities could rarely be assured. Access to high-quality, efficacious medicines was extremely limited across low and middle-income countries. By 1978 it was estimated that, at most, half of the world’s population had access to essential medicines.

In 1975, the World Health Assembly asked the WHO to assist countries in selecting and procuring essential medicines, so in 1977 the first WHO Model List of Essential Medicines was published. At the Alma Ata Conference on Primary Healthcare in 1978, the provision of essential medicines was recognised as one of eight key components of primary health care.

For the first time, there was a centralised source of information for countries to determine the most efficacious agents for particular clinical situations; “the list helped to establish the principle that some medicines were more useful than others and that essential medicines were often inaccessible to many populations”.

Support for essential medicines was not universal. The concept of an essential medicines list was considered controversial as late as 1987, when the International Federation of the Pharmaceutical Manufacturers Associations (IFPMA) called the medical and economic arguments for WHO’s model
Essential Medicines List ‘fallacious’, stating that adopting an essential medicines policy could result in ‘sub-optimal medical care and might reduce health standards’.4 Nevertheless, ‘essential medicines policy’ came to encompass evidence-based rational selection of a limited number of agents, guided by treatment guidelines, and later, particularly in the wake of the 1985 Nairobi Conference of Experts on the Rational Use of Drugs, to also include centralised or streamlined procurement, distribution, rational use and quality assurance.2,19 It is these principles within National Medicines Policies that define the policy as ‘encompassing Essential Medicines’.6

From 2002, an evidence-based approach was adopted for the inclusion of medicines on the model list, taking into account relevance to public health, efficacy, safety and cost-effectiveness. WHO publishes explanations and evidence to support these decisions.4

One of the fundamental justifications for essential medicines, in addition to clinical benefits, was in managing medication costs, and national essential medicines lists were adopted in many cases to help establish economies of scale that would ensure affordable prices for medicines. Integral to this, in the poorest countries, from the late 1980s onwards, was centralised procurement by a national (or large

Figure 1: The Essential Medicines Cycle20

[Diagram of the Essential Medicines Cycle]
regional) authority and this model is still in place today in a large number of least developed countries.

The success of essential medicines

The concept of essential medicines achieved many of its aims. It moved medicines supply away from a market driven model towards one that focused on public health.\textsuperscript{21} As summarized by Mirza in 2008, “The [essential medicines] approach is fair, efficient and above all based on common sense. This is also a way of overcoming imperfections and failures of the pharmaceutical market. The concept is not only applicable in the public sector where it is most used but also in the private sector, especially in health insurance systems. It contributes to achieving health objectives and is based on sound economics and ethics.”\textsuperscript{21}

There is little doubt that, globally, essential medicines policy improved access to high quality, cost-effective therapies in low and middle-income countries.

The limitations of essential medicines

Despite these advances, by 1988 only 20% of ‘developing countries’ had a functioning and adequate procurement and distribution system for essential medicines.\textsuperscript{22}

By 2003, the number of people with access to essential medicines worldwide had nearly doubled to 4 billion, from 2.1 billion in 1977. The ratio of people with access to medicines had improved from something less than half to roughly two thirds.\textsuperscript{1}

Most low and middle-income countries now have a National Medicines Policy (NMP), enshrining the principles of ‘essential medicines’.\textsuperscript{12} In 2007, 94% of low-income countries reported having an NMP (though only 23% of these had been updated in the preceding five years). In 2013, this figure of 94% of low-income countries with an NMP was replicated.\textsuperscript{23}

Despite the progress in national policy development, access to essential medicines remains poor across the Pacific Island Countries (PICs) and globally. A meta-analysis in 2009 showed that the global mean availability for a selection of 15 medicines, at the clinic level, in 36 low- and middle-income countries was only 38.4% in the public sector.\textsuperscript{3} In the Western Pacific region, availability was
43.0%, whilst across all WHO regions, availability in the public sector ranged from 29.4% - 54.4%. In the private sector, in low and middle-income countries, the global average was 64.2%.³

A 2014 study using the same methodology across 23 low and middle-income countries found that the global median availability of essential medicines in the public sector was still only 40.0%.¹¹ These data point to the fact there was – and remains – a growing sense that the gains stemming from essential medicines policy had stagnated and that greater innovation in supply chains was required to ensure access to these essential medicines across the population.

**Availability of - and access to - essential medicines**

The failure of drug supply chains is the result of a complex set of circumstances. Limited funding (for both procurement and transport), weak public infrastructure, insufficient staff numbers and capacity, poor training and remuneration, inadequate storage facilities, the absence of pharmacy standards, parallel procurement and distribution systems for some medicines, corruption and theft all probably contribute to some degree but it is unclear to what extent each plays a role.

A systematic review examining some of the proposed mechanisms for improving the availability of essential medicines was published in 2011.⁵ This review analysed papers that had specifically examined the effect of a pharmacy system intervention on the availability of essential medicines at the primary healthcare level. Generally, there has been a paucity of published work in this area. The review found that many papers have explored availability and provided theories about possible mechanisms to improve availability but very few have systematically tested these mechanisms or possible solutions. Some evidence was found that suggested staff supervisory visits, community-directed interventions, staff training and the integration of disease-specific programs may all improve availability but in 2011, no published work was found examining the use of emerging, electronic or mobile technologies for improving availability. This was identified as a gap in the research field, with the potential to improve supply chains for essential medicines.⁵

Globally, mobile technologies, including mobile electronic inventory systems, have the potential to greatly assist decision making, in addition to improving availability. Potential benefits include real-time drug usage and availability data being fed back to central authorities, more accurate forecasting,
disease outbreak monitoring, individual clinic performance monitoring and the ability to quickly move stock around during natural disasters.

An evident problem has been the slowness with which emerging technologies have been adopted. Despite the mainstream advent of the internet in the mid-1990s, drug orders are overwhelmingly still placed using hard-copy paper based systems and quantification is done manually by clinical staff untrained for the task, which lies outside the ‘normal’ core competencies of clinical staff. Improving information technology and the spread of mobile and internet services offers opportunities to change supply practices, both at the central and peripheral levels, but take-up has been slow. This is addressed in the literature review, which is presented in the next chapter.

**Box 1: The relationship between medicine patents, essential medicines and the measures of availability used in this thesis**

In 1994, the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) was agreed to by participating countries at the inception of the World Trade Organisation. In basic terms, the agreement binds signatory countries to rules regarding intellectual property and patents, including those pertaining to drugs. The agreement makes 20 year drug patents the international standard and binds countries to not use generic versions of drugs covered by patents in other signatory countries. The agreement is controversial; it aims to promote innovation in drug development but it also has the effect of making some life-saving medicines less affordable. This problem garnered significant attention following the invention of the first effective anti-retroviral drugs for treating HIV, which were largely unaffordable for low and middle-income countries for many years.

It has been suggested that TRIPS is partly responsible for the poor availability of essential medicines in low and middle-income countries. While this is probably correct for some proportion of newer agents, this is not true for the vast majority of medicines on national EMLs. Of the items contained in the current WHO Model Essential Medicines List, only 4% are under patent and most studies into medicines availability only consider items not under patent, for which generics are available. Advocates have argued that the high cost of medicines covered by patents has prevented items from inclusion onto the Model Essential Medicines List but it is perhaps unrealistic to expect
that all new medicines could be immediately included, given the costs of drug development.\textsuperscript{30} That said, whilst the consequences of TRIPS and its impact on access to medicines remains an important area of research, it is outside the scope of this thesis. The basket of medicines developed for the research reported in this thesis (Chapter 7) contains no patent-protected medicines and the WHO Priority Medicines for Mothers and Children contains only one set of items under patent protection (first line therapies for HIV, for which there are several exceptions now available to the TRIPS provisions in developing nations).

The concept of essential medicines remains as relevant today as it was 35 years ago. A strong National Medicines Policy, incorporating the core principles of essential medicines, is a pre-requisite for a strong public health system. Basic essential medicines principles are insufficient however. To improve access, an emphasis must be placed on innovative supply chain mechanisms, using emerging technologies to support existing human capacity and established systems.

\textbf{Conclusion}

Essential medicines policy has improved access to high quality, evidence-based medicines globally since its inception in the 1970s. It remains highly relevant but it has proven inadequate in improving basic medicines availability, due largely to chronic weaknesses in local and national medical supply chains.

Emerging technologies have the potential to support and improve medical supply chains in low and middle-income countries but there is a paucity of evidence for models of best practice for countries to implement.
Chapter 3: Literature Review – do emerging technologies improve the availability of essential medicines?

Introduction

Globally, the availability of essential medicines at the primary healthcare level remains low. There is no evidence to suggest availability has improved since the advent of the internet in the mid-1990s. A 2009 review found the overall mean availability of generic medicines in the public sector to be 38.4%, ranging from 29.4% to 54.4% across WHO regions. A 2014 review supported this, finding that the global mean availability of essential medicines in the public sector was 40.0%. Examples of recent country-level surveys using the WHO/Health Action International availability assessment methodology or similar (see Chapter 6) are presented below. These have reported similar results, except for Saouadogo in Burkina Faso.

Table 1: Examples of recent surveys using HAO/WHO methodology

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Delhi, India</td>
<td>49.3%</td>
</tr>
<tr>
<td>2012</td>
<td>Guatemala</td>
<td>25%</td>
</tr>
<tr>
<td>2012</td>
<td>Bangladesh</td>
<td>6-15%</td>
</tr>
<tr>
<td>2011</td>
<td>Karachi, Pakistan</td>
<td>39%</td>
</tr>
<tr>
<td>2011</td>
<td>Burkina Faso</td>
<td>77.7%</td>
</tr>
</tbody>
</table>

The role of telemedicine is becoming well established in published literature, with an increasing number of papers exploring this area, however the focus remains on ‘telehealth’ and there is a lack of quality in published work.

The increasing availability of and access to the internet and mobile phones in low and middle-income countries is opening up the potential for new, ‘disruptive health technologies’. It has been hypothesised that emerging technologies may help to improve the availability of medicines in low and
middle-income countries. This chapter presents the results of a literature review of intervention studies to improve the availability of essential medicines using emerging technologies.

**Search methodology**

A search was conducted for all papers describing intervention studies to improve the availability of essential medicines in low and middle-income countries, using computer, electronic or web-based technologies.

**Primary Research Question:** That mobile, internet and computer technologies, implemented in pharmaceutical supply chains, can improve the availability of essential medicines in low and middle-income countries, when compared with established supply systems.

**Search database:** Medline, International Pharmaceutical Abstracts and Google Scholar. Hand searching of reference lists of potentially relevant articles was also conducted.

**Analytical Methodology:** GRADE

**Original Search date:** 14th July, 2014 (Medline) from database inception to date

**Updated search date:** 28th February 2016 (IPA) from database inception to date; 12th March 2016 (Medline) from 14th July 2014 – date.

**Criteria for selection**

Necessarily, broad inclusion criteria were used, due to the non-specific nature of the search query. All intervention or observational studies were included that described any computer, mobile-device or web-based technology to improve stock management of pharmaceuticals in any health setting in low or middle-income countries (the list of low or middle-income countries used is listed below). Both qualitative and quantitative studies were included. English language papers only were included.

A preliminary analysis of available studies revealed that meta-analysis was not possible due to heterogeneity: different study methodologies, outcome measures and statistical analyses. As such, the results of this review are presented narratively.
Measures of effect

Any logically applied measure of effect related to availability of essential medicines was included in the results.

Results

Figure 2 describes the search methodology and outcomes of this literature review. Table 2 summarises the eleven studies that were included.

Figure 2: Search methodology and selection of papers
Additional Search Terms

Countries (low and middle income countries, World Bank)
Afghanistan or Guatemala or Panama or Albania or Guinea or Papua New Guinea or Algeria or 
Guinea-Bissau or Paraguay or American Samoa or Guyana or Peru or Angola or Haiti or Philippines 
or Argentina or Honduras or Romania or Armenia or India or Russian Federation or Azerbaijan or 
Indonesia or Rwanda or Bangladesh or Iran or Samoa or Belarus or Iraq or Sao Tome and Principe or 
Belize or Jamaica or Senegal or Benin or Jordan or Serbia or Bhutan or Kazakhstan or Seychelles or 
Bolivia or Kenya or Sierra Leone or Bosnia and Herzegovina or Kiribati or Solomon Islands or 
Botswana or North Korea or Somalia or Brazil or Kosovo or South Africa or Bulgaria or Kyrgyz or 
South-Sudan or Burkina Faso or Laos or Sri Lanka or Burundi or Lebanon or St Lucia or Cambodia 
or Lesotho or Saint Vincent and Grenadines or Cameroon or Liberia or Sudan or Cape Verde or Libya 
or Suriname or Central-African-Republic or Macedonia or Swaziland or Chad or Madagascar or Syria 
or Malawi or Tajikistan or Colombia or Malaysia or Tanzania or Comoros or Maldives or Thailand or 
Democratic-Republic-of-Congo or Mali or Timor-Leste or Congo or Marshall Islands or Togo or 
Costa Rica or Mauritania or Tonga or Ivory Coast or Mauritius or Tunisia or Cuba or Mexico or 
Turkey or Djibouti or Micronesia or Turkmenistan or Dominica or Moldova or Tuvalu or Dominican-
Republic or Mongolia or Uganda or Ecuador or Montenegro or Ukraine or Egypt or Morocco or 
Uzbekistan or El Salvador or Mozambique or Vanuatu or Eritrea or Myanmar or Venezuela or 
Ethiopia or Namibia or Vietnam or Fiji or Nepal or Palestine or Gabon or Nicaragua or Yemen or 
Gambia or Niger or Zambia or Georgia or Nigeria or Zimbabwe or Ghana or Pakistan or Grenada or 
Palau

Drugs
Amoxicillin, ampicillin, ceftriaxone, gentamicin, oxygen, Oral Rehydration Salts (ORS), zinc 
sulphate, Artemisinin Combination Therapies (ACTs), artesunate, procaine benzylpenicillin,
Antiretrovirals (ARVs), paracetamol, morphine, oxytocins, misoprostol, sodium chloride, sodium lactate compound, magnesium sulphate, calcium gluconate, hydralazine, methyldopa, azithromycin, cefixime, benthazine benzylpenicillin, nifedipine, dexamethasone, tetanus vaccine, contraceptives

**Diseases**

Pneumonia, diarrhoea, malaria, neonatal sepsis, HIV, Vitamin A deficiency, palliative care and pain, vaccination, post-partum haemorrhage, pre-eclampsia, maternal sepsis, abortion services, miscarriage, Sexually Transmitted Infections, pre-term labour, prevention of tetanus, contraception

Papers returned

These search terms returned 1130 results. 1087 of these were excluded as not relevant to the topic or non-English. Forty-three papers were reviewed by abstract only and from these, 25 were selected for full paper review. Of these, eleven were selected as being relevant.

*Table 2: Literature review summary of results*

<table>
<thead>
<tr>
<th>Title of paper</th>
<th>Authors</th>
<th>Study type</th>
<th>Results</th>
<th>Publication and year</th>
<th>GRADE assess</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Implementation and evaluation of a web based system for pharmacy stock management in rural Haiti ³⁹</td>
<td>Berger E, et al</td>
<td>Before-and-after intervention study</td>
<td>Stock outs of key medications reduced from 2.6% to 1.1%, P&lt;0.001</td>
<td>American Medical Informatics Association 2007 Symposium Proceedings (p. 46-50)</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>Title</td>
<td>Authors</td>
<td>Methodology</td>
<td>Summary</td>
<td>Journal/Publication Details</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------</td>
<td>----------------------------------</td>
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<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>3</td>
<td>Use of an Innovative, Affordable, and Open-Source Short Message Service-Based Tool to Monitor Malaria in Remote Areas of Uganda</td>
<td>Asiimwe C, et al</td>
<td>Cross-sectional descriptive study</td>
<td>12.1% (Kabale District), 54.3% (Gulu District) reported total stock-outs of ACTs. No pre-intervention data.</td>
<td>Am. J. Trop. Med. Hyg., 85(1), 2011, pp. 26–33</td>
</tr>
<tr>
<td>4</td>
<td>SMS for Life: a pilot project to improve anti-malarial drug supply management in rural Tanzania using standard technology</td>
<td>Barrington J, et al</td>
<td>Before-and-after intervention study</td>
<td>Proportion of health facilities with no stock of one or more anti-malarial medicine reduced from 78% to 26%. Overall, AL stocks increased by 64%; quinine stock increased 36%.</td>
<td>Malaria Journal 2010, 9:298</td>
</tr>
<tr>
<td>5</td>
<td>Taking knowledge for health the extra mile: participatory evaluation of a mobile phone intervention for community health workers in Malawi</td>
<td>Campbell N, et al</td>
<td>Retrospective survey</td>
<td>Qualitative, anecdotal reports in retrospective focus groups. No statistical data reported</td>
<td>Global Health: Science and Practice 2014, 2:1</td>
</tr>
<tr>
<td>6</td>
<td>The AMPATH nutritional information system: designing a food distribution electronic record system in rural Kenya</td>
<td>Lim J, et al</td>
<td>Case study (Description of project)</td>
<td>Enrolled patients increased from 2000 to 30,000 per week.</td>
<td>Journal of the American Medical Informatics Association, 2009, 16:6</td>
</tr>
<tr>
<td>7</td>
<td>Strengthening pharmaceutical systems for palliative care services in resource limited settings: piloting a mHealth application across a rural and urban setting in Uganda</td>
<td>Namisango E, et al</td>
<td>Before and after intervention study</td>
<td>Frequency of stock outs reduced from 2/qtr (rural) and 3/qtr (urban) to 1/qtr in both. % of total stock that expired reduced from 3% to 0.5% (urban) and 58% to 0% (rural)</td>
<td>BMC Palliative Care, 2016, 15:20</td>
</tr>
</tbody>
</table>
8. A cross-sectional pilot study assessing needs and attitudes to implementation of Information and Communication Technology for rational use of medicines among healthcare staff in rural Tanzania

- Nilseng J, et al
- Prospective, qualitative survey of potential users
- All interviewees (20) reported that the prototype tablet software could help improve the drug ordering system
- BMC Medical Informatics and Decision Making, 2014, 14:78


- Nonaka D, et al
- Longitudinal study
- 20.6% of phone calls made using distributed mobile phones related to ‘malaria case treatment, Vitamin A distribution and delivery’

10. Computerized calculation of essential drug requirements

- Soeters R, Bannenberg W.
- Prospective theoretical analysis
- Estimated that the drug budget could be reduced by 45%
- Social Science and Medicine, 1988, 27:9

11. Developing a computer database for registering and monitoring patients on chronic drug therapy to determine drug consumption: a pilot study

- Tsoto CB, et al
- Case study (Description of project)
- Information on the amount of drugs being used was collected for all 434 patients registered on the database
- The Central African Journal of Medicine, 2001, 47:8

Description of results

No high quality intervention studies testing this hypothesis across a wide range of supplies were identified in this review of the literature. Some studies of lower quality were found however and these are discussed below. Generally, there is a paucity of published work in this field and the quality of some work is low. Most papers were retrospective, descriptive discussions of work that, whilst of
benefit, do not sufficiently address the hypothesis. Several papers used quasi-measures of medicines availability that are of limited value.

All but one of the studies lacked a control group and have not adequately controlled for bias. Three of the papers described a similar methodology, concentrating on medicines for a single disease class and it is unclear if the Short Message Service (SMS)-based modality described would be scalable to include all medicines from all disease categories.

There is the potential for significant publication bias in this field, as researchers are less likely to publicise the details of negative or inconclusive research and such results pertaining to real world settings can adversely affect funding from donor partners.  

1. Reducing stock-outs of life saving malaria commodities using mobile phone text-messaging: 
   SMS for life study in Kenya

This intervention study described an SMS stock reporting system for Artemether-Lumefantrine (AL, for malaria) and malaria RDTs, implemented in all 87 public health facilities across five districts in Kenya. The study showed stock outs of one or more AL packs reduced by 38% over 26 weeks, whilst total stock-outs (of all types of AL packs) went from 5% to 0% at the conclusion of the study. Stock outs of RDTs declined by 24%. Overall uptake of the program was excellent, with a facility response rate of 97%.

The study methodology was systematic and comprehensive. All 87 facilities in five districts were enrolled and the results were positive. The remaining national results, presumably from all remaining districts, were used as a control group, which was a major strength of the study, though the methodology was not comprehensively described. Results for RDT stock-outs were not reported in the control group, for example.

One key weakness was that the study considered only two commodities and it is not clear how the technology could be applied across a large number of stock lines.
2. Implementation and evaluation of a web based system for pharmacy stock management in rural Haiti

This descriptive study outlines the implementation of an innovative web-based system for stock management that has several parallels with the system implemented in the Solomon Islands. The study examined 450 stock lines over 9 sites. The results showed overall stock-outs decreased from 2.6% to 1.1% over the first year of implementation.

Whilst not a prospective intervention study, the retrospective analysis was systematic and the results were positive and statistically significant. The main strength of this study was that the technology was applied to all product lines and a valid, methodical form of measurement was applied.

The key weakness of this study was that the data were not validated through physical stock checks. Only the electronic record was used to assess availability. Furthermore, there was no control group to properly account for confounding. Importantly, the methodology for measuring stock availability is not widely used as it does not take into account the varying importance of different stock lines, giving equal weight to less important or redundant products. The study was presented as a paper at a symposium and it is unknown if the work has undergone peer review.

Of particular interest was the interface for stock entry, which replicated the manual bin cards in prior use, which health workers were already familiar with. This innovative method is likely to have reduced training requirements and increased uptake.

This study demonstrated the potential application of web-based technologies in improving stock availability and, whilst the data analysis differed from ours and is not directly comparable, this study should inform future work in this field.

3. Use of an Innovative, Affordable, and Open-Source Short Message Service (SMS) Based Tool to Monitor Malaria in Remote Areas of Uganda

The focus of this study was the collection of case data, RDT results and patient information using SMSs from mobile phones. The reporting of stock availability appears to have been a secondary consideration and no pre-intervention data are reported. The focus of this study was on gathering
information, rather than an intervention. Nevertheless, the gathering of commodity data is likely to be beneficial to supply stores. The study examined the availability of Artemisinin Combination Therapies (ACTs).

The study was undertaken in two districts of Uganda. From December 2009 – August 2010, an average 12.1% of the 104 health centres in Kabale District reported a total ACT stockout for at least a period of one week. In Gulu, these total stock-outs were reported by 54.3% of the 43 health centres. As in other studies focusing solely on malaria commodities, it is unclear that the program could be scalable to include all medical commodities.

4. SMS for Life: a pilot project to improve anti-malarial drug supply management in rural Tanzania using standard technology

The methodology of this study closely resembled Githinji et al in Kenya. An SMS stock-reporting system was implemented in three districts, involving 129 health facilities. The proportion of health facilities with no stock of one or more anti-malarial medicine (ACTs or Quinine) fell from 78% to 26% over 21 weeks. During the study, AL stocks increased by 64% and quinine stock increased 36% across the three districts, though these data were based solely on the total stock available in each district, not the facility-by-facility availability and is thus of minimal relevance.

Whilst positive, many of the gains achieved appear to have been derived from emergency or supplementary orders supplied immediately following the initial data collection and, over the short timeframe of the study (21 weeks), these are likely to have made a substantial impact on the final results. The long-term viability – and cost – of this methodology is unknown. This shortcoming is acknowledged by the authors however and they correctly point out that the existence of the data allowed these supplementary orders to be made efficiently, as well as allowing re-distribution between facilities in some areas.
5. Taking knowledge for health the extra mile: participatory evaluation of a mobile phone intervention for community health workers in Malawi

This study looked at the effect of distributing mobile phones to Community Health Workers (CHWs) in Malawi, to enable communication between them and other actors in the health system as a means of promoting ‘knowledge sharing’. The mobile phones were distributed without specific software or specialised functionality and the primary method of communication was text messaging.

The primary data collection tool in this study was a retrospective survey, using a pre- and post-intervention qualitative ‘participatory evaluation’ methodology called Net-Map, which is fully described in the paper but which does not relate to medicines availability. The availability of medicines availability was measured secondary to this primary outcome, by interviewing Community Health Workers (CHWs) during focus group discussions.

No data on medicines availability is given; the authors state that CHWs reported a reduction in stock-outs but there is no reference for this or supporting information.

The study did not have a control group, which it acknowledged was a weakness.

As a measure of medicines availability, the study provides barely more than anecdotal evidence.

6. The AMPATH nutritional information system: designing a food distribution electronic record system in rural Kenya

This paper describes the establishment of a food distribution electronic record system in Kenya. Though not strictly pertaining to essential medicines, the paper was returned using our search methodology and as there are strong parallels between the distribution of emergency food products and the distribution of medicines, it was decided to include it in this discussion.

The paper is predominantly a descriptive article on the development of the electronic record system to support the program. Its quantitative measure is that the number of people supported with food distribution rose from 2000 to 30,000 but there is no control group or clear evidence of causation.

There is an obvious bias in that funding to the program was increased simultaneously, so the number of people supported would be expected to rise regardless of the electronic system.
7. Strengthening pharmaceutical systems for palliative care services in resource limited settings: piloting a mHealth application across a rural and urban setting in Uganda

This paper describes the implementation of a mobile application for tracking patients and stock in a hospice and clinic setting. The study design was a pre and post-intervention study in 2 sites (urban and rural) across 197 and 297 days respectively.

The frequency of stock-outs for opioids decreased from 3 per quarter to 1 per quarter in the urban facility and from 2 per quarter to 1 per quarter in the rural facility. The % of whole stock value that expired reduced from 3% to 0% in the urban facility and from 58% to 0% in the rural facility. Though not necessarily related to medicines availability, the time spent preparing pharmacy reports also reduced, from 14 days to 1 day at the urban facility and from 5 days to 2 days at the rural facility.

This study was well conducted, with baseline and follow-up data collected using the same methodology and well defined indicators.

Unfortunately, the study did not have a control group and the sample size was very small, looking at only one set of commodities across two facilities, but there is no reason to indicate the methodology (and the intervention) could not be scaled up. The study also does not list the medicines it measured, instead just saying ‘opioids’.

It was also not explained why follow-up data was collected at 197 days in one facility and 297 days in another. This appears to be a significant confounder.

8. A cross-sectional pilot study assessing needs and attitudes to implementation of Information and Communication Technology for rational use of medicines among healthcare staff in rural Tanzania

This qualitative study measured the perceptions of 20 health workers responsible for stock ordering at 13 health facilities on their opinion of a prototype electronic application for stock ordering.

All 20 health workers reported that it could assist in stock management.
The methodology for this study was very weak. The staff saw only a prototype version of the software that was not functional and this was done in a group setting instead of on site at health facilities. The metric used for whether it could improve stock management was simply that health workers, when asked, reported it could help them manage stock – the exact question posed to health workers was not even recorded. It is possible that health workers would respond positively to this sort of question regardless of their opinion due to basic politeness in most cultures.

The sample size was also very small and not randomised.

Given the methodology, no control group or baseline data was possible and at the time of publishing the study, the software had still not been implemented.


This paper described the implementation and assessment of a mobile phone distribution program to village health volunteers from 154 (out of 158) villages in Xepone district, Laos. No specific software or applications were used; health workers were simply encouraged to use the mobile phones for work purposes.

Malaria treatment items were available in 59.1% of villages, while village first aid kits were available in 24.7% of villages. Across the course of the study, 20.6% of the calls from health workers to their supervisors were regarding ‘a variety of topics, including malaria case treatment, vitamin A distribution and delivery’.

The study design was a longitudinal intervention study with a large sample group but no control group.

The study methodology is poorly described in this paper. It reports on the availability of malaria treatment items and village first aid kits but does not say when this data was collected in each village, even whether it was at baseline or follow-up, so it is impossible to interpret the effect of the mobile phones. The data on the percentage of phone calls relating to Vitamin A distribution has been grouped with the calls on malaria case management so it is not possible to separate the two data points out.
10. Computerized calculation of essential drug requirements

This study described a methodology for calculating drug requirements in Gabon using a computer and demonstrated how they could be used to achieve savings in the procurement budget. The study was undertaken in 1988, soon after the advent of easily obtainable personal computers and is notable for its foresight at the time.

The study concluded that a saving of 45% of the drug budget could be achieved, with a commensurate improvement in availability but the findings were only theoretical and had not been implemented at the time of publishing.

The study authors acknowledge the key weakness of the study, in that it was too early to establish the actual effectiveness of the program and it had not actually been implemented. In implying that reducing the cost of procurement will increase the availability of medicines, the study does not give enough significance to other factors that affect the availability of medicines at the primary level though this was not well understood in 1988.

With the benefit of hindsight, we know that the availability of personal computers on their own did not improve the availability of essential medicines in most countries, as evidenced by the fact that the average availability of essential medicines globally did not increase throughout the 1990s.

11. Developing a computer database for registering and monitoring patients on chronic drug therapy to determine drug consumption: a pilot study

This paper describes a program to establish a computerised database of actual patient drug consumption as a means of determining drug requirements. It was implemented for 434 patients in Zimbabwe in 2001.

The study design is a longitudinal intervention study over 16 months.

Data were collected on all patients and this was used to determine drug requirements, which are presented in the paper. The authors then state that this is a superior method for quantification but they
do not actually measure the availability of medicines at baseline or follow-up; this is an obvious key weakness.

The study acknowledges another weakness in that the sample population is not representative but it does include all chronic patients from five (non-random) facilities. By including only chronic patients, it is difficult to extrapolate the results to all medicines but the study does not attempt to do so. The method of using actual consumption to determine drug requirements is theoretically more accurate in chronic patients and the methodology is thus logical.

Summary

This review has found limited research into the implementation of emerging technologies for improving the availability of essential medicines. This may be due, in part, to the fact that operational field research is difficult to do when applying a rigorous methodology. Such research is time consuming and it can be expensive. The technology to support these interventions has also not been around for a long time in resource-limited settings.

The existing research suggests however that emerging technologies have the potential to improve availability of medicines at health facilities and published results to date warrant further work in this area.

Further research should concentrate on those technologies with the potential to improve availability across a comprehensive range of item lines. Those studies limited to a single disease area have not been able to sufficiently address potential biases or logistically account for a process of wide scale expansion of the piloted system. There has been some previous work suggesting that a supply chain focus on a single disease can negatively impact on the management of others and three of these four papers concentrate specifically on malaria.43, 44

Future research should apply prospective methodologies and use valid, widely accepted measures of stock availability. In particular, it is important to conduct physical stock checks to confirm the
electronic record and validate results. Whilst difficult to design in a health systems context, the use of a control group is preferable.

There has been a tendency in some studies to rush to publish preliminary data or descriptive studies without rigorous data collection or analysis or using weak methodologies. These studies contribute little to the field, may be misinterpreted and should be discouraged.

Nonetheless, these published papers suggest emerging technologies have the potential to improve medicines availability and several warrant further, high quality research.
Chapter 4: Essential medicines policy in Solomon Islands

Introduction

The Solomon Islands is a Pacific Island Country (PIC) with an estimated population of 572,900 (2015) – its capital is Honiara.\textsuperscript{45} It extends in an island chain from PNG to Vanuatu, north east of Australia. It is a least-developed country, with an estimated GNI per capita in 2014 of US $1,830.\textsuperscript{46, 47}

This chapter frames the global medicines situation in the Solomon Islands context. It provides a brief history of the country, an overview of the current health system and a background to the current National Medicines Policy. This chapter illustrates both the benefits and shortfalls of essential medicines policy as it pertains to this single Pacific Island Country and help to place this research project in its historical context.

Modern history of Solomon Islands

There is evidence of human habitation of the area encompassing Solomon Islands for nearly 30,000 years. It was first discovered by Europeans in 1568 by the Spanish explorer Alvaro de Mendana.\textsuperscript{48} The country is located in the Pacific region known as Melanesia and approximately 95% of Solomon Islanders are of Melanesian descent, with the remainder predominantly Polynesian and Micronesian.
Most of modern-day Solomon Islands became a British Protectorate in 1893, under a British Governor, but very little infrastructure was invested in the area, beyond a few mission stations and coconut plantations. The absence of significant investment during this period meant little transport infrastructure, such as roads or wharves, was established and there were few – if any – recognisable urban areas outside of Tulagi, the colonial capital. From 1893 until 1942, the ‘British Solomon Islands Protectorate’ was a largely unknown outpost of the British Empire.

In World War 2, the islands were invaded by the Japanese army, which took over the main island of Guadalcanal in 1942 – this became their southern-most conquest of the war. The United States attacked the Japanese in August 1942, commencing the six month long Battle of Guadalcanal, a major turning point in the Pacific campaign, which concluded in February, 1943. Following this, the Americans created one of their largest bases in the Pacific around Henderson Airfield and to this they added wharves, roads, a hospital and infrastructure to support the movement of huge troop numbers. This grew into a city – Honiara – which became the capital at the end of the war, when the British resumed governance.

After neighbouring PNG gained independence in 1975, Solomon Islands gained independence from Britain in 1978. The country still suffered from a chronic lack of infrastructure investment outside of Honiara however and the public service lacked the capacity to run the fledgling country. Rapid urbanisation began to occur, as people moved towards Honiara for employment and education opportunities and corruption – centred on logging and land allocations in the capital – was apparent.

In 1999, increasing tensions over land in Honiara and elsewhere on the main island of Guadalcanal precipitated a government coup that was the defining event of an ensuing four years of social and institutional unrest, known as The Tensions. This period saw a near-total breakdown in public institutions, sporadic violence focussed around Honiara and other urban areas and general lawlessness. This period finished in late 2003, when the Regional Assistance Mission to the Solomon Islands (RAMSI), a multi-lateral grouping of Pacific Island Countries (PICs) backed by Australia and New Zealand, was inaugurated and tasked with re-establishing law and order and rebuild public institutions. RAMSI has been largely successful in resolving violence and building stability in public
institutions but the Tensions remain a key period in the country’s post-independence modern history and the damage caused to the health system is still apparent.52

Overview of current health system

Healthcare in Solomon Islands is Government and donor-funded and provided free to patients throughout the country, including the provision of all essential medicines in the public system. Healthcare facilities are defined by service delivery, ranging from Nurse Aid Posts to Clinics, Health Centres and Provincial Hospitals. There is one tertiary centre in the country, the National Referral Hospital in Honiara. The pharmacy private sector is negligible and contained entirely within urban areas, with six pharmacies in Honiara and one pharmacy in Auki.

The National Pharmacy Services Division (NPSD) is a division of the Ministry of Health and Medical Services. NPSD, through the National Medical Stores (NMS), acts as the sole procurer and primary distributor of drugs and medical supplies throughout the country, distributing to primary healthcare facilities through a network of twelve Second Level Medical Stores (SLMS) situated in strategic locations across the nine provinces. The SLMS in turn supply the primary healthcare facilities (hospitals, health centres and clinics) in their catchment areas (Figure 4A and 4B). NMS also supplies a number of primary healthcare facilities directly. The provision of medicines presents frequent challenges; the country is made up of over 900 islands, has a tropical climate with year-round high temperatures and humidity and there is poor transport infrastructure in every province.

Of particular interest however, the current manual, paper-based ordering system used by SLMS is slow, unwieldy and provides little data to NMS and NPSD about the provision of medicines to the primary level.

The NPSD runs the SLMS, which are predominantly staffed by Pharmacy Officers. Pharmacy Officers have undergone a 2-year certificate-training course run locally by the Training Unit of the NPSD, supported since 2005 by Australian volunteer pharmacists.
Primary healthcare facilities are run predominantly by nurses and nurse aides, except in provincial hospitals (which were not included in this study). The nine provincial governments (and Honiara City Council) are responsible for the running of primary healthcare facilities but share payroll and some other major costs with the national Government.

The life expectancy of Solomon Islanders in 2013 was estimated at 67.5 years.\textsuperscript{46} Though statistics vary widely between agencies and even from year-to-year, WHO reports that as of 2012, the under-5 mortality rate in the country was 31.1/1000.\textsuperscript{53} The country-reported Maternal Mortality Rate for 2008 – 2012 was 150/100,000.\textsuperscript{54} For 2010, UNICEF reported the Adjusted Maternal Mortality rate was 93/100,000.\textsuperscript{54}
Background to the medical supply chain

Between 1978 and 1991, the procurement of drugs and medical supplies in Solomon Islands was undertaken by the Government procurement agency (under the Ministry of Finance and Treasury). In 1991, this responsibility was transferred to a dedicated NMS under the auspices of the Ministry of Health and Medical Services. All medical procurement was centralised under this one department and the supply to facilities was undertaken directly from there. At that time, clinics ordered periodically, directly from NMS in Honiara. Anecdotal reports suggest the existence of an Essential Medicines List in the 1990s but it is understood that no record of this original list still exists. The system created better economies of scale and good value-for-money tenders were apparently achieved. The supply to clinics was cumbersome and inefficient however. Isolated clinics in remote areas had to pay substantial transport costs and had limited access to the NMS facility in Honiara, from where they were supposed to collect orders.55

The Tensions began following a coup in 1999. Though no published data from the period before and during the Tensions exists, interviews with nurses working in the health system over this time suggest
that availability of medicines in clinics at this time was extremely low. Certainly, it is known that between 1999 and 2003, many clinics had no supplies whatsoever and were forced to close. Nearby fighting, threats of violence and the absence of staff, many of whom returned to their home villages, also contributed significantly to the closure of clinics.

The civil unrest essentially crippled the public service and health services deteriorated markedly.56 NMS had extremely limited money with which to purchase medical supplies and almost no money to transport these supplies around the country.

The public suffered enormously; by 2003 for example, the Solomon Islands had the highest rate of malaria transmission in the world, outside of sub-Saharan Africa.57 Only around 50% of suspected cases were being tested and treatment rates are unknown.57

The country faced acute challenges in trying to meet Millennium Development Goals (MDGs) 4 (Reduce Child Mortality) & 5 (Improve Maternal Health) by 2015.58

1978 – 2003: the limitations of essential medicines policy

As has been illustrated, by 2003 the Solomon Islands presented a text-book case study demonstrating that having an essential medicines policy is insufficient in providing access to medicines.6 Despite the existence of an Essential Medicines List (EML), access to medicines remained low. Due largely to internal ethnic conflict and chronic underfunding of the health system, insufficient effort had been put into strengthening local supply systems and actually integrating the broad concepts of essential medicines with practical local measures, such as matching local standard treatment guidelines (STGs) with the annual tender and the EML itself. The overall design of the supply system, requiring clinics to collect drugs from Honiara was poor and internal conflict further weakened the system.55

In the absence of strong supply chain mechanisms, the positive elements of ‘essential medicines’ encapsulated in the National Medicines Policy were inconsequential – patients still had a very limited chance of a required medicine actually being available at the clinic.59
The rebuilding of the healthcare system was commenced in 2004 with the support of a variety of donors. Substantial budgetary and technical support was provided by Australia under the Health Institutional Strengthening Project (HISP). The NPSD had managed to retain a core of professional staff who now formed an experienced group around which rebuilding could occur. The standard pharmacy qualification in the country, the two year Pharmacy Officer Certificate course, was not recognised overseas and this probably had the effect of preventing the movement of staff internationally, as had happened in both the medical and legal professions from 1999-2003. The result of this was that the Pharmacy Division emerged from the Tensions with a core professional cadre, better placed to rebuild than many other Government departments. Australian aid was provided via budgetary support, technical assistance and long-term volunteers.

The supply of medicines to the primary healthcare setting was decentralised from 2004 onwards, with the establishment of SLMSs in strategic provincial locations. Primary healthcare facilities were now able to order from local supply facilities, theoretically saving on transport costs. This was a step in the right direction but inconsistent centralised procurement processes, inadequate human resources and markedly insufficient infrastructure in provincial areas meant that large quantities of medical supplies could not practically and consistently be supplied. Many provincial sites were ‘SLMS’ in name only, they were completely inadequate for the bulk storage and distribution of medical supplies and most were under-staffed.

Subsequent surveys of clinics and internal reports showed limited increases in availability. Procurement practices at NMS remained weak, with limited data to guide quantification. Tenders were conducted sporadically, less than annually and often within limited timeframes by short term advisors. Despite severe drug shortages, NMS could do little more than order roughly what had been ordered the year before and continually place expensive emergency airfreight orders to cover gaps. By late 2007, the availability of essential medicines at NMS was 47% and was likely much lower in primary healthcare facilities.
In 2005/06, the NMS installed a fully functional electronic inventory system, one of the first of the PICs to do so. This software, mSupply©, tracks the movement of stock through NMS in Honiara and, from 2007, the National Referral Hospital. It provided data for ordering and tender quantifications but it would be several years until staff had built up proficiency in it and until the quality of data were sufficient for reliable forecasting.

Since 2005, all PICs have installed electronic inventory systems at the central level and rely on them, to varying extents, to aid in stock management.

In 2008, the NPSD developed standards governing the SLMS. These standards stipulated their functionality, HR requirements, infrastructure and supply mechanisms. The NPSD then commenced a long-term program of bringing the facilities up to standard, with a focus on staffing and infrastructure.

In 2008, the national Essential Medicines List (EML) was completely re-written and the National Drugs and Therapeutics Committee (later the National Medicines and Therapeutics Committee) was formed to oversee changes to the list and to provide oversight to treatment guidelines. Crucially, the
EML was published and distributed both nationally and overseas. This gave clarity to nurses and helped provide transparency to the Government and donor partners.

A new Standard Treatment Manual for Children was developed in 2007 and published in 2008, followed by a Standard Treatment Manual for Adults, published in 2009.63,64 By 2012, there were 14 (0.27 /10,000) licensed pharmacists in Solomon Islands, of which eight (0.15/10,000) were in the public sector, and 46 (0.88 /10,000) pharmacy officers.65 The pharmacy officers have all completed the two-year in-country certificate course and generally carry out all dispensing and supply functions in hospitals and provincially. Several Pharmacy Officers hold senior positions within the NPSD, including the Manager of NMS.65

**Ordering and stock management**

The SLMS and clinic ordering sheets were updated to reflect the changes to the EML in 2008. Additionally nurses were trained to undertake a stocktake every two months and apply a quantification formula to each item:

\[
\text{Usage} = (\text{Last stocktake} + \text{stock received since last stocktake}) - \text{Current stock on hand}
\]

\[
\text{Order} = 2 \times \text{Usage} - \text{Current stock on hand}
\]

Pharmacy Officers at SLMS would review these clinic order sheets and fill orders as quickly as possible. No record of supply was kept, apart from on the physical order sheet, which was returned to the clinic.

Pharmacy Officers were then required to undertake the same formula when sending their own orders from SLMS to NMS. At NMS, they would fill the orders and keep an electronic record of these SLMS supplies (as well as recording the supply on the order sheets, which were returned to SLMS) but they had no record of what was being supplied on to clinics and no real-time information of stock-on-hand at SLMS.

At any given time, it was impossible for NMS to say how much of Drug A was at SLMS X or how much of Drug A had been sent to Clinic Y.
The development of mSupply Mobile

As early as 2011, NMS had begun to talk to their stock management software supplier (Sustainable Solutions, Kathmandu, Nepal) about the possibility of developing a better system for supplying clinics from SLMS and for tracking stock. Several SLMS had desktop computers but power to these was sporadic and they were regularly misused leading to computer viruses and a lack of storage space. Updating computer virus protection software regularly was impractical and when they broke down, it was difficult and expensive to replace parts. NMS and Sustainable Solutions therefore discussed the prospect of using tablet computers to undertake stock management in the provinces. No Pacific Island Country had attempted this in the public sector at that stage.

The software was developed by Sustainable Solutions, in partnership with NMS across 2012. The Pharmacy Services Division spent much of 2012 planning the implementation of the new system and sourcing funding. It was determined to roll it out to those SLMS with the best internet at the time, as the software relies on a web-based interface.

The Pharmacy Services Division realised that this was a potentially beneficial program for the region and partnered with the Centre for International Child Health at the University of Melbourne to systematically evaluate the program’s implementation.

The research reported in this thesis presents the results of that evaluation and establishes a potential model for implementation of mobile electronic pharmaceutical inventory in the Pacific Island setting. Solomon Islands is the first PIC to implement mobile electronic inventory and one of the first low-income countries in the world to systematically assess its impact.

Table 3: Comparative characteristics of regional neighbours

<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
<th>Population density (people/km²)</th>
<th>Pharmacy staff/10,000 (public sector)</th>
<th>GDP per capita ($USD)</th>
<th>Life expectancy (m/f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solomon Islands</td>
<td>572,900</td>
<td>20.05</td>
<td>1.03/10,000</td>
<td>$1953</td>
<td>69 / 72</td>
</tr>
<tr>
<td>PNG</td>
<td>7,321,000</td>
<td>16.17</td>
<td>0.068/10,000</td>
<td>$2088</td>
<td>62 / 65</td>
</tr>
</tbody>
</table>
Solomon Islands has similar characteristics to several neighbours (Table 3). With the exception of Kiribati, their population density is less than 50 people/km², they share a low GDP/capita (with the exception, to some extent, of Fiji) and they all have ≤ 1 pharmacy staff/10,000 (Table 3). PNG has an exceptionally low ratio of pharmacy personnel to population (0.068/10,000), which to some degree reflects the larger proportion of private pharmacies in that country, particularly in urban areas.

The countries listed all share similar supply chain characteristics. They are all island countries with limited transport infrastructure and each is located in the south Pacific, in a tropical region. PNG, Vanuatu, Solomon Islands and Fiji are considered within ‘Melanesia’, whilst Kiribati is considered part of ‘Micronesia’.

They each have a National Medicines Policy encompassing essential medicines principles and each have published an Essential Medicines List in the past five years. Each has a centralised procurement agency (through the Ministry of Health or equivalent) and each, with the exception of Kiribati, has a decentralised distribution system, through a network of second level medical stores (or equivalent facilities). Importantly, each of these countries uses mSupply stock management software as their primary warehouse inventory software. These characteristics are of interest in later considering the external validity of the results and their generalisability to other Pacific nations.

**Conclusion**

Solomon Islands procures medicines centrally, through the National Medical Stores and distributes these to approximately 320 health facilities through a network of 12 Second Level Medical Stores, situated throughout the country at strategic locations.
Solomon Islands presents an interesting case study of a low-income country developing and implementing a national medicines policy incorporating the principles of essential medicines, whilst facing significant challenges. The country shares some similar characteristics with its regional neighbours.

Despite these challenges, the country has made strong progress and by early 2013 was ready to implement a new supply chain mechanism, using mobile electronic inventory at the SLMS level. The following chapter describes the development of this new supply system and compares it to the existing paper-based system.
Chapter 5: Description of Supply Systems

Introduction

Chapter 4 presented an overarching description of the Solomon Islands health system and the medical supply chain. In simple terms, NMS is responsible for supplying approximately 320 clinics via a network of SLMS.

The mobile electronic inventory system described in this research was implemented at six out of the twelve SLMS, as shown in red in Figure 6 below, replacing the pre-existing paper based ordering system.

This chapter describes these two SLMS supply systems (paper-based and electronic) and gives a more detailed background to the development and implementation of the new mobile electronic inventory system that replaced the established, ‘paper-based’ ordering system in the study intervention group.

![Figure 6: Medical supply chain schematic](image-url)
Established, manual ‘paper-based’ system

Under this established system, in place since at least 2004/5, SLMS maintain entirely hard-copy stock records. For every item, a stock card is kept on the shelf which is updated every time stock comes in and out. To check the availability of a given item, one needs to physically check the stock card on the shelf or count the stock. Stock cards are sometimes referred to as ‘bin cards’.

Every two months, a full stocktake is done to update the stock cards and these updated figures are entered onto template order forms (pre-printed on A4 sheets of paper). These paper forms contain a list, in tabulated form, of every standard item available for ordering, including space for the amount supplied last order cycle, the amount currently in stock and a calculated order quantity, as shown in Figure 7.

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>AMRENDAZOLE TABS 200MG BOT/100</td>
<td>100</td>
</tr>
<tr>
<td>41</td>
<td>AMOXICILLIN TABS 250MG BOT/1000</td>
<td>1000</td>
</tr>
<tr>
<td>45</td>
<td>ASPIRIN TABS 300MG BOT/1000</td>
<td>1000</td>
</tr>
<tr>
<td>55</td>
<td>BISACODYL TABS 5MG BOT/100</td>
<td>100</td>
</tr>
<tr>
<td>414</td>
<td>BOX, CARDBOARD, PACKING</td>
<td>each</td>
</tr>
</tbody>
</table>

*Figure 7: Example of clinic ordering sheet (unfilled)*

The Pharmacy Officer at the SLMS fills in the current stock on hand and calculates the required ordering quantity, taking into account the amount counted in the last stock take, the amount subsequently supplied and the current stock on hand. An order to cover 2 months + 2 months buffer stock is calculated and entered against each item.

**Calculation**

*Last stocktake + Stock received since last stocktake = X*

*Current stock = Y*

*X – Y = Usage*

*Order = (2 * Usage) - Y*

Examples on a current order sheet are presented in Figure 8.
The SLMS sends this hard-copy sheet to NMS (usually, no copy is made) by whatever means they can. This would typically be carried by a trusted staff member or friend by plane or ship to the NMS.

When NMS receives the order form, it is reviewed by the Customer Service team, who enter the data into a central computer system and check the individual calculated order amounts. They are able to make corrections based on their assessment of stock amounts and they can adjust the amount supplied based on the amount of stock available at NMS. For this reason, the amount of stock ordered does not necessarily equal the amount supplied.

Aid Posts, clinics and area health centres place orders with the SLMS in a near-identical manner.

Their order forms are smaller, containing a limited number of items, but the format is the same.

Nurses fill in the current stocktake amount and calculate the amount required for each item, complete their order form and send it to their nearest SLMS. This is typically carried by OBM (Out-Board Motor, meaning a small speed boat) or overland.

When it arrives at the SLMS, the order form is checked by the Pharmacy Officer, who then puts together the supplies. The SLMS Pharmacy Officer writes the quantity supplied to the clinic on the clinic order form, which is returned to the clinic with their supplies. Multiple orders can be placed on a single order form, as subsequent columns are filled in.

Typically, no record of this is kept at the SLMS; the record is solely kept on the clinic order forms, which are filed at the SLMS when they are completely filled and a new copy supplied. To check what has been supplied to any individual clinic, it is necessary to go to the clinic itself and physically check their current order sheet and to go to the SLMS and check the completed order sheets kept on file.

<table>
<thead>
<tr>
<th>CAT NO</th>
<th>DESCRIPTION</th>
<th>UNIT</th>
<th>Due Date 12 / 3 / 2012</th>
<th>Due Date 13 / 5 / 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>ALBENDAZOLE TABS 200MG BOC/100</td>
<td>100</td>
<td>4 2 2 3</td>
<td>8 4</td>
</tr>
<tr>
<td>41</td>
<td>AMOXYCILIN TABS 250MG BOC/1000</td>
<td>1000</td>
<td>10 5 4 4</td>
<td>8 4</td>
</tr>
<tr>
<td>45</td>
<td>ASPIRIN TABS 300MG BOC/100</td>
<td>1000</td>
<td>12 2 2 10</td>
<td>0 0</td>
</tr>
<tr>
<td>55</td>
<td>BSACODYL TABS 5MG BOC/100</td>
<td>100</td>
<td>2 3 1 1</td>
<td>3 0</td>
</tr>
<tr>
<td>414</td>
<td>BOX, CARDBOARD, PACKING</td>
<td>each</td>
<td>4 1 1 1</td>
<td>1 7</td>
</tr>
</tbody>
</table>

Figure 8: Example of current order sheet (filled)
This paper-based ‘pull’ system is used extensively throughout the Pacific region and elsewhere where a centralised procurement agency is responsible for distribution of medicines to primary healthcare facilities, including in Africa.\(^7\)

**Strengths:**

- The established, paper-based stock management method is widely taught and there are numerous existing resources to aid training. It is reasonably widely understood at the central level (though comprehension at the primary healthcare level varies enormously and is generally poor).
- It doesn’t require electricity or internet access. Generally, there is community goodwill towards medicines supply and the order sheets are delivered to supply sites at no cost by local boat drivers, private businesses or other transport providers.

**Weaknesses:**

- The system is entirely paper-based and no soft-copies are made. If the order sheet gets lost, stolen or ruined in transit, the data on previous stock-on-hand are also lost.
- The order form must move physically from facility to facility, which increases lead times. Staff must find means by which to send the order forms to SLMS (for which there is no budget). Usually this is done by waiting for people who are travelling from place-to-place anyway and hoping they deliver the order to the SLMS in a timely fashion.
- The method is time-consuming, as the local staff member completes quantification calculations for each item and these are individually double-checked at another step in the supply chain.
- The ‘double-entry’ nature of the system increases the risk of data entry mistakes.
- Order sheets need to be printed. If paper isn’t available or local printers are broken, new forms need to be sent out from Honiara to provincial areas.
- The central agency (NMS) has no awareness of what is being supplied to the clinic level without going to provincial areas and conducting physical audits of paper forms. To properly
audit the quantities sent to individual clinics then often requires travelling all the way to the clinic, where the order forms are generally kept.

**Mobile electronic inventory**

Ordering from NMS

The roll-out of mobile electronic inventory systems commenced in April 2013. When the mobile electronic inventory system was installed in a SLMS, a full stocktake was carried out and the data were entered into the software (mSupply Mobile) via iPads. Stock cards were thereafter no longer necessary. Stock arriving from NMS updates automatically on arrival, as it has been entered by NMS staff and the software communicates with the central level. All items being sent out to clinics from SLMS must then be entered by the Pharmacy Officer. Both the Pharmacy Officer at the SLMS and the staff at NMS can look at the stock-on-hand in real time.

The Pharmacy Officers were still required to conduct a stocktake every two months but any changes to stock levels were entered as a ‘New Stocktake’ straight into the mobile module web-based interface (using an iPad). These stocktake figures are automatically downloaded by the system at NMS, which generates order quantities based on the current and preceding figures. There are no data entries or manual calculations required. No paper order is sent back and forth from SLMS to NMS, though NMS does print out an invoice to be sent with each order for checking on arrival.

Figure 9 shows the home screen for mSupply Mobile, displaying the basic functions.

![Figure 9: Screenshot, mSupply Mobile homescreen](image-url)
Orders from clinics

From the clinic level, paper orders are still sent to the SLMS and items are supplied according to the manual paper-based model but each order is entered into the mobile module as a ‘New Customer Invoice’ pertaining to that specific clinic. This information is instantly communicated to the NMS system, allowing both the SLMS and NMS to view all items sent to each clinic from those SLMS in real-time. Lead times between the clinic and SLMS are theoretically unchanged, but SLMS and NMS staff are able to more closely watch supply trends to individual facilities and in catchment areas. For example, if a facility has not ordered Zinc Sulphate in the preceding six months, NMS can flag this anomaly and enquire specifically with that facility as to whether it needs additional training or support, rather than provide more expensive additional support to a large area.

Further, a record of the order is captured and cannot be lost if an order sheet is misplaced.

Strengths:

- Lead times from SLMS to NMS are substantially reduced and order sheets from SLMS to NMS cannot be lost, destroyed or stolen.
- The data available to NMS is substantially increased, allowing better M&E and greater transparency throughout the system.
- The risk of error from incorrect calculations or data entry mistakes is substantially decreased.

Weaknesses:

- The system required electricity and internet access; Solomon Islands is amongst the worst countries in the world in the provision of these two services. It is the second most expensive country for internet provision in the world and has the second slowest internet speeds in the world.\(^71\),\(^72\) Further, it has the second lowest level of access to electricity in the region (12-14% of the population; 4% in rural areas)\(^73\) and the most expensive electricity in the Pacific region.\(^74\)
The system is novel and requires re-training of pharmacy officers. Nurses at the clinic level were not necessarily aware of the change (though this means they did not require additional training).

Implementation of mobile electronic inventory

Funding

The funding for the hardware (6 iPads and security cases) was provided through the Pacific Technical Assistance Mechanism Procurement Fund, provided by the Australian Aid Program (DFAT). The iPads were purchased in 2012 and the software was installed on them in the first quarter of 2013. The software development was undertaken free by Sustainable Solutions, who retained all trademarks and intellectual property rights. Each site using mSupply Mobile was required to purchase a license but this licensing fee was waived for the first 12 months by Sustainable Solutions. Thereafter, the licensing of each site was intended to be funded under the existing recurrent SIG budget for NMS.

Installation and training

As the baseline data collection was being finished at each SLMS in April 2013, tours to each of the six SLMS in the intervention group were commenced.

At each site, the candidate and the local pharmacy officer undertook a complete stocktake of all items and physically installed the iPads (each was secured to the facility using a security cable and lockable case). The data from the stocktake was entered into the software, with the Pharmacy Officers simultaneously learning how to undertake a stocktake on the software, one of the core functions.

When implementing the new electronic system, it is necessary to enter the initial stock take based on a physical count of available stock, as stock cards have been regularly shown to be inaccurate. Staff are trained to undertake a physical stocktake count every two months, prior to the due date for their regular main order but if they have completed their daily stock entries correctly, then there will theoretically be no changes made during the stocktake, as the data automatically updates with each order received and issued.
For at least two subsequent days, training was then conducted on other core functions of the mSupply Mobile software, including checking receiving orders and issuing stock to clinics.

The installation and training took three to four days at each facility and every Pharmacy Officer on staff was shown how to use the software. The same person conducted the installation and training at every site, to help ensure consistency.

Incorporation into existing systems

Critical to the success of the program is the incorporation of the new technology into existing systems and processes. The lead researcher undertook planning with the Senior Pharmacy Officer at each site on the first day of installation to identify exactly how the software would be incorporated. It is believed this is a critical factor in determining uptake of the new system.

Competence with the software is obviously a pre-requisite for uptake but the exact process for use of the iPads within the local supply system was slightly different at each site and this helped to give local staff ownership of the system.

The installation and implementation was completed in under four weeks, from mid-April to mid-May 2013.

Feedback

The immediate feedback from staff was positive – in particular, several pharmacy staff reported pride in having a new technology that was not available to all hospital staff. Staff made several suggestions for changes to the software, which were passed on to Sustainable Solutions. These included:

- Allowing pharmacy officers to see, review and adjust order quantities from NMS, prior to them being sent. Under the new system, the order quantities were generated automatically at NMS following a provincial stocktake being entered and local staff reported a sense of losing some autonomy because of this.

- The introduction of ‘store and send’ software, where data entry can be done offline and uploaded at times when the internet works better. This remains unavailable in the current
iteration of the software, though Sustainable Solution is trying to develop this. One hindrance to this is that the system checks the availability of each line item as an order is placed; if orders are placed offline, it cannot carry out this task.

- An ability to print clinic orders that had been entered into mSupply Mobile. Under the new system, Pharmacy Officers still had to fill in hard copy order sheets from clinics, in addition to entering the quantities into mSupply mobile and this duplication resulted in an increased workload and an increased risk of errors.

- When master-lists were adjusted on the main NMS server, they were automatically updated to all mobile customers (this was a back-office technical change requested by NMS staff that did not affect SLMS users).

The biggest issue impacting use was the availability and quality of the internet. For much of the year for example, one site (Munda) had to take the iPad approximately 2km into town to enter hand-written data, which was done periodically for stock issues and after every stocktake.

Impediments

The key impediment for the program has been the quality of internet access in Solomon Islands, which is believed to be the slowest amongst the PICs. The technology was a web-based interface. The only software installed on the computer was the browser and cached pages from the website. If the internet was unavailable, the software didn’t work. Paradoxically, the Solomon Islands therefore provides an ideal environment for the evaluation of this technology. In basic terms, if it can be shown to work in Solomon Islands, which also has prohibitively expensive electricity, it is theoretically possible in almost any other context.

Another issue identified in advance of the project was the poor computer literacy of Solomon Islanders. The problem of upskilling in technology across the widely dispersed Pacific islands has been well established and the NPSD had encountered this in previous projects. This was recognised during the software development phase and a focus was placed on designing a simple, intuitive
interface. The resulting software proved resilient and staff demonstrated proficiency in each case after two days of training. No formal assessment of proficiency was undertaken however. This would have been beneficial to future implementation projects and training programs.

There were several early bugs in the software which caused delays in the first two months, most notably a scrolling issue during stocktakes. In short, sometimes when scrolling alphabetically through the full list of items whilst entering quantities during a stocktake, the screen would jump to another section in the alphabet and users would have to scroll back and forth to find the spot they had left.

This was time consuming, annoying and increased the risk of data entry errors. The scrolling problem was a software glitch that was resolved satisfactorily by Sustainable Solutions.

Being able to address software bugs quickly and economically is one of the most compelling reasons to choose ‘off-the-shelf’ software products rather than attempting to develop entirely new software packages from scratch.

Future Directions

The future direction of mobile electronic inventory in Solomon Islands is to a certain extent dependent on the feedback provided by this study. It seems likely however that mobile technology will increasingly be used for stock management in all settings and it would be beneficial if this was done using an evidence base, with experiences shared between countries.

Conclusions

mSupply Mobile© is a novel stock management software that was implemented in some SLMSs in the Solomon Islands in 2013. There are perceived benefits and drawbacks to the software, which have been outlined in this chapter, along with the process of implementation undertaken. This thesis describes research conducted to assess its effectiveness at improving the availability of medicines in clinics.
Chapter 6: Measuring medicines availability – current methods and controversies

Introduction

Measuring medicines availability is central to this thesis. There is no universally accepted gold-standard for measuring medicines availability at the primary healthcare level and different methodologies may be appropriate to different contexts. This chapter examines the most common measures for availability, identifies the best data collection methodology and provide a defence of the methodology.

Measuring medicines availability

Despite a body of literature examining and discussing the availability of essential medicines in low and middle-income countries, there is no universally accepted tool or indicator for actually measuring availability. This may seem unsurprising, as different countries can have markedly different healthcare and supply systems but uniformity in data collection is important, to be able to compare trends across regions and over time.

When a study reports that ‘country X had 65% availability of essential medicines, or that ‘availability improved by 40%’, it can be difficult to interpret what that means and this is important, particularly in trying to weigh the merits of different interventions for improving availability.

Definitions and methodologies for medicines availability

The definition for medicines availability has varied widely. When a study reports that Drug X had 50% availability, this may mean ‘50% of all items were available across all facilities’; it may mean ‘all items were available in 50% of facilities’; it may mean that ‘all items were available 50% of the time’ or it may mean that ‘50% of a selection of medicines were available’.

Another common reporting measure has been ‘days out of stock’, which is readily comprehensible when referring to a single commodity but far less so when referring to multiple items. If one was to do
a survey of 10 items, for example, and find an out-of-stock average of 30 days per year, this could mean all 10 items were nearly always available except for sporadic days, it may mean that they were nearly always available except for one month when none were available or it could mean that nine items were always available but one item was almost never available. Without access to raw data, interpreting and comparing these metrics is difficult.

The methodology for data collection has similarly varied. Surveys using proxy measures, such as ‘days out of stock’, largely take data from secondary sources such as stock cards, which are dependent on accurate written record-keeping for reliability (which may not be the reality). More recently, at least one paper has solely used electronic inventory records to determine availability, which will almost certainly be inaccurate during the implementation phase for a new electronic system and is thus a fundamentally flawed way to measure the effectiveness of these novel systems.

Other studies have assessed availability against full drug formularies, which does not necessarily take into account the varying importance of different agents or local context. In Solomon Islands, HIV medicines would very rarely be available at the primary healthcare level, despite being on the Essential Medicines List, as they are provided directly to patients by the national program. Their ‘unavailability’ at a given facility does not reflect on the stock management performance of that facility. Similarly, it is less important to have basic antacids available for example, than it is to have basic antibiotics available and they should arguably not be given equal importance in surveys.

Checking every item on a formulary is also impractical and expensive.

Prioritisation is thus important but it can be misleading if an appropriate list of sentinel drugs is not selected. One large study looked only at the availability of medicines for chronic non-communicable health conditions, which is a limited methodology as quantification for these items is easier than for those items which are likely to be needed sporadically but are nonetheless life-saving for acute conditions (such as antimalarial agents).

Finally, other studies have looked at an unsatisfactorily small sample of items or only one disease state. Though these may examine the availability of a particularly critical item or group of
items, they do not provide sufficient information for assessment of the overall performance of the supply chain.

WHO/HAI Project on Medicines Prices and Availability

In 2001, the World Health Assembly passed a resolution to “explore the feasibility and effectiveness of implementing...systems for voluntary monitoring and reporting of drug prices with a view to improving equity in access to essential drugs in health systems”. Implied in this – and stemming from it – were efforts to also monitor and report medicines availability.

In response to this, recognising the importance of uniformity in measuring the availability (and cost) of essential medicines and the need to strengthen methodologies, Health Action International (HAI) and the World Health Organisation (WHO) established the WHO/HAI Project on Medicines Prices and Availability in 2001 to develop a methodology for collecting and analysing data on medicines pricing, availability and affordability and to publish these data systematically.

They launched their new methodology – ‘Medicine Prices – a New Approach to Measurement’ – in 2003, following pilot testing across nine low and middle-income countries. Their system provides sound principles for assessment and is widely and easily applicable across different contexts. A 2010 validation survey found that the WHO/HAI survey approach ‘strikes an appropriate balance between modest research costs and optimal information for policy’. In that paper, researchers found that focusing on commonly used medicines produced sufficient and valid results.

Importantly, they also publish the results of all surveys carried out using the methodology and these have become the basis for valid meta-analyses of medicines availability globally. It is from these meta-analyses that the most widely quoted global statistics on medicines availability are obtained.

Though the WHO/HAI methodology was not designed to assess the impact of a specific intervention on medicines availability, it is nonetheless the most valid tool available.

This study has followed the principles of the WHO/HAI methodology pertaining to medicines availability. Medicines are available free of charge in the Solomon Islands and it is therefore unnecessary to assess pricing and affordability from the perspective of the patient.

Key principles of their survey methodology that this research project adheres to are:
- **Contextually appropriate basket of medicines**: The WHO/HAI Project on Medicines Pricing and Availability advocates using a contextually appropriate basket of medicines and this methodology has been widely used elsewhere as a measure of overall stock management in a number of robust studies. It is a manageable way of measuring the availability of the most relevant, important items across a range of disease areas and the results are most easily comparable between different areas and even between different countries. Selecting an evidence-based basket of medicines is therefore the remaining challenge.

It is proposed that the WHO Priority Medicines for Mothers and Children are a reasonable, evidence-based basis for a basket of medicines, once locally adapted. At the clinic level, 17 (of 31 total priority medicines) items that should be available at that level of the health system were examined in this research project. The Solomon Islands Essential Medicines List (EML) was used to define which of the 31 medicines should be available at the clinic level.

The WHO Priority Medicines (see Box below), used as the basis for a basket of medicines, may then be used to assess availability between countries.

- **Physical Stock Check**: It is important that availability results be accurately verified to determine where gaps in the system exist. In a facility using bin cards, it would be inaccurate to use the bin cards only to determine availability, as they may not be properly maintained. Similarly, using order sheets or electronic records to determine the availability of an item does not verify the accuracy of the check. A physical stock check by an independent assessor, who must sight the goods, remains the only truly accurate verification.

Data collection teams carried out physical stock checks in all clinics visited.

- **Cross sectional**: If it is accepted that physical stock checks are a necessary step in determining availability, longitudinal measures of availability become unacceptable, unless physical stock checks are conducted every day by an independent assessor, over an extended period of time, which is prohibitively expensive in most contexts. Usually, continuous measures of availability (such as ‘days out of stock’) are taken from written records, such as bin cards, with no verification as to their accuracy. It would be possible to run secondary verification checks on
the data source (so, verify the accuracy of the bin cards on the day of visitation and then use the bin cards for a retrospective longitudinal assessment) but this still does not provide a gold standard of verification.

- **Large number of facilities:** The nature of sampling – in this study’s case, using cross-sectional, physical checks of a basket of medicines – means that in individual facilities, small anomalies may be misinterpreted, which is an argument for using ‘days out of stock’ or measuring availability against a full formulary. An unusual rise or fall in availability that day (for example, when a major order is running late) can give an inaccurate picture of that facility. This can be resolved to an extent by using a sufficiently large sample size of facilities and taking the mean percentage of all facilities surveyed.

The WHO/HAI methodology advocates selecting clinics across both urban and rural areas. This study excludes all urban clinics (those in Honiara) as they are supplied directly from NMS and do not meet the study criteria.

- **Standardised quantities:** One of the most contentious issues around the determination of availability is how many of a particular item must be on the shelf for it to be deemed ‘available’. Studies have variously used the following measures: an unopened full bulk pack (100 or 1000); an arbitrary number (e.g. 10 or 100); a Defined Daily Dose (DDD) for one person; a full treatment course for one person or; a single tablet or dose. Arguments can be mounted for any or a combination of these measures; varying clinic sizes and case-loads mean that 50 amoxicillin capsules may be sufficient for one clinic for an entire month, whilst in a nearby clinic, they would be exhausted in a few hours. Establishing a standardised, arbitrary quantity for each product is thus difficult, even within a single country. On the other hand, using measures of availability below at least a full treatment course can mean that an item is not ‘practically’ available, despite being present on the shelf. Three amoxicillin capsules may be present, but they are unlikely to provide any benefit even to a single patient and a single ‘Defined Daily Dose’ (DDD) is thus insufficient. It is therefore argued that one full treatment course, for at least one patient, at the time of inspection, is the fairest quantity that can be
universally applied within and between countries. It is easier to provide training to data collection teams, using this standardised model, as the quantity to be checked for each item does not vary between facilities. The major limitation of using this measure is that in an even moderately busy clinic, a single treatment course of a given medicine is likely to be used in the space of a day, which would make the medicine ‘unavailable’ later in the same day. Using large sample sizes may partially account for this limitation.

**Definition**

For these reasons, the availability data collection tool in this study defines percentage availability as the number of in-date items available (from the Priority Medicines for Mothers and Children) by physical check, on the day of visitation, divided by the number of priority medicines listed on the formulary at that level of the health system (17 for clinics), according to Solomon Islands’ EML.

This definition meets the overarching principles of the WHO/HAI assessment methodology and is appropriate for the Solomon Islands context and the study design.\(^8^1\)

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*The priority medicines for mothers and children*

In early 2011, WHO published a list of ‘Priority Medicines for mothers and children’ to advocate for improved access to medicines that would have the biggest impact on MDGs 4 and 5.\(^8^5\) These medicines treat the most important causes of maternal, newborn and child deaths. They include medicines for managing post-partum haemorrhage, pre-eclampsia, sexually transmitted infections, maternal and neonatal sepsis, pre-term birth, pneumonia, diarrhoea, malaria, HIV, vitamin A deficiency, palliative care and pain. The list was updated in 2012.\(^8^6\)

The inclusion of these priority items on national EMLs remains inadequate globally and in the Pacific Islands region but all of them except mifepristone combined with misoprostol are listed on the Solomon Islands’ EML.\(^8^7\)\(^8^8\)
Whilst the majority of these agents are available on the Essential Medicines List of the Solomon Islands, there were numerous reports that many were not available at the primary healthcare level or that nurses did not know how to use them. Despite good decisions made by the National Medicines & Therapeutics Committee – the body responsible for the selection of the Essential Medicines List and Treatment Guidelines – giving the country up-to-date treatment guidelines and a relatively strong Essential Medicines List, many patients did not have access to life-saving drugs.

The list is broadly representative of the medical supply chain, containing injectables, cold chain items, reproductive health commodities, adult and child dose formulations and bulky items and it has been used elsewhere as a measure of medicines availability. The NPSD in Solomon Islands decided in 2012 to use it as the base basket of medicines to assess medicines availability at the primary healthcare level (with the addition of some other items, such as male and female condoms). This list has thus been used as the basis for the basket of medicines in this thesis.

**External validity**

Measuring the impact of specific interventions to improve medicines availability in a real world setting is difficult, particularly using a system-wide approach. In a large health system, there are innumerable potential confounders that impact on availability and accurately measuring the impact of each is implausible.

This has proven difficult globally; despite a large body of work exploring medicines availability, there have been relatively few studies assessing the actual impact of interventions intended to improve availability. In those studies that have been published, the external validity of the results has been broadly problematic – not only is it difficult to take the multiple confounders into account but the contextual factors impacting availability in each setting tend to be very specific. What works in one supply chain is not necessarily applicable in another setting – but this project represents a step towards improving the robustness by attempting a controlled model of research on a wide scale.
Conclusion

Whilst there is no universally accepted tool for measuring medicines availability, the WHO/HAI Project on Medicines Pricing and Availability is a very strong, widely accepted mechanism for measuring availability and comparing this across countries and regions. The study methodology closely follows the WHO/HAI principles, adapted for the local context and the primary research question.

Despite this, the external validity of studies assessing interventions to improve medicines availability in a real world setting remains problematic, due to the highly contextual nature of other factors impacting on availability and the unknown extent to which each factor has an effect.
Chapter 7 (Primary study): A before-and-after survey of medicines availability

This chapter is presented as a work prepared for publication.

Position in the thesis

The Solomon Islands Ministry of Health and Medical Services identified a need to improve supply chain systems for essential medicines at the provincial level, with the primary outcome measure of medicines availability at the primary healthcare level. Mobile electronic inventory management software was developed in conjunction with a private software provider, as described in Chapter Five. NMS implemented the new software in six SLMS, in conjunction with a series of educational interventions across all clinics.

The effect of these interventions on the availability of medicines in clinics has been evaluated with a partially randomised, controlled pre- and post-intervention effectiveness study.

This chapter presents the results of that evaluation. The primary outcome measure is medicines availability at the clinic level, as defined and justified in Chapter Six, across both the control and intervention groups.

The results of medicines availability as measured at the SLMS level and for each individual item are included.

One paper forms the basis of this chapter:

Nunan M et al, Improving access to priority medicines for mothers and children in low-resource settings using a mobile electronic inventory system: a before and after intervention study.

Submitted for publication and pending review, 2017.

The author of this thesis declares a contribution of 80% to the development of this paper.

During the development of this paper, aspects of this research were presented at the following
conferences and meetings:

1. Australia / Solomon Islands Bilateral Aid Talks (Solomon Islands - Australia Partnership for Development), Heritage Park Hotel, Honiara Solomon Islands, 1st May, 2013

Presentation: mSupply Mobile Electronic Inventory – improving medicines supply at the primary healthcare level

Speakers: Michael Nunan, Willie Horoto


Presentation: Provincial distribution to primary healthcare level (Electronic Inventory)

Speakers: Michael Nunan, Willie Horoto, Timmy Manea

3. PSA15 (Pharmaceutical Society of Australia’s Annual Conference), Sofitel Sydney Wentworth Hotel, Sydney Australia, 31st July – 2nd August, 2015

Presentation: The implementation of mobile technologies for medical supply chains in developing countries: from the Pacific Islands to an Ebola outbreak

Speaker: Michael Nunan
Improving access to priority medicines for mothers and children in low-resource settings using a mobile electronic inventory system: a before and after intervention study

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Abstract

Background: The global average availability of essential medicines in primary healthcare facilities in low-resource settings remains low but there is insufficient research examining interventions to improve this. This study examined if a mobile electronic inventory system could improve medicines availability and is the first large study of its kind.

Methodology: A 12 month, partially randomised, controlled, pre- and post-intervention effectiveness study of 30 clinics (40 control, 40 intervention) was conducted in Solomon Islands. Mobile inventory was implemented in Second Level Medical Stores; this was coupled to educational interventions in every clinic. A basket of 17 medicines was used as the denominator for determining the percentage availability of medicines.

Results: Pre- and post-intervention data was collected from 68 clinics. Overall medicines availability increased from 64.2 to 74.1% (p<0.001); there was no difference in the magnitude of change between the intervention and control groups.

Conclusions: It is difficult to attribute medicines availability to specific interventions in a real-world setting but it is expected that the effect of mobile electronic inventory will become clearer with further research and more time. Other potential benefits from these systems include greater transparency and improvements to forecasting, real-time stock visibility, rational use of medicines and disaster response.
**Introduction**

The World Health Organization’s model list of essential medicines has undoubtedly improved access to high quality, evidence-based medicines in low resource settings. However, despite 94% of countries having a National Medicines Policy incorporating the concept of essential medicines, the global average availability of essential medicines in primary healthcare facilities in the public sector in low and middle income countries was only 38.4% in 2009, and 40.0% in 2014. One key reason for poor availability of essential medicines is weak supply chains for medicines. Although there are emerging technologies that may strengthen supply chains, there has been a paucity of evidence evaluating such technologies in the field.

Solomon Islands is a Pacific Island Country (PIC) with a population of 570,000. It is considered a least developed country, with a per-capita GDP of US$1,953. Despite having a National Medicines Policy incorporating the concept of essential medicines, the availability of medicines at the primary healthcare level remained low in 2013, as evidenced by the baseline data from this study.

The supply of medicines in the Solomon Islands is the responsibility of the National Pharmacy Division of the Solomon Island Government, which procures medicines through the National Medical Stores (NMS) and supplies approximately 320 clinics in 9 provinces through a network of Second Level Medical Stores (SLMS) (Figure 1).

The aim of this study was to investigate the impact of a mobile electronic inventory system at SLMS in provincial areas of Solomon Islands, coupled with educational initiatives at the primary healthcare level. This study assessed the impact of this system on the availability of essential medicines at the clinic level, using a controlled before and after study design.

This is the first large study examining the implementation of mobile electronic inventory in a least developed country, covering the complete medicines inventory, using a controlled methodology.

**Methods**

**Study design**

A controlled, partially randomized 12 month pre- and post-intervention effectiveness study of clinics in the Solomon Islands. All clinics in the study were allocated to either a control group or an intervention group, based on their supplying store.

**Interventions**

The main intervention in this study was the implementation of a mobile electronic inventory system, at Second Level Medical Stores, called mSupply Mobile™ (v.1, Sustainable Solutions™, Nepal/New Zealand), which runs on tablet computers. The parent program, mSupply™ (Sustainable Solutions™, Nepal/New Zealand), has been in use in the Solomon Islands NMS since 2005. Solomon Islands was the first country to introduce mSupply Mobile, which was designed in collaboration with the Solomon Islands Pharmacy Division and the research team.

mSupply Mobile allows facilities to stocktake, calculate and place orders and issue stock to ‘customers’ such as clinics or patients. The data from each mobile site syncs with a central server (typically located at the National Medical Stores).

As part of this study all 320 clinics across the control, intervention and excluded groups also received a package of education and training interventions, focused on the priority medicines. These included posters, newsletters, radio shows and a dosing wall chart (Table 1).

**Table 1: Educational interventions implemented as part of the study**

- Zine Sulphate & ORS Poster, as used in a pilot study conducted in Western Province in 2011/12.
- Dosing wall chart for Priority Medicines for Mothers and Children
- Series of 10 ‘Patient Information Cards’, double-sided A5, disease-focused cards.
- Quarterly newsletters focusing on Child and Maternal Health over 12 months
- Monthly radio shows focusing on Child and Maternal Health over 12 months
- The Solomon Islands Standard Treatment Manual for Children was re-printed and distributed to all clinics
Clinic selection and eligibility criteria
The study included all clinics in Solomon Islands that were:

i. supplied through only one SLMS (not directly from NMS)
ii. the SLMS could be identified and was consistent (each clinic used only one SLMS for all supplies).

There were 121 clinics in the intervention group. The 6 SLMS supplying these clinics were installed with the mSupply Mobile inventory management system on iPads (Apple) and on-site training conducted in its use; 6 iPads were installed in total. The intervention group SLMS were purposely selected, based on the need to have adequate internet speeds for mSupply mobile to function, at the time of study commencement. The 6 selected SLMS were the only SLMS to have adequate internet at the time of study planning and randomization was therefore not possible at this point.

There were 104 clinics in the control group. The 6 SLMS supplying these clinics continued to use the manual, paper-based method of managing inventory supply. Approximately 100 clinics were excluded, as they were supplied directly from NMS, their supply site could not be definitively identified or they were too isolated for data collection teams to visit in a practical timeframe. Figure 2 shows a map of the study sites.

Population analysed
The population comprised 121 clinics in the intervention group and 104 clinics in the control group, with 100 clinics excluded. 40 clinics from each group (30 control) were then randomly selected by paper drawn from a hat, with an independent witness. Study site assessments were conducted in all randomly selected clinics at baseline and at 12 months follow-up. All medicines and consumables are managed via the mobile system but audits were conducted on a subset of medicines only.

Data sources and definitions
The WHO Priority Life Saving Medicines for Mothers and Children was used for the audit of medicines availability. Of the 31 priority medicines, 17 are expected to be available at the clinic level in Solomon Islands, based on the National Essential Medicines List. These 17 medicines comprised the 'basket of medicines' that was assessed. All 17 medicines are supplied to clinics exclusively through the public system. There is no private supply of medicines to clinics in Solomon Islands. Medicines donations are possible through unofficial channels but donations are believed to be rare at the clinic level.

The primary outcome was the percentage of the 17 medicines available across all clinics in each group. Data analysis was limited to those clinics that contributed both pre- and post-intervention data.

An item was considered to be available if a sufficient quantity for one full treatment course, of in-dated stock, was available and could be physically acquired by a data collection team member on the day of visitation, as per the HAI/WHO method for measuring medicines availability. The percentage availability was calculated for each facility using 17 medicines as the denominator.

The medicines assessed were:
- Acetaminophen (Paracetamol)
- Aminosulphate
- Artesunate suppositories/injections
- Benzathine penicillin
- Coartem (Artemether and Lumefantrine)
- Levonorgestrel/Ethynylestradiol
- Medroxyprogesterone
- Morphine or Pethidine
- Oral Rehydration Salts
- Oxytocin or Syntometrine (Oxytocin/Ergometrine)
- Paracetamol
- Procaine Benzylpenicillin
- Sodium Chloride (Normal Saline) for injection
- STI Treatment Pack (Azithromycin and Ceftriaxone)
- Tetanus Vaccine
- Vitamin A
- Zinc Sulphate

The definitions for each item (strength, dose, form) contained in the WHO list were used as the basis for acceptability when assessing availability. SLMS supply all clinics within a pre-determined geographic area; they are located either at provincial hospitals or at health centers. Medicines availability at the SLMS level was assessed as a secondary outcome. The SLMS availability percentage is
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calculated using either a denominator of all 31 priority medicines (provincial hospital SLMS) or 23 medicines (those supposed to be available at area health center SLMS). The data were collected by 2 data collection teams each consisting of a pharmacist, 2 pharmacy officers and a nurse. All members of both teams received training at NMS and on site at the Mataniko Child Health Clinic. Data were collected in hard copy and entered into a computer using EpiData, by the lead researcher (MN), who did not participate directly in data collection.

Ethical considerations
The study was approved by the Health Research Ethics Committee at the University of Melbourne and the Health Research and Ethics Committee of the Solomon Islands Ministry of Health & Medical Services.

Data Analysis
The hypothesis was that the magnitude of change in the availability of essential medicines in the intervention group would be larger than in the control group. Statistical analysis was conducted using STATA® Version 13.1 (StataCorp, College Station, Texas).

Firstly, normality testing of the overall availability distribution curve at pre- and post-intervention was conducted with a Shapiro-Wilk test and by looking at the histogram distribution curve. This allowed for the use of a 2-sample t-test to look for differences between the groups at baseline. Whilst the data were not continuous, this was appropriate as the primary outcome variable had 18 possible data points (0-17 out of 17 medicines) and the distribution of availability across clinics approximated normality.

The difference in the magnitude of change was then determined with a before and after paired t-test. Due to the significant difference between the 2 groups at baseline, a linear regression comparing follow-up availability between groups was performed adjusting for baseline availability. This used the baseline availability as the explanatory variable and the follow-up availability as the dependent variable.

Availability of items at the SLMS level and availability of each item across all clinics has also been reported at baseline and follow-up. The availability by item across all clinics is calculated as the percentage of clinics (n=58) that had the item in stock on the day of visitation. McNemar’s Test was used to test for a change in availability for each item across all clinics.

Results
The study was carried out from April 2013 to April 2014 in the Solomon Islands. Of the 80 clinics, 3 clinics were missed during the baseline data collection phase and a further 9 were missed at follow-up; this was due to staff absences, adverse weather conditions preventing travel to the facility, or the closure of clinics for other reasons. Only those clinics for which pre- and post-intervention data are available were used (n = 68, Control = 36, Intervention = 32). The clinic selection and loss to follow-up is presented in Figure 3.

Implementation of Interventions
The mobile inventory system was installed in all 6 intervention SLMS sites by the first week of May, 2013. No iPads were lost and all remained in use over the 12 month study period. The majority 517/726 (71%) of normal monthly clinic orders were entered into the mobile devices in the first 12 months, with an additional 86 supplementary orders also submitted through the devices.

Primary outcome: average availability across all primary care clinics
The overall mean availability of medicines at baseline was 64.2% (SD = 14.5%). Medicines availability increased by 9.9% overall from baseline to follow-up (p<0.001). The results for each group are shown in Table 2. There was strong evidence of a difference in medicines availability between the 2 groups at baseline, with the intervention group having 16.0% (95% CI: 3.4 - 16.7%) higher availability (p=0.004) at baseline than the control group. Follow-up availability was not different (95% CI: -6.6% to 6.3%, p=0.957) in the intervention group than the control group, adjusting for baseline availability. This analytical model did not show any evidence for a difference in the magnitude of change between the control and intervention groups.

Medicines availability by SLMS
Table 3 presents the percentage availability at baseline and follow-up and the percentage difference between them for 11 SLMS. The medicines availability data for Taaraa SLMS was not collected at follow-up.

Medicines availability by item
The results for every medicine item in our study “basket” of 17 essential medicines are shown in Table 4. There was strong evidence of large increases in the availability of zinc sulphate (85.3% [95% CI: 75.4 to 95.2], p<0.001), STI treatment packs (27.9% [95% CI: 10.8 to 45.1], p=0.022), artesunate (50.9% [95% CI: 15.7 to 66.0], p<0.001) and the combined oral contraceptive pill (29.4% [95% CI: 15.7 to 43.2], p<0.001). Conversely, there was evidence for smaller decreases in the availability of procaine benzylpenicillin (-13.5% [95% CI: -24.6 to -1.9], p=0.023) and aetrifline in spirit (-20.5% [95% CI: -35.3 to -5.9], p=0.007).

Discussion
This study investigated the impact of a mobile electronic inventory system, coupled with educational initiatives, on the availability of medicines at the clinic level in a least developed country. The study did not support this hypothesis that mobile electronic inventory improved medicines availability, but identified lessons in the implementation model that could be used by other countries.

The study design had several strengths; the new system was implemented across the full range of medicines used in the clinics. It was conducted in a real-world setting, over a 12 month period and used a control group of similar size to the intervention group. The clinics in which availability was measured were chosen randomly.

The study design also had weaknesses however. One of the challenges of this study was that the intervention and control groups were dissimilar at baseline. The intervention sites were purposely selected based on the speed and reliability of their internet (which, at the time, was essential for the system to work), which meant there was a selection bias. The same factors impacting on internet access and reliability in these sites might also impact on factors that influence the availability of essential medicines in strategic locations (excluding local infrastructure, better governance and stronger transport infrastructure). Moreover, as there was a significant difference in baseline medicines availability, this is likely to have impacted on the difference in the magnitude of change between the 2 groups mainly because there is expected to be a diminishing rate of return from interventions to improve availability (disproportionately affecting the intervention group, which had greater availability at baseline). As medicines availability at baseline was lower in the intervention group, this left less room for improvement in this group.

It is also possible that there is also a ceiling effect, in that it becomes exponentially more difficult to increase medicines availability beyond a certain point and if that is the case, one would expect the effect of interventions to diminish as that point is approached. We have tried to address these issues as best as possible with our data analysis but they do serve to highlight the challenges of assessing interventions impacting on access to medicines in a field setting. These challenges may help to explain the lack of published research in this field.

The observed changes in medicines availability were investigated using statistical tests (Table 4) for 17 individual medicines. By chance alone, it would be expected to see at least one with a p value <0.05 and so the result for each individual medicine should not be over-interpreted.

The clinics involved were also aware that the study was taking place. Some of the increase in medicines availability may have been due to the Hawthorne effect, in that the nurses may have improved their performance because they knew they would be assessed again after 12 months.

This study did not specifically investigate the relative costs of both supply systems.

One pressing and obvious question stemming from the results in this paper is “why did medicines availability improve in the control group?”

Though many suggestions to improve medicines availability have been proposed, there has been a paucity of high quality published research assessing the impact of pharmaceutical supply interventions on the availability of essential medicines. Past research has focused on individual products or groups of products and a 2011 paper found no
large intervention study using a control group in a real-world setting.

The availability of medicines at the primary healthcare level is the result of many factors, including transport and storage infrastructure, local and national forecasting and procurement, weather and geography, HR, staff education and experience and health financing. The relative effect of each intervention in a real-world setting is difficult to determine; improving the availability of medicines at the primary healthcare level requires a multi-faceted set of interventions and they are likely to be mutually reinforcing. It logically follows that it was impossible in this study to objectively analyze each factor that has contributed to a change in medicines availability but there were several interesting anecdotal observations that can be highlighted using available data. Lata, an intervention group SLMS, reported frequent problems with internet availability and speeds and Table 3 shows that medicines availability decreased in Lata by 9.7%. Conversely, the Pharmacy Officer working in Susubona, a control group SLMS, was changed during the course of the study — the only significant staff change in any SLMS during the 12 month period — and availability increased there by 26.1%. These issues are subjective, but they are given here to represent typical examples of the complex factors influencing medicines availability. It may be possible with larger sample sizes or novel methodologies to adjust for more confounders but probably impossible to adjust for all.

Electronic systems are likely to play an increasing role in the provision of essential medicines in low-resource settings however and medicines availability did increase in the intervention group. This study has established a model for implementing mobile electronic inventory in the Pacific island setting. Although no evidence was found of a difference in the improvement in medicines availability between the intervention and control groups, it is worthwhile to consider why and possible improvements to this model. The provision of more reliable internet would help future implementation and at least one test site (Lata) was severely hampered by this. The latest version of the software, allowing store-and-send syncing, is also likely to improve usage as this means the devices do not need constant internet to function.

Electricity was not a significant factor in this study but in sites without reliable power supply, solar power is normally sufficient to regularly charge tablets devices.

Digital literacy amongst staff in this study was generally poor — although the software was intuitive and staff demonstrated proficiency after 2 days of one-on-one training, this may have accounted for some of the lack of observed effect in the intervention group. With increasing use of smartphones in low resource settings, basic digital literacy is likely to improve.

It is expected that the effect of mobile electronic inventory would become clearer with further research. There would be benefit in larger studies looking at the longer-term effects and greater efforts to ensure similar group characteristics in the study methodology.

In addition to the changes in availability, electronic health tools generate high quality data for central planners to aid in forecasting, epidemiology, performance management and disaster response. Even if they were not shown to significantly improve availability at the primary healthcare level, these benefits may justify the use of mobile inventory systems.15,19

The Solomon Islands Government has now implemented mobile electronic inventory in all SLMS in the country.

Conclusions

The study did not show that mobile electronic inventory improved the availability of medicines at the clinic level. The magnitude of improvement in medicines availability after a multi-faceted pharmacy intervention was similar in the intervention group, which used mSupply Mobile® and the control group which did not.

This study did find that a new, mobile supply system could be implemented successfully on a large scale, across the full medicines inventory in a challenging setting. It is difficult to attribute medicines availability to specific interventions in a real-world setting but it is expected that the effect of mobile electronic inventory will become clearer with further research and more time. Other potential benefits from these systems include greater transparency and improvements to forecasting.
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real-time stock visibility, rational use of medicines and disaster response. Program (Department of Foreign Affairs and Trade).

Acknowledgements
This work was supported by the Solomon Islands Government Ministry of Health and Medical Services and the Australian Aid

Disclosures
None of the authors report any conflicts of interest.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Percentage availability of medicines at clinic level, by group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline (%) Mean (SD)</td>
</tr>
<tr>
<td>Control (n= 35)</td>
<td>59.3% (16.0)</td>
</tr>
<tr>
<td>Intervention (n= 32)</td>
<td>65.5% (10.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Percentage availability of medicines by Second Level Medical Store (number of medicines available / number of medicines expected to be available at that SLMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
</tr>
<tr>
<td>Facility</td>
<td>SLMS % Avail</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Afso</td>
<td>19/23 (82.6%)</td>
</tr>
<tr>
<td>Balia</td>
<td>23/31 (74.2%)</td>
</tr>
<tr>
<td>Kiris Kiru</td>
<td>27/31 (87.1%)</td>
</tr>
<tr>
<td>Seghe</td>
<td>18/23 (78.3%)</td>
</tr>
<tr>
<td>Sarubona</td>
<td>13/23 (56.5%)</td>
</tr>
<tr>
<td>Taxaraha: Excluded</td>
<td>20/23 (87.0%)</td>
</tr>
<tr>
<td>Mean (Control)</td>
<td>75.7% (n=5)</td>
</tr>
<tr>
<td>Intervention</td>
<td></td>
</tr>
<tr>
<td>Gizo</td>
<td>22/31 (71.0%)</td>
</tr>
<tr>
<td>K砒n’uhi</td>
<td>28/31 (90.3%)</td>
</tr>
<tr>
<td>Lata</td>
<td>27/31 (87.1%)</td>
</tr>
<tr>
<td>Manda</td>
<td>28/31 (90.3%)</td>
</tr>
<tr>
<td>Taro</td>
<td>23/31 (74.2%)</td>
</tr>
<tr>
<td>Tukuri</td>
<td>27/31 (87.1%)</td>
</tr>
<tr>
<td>Mean (Intervention)</td>
<td>83.3% (n=6)</td>
</tr>
<tr>
<td>Mean (Overall)</td>
<td>79.9% (n=11)</td>
</tr>
</tbody>
</table>
### Table 4  Availability of each medicine at clinic level

<table>
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<tr>
<th></th>
<th>Pre-Intervention (n=68 clinics)</th>
<th>Post-Intervention (n=68 clinics)</th>
<th>Change in availability</th>
<th>95 % Confidence Interval</th>
<th>p-value</th>
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<tbody>
<tr>
<td></td>
<td>Count</td>
<td>%</td>
<td>Count</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Acriflavine</td>
<td>63/68</td>
<td>92.6%</td>
<td>49/68</td>
<td>72.1%</td>
<td>- 20.5%</td>
</tr>
<tr>
<td>Amoxicillin adult</td>
<td>41/68</td>
<td>60.3%</td>
<td>42/68</td>
<td>61.8%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Artesunate</td>
<td>28/68</td>
<td>41.2%</td>
<td>49/68</td>
<td>72.1%</td>
<td>30.9%</td>
</tr>
<tr>
<td>Benzathine penicillin</td>
<td>64/68</td>
<td>94.1%</td>
<td>60/68</td>
<td>88.2%</td>
<td>- 5.9%</td>
</tr>
<tr>
<td>Coartem</td>
<td>58/68</td>
<td>85.3%</td>
<td>60/68</td>
<td>88.2%</td>
<td>2.9%</td>
</tr>
<tr>
<td>COC pill</td>
<td>45/68</td>
<td>65.7%</td>
<td>65/68</td>
<td>95.0%</td>
<td>29.4%</td>
</tr>
<tr>
<td>Depo-Provera</td>
<td>63/68</td>
<td>92.6%</td>
<td>62/68</td>
<td>91.2%</td>
<td>- 1.4%</td>
</tr>
<tr>
<td>Morphine or pethidine</td>
<td>21/68</td>
<td>30.5%</td>
<td>28/68</td>
<td>41.2%</td>
<td>10.3%</td>
</tr>
<tr>
<td>ORS sachets</td>
<td>60/68</td>
<td>88.2%</td>
<td>65/68</td>
<td>95.0%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Oxycetin or Systametin</td>
<td>19/68</td>
<td>27.5%</td>
<td>26/68</td>
<td>38.2%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Paracetamol adult dose</td>
<td>56/68</td>
<td>82.4%</td>
<td>53/68</td>
<td>77.9%</td>
<td>- 4.5%</td>
</tr>
<tr>
<td>Procaine-Benzyl Penicillin</td>
<td>66/68</td>
<td>97.1%</td>
<td>57/68</td>
<td>83.8%</td>
<td>- 13.3%</td>
</tr>
<tr>
<td>Normal Saline</td>
<td>59/68</td>
<td>86.8%</td>
<td>60/68</td>
<td>88.2%</td>
<td>1.4%</td>
</tr>
<tr>
<td>STI Treatment Pack</td>
<td>27/68</td>
<td>39.7%</td>
<td>46/68</td>
<td>67.6%</td>
<td>27.9%</td>
</tr>
<tr>
<td>Tetanus Vaccine</td>
<td>29/68</td>
<td>42.6%</td>
<td>36/68</td>
<td>52.9%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Vitamin A Caps</td>
<td>41/68</td>
<td>60.3%</td>
<td>30/68</td>
<td>55.9%</td>
<td>- 4.4%</td>
</tr>
<tr>
<td>Zinc Sulphate</td>
<td>2/68</td>
<td>2.9%</td>
<td>60/68</td>
<td>88.2%</td>
<td>85.3%</td>
</tr>
</tbody>
</table>

### References

Paper for Submission:
Improving access to essential medicines using a mobile inventory system


Chapter elements and results not included in the paper:

Rationale for study design

The study design was developed to support the establishment of the program in Solomon Islands in 2012, as described in Chapter 5; the project would have gone ahead regardless of a research component. The National Pharmacy Services Division (NPSD) sought to introduce a mobile electronic inventory system at twelve sites. Funding was available for only six iPad tablet devices however. Further, in 2012 internet availability was insufficient to accommodate a rollout to all twelve facilities. The system was thus introduced in areas with the best internet, creating an environment to undertake a controlled study in a real world setting. In the intervention arm, six SLMS, supplying 120 clinics, would receive mobile electronic inventory. In the control arm, six SLMS, supplying 100 clinics, would maintain the existing paper-based system.

By evaluating the implementation systematically, the NPSD sought to measure the impact of mobile electronic inventory, advocate for future funding and model implementation in other SLMS in Solomon Islands and regional nations.

To permit sufficient time for the interventions to have a measurable effect, within the constraints of available funding, a 12 month research timeframe was determined. Over a 12 month period, seasonal weather and annual local cultural events result in variation in the performance of the medical system in Solomon Islands. For example, transport in the islands is hampered during the wet season from December to April and over major religious holidays. To minimise confounding caused by this, before-and-after data collection occurred at the same time of year. 12 months was thus a logical, economic and methodologically sound timeframe.

The sample size calculation was undertaken within these parameters and is detailed in the ‘Clinic selection and statistical methods’ (below).
Clinic selection and statistical methods

Sample Size

The sample size was based on necessary power to identify an estimated improvement in medicines availability from 55% at baseline to 70% at follow-up in the intervention group. This was based on historical data from clinics and a pilot study (unpublished) conducted in 2012. Sample size calculations determined 36 clinics were required in each group, based on 80% power and a two-sided test with $\alpha=0.05$.

An additional four clinics were included in each group to allow for dropout, bringing the total sample size to $n=40$ in each group.

Excluded clinics and areas

Approximately 100 clinics were excluded as follows:

i. All clinics in Renbel Province, including Tingoa SLMS. Occasionally, shipping delays result in these clinics being supplied directly by airfreight from NMS. Travel to and within the province is extremely difficult and time consuming; at the time of planning, the airport was closed and shipping is infrequent.
ii. All clinics supplied by Malu’u and Atoifi SLMS, Malaita Province. Intermittently, these clinics are supplied by Kilu’ufi SLMS, NMS or their supply source is unclear. It was not possible to allocate them to a group definitively.

iii. All clinics in Temotu outer islands and Malaita outer islands. These clinics are regularly supplied by NMS. Travel to them is extremely time-consuming, given their isolation.

iv. All clinics on Savo Island and Russell Islands. These clinics are regularly supplied directly from NMS.

v. All clinics in the Shortland Islands (near Bougainville, PNG). These clinics are occasionally supplied directly from NMS.

vi. All clinics on Guadalcanal and within Honiara City Council. These clinics are regularly supplied directly from NMS.

Primary healthcare facility nomenclature

At the time this study was conducted, Solomon Islands MHMS actually designated several of the study facilities ‘Nurse Aid Posts’ and four of the facilities assessed were designated small Area Health Centres. The classification of Area Health Centre, Clinic and Nurse Aid Post was poorly defined at that time in Solomon Islands. For the purposes of this study, all have been considered equally and the term ‘clinic’ here refers to all primary healthcare facilities.

All clinics are staffed by Nurse Aides and/or Registered Nurses and there are no strict definitions governing their designation. These definitions are being addressed by the Solomon Islands Role Delineation Policy, though this remains incomplete at the time of writing.

All facilities should be supplied with the 17 medicines under assessment and the supply chain mechanisms are consistent across all facilities supplied by SLMS.

### Educational interventions implemented as part of the study
• Zinc Sulphate & ORS Poster, as used in a pilot study conducted in Western Province in 2011/12.
• Dosing wall chart for Priority Medicines for Mothers and Children
• Series of 10 ‘Patient Information Cards’, double-sided A5, disease focussed cards.
• Quarterly newsletters focussing on Child and Maternal Health over 12 months
• Monthly radio shows focussing on Child and Maternal Health over 12 months
• The Solomon Islands Standard Treatment Manual for Children was re-printed and distributed to all clinics
• Official memo instructing health workers to use Amoxicillin instead of Co-Trimoxazole for treatment of pneumonia in children.

Figure 11: Map showing all facilities included in study
### Full study results, every clinic

**Table 4: Complete results by clinic**

<table>
<thead>
<tr>
<th>Clinic Name</th>
<th>Group</th>
<th>Baseline</th>
<th>Follow-Up</th>
<th>Availability of interventions at follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Male Condoms</td>
</tr>
<tr>
<td>----------------</td>
<td>-------</td>
<td>----------</td>
<td>-----------</td>
<td>--------------</td>
</tr>
<tr>
<td>Arara</td>
<td>C</td>
<td>76.5%</td>
<td>17.7%</td>
<td>✓</td>
</tr>
<tr>
<td>Aua</td>
<td>C</td>
<td>58.8%</td>
<td>11.8%</td>
<td>✓</td>
</tr>
<tr>
<td>Batuna</td>
<td>C</td>
<td>64.7%</td>
<td>5.9%</td>
<td>✓</td>
</tr>
<tr>
<td>Borodao</td>
<td>C</td>
<td>58.8%</td>
<td>11.8%</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Hageulu</td>
<td>C</td>
<td>35.3%</td>
<td>23.53%</td>
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<td>Hoffi</td>
<td>C</td>
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<td>✓</td>
</tr>
<tr>
<td>Homa</td>
<td>C</td>
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<td>11.8%</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Kaonasugu</td>
<td>C</td>
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<td>5.9%</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Konide</td>
<td>C</td>
<td>47.8%</td>
<td>8.7%</td>
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<tr>
<td>Lelegia</td>
<td>C</td>
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<tr>
<td>Manasagu</td>
<td>C</td>
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<td>11.8%</td>
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<tr>
<td>Marogu</td>
<td>C</td>
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<td>0</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Muanu</td>
<td>C</td>
<td>29.4%</td>
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<tr>
<td>Mwaniwiriwiri</td>
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<td>11.8%</td>
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<tr>
<td>Naharahau</td>
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<td>11.8%</td>
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<tr>
<td>Narame</td>
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<td>5.9%</td>
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</tr>
<tr>
<td>Narate</td>
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<tr>
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<tr>
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<td>Tinge</td>
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<td>64.7%</td>
<td>17.7%</td>
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</tbody>
</table>
Chapter 8: Before-and-after survey of health worker comprehension

Introduction

Health worker comprehension is a key element of overall access to medicines. Whilst availability is another fundamental, it is equally important that staff know how to use medicines correctly and safely.

In the Solomon Islands, primary healthcare facilities (clinics) are staffed by registered nurses and nurse aides. A pre- and post-intervention effectiveness study was carried out, focussing on the availability of the WHO Priority Medicines for Mothers and Children. This was done in clinics across Solomon Islands over a 12 month period, measuring the availability of 17 medicines from the priority list.

Health workers were also tested on their comprehension of the priority medicines and examined on whether their comprehension improved following a 12 month series of educational interventions. Though distinct data collection tools were used for this indicator, this exercise was carried out in conjunction with the primary study examining medicines availability described in Chapter 7.

This chapter describes the study of staff comprehension of the priority medicines.

Methodology

Study Design

A pre- and post-intervention effectiveness study of health workers’ (nurses and nurse aides) comprehension of the WHO Priority Medicines, conducted over 12 months in clinics in Solomon Islands.

Clinics had been allocated to either a control or intervention group for the purposes of the simultaneous study into medicines availability, described in Chapter 7, and health workers were assigned to these groups accordingly. This was done mainly to determine if there were a difference in the baseline characteristics of the two groups. The educational interventions were applied across all
clinics however and the intervention and control arms were expected to perform similarly in this separate study of staff comprehension.

The detailed description of clinic selection and sample size determination is in Chapter 7.

Population analysed

All registered nurses and nurse aides working in each clinic on the day of visitation were surveyed in the pre-intervention phase.

In Solomon Islands, registered nurses must have completed a three year (diploma) or four year (bachelor) qualification at a recognised training institution, with an additional year of supervised training. Nurse aides must have completed a one year certificate course at a nurse training facility, with an additional six months of supervised training. Midwives must be registered nurses, who undergo an additional one year of training. For the purposes of this study, midwives were recorded as registered nurses.

Data sources and definitions:

Forty clinics were randomly selected from each of a control and intervention group; the total number of clinics was 80.

Comprehension was determined by a 30 question survey, conducted by interview with all nurses and nurse aides on duty on the day of visitation, once at baseline and once at 12 months follow-up. The interview was conducted by a nurse or midwife from the Child & Reproductive Health Division, using a paper questionnaire that they filled in based on the participant’s responses. The same questionnaire was used for all staff in all facilities.

The 30 part questionnaire was developed in conjunction with the Maternal and Child Health Division based on a model used in a pilot study (unpublished) in 2012.

Data were collected in hard copy form and taken back to Honiara, where it was assessed and entered by the study coordinator. The data were entered into an EpiData database and exported to STATA for analysis.
Interventions

All clinics

All clinics in both groups (and excluded clinics) received an education package comprising:

- Zinc Sulphate & ORS Poster, as used in a pilot study conducted in Western Province in 2011/12.
- Dosing wall chart for Priority Medicines for Mothers and Children
- Series of 10 ‘Patient Information Cards’, double-sided A5, disease focussed cards.
- Quarterly newsletters focussing on Child and Maternal Health over 12 months
- Monthly radio shows focussing on Child and Maternal Health over 12 months
- The Solomon Islands Standard Treatment Manual for Children was re-printed and distributed to all clinics

In addition to these interventions, all Pharmacy Officers were verbally instructed by phone or radio to monitor orders to ensure that the Priority Medicines were being ordered by clinics. If a clinic had not ordered one of the priority medicines, Pharmacy Officers were encouraged to follow up with clinics to enquire why this was the case; ultimately, items were not to be supplied unless ordered however. It is unknown to what extent this instruction was followed but direct communication between SLMS and clinics is often problematic.

An official memo was sent to all clinics by the Chief Pharmacist instructing them to not use Co-Trimoxazole in the treatment of pneumonia and to refer to Treatment Guidelines when diagnosing and determining treatment regimens. This was felt to be a necessary intervention after the baseline data collection showed inappropriate use of Co-Trimoxazole was a major issue across the majority of facilities.

During post-intervention data collection, the teams recorded which of the educational interventions were actually available at the clinic on the day of visitation. The verification of the extent to which interventions were implemented is presented in Chapter 10.
**Intervention group**

Clinics supplied through intervention group SLMS were supplied via mobile electronic inventory, as described in Chapter 5. This was not expected to impact on staff comprehension at the clinic level.

**Rationale for study design**

This study was conducted simultaneously with the primary study into medicines availability. The purpose of that primary study was to examine the effect of mobile electronic inventory systems on medicines availability and SLMS were controlled to either receive or not receive that intervention.

When undertaking the educational interventions described in this subsidiary study, it would not have been possible to apply them only to the intervention group. Several of them were in universally distributed media, including the quarterly newsletter and the pharmacy radio show, which reach every clinic. Similarly, nurses move around between facilities and it would have been impossible to control for this, as individual provinces are responsible for nurse placements, the movement of nurses is often quite fluid and current nurse positions are not recorded in any central register.

Even if it had been possible however, applying these educational interventions only in the intervention arm would have confounded the results of the primary study. It would have been impossible to separate out the effect of the educational interventions and determine to what extent the mobile electronic inventory system had influenced medicines availability.

**Data analysis, management and ethics**

Comprehension was defined as the number of questions answered correctly, out of a total of 30, expressed as a percentage. Answers were marked correct or not correct and scored binomially. No part marks or half-points were given.

The overall mean comprehension was taken as the average percentage score from all nurses (Registered Nurses and Nurse Aides) in each group.

Data collection teams recorded if staff were registered nurses or nurse aides, the clinic and what group they were from but no other details were collected. The pre- and post analysis is therefore unpaired.
and responses have been included from nurses in all clinics, regardless of whether before-and-after data were collected for each clinic.

There were 31 data points for each completed survey, which approximated a continuous dataset. Visual examination of a histogram was used to see if the data were normally distributed. The data were unpaired, and a two sample t-test was thus used to examine for a difference between the control and intervention groups at baseline and to examine the difference between baseline and follow-up in both groups.

A two sample t-test was used to examine for a difference between registered nurses and nurse aides at both baseline and follow-up.

Confidentiality

No nurses’ names were recorded during comprehension surveys, though nurse type (nurse aide or registered nurse) was recorded, along with the clinic being sampled. Theoretically, it would be possible to take the raw data and potentially identify a number of participating nurses. For this reason, individual clinic results have not been published.

The data are to be stored securely for five years.

Ethical considerations

The study was approved by the Health Research Ethics Committee at the University of Melbourne (Ethics ID: 1238837) and the Health Research and Ethics Committee of the Solomon Islands Ministry of Health & Medical Services (Certificate number: HRC 12/29) (Appendix 3).

Data collection tools

A 30 part questionnaire in A4 hard-copy form was used and answers were recorded by pen. The same test was used for both registered nurses and nurse aides.
Results

Timeline

The data collection across all clinics took one month. The study was carried out from April 2013 to April 2014 in the Solomon Islands.

Selection and loss to follow up - Comprehension

101 nurses (intervention n = 52; control n = 49) were interviewed from 77 clinics at baseline. Of these, 36 were registered nurses and 65 were nurse aides.

83 nurses (intervention n = 40; control n = 43) were interviewed from 69 clinics at follow-up. Of these, 28 were registered nurses and 55 were nurse aides.

All nurses gave their consent to participate in the study. Nurse details were not recorded and the data are unpaired; all nurses were therefore included in the comprehension analysis, regardless of whether pre- and post-intervention data were collected from each clinic.

Baseline comprehension

Overall, mean comprehension was 58.5% at baseline (n = 101, s.d. = 13.8). In the control group, comprehension was 58.6% (n = 50, s.d. = 13.0) and in the intervention group, it was 58.4% (n = 51, s.d. = 14.6).

No significant difference was observed between the two groups at baseline; t = -0.06, p = .9513
The 31 possible data points simulated a continuous variable and the distribution of scores at both baseline and follow-up closely approximated normality.

![Figure 12: Comprehension by nurse, distribution histogram – baseline and follow-up](image)

**Magnitude of change in comprehension**

At follow-up, overall comprehension was 72.2% (n = 83, s.d. = 13.3). The mean increase in comprehension was 13.7% (s.e. = 2.0); t=6.83, p<0.001

In the control group, comprehension increased by 13.5% from baseline (mean =58.6%, n = 50, s.d. = 13.0) to follow-up (mean = 72.1%, n = 43, s.d. = 13.2); t=4.94, p<0.001

In the intervention group, comprehension increased by 14.0% from baseline (mean = 58.4%, n = 51, s.d. = 14.6) to follow-up (mean = 72.4%, n = 40, s.d. = 13.5); t=4.68, p<0.001

There was no significant difference in the magnitude of change between the two groups. This met expectations as all educational interventions were applied equally to both groups.

**Table 5: Staff comprehension by group**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Intervention (n=30 questions)</th>
<th>Post-Intervention (n= 30 questions)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>95% CI</td>
<td>Mean</td>
</tr>
<tr>
<td>Control</td>
<td>58.6%</td>
<td>54.9 , 62.3</td>
<td>72.1%</td>
</tr>
<tr>
<td>Intervention</td>
<td>58.4%</td>
<td>54.3 , 62.5</td>
<td>72.4%</td>
</tr>
<tr>
<td>Overall</td>
<td>58.5%</td>
<td>55.8 , 61.2</td>
<td>72.2%</td>
</tr>
</tbody>
</table>
Nurse aides vs registered nurses

Registered Nurses were expected to perform better than Nurse Aides and this was examined.

At baseline, registered nurses (n = 36, mean = 65.6%, s.d. = 12.1) performed 11.0% better than nurse aides (n = 65, mean = 54.6%, s.d. = 13.2), t= -4.12, p<0.001

At follow-up, registered nurses continued to perform better than nurse aides.

At follow-up, registered nurses improved by 12.6% (n = 28, mean = 78.2%, s.e. = 2.0); t=4.4, p<0.001, whilst nurse aides improved by 14.6% (n = 55, mean = 69.2%, s.e. = 1.8); t=6.0, p<0.001.

The gap between nurse aides and registered nurses narrowed to 9.0% but remained statistically significant.

Table 6: Comprehension results by question

Results by question

<table>
<thead>
<tr>
<th>Question</th>
<th>Baseline (n = 101)</th>
<th>Follow-Up (n = 83)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the main indication for Zinc in children?</td>
<td>60.4%</td>
<td>89.2%</td>
</tr>
<tr>
<td>2. What is the benefit of giving a child Zinc for diarrhoea?</td>
<td>22.8%</td>
<td>79.5%</td>
</tr>
<tr>
<td>3. What is the benefit of giving a child ORS for diarrhoea?</td>
<td>83.2%</td>
<td>95.2%</td>
</tr>
<tr>
<td>4. Should the child be given less ORS if they are being given Zinc?</td>
<td>36.6%</td>
<td>67.5%</td>
</tr>
<tr>
<td>5. What is the recommended dose of Zinc in diarrhoea?</td>
<td>5.9%</td>
<td>10.8%</td>
</tr>
<tr>
<td>6. What is the duration of Zinc therapy in diarrhoea?</td>
<td>31.7%</td>
<td>73.5%</td>
</tr>
<tr>
<td>7. How do you prepare ORS sachets for use?</td>
<td>89.1%</td>
<td>91.6%</td>
</tr>
<tr>
<td>8. How often do you use Vitamin A in children?</td>
<td>52.5%</td>
<td>100%</td>
</tr>
<tr>
<td>9. How do you give Vitamin A in children?</td>
<td>95.0%</td>
<td>97.6%</td>
</tr>
<tr>
<td>10. What is the dosing schedule of Vitamin A in children with Xerophthalmia or severe malnutrition?</td>
<td>5.0%</td>
<td>15.7%</td>
</tr>
<tr>
<td>11. How does a patient take the new STI Treatment Pack?</td>
<td>57.4%</td>
<td>83.1%</td>
</tr>
<tr>
<td>12. What is the treatment for malaria in the 1st trimester of pregnancy?</td>
<td>35.6%</td>
<td>57.8%</td>
</tr>
<tr>
<td>13. What is an appropriate treatment for an unconscious malaria patient before referral?</td>
<td>85.1%</td>
<td>90.4%</td>
</tr>
</tbody>
</table>
14. How do you give Coartem to a baby under 5kg? 57.4% 61.4%
15. What is one symptom of G6DP deficiency in patients taking Primaquine? 64.4% 78.3%
16. What is one symptom suggesting severe pneumonia in children? 97.0% 98.8%
17. What is the frequency (timing) and duration of amoxicillin in children? 83.2% 89.2%
18. What route is Procaine Benzylpenicillin given by? 98.0% 95.2%
19. What is the schedule for Tetanus vaccination in mothers? 74.3% 81.9%
20. What is an appropriate treatment for neonatal sepsis before referral? 66.3% 85.5%
21. What do you use Acriflavine or Chlorhexidine for after birth? 88.1% 98.8%
22. What fluids would you use in severe dehydration in children? 72.3% 84.3%
23. How often should pregnant mothers take Fefol tablets? 92.1% 96.4%
24. What is the first treatment given for post-partum hemorrhage (bleeding in a mother after birth)? 92.1% 85.5%
25. What two medicines are in the new STI Treatment Pack? 17.8% 32.5%
26. What is a medicine you could give for maternal sepsis? 54.5% 63.9%
27. What are the signs and symptoms of maternal sepsis? 66.3% 72.3%
28. What is one condition you would give metronidazole for in mothers or children? 55.4% 63.9%
29. What is Magnesium Sulphate used for in pregnancy? 14.9% 26.5%
30. What drug do you use to treat Magnesium Sulphate toxicity/overdose? 1.0% 1.2%

Discussion

The educational interventions were successful in improving health worker comprehension around the 31 priority medicines. It was expected that a uniform increase in comprehension would be seen across both groups, as these interventions were applied equally across all clinics and this was observed. Registered nurses performed better than nurse aides at baseline and follow-up. This met expectations, as registered nurses can be assumed to have received more training and to have undergone more stringent entry requirements for training programs. This is an important finding and warrants closer examination, as it may help to guide policy on nurse training and staff development planning.
Measuring the competency of health workers is difficult and potentially subjective in any setting; this methodology should not be considered a proxy measure of clinical competency or even a measure of comprehension pertaining to the full spectrum of essential medicines. This study sought to measure the general awareness of health workers in regards a very limited set of priority medicines. The questionnaire, developed in conjunction with the Child and Maternal Health Division in Solomon Islands, asked questions relating only to the basic diagnosis, indication and dosage, specifically for the Priority Medicines for Mothers and Children.

Stronger tools to measure competency have been applied in other studies but these methodologies were impractical in this study due to time limitations; if staff comprehension was to be the primary study outcome, it may be beneficial to use multiple measurement tools over longer periods of time and especially to observe clinical practice.

Limitations of this methodology

The questionnaire is a limited examination of health worker knowledge pertaining to a selected list of medicines – measuring comprehension in this way is quick and potentially efficient but it cannot be equated with more rigorous tests of competency, which may involve longitudinal staff observation and practical skills testing.

The questionnaires are undertaken orally by nurses or midwives on the data collection teams; this means there is an interviewer bias.

The same questionnaire was used at baseline and follow-up; though the answers were not formally given to nurses at baseline or throughout the year, the nurses’ responses at follow-up 12 months later may simply reflect nurse recall of those specific questions and not broader knowledge of the priority medicines.

Conclusions

Strong improvements in health worker comprehension were observed over the 12 month study period. Registered nurses performed better than nurse aides at both baseline and follow-up. Measuring health
worker comprehension in this way should not be considered a proxy measure of clinical competency however.

It is difficult to attribute all improvements in staff comprehension to the educational interventions described in this research but they appear to be well correlated.
Chapter 9: Before-and-after survey of medicines usage

Introduction

A pre- and post-intervention effectiveness study of a mobile electronic inventory tool was carried out in the Solomon Islands, focusing on the availability of the WHO Priority Medicines for Mothers and Children. This was carried out in clinics across Solomon Islands over a 12 month period, measuring the availability of 17 medicines from the priority list; health worker comprehension was also examined in those clinics. The results of these surveys have been presented in Chapters 7 and 8.

The aim of improving access to medicines is ultimately to improve the rational use of medicines. The preceding chapters have shown that there were improvements in both the availability of priority medicines and health workers’ comprehension of medicines over the 12 month period. It is logical to explore if this translated into rational usage of those medicines.

For this reason, the usage of the WHO priority medicines for mothers and children at the primary healthcare level in Solomon Islands was examined by auditing outpatient registers in clinics across Solomon Islands.

Though distinct data collection tools were used for this indicator, this exercise was carried out simultaneously with the surveys examining medicines availability and staff comprehension.

Methodology

Study design

A controlled pre- and post-intervention effectiveness study of medicines usage, conducted over 12 months in clinics in Solomon Islands. Clinics had been allocated to either a control or intervention group for the purposes of the simultaneous study into medicines availability.

The detailed description of clinic selection and sample size determination is in Chapter 7.

Data were collected at both baseline and follow-up from the six months preceding each day of visitation.
Population analysed

All episodes of care for any of the eleven nominated conditions (shown below) in eligible patients in clinic treatment registers during the preceding six months prior to the day of visitation were recorded. As data collection took one month (April) all episodes of care from the preceding October until the day of visitation were included.

Data sources and definitions

Usage was determined by looking at relevant episodes of care from the outpatient treatment registers, admission registers and antenatal cards available in the clinic on the day of visitation. Data were collected by two data collection teams, the makeup of whom is described in Chapter 7. Data were recorded on the diagnosis, patient age, sex and treatment given, including all available information on the medicine selection, dosage, frequency and duration, in de-identified form. No names of patients were recorded. This information was transcribed by hand, by data collection team members, onto data collection sheets, which were then taken to Honiara for assessment.

The outpatient treatment registers are used to record the details, diagnosis and treatment of all patients presenting to a clinic who do not get admitted. The registers are used as patient records for representations and for data collection across a variety of vertical programs.

An eligible episode of care was any patient presenting in the preceding six months to day of visitation, for any of the following conditions:

i. Child Pneumonia

ii. Child Diarrhoea

iii. Child Malaria

iv. Neonatal Sepsis

v. Post-Partum Haemorrhage

vi. Pre-Eclampsia/Eclampsia

vii. Maternal Sepsis

viii. Incomplete Abortion/Miscarriage
ix. STIs (male or female)

x. Pre-Term Labour

xi. Maternal Malaria

A child was defined as age 0-5 (this definition is taken from the WHO Priority List).

HIV was excluded as this is not typically managed at clinics in the Solomon Islands, where the incidence rate is very low. Patients are managed directly by the National HIV Program.

Vitamin A supplementation and contraception were excluded as these ‘conditions’ are only recorded when a person receives the treatment.

Prevention of tetanus in pregnancy was excluded as records are only kept for those mothers that receive vaccination and during the testing phase of the study, it was found those records were often incomplete or unclear. It was impossible to determine, using this methodology, the number of mothers who didn’t receive a tetanus vaccination and it was thus excluded.

Palliative care / pain relief were excluded as these patients are usually referred to a tertiary facility in Solomon Islands and would not be captured in clinic data.

During post-intervention data collection, the month in which the episode of care occurred (during the preceding six months) was recorded.

The treatment definitions for determining RUM were taken from the Solomon Islands Standard Treatment Manual (separate Manuals for Children and Adults) or accepted disease treatment protocols used in the Solomon Islands and approved by the National Medicines and Therapeutics Committee. All treatment definitions were reviewed by the Research team, including Dr Divinal Ogaoga (Director, Child & Reproductive Health Division) and the Medicines Information Centre.

The pharmacist and an additional pharmacist/pharmacy officer on the data collection teams were responsible for recording and transcribing this information from the data sources in the clinics.

Data were collected in hard copy form and taken back to Honiara, where it was assessed and entered by the study coordinator. The data were entered for all three indicators separately, using the EpiData program and exported to STATA, which was used for all data analysis.
The data collection across all clinics took one month.

Data analysis, management and ethics

*Primary binomial indicator*

The system of classification used in this study is a rapid tool for measuring rational use from a large data set and for showing longitudinal changes in prescribing practices.

The usage indicator was determined by binomially classifying all episodes of care into 1 (rational selection of medicines) or 0 (irrational selection of medicines) according to the diagnosis and treatment regimen recorded. Under this binomial system, a classification of 1 considered only whether the correct medicines to treat the diagnosed condition had been given, ignoring dose, frequency, duration and other medicines given.

The mean RUM was defined as the number of episodes of care classified as ‘rational’, divided by the total number of episodes of care.

All episodes of care have been included, regardless of whether before and after data had been collected from a given clinic, as the two datasets are distinct, no patients are repeated and the observations are thus unpaired.

The usage indicator was a binomial, unpaired dataset so a $\chi^2$ test has been used to compare groups.

The change in usage between the two groups has been analysed using a $\chi^2$ test.

The usage percentage for each disease category has been presented for baseline and follow-up.

*Secondary indicator*

The binomial classification of ‘rational selection’ was further broken down into seven sub-categories.

To do this objectively, a set of ‘necessary’ agents, ‘acceptable’ agents and ‘unacceptable’ agents were defined for each of 11 conditions. To be classified as ‘rational’ use, the episode of care must have received every item from the set of necessary agents. If they had been prescribed all the necessary agents, they were classified as 1-7 under this system.
If the patient had not been prescribed all of the necessary agents for their condition, they were classified as an ‘8’, under this system.

These classifications are explained in Table 7 (below).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rational use of medicines, according to defined treatment, with all information known</td>
</tr>
<tr>
<td>2</td>
<td>Rational use of medicines with known information but details missing of dose, frequency or duration</td>
</tr>
<tr>
<td>3</td>
<td>Rational use of medicines, with additional items prescribed, unlikely to cause harm</td>
</tr>
<tr>
<td>4</td>
<td>Correct items given but additional antibiotics inappropriately prescribed</td>
</tr>
<tr>
<td>5</td>
<td>Correct items given, but additional items prescribed with potential to cause harm</td>
</tr>
<tr>
<td>6</td>
<td>Correct items given but underdosing</td>
</tr>
<tr>
<td>7</td>
<td>Correct items given but overdosing</td>
</tr>
<tr>
<td>8</td>
<td>Incorrect items given</td>
</tr>
</tbody>
</table>

*Table 7: Definitions of RUM classifications*

Each episode of care was classified as a single disease, regardless of multiple diagnoses or co-morbidities. To achieve this, the first listed diagnosis in the treatment register was taken as the diagnosis. To determine rational treatment however, every diagnosis was considered. For example, if a patient was recorded as having Pneumonia and Malaria, this was entered into the overall database as ‘Pneumonia’ only. When determining if the patient was treated correctly however, both diseases were considered and thus, treatment for both Pneumonia and Malaria would have been necessary to assign a ‘rational use’ classification of 1.

Each episode of care was allocated the highest appropriate number it could be given. For example, if the correct items were given but underdosed, whilst additional items were also given with potential to cause harm, then it was classified as a 6, rather than a 5.

A key limitation in this methodology was the lack of information contained in facility treatment registers. It was very unusual to be able to classify an episode of care as a 1, due to the rarity of nurses recording full information on dose, frequency and duration.
For this reason, the results focus on the binomial question of correct selection of medicines.

Any episode of care classified as 1-7 was given an additional binomial categorisation of RUM = 1.

Any episode of care classified as 8 was given an additional categorisation of RUM = 0.

All classifications were determined after all data had been collected, based on the diagnosis and treatment recorded by data collection teams in the field. Only one person – the primary researcher – did the initial classifications and one person did a data verification step (described below).

**WHO measures of rational prescribing**

In addition to the novel system of classification proposed, the prescribing records were analysed using the WHO / International Network for the Rational Use of Drugs (INRUD) drug use indicators.

The WHO and INRUD have published Drug Use Indicators for Primary Healthcare Facilities, defining five prescribing indicators to assess the quality of prescribing in health facilities\(^2\).\(^3\). These are:

1. Average number of drugs per encounter
2. % of medicines prescribed by generic name
3. % of encounters with an antibiotic prescribed
4. % of encounters with an injection prescribed
5. % of medicines prescribed from national Essential Medicines List (EML)

In Solomon Islands, it is not useful to use the ‘% of medicines prescribed by generic name’ or the ‘% of medicines prescribed from the national EML’ as an indicator of prescribing in the public sector, as EML medicines are the only ones made available and the naming of medicines is standardised (though not always original generic names). The three medicines regularly prescribed by ‘trade’ names in this study were Coartem (Artemether/Lumefantrine), Panadol (Paracetamol) and Septrin (Co-Trimoxazole) but this was not determined as an accurate indicator of poor prescribing practice in Solomon Islands, given these names are universally used and well recognised across the country.
Data were collected on indicators 1, 3 and 4 however and these are presented for baseline and follow-up as an additional means for assessing rational prescribing.

Confidentiality

Data on episodes of care was collected retrospectively, using clinic registers and no permission could be, or was, sought from patients. For this reason, no identifying patient details were collected beyond age, sex and weight. Individual patient results containing clinic details will not be published.

The data are to be stored securely for five years.

Data verification

The assessment of RUM for each episode of care is to some extent subjective and data verification was required. This was done to ensure the episodes of care were being assessed equally at baseline and follow-up.

The two indicators described in Chapters 7 and 8 are entirely objective data sets and verification was not required.

To verify the assessments of Rational Use of Medicines, data collection sheets for the usage indicator were randomly selected and ≈5% of the episodes of care from each of the pre-intervention and post-intervention phases randomly selected (n = 300 for both pre- and post-intervention data). The random selection was carried out by generating 300 random numbers between 1 and 6000 using Microsoft Excel®.

The details of these selected episodes of care were transcribed onto blank sheets to disguise the initial assessment coding from the reviewer, whilst their assessment coding was recorded separately (the original sheets could not be given to a reviewer, as the original coding by the primary researcher was recorded on them and they would thus be un-blinded).

An independent external reviewer, a pharmacist with experience reviewing clinic treatment registers in multiple low-income countries, assessed each episode of care, coding it according to the criteria
used by the primary researcher. The reviewer was blinded as to whether they were assessing pre- or post-intervention data for each episode of care and to the original assessment classification.

The difference in agreement between the original assessment and the reviewer’s assessment was compared between baseline and follow-up.

This was done for the binomial determination of RUM by determining the kappa statistic to describe the level of agreement between the original assessment and the reviewer’s assessment. The kappa statistic at baseline and follow-up were then compared.

For the 1-8 categorisation of RUM, the proportion of episodes of care in agreement between the original assessment and the reviewer’s assessment was determined and the difference between baseline and follow-up was then assessed using a two-sample test of proportions.

Data management

Data were collected on data collection forms in the field and returned to the principal investigator in Honiara. Data were entered into the study database (EpiData) by the coordinator.

The assessment of Rational Use of Medicines from the ‘Usage’ data collection forms was carried out by the study coordinator using a coding system to categorise each episode.

The data are stored at the University of Melbourne and electronic copies are password protected.

Data collection tools

Template data collection sheets in double-sided A4 hard-copy form were used and answers were recorded by pen. Two templates were used at different times by the data collection teams, one recording three episodes of care per page and the other recording twelve episodes of care per page. Both templates captured identical information however. Samples of both are provided in the appendices.

Ethical considerations

The study was approved by the Health Research Ethics Committee at the University of Melbourne (Ethics ID: 1238837) and the Health Research and Ethics Committee of the Solomon Islands Ministry of Health & Medical Services (Certificate number: HRC 12/29) (Appendix 3).
Results

Timeline

The study was carried out from April 2013 to April 2014 in the Solomon Islands, according to the methodology described above.

Selection and loss to follow up

6147 episodes of care (intervention n = 4064; control n = 2083) were recorded in the pre-intervention data collection phase, from 77 clinics.

6400 episodes of care (intervention n = 2956; control n = 3444) were recorded in the post-intervention data collection phase, from 69 clinics.

Where patients were admitted with no further details, they were excluded. Admitted patients have treatments listed in separate registers and may not be captured in outpatient registers. Children were only included if their age was recorded (1-60 months).

All episodes of care were included in the usage analysis, regardless of whether pre- and post-intervention data had been collected from each clinic.

Baseline usage

Overall, at baseline, 55.4% (3404/6147) episodes of care were classified as rational treatment, using the binomial RUM classification.

No difference was observed at baseline between the control group (n = 2083, mean = 54.2%, s.e. = 1.1) and intervention group (n = 4064, mean = 56.0%, s.e. = 0.8); $\chi^2 = 1.91$, p=0.167.

Magnitude of change

Overall, RUM improved by 6.5% from baseline (mean = 55.4%, 3403/6147) to follow-up (mean = 61.9%, 3962/6400); $\chi^2 = 55.1$, p<0.005. This was a relative improvement of 11.7% from baseline.

Improvements in RUM were observed in both groups.
In the control group, RUM improved by 9.2% from baseline (mean = 54.2%, 1128/2083) to follow-up (mean = 63.4%, 2184/3444); \( \chi^2 = 46.4, p<0.005 \)

In the intervention group, RUM improved by 4.1% from baseline (mean = 56.0%, 2276/4064) to follow-up (mean = 60.1%, 1778/2956); \( \chi^2 = 12.0, p<0.005 \)

**Overall Usage**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Intervention</th>
<th>Post-Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>95% CI</strong></td>
</tr>
<tr>
<td>Control</td>
<td>1128/2083 (54.2%)</td>
<td>52.0, 56.3</td>
</tr>
<tr>
<td>Intervention</td>
<td>2276/4064 (56.0%)</td>
<td>54.5, 57.5</td>
</tr>
<tr>
<td>Overall</td>
<td>3404/6147 (55.4%)</td>
<td>54.1, 56.6</td>
</tr>
</tbody>
</table>

This meant that at follow-up, RUM was 3.3% higher in the control group than the intervention group \( (\chi^2 = 7.2, p = 0.007) \), though this small difference may not have been clinically significant.

**Male vs Female, children < 5 years of age**

In children < 5, there were more males treated than females both at baseline and follow-up.

At baseline, in patients <5 where the sex was recorded (excluding 173 patients where the sex was not recorded), 55.1% (3193/5796) of patients were male, whilst 44.9% (2603/5796) of patients were female; \( p<0.005 \).

At follow-up (excluding 168 patients who did not have their sex recorded), 53.5% (3239/6056) of patients were male, whilst 46.5% (2817/6056) were female; \( p<0.005 \)

There was strong evidence of a difference in the treatment of males vs. females in patients <5 at baseline.
At baseline, 53.6% (1396/2603) of females received RUM, whilst 57.2% (1825/3193) males received RUM. This was a 3.6% difference in favour of males ($\chi^2 = 7.2$, $p=0.007$).

At follow-up, the gap between males and females had narrowed; 60.3% (1698/2817) of females received RUM, whilst 62.5% (2025/3193) of males received RUM. There was no longer evidence of a difference between males and females at follow-up ($\chi^2 = 3.2$, $p = 0.074$).

Overall, combining pre- and post-intervention data, 56.8% (3188/5608) of women received RUM, whilst 60.1% (3963/6595) of men received RUM; this was a 3.3% difference ($\chi^2 = 13.1$, $p<0.005$).

Sexually transmitted diseases, by sex

Combining pre- and post-intervention episodes of care, there were 283 patients diagnosed with a sexually transmitted bacterial infection (STI) (male $n = 162$, female $n = 121$). An analysis was carried out to determine if there was a difference between male and female for RUM of STIs. This found that 69.1% (112/162) of males received the correct choice of drugs, compared with 54.5% (66/121) of females. This was a 14.6% difference; $\chi^2 = 6.3$, $p=0.012$.

Table 9: RUM (binomial) by disease category

RUM by disease category

<table>
<thead>
<tr>
<th>Disease</th>
<th>Baseline</th>
<th>Follow-up</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>2523/4385 (57.5%)</td>
<td>2998/4749 (63.1%)</td>
<td>+ 5.6%</td>
</tr>
<tr>
<td></td>
<td>($\chi^2 = 29.8$, $p&lt;0.005$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>69/760 (9.1%)</td>
<td>118/685 (17.2%)</td>
<td>+ 8.1%</td>
</tr>
<tr>
<td></td>
<td>($\chi^2 = 21.2$, $p&lt;0.005$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Malaria</td>
<td>725/821 (88.3%)</td>
<td>724/790 (91.7%)</td>
<td>+ 3.4%</td>
</tr>
<tr>
<td></td>
<td>($\chi^2 = 5.0$, $p=0.026$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonatal Sepsis</td>
<td>2/3 (66.7%)</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>PPH</td>
<td>2/6 (33.3%)</td>
<td>0/2 (0%)</td>
<td>- 33.3%</td>
</tr>
<tr>
<td>Pre-eclampsia / Eclampsia</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Maternal Sepsis</td>
<td>0</td>
<td>1/1</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Incomplete abortion / Miscarriage  
6/26 (23.1%)  13/21 (61.9%)  + 38.8%  
($\chi^2 = 7.3, p=0.007$)

Bacterial STIs  
72/136 (52.9%)  106/149 (71.1%)  + 18.2%  
($\chi^2 = 10.0, p=0.002$)

Pre-term labour  
0/1  0  N/A

Maternal Malaria  
5/9 (55.6%)  2/3 (66.7%)  + 11.1%

There was strong evidence of improvements in the choice of drugs used to treat pneumonia, diarrhoea, childhood malaria, incomplete abortion/miscarriage and bacterial STIs.

Childhood diarrhoea

The table above defines rational treatment of diarrhoea as having received both zinc sulphate and ORS. Patients receiving only zinc sulphate were recorded as receiving ‘irrational’ treatment, by this binomial definition. It is believed that the use of ORS is often not recorded in treatment registers by clinic nurses however. It is interesting therefore to look solely at the use of zinc sulphate in children < 5 years with diarrhoea.

The mean usage of zinc sulphate in childhood diarrhoea, with or without ORS, increased from 106/771 (13.7%) at baseline to 283/710 (39.9%) ($p<0.005, \chi^2$) at follow-up.

Table 10: RUM classification 1-8, pre- and post-intervention

RUM by classifications 1-8

<table>
<thead>
<tr>
<th>RUM classification</th>
<th>Pre-Intervention (n=6147 episodes of care)</th>
<th>Post-Intervention (n=6400 episodes of care)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
</tr>
<tr>
<td>1</td>
<td>1152</td>
<td>19.02</td>
<td>1128</td>
</tr>
<tr>
<td>2</td>
<td>1654</td>
<td>27.30</td>
<td>2036</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>0.33</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>110</td>
<td>1.82</td>
<td>101</td>
</tr>
</tbody>
</table>
1: Rational Use of Medicines according to defined treatment
2: Rational Use of Medicines with known information but unable to fully determine Dose, Duration or Frequency
3: Rational Use of Medicines according to defined treatment with additional items prescribed unlikely to cause harm
4: Irrational Use: correct treatment given but antibiotics also inappropriately prescribed
5: Irrational Use: correct treatment given but additional items given, likely to cause harm
6: Irrational Use: correct item/s but under dosing (where known)
7: Irrational Use: correct item/s but overdosing (where known)
8: Irrational Use: wrong items prescribed and/or necessary item/s not prescribed

Usage by month

At follow-up, the month of treatment for each episode of care was recorded, from October 2013 – April 2014. The mean RUM score, using the binominal methodology, has been recorded for each month and those results are presented in Figure 20 below. Mean RUM was 56.3% in October, which was largely unchanged from baseline. From November, RUM increased most months, finishing at 65.0% in April. These results suggest that the interventions may have taken some time to be disseminated to clinics or absorbed by staff.

A decline in RUM was observed in January as shown in Figure 20. This may be due to the fact that many nurses go on leave in January and clinics are often under-staffed or staffed with more inexperienced nurses.

These month-by-month results exclude 154 episodes of care for which the month of treatment was not properly recorded. In these cases, it is known that the presentation was within the six month time of interest, as the clinic treatment registers record cases sequentially but the exact date was sometimes not written down or was not recorded by the data collection teams.
Table 11: WHO/INRUD drug use indicators

WHO/INRUD Drug Use Indicators for Primary Healthcare Facilities

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Optimal</th>
<th>Baseline (n = 6147)</th>
<th>Follow-Up (n = 6400)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave number of items per encounter</td>
<td>≤ 3</td>
<td>1.57</td>
<td>1.64</td>
<td>0.08</td>
</tr>
<tr>
<td>% of encounters with an antibiotic prescribed</td>
<td>≤ 30%</td>
<td>79.0%</td>
<td>82.5%</td>
<td>3.5%</td>
</tr>
<tr>
<td>% of encounters with an injection prescribed</td>
<td>≤ 10%</td>
<td>36.6%</td>
<td>42.3%</td>
<td>5.7%</td>
</tr>
</tbody>
</table>

The average number of items per encounter was well within the optimal range at both baseline and follow-up and the change over the 12 month study period was neither statistically nor clinically significant.

The number of times an antibiotic was prescribed increased by 3.5% from baseline (79.0%) to follow-up (82.5%); p<0.05. The percentage of encounters in which an antibiotic was used exceeded the WHO/INRUD recommended range (<30%) at both baseline and follow-up.
The number of times injection was used increased by 5.7% from baseline (36.6%) to follow-up (42.3%); p<0.05. The percentage of encounters in which an injection was used exceeded the WHO/INRUD recommended range (<10%) at both baseline and follow-up.

Data Verification

Three hundred episodes of care from the pre-intervention and post-intervention data sets were randomly selected and assessed by an independent, blinded examiner. This was to determine if the magnitude of agreement between the original assessment and the reviewer’s assessment was the same at baseline and follow-up.

The reviewer made an assessment of each episode of care using both the binomial definition of RUM and the 1-8 classification defined in this study.

For the binomial classification of RUM, in the pre-intervention dataset, 0.2% (7/300) of the reviewer’s assessments did not agree with the original assessment. In the post-intervention dataset, 0.1% (4/300) of the reviewer’s assessments did not agree with the original assessment.

A kappa statistic was calculated to describe the agreement between the original assessment and the reviewer’s assessment. A permutation test was undertaken to determine if there was a difference between the kappa statistics at baseline and follow up.

The mean difference in the kappa statistic from baseline (Ƙ = 0.952) to follow-up (Ƙ = 0.970) was 0.018 [-0.029, 0.066]; p = 0.534. The magnitude of difference between the original assessment and the reviewer’s assessment was therefore the same between baseline and follow-up.

For the 1-8 classification of RUM, in the pre-intervention dataset, 0.7% (21/300) of the reviewer’s assessments did not agree with the original assessment. In the post-intervention dataset, 0.8% (24/300) of the reviewer’s assessments did not agree with the original assessment.

A two-sample proportion test was used to test the difference in proportions. A difference of -0.01 [-0.05, 0.03] was observed; p = 0.642.
There was no evidence of a difference in the magnitude of agreement between the original assessment and the reviewer’s assessment, between baseline and follow-up. It was thus determined that the assessment of RUM was carried out equally at baseline and follow-up.

**Discussion**

There was strong evidence that the usage of the priority medicines improved over the 12 month period. There were improvements observed across multiple disease areas, including childhood pneumonia, malaria and diarrhoea, as well as incomplete abortion/miscarriage, bacterial STIs and maternal malaria.

It is not possible, using this methodology, to determine the extent to which each individual educational intervention has contributed to these improvements but it is possible and perhaps likely that the interventions are mutually reinforcing.

The data indicate that prescribing may not be optimal in Solomon Islands; the proportion of encounters in which an antibiotic or an injection is prescribed is well above recommended optimal ranges, though some contextualisation of these ‘optimal’ ranges is necessary.

The number of items per prescription is well within the recommended optimal range; the data suggest that polypharmacy is not a substantial problem in Solomon Islands. This is an interesting finding that may be a function of medicines availability, economics and, particularly, local culture.

*Males vs. Females*

In children < 5, there were more males treated than females both at baseline and follow-up.

This finding was unsurprising and has been well documented in other studies; males under 5 tend to be more vulnerable to disease.\(^2\,\text{a}^4,\text{a}5\) More concerning however was the *treatment* of males vs females. Overall, combining pre- and post-intervention data across all age groups, 56.8% (3188/5608) of women received RUM, whilst 60.1% (3963/6595) of men received RUM. Whilst this was a statistically significant difference, further research would be required to determine its clinical significance. Other studies have suggested a gender bias in the treatment of children <5.\(^2\,\text{b}^6\) It may be in Solomon Islands that males <5 present with more serious clinical signs and are thus treated more
carefully. Some of the effect in adults may be explained by the differing indications for treatments and differential effects of gender-related conditions. In adult males, only sexually transmitted infections (STIs) were recorded, which are relatively easier to treat, compared with incomplete abortions/miscarriage for example.

Even when considering STIs on their own however, there were stark differences. Overall, there were 283 patients diagnosed with an STI (male = 162, female = 121). Males received the correct choice of drug 14.6% more often than females. This meant they were 26.8% more likely to receive the correct choice of drug, relative to females.

It is important to remember that this includes only cases where the health worker has actually diagnosed and recorded a bacterial STI and it is thus both statistically and clinically significant – and quite concerning. Men appear to be able to access the correct drugs for STIs more often than women, though the reasons are unclear. Further work in this is warranted.

**WHO/INRUD Drug Use Indicators**

The study found that antibiotics were being used too often in Solomon Islands, measured against the optimal range published in the WHO/INRUD Drug Use Indicators.

This is concerning but it is important to contextualise this. These are global recommendations and the need for antibiotics is likely to be higher in the tropical setting. Further, many clinics in Solomon Islands are remote and prescribers may be correct to take a cautious approach.

The percentage of encounters with an injection prescribed was well above the recommended range at baseline and follow-up. An increase in the use of injections was observed over the 12 month study period. Much of this is probably due to children with pneumonia being given injectable procaine benzylpenicillin instead of oral co-trimoxazole but it is nonetheless concerning when oral antibiotics are supposed to be available. The large number of injections used in Solomon Islands is of clinical concern. There are higher risks associated with the use of injections and this is likely to be placing patients unnecessarily at risk. These results warrant further investigation.

The number of items per prescription was well within the optimal published range. This suggests polypharmacy is not a problem in Solomon Islands.
Validation of methodology

The data verification tests demonstrated that there was no observable difference between the original assessment of RUM and an independent reviewer’s assessment. This is positive for two reasons. Firstly, the original assessment was not an observable source of bias, which was a risk due to the possibly subjective nature of RUM assessment and the fact that the original assessor was not blinded. Secondly, the data verification helps to validate the assessment tool, showing that it is a replicable method for rapidly determining RUM.

Limitations of the methodology

This study proposes a rapid way to assess Rational Use of Medicines at the clinic level but there are flaws in this methodology. The dose, duration and frequency are not being adequately recorded in clinic treatment registers and there are insufficient details of patients’ symptoms to definitively determine rational prescribing.

Other studies have used observational techniques and/or exit interviews to determine rational use but this is time consuming, expensive and it has been difficult to determine the extent to which observer bias has distorted the results of studies using this methodology.\textsuperscript{97, 98} Further, it is difficult to record episodes of care over long periods of time in multiple facilities using this method and these studies thus tend to be cross-sectional.

The methodology described does not allow for verification of the diagnosis made for each episode of care and the diagnosis recorded in each case has been accepted at face value. It is inevitable that nurses have made some errors in diagnosing patients or recording diagnoses. Further, a nurse may justifiably feel, for example, that a patient does not warrant antibiotic therapy but has made a recording of pneumonia regardless. This management may be appropriate but for the purposes of this study have been recorded as ‘irrational’. The extent to which this is the case across this dataset is unclear.
Conclusions

There was strong evidence of an improvement in the usage of medicines over the 12 month period. These improvements were seen across every province and increased over the six month post-intervention period. On this basis, they appear to be sustainable but further longitudinal analysis would be beneficial. It is unclear whether these improvements were related to improvements in medicines availability or staff comprehension. These relationships are explored in the next chapter.
Chapter 10: Summary of results

Introduction

In the three preceding chapters, the individual results of simultaneous surveys into medicines availability, staff comprehension and medicines usage have been presented. This chapter explores the relationships between these three indicators.

In an ideal world, the rational usage of medicines is simply an outcome of medicines being available and staff knowing how to use those medicines; it is necessary though to examine to what extent this is true and to consider other factors that may impact on medicines usage.

In this chapter, data are also presented exploring the extent to which the study interventions were implemented over the 12 month study period.

Methodology

Data analysis

Using the data from the surveys described in Chapters 7, 8 and 9, the change in availability, comprehension and usage (RUM) has been calculated for each clinic respectively.

Only those clinics for which pre- and post-intervention data were collected have been included (total = 68). At baseline, a comprehension survey was not collected at one clinic (Togha), which has thus been excluded from this analysis; n = 67.

Change in availability

The change in availability for each clinic is defined as the difference in availability at follow-up, compared with baseline. Availability is expressed as a percentage, which been calculated from the number of medicines available out of 17 priority items on the day of visitation.

Change in comprehension

To calculate the change in comprehension for each clinic, the pre-intervention comprehension score has been subtracted from the post-intervention score. Where more than one nurse was present at a
clinic and participated in the comprehension survey, the average comprehension score of all nurses for that clinic has been taken.

Change in medicines usage

Each episode of care was determined to be either rational or irrational, using the binomial method described in Chapter 9. To calculate the change in usage, the mean score for all episodes of care from each clinic has been calculated at both baseline and follow-up.

For each clinic, a single statistic therefore existed for each of three variables (availability, comprehension and usage) at both baseline and follow-up.

Two simple linear regression models were run using STATA to test for a correlation between medicines usage and availability and then between medicines usage and staff comprehension.

A multiple regression analysis was then run examining medicines usage against availability and staff comprehension.

Implementation of interventions

Mobile electronic inventory

Data were collected on the number of orders entered into the new system by each SLMS and from each clinic. Clinics are expected to place six main orders each year. In every clinic that placed more than six orders, each order over six was considered to definitively be a supplementary order and it was counted as such. The number of regular orders was thus determined and has been expressed as a percentage of the total expected regular orders over the 12 month period.

Educational interventions

At follow-up, data were collected on the availability of each educational intervention at every clinic and this has been expressed as a percentage of the total number of clinics for each intervention.
Verification of the extent to which key interventions were implemented

Mobile inventory system (primary intervention)

The mobile inventory system was installed in all six SLMS sites by the first week of May, 2013. These SLMSs together covered 121 primary healthcare facilities; these formed the intervention group. There were thus 121 facilities in the intervention group, using mobile inventory at their supply sites; main orders are placed with SLMS every two months (6 per year per facility).

\[
\begin{array}{ccc}
121 \text{ clinics} & \times & 6 \text{ main orders} \\
(\text{Intervention group}) & & (\text{Annually}) \\
& = & 726 \\
& & (\text{Min number of orders})
\end{array}
\]

A minimum of 726 orders should therefore have been entered for facilities by SLMS, using the mobile inventory system; supplementary orders may be placed by clinics at any time however, meaning more orders can be entered into the mobile system.

Over the 12 month period, 603 clinic orders were entered through the mobile system. 86 of these can be definitively identified as supplementary orders, as they exceeded the six normal orders a clinic would usually make in a 12 month period.

Therefore, 517 can be considered as likely ‘normal’ orders.

517/726 (71.2%) of normal orders were entered into the new system, with an additional 86 supplementary orders.

The SLMS also supply the provincial hospitals and area health centres in which they are based. They provide daily ward supply and dispensary orders for those facilities and all such orders should be entered into the mobile inventory system. These hospital orders were not included in this study but were included in the roll-out of the new system and the data from them has been captured.
In total, including clinic orders and local hospital orders, 1537 orders were placed through the new mobile system over the 12 month trial phase.

Educational interventions (applied to all facilities)

The seven key educational interventions, or resources, are outlined in Chapter 7 and contained in the appendices. Data were collected on their availability at each clinic during post-intervention data collection. The table below shows the percentage of clinics that had the relevant resource available on the day of visitation during post-intervention data collection.

Table 12: Availability of educational interventions by group

<table>
<thead>
<tr>
<th>Educational Intervention</th>
<th>Intervention Group (n=32)</th>
<th>Control Group (n=37)</th>
<th>Overall (n=69)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children’s Standard Treatment Manual</td>
<td>29/32 (90.6%)</td>
<td>36/37 (97.3%)</td>
<td>65/69 (94.2%)</td>
</tr>
<tr>
<td>Dosing wall chart</td>
<td>12/32 (37.5%)</td>
<td>15/37 (40.5%)</td>
<td>27/69 (39.1%)</td>
</tr>
<tr>
<td>Patient Info Cards</td>
<td>8/32 (25.0%)</td>
<td>12/37 (32.4%)</td>
<td>20/69 (29.0%)</td>
</tr>
<tr>
<td>Zinc/ORS poster</td>
<td>21/32 (65.6%)</td>
<td>24/37 (64.9%)</td>
<td>45/69 (65.2%)</td>
</tr>
<tr>
<td>MIC Newsletter</td>
<td>23/32 (71.9%)</td>
<td>23/37 (62.2%)</td>
<td>46/69 (66.7%)</td>
</tr>
<tr>
<td>Seprtin Memo</td>
<td>18/32 (56.3%)</td>
<td>19/37 (51.4%)</td>
<td>37/69 (53.6%)</td>
</tr>
<tr>
<td>Working radio</td>
<td>16/32 (50.0%)</td>
<td>21/37 (56.8%)</td>
<td>37/69 (53.6%)</td>
</tr>
</tbody>
</table>

Definitions:
- Children’s Standard Treatment Manual (Orange booklet) available
- Priority Medicines for Mothers and Children A3 dosing wall flipchart available
- At least one Patient Info Card available in the clinic
- Zinc/ORS in Diarrhoea poster displayed
- At least one MIC newsletter (from preceding 12 months) available in the clinic
- Ministry memo on the use of Septrin in Pneumonia available
- Radio working on the day of visitation

The availability (or not) of various educational interventions on the day of visitation does not necessarily imply that the intervention was always, or never, available and it is an imprecise measure of the reach of each initiative. The Patient Information Cards, which were available in just 20/69
clinics (29.0%), were designed to be given out to patients; in many facilities, their lack of availability may simply imply that they had all been distributed and their stock exhausted by the follow-up data collection period. Similarly the Ministry memo regarding the use of Septrin may have been read and discarded previously by clinic nurses. On the other hand, whilst the Children’s Standard Treatment Manual was available in 65/69 clinics (94.2%) across both groups, this does not imply that it was necessarily being used properly (or at all). The availability of each intervention on the day of visitation should thus not be considered an accurate measure of its availability throughout the year and certainly not a proxy measure of its effectiveness.

Results

As described in Chapter 7, there was a 9.9% improvement in availability overall; there was a 7% improvement in the intervention group and a 12.4% increase in the control group. A regression analysis demonstrated no difference in the magnitude of change between the two groups.

It was determined to examine if changes in availability at follow-up correlated with improvements in RUM.

A paired regression analysis was run on this and there was insufficient evidence to show a clear correlation (coefficient: 0.001 [-.002, .005], p=0.442), though the relationship was positive.

It was then determined to examine if improvements in comprehension correlated with improvements in RUM. A paired regression was run on this and they were observed to be closely correlated (coefficient: 0.004 [.001, .007], p=0.008). For every 1% increase in comprehension, there was a 0.4% increase in RUM.
Finally, a multiple regression analysis was run to examine changes in RUM against changes in both availability and comprehension. Again, there was insufficient evidence to show a correlation between changes in availability and changes in RUM but there was strong evidence of a close correlation between changes in comprehension and RUM (coefficient: 0.004 [.001, .007], p=0.011). Even adjusting for changes in availability at clinics, for every 1% increase in comprehension, there was a 0.4% increase in RUM.

Availability is obviously a pre-requisite for RUM – nurses cannot use medicines that aren’t on the shelf – but as the paired regression analysis above has demonstrated, simply improving availability (without improving comprehension) had no observable effect on RUM in the clinics in this study. More data may be required to show a correlation between availability and RUM or it may be that no correlation exists.

Table 13: Multiple regression analysis for improvements in RUM by availability, comprehension

<table>
<thead>
<tr>
<th>Multiple regression analysis: Improvement in RUM</th>
<th>n=67</th>
<th>R² = .1048</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef</td>
<td></td>
<td>P&gt;</td>
</tr>
<tr>
<td>Availability change</td>
<td>.0007</td>
<td>.680</td>
</tr>
</tbody>
</table>
Key confounders and events

During the study period, the following key events occurred in SLMS facilities and within the Solomon Islands.

Infrastructure projects

There were two major infrastructure projects completed at SLMS during the 12 month study period. These infrastructure projects both involved the construction of substantial new buildings, to the national standard (4.5m²/clinic serviced + 40m²), with new shelving and greatly improved storage conditions. These were both substantial improvements on the existing infrastructure at both sites, meaning larger quantities of stock could be held and distributed from both.

Both infrastructure projects were carried out in control group SLMS and this would be expected to improve the supply to clinics in those catchment areas.

Infrastructure projects were completed and opened at Seghe SLMS (Control Group) and at Afio SLMS (Control Group).

Human resources

One pharmacy officer left (replaced by another Pharmacy Officer) in Buala SLMS, Isabel Province (Control Group) due to performance and personal issues.

Natural disasters

2013 Temotu Tsunami

On February 6th 2013, immediately prior to the commencement of the study, a magnitude 8.0 earthquake and tsunami struck Temotu Province, affecting 6500 people and killing approximately 15. The data collection team was able to complete their task at baseline and follow-up but this event severely disrupted medical services and supply systems in the province throughout the year.
2014 Honiara Floods

On April 3rd 2014, as the teams were preparing to leave for post-intervention data collection, flash floods hit Honiara and surrounding areas of Guadalcanal, following three days of heavy rain. More than 23 people (and possibly up to 50) were killed and 50,000 were affected. The post-intervention data collection took place but was delayed in several areas. Data collection was completed by the end of the first week of May. Staff taking leave at this time was a key reason for the loss to follow up of several clinics.

Other potential confounders

- No data were collected on the training programs provided by other Divisions of the Ministry of Health or by external stakeholders over 2013/14. Collecting this information would be difficult and inherently flawed, as there is no central database or record of training provided to health staff in Solomon Islands and many NGOs and multilaterals work independently of the Ministry of Health. These trainings could be confounders and since they are likely to have been unevenly applied across clinics, their effect would be difficult to quantify.

- Many staff in the NPSD are inexperienced and it is possible that simply by gaining more experience over the course of the 12 month study period, their performance would improve. If true, this effect would be more pronounced in inexperienced staff. The analysis of group characteristics in Chapter 7 showed that the control group was more inexperienced.

Discussion

This study provides some evidence towards demonstrating that interventions to improve only availability without improving comprehension are less likely to improve Rational Use of Medicines. It is important to remember that this study has applied an imperfect measure of comprehension and it would be unrealistic to expect improvements in the questionnaire results to translate into practice changes.
Other factors, apart from availability and staff comprehension, may impact on rational usage of medicines. These include staff time constraints, confidence, local culture and religious beliefs (particularly pertaining to STIs and contraception), misreported diagnoses and rationing of medicines (e.g. when a nurse chooses to withhold treatment for more mild cases, as they perceive their stock may run out).

This last factor is important in the context of this work and should be addressed through the consistent supply of stock. If nurses are confident that each subsequent order will be filled, rationing is less likely.

**External Validity**

Some generalities of this methodology may be broadly applicable across any public health system with a decentralised supply chain to a primary health care network of facilities. These supply chain mechanisms are evident across much of Africa and the Pacific in particular.

The specific lessons and conclusions from this research may have more limited external validity however. Solomon Islands is a thinly dispersed, island country with poor transport infrastructure and communications. It has a relatively stable government (compared to many central African nations for example) and a high burden of communicable disease. The medical supply chain runs almost entirely by boat and there are few formal, private transport suppliers down to the village level.

Predominantly, the lessons and methodology are likely to be most relevant in similar countries in the region, particularly in Melanesia; Vanuatu and PNG are the most obvious countries sharing similar characteristics, whilst Fiji (wealthier and with stronger transport infrastructure) and Kiribati (less populous and more widely dispersed) share some characteristics.
Summary

Multifaceted interventions are required to improve RUM. Medicines availability remains a pre-requisite for access to medicines but these results suggest that efforts to improve medicines availability are unlikely to improve RUM, without concurrent efforts to improve staff comprehension.
Chapter 11: Case Study

Scaling up zinc treatment for childhood diarrhoea in Solomon Islands

This chapter is presented as a published work.

Position in the thesis

The results of studies into availability, comprehension and the rational usage of the priority medicines for mothers and children have been presented in the preceding chapters of this thesis. It is instructive to look more closely at a single disease state and the usage of medicines related to that disease, as a case study. This allows one to look more closely at the issues affecting the rational use of medicines and to better quantify the relationship between availability, comprehension and usage. Childhood diarrhoea was selected for this case study.

The usage of zinc sulphate and other agents for use in childhood diarrhoea was examined over the 12 month study period. This chapter presents the results of this analysis as a case study.

One paper forms the basis of this chapter:


The author of this thesis declares a contribution of 80% to the development of this paper.
RESEARCH ARTICLE

Scaling up zinc treatment for childhood diarrhoea in the developing country setting: a before- and after-intervention study

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Abstract

Introduction: Zinc sulphate is an important intervention for the treatment of diarrhoea in children in developing countries. We undertook a series of interventions to increase the availability and usage of zinc sulphate at primary healthcare facilities in the Solomon Islands.

Methodology: A 12 month before-and-after intervention effectiveness trial in 80 randomly selected clinics. Data was collected on whether children <5 years old with diarrhoea had received zinc. Data was also collected on other medications received, the availability of zinc and staff comprehension. A series of interventions were implemented by the National Pharmacy Services Division.

Results: The mean usage of zinc sulphate increased by 191.2% over baseline; from 106/771 (13.7%) at baseline to 265/719 (37.9%) (p < 0.05, χ²) at follow-up, the use of oral rehydration salts (ORS) did not decrease. The availability of zinc sulphate increased from 377 clinics (3.5%) to 6169 clinics (84.0%) (p < 0.05).

Summary: Low-cost interventions can improve the usage of zinc sulphate in the Pacific island setting. This paper provides a model for other countries to increase uptake of zinc sulphate and other interventions at the primary healthcare level.

Keywords: essential medicines, zinc sulphate, child health, access to medicines, developing countries, Pacific island countries, diarrhoea.

INTRODUCTION

Zinc sulphate is an important intervention for the treatment of diarrhoea in children in developing countries. It has been shown to be effective in:

- Reducing the severity and duration of acute diarrhoea
- Decreasing mortality and improving weight gain among children with severe malnutrition
- Preventing diarrhoea in neonatal babies
- Reducing the severity and duration of diarrhoea
- Reducing the risk of subsequent episodes of diarrhoea

The Solomon Islands is a least-developed Pacific island country, with a population of 560,000. In 2009 by the National Medicines and Therapeutics Committee. This was a positive step but no subsequent training was conducted or specific information packages were introduced in relation to its use. Zinc remained largely unknown and anecdotal evidence suggested that it was not available in clinics and not being used in children with diarrhoea.

This situation is reflected more broadly in the Asia-Pacific, where many countries have been slow to convert evidence into practice on the use of zinc sulphate. A global study in 2012 found that less than 15% of surveyed countries included zinc sulphate on their EMLs and that less than 10% of countries in the Western Pacific Region had done so. Those countries that have included zinc sulphate have had mixed success scaling up its usage, most notably in Bangladesh, which
achieved between 10 (rural) and 25% (urban) usage of zinc for diarrhoea in children <5 years old following a promotional campaign.8

All medicines, including zinc sulphate, are provided free of charge through public clinics in the Solomon Islands. Medicines are provided through the National Pharmacy Services Division which distributes to 320 clinics across nine provinces, through a network of Second Level Medical Stores. Nurses in the clinics order drugs bimonthly.

A pilot project in Western Province, Solomon Islands in 2011/2012, used low-cost interventions to improve the availability of zinc sulphate at the primary healthcare level, in 45 clinics. These interventions included a locally produced informative poster and patient information cards. Pharmacy officers were instructed to question clinic drug orders that did not request zinc:

The pilot study only evaluated availability and did not assess whether zinc was actually being used in children with diarrhoea.

The results of this pilot study, which was presented at the Asia-Pacific Conference on National Medicines Policies, were used as the model for scale-up across the country. Additional interventions included a radio program, an article in a health newsletter and the redistribution of the Standard Treatment Manual for Children. These relatively low-cost interventions were implemented across the entire country (approximately 320 clinics), and the effect on availability of zinc in clinics and the usage of zinc for diarrhoea in children less than 5 years of age was measured.

An increasing number of Australian pharmacists have undertaken long-term work in developing countries in the Asia-Pacific region. This area of pharmacy practice has demonstrated a beneficial impact on health outcomes for vulnerable populations in our region. This paper describes the outcome of a project undertaken by the Solomon Islands Ministry of Health, with the support of Australian pharmacists and researchers.

RESEARCH HYPOTHESIS

That a series of low cost, clinic-level educational interventions by pharmacy for nurses can improve the availability and usage of zinc sulphate for childhood diarrhoea at the primary healthcare level in the Solomon Islands.

METHODOLOGY

The study design was a 12-month before-and-after intervention effectiveness trial.

Eighty clinics were randomly selected from seven provinces in the Solomon Islands. Two provinces were excluded (Guadalcanal and Renbel), as they are extremely difficult to access and are supplied directly from National Medical Stores and not through a Second Level Medical Store.

Data collection teams comprising a pharmacist, two pharmacy officers and a child health nurse visited all 80 health clinics in a single month, in April 2013. Data was extracted from clinic outpatient treatment registers. An eligible episode of care was defined as a child less than 5 years, presenting in the preceding 5 months with a diagnosis of diarrhoea or dysentery. The age and sex of each child was recorded, along with whether or not zinc sulphate had been given; the data was otherwise de-identified. Teams also recorded other prescribed medications for diarrhoea, including oral rehydration salts (ORS), antidiarrhoeal and antibiotics. Patients were included even where additional diagnoses had been recorded.

Patients who had been admitted into an inpatient setting were excluded, as these patients' treatments are usually recorded in a separate treatment register. Most clinics had only outpatient facilities and those admitted patients comprised only a small fraction of the overall number.

The visiting teams checked whether zinc was available in the clinic on the day of visitation and if it was in-date.

A five-question comprehension survey was also conducted with each staff member working in the clinics on the day of visitation, assessing knowledge on the use of zinc sulphate.

The interventions were commenced following baseline data collection. All clinics in the country received:

- 'Zinc Sulphate & ORS Poster', as used in a pilot study conducted in Western Province in 2011/2012
- Tabulated dosing chart for the 31 WHO Priority Medicines for Mothers and Children, Doubled A3-size flip chart with a two-page spread showing doses of medicines for women and a two-page spread showing doses of medicines for children
- 'Patient Information Cards'; double-sided A3, disease-focused information cards (in the local pidgin language, using pictures) on childhood diarrhoea to be given to the parents of patients. These cards were produced by local pharmacists and the research team, containing basic disease information, signs and symptoms, warning signs, treatment and prevention. These were targeted at patients and families but it was anticipated that they might also prompt discussions with nurses.
Zinc treatment for childhood diarrhoea

The cards on diarrhoea were part of a series of cards made available to all clinics; eight other diseases were covered by similar cards.

- Several articles on childhood diarrhoea and zinc sulphate in the widely distributed health newsletter produced by the National Medicines Information Centre.
- An episode of the monthly Pharmacy Radio show played through the VITF radio network available in clinics.
- The Solomon Islands Standard Treatment Manual for Children was reprinted and distributed to all clinics.

No training workshops were held; these are an expensive intervention and take clinical staff away from primary healthcare facilities for the duration of training and travel. All educational interventions in our study were low cost and designed for clinic level implementation.

Post-intervention data collection was conducted at 12 months post-baseline in the same 80 clinics, again taking data from the 6 months prior to the day of visitation. At follow-up, the month in which the episode of care had occurred was also recorded.

The same comprehension survey was also conducted at follow-up. Nurse names were not recorded; answers to the survey were not distributed at any stage of the study.

The primary study outcome was the mean percentage of episodes of management of children with diarrhoea where zinc sulphate was used.

Ethics approval was granted by the SI National Health Research and Ethics Committee and the University of Melbourne.

RESULTS

Eighty clinics were randomly selected for baseline data collection; three were closed or could not be visited due to weather or staff absence. Data was thus collected from 77 clinics at baseline; 771 episodes of care were recorded.

At follow-up, eight further clinics were closed and could not be visited; data was thus collected from 69 clinics at follow-up; 710 episodes of care were recorded.

The data is unpaired and all episodes of care from baseline and follow-up have been included.

Figure 1 Clinic recruitment and loss to follow-up.
The clinic selection and loss to follow-up is shown in Figure 1.

The mean usage of zinc sulphate increased by 191.2% over baseline; from 106/771 (13.7%) at baseline to 283/710 (39.9%) (p < 0.05, χ²) at follow-up.

The dose, frequency and duration are not being regularly recorded in clinics. At baseline, 31 out of 106 patients receiving zinc sulphate had the dose recorded, 26/106 had the frequency recorded and 12/106 had the duration recorded. Of these, 30/31 (97%) received the correct dose, 25/26 (96%) had the correct frequency and 12/13 (92%) had the correct duration.

At follow-up, 118 out of 283 patients receiving zinc had the dose recorded, 91/283 had the frequency recorded and 93/283 had the duration recorded. Of these, 117/118 (99%) received the correct dose, 87/91 (96%) had the correct frequency and 71/93 (76%) had the correct duration.

The availability of zinc sulphate at the primary healthcare level can be considered a prerequisite for rational usage; the availability of in-date zinc sulphate increased from 3/77 clinics (3.9%) to 61/69 clinics (88.4%) (p < 0.05).

A further 34/77 (44.2%) clinics had expired stock of zinc available at baseline. This reduced to 2/69 (2.9%) clinics with expired stock at follow-up.

The specific month of treatment was recorded at follow-up to determine longitudinal changes over the intervention period. The usage of zinc increased every subsequent month except one, from October 2013 to April 2014, as shown in Figure 2a.

The province for each episode of care was recorded at baseline and follow-up. As is shown in Figure 2b, Western Province had zinc usage of 97/253 (38.3%) at baseline, while every other province had a mean usage close to zero, suggesting that the original Western Province pilot study had an ongoing positive effect on the usage of zinc, 18 months after commencement. Zinc usage had not previously been measured in this way.

Mean usage of zinc increased in every province, as is shown in Figure 2a.

Comprehension on the use of zinc sulphate also increased. The number of nurses answering correctly increased for four out of five questions.

Roughly half of all children presenting with diarrhoea at baseline (39/771, 51.5%) and follow-up were given antibiotics (350/710, 49.3%). The mean usage of antibiotics did not change significantly at follow-up, nor did the choice of antibiotic. Our methodology did not allow us to determine if the prescribing of antibiotics was clinically appropriate.

At baseline, 112/771 (14.5%) patients received albendazole. The usage of albendazole decreased by 7.7% (p < 0.05) at follow-up. Further investigation would be required to determine if this was related to the increased usage of zinc sulphate.

ORS use did not change at follow-up. ORS was used in 302/771 patients (39.2%) at baseline and 277/710 (39.0%) at follow-up (Table 1).

In those patients where sex was recorded, 411/735 (55.9%) were male at baseline and 376/693 (54.3%) were male at follow-up.

**DISCUSSION**

Translating strong decision making at the central level into good practice at the primary healthcare level is an acute challenge in the developing country setting.

Developing contextually appropriate interventions to turn evidence into practice is critical for patient outcomes and the use of zinc sulphate in childhood diarrhoea provides an excellent case study for this. Zinc sulphate is a relatively low-cost intervention with the potential to save lives. Diarrhoea remains the number two cause of post-neonatal death in children under 5 both in the Solomon Islands and globally.15
Despite its low cost and known benefits, uptake of zinc sulphate in the Solomon Islands remained low after several years on the EML. Promotional activities to increase awareness of zinc sulphate for the treatment of childhood diarrhoea have been successful to a degree in several other settings, including Bangladesh, a pilot project in the Solomon Islands had demonstrated increasing availability at the clinic level but actual usage had not been investigated.

Our study showed that a scaled up version of this pilot project, using low-cost educational interventions with no training workshops, significantly increased both the availability and usage of zinc sulphate across the Solomon Islands. This may provide a model for other countries in the Asia-Pacific region seeking to similarly increase usage.

This model should be considered for all other new items included on the EML, as part of concerted efforts to translate policy-level decision making into good practice. These initiatives should be considered at the time of decision making by National Medicines and Therapeutics Committees.

The availability of each educational intervention was recorded in each facility at follow-up; however, these should not be considered an absolute measure of availability and certainly not an indication of usage. Only 20/69 (29.1%) clinics had Patient Information Cards on the day of visitation; however, as these were intended to be
distributed to patients, their lack of availability on the day of visitation may simply indicate that they had all been given out. Conversely, 65/69 (94.2%) clinics had the Standard Treatment Manual for Children but this does not indicate correct usage of these guidelines.

Increasing the availability of zinc sulphate was achieved through a broader series of interventions and systemic improvements, including methods not described here. The availability of zinc sulphate should be considered a prerequisite for improving usage; educational initiatives should be linked to contextually appropriate supply chain strengthening. It is noted that the use of expired medicines is strongly discouraged in the Solomon Islands. The high proportion of expired stock at baseline probably reflects infrequent usage by clinics or training shortfalls.

The variation in mean usage of zinc between different provinces at follow-up suggests that local contextualisation remains critical. The interventions also may not have universally reached facilities.

The usage of ORS did not change at follow-up. This suggests that increased levels of zinc usage did not reduce ORS usage, as has been shown elsewhere. Although ORS usage appeared low, anecdotaly many nurses say that ORS is not recorded in treatment registers when given to patients with diarrhoea, as it may not be considered a ‘drug’ for recording purposes. ORS was available in 88.3% of clinics at baseline and 99.7% of clinics at follow-up and has been widely ordered at all levels for many years, suggesting higher usage than we found.

The clinic outpatient registers are considered a good record of medicines received by patients in the Solomon Islands; prescriptions are not used at the clinic level. Medicines are supplied directly at the time of consultation by the examining nurse; medications that are not available are not recorded. We are confident that the record contained in the treatment registers is the best available record of medications received. However, the dose, frequency and duration are not being regularly recorded in these treatment registers. In episodes of care where they were recorded, the percentage of patients receiving the ‘correct’ dose, frequency and duration is high. Further work is required in investigating this.

We have not shown a causative link between any single intervention and an improvement in the usage of zinc using our methodology; it is possible that the interventions are mutually reinforcing. This question might be addressed in a controlled study.

This research has not examined patient compliance, carer comprehension or patient outcomes. This patient outcome data would better reflect the true impact of these interventions but would be difficult to establish on this scale, in such a difficult setting. Future research focussing on this area, perhaps in a smaller sample population, would be beneficial.

SUMMARY

Low-cost pharmacy interventions can be effective in improving the usage of zinc sulphate in the developing country setting. These interventions could be implemented in similar settings.

National Medicines and Therapeutics Committees should consider similar campaigns for all new items added to EMLs in the developing country setting.

This paper provides a model for other countries in the Asia-Pacific region – particularly in small-island settings – to increase uptake of zinc sulphate and other low-cost interventions at the primary healthcare level. This paper demonstrates the beneficial effect of Australian-supported pharmacy practice among our regional neighbours.

FUNDING

Funding for this project was provided by the Solomon Islands Ministry of Health and Medical Services and the Australian Aid Program (DFAT).

Competing interests

None declared.

REFERENCES


Received: 21 August 2015
Revised version received: 29 November 2015
Accepted: 14 December 2015
Chapter 12: Conclusions

Findings of the studies

The study data did not support the primary hypothesis; the magnitude of change in medicines availability was the same across both groups, despite the implementation of mobile electronic inventory in the intervention group.

This finding is tempered by the fact that availability remained higher in the intervention group at follow-up and that, as medicines availability increases, there are likely to be diminishing rates of return from interventions to improve availability.

The data also showed that both comprehension and rational usage of medicines improved over the 12 month study period.

It was demonstrated that improving availability of medicines without improving comprehension does not result in improved usage of medicines. Whilst availability remains a pre-requisite for usage (nurses cannot use medicines that are not on the shelf), improving availability in the absence of mechanisms to improve comprehension is less likely to benefit patients.

Mobile electronic inventory may play a role in improving availability but other factors such as infrastructure improvements, staff training and transport infrastructure are all also important; the extent to which each factor impacts on availability is unclear. With improving access to electricity and the internet, electronic stock management systems are likely to become more common and it is important for Pacific island countries to roll them out using demonstrated implementation models; to this end, further research would be beneficial.

Limitations of the studies

- The main limitation was that the two groups were not randomised and there were large differences in availability at baseline. This is difficult to address in a real-world setting, as it was impractical to install mobile electronic inventory at all sites and the intervention SLMS were purposively selected, but it does compromise the validity of these results.
• It is extremely difficult to control for all confounders during health systems research of this nature. Some of these have been addressed in this thesis, including staff movement, infrastructure projects and external training provided by other donors but there are undoubtedly dozens more.

• The reliability of internet in Solomon Islands during the study period was also a significant limitation. Improving internet speeds and reliability throughout the country (and globally) are likely to address this shortcoming but equally, new technologies allowing 'store-and-send', where data is synced periodically, will also help to address this issue. This is further addressed in Chapter 13.

• The study still had a limited sample size and the 12-month period of implementation may have been insufficient to fully detect changes in availability and other outcomes.

• In randomly selecting the clinics in which the indicators were measured it would have been logical to attempt covariate adaptive randomization, to better ensure that the two groups had similar characteristics. This was impossible however, as we had insufficient data on the size, demographics, catchment area and staffing for each facility.

• The comprehension survey was also an imperfect way of measuring comprehension and certainly not a measure of competence; a more detailed methodology could be developed to assess staff comprehension and competence but it would be difficult to undertake this across 80 clinics in under one month.

• The study was unblinded. In a study of this nature, it would be difficult to design a double-blinded methodology but blinding the researchers during the data analysis may have been beneficial.

A model for implementation of mobile electronic inventory

There are several key elements that should form a basis for the implementation of mobile electronic inventory.
• Consistent internet and electricity; staff are more likely to revert back to old ways of doing things if new methodologies are sporadically unavailable.

• Local ownership; as much and as quickly as possible, local staff should take ownership of training, technical support and physical ownership of computer hardware.

• Off-the-shelf software: developing new software can seem a cost-effective means to develop contextually appropriate software that ensures local ownership of the project. In practice, developing new software is inherently risky, prone to bugs and can be expensive to maintain. Risks include incompatibility with other systems, lack of 24/7 software support, system bugs that go unaddressed, cost-blowouts, no access to upgrades, a general lack of features, a lack of ongoing structured training modules, interfaces that are unintuitive or poorly thought through and non-transparent maintenance contracts. Often a small number of international consultants may actually do the coding and have a personalised monopoly on maintenance and where companies have been formed to carry out specific contracts, those companies can dissolve when the initial project is finished, leaving the local user with no recourse for maintenance. Buying stock management software ‘off the shelf’ avoids many of these potential pitfalls and there are several international companies providing such products.

• Compatibility with existing software; where new products are purchased, they should be fully compatible with existing supply systems available in existing warehouses or hospitals. As patient management information systems become digitalised, it is also likely that compatibility with these systems may be required to some extent.

• Rapid roll-out; the installation and training for new systems should be carried out as rapidly as possible, whilst ensuring quality. Lengthy delays between training and installation may result in a loss of enthusiasm from staff.
Future research

Some evidence has been provided to support the implementation of mobile electronic inventory systems, though it has not been conclusively shown that such systems result in improved availability. Future research should seek to answer these questions, with a focus on the following areas.

Longitudinal studies
It is likely the effects of new supply chain mechanisms will only become apparent in the long-term. Future research would ideally collect data over several years though the practical difficulties of this are obvious.

Relative cost
No analysis has been presented showing the relative costs associated with the various supply models; this is obviously a critical factor. Cost analysis should again be long-term (there are higher establishment costs in setting up electronic inventory systems but fewer ongoing costs) and try to take into account staff time and transport costs.

Subsidiary benefits/risks
Mobile electronic inventory brings benefits that are not directly associated with the availability of medicines at primary healthcare facilities. Primarily, they provide real-time data back to central health planning authorities that may help in procurement and forecasting, budgeting, epidemiology, outbreak management and disaster response; these elements may support the implementation of mobile electronic inventory, even in the absence of improved availability. This research has not looked at these areas.

Mobile data collection
The data for this study was collected in hard copy and data entry and assessment was undertaken in Honiara and Melbourne; this is time consuming and error-prone (due to duplication). Mobile data collection has been trialled in some settings (including, since this study concluded, in Solomon Islands). This technology has the potential to reduce the costs of data collection by reducing duplication of data entry and crowd-sourcing data collection teams (using other medical tours that are visiting clinics anyway). This is worth considering in future research.
Ideal design for future research

Running a prospective before-and-after controlled study is difficult to replicate in a real-world context but it remains the best method for assessing novel supply chain mechanisms. The blinding of participants is not possible in research of this nature.

The study design could have been improved by randomisation of which SLMS received the tablet computers; this was based on which sites had the best internet and this created an inherent bias. The random selection of clinics for data collection could have been improved by stratified sampling to ensure an equal number of clinics from each SLMS. This is a key recommendation for future research design.

Mobile data collection tools could potentially increase the number of facilities covered and lower costs.

A longer timeline would strengthen this study; 12 months may be insufficient to determine the full effect and sustainability of the program.

A formal assessment of user proficiency in the new software following the initial training (and possibly at subsequent intervals) would have supported the anecdotal conclusion that ‘staff demonstrated proficiency’ and would have provided valuable feedback for further training.

Future directions for mobile electronic inventory in Solomon Islands

The immediate next phase is to implement the new system in the remaining six SLMS. This expansion is largely dependent on the feedback provided by this study.

A logical next step is to then provide this novel system to those clinics where internet is available, to facilitate direct online ordering from primary healthcare facilities to SLMS. This would further reduce lead times on clinic orders, reduce the cost of sending hard-copy orders to SLMS and reduce data entry duplication, as well as providing clinic-level real-time stock information.
Finally, more work on utilising the data being provided by the new system is necessary. It is now possible to identify in real-time for example, those clinics that are not ordering zinc sulphate or appropriate antibiotics. Having identified them, the Pharmacy Division can provide targeted support to those facilities, rather than providing expensive upskilling training to every clinic, when a large proportion may already be ordering correctly.

Poor ordering practices are indicative of poor clinical practice and this information can be fed back from the stock management software into training programs across the health sector.

Building these reporting tools requires further inputs however. A potential model may be to provide data and epidemiological analysis via external support, rather than having NMS analyse the data themselves.

A further proposed direction is to utilise the real-time stock data during natural disasters and other emergencies, by providing facility stock levels to health planners and disaster response coordinators to better plan the response. For example, if an earthquake hit a particular area and NMS was running short on sutures, health planners could immediately look at which facilities in adjacent areas had sutures and plan the movement of stock to affected areas more quickly.
Chapter 13: Placing this work in context – the future and broader implications

Introduction

This thesis has described the background to, methodology and results of a study into the effect of a mobile electronic medicines inventory system on the access, understanding and utilisation of priority medicines for mothers and children in the Solomon Islands. This work should be seen in a broader context of health care within a developing country.

The limited availability of essential medicines globally is due, at least in part, to weak medicines supply chains and emerging technologies have the potential to address gaps in this area. There is an increasing shift towards utilising new technologies for managing medicines supply chains in low resource settings and there is an emerging field of innovation, of which the project described in this thesis is a part.

This chapter provides an overview of current medical supply chain innovations, with a focus on mobile electronic inventory in low-resource settings over the last 20 years, outlining the current enablers, challenges and innovations in the field. Looking also to the future, this chapter attempts to take the findings and conclusions of the research described in this thesis and place this project in that broader global health care context.

Methodology

The research in this chapter has been derived from semi-structured surveys with key industry experts in the field and is supported by a targeted literature review using a range of search tools (Google Scholar and PubMed).

Industry experts were contacted by email and asked open-ended questions about the enablers, challenges and recent innovations pertaining specifically to mobile electronic inventory systems in low-resource settings and to medical supply chain innovation more generally.
The responses from these experts informed several key topic areas for discussion, which were augmented by personal experiences from the candidate during the course of this research. These discussion topics are outlined briefly and each is then explored more fully by specific targeted literature searches.

Experts consulted

**Senior executive:** Medical supply chain management software company, providing services specifically for low-income settings

**Manager:** Hospital-based health data collection company, Australia

**Executive:** NGO public health research and consulting firm (US-based)

**Executive:** Global, non-profit healthcare foundation, specialising in healthcare service delivery in Africa

**Mobile Communication Research Consultant:** Major bilateral health program (PNG) &; Research Fellow: Australian University

**Photovoltaic Engineer, renewable energies expert:** Private sector energy consultancy based in the Pacific Islands

**Background**

There is an argument to suggest that medical supply chains in developing countries have been slow to harness emerging technologies. Known as The Yellow Bible, ‘Managing Drug Supply’ was the leading reference book for managing essential medicines in low-resource settings for several decades. First released in 1981, a second edition was published in 1997, of which 10,000 copies were distributed in over 60 countries.

Despite its popularity, the 1997 Edition – widely recognisable and commonly seen on the bookshelves of procurement and pharmacy departments in developing countries – does not contain any section on Information Technology. To put that in context, in 1997 the internet had become widely available in
high-income countries and desktop computers, even then, had become commonplace in developing countries – but the leading reference book for medical supply chains in that period did not devote any pages to the concept that computers could be used to manage medical supplies in low-resource settings. Sadly though, this could be seen as a reflection on supply chain strategy in that era. No published research could be found from the period preceding 1997 testing whether IT innovations worked in improving access to medicines. Another edition of the book would not be published until 15 years later, during which time medicines availability did not increase in developing countries.\textsuperscript{3,11} Despite its popularity, there is no evidence that Managing Drug Supply improved availability globally and it is difficult not to reflect on this without considering the missed opportunities with Information Technology.

By 2012, the third edition of the book – now renamed ‘Managing Access to Medicines and Health Technologies’ – has addressed ‘Pharmaceutical Management Information Systems’ and ‘Computers in Pharmaceutical Management’ in comprehensive chapters and it is hoped that this is a driver for procurement agencies within countries to invest more heavily in evidence-based information technology.\textsuperscript{101} This is difficult however, as outlined in Chapter Three, because there is still very little published research on the impact of electronic inventory systems in low-resource settings. Anecdotally, most health facilities in developing countries still rely on old-fashioned stock cards, which have demonstrated their ineffectiveness for decades. Today as we move into an era of smartphones and rapidly increasing access to the internet, there is a limited evidence base to provide basic principles to guide the implementation of new supply chain technologies.

This is the context in which the research described in this thesis has been conducted. As described in Chapter 3 of this thesis, there have been no large-scale intervention studies published examining the implementation of a mobile electronic medicines inventory system, for the full range of medical commodities, in a real world setting.
eHealth and mHealth

There has been considerable research and commentary examining ‘eHealth’ more broadly and while this has not necessarily been translated into improving access to medicines, there are important lessons and implications we can draw from this. eHealth has been defined as the use of any electronic system for healthcare, consisting mainly of computers or telecommunications. mHealth, as a subset, has been more specifically defined as the use of mobile technology (including devices such as smartphones and tablet computers) for healthcare. Since the advent of modern smartphones, around 2007/2008, the line between these concepts – and between devices – has been blurred, with mobile phones able to perform the more powerful functions previously limited to desktop or laptop computers.

Leading up to, and particularly since, the advent of widely available, relatively inexpensive internet in 1995, the focus for eHealth has been on clinical decision-making support and diagnostics, with some data collection. This has not fed broadly into supply chain mechanisms except on the most superficial level, perhaps in part because few centralised departments have had strong electronic inventory systems. Rudimentary Short Message Service (SMS)-based systems have seen health workers texting pharmaceutical stock levels or stock-outs to central authorities or supply stores but these have not necessarily been integrated with fully functional electronic inventory systems.

One reason for this is that mobile electronic inventory systems need an underlying database architecture to feed data into and according to the industry experts we consulted, these have not been in place or under-utilised.

A recent trend in mHealth has been SMS-based notification systems alerting central authorities to instances such as stock-outs. Whilst it is possible to manage a small selection of essential medicines through simple SMS-based systems – as was discussed in the Literature Review in Chapter 3 – these systems are unlikely to be scalable for the management of >100 items (medicines and health consumables) across hundreds of facilities. To support that kind of functionality requires robust, contextually appropriate inventory databases at the central level and in the mid-1990s, these were not in place. Anecdotally, from the 1990s into the 2000s, most inventory management was done using
Microsoft Excel® or locally built, simple databases entirely incapable of supporting disparate mobile systems.

Perhaps also, medical supply chains have not been given equal consideration by health planners from high-income settings, who have long been used to near-universal availability of medicines. Strengthening and modernising the supply chain does not necessarily attract donor attention and anecdotally, many medical supply chain experts have become used to hearing the idea that access to medicines could be improved simply by buying more stock, which is a dangerous over-simplification.

There is also an inevitable inability to predict major trends in technology and plan for them. This is demonstrated by ‘A Systematic Review of the Use of Telehealth in Asian Countries’, which was published in 2009 and based on a literature search conducted for the ten years leading up to June 2007. Coincidentally – and, undoubtedly, frustratingly for the authors – the Apple iPhone was released the very same month, starting a global trend that would instantly render much of their paper obsolete. The first Android enabled smartphone was released in October 2008, accelerating access to smartphones in low-income settings. Research preceding that period could not possibly have foreseen the impact smartphones were to subsequently have.

A smartphone is defined as a mobile device that combines traditional phone functions, such as the ability to make and receive calls, with some of the functions of a personal computer. Functionality may include touchscreens, GPS navigation, cameras, internet connectivity, video drivers, high definition screens and the ability to run third party software applications (‘Apps’). Today, 2.6 billion people – around a third of the world’s population – use a smartphone and this is not limited to high-income settings. 28% of Nigerians, 26% of Kenyans, 41% of Brazilians and 21% of Indonesians have smartphones. The phenomenon is not entirely global however; only 4% of Ethiopians have a smartphone, along with 4% of Ugandans and 11% of Pakistanis.

In the Pacific Islands, smartphone penetration has not been analysed but over 60% of the population now has a mobile phone and mobile networks have been identified as a key enabler in overcoming geographic and economic barriers to internet accessibility. The pace of mobile phone penetration
has outpaced the internet but there have been rapid increases in the availability of internet services in developing countries in the last few years and several projects are seeking to extend internet coverage even further, to some of the remotest populations in the world.\textsuperscript{107} These factors mean that there is an opportunity to change the paradigm of medicines supply in developing countries. Essential Medicines policy has undoubtedly improved access to better quality medicines with a higher evidence base but the availability of medicines at the primary healthcare level has stagnated for decades.\textsuperscript{3,4} Robust, pragmatic research into potential models for the utilisation of these emerging technologies is urgently required and this thesis contributes to that evidence base.

Research into emerging technologies by its nature risks being immediately superseded. Since the planning phase for this project in 2012, several new technologies have already emerged on the market that would ideally supersede aspects of this study design. It is likely that fundamental principles will continue to cut across emerging technologies however and the speed of change should never excuse the need for robust research.

In the absence of a larger body of research, the aim of the research reported in this chapter is to investigate the views and opinions of key industry experts in the field and explore the enablers, challenges and new innovations in the field of medicines access, supply and inventory control in developing countries.

**Enablers**

**Robust electronic inventory systems**

There has been an increasing acceptance of the need for robust, fully functional electronic inventory systems at the central level and these are far more evident in the field now, though certainly not ubiquitous. In the Pacific Islands, all countries except Fiji and Samoa are operating internationally available, off-the-shelf, commercial stock management software at the central level. Several software projects around the world however, which are ostensibly inventory management systems, are in fact
only data collection apps, with limited functionality, for primary healthcare facilities, reporting on stock-outs or passing orders up to the central level.\textsuperscript{38, 41, 103} This is problematic because they may disguise the need for more comprehensive systems and undermine investment in more end-to-end software.

Mobile technologies

Mobile phones have become nearly ubiquitous globally and ‘smartphones’ – able to support highly functional but intuitive applications – have become widely available even in most low-resource settings.\textsuperscript{107, 108} One expert identified that the decreased cost of these devices has made them more affordable, whilst they now have an increased software capability, enabling them to do more complex tasks. This has been coupled to societal changes that make people ‘used to doing things’ on a mobile device.\textsuperscript{109}

Internet penetration

Internet penetration into low-resource settings has been slower than mobile networks but the trajectory of access remains positive and this should allow more economic applications even in isolated areas.\textsuperscript{108} One hundred and ninety two countries have 3G mobile internet networks, covering nearly 50\% of the world’s population.\textsuperscript{110} The availability of internet services might be assumed to be more common in urban settings, where many medical stores are based and it is thus likely that far more than 50\% of stores supplying clinics would have access to the internet.

GPS enabled devices

GPS tracking has not been fully realised as an enabler in a supply chain context yet but it has the potential to improve systems, as does the increasing number of GPS-enabled devices. Geo-location is not widely used for supply chains in developing countries yet but the potential applications include product security, payment services and end-to-end supply chain tracking.
Challenges

New technology, old problems

When asked to identify the key challenges to the uptake of emerging supply chain innovations, none of the industry leaders interviewed identified any major technical challenges. Instead, all our experts identified human resource elements such as ‘entrenched attitudes’, ‘(un)willingness at corporate/executive level to understand and support the opportunities for doing things differently’, ‘organisational structures and historically precious and inefficient methods of managing supply chain’, ‘political will’ and a ‘lack of willingness to change’.109, 111, 112 These are of course universal problems in capacity-building in a low-resource context, though they are exacerbated to an extent with emerging technologies as there are challenges with the ‘capacity of staff to undertake and manage the changes’.111 One expert pointed out there is a ‘lack of culture of data usage’ in low-income settings.113 Coupled to this are the more insidious challenges related to supply chain strengthening. The procurement and distribution of drugs and medical supplies represents a significant portion of national health budgets and supply systems can be compromised by deliberate actions or entrenched, ‘arcane’ bureaucracies.23 Electronic inventory systems seek to make supply chains more transparent and our experts pointed out that this in itself can be a challenge to overcome. It is not in the interests of some people in many countries to embrace transparency, though it must be stressed that in the course of the work described in this thesis, in Solomon Islands, such problems were never observed. The challenges in some settings are not necessarily deliberate of course. The Government Departments and contracted private sector partners responsible for medical supply chains are often subject to complicated and out-dated bureaucratic processes, which are a hallmark of countries with weak public institutions.114, 115 It can take excessive periods of time to undertake tenders, run procurement projects, including payments and manage contracts. One expert also pointed out that despite the falling costs of SMS and internet-enabled devices, the user-costs can still be prohibitive to the lowest-level users.112
“…the Fresh Produce Development Agency has for years run a service which allows anyone in Papua New Guinea to be able to text in to find out about the price, supply levels and quality of fruit and vegetables at markets around the country. But the cost is 35 toea per SMS, which may be too high for the service to be of value to users. Certainly, growers are not using it in great numbers.”

These impositions on medical supply chains will continue to affect the potential benefits stemming from innovation but innovative ways to reduce data usage (e.g. toggling data on and off, sharing information through local networks rather than over the internet and periodic syncing rather than constant internet connectivity) may play a role.

Finally, entrenched attitudes run right through organisations and probably require change management strategies coupled to the roll-out of new innovations. Anecdotally, health workers remain reluctant to give up their paper records and rely on ‘unproven’ technologies.

**Current state innovations**

**Asynchronous data transfer**

Some key trends appear to be emerging in software development in low-income settings. In particular, there is growing recognition of the need for software to work in an offline mode, with the ability to store data locally and upload this data whenever internet connectivity becomes available. This asynchronous data transfer may be referred to as ‘store and send’ modality. ‘Store and send’ was originally envisioned in an e-health context for when healthcare providers and patients were not available at the same time. The healthcare provider or the patient would prepare an electronic package, potentially containing diagnostic information or clinical notes and these would be emailed and stored at the recipient’s end or stored on a web server for the recipient to access when they became available.

With the advent of advanced smart phones and tablet computers, it has become possible to store such data at the sender’s end on databases that sit on the sender’s device until internet becomes available.
In some cases, the sender may not even be aware when the information is sent, only that the transfer takes place whenever internet becomes available.

In the project described in this thesis, the mobile software was required to be online at the time of use, which was a significant limiting factor. Participating Pharmacy Officers worked hard to overcome this deficiency, undertaking work during periods when the internet was more likely to be available and occasionally travelling by foot to different locations to enter data – but this flexibility and improvisation is less likely to be scalable and staff may not be prepared to do this additional work in the long-term. With a store and send modality, staff can undertake data entry at any time, in any location and would not usually have to undertake additional work to facilitate data uploading. In those cases where travel is required to access the internet, staff could do this on a periodic basis, rather than every time they wanted to access the software.

Store and send functionality presents technical difficulties. It requires that a local database be built on the device, which is technically difficult, can use up memory and cause the device to run more slowly. The increasing availability of cheaper, more powerful devices, with increased memory is reducing the significance of these problems.

The alternative to store and send are non-networked, stand-alone systems, whereby a physical connection would need to be made to transfer data (using removable memory devices or data cables). In remote locations, these are impractical and unlikely to provide anywhere near real-time data to central authorities. Interestingly, a new version of the software used in this research (mSupply Mobile©) is now available, incorporating store-and-send modality. All mobile inventory projects in low resource settings should consider incorporating this functionality.

Shifting quantification methods

Currently, ‘best-practice’ supply chains run a ‘pull’ system for primary healthcare facilities, whereby each facility is responsible for quantifying its needs and ordering the amount of stock they think they will need. Traditionally, there had been a direct link between clinical practice and item quantification,
whereby the number of patients receiving a specific item for a specific disease would be tallied and this tally be used to quantify facility needs. For example, the number of patients diagnosed with malaria would be counted each month and this would provide the means of quantification for calculating the required number of antimalarials for the next order. This model is problematic and impractical in many healthcare facilities, due to the heavy demands on health workers’ time. Tallying patients is arduous, even where good records are kept, especially in larger facilities. Often, records are not well kept or wholly inaccurate. Many facilities do not properly record all patient encounters and this inevitably impacts on tally systems, which consequently do not fully capture item usage.

The alternative quantification method within a ‘pull’ system, is for facilities to look strictly at usage; that is, to run a stocktake every time they want to place an order, physically counting all items on their shelves, comparing that to their last stocktake to quantify their usage, and subtracting the stock they still have on hand. This is a more accurate measure of usage that takes into account leakage, unrecorded item dispensing and theft. It is still problematic however, as the quantification formula can be confusing to staff with little grounding in maths. They are also expected to apply the formula across dozens of items, so it is extremely time consuming and inefficient.

A number of experts predicted that electronic inventory systems will increasingly be used to turn the paradigm around and return to ‘push’ supply chain systems, with the quantification data being supplied automatically back to the central level, where the calculations will be done automatically. The responsibility for calculating needs would return to the central level and be largely automatically generated through the software. This methodology would reduce the workload on facility staff, reduce wastage and possibly improve availability.

Electronic systems may even offer a pathway to return to a concept of using clinical data (such as patient disease tallies) to inform quantification, particularly where inventory systems are integrated with clinical systems. An electronic patient record system may provide data on the number of patients with diabetes for example and this could be used to at least approximate the amount of insulin required. Electronic records cannot substitute for sound data entry however and it is thus imperative
that systems are designed for data entry to be at least as fast as existing, hand-written records. Electronic systems also do not necessarily address problems with leakage and theft, thus periodic stocktakes will remain necessary.

Moving beyond simple concepts of quantification, electronic inventory systems may more easily enable useful data analysis, to guide practice. If a spike in the usage of zinc sulphate in a particular area is detected by an electronic inventory system, this may be used to identify a diarrhoea outbreak, allowing public health interventions to be implemented earlier. Similarly, if inventory systems demonstrate an increase in the use of antibiotics for patients in a surgical ward, this may be used to inform the practice of infection control teams and other clinical staff. The present project did not examine data in this way but subsequent projects looking at this are a logical extension of the technology.

Off-the-shelf software

The other trend in software has been towards seeking ‘off-the-shelf’ products, rather than developing customised software. This means that clients may be more inclined to approach existing software providers than develop their own idiosyncratic systems for local use, as was more common in the 1990s and 2000s. These locally built systems are sadly common throughout low-resource settings, where old, unused, redundant systems often sit idle on ageing IT networks. Also commonly seen are complex Microsoft Excel© spreadsheets, with complicated formulas and multiple sheets within single files. Although excellent for some functions, Excel is not a practical database for inventory management and should not be used as such. Locally developed software is becoming rarer, due to the increasing complexity of IT systems and the interoperability requirements. There are drawbacks to this – custom-made systems can be designed for a specific local context and adapted to suit the exact specifications of an organisation. Off-the-shelf products may be customisable but only to a point and are most often only available in major languages.
Management Sciences for Health has said “Although the idea of custom-built software is attractive, purchasing software that has already been written and tested by others is usually preferable, unless a suitable program cannot be found”.\textsuperscript{101} On balance, off-the-shelf products are likely to provide much better value for money and longevity. Systems built by individuals for a local context are prone to ‘bugs’, do not get ongoing support and updates and can be subject to spiralling costs, as often only one programmer is familiar with the backend code. The United Nations Commission on Life-Saving Commodities for Women and Children has developed an Inventory of Information and Communication Technology Solutions for Supply Chains, which lists a number of electronic inventory systems currently being used in low-resource settings.\textsuperscript{119} The inventory lists 46 systems covering functionality such as quantification, inventory management and procurement but not all are commercially available. AccessRH for example, is a UNFPA stock tracking system that is used in over 140 countries but only for those commodities procured through UNFPA. Few are apparently available incorporating both a central warehouse system with a mobile field version.

‘Internet for all’

While there is a perception of the internet as being universally available, up to two thirds of the global population does \textit{not} yet have access to the internet.\textsuperscript{120} Several projects around the world are looking to address this, including two high profile Google© projects using high-altitude balloons (‘Project Loon’) and satellites. Other projects are exploring these and other technologies, including drones and low-altitude balloons.\textsuperscript{121} Expanded internet access was cited by nearly all the industry experts consulted for this chapter as a key enabler for realising the benefits of emerging innovations in health and medical supply chains. Whilst it is difficult to predict which (if any) of these projects may end up becoming a mainstream source of internet for large numbers of people, ‘internet-for-all’ – if achieved – would be likely to improve healthcare, community resilience and disaster response in all low-resource settings.
Are SMS projects obsolete?

The rising popularity – and functionality – of smartphones raises the possibility that SMS projects, which have been successfully implemented in Africa in particular, may become obsolete.\(^{38, 41}\) This question was specifically addressed in two 2015 articles, which make the point that ‘SMS projects and toll-free numbers are still of great value’ in PNG and similar contexts.\(^{122, 123}\) Pointing out that many Pacific Islanders still did not know how to use features on smartphone handsets and that the majority of coverage in Melanesian countries remains only 2G, the articles opined that user friendly services, including SMS, would remain useful for poor people ‘in many parts of the world… for years to come’. This is also true in countries as large as India, where 2G coverage, or less, remains the only network option for large sections of the country.\(^{124}\)

The Literature Review in Chapter 3 did not find an SMS project that had been implemented across the full range of essential medicines and consumables required by a primary healthcare facility and it is unlikely, given shifting trends towards smartphones, that SMS projects will play an increasing role in comprehensive supply chain management but SMS projects are likely to continue to play some continuing role, particularly for patient reporting, vertical programs and monitoring & evaluation.

Renewable energy and improved power storage

New energy sources, including more efficient solar power generation and micro-hydro power sources have raised hopes that electricity could also be expanded to isolated communities. Many communities in the Pacific Islands region have no electricity at all or rely on rudimentary solar panels to power basic lights and mobile phones. According to an expert who participated in this study, there has been a five-fold reduction in the price of solar power over the last decade, which is rapidly accelerating uptake globally. This is coupled to increasingly supportive policy environments, vocational training and favourable tax incentives in many countries.\(^{125}\) Two of the SLMS using mobile electronic
inventory in the project described in this thesis were entirely powered by photovoltaic systems, generating power not only for IT devices but for refrigerators, lights and fans.

The greatest challenges for renewable energies such as wind and solar, being by their nature intermittent, still lie in their inability to reliably power large scale utility grids. One of the participating experts sees the greatest promise in local systems, as might be used to power a single clinic or store, but such systems would be entirely adequate for tablet or telephone-based mobile electronic inventory systems, which do not require constant electricity. Another expert supported this, stating their belief that the provision of solar chargers should be included as a part of every mobile electronic health project.112 Innovations in battery technology may also help, limiting the frequency with which devices need to be recharged.112

**Future state topic areas**

We also asked our experts to speculate on supply chain innovations that may begin to emerge in the next five to ten years. These predictions may form the basis for future research but our project has demonstrated that the technology moves quickly and that putting together the research methodology to support best practice for the roll-out of new technologies should perhaps start before the technology has been perfected.

**Data capture, collation and analysis**

There is enormous potential to use data to optimise the supply chain, mirroring in the public sector what has been occurring for a long time in the private sector.113 Data analysis is likely to play an increasing role, both in supply chain strengthening and in feeding information to other parts of the healthcare sector, such as clinical services or pharmacovigilance. Central to this premise is the potential for the use of ‘big data’, using the extremely high volumes of information that are produced by IT-based systems to solve problems or answer questions. A key element of this may be data
linkage whereby data is drawn from a variety of sources, including even disparate, non-traditional sources, such as weather reports, census data or commodity prices, to design better supply chains.

Utilising data is not without risk however, as low-income countries may be more prone to security breaches, cyber-crime and insufficient infrastructure. An inability to harness data also means ‘the exploration of data-based knowledge to improve development is not automatic’.126

Use of smartphones and wearable devices

Clinic staff in PNG have already used smartphones to photograph and geotag orders arriving at health facilities. These mechanisms were designed to aid end-to-end product visibility but they could be extended to help with quantification and quality assurance. Staff wearing mobile-enabled watches for example could simply swipe over RFID chips in boxes of supplies and this could feed data back into the system. Such technology might be more feasible in the warehouse setting than in remote communities but even in isolated areas, it has the potential to reduce the need for unreliable radio and slow written communication between clinics and suppliers.

Common barcode standards

Tied closely to the concept of RFID chips, wearable devices and smartphones, common barcode standards would be required to enable some of these potential advances. Common barcoding should be adopted, according to one participating expert, who also identified them as an enabler that would allow more automation at the warehouse level. Currently, most barcodes in the low-income setting must be entered into a computer database when a product arrives and they identify only the product itself (drug and brand name). Common barcode standards would mean barcodes could also identify the batch number and expiry date. This would obviously also require compliance by the major suppliers.
Other sources have speculated on ‘the end of barcodes’, to be replaced by Radio Frequency Identification (RFID), but this will probably not occur for some time. Widespread adoption of common barcode or RFID standards may help to address problems with counterfeiting.

Drone deliveries

All our experts raised the prospect of drone deliveries, though they were divided on what this might look like. One participating expert felt that autonomous ground vehicles would play a bigger role in supply chains but that aerial vehicles could be used for ‘lightweight emergency deliveries and some cold chain items’. Another expert did not talk about driverless ground vehicles but predicted that flying drones would be used to supply into ‘remote or difficult locations’. A third expert predicted that unmanned aerial vehicles (UAVs) would be in use in medical supply chains within five to ten years in his home country of Nigeria.

Drones have been used in low-resource settings such as PNG, where they were used to deliver sputum samples to laboratories as part of a TB program, and the feasibility of drones for delivering routine laboratory samples has been demonstrated. Currently, high profile pilot projects are being carried out in places such as Rwanda, however there has been no successful, widespread scale-up of the technology for delivering medical supplies. A practical model would probably require a heavier payload, greater range and better autonomy than what is currently available on the market. Innovation in this area is likely to also be driven strongly by the private sector, with companies such as Google and Amazon already testing prototype services, albeit for the high-income setting.

Distribution of other products, including nutritional supplements

It has long been understood that parallel supply chains weaken health systems. The dissemination of electronic inventory systems may allow more sophistication to be applied to this model and may allow the expansion of what is supplied in a traditional health system supply chain to more non-traditional commodities, such as nutritional supplements, fortified foods and health promotion
resources. This becomes possible as the size and complexity of ordering by health staff is reduced and they may be more able to manage larger inventories than what was previously possible.

**Resulting technology - Data collection app**

The data collected for the project described in this thesis was undertaken in hard copy and transcribed manually into an electronic database. A mobile application has now been developed replicating the information collected in this study and has been made freely available for use on any Android-enabled device.\(^\text{134}\)

**Discussion**

There are a number of enablers supporting supply chain innovation at the moment. These include but are probably not limited to; the growing availability of smartphones, an increase in internet coverage in isolated areas, asynchronous data transfer, the growing presence of strong electronic inventory management systems at central levels and a growth in GPS enabled devices. The key challenge identified by all our experts was entrenched practices and reluctance by management to embrace change. This is witnessed across the development sector but the problem is probably acute with emerging technologies.

Investment is required in strong central supply facilities supported by robust supply chain software, internet availability, electricity and computer literacy. There are likely effects stemming from supply chain innovation that have not been explored by the research described in this thesis but which have been identified by our experts and anecdotally in the course of this project. These include workload efficiencies, more and better data, lower costs, patient safety, lower lead times leading to more timely access, and greater transparency from having visibility of stock through the entire supply chain.

Finally, supply chain innovations do not fix supply chains. This was illustrated by an incident observed at a private medical warehouse in Lagos, Nigeria by the candidate. Having completed
training and had supply chain software installed on their computers, the warehouse managers at the facility informed the trainers that they needed to ship 21 orders, with 290 item lines in each order, within 3 days and asked ‘could the software facilitate this’? When told this was still impossible in such a short space of time – they wouldn’t have the staff to pick the stock off the shelves, sufficient space in their packing area to put the orders together or sufficient transport to clear the orders out of their warehouse – they looked accusingly at the computer, as if it was the software’s fault. The best software system in the world can only augment and strengthen a functional supply chain, it cannot substitute for it – this is a point worth remembering.

Summary

Supply chain innovations are likely to become increasingly utilised over the next five to ten years in low resource settings. These include the growing use of smart phones, the integration of supply chain technology with clinical practice, a move towards ‘off-the-shelf’ software and asynchronous data transfer. Despite the growing use of smart devices, SMS projects are likely to continue to play a role, especially in remote communities.

These innovations will be enabled by the increased availability of internet, the increasing usage of smart devices in low income countries and improvements in renewable power generation and storage. The key remaining challenge to harnessing new supply chain innovations are human resources, resistance to change and entrenched bureaucracies. These should give impetus to well-designed research that can demonstrate improved outcomes from emerging technologies in real-world settings.

This thesis has described the findings of one such research project into mobile electronic inventory systems. It has provided a possible template for the implementation of similar projects and provided suggestions for ways by which to improve on that research methodology.
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Appendices

Appendix 1: Plain language statement to nurses

Plain Language Statement to nurses prior to undertaking questionnaire (can be made in English or translated into Pidgin):

"Hello, my name is _________ and these are my colleagues, _______.
We are doing a survey for the National Pharmacy Division and the Child Health Program at the Solomon Islands Ministry of Health. The survey is being done with the support of the University of Melbourne. This project is being overseen by the Solomon Islands Health Research & Ethics Committee.

Part of this survey is to do a questionnaire with you (all the nurses in all the clinics we are visiting). This is to look at how nurses use medicines for mothers and for children. We would like to ask you some questions about these medicines and some medical conditions. We expect that this will take about 20 minutes.

We will not record your name or any details about you, except whether you are a Registered Nurse or a Nurse Aide. We simply want you to give us your best, most honest answers, which will be recorded confidentially. You do not need to answer every question and we don’t expect anyone to get them all correct. Some questions may have more than one correct answer and afterwards, we will not give you a list of correct answers BUT you may ask us any questions you would like when we have finished.

Whatever you answer for any question, your results will not be reported back to the province or to the Ministry of Health – the answer sheet will be kept by us at the Pharmacy Division but your name will not be recorded anywhere. These answer sheets must be held by us for five years and they will then be destroyed, just like we destroy prescriptions confidentially.

Because we will not record your name, we will not be able to give you your personal result now or at any time in the future. We will compile the results of all staff from the clinics we are visiting and we will publish the average results in the quarterly Pharmacy Newsletter.

You do not need to take part in this survey if you do not want to. You can ask us any questions you would like or clarify anything you don’t understand before agreeing or declining to be involved.

If you would like to ask any questions later, you can contact us through the Medicines Information Centre, on Radio Selcall 5555 or by phone on 24697".
Appendix 2.1: Availability survey – data collection form

### CLINIC NAME

- **PROVINCE:**
- **SLMS (OR NMS):**
- **MOBILE No:**
- **ASSESSOR:**

**FRIDGE?/TYPE:**

**FRIDGE WORKING? Y/N**

**CONDOMS AV? (circle MALE / FEMALE)**

---

### Availability of Priority Medicines for Mothers and Children

#### Nurse Aid Posts & Rural Health Clinics

<table>
<thead>
<tr>
<th>Item</th>
<th>Av</th>
<th>Ex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acriflavine in syrup 0.2%/70% (or Chlorhexidine Equivalent)</td>
<td>Oxytocin 5U/ml injection or</td>
<td>Syntometrine 5IU/0.5mg</td>
</tr>
<tr>
<td>Amoxicillin adult oral dose form</td>
<td>Paracetamol 300mg tabs/caps</td>
<td></td>
</tr>
<tr>
<td>Artesunate suppositories or inj</td>
<td>Procaine Benzylpenicillin inj</td>
<td></td>
</tr>
<tr>
<td>Benzathine penicillin 12MU inj</td>
<td>Sodium Chloride 0.9% soln</td>
<td></td>
</tr>
<tr>
<td>Coartem Tablets (at least two weight categories)</td>
<td>STI Treatment Pack (Azith/Cefixime)</td>
<td></td>
</tr>
<tr>
<td>Levonorgestrel/ethynylestradiol 0.15mg/0.03mg tabs or equiv</td>
<td>Tetanus Toxoid Vaccine</td>
<td></td>
</tr>
<tr>
<td>Medroxyprogesterone 150mg/ml inj or equiv</td>
<td>Vitamin A 100,000 or 200,000 IU caps</td>
<td></td>
</tr>
<tr>
<td>Morphine or Pethidine tabs or inj</td>
<td>Zinc Sulphate 20mg disp tabs</td>
<td></td>
</tr>
<tr>
<td>Oral Rehydration Salts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Area Health Centres

<table>
<thead>
<tr>
<th>Item</th>
<th>Av</th>
<th>Ex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin 500mg injection</td>
<td>Magnesium Sulfate 30% injection</td>
<td></td>
</tr>
<tr>
<td>Calcium Gluconate 10% injection</td>
<td>Methylprednisolone oral dose form</td>
<td></td>
</tr>
<tr>
<td>Gentamicin injection</td>
<td>Metronidazole tablets or supps</td>
<td></td>
</tr>
</tbody>
</table>

#### Provincial Hospitals & Specialist Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Av</th>
<th>Ex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceftrixone injection</td>
<td>Metronidazole injection</td>
<td></td>
</tr>
<tr>
<td>Dexamethasonate 4mg inj</td>
<td>Misoprostol 200mcg tabs</td>
<td></td>
</tr>
<tr>
<td>Hydralazine 20mg inj or 25mg tabs</td>
<td>Nifedipine 20mg SR or 10mg IR</td>
<td></td>
</tr>
<tr>
<td>Levonorgestrel 750 mcg tab</td>
<td>Medical Oxygen Gas</td>
<td></td>
</tr>
</tbody>
</table>

### OVERALL AVAILABILITY

<table>
<thead>
<tr>
<th>Item</th>
<th>Av</th>
<th>Ex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceftrixone in Sprit is interchangeable here with any appropriate Chlorhexidine preparation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIV medications are supplied for specific patients only in the Solomon Islands and are not included here</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceftrixone and Azithromycin are included together on this form. Levonorgestrel implant is not available in SI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ b = 17 \text{ for NAPs and RHCs; 23 for AHCs; 31 for Hospitals/Specialist} \]

Notes
Appendix 2.2: Staff comprehension survey

Child & Maternal Health Survey: Priority medicines for mothers and children

Facility: NAP / RHC / AHC

RN / NA

(Please circle)

Province: Zone:

Assessors Name: Contact Ph / email: Date:

Please complete the following sections as per instructions. Any questions: contact Michael Nunan (7502847) or michael.nunan@rch.org.au or radio selcall: 5555

Instructions

1. Explain the survey to the nurses clearly, before seeking their permission to participate. Explain that their answers will remain confidential and that we are trying to help improve knowledge around these medicines.

2. Ask each question in this order. Do not return to any questions to change answers.

3. Move slowly and give nurse time to think but not too long! If they don’t know the answer just write ‘don’t know’ and move on.

4. Please record answers as accurately as possible; do not just mark ‘correct’ or ‘incorrect’. The answers may be used later to review the nurses’ score.

5. Ask questions in a neutral manner. Don’t comment on answers or correct nurses until the end of the survey.

6. Determine whether an answer is correct by using the answer guide; if you are unsure, record the answer as accurately as possible and refer to the chief investigator.

7. Mark each question by clearly circling ‘Y’ or ‘N’.

8. Do NOT let the nurses see your marks or notes; simply thank them for participating and discreetly mark your survey without comment.

9. Be supportive of nurses – we are only looking to survey knowledge, not find bad nurses or judge clinics.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer: Try to write their exact words or circle the given answer</th>
<th>Correct?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the main indication for Zinc in children?</td>
<td>What nao main indication lo zinc lo pikinini?</td>
<td>Y / N</td>
</tr>
<tr>
<td>2. What is the benefit of giving a child Zinc for diarrhoea?</td>
<td>What nao benefit lo zinc fo pikinini taem diarrhoea?</td>
<td>Y / N</td>
</tr>
<tr>
<td>3. What is the benefit of giving a child ORS for diarrhoea?</td>
<td>What nao benefit lo ORS fo pikinini taem diarrhoea?</td>
<td>Y / N</td>
</tr>
<tr>
<td>4. Should the child be given less ORS if they are being given Zinc?</td>
<td>Waswe pikinini baie givem lelebet ORS if givem zinc lo pikinini, or saemsaem?</td>
<td>Y / N</td>
</tr>
<tr>
<td>5. What is the recommended dose of Zinc in diarrhoea?</td>
<td>What nao recommended dose lo zinc lo diarrhoea lo pikinini?</td>
<td>Y / N</td>
</tr>
<tr>
<td>6. What is the duration of Zinc therapy in diarrhoea?</td>
<td>How many days lo treatment lo pikinini taem hem diarrhoea?</td>
<td>Y / N</td>
</tr>
<tr>
<td>7. How do you prepare ORS sachets for use?</td>
<td>Hao nao lu save wakim ORS sachets fo givim long pikinini?</td>
<td>Y / N</td>
</tr>
<tr>
<td>8. How often do you use Vitamin A in children?</td>
<td>Wat taem bae lu givim Vitamin A long pikinini?</td>
<td>Y / N</td>
</tr>
<tr>
<td>9. How do you give Vitamin A in children?</td>
<td>Hao lu givim Vitamin A long pikinini?</td>
<td>Y / N</td>
</tr>
<tr>
<td>10. What is the dosing schedule of Vitamin A in children with Xerophthalmia or severe malnutrition?</td>
<td>What dosage lo Vitamin A long pikinini wea hemi siki witim eye problem or malnutrition?</td>
<td>Y / N</td>
</tr>
<tr>
<td>11. How does a patient take the new STI Treatment Pack?</td>
<td>Hao siki patient tekim nii STI treatment blo umi?</td>
<td>Y / N</td>
</tr>
<tr>
<td>12. What is the treatment for malaria in the 1st trimester of pregnancy?</td>
<td>Hao lu trimin malaria lo babule mere long 1st trimester?</td>
<td>Y / N</td>
</tr>
<tr>
<td>Question</td>
<td>Correct?</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>What is one symptom suggesting severe pneumonia in children?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Hao nao iu save lukim smol pikinini wea hemi garem barava siki witim shortwind or chest infection?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>What is the frequency (timing) and duration of amoxicillin in children?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Hao nao iu givim amoxicillin long pikinini?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>What route is Procaine Benzylpenicillin given by?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wea nao iu nila procaine penicillin?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>What is the schedule for Tetanus vaccination in mothers?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat taem iu givim tetanus vaccine long mami taem hem babule?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>What is an appropriate treatment for neonatal sepsis before referral?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat nao iu givim lo smol pikinini wea hemi barava siki bifor iu sendim hem go long hospital?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>What do you use Acriflavine or Chlorhexidine for after birth?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat bae iu usim Acriflavine fo taem bebe hem bonem?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>What fluids would you use in severe dehydration in children?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat kaen fluids iu save usim long pikinini wea hemi garem barava dehydration?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>How often should pregnant mothers take Fefol tablets?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat taem bae iu givim Fefol tablets long babule mere?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is the first treatment given for post-partum hemorrhage (bleeding in a mother after birth)?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat meresin bae iu iusim taem mami hemi bld olowe?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What two medicines are in the new STI Treatment Pack?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat nao tufela meresin wea hemi insaet niu STI pack?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is a medicine you could give for maternal sepsis?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>Wat meresin iu save iusim suppos mami garem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>27. What are the signs and symptoms of maternal sepsis?</td>
<td>Hao nao iu lukim mami wea hemi barava siki taem hem bonem bebe?</td>
<td></td>
</tr>
<tr>
<td>Correct?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>28. What is one condition you would give metronidazole for in mothers or children?</td>
<td>Iu save telim wanfala siki wea iu bae usim metronidazole?</td>
<td></td>
</tr>
<tr>
<td>Correct?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>29. What is Magnesium Sulphate used for in pregnancy?</td>
<td>Wat nao iu save usim Magnesium Sulphate fo doim long babule mere?</td>
<td></td>
</tr>
<tr>
<td>Correct?</td>
<td>Y / N</td>
<td></td>
</tr>
<tr>
<td>30. What drug do you use to treat Magnesium Sulphate toxicity/overdose?</td>
<td>Wat nao meresin iu save givim taem magnesium mekim iu siki moa?</td>
<td></td>
</tr>
<tr>
<td>Correct?</td>
<td>Y / N</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: Research Certificate (Ethics Approval)

No. HRC12/20

National Health Research & Ethics Committee
Solomon Islands Ministry of Health & Medical Services

Research Certificate

To: Michael Naron
National Pharmacy Division
MinMS

The National Health Research & Ethics Committee (NHREC) of the Ministry of Health & Medical Services, Solomon Island have approved your application to do research on "Beyond the National Drug & Therapeutic Committee, improving access to medicines for mother and children in Solomon Island" through the expedited process on the 16th Nov 2012.

You are hereby granted permission to conduct your research in Solomon Island in 2013.

[Signature]
[Date]

[Seal]
Appendix 4: Dosing Wall Chart

Priority Medicines for Mothers & Children

Solomon Islands Medicines Dosing Wall Chart for Primary Healthcare Facilities

National Pharmacy Services Division
Medicines Information Centre
## Medicines for Children

<table>
<thead>
<tr>
<th>Drug</th>
<th>Indication</th>
<th>Dose</th>
<th>Dose Form</th>
<th>3-5.9</th>
<th>6-9.9</th>
<th>10-14.9</th>
<th>15-19.9</th>
<th>20-29.9</th>
<th>30-39.9</th>
<th>40-49.9</th>
<th>&gt;50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albendazole</td>
<td>Worm infestation</td>
<td>Once daily for 3 days</td>
<td>Tablet 200mg</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>Mild pneumonia</td>
<td>15mg/kg TDS for 5-10 days</td>
<td>Suspension 125mg in 5mL</td>
<td>2.5</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skin infections</td>
<td>Capsule 250mg</td>
<td>cap</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Ampicillin</td>
<td>Moderate-severe pneumonia</td>
<td>25-50mg/kg QID for 10 days</td>
<td>Injection 500mg in 2mL</td>
<td>0.4</td>
<td>0.8</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Artesunate</td>
<td>Severe malaria</td>
<td>Single dose at once, then refer to NRH</td>
<td>Suppository 50mg</td>
<td>½</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suppository 200mg</td>
<td>sup</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1½</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Benzathine penicillin</td>
<td>Congenital syphilis</td>
<td>37.5mg/kg as a single dose at once</td>
<td>Injection 600mg (1 mega unit) in 4mL</td>
<td>0.5</td>
<td>1</td>
<td>1.7</td>
<td>2.5</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Acute rheumatic fever</td>
<td></td>
<td>ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzylpenicillin</td>
<td>Congenital syphilis</td>
<td>30-60mg/kg QID for 10 days</td>
<td>Injection 600mg (1 mega unit) in 2mL</td>
<td>0.3</td>
<td>0.6</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2</td>
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<tr>
<td></td>
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<td>ml</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Moderate pneumonia</td>
<td></td>
<td>ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ceftriaxone</td>
<td>Meningitis</td>
<td>50-100mg/kg daily</td>
<td>Injection 250mg in 1mL</td>
<td>0.6</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>Chloramphenicol</td>
<td>Meningitis</td>
<td>12.5-25mg/kg QID</td>
<td>Injection 1g in 10mL</td>
<td>0.4</td>
<td>0.6</td>
<td>1.25</td>
<td>1.8</td>
<td>2.5</td>
<td>3.5</td>
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<tr>
<td></td>
<td>Severe pneumonia</td>
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<td>ml</td>
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<tr>
<td></td>
<td>Pertussis/pneumonia</td>
<td></td>
<td>ml</td>
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<tr>
<td>Cloxacillin</td>
<td>Bone, joint, muscle infections</td>
<td>25-50mg/kg QID</td>
<td>Injection 500mg in 2mL</td>
<td>0.3</td>
<td>0.6</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td></td>
<td></td>
<td>Suspen. 125ml in 5mL</td>
<td>ml</td>
<td>1.5</td>
<td>2.5</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>Capsule 250mg</td>
<td>cap</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1½</td>
<td>2</td>
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<tr>
<td>Coartem®</td>
<td>Malaria (p.falciparum &amp; vivax)</td>
<td>BD for 3 days</td>
<td>Tablet 20mg/120mg</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(Artemether/Lumefantrine)</td>
<td></td>
<td></td>
<td>ml</td>
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</tr>
<tr>
<td>Co-trimoxazole</td>
<td>Acute otitis media</td>
<td>4mg/kg BD for 5 days</td>
<td>Tablet 80mg/400mg</td>
<td></td>
<td>⅔</td>
<td>⅔</td>
<td>⅔</td>
<td>⅓</td>
<td>1⅓</td>
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<tr>
<td>(Trimethoprim/Sulfamethoxazole)</td>
<td>UTI</td>
<td></td>
<td>ml</td>
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</tr>
<tr>
<td></td>
<td>Diarrhoea with blood</td>
<td></td>
<td>ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diazepam</td>
<td>Convulsions</td>
<td>0.1-0.3mg/kg PRN</td>
<td>Injection 10mg in 2mL</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
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<tr>
<td></td>
<td></td>
<td>Retching using injection 10mg in 2mL</td>
<td>ml</td>
<td>0.3</td>
<td>0.3</td>
<td>0.6</td>
<td>1</td>
<td>1.2</td>
<td>2</td>
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<tr>
<td>Erythromycin</td>
<td>Pertussis</td>
<td>7.5-12.5mg/kg QID</td>
<td>Suspension 200mg in 5mL</td>
<td>0.5</td>
<td>1</td>
<td>2.5</td>
<td>3</td>
<td>5</td>
<td>-</td>
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</tr>
<tr>
<td></td>
<td>Pneumonia</td>
<td>Tablet 250mg</td>
<td>ml</td>
<td></td>
<td>½</td>
<td>1½</td>
<td>1½</td>
<td>1</td>
<td>1½</td>
<td>2</td>
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</tr>
<tr>
<td>Frusemide</td>
<td>Heart failure</td>
<td>0.5-2mg/kg BD</td>
<td>Injection 20mg in 2mL</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.8</td>
<td>1</td>
<td>1.6</td>
<td>2</td>
<td>2</td>
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<tr>
<td></td>
<td></td>
<td>Tablet 20mg</td>
<td>ml</td>
<td></td>
<td></td>
<td>⅔</td>
<td>⅔</td>
<td>⅔</td>
<td>⅓</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Medication</td>
<td>Indication</td>
<td>Dosage</td>
<td>Formulation</td>
<td>Volumes (ml)</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.8</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>-----------------------</td>
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<tr>
<td>Hydrocortisone</td>
<td>Severe acute asthma</td>
<td>2-4mg/kg QID until</td>
<td>Injection 100mg in 2mL</td>
<td>1ml</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.8</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Iron</td>
<td>Mild-moderate anaemia</td>
<td>2-5mg/kg once daily for 4 weeks, then recheck Hb</td>
<td>Mixture 6mg in 1mL</td>
<td>1ml</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>10</td>
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<tr>
<td>Metronidazole</td>
<td>Diarrhoea with blood</td>
<td>7.5mg/kg TDS for 5 days</td>
<td>Injection 500mg in 100mL</td>
<td>5ml</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tablet 250mg</td>
<td>tab</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Suppository 500mg</td>
<td>sup</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1</td>
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<tr>
<td>Morphine</td>
<td>Severe pain Palleative care</td>
<td>0.05-0.2mg/kg QID PRN</td>
<td>Injection 10mg in 1mL</td>
<td>1ml</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
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<tr>
<td>Multivitamin</td>
<td>Malnutrition</td>
<td>Once daily</td>
<td>Liquid</td>
<td>tab</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td></td>
<td></td>
<td>Tablet</td>
<td>tab</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>ORS</td>
<td>Some dehydration in diarrhoea</td>
<td>PRN</td>
<td>Packet</td>
<td>pkt</td>
<td>Dissolve packet in water, one big cupful given every hour or more frequently as tolerated</td>
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<tr>
<td>Paracetamol</td>
<td>Fever Pain</td>
<td>15mg/kg QID prn</td>
<td>Suspension 120mg in 5mL</td>
<td>2.5</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Tablet 100mg</td>
<td>tab</td>
<td>%</td>
<td>1</td>
<td>3%</td>
<td>2%</td>
<td>3</td>
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<td></td>
<td></td>
<td></td>
<td>Tablet 500mg</td>
<td>tab</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Suppository 125mg</td>
<td>sup</td>
<td>%</td>
<td>1</td>
<td>1%</td>
<td>2%</td>
<td>3</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Suppository 250mg</td>
<td>sup</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1</td>
<td>1%</td>
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<tr>
<td>Prednisolone</td>
<td>Mild-severe acute asthma attack</td>
<td>1mg/kg once daily for 3 days</td>
<td>Tablet 5mg</td>
<td>tab</td>
<td>%</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Primaquine</td>
<td>Malaria (p. viv.)</td>
<td>0.25mg/kg once daily for 14 days</td>
<td>Tablet 7.5mg</td>
<td>tab</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Procaine benzylpenicillin</td>
<td>Various infections</td>
<td>50mg/kg once daily</td>
<td>Injection 250mg in 1mL</td>
<td>0.6</td>
<td>1.2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Quinine</td>
<td>Severe malaria</td>
<td>20mg/kg loading dose</td>
<td>Injection 600mg in 10mL</td>
<td>1ml</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Start 12 hours after loading dose, 10mg/kg BD IV or TDS oral</td>
<td>Injection 600mg in 10mL</td>
<td>0.6</td>
<td>1</td>
<td>2</td>
<td>2.5</td>
<td>4</td>
<td>5</td>
<td>7.5</td>
<td>10</td>
</tr>
<tr>
<td>Salbutamol (Use a spacer if available)</td>
<td>Mild acute asthma attack</td>
<td>6-12 puffs PRN</td>
<td>Inhaler 100mcg/dose</td>
<td>inh</td>
<td>6</td>
<td>puffs in &lt;6yr old</td>
<td>12 puffs &gt;6yr old</td>
<td></td>
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<td></td>
<td></td>
<td>G.15mg/kg QID</td>
<td>Tablet 4mg</td>
<td>tab</td>
<td>-</td>
<td>-</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate acute asthma attack</td>
<td>4-6 hourly PRN</td>
<td>Nebuliser 5mg in 1mL</td>
<td>ml</td>
<td>0.5ml in &lt;6yr old</td>
<td>1mL in &gt;6yr old</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>caps</td>
<td>Capsule 100.000iu</td>
<td>cap</td>
<td>1 capsule in &lt;1yr old</td>
<td>2 capsules in &gt;1yr old</td>
<td></td>
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</tr>
<tr>
<td>Zinc sulphate</td>
<td>Malnutrition</td>
<td>1mg/kg once daily for 5 days</td>
<td>Dispersible tablet 20mg</td>
<td>tab</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>1</td>
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## Medicines for Women and Mothers

<table>
<thead>
<tr>
<th>Drug</th>
<th>Indication</th>
<th>Dose Form</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoxycillin</td>
<td>Various infections</td>
<td>Capsule 250mg</td>
<td>2 capsules twice daily for 5-10 days</td>
</tr>
<tr>
<td></td>
<td>Pneumonia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UTI in pregnant women</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pyelonephritis</td>
<td>Capsule 250mg</td>
<td>4 capsules every 4 hours</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>Various infections</td>
<td>Injection 500mg in 2mL</td>
<td>500mg-1g every 4-6 hours, maximum 14g daily</td>
</tr>
<tr>
<td></td>
<td>Pneumonia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maternal sepsis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artesunate</td>
<td>Severe malaria</td>
<td>Suppository 200mg</td>
<td>Insert 2 suppositories and repeat in 10 minutes, then refer to NRH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Injection 60mg in 6mL</td>
<td>According to guidelines</td>
</tr>
<tr>
<td>Benzathine penicillin</td>
<td>Syphilis</td>
<td>Injection 900mg (1.2 mega units) in 4mL</td>
<td>1.8g as single dose</td>
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<tr>
<td></td>
<td>Prevention of rheumatic fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzylpenicillin</td>
<td>Pneumonia</td>
<td>Injection 600mg in 2mL</td>
<td>2g every 4 hours</td>
</tr>
<tr>
<td></td>
<td>Septicaemia</td>
<td>Injection 3g in 10mL</td>
<td></td>
</tr>
<tr>
<td>Calcium gluconate</td>
<td>Magnesium toxicity</td>
<td>Injection 10%</td>
<td>Infuse 10 mL of 10% diluted with sodium chloride 0.9% over 5–10 minutes, repeating once or twice if necessary</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>Severe infections</td>
<td>Injection 250mg in 1mL</td>
<td>500mg-2g, daily or twice daily</td>
</tr>
<tr>
<td></td>
<td>Pneumonia</td>
<td>Injection 1g in 4mL</td>
<td></td>
</tr>
<tr>
<td>Coartem®</td>
<td>Malaria (Plasmodium  falciparum)</td>
<td>Tablet 20mg/120mg</td>
<td>According to guidelines, twice daily for 3 days</td>
</tr>
<tr>
<td>(Artemether/Lumefantrine)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Dexamethasone</td>
<td>Improvement of fetal lung maturity</td>
<td>Injection</td>
<td>Seek specialist advice</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>Various infections</td>
<td>Injection 80mg in 20mL</td>
<td>6mg/kg at once, maximum of 400mg, then refer to NRH</td>
</tr>
<tr>
<td></td>
<td>Maternal sepsis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Prevention of iron and folate</td>
<td>Fefol® Tablet 200mg/0.4mg</td>
<td>1 tablet daily</td>
</tr>
<tr>
<td>FEFOL: Ferrous Sulphate / Folic Acid</td>
<td>deficiency during pregnancy</td>
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<tr>
<td></td>
<td>Iron deficiency anaemia</td>
<td>Fefol® Tablet 200mg/0.4mg</td>
<td>1 tablet twice daily</td>
</tr>
<tr>
<td>Hydralazine</td>
<td>Hypertensive emergency</td>
<td>Injection 20mg</td>
<td>2.5mg slowly every 20 minutes until Blood Pressure is controlled</td>
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<tr>
<td></td>
<td>Severe hypertension</td>
<td>Tablet 25mg</td>
<td>1 tablet twice daily, increased to maximum 100mg (4 tabs) twice daily</td>
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<tr>
<td><strong>Magnesium sulphate</strong></td>
<td>Severe pre-eclampsia Eclampsia</td>
<td>Injection 50%, 5g in 10mL</td>
<td>8mL over 10 minutes, followed by maintenance infusion of 4mL/hour (2g/hour). Another 2–4g dose may be given if there is a further seizure.</td>
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<tr>
<td>------------------------</td>
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<tr>
<td><strong>Methyldopa</strong></td>
<td>Severe hypertension</td>
<td>Tablet 250mg</td>
<td>½ -1 tablet twice daily, then adjust by ½ tablet daily at 2-day intervals, increased to maximum of 4 tablets daily.</td>
</tr>
<tr>
<td><strong>Metoclopramide</strong></td>
<td>Nausea and vomiting in pregnancy</td>
<td>Tablet 10mg</td>
<td>1 tablet three times daily, when required for nausea and vomiting</td>
</tr>
<tr>
<td><strong>Metronidazole</strong></td>
<td>Various infections Maternal sepsis</td>
<td>Injection 500mg in 100mL</td>
<td>500mg 2 – 3 times daily as part of multidrug regimen, maximum 4g daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tablet 250mg</td>
<td>1-2 tablets three times daily</td>
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<tr>
<td></td>
<td></td>
<td>Suppository 500mg</td>
<td>2 suppositories 2 – 3 times daily</td>
</tr>
<tr>
<td><strong>Misoprostol</strong></td>
<td>Post-partum haemorrhage Abortion</td>
<td>Tablets 200mg</td>
<td>Seek specialist advice</td>
</tr>
<tr>
<td><strong>Nifedipine</strong></td>
<td>Severe hypertension</td>
<td>Tablets 20mg SR</td>
<td>½ tablet crushed or chewed, repeated after 30 minutes. Maintenance with 1-2 tablets twice daily</td>
</tr>
<tr>
<td></td>
<td>Inhibition of uterine contractions</td>
<td>Tablets 20mg SR</td>
<td>1 tablet crushed or chewed, repeated after 30 minutes if uterine contractions persist. If contractions continue after 3 hours, give tablet every 3–8 hours until contractions cease or labour is established, maximum 8 tablets daily.</td>
</tr>
<tr>
<td><strong>Oxytocin</strong></td>
<td>Post-partum haemorrhage</td>
<td>Injection 5IU in 1mL</td>
<td>1mL in women who have given birth once or more before this labour 2mL in women whose first pregnancy/labour it is</td>
</tr>
<tr>
<td></td>
<td>Induction and augmentation of labour</td>
<td></td>
<td>1mL in women who have given birth once or more before this labour 2mL in women whose first pregnancy/labour it is</td>
</tr>
<tr>
<td><strong>Syntometrine® (Oxytoxin/ergotamine)</strong></td>
<td>Post-partum haemorrhage</td>
<td>Injection 5IU/0.5mg in 1mL</td>
<td>1 mL Syntometrine® IM following expulsion of the placenta or when bleeding occurs. Dose may be repeated after 2 hours.</td>
</tr>
<tr>
<td><strong>Phytonadione</strong></td>
<td>Haemorrhage due to hypoprothrombinaemia</td>
<td>Injection 10mg in 1mL</td>
<td>Serious bleeding: single dose IV 5–10 mg (depending on INR), assess patient continually until INR &lt;5 and bleeding stops. If INR is unavailable, single dose 5mg and immediately refer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Injection 1mg in 1mL</td>
<td></td>
</tr>
<tr>
<td><strong>Primaquine</strong></td>
<td>Malaria (p.65)</td>
<td>Tablet 7.5mg</td>
<td>2 tablets daily for 14 days following course of Coartem® CONTRAINDIATED IN PREGNANCY – USE AFTER DELIVERY</td>
</tr>
<tr>
<td><strong>Pyridoxine</strong></td>
<td>Nausea and vomiting in pregnancy</td>
<td>Tablet 50mg</td>
<td>½ tablet four times daily</td>
</tr>
<tr>
<td><strong>Quinine dihydrochloride</strong></td>
<td>Severe malaria</td>
<td>Injection 600mg in 10mL</td>
<td>Loading dose 20mg/kg, max 1.4g, then start maintenance dose 10mg/kg, maximum 700mg three times daily, starting 8 hours after loading dose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>injection 600mg in 10mL</td>
<td></td>
</tr>
<tr>
<td><strong>Sodium chloride</strong></td>
<td>Fluid replacement</td>
<td>Infusion 0.9% in 1000mL</td>
<td>As per medical advice</td>
</tr>
<tr>
<td><strong>STI Pack (AZithromycin / Cefixime)</strong></td>
<td>Chlamydial and/or gonococcal infection</td>
<td>2 x azithromycin tablet 500mg</td>
<td>Give all 3 tablets at once as a single dose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 x cefixime tablet 400mg</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 5: Patient Information Cards: Example

Shown: Childhood Diarrhoea

**DIARRHOEA**

**What is diarrhoea?**

Diarrhoea is the frequent passing of watery poo. There are lots of causes of diarrhoea (eg. food poisoning or an infection). In adults, diarrhoea will usually go away in 1-2 days. In babies and children, diarrhoea can be very dangerous, as it can cause severe dehydration quickly.

**What are some signs of diarrhoea?**

- Urgency to go to the toilet
- Frequent watery stools
- Abdominal pain/cramps
- Nausea/vomiting

**Some serious symptoms (see a doctor/nurse):**

- Sunken eyes and excessive thirst
- Repeated vomiting/inability to keep fluids down
- Blood in the poo
- Painful passing of poo
- Fever
- Diarrhoea for more than 2 days

**How can you help to prevent diarrhoea?**

- Wash your hands with soap and water often, especially after going to the toilet, before you handle or eat food, after you sneeze or cough and when caring for someone who is sick.

**How can you treat diarrhoea?**

If you have any serious symptoms (see front of card), you should see a Doctor or Nurse as soon as you can. If your baby or young child has diarrhoea, you should have them seen by a Doctor or Nurse as soon as possible as they are at risk of severe dehydration.

Treatment:

- Drink lots of fluids (diarrhoea is very dehydrating)
- Drink Oral Rehydration Solution (ORS)
- Drink coconut juice
- Give children and babies zinc sulphate
- Avoid fatty/sweet/spicy foods
- Avoid alcohol
- Sometimes, doctors or nurses may give antibiotics or anti-diarrhoeal tablets

**Where can you get more information about diarrhoea?**

- A &E, National Referral Hospital, Honiara
  Phone: 24313
- Your local doctor, nurse or pharmacist
- Your local clinic or hospital

Produced by Medicines Information Centre, National Referral Hospital, Honiara
DIARRHOEA

Wat nao diarrhoea?
Diarrhoea hem meanim taem iu garem beli ran. Staka samting na cosim diarrhoea oslem siknes o kaikai hem no gud. Lo oklanka biki man diarrhoea hem save finis seleva insaed lo tufala dei nomoa. Lo beli an pikini taem diarrhoea kasem oklanka hem densaras bae causim tumas wata hem aot (dehydration).

Wat nao saens lo diarrhoea?
- Usim toilet olowe
- Watery beli ran
- Soa lo beli
- Laek toroaot

Warning saen fo go lukim Nes o dokta
- Sunken eyes
- Barava laek diringi (thirsty)
- Staka toroaot
- Pikiniini less fo diringi o kaikai
- Blad lo beli run
- Pikiniini filim hot (fever)
- Beli run ovam tufala dei

Weis fo stopem beli run kam bak moa?
Washim hands blo olowe wetem soap an wata taem iu usim toilet, afta taem iu kof o snis, bifo iu kaikai an bifo an afta taem iu lukim samwan hem siki.

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Hao na iu save treatim diarrhoea?
Taem iu garem serious simtoms lo diarrhoea o taem beibi o pikiniini hem garem diarrhoea, iu nid fo lukim Dokta o Nes kwiktaem. Treatment lo hem:

- Drinkim staka klin wata (diarrhoea hem causim dehydration)
- Drinkim Oral Rehydration Solution (ORS)
- Drinkim wata blo coconut
- Beibi an pikiniini bae oklaka tekem zinc fo stopem diarrhoea kwiktaem
- Bae iu no kaikai girisi, swit or spicy kaikai
- Bae iu no drinkim alcohol
- Samtaems iu nid fo tekem antibiotics or meresin fo diarrhoea(anti-diarrhoea)

Sapos iu laekem samfala informeson moa, iu kontaktim:
- A &E, National Referral Hospital, Honiara
  Phone: 24313
- Lokol Dokta, Nes or Pharmacist
- Lokol Klinic or Hospital

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Note: Cards were printed double-sided (English and Pijin versions) on A5, 250GSM white paper.
Other patient information card topics:

Contraception
HIV
Maternal Sepsis
Neonatal sepsis
Pneumonia
Preterm Labour
Sexually Transmitted Infections
Vitamin A Deficiency
Appendix 6: Zinc/ORS Poster

GIVIM Zinc & ORS Fo Bele-ran


*Give Zinc for diarrhoea, 1mg/kg once a day for minimum 5 days. It will help your child get better quicker, and will stop the diarrhoea from coming back again.*

**ORS** - Lu nid fo givim ORS eni taem long dei, taem pikinini garem beli-ran. Olketa bae tekem ORS go-go kaseem taem bell-ran hemi finis. **Putim 1 pak long 1 lita klin wata.**

*Give ORS regularly throughout the day when your child has diarrhoea, until the diarrhoea stops.*