NETTING PARADISE

Betrayal of Trust

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Table of Contents

Authors Note

The first mosquito nets treated with an insecticide were known as Insecticide Treated Nets (ITNs). The insecticidal properties were short lived, and were later replaced with Long Lasting Insecticidal Nets (LLINs) when treated mosquito nets became wash proof and longer lasting in terms of insecticidal action.

Within the malaria scientific community, there has been an increasing trend in the last few years to refer to all LLINs as ITNs. This supposedly recognises that LLINs are a type of ITN, and practically all treated nets on the market are now long lasting ITNs.

In my working career, I have always referred to treated malaria nets as LLINs. The name suggests that they should last a long time, even though they are not as long lasting as they once were, as this book explores. For this reason, I have gone against the generic use of ITNs and referred to long-lasting treated nets as LLINs throughout the book.

If you like this book, and would like to make a contribution to its publication, please go to website https://nettingparadise.com/. Please note all contributions will be split and 50% of funds raised will go towards research to improve LLINs.

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ABBREVIATIONS

AAV	Adopt A Village
ACT	Artemisinin-based Combination Therapy
AI	Artificial Intelligence
AMF	Against Malaria Foundation
BCC	Behaviour Change Communication
CCM	Country Coordinating Mechanism
CPHL	Central Public Health Laboratories
CPS	Community Profile System
DDT	dichlorodiphenyltrichloroethane
DHT	District Health Team
GF	Global Fund
IMR	Institute of Medical Research
IRS	Indoor Residual Spraying
ITN	Insecticide Treated Net
HEO	Health Extension Officer
LLIN	Long-Lasing Insecticidal Net
NDoH	National Department of Health
NHIS	National Health Information System
NMCP	National Malaria Control Program
NSO	National Statistics Office
OSF	Oil Search Foundation
PBO	Piperonyl Butoxide (synergist added to LLINs)
PNG	Papua New Guinea
PNGSDP	PNG Sustainable Development Program
PQT-VCP	WHO Prequalification Vector Control Products Unit
PSI	Population Services International
PSSB	Pharmaceutical Services Standards Branch
RAM	Rotarians Against Malaria
RBM	Roll Back Malaria
RDT	Rapid Diagnostic Test
SOC	Shipper Owned Container
WHO	World Health Organisation
WHOPES	WHO Pesticide Evaluation Scheme

Netting Paradise

INTRODUCTION

TREATED MOSQUITO NETS FAIL TO CONTROL MALARIA IN WORLDWIDE

Long Lasting Insecticidal Nets (LLINs) are no longer as effective as they used to be. This has contributed to rising malaria cases globally and led to the waste of billions of dollars in aid and malaria still accounting globally for the deaths of over 600,000 people each year.

In Papua New Guinea (PNG), malaria rates dropped significantly between 2007 and 2015 due to a national program which distributed LLINs across the country. In 2016, however, experts noticed that cases of malaria were steadily increasing. This came as a surprise given that from 2007 to 2019, PNG received LLINs from a single manufacturer for the national malaria control program. After a scientific investigation was carried out on the nets, it was determined that nets manufactured between 2007 and 2012, killed 100% of mosquitoes when new and remained effective killing mosquitos for over 5 years. But from LLINs manufactured from 2013 onwards, the same LLIN brand failed to kill all mosquitoes even when new, and lost most of its insecticidal effectiveness within a year.

Due to these findings, PNG began using other LLIN brands from 2020, but most performed worse than the LLINs received before 2013 and similar to the ineffective 2013–2019 LLINs. When this was reported to global stakeholders, including The Global Fund and WHO, they failed to acknowledge and address the problem.

All LLINs produced globally are evaluated under what is called WHOPES (WHO Pesticide Evaluation Scheme). The scheme has failed to ensure consistent product quality, leading to a dramatic decline in LLIN performance driven by a donor-funded market that rewarded quantity over quality. As a result, ineffective LLINs continue to be purchased, despite their compromised ability to control malaria. This has led to massive financial waste and an increased risk for thousands of people from a preventable disease, highlighting serious flaws in the global health system's ability to respond to problems.

Netting Paradise is a story about the discovery of these poorly performing nets and the reaction of a global health system mired be fear of rocking the boat. It is also the story of a dedicated group of individuals belonging to Rotarians Against Malaria (RAM) who, for fifteen years, consistently delivered LLINs to all households in every village in PNG every three years. This was a significant challenge given PNG's poor infrastructure and the fact that many villages lie in remote mountain ranges and islands only reachable by dinghy over dangerous seas. RAM's efforts were seriously undermined by the change in efficacy in LLINS.

Each Chapter is a story in itself so please feel free to read the book in any order. The story of malaria control in PNG starts from Chapter One, while the issues of ineffective LLINs starts in Chapter Seven. Please refer to the Chapter Descriptions below.

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CHAPTER DESCRIPTION

Preface – How my story and the PNG malaria program began.

Chapter One – "Mal Aria" – Explores the history of malaria, its global impact and the history of the measures taken to treat and control the disease. It outlines the development of Long-Lasting Insecticidal Nets (LLINs) in humanity's bid to eliminate malaria.

Chapter Two - The Beginning of the Rotarians Against Malaria (RAM) Program – Recounts my arrival in PNG, the beginnings of RAM's malaria LLN distribution program and the first phase of implementation.

Chapter Three - Papua New Guinea – Gives a glimpse into the country of PNG, its history, people and geography, and the key challenges to running a program in PNG.

Chapter Four - PNG LLIN Distribution Strategy – Provides an outline of how the program was planned and organised to distribute nets to all villages every three years throughout PNG.

Chapter Five - The Malaria Program Partners – Offers a background to the donors and implementing parties working towards malaria control in PNG, including the Global Fund, Against Malaria Foundation, PNG SDP, Rotary International, RAM and others.

Chapter Six - Issues Faced in Field Operations – Outlines the challenges faced in implementing an LLIN distribution program in PNG, including issues such as geography, fraud, relationships, staff discipline etc.

Chapter Seven - World Health Organisation Pesticide Evaluation Scheme (WHOPES) – Delves into the historical body's control of the quality of LLINs and other pest control products. It also highlights how LLINs were approved, and how the approval system ultimately has failed and now allows poorly efficacious LLINs to still be sold worldwide. Despite WHOPES no longer existing, its legacy lives on.

Chapter Eight - Signs of Trouble of LLINs in PNG - Explores how, following a successful reduction of malaria in the early years of RAM's malaria program, malaria in PNG began to rise and continues to rise. This chapter covers the discovery that the LLINs supplied in PNG were no longer as good as they used to be, and more importantly, the difficulties experienced with the global malaria community to persuade them that this was a global problem, not just a PNG problem. In both cases, nothing was properly addressed or resolved, resulting in business as usual and the continued purchase of poorly efficacious LLINs costing billions in wasted aid.

Chapter Nine - Public/Private Partnerships - Outlines the role of the private sector in the public sector and the possible conflicts of interest affecting the ultimate efficacy of LLINs.

Chapter Ten - The Hare and The Tortoise – Unpacks the world's desire to have single "magic bullet" quick fixes for malaria (and other issues) and how slow and varied interventions, which are properly implemented, are likely to have more lasting results on malaria.

Chapter Eleven – Future Malaria Control Recommendations – Suggests possible future malaria control options for the future.

PREFACE

For most of my adult life, I've been known as the Mosquito Man, the Net Man, or the Malaria Man, names that reflect my 33 years working to prevent and eliminate malaria around the world.

I was born in Nigeria to Christian missionaries from the United Kingdom. Their faith and dedication inspired me, though I chose a different mission path. After a brief stint in the UK police force, I realized my interest lay in solving mysteries and also exploring remote places. That curiosity led me to malaria, a disease that kills hundreds of thousands each year, and gave me a purpose that matched my investigative inclinations.

In the 1980s, while teaching biology at a high school in the town of Chinhoyi, Zimbabwe, I began learning about malaria interventions in rural communities. In 1991, I joined the Blair Research Institute (now the Zimbabwe National Health Institute of Health Research) in Harare as a government health researcher, focusing on how mosquito nets and other interventions could reduce malaria cases and deaths. I also launched my own community-based malaria programs; one a rural net distribution program in the Zambezi Valley, selling nets through health centres in remote areas and by mail order, and secondly, working with schools and communities to wipe out mosquito breeding sites.

From 1998 to 2001, I worked in Eastern Afghanistan during the original Taliban rule, managing a malaria control program in often remote mountainous villages. I also consulted in Tajikistan, India, Malawi, and Kenya, gaining insight into how malaria strategies vary across regions. In 2001, I moved to West Africa to work with the World Health Organization in Liberia, Sierra Leone, and Guinea, before joining UNICEF as a malaria program officer in Mozambique for seven and a half years.

In Mozambique, I refined strategies for distributing LLINs and coordinated all malaria-related projects for UNICEF. Our UNICEF program delivered over half a million nets between 2002 and 2009. Eventually, UNICEF shifted its focus away from malaria, (a surprising decision as UNICEF was one of the founders of the global Roll Back Malaria initiative) and my international post was replaced with a local one. Faced with the challenge of finding new work, I eventually came across an unusual job listing: *Rotarians Against Malaria (RAM) is seeking someone to deliver five million nets in five years in Papua New Guinea (PNG).*

Though I'd never handled such a large-scale distribution, mosquito nets had been a constant in my career. The job felt like a natural next step, even though I'd been telling myself it was time to move on from LLINs. After an interview at Bangkok Airport with the chairman of RAM, I was soon on a plane to PNG. It felt surreal. Rotary was something I associated with retired businessmen doing good, and the scale of this project was far beyond what I expected. I knew little about PNG beyond its birds of paradise, and online information about the program was scarce.

Over the next 15 years, I witnessed both the successes and failures of LLINs in PNG. Initially, the nets dramatically reduced malaria and saved lives. But after 2013, a change in the chemical composition of the nets led to a resurgence of malaria. Investigations revealed serious flaws in how LLINs are regulated and monitored globally. Despite strong evidence of reduced effectiveness published globally, these LLINs continued to be approved and widely distributed, costing billions in aid, with limited impact on malaria.

This book shares the journey of the malaria program in PNG, the challenges faced, and the lessons learned. It offers a glimpse into what a successful malaria control effort can look like if the tools we rely on truly work. With the right strategies, effective interventions and efficacious LLINs, eliminating this deadly disease is still within reach but a change in attitude is needed, not just business as usual.

CHAPTER ONE – "Mal Aria"

Chapter Summary

- Malaria is an ancient and lethal disease transmitted by mosquitoes
- Malaria lifecycle and dependency on temperature
- Developing medicines for malaria
- Early days of malaria control targeting larval habitats and prevention of mosquito bites.
- Development of insecticides and eventually treatment of mosquito nets.

An Ancient Disease

Malaria is an ancient disease that has plagued humans since their early existence. For centuries people thought that malaria, a deadly disease, now known to be spread by a specific type of mosquito, was transmitted through the air. Its name, "*mal aria*", means bad air in Italian often associated with swamps. It is a name that perhaps captures the fear that people may have had of this invisible killer that gripped thousands with horrendous fevers, seemingly out of nowhere.

Malaria is a protozoan parasite that lives in the blood of many species on Earth and has probably existed for millions of years. There are at least 200 known species of malaria parasites that exist in birds, reptiles such as lizards, and mammals such as bats, antelope, mice, monkeys and man. Similar malaria parasites are found in apes like chimpanzees and gorillas, and it is likely that malaria parasites transferred to humans when humans were living in close proximity to primates. While most malaria parasites are host specific (i.e. they cannot jump around from one species of animal to another), humans suffer from five malaria species known as Plasmodium *falciparum, P. vivax, P. ovale, P. malariae and P. knowlesi*, the latter being a monkey parasite predominantly found in south-east Asia where monkeys closely coexist with humans.

Malaria parasites are usually transmitted through the bites of certain types of female Anopheline mosquitoes. There are worldwide over 400 species of Anopheline mosquitoes, but only about 70 can transmit malaria, with about 40 species being considered major vectors. In PNG, the main malaria vector is *Anopheles farauti*, which is composed of nearly eight identical species with different behavioural and ecological characteristics. Interestingly, not all these *An. farauti* species transmit malaria. It should also be noted malaria parasites can also be transmitted directly from one person to another through direct transfer of blood such as in blood transfusions.

It should be noted that Anopheline mosquitoes are generally very easy to identify from other mosquitoes due to their unique resting position. When resting, adult mosquitoes rest with the abdomens (backsides) in the air and their heads close to the resting surface. Other species of mosquito, such as Culicine and Aedes mosquitoes responsible for diseases such as yellow fever, dengue, chikungunya, Japanese encephalitis, Zika, and filariasis (elephantiasis) - tend to rest with their bodies parallel to the resting surface.

When an Anopheline mosquito bites a person, it spits out saliva which contains an anticoagulant to prevent the blood from clotting and blocking its mouthparts (proboscis). If the mosquito is infected with malaria, it also injects the malaria parasites (known as sporozoites) into the person's bloodstream at the same time as the saliva. Once in the bloodstream, the sporozoites make their way to the liver, where they invade liver cells and form hypnozoites.

This is where the malaria story gets more interesting. Hypnozoites grow and develop, eventually bursting to release merozoites, which invade red blood cells to start the malaria cycle again. However,

in certain species, particularly *P. vivax* and *P. ovale*, some hypnozoites go into a type of hibernation. Depending on the variety and the part of the world, these hypnozoites can burst out later and start the malaria cycle again without involving a mosquito. My own father, a missionary in Nigeria, was hospitalized with malaria in Manchester, United Kingdom, two years after returning from Nigeria. This "party trick" of remaining dormant in the liver allows some species of malaria to survive in colder places and winter periods when mosquitoes cannot survive as adults.

You will likely know you have malaria by the severe, recurring fever. The fever starts with a 15-to-60-minute cold stage of shivering and the body feeling very cold. This is followed by a hot stage lasting 2-to-6 hours, with a fever that can reach 41°C, causing flushed skin, headache, nausea, and vomiting. Finally, there's a sweating stage lasting 2-to-4 hours, where the fever drops rapidly, and the patient sweats profusely. If you experience these symptoms, you should seek medical treatment immediately. Delaying treatment can be fatal, especially if you live in, or have recently visited, tropical regions of the world.

Malaria fever is linked to the malaria parasite's life cycle. The fever is caused by the malaria parasite stage known as merozoites which develop in red blood cells. A merozoite in blood plasma invades a red blood cell after which it multiplies and grows up to produce 16 to 32 new merozoites. When fully developed, the merozoites burst together from red blood cells every 24, 48, or 72 hours, depending on the species. The release of merozoites causes an immune response and subsequent fever. *P. knowlesi* causes fevers every 24 hours, *P. vivax* and *P. ovale* every 48 hours, and *P. malariae* every 72 hours. *P. falciparum*, however, causes erratic fevers, making it harder to identify without testing the blood with a microscope or rapid diagnostic test (RDT).

The malaria parasite's life cycle becomes more complicated when it passes from one human to another. Merozoites, which invade and multiply in red blood cells, can also transform into sexual forms known as gametocytes. There are male and female gametocytes, which remain within the red blood cells and float in the bloodstream until they are hopefully ingested by a female Anopheline mosquito. When the mosquito ingests the gametocytes, they combine with a gametocyte of the opposite sex in the mosquito's stomach to form an ookinete. The ookinete then invades the mosquito's stomach wall, growing and dividing to form an oocyst. The oocyst grows on the outside of the mosquito's stomach wall and eventually bursts to release many new parasites called sporozoites into the mosquito body. The sporozoites then travel to the mosquito's salivary glands starting the whole cycle again.

Today, malaria remains a very serious and often fatal disease in humans when left untreated. In 2022, the World Health Organisation (WHO) estimated that globally there were 249 million reported cases of malaria and 608,000 reported malaria deaths (2.4 deaths per thousand cases). Most of these malaria cases and deaths occur in Africa (estimated at about 96% of cases), particularly amongst children under five years old. Outside of Africa, one country stands out in terms of malaria, and that is Papua New Guinea (PNG). PNG accounts for about 88% of the confirmed malaria cases in the Western Pacific region and has one of the highest numbers of confirmed and assumed malaria cases in any country in the world outside of Africa. This makes PNG of special interest to the malaria world.

A Temperature-Dependent Disease

One of malaria's “weaknesses” is that it is often restricted to warmer climates because mosquitoes need warmth for their lifecycle development. Cold temperatures knock mosquitos out and consequently the parasite which is also “cold-blooded”. In scientific literature, it is estimated that *P. vivax* needs an average temperature of 16°C to develop in a mosquito while *P. falciparum* needs an average temperature of 18°C. But even at these temperatures, malaria parasites have difficulty surviving and malaria transmission dynamics are poor, and it is only as temperatures further increase

that malaria starts thriving. Essentially, the warmer the temperature, ideally over 24 °C, the faster the mosquito and the malaria parasite develop and high transmission and outbreaks can occur.

In cold temperatures, an adult mosquito will die before the parasites can develop. Mosquitoes live only about 30 days on average, so the parasite must develop within the mosquito before it dies. At average temperatures of 20°C, P. vivax takes about 20 days to develop in a mosquito, while P. falciparum needs about 24 days. With a maximum life cycle of about 30 days, and mosquitoes generally not feeding for the first three days of their life, the malaria parasite has little time to develop in its mosquito host. Furthermore, few mosquitoes live to 30 days in reality. After they emerge as flying adults from their water nurseries, some scientists estimate that up to 30% of adult mosquitoes die each day, so it takes thousands of mosquitoes for a few to survive to 30 days and for any malaria parasites to survive.

Therefore, *P. falciparum* malaria is mainly found in hot tropical parts of our planet, with high temperatures year-round. *P. ovale,* and particularly P*. vivax*, which can hibernate in the liver, have also historically been found in higher latitudes where summers are hot and winters are cold. *P. vivax* has been recorded in the past in northern countries like the United Kingdom, Holland, and northern Russia, for example. During summer, the parasites could multiply, while in winter, *P. vivax* would remain dormant in the liver, ready to emerge the following year.

There is a theory that good parasites do not kill their hosts, as they depend on them for survival. P*. falciparum* does not seem to follow this rule, suggesting it is still learning to live with its host or that its survival does not depend on whether some people die. *P. vivax* can also kill, but less often. It can be argued that *P. vivax* survives in more marginal areas, and if it kills its host, its chances of survival from one generation to the next diminish.

Conversely, *P. falciparum* is not as deadly as many people think for those who have lived with it in their communities for centuries. In these communities, children suffer the most because they are born with little immunity and must develop it throughout their childhood. Historically, without medicine, up to 20% of children in Africa died before the age of five due to malaria. If they survived past this age, they were unlikely to die from malaria later in life. Europeans, however, have no historical immunity to malaria, making *P. falciparum* particularly deadly if not treated promptly.

The Long Search for Treatments

It took a long time for scientists and experts to find effective malaria treatments. A major problem was distinguishing malaria from other fevers. Malaria was not accurately described until the late nineteenth century, so treatment remained elusive until it was clearly distinguished from other fever diseases. It was only in 1880 that the first malaria parasites were identified in Algeria by a scientist named Laveran. However, attempts to treat malaria date back much earlier.

In around 1600, a Jesuit priest in Peru discovered the use of a "fever bark tree" by local Indians to treat diseases with certain types of fevers. According to legend, he used the tree to treat a princess who then brought it to Europe. This bark, known as Jesuit's Powder, came from the Chinchona tree and produced quinine. Despite its early discovery, it took over a hundred years to realize that Chinchona bark cured only diseases with intermittent fevers. It wasn't until 1820 that the active ingredient, quinine, was isolated and used to treat malaria effectively in the tropics. Chinchona trees were then exported from Peru and plantations started in Indonesia and India. The irony of the large-scale cultivation of Chinchona in 1854 is that it preceded the actual description of malaria as a distinctive disease.

The urgency to find treatments for malaria became more acute during the latter part of the 19th and early 20th Century, when Europeans increasingly found themselves warring in tropical parts of the world. For example, many British troops traveling through Beira in Mozambique to fight in the Boer War (1899 – 1902) fell ill and died of malaria before reaching South Africa. During the First World War, countries with access to quinine fared much better. In 1924, a new synthetic antimalarial drug, pamaquine (Plasmoquine), was introduced. Ten years later, chloroquine was developed in Germany in 1934, followed by primaquine in 1952, which is the only drug able to destroy the liver stage hypnozoites of *P. vivax* and *P. ovale*. Despite these developments, malaria significantly impacted soldiers deployed in the tropics during World War Two. In the Pacific region, there was a saying that malaria was more dangerous than the Japanese. War was also a powerful incentive to have good treatments for malaria.

Chloroquine increasingly became the global drug of choice for malaria. It is interesting to note that chloroquine (Resochin) was discovered by German scientists along with another drug, 3-methyl-chloroquine (Sontachin). The formula for Resochin was passed to a sister company in the United States, while Sontachin was manufactured by the Germans. During the war, French soldiers found a stock of Sontachin in Tunis and handed it to the Americans, who scientists improved its efficacy. They compared the new formulation with Resochin and found it was the same formula given in 1934 which had been considered toxic at the time and not developed further. From then on, chloroquine (Resochin) became the worldwide antimalarial of choice. While generally safe, chloroquine can cause side effects like severe itching and, in my case, vomiting after prolonged use as a prophylaxis in Zimbabwe.

Another key breakthrough for malaria control was understanding the lifecycle of the adult Anopheles mosquito, which, if disrupted, could reduce the number of malaria carriers and therefore the chances of spreading malaria. Mosquitoes lay their eggs in open water, which hatch into fast-wriggling larvae. In the case of Anopheline mosquitoes that transmit malaria, the preferred larval habitats to lay eggs are often clean rain water puddles which are exposed to sunlight.

Anopheline larvae are easy to recognize as they rest parallel to the water surface, unlike other mosquito larvae, which hang down with their tails (syphons) attached to the surface. In hot weather, the development of mosquito larvae can take seven days or less. When the larvae are fully grown, they change into a non-feeding form known as pupae. After a day or two, adult mosquitoes emerge from the pupae.

In the end, it all made sense. Mosquitoes develop in water, and intermittent fevers in England, Holland, Russia, and Italy were all associated with swamps. Such fevers were even recorded in Roman times during their summers. The answer was clear; no open standing water meant no mosquitoes, which means no malaria transmission. This can be summed up as "no water, no mosquitoes, and no malaria."

Even before 1900, when it was conclusively proved that malaria was transmitted by mosquitoes, malaria control measures were implemented in Sierra Leone and Cuba in 1899 and in Malaysia in 1901. Perhaps the most spectacularly successful program was in the Panama Canal from 1904 to 1914, where both malaria and yellow fever were eliminated in the Panama Canal zone. In all these areas, the main emphasis was on controlling mosquitoes, particularly young mosquito larvae living in water.

The Panama Canal Project began in 1881 by the French to create a shipping shortcut between the Atlantic and Pacific Oceans, significantly reducing shipping distances and costs. However, the area through which the canal was to pass was infested with malaria and yellow fever. Malaria ultimately thwarted the French attempts to build the canal, as many workers died from malaria and yellow fever. This caused investor confidence to falter and the French efforts to collapse.

In 1904, the United States took over the responsibility of building the Panama Canal. They employed General William C. Gorgas and his deputy Joseph A. A. Le Prince, who had already eradicated malaria and yellow fever in Cuba, and were asked to repeat their success in the Panama Canal.

Le Prince wrote a book about the malaria control program in Panama, detailing the extent to which the control teams went to eliminate malaria. The program was run with military precision and included extensive sanitation projects, city water systems, fumigation of buildings, spraying of mosquito larval habitats with oil and larvicide (Paris Green), the installation of mosquito netting and window screens in houses and dormitories, and the elimination of stagnant water. Additionally, teams of workers swatted adult mosquitoes resting in houses and tracked swarms to potential larval habitats which were then treated with larvicides.

Within a few years, Gorgas and Le Prince's teams had eradicated both yellow fever and malaria from the Panama Canal Zone. This success highlights the importance of an almost military approach, good financial backing, and thorough implementation of malaria control methods. This attention to detail and military precision is perhaps an approach to malaria control that later malaria control programs have tended to forget.

Malaria control continued from 1914 using similar methods to those in the Panama Canal, focusing on sanitation and environmental control against mosquito larvae (spraying water and draining swamps) and mosquito nets to prevent bites at night. Another famous malaria control program occurred in Brazil in 1939, when the African mosquito (*Anopheles gambiae*) invaded and spread across the country. Frederick Soper led this program, treating the problem as a war and using all available methods to eliminate *An. gambiae* from Brazil within two years. Similar success was also achieved in Palestine by 1926 and Egypt between 1942 and 1945.

While sanitation methods expanded malaria control, other methods developed, particularly insecticides for adult mosquitoes. Early methods used certain species of Chrysanthemum flowers known in China to control insects. The flowers, called "Caucasian Insect Powder Plant" and "Feverfew," were ground into "Caucasian insect powder" and sold across Europe from the 1850s. However, the powder was too expensive for widespread use until the active ingredients were isolated in 1922, leading to pyrethrum. Pyrethrum, the first commercial synthesized insecticide, was used against adult mosquitoes for malaria control in South Africa, the Netherlands, and India by 1935. Additionally, pyrethrum insect powder mixed with sawdust produced mosquito coils, first made in Japan in the 1880s, and still used today to repel mosquitoes.

Malaria control advanced further when German scientists discovered the insecticidal action of dichloro-diphenyl-trichloroethane (DDT) in the early 1940s. This led to other organochlorine insecticides like Hexachlorocyclohexane (HCH) and Dieldrin, which had long residual activity.

The first successful use of new insecticides was in Cyprus in the early 1950s. DDT was the insecticide of choice, used as a larvicide, and Cyprus became the first country to eliminate malaria using this method. Venezuela also used DDT as a residual insecticide in households, leading to the elimination of malaria in northern Venezuela by the 1950s.

These successes led the World Health Organization (WHO) to initiate a worldwide malaria eradication program in 1955. Using DDT as a residual insecticide on the walls of houses, known as Indoor Residual Spraying (IRS), malaria was eliminated from Europe, most of North America, many parts of South America, the Caribbean, and countries like Australia, Japan, Singapore, Korea, and Taiwan. However, by 1969, malaria had returned to several countries and was uncontrolled in many others, particularly in Africa, due to donor fatigue and insecticide resistance. Consequently, malaria elimination shifted to

malaria control in 1969, leading to a general increase in malaria cases in affected countries. From 1974 to 1977, malaria cases doubled, and although the cases were later reduced, during the 1980s, malaria levels remained higher than those recorded during the eradication program.

In 1979, a WHO Expert Committee assessed the status of global antimalaria programs. Of the 143 countries where malaria was originally endemic, 37 were malaria-free, and another 16 had reduced malaria to minimal levels. However, despite the DDT elimination program, 90 countries still faced moderate to high malaria risk. Consequently, the worldwide elimination program was stopped, and malaria control efforts reverted to individual countries, integrating malaria control into their overall health systems. In many cases, this meant relying solely on the Primary Health Care system for treatment, with minimal vector control efforts. Some countries, like South Africa and Zimbabwe, continued house spraying with their own resources, but overall, IRS was abandoned, leading to a resurgence of malaria in many countries. DDT also became unpopular due to its persistence in the food chain and subsequent perceived environmental impact, as highlighted in Rachel Carson's 1962 book, Silent Spring.

After the global IRS program ended in 1979, malaria control shifted toward mass and presumptive treatment. Chloroquine, which was a cheap and widely available drug, was given to anyone with a fever, assuming they might have malaria.

The alternative to presumptive treatment was laboratory testing. In the 1980s and earlier, this meant examining stained blood samples under a microscope, a method that required skill and patience. Microscopists had to inspect 100 fields of view to confirm a negative result, which was time-consuming and often led to errors due to fatigue. Doctors frequently ignored these results and treated patients anyway, discouraging microscopists. In busy hospitals, where there few microscopists who could only examine about 60 slides a day, this meant most suspected malaria cases were treated without proper diagnosis.

Because chloroquine was inexpensive, precise diagnosis wasn’t prioritized. Still, microscopy remained valuable where possible. When I began working in malaria in 1991, quick access to chloroquine was vital. In Zimbabwe, it was sold in shops, and people were urged to self-treat early using a full adult dose, promoted through media campaigns.

Mass treatment with chloroquine was simple and effective, until drug resistance emerged. First reported in Thailand in 1957, chloroquine resistance spread globally over the next decades, reaching Malaysia, South America, and much of Asia and Africa by the 1980s.

As resistance grew, other drugs like SP (Sulfadoxine-pyrimethamine) and amodiaquine were used. In Papua New Guinea, SP was combined with chloroquine or amodiaquine around 2000. However, resistance to SP also developed, making treatment more difficult and requiring stronger drugs like quinine. Fortunately, alternative drugs were being developed.

In 1972, Chinese scientists synthesized Artemisinin from the Sweet Wormwood plant. This drug was very effective against malaria, and to combat future drug resistance, it was later combined with other drugs to form Artemisinin Combination Therapies (ACTs), such as Coartem (artemether-lumefantrine), introduced in 1999. ACTs were highly effective but much more expensive than earlier treatments. Presumptive use risked accelerating resistance, and microscopy remained costly and inconsistent.

In the 1990s, Rapid Diagnostic Tests (RDTs) were developed. Though less sensitive than microscopy and initially limited to detecting *P. falciparum*, they were affordable and gave results in 20 minutes. Later RDT versions could identify all malaria species, though they still couldn’t detect very low parasite

levels like microscopy which remains the gold standard in the field, though other laboratory-based tests now exist.

By 2002, with the launch of the Global Fund, effective RDTs enabled targeted use of ACTs, ensuring only confirmed cases received treatment.

Mosquito Nets

Concurrent with all these developments, the last important part of the present global malaria control strategy was the development of Insecticide Treated mosquito Nets (ITNs) and the later Long-Lasting Insecticidal Nets (LLINs) which became an important key part of the global efforts against malaria, and an important discussion point in this story.

Mosquito nets have been used for centuries, with historical records showing their use by the Romans, Greeks, Indonesians and Cleopatra in Egypt. Over the last 130 years, mosquito nets have been advocated as a key component for malaria prevention and control worldwide.

Mosquito nets form a physical barrier from biting mosquitoes, which is particularly important for malaria carrying mosquitoes which only bite at night. Despite not being fool proof, particularly when having to leave the net, mosquito nets have always provided reliable protection against malaria.

The combination of mosquito nets with insecticides marked a turning point in malaria control. These treated nets provide physical protection while also killing mosquitoes that come into contact with them, significantly reducing transmission. As a result, they safeguard not only those sleeping under the nets but also others nearby, creating a broader protective effect across the community.

In the 1950s, new insecticides based on pyrethrum were developed, known as synthetic pyrethroids. Early versions of synthetic pyrethroids, were sensitive to sunlight and didn't last long in the environment. Later, more stable and long-lasting synthetic pyrethroids were developed, such as Permethrin (developed in 1973, marketed in 1977) and Deltamethrin (developed in 1974, marketed in 1978). Other long-lasting synthetic pyrethroids were later developed and include Lambda-cyhalothrin, Cypermethrin, and Alphacypermethrin. These insecticides are extremely toxic to insects but very safe for humans. Their only downside is that they are also toxic to fish, making them unsuitable for use as larvicides.

With the development of these more durable synthetic pyrethroids, the idea of combining them with mosquito nets was born. During the early 1980s, scientists conducted several trials on treated mosquito nets, with competition between French and English-speaking researchers. The first papers on using ITNs against malaria were published in 1984 from Burkina Faso and Mali. In 1987, papers were published from Tanzania and Papua New Guinea, followed by Gambia in 1988.[1]

Treating nets with synthetic pyrethroids has one problem. The insecticide only remains for a few months, and if you wash the net, the duration is shortened. In practice, this meant that ITNs needed re-treatment every six months, which was tedious and labour-intensive.

By 2001, the first Long-Lasting Insecticidal Net (LLIN) was registered (prequalified) by the World Health Organisation (WHO) Pesticide Evaluation Scheme (WHOPES). This LLIN was known as the Olyset net and manufactured by the Japanese company Sumitomo. This was followed by the PermaNet 2.0 in

[1] In PNG, the trials were carried out by the PNG Institute of Medical Research (IMR). The PNG IMR would go on to play a pivotal role in the country's malaria research and later studies of declining efficacy of LLINs which is a major feature of this book.

2004, made by the Danish company Vestergaard Frandsen. Following the WHOPES evaluation, these LLINs could be sold on the open market for public health programs[2].

Initially, only these two types of LLINs were available sparking competition and rivalry between them. The Olyset net, made of polyethylene infused with permethrin, was heavy, rigid, and bulky. Its design allowed for the slow release of insecticide over time. In contrast, the PermaNet 2.0 was made from polyester, making it softer, lighter, and more comfortable to the touch. For polyester nets, insecticide was applied to the surface of the fibres using a glue or binder, enabling gradual release to effectively kill mosquitoes.

Although permethrin had a shorter residual effect compared to deltamethrin, it offered a significant advantage: strong repellency. This meant that mosquitoes were less likely to bite individuals even when their skin was pressed against the netting. Other synthetic pyrethroids often lack this level of repellency, which can result in mosquitoes biting through the net when people inadvertently lean against it from the inside. Olyset nets were also touted as being more durable while PermaNet 2.0 was better liked communities due to its softness.

Other LLINs were later prequalified by WHOPES, but for the first few years, only Olyset and PermaNet were available, giving them a global monopoly. I was closely involved with distributing Olyset nets in Mozambique and PermaNet in PNG, but throughout, the intense rivalry remained between the two products.

It is PermaNet 2.0 which much of this book is about, together with other Long Lasting Insecticidal Nets (LLINs) which were to follow. Many of these nets were similar or copies of the PermaNet 2.0 and others similar to the Olyset net in that they are made of polyethylene and the insecticide was impregnated into the net fibres.

LLINs became the mainstay of malaria control worldwide from 2003 onwards, including Papua New Guinea (PNG). It was my job to coordinate the distribution of LLINs throughout PNG from 2010 to 2024.

In PNG, like other countries in the world, the strategy was to distribute LLINs to all malaria affected households every three years. In addition to this, all suspected cases of malaria were to be tested with microscopy or Rapid Diagnostic Test (RDT), and finally treat all confirmed cases of malaria with ACTs.

[2] One of the mysteries about LLINs is who developed the technology to make ITNs more Long Lasting. Sumitomo had been working on impregnating polyethylene fibres with slow releasing insecticides since the early 1990's. It is not clear who developed the methodology to stick the insecticide onto the surface of fibres of polyester nets. In 1999, I attended a malaria ITN conference in Dar es Salaam, Tanzania. At this meeting I met a chemist from the United States who claimed that he had the technology to make insecticides last longer on nets without frequent re-treatment. I do not know what became of the chemist, but I suspect he sold his technology to an insecticide or bed net company. I often wonder if he was one of the fathers of polyester LLINs.

CHAPTER TWO - The Beginning of the Rotarians Against Malaria (RAM) Program

Chapter Summary

- The journey to PNG.
- The first days of building the program
- The first phase of implementation

After accepting the malaria position in Papua New Guinea, I decided to go there as soon as possible. I took a month's leave before my contract with UNICEF ended and headed for the United Kingdom (UK). Apart from seeing my children who were both living in the UK, it was the only country where there was a PNG High Commission from which I could collect my work visa. I was told that the visa had been processed and should be ready when I arrived in London, but I was about to learn a valuable lesson about PNG, and the way things might get done in the future.

Upon reaching London, the PNG High Commission informed me that my visa had not arrived from PNG and was therefore not ready. They also required additional documentation, including a medical report, police report, and an HIV test, information I hadn't received beforehand. PNG was one of the few countries that also mandated an HIV test result before allowing employment, meaning I had to undergo an HIV/AIDS test.

This is when I discovered the conveniences of the developing world compared to the developed world. In the developing world, obtaining an HIV test is straightforward. You visit a specialized clinic, receive counselling, and within thirty minutes, you have your results. In the UK in 2009, it turned out the same test would take many days, three of which was to make an appointment in advance, and probably another seven days to get a result.

The weather in the UK at this time was the coldest on record for many years. I was freezing, with much black ice which made walking on the streets dangerous. I was also sleeping on the floor of my daughter's student residence sharing the space with two dogs. I was then informed that the PNG High Commission was closing for three weeks over the Christmas and New Year period.

Frustrated and freezing, I decided to return to Mozambique where it was warm. I found a cheap flight with TAP (Transportes Aéreos Portugueses) and spent Christmas Eve sleeping in Lisbon Airport, waiting for my early morning flight on Christmas Day to Maputo, the capital of Mozambique.

The break in Mozambique was a blur, except for the joy of seeing my partner and friends. Before heading to the UK, I had completed a full medical check-up, but all documents were in Portuguese. I had to translate documents like chest X-ray reports into English for the PNG Immigration. The most challenging document was a Mozambican police report, which also needed translation. The holiday season delayed the process, but by January 13th, I finally confirmed that my visa was ready, and all documents were translated correctly.

I returned to London in mid-January, obtained my visa, and travelled via Dubai, Kuala Lumpur, Singapore, and finally Port Moresby, arriving on the morning of Thursday, January 22nd 2010, only five weeks later than expected. This delay was a sign of what was to come.

I arrived at Jackson's Airport in Port Moresby at six in the morning, only to find out that nearly all flights to the city, other than those from Australia, arrive between five and six in the morning. Luckily, Mark Seddon, my future official employer, was there to meet me. Mark was the son of Ron Seddon the

Director of Rotarians Against Malaria (RAM), and it was Mark's company, Nelson Lee and Associates (NLA), which had won a contract from the Rotary Club of Port Moresby to manage all human resources for their new program.

Mark was young and energetic, and I hit it off with him immediately. He took me to a large supermarket (Boroko Food World) in Port Moresby, where we enjoyed a hearty British breakfast. Afterward, I was taken to my new small flat, pre-arranged for me and situated near the waterfront overlooking what is now the old docks of Port Moresby. Jet-lagged, the rest of the day was a blur, but I do recall briefly meeting with Ron Seddon, whom I'd previously met in Bangkok for the job interview. Ron was the program director and my initial guide to all things PNG. I was also introduced to my new office and the staff already recruited to run the project. Additionally, I was given a car to borrow and some money to equip my flat with essentials like crockery and bed sheets, though the rest of the flat was fully furnished.

Ron Seddon held a number of roles, which included being the president of the Chamber of Commerce, a member of the Rotary Club of Port Moresby, the Chairman of Rotarians Against Malaria (RAM) and director of Hertz Car Rental. Both the Hertz office and the RAM office were situated in the same building near the airport, allowing Ron to manage both his company and RAM simultaneously.

One of the first things I discovered was that RAM had already received thirteen million US dollars for the malaria grant and this was already sitting in a US dollar account in a bank in Port Moresby. Despite this, the project was already three months behind schedule, and there was a significant expectation for me to get the program rolling as quickly as possible. I found that some preparations had already been made such as procuring Long-Lasting Insecticidal Nets (LLINs), employing a few staff, gathering basic population information, and contacting specific people in Non-Governmental Organizations (NGOs) across the country, but there was still a lot to be done. The finance team was at least fully operational, but the implementation plan and necessary documentation for field operations were lacking.

The LLINs had been ordered and were either in the country or on their way. The number of LLINs procured had been based on the 2000 census in terms of the number of LLINs required for each province. Ron Seddon had also ordered six old open-top Land Rovers from the Singaporean army, painted in bright blue and yellow colours. Privately, I was appalled, as I considered Land Rovers, especially old ones, to be the most unreliable vehicles on earth. My scepticism about them would prove to be correct in all my dealings with all Land Rovers in PNG.

I realized the enormous amount of work ahead before we could even begin. For example, administrative forms, apart from internal accounting forms, hadn't been designed or prepared. Fortunately, my experience running similar programs in Mozambique gave me a clear idea of how I wanted things to be done and the type of paperwork that would be needed.

During the first week, I met many partners and RAM staff. The RAM project was funded by the Global Fund, with all activities coordinated by the Country Coordinating Mechanism (CCM). Ron Seddon was the Deputy Chairman of the CCM, and the Chairperson was Lady Roslyn Morauta, a formidable lady who was the wife of a former PNG Prime Minister and now the Chair of the Global Fund board.

In my first week, a CCM meeting was held, and I was introduced to everyone. One surprising encounter was with a fellow Zimbabwean, Dr. Paulinus Sikosana. I had met him when he was a Provincial Medical Director in Matabeleland, Zimbabwe, and later as Secretary for Health under Dr. Timothy Stamps, the then white Minister for Health. Dr. Sikosana's journey had taken him from Zimbabwe to Malawi, then Mozambique, and now, astonishingly, to PNG. It was heart-warming to find a compatriot so far from

home, and over time, I discovered that Zimbabweans had a significant presence in PNG, meeting several familiar faces from my past as time went on.

From the word go, I was thrown into the deep end. Apart from the money in the bank, there was no clear guidance from RAM on how to execute the project. Ron Seddon, representing RAM and the Rotary Club of Port Moresby, advised against involving the government and the Department of Health, preferring to use churches and NGOs for operations. This approach struck me as unusual, since my previous experiences in malaria programs, had always involved local government health departments. Some staff had already been employed for the project, and to my surprise, those employed as field staff referred to themselves as "boys." When I called a meeting, the administration staff would instruct others to call the "boys" or field officers to attend.[3]

The RAM Field Officers were a diverse group with little in common. We had two teams, each led by what is known in PNG as a Health Extension Officer (HEO). HEOs are similar to Clinical Officers in Africa. HEOs are essentially doctors with less training and lower pay, allowing developing countries like Zimbabwe, Malawi, and PNG to staff rural areas with trained medical personnel but at lower cost than doctors. It can be noted that many doctors also do not want to work in remote areas, hence the need for HEOs. HEOs, due to their experience, are often effective leaders, having often managed remote health facilities during their training and future employment.

The rest of the team was a mixed bag of skills and backgrounds. One had been a bouncer in a nightclub, two were nurses, one a former policeman, another an itinerant preacher, one a mechanic, and several had university degrees (or had started and never finished their degrees) and some had some NGO experience. It quickly became clear that specific qualifications were not predictive of success in this work. Some highly qualified individuals struggled, while others with fewer credentials excelled. This made recruitment a game of chance, often taking months to determine if a field officer was suitable or not.

My first challenge was to bring structure to the program. We had a functional HR unit administered by Mark Seddon and Nelson Lee and Associates (NLA) and a finance team, but none of them had field experience. I had a vision of what needed to be done, but I had to gather the necessary information and design all the forms we needed for every aspect of the project. For the first three months, I worked every night and most weekends until 10 PM to get everything in place before implementation. This included designing forms, establishing payment protocols, and giving strict instructions on cash reconciliation, which would be a major challenge in the years ahead.

Before my arrival, the previously employed Field Officers had written security protocols, reflecting concerns about safety outside of Port Moresby. These protocols suggested hiring security guards, which would have made the project expensive and inflexible. I argued against these protocols, much to the staff's surprise, but we couldn't afford full-time security and I felt it sent the wrong signals to the communities we would be working in. Instead, we implemented a rule that RAM staff would always work with local contacts from the National Department of Health (NDoH) or other institutions familiar with the communities we worked with. While there were minor incidents, there were no serious security issues over the fourteen years I was in charge. We scrapped the security protocols and put new Standard Operating Procedures (SOPs) in place for everything else, including vehicle use, stock sheets, payment forms, and survey books.

[3] Coming from Africa, I found this terminology surprising. In my experience, calling an adult male a "boy" was considered insulting and colonial. In Zimbabwe, terms like house boys, garden boys, and kitchen boys were used by older whites and some insensitive Africans, and was no longer seen as being Politically Correct. However, in PNG, the term seemed to carry no colonial overtones, and eventually, I sometimes adopted it myself.

Another major obstacle was estimating the number of nets needed for each location. This was essential for logistics management, but I was lucky in two respects. Ron Seddon had obtained a database, the Community Profile System (CPS), from the 2000 National Population Census, which provided detailed population information down to the village level. The CPS program was clunky, and extracting data for each village would have been time-consuming. Fortunately, Bing, the IT person who worked for both Hertz and RAM, managed to convert the CPS data into Excel. This made it easy to prepare population databases with estimates of all villages and districts for 2010 in each province.

Maps are another passion of mine. I needed Shape Files to create accurate maps. Initially, the National Statistics Office (NSO) offered help but at a high cost. Then, I turned to my former employer, UNICEF. In Mozambique, I had used a UNICEF program called Child Info, which included comprehensive population data and maps. I asked the UNICEF Representative in PNG for access to these data files and struck gold. The UNICEF database contained all the Shape Files I needed, as well as the locations of all villages surveyed in the 2000 Census.

With the right data and maps, I was able to organize and plan the program effectively.

The challenges were numerous. Firstly, in some areas, there were no NGOs at all, so we had to implement the distribution program ourselves. Secondly, even when we found excellent implementing NGO partners, they would only operate in their designated areas and couldn't be persuaded to work in unfamiliar regions, which ultimately turned out to be a wise decision for both parties. Thirdly, many local organizations mistook us for a donor and presented us with exorbitant costs and demands, including budgets for new cars and boats for operations that would last only four weeks. The biggest problem however was the accountability of these organizations; many were small and struggled to provide reconciliations or detailed reports on the funds received and activities conducted. This had been the Achilles' heel of the National Department of Health (NDoH) program before RAM's involvement, as very few programs could produce good technical or financial reports. RAM had also faced challenges with other NGOs, even international ones, who failed to account for their activities and funds in a manner needed by our donor the Global Fund.

Fortunately, the first area we had to distribute nets was Central Province, outside of Port Moresby. Most of this province was accessible by roads, but there were few partners available other than local government and church health services. I persuaded Ron that our RAM project officers should act as implementers themselves or guide other implementers, as they needed to learn how to manage everything to assist other implementing partners effectively in the future. Our first implementation area was Kairuku, with its district centre at Bereina, which is about 140 kilometres from Port Moresby. Bereina and the surrounding district had no operating NGOs at the time or church partners, apart from church-supported health centres. Based on this, we decided to work with local health workers whether government or church based.

The RAM team stayed at the district hospital in Bereina, where we took over an old maternity ward and slept on the floor, including myself. Sleeping on a stone floor with a thin mattress was challenging, and we had only one smelly bush toilet and washing area. There were also reports of poisonous snakes in the area, which we had to be cautious of when going to the toilet at night.

In Bereina, there was significant resistance from the Project Officers towards the project and location, especially as many of them had grown up in the city and were not used to rural life. They were sceptical of my ideas, but since they were getting paid, fortunately they did their tasks as required. By the end of the exercise, they were convinced that the methodology would work.

This period was also an opportunity for me to learn about the local context. We had to conduct a household census in each village, recording everyone in a household by name, sex, age, and relationship to the head of the household. I was astonished when the first household I visited was a single-room house with fourteen people living in it. Even more surprising was that the household consisted of two parents and twelve children, all under the age of thirteen. The mother had given birth to one child every year and still appeared fit and strong.

Another fascinating aspect of the area was that many older people were covered in tattoos, and older women walked around bare-breasted, which was new to me. In most places I had worked, missionaries had influenced the culture, and women were usually fully covered.

Overall, the first program in Kairuku was a challenging yet insightful experience that laid the foundation for the program's future success.

Apart from a few difficulties, particularly some staff members getting drunk, the Bereina and Kairuku operations went well and we managed to distribute all the nets in a reasonable manner. However, in terms alcohol, I quickly learnt very early on, how this could disrupt work. For example, I had informed the team leader that I would arrive at 1700 one afternoon and requested that he meet me. When I arrived, he was nowhere to be found and turned up at three o'clock in the morning very drunk. He informed me that a local leader had invited them for a drink, and culturally they could not really refuse.

Whether this was true or not, he did not answer his phone for many hours and I was left with the decision whether to fire him or not. To this day, I never know whether I made the right decision. I did not fire him as the project had literally just started and I had no other leadership person to take over. Therefore, he continued in his role but sadly I was forced later to terminate him on other issues even though he was in fact an excellent team leader.

The other real failure was the Singaporean Land Rovers. Before we had even left Port Moresby, three of the Land Rovers broke their timing belts and were out of order. Of the remaining three we took to Kairuku, only one returned back to Port Moresby on its own power with the others being towed back. They were lovely nostalgic vehicles to have, particularly as they were open with canvas tops, and the RAM Field Officers loved driving them. Like Land Rovers should, they could go to locations other vehicles had difficulty reaching, but you were never sure if they would come back from their trips.

Surprisingly, nearly all of the Land Rovers broke their timing belts which extensively damaged their engines: it was always a surprise to me that the Singaporean army had not replaced them within strict maintenance schedules. The other thing that struck me about these Land Rovers, was they were also very popular with the British Army, but the difference between the Land Rover I used to own and loved in Zimbabwe and the old Land Rovers we had in PNG was that in the military there was an army of mechanics to keep them of the road. Basically, the Land Rovers were very high maintenance and I was extremely happy when these vehicles were ultimately replaced with new Toyota Land Cruisers.

As luck would have it, the Land Cruisers we received were also nearly as good as Land Rovers in terms of reaching difficult areas. The Land Cruisers we had been supplied came with addition differential locks on the gear box and front and rear differentials. This meant the driver could lock all the wheels on the Land Cruiser, and if need be, this allowed them to plough through almost any terrain. The other great thing about the Land Cruisers is that they rarely broke down and we could rely on them to take us anywhere.

Overall, we had passed our first test. We had covered our first pilot area of Kairuku without any serious incident and we were ready to move forward. However, we still had not made a decision of whom was ultimately going to implement the program.

After endless negotiations with a number of NGOs, who I generally felt were unrealistic in their demands, I no longer felt it was useful to work with them, unless they collaborated with the RAM staff. Most of them had no operational capacity, reporting capacity or infrastructure to operate the program. The other main problem with most of them was that they wanted RAM to supply brand new vehicles or boats for operations which would only last a month, or would want additional funds, for example to store nets in their premises. The bigger problem was that I did not see that they had any organisational ability to work outside of their areas of influence, (or even within their area of operations), and more importantly, there were many places where no NGOs operated.

I finally had to go to Ron Seddon and beg him to reconsider his reliance on the use of NGOs. I pointed out that there was only one organisation that covered everywhere in the country and that was the government, and in case of malaria, this meant the National Department of Health (NDoH) and its Provincial Health Authorities (PHA). I also pointed out, that the reason that RAM had been awarded this grant was because the NDoH and the PHAs had been woefully poor at handling and reconciling money, so the solution was to keep the money within RAM control, but work closely with the health staff at provincial level to get the work done. After much consideration, Ron agreed to these changes but warned me that it should all work out well and make the Rotary Club of Port Moresby look good at the end of the operations.

With this newfound implementation freedom, RAM staff could now work directly with the provincial authorities, particularly health, and would collaborate with local district and health centre staff and if willing, with other local organisations. This turned out to be the winning formula for everyone involved.

Previously, when the National Department of Health (NDoH) managed the program, it was reported that often provincial staff would handle everything themselves and receive all the funds for per diems. This approach angered local health staff, as the provincial staff operated in their areas with little cooperation, collaboration, or resource sharing with those on the ground and the communities served. This often meant that not all villages or households were reached, leading to resentment towards the program.

By not directly involving NGOs or church groups directly in organizing activities on the ground, RAM gained more flexibility to use our field officers as needed. From Kairuku, we expanded into the districts of Rigo and Goilala in Central Province and into Gulf and Oro Provinces. Goilala District was our first district requiring aircraft, and we were fortunate to find Central Aviation, a local company run by New Zealand pilots. Although I thought they were a little crazy, working with Central Aviation was an eye-opener. I accompanied them to some of the most challenging airstrips I have ever experienced, including those on mountain tops and situated within deep valleys. My heart was in my mouth during these thrilling, yet dangerous, landings.

The "fly-in" areas of Goilala District introduced new challenges. In Kairuku, we had an Admin Officer who also acted as a finance officer, distributing small amounts of money to field officers for their daily operations. This minimized the risk of money being stolen, lost, or squandered. However, in Goilala, we could only send one officer to each location, meaning each officer had to carry enough funds for all their needs. In remote mountainous areas, trekking was necessary, and it became clear that very few people in PNG would do things for free, even for the public good of their own community.

Handing out large sums of cash to staff wasn't just a bold move, it was essential to making the LLIN distribution program work. Without it, the costs would have skyrocketed.

Managing cash always comes with risks. But RAM rose to the challenge and managed to track nearly every dollar, with only a tiny fraction unaccounted for. In a program filled with logistical hurdles, this level of financial control stands out as one of RAM's most remarkable achievements.

Overall, the first four months were thrilling. I got to know PNG the hard way, designed a program that worked, and produced high-quality technical and financial reports. Most importantly, we established a collaborative program with provincial health departments, meeting our targets of reaching every household and village in the provinces we visited.

We also learnt invaluable lessons such as banning the use of alcohol in all operations. My English tendencies of fair play and officers being able to control their drinking habits was proven to be naive and unrealistic.

Ferry that went to Kerema and the airplane used for the remote areas of Gulf Province

CHAPTER THREE - Papua New Guinea – The Country

Chapter Summary

- This gives an introduction to PNG, its origins, history, terrain, people, language, customs and some basics of the PNG society.

Papua New Guinea (PNG) is often seen as a fascinating and unique country. Locals and visitors alike often refer to it as the "land of opportunity." This idea carries both positive and negative meanings. While many believe anything is possible in PNG, others associate it with insecurity, especially in Port Moresby, which is frequently ranked among the world's most dangerous cities.

PNG is located just south of the equator, about 150 kilometres north of mainland Australia, separated by the Torres Strait. Some Australian islands, such as Boigu and Saibai, lie within five kilometres of PNG's border, making the two nations close neighbours with shared cultural ties, especially in regions where frequent local travel occurs.

The mainland of PNG sits on the world's second-largest island, after Greenland. PNG occupies the eastern half, while the western side belongs to Indonesia, formerly known as Irian Jaya, now divided into the provinces of Papua and West Papua. In addition to its mainland, PNG includes over 600 islands. The mainland is divided into 17 provinces, and the islands form five more, mostly located to the north and west of the main island.

The PNG is predominantly mountainous, with several peaks reaching over 4,000 meters in some areas, the highest mountain being Mount Wilhelm at 4,509m. The main island is divided north and south by a range of mountains that effectively divides the country as there is no road presently that crosses these mountains. Similarly, from the mountains come a number of large rivers flowing north and south, many of which do not have bridges further dividing the coastal areas into none connected entities. From the rivers, also come large coastal swamplands in many places, which to date, have defied road construction. These geographic features have resulted in PNG having about seven different road systems on the main island meaning that most travel between provinces in PNG is by air.

Overall, the landscape presents significant challenges for habitation, development, and infrastructure construction which all require substantial investment. These aspects of terrain make logistics such as the delivery of mosquito nets extremely expensive as one tries to access every part of the country, particularly remote mountainous areas, swamps, and outer islands which also often have their own corresponding mountains and swamps as well.

PNG lies within the tropics between 1 to 12 degrees latitude south of the equator. This means that the country has a hot tropical climate with a wet season from December to March and a drier season from May to October in the southern regions. However, rainfall patterns vary across different parts of the country, making it reasonable to expect rain at almost any time in most areas.

Depending on the sources you use, PNG is home to a population of just over eleven million people in 2025 though some sources estimate that the population is much higher. PNG is also home to more than 800 languages and tribes. This remarkable diversity has resulted in a nation rich in cultural customs and values.

Despite its strong traditional foundations, PNG fell under missionary influence early on. The French Catholic Marist Missionaries were first to arrive in 1847 followed by other churches such as a London Missionary Society in 1871, the Wesleyans in 1875 and the Lutherans by 1886. For this reason, today,

most people in PNG identify with a Christian church. This ultimately resulted in a blending of indigenous customs with Christian beliefs producing a unique cultural landscape, sometimes leading to practices that, from a Western perspective, may seem unusual. This fusion of traditions and faith continues to influence social norms and cultural expressions across the country.

Studies suggest that PNG came into life as a landmass about five million years ago and was part of a greater Australian land mass known as Sahul. The first people however did not arrive in PNG (along with Australia) until about 60,000 years ago, probably during the last but one ice age, when a landmass ran practically all the way from Asia to Australia through today's Indonesia.

One curious thing about PNG is that its wildlife is closer to that of Australia than to Indonesia. There are plenty of marsupials in PNG like those found in Australia but no mammals such as monkeys. Dividing Indonesia between Sulawesi and Borneo, and the islands of Bali and Lombok lies what is known as the "Wallace Line" which also divides the ancient Asian landmasses of Sahul form Sunda. On one side of this line, mammals can be found, and on the other side, only find marsupials can be found. Many of the marsupials are similar to those in Australia suggesting land links at various times in the past. PNG only has the smaller types of wallabies and many types of tree kangaroo, but the larger kangaroos of Australia are absent.

As ancestors of PNG managed to pass from Asia to Indonesia, but not mammals, this suggests that even in the extremes of ice ages, there was a passage of water that was narrow enough for man to pass but was big enough to keep out other forms of animals such as mammals. This presupposes that even in early days, ancestors of the region managed to use at a minimum, rudimentary boats to travel to Australia and PNG.

Boats, canoes or rafts became a feature of the PNG way of life, and over time, gradually all other islands in PNG became inhabited ending with Manus Island about 21,000 years ago. It is also likely that PNG was populated by successive groups of migrants which is reflected in the many different characteristics of PNG tribes and groups as well as their languages.

It is assumed that the earliest people to arrive were hunter gatherers as the first gardens only appeared about 10,000 years ago during which time bananas were domesticated. With other new immigrants arriving 3,300 years ago, other plants such as sugar cane, taro and sago were domesticated, and it is from PNG that these plants spread into other parts of the world. This suggests that historically, PNG was not as isolated as Western Explorers have previously believed. Domestic animals such as dogs and chickens arrived about 3,300 years ago though pigs may have arrived earlier. Sweet potatoes arrived about 300 years ago and largely replace taro as a staple crop. Sweet potato is attributed to allowing the population of the highlands to grow substantially.

PNG's 800 languages are divided into two language groups known as the Papuan and Austronesian languages. The Papuan languages are the older in PNG with the Austronesian languages which arrived with the Lapita People. The Papuan languages are not generally related to each other while the Austronesian languages are all related to each other and are found mainly found in coastal areas. This suggests that perhaps the latest immigrants gradually pushed earlier arrivals further into the interior or simply dominated or integrated those living on the coast into their cultures.

European contact with PNG probably first occurred in 1512 with the Portuguese explorer António de Abreu who spotted the north coast of Papua. However, the Portuguese explorer Don Jorge de Meneses is usually credited with the European discovery of the principal island of PNG around 1526-27 and who gave the name Ilha dos Papuas (Island of the Papuans), "papua" apparently meaning frizzy hair in Malay. Jorge de Meneses was looking for spices to import into Europe.

Europeans however were not the first visitors or traders to PNG as it is thought that traders had been visiting from Asia for thousands of years. One such example being the trade in sea cucumbers (Beche du Mere) where traders collected sea cucumbers to send to ancient Chinese markets. However, it was Europeans that perhaps really put Ilha dos Papuas on the world map and gradually opened up the island to the rest of the world.

Twenty years after Jorge de Menese in 1545, the western part of the island (now Indonesia) was visited by a Spanish explorer Oritz de Rete who then gave the island another name of Nueva Guinea (New Guinea) as the terrain reminded him of the Guinea coast in West Africa.

PNG was then left alone by Europeans for another sixty years until another Spanish explorer Luis Vaez de Torres mapped the island in 1606 and gave his name to the Torres Strait. Previous to Torres, it is said that Europeans had thought that Ilha dos Papuas was joined to Australia.

The British first arrived in Papua New Guinea in 1699, when William Dampier sailed along the north coast of the mainland and the east and south coasts of New Ireland. After that, European visits became more frequent. In 1767, English explorer Philip Carteret navigated the waters between New Ireland and Manus. In 1770, James Cook passed through the Torres Strait, and in 1786, French explorer Louis de Bougainville reached the eastern tip of New Guinea and sailed along the coast of Bougainville. Shortly afterward, in 1788, the British landed the first convicts in Australia, establishing a colonial presence that extended British influence into southern Papua New Guinea.

During the next hundred years visitors to PNG became more frequent as the area attracted scientists, traders and the inevitable missionaries. Together myth states they were often called the three Ms, Mercenaries, Missionaries and Misfits as a reflection of the personalities that arrived in country. The politicians soon followed (mercenaries or misfits) in 1884 and the British created British New Guinea (Southern Modern PNG) a protectorate of the British Empire. In the same year, the Germans took over the north eastern part of the island which it administered under a chartered company which was eventually taken over by the German Imperial Government in 1889 to become German New Guinea. The British part of the island was handed over to the Australians for administration on 16 September in 1902. Finally in 1914, after the start of the First World War, the north of PNG changed from German to Australian control and the rest was made an Australian Protectorate. The Australians ruled for seventy years, with the Papuans in the south becoming Australian Citizens with better human rights than the Aborigines in their Australian homeland. Finally, in 1975, Papua New Guinea received its independence and the Papuan population lost their Australian citizenship much to the dismay of many PNG people who had previously had Australian citizenship.

The Australians left some interesting legacies in PNG. Apart from the Australian behavioural habits of saying G'day and probably binge drinking, the Australians did not greatly invest in building roads, though a notable exception is the highlands highway from Lae to Tari and beyond but rather invested in a huge number (over 700) of rural airfields throughout the country which meant that much on the country could only be reached by air. This policy left many parts of the modern PNG population very isolated as it cost a great deal of effort or cash to leave these remote areas to visit the wider world. It could be speculated that this was done on purpose by the Australians to divide and rule. Sadly, since 1975, the successive PNG governments have done little to improve the road system or the rural air fields, many of which are now in disrepair. PNG is still left with at least seven road systems on the mainland which do not join up and which requires most people to travel around much of the country by air or by boat. In some areas, the infrastructure is so poor, that they can only be reached by helicopters or long treks. Despite these limitations, most towns in PNG are a mixture of people from all parts of PNG.

In the book Guns, Germs and Steel the author Jarad Diamond, considers PNG people to be extremely independent in their thinking and suggests that PNG people are some of the most intelligent and independent on the planet. On the other hand, some might consider many Papua New Guineans having difficulty living in large multi-racial groups as traditionally they had little or no previous experience of this in the past.

As reflected by the larger number of languages, It does not appear that PNG ever developed large societies. Even a small island like Manus, has three languages. This is likely because the terrain was too difficult to have effective communication or control over large areas of land by any one group. This still holds true to this day, and the central government in Port Moresby, and provincial governments, still appear to have tenuous control over many parts of the country, and as often reported in the press, resulting in under-development and poor security in some areas.

An interesting feature of PNG is its languages. While there are 800 languages spoken traditionally known locally as “Tok Ples” meaning language of the place where each is spoken, there are only four official languages, English, Tok Pisin, Hiri Motu and Papua New Guinean Sign Language. Of these, only English and Tok Pisin are spoken nationally. Hiri Motu is the major language spoken in villages in and around the capital Port Moresby. In additional to Motu, there is a pidgin version of Hiri Motu known as Police Motu that was formally used throughout most of the British New Guinea as a means of communication by government and churches. Police Motu, while still be spoken in some areas, has now largely been replaced by Tok Pisin.

Of these official languages, Tok Pisin is the one spoken by the greatest number in the country, particularly in the New Guinea Islands and Highlands. Strangely it is absent in some areas, particularly along the South Coast where the English or Motu have dominated, though this is changing, and Tok Pisin is now spoken in almost every part of the country.

Many people believe Tok Pisin comes from the German language, because it was originally spoken in areas controlled by Germany, particularly in the plantations. It also includes a few German words such as "raus," meaning "get out" or "go away." German colonists, who lived in the north of the country and many of the islands, probably used this word frequently with native people explaining why it remains in the language.

Tok Pisin in reality has few German words such as “beten” to pray which is also found in Tok Pisin as “prei”. The other confusion comes from the Tok Pisin word “haus” for house . Haus is spelt like the German way of spelling house , but Tok Pisin is spelt in a phonetic manner, and therefore the word “haus” could equally have come from English or German. Whatever the German influence, it appears that the Germans did their best to eradicate Tok Pisin from their shores.

Many foreign words in Tok Pisin have roots in religion, introduced by missionaries from various backgrounds. For example, the Tok Pisin word "pekato," meaning sin, originates from Latin or was introduced through Portuguese by the Jesuits. Interestingly, Tok Pisin seems to have more Portuguese loanwords than German. Some examples include "pato," meaning duck, "atum," meaning tuna, and several religious terms like "baptismo," meaning baptism. This linguistic influence reflects the complex history of cultural and religious interactions in the region.

One of the more unusual words found in Tok Pisin is "sanguma," meaning witch doctor. Interestingly, this word appears to be same word in Zulu from South Africa. There are a number of theories regarding this word which state that it may from a language in Madang in PNG or that it originated from interactions between early British maritime trade from people coming from South Africa.

The connection to South Africa is further suggested by the physical characteristics of coastal communities in West New Britain. In many villages in West New Britain, many of the villagers have a very strong resemblance to people from South East Africa and this has made me wonder if African sailors might have jumped ship in this region.

For the rest of it, Tok Pisin is mainly English in origin with local imported words from many sources. For the English, it appears not to be the English of the high classes, but the English of the masses, probably for the most part from English (or Australian) Sailors giving pidgin English a very distinctive flavour. Perhaps the most English of all words is "bagarap" giving lovely expressions such as "Kar i bagarap" meaning the car is broken down or other similar sense. A typical greeting, and one straight from Northern England "U aurait" replied by "Tenk u tru, mi aurait". Are you all right, yes thank you, I am all right.

Predominance of English might make Tok Pisin seem easy to learn. In my experience, quite the opposite. Tok Pisin words often do not have the direct equivalent of many English words and you have to arrive at another way of saying the same thing. Simple words such as 'complicated' do not exist in Pidgin and you have to get the same sense by describing the word in another way 'i givim trabel tumas" it gives too much trouble or "mipela no can fixim isi" meaning we cannot fix it easily. Other concepts also are translated in logical though sometimes strange ways. Pregnant woman being "belmeri", angry becoming "bel hat" and patience "bel isi" which reflecting emotional states felt in the stomach. Which perhaps brings us to one other mystery. All women in Tok Pisin are Mary "meri" like the Australian Sheila for women. Why Mary, one can only assume it comes from missionaries talking about the Virgin Mary to which perhaps women and men in PNG aspired. Whatever the reason, you get "hausmeri" for domestic servant, "meri blaus" for the ubiquitous long blouse that most women in PNG wear. Other logical words in Tok Pisin include "Tokples" (local language) as mentioned before, "hausmoni" (bank) and "haussik" (hospital).

Economy, Culture and Politics

The economy of PNG is dominated by agriculture, forestry, fishing, and the extraction of minerals and energy resources like gold, copper, oil, and natural gas. In general, PNG has a trade surplus with major exports including natural gas, gold, copper ore, crude petroleum, and palm oil. Against this though, only about 15% of the population are in employment, many children do not progress beyond primary school, and a significant portion of the population live below the poverty line. Malnutrition is also reported to be a serious issue, affecting brain development and learning.

A description of PNG without mentioning betel nut (known locally as "buai") would be wrong. Many visitors that come to PNG notice quickly the red stains on the streets, particularly at road junction and in market places. Betel nut is ingrained in the culture, it is a very addictive drug, and it is chewed by a large percentage of the population.

Betel or Areca nut comes from a palm tree and ingested in much of Asia and some parts of the pacific. It is deeply ingrained in religious and social functions in many counties apart from PNG. However, depending on the country, the betel nut can be prepared in a variety of ways, often being sold in ready to eat packets. In PNG, the process is quite simple, the husk is removed from the nut, and when eaten or chewed, it is often chewed with "mustard" (known locally as "daga") from a vine together with lime (calcium hydroxide) which often comes from coral. The lime causes a great deal of red coloured saliva to be formed and forces those chewing to spit saliva, often in large quantities.

Buai has similar mild effects as smoking but users claim it keeps them awake. Like cigarettes, buai is extremely addictive and like cigarette smoking comes with health issues, which in the case of buai,

may cause throat cancer and other health issues. As it is addictive, like cigarettes, those who are addicted, need a buai shot frequently which can be disruptive in the workplace. Like cigarettes, the habit is very expensive, particularly for those who do not work or earn a lot of money.

The last complication of PNG worth mentioning is PNG politics.

PNG remains within the British Commonwealth and the British Monarch (presently King Charles) is still the official Head of State of PNG. One of the strangest aspects of coming to PNG as an Englishman is making a toast to the king or the queen for most of my time in PNG. This is something that rarely happened when I lived in the UK.

I am also a citizen of Zimbabwe, which for all practical purposes has a single ruling party. Even though other political parties did exist, in reality, they have had little influence on the government of the country. This was also true of other countries that I have worked in such as Mozambique and Afghanistan under the first Taliban leadership.

In comparison, PNG has 46 registered parties of which only five take up most of the seats. In this respect, PNG is truly a multiparty democracy and not so dissimilar to the UK. This is very good except that PNG parliamentarians are notorious for changing party allegiances.

On 12 September 2024, there was a vote of no confidence against the present Prime Minister James Marape. There are 111 seats in the Parliament of PNG, so therefore the opposition who proposed the vote of no confidence thought they would get as least 56 votes or more to win the vote. In the end, Prime Minister James Marape won by 75 votes with only 35 voting against. The question begs how could the opposition even think of winning a vote, or had many of the politicians had changed their minds at the last moment. The shifting alliances of PNG politics is an interesting story in its own rights, and the present Prime Minister (as with many previous prime ministers) is a master at keeping himself and his party in power.

Despite all the difficulties of living in PNG, from my own experience, most Papua New Guineans are extremely warm, generous hearted and welcoming. As mentioned later, in my experience, some of them make some of the best workers I have found compared to other places I have worked in the past.

There are others however, such as the “rascals”, which refers to any individual who makes profit from others. This ranges from con artists and pick pockets to serious crime. The rascals are a sad reflection on the reputation of PNG and continue to make PNG continually more insecure. The greatest challenge for PNG in the future is improving law and order.

So many aspects of PNG life are interesting yet remain uncertain in their outcomes. This is the background upon which Rotarians Against Malaria needed to build a malaria program to reach every part of the country.

Nothing in PNG remains certain other than uncertainty itself and is indeed a land of opportunity for those who take up the challenge.

EXAMPLE OF PNG INFRASTRUCTURE

Roads without Bridges in Bougainville

Typical PNG Road in the PNG Highlands

CHAPTER FOUR - PNG LLIN Distribution Strategy

Chapter Summary

- Outlines all the stages of program implementation from quantification, procurement, and deliver of LLINs country wide, including all the processes needed to survey, allocate and distribute nets to household level ensuring that everyone gets their fair share of LLINs

Overview

In most countries, Long Lasting Insecticidal Nets (LLINs) are distributed in huge campaigns, and if the country is small enough, countrywide at one time. Such campaigns require a huge amount of organisation and the training of thousands of staff in a short space of time. From experience, campaign staff often do not follow their instructions well, sometimes resulting in a diversity of approaches in different locations. This approach also means that health staff have to be retrained every time there is a new campaign.

PNG is a difficult country in terms of terrain and access. Carrying national LLIN campaigns in PNG are very difficult to manage. Instead, in terms of LLINs countrywide campaigns, PNG decided to have rolling campaigns where provinces and districts are visited in a sequential manner in a three-year cycle. This means that the program returns to the same provinces and districts at approximately the same time of the year at three year intervals.

The advantage of this approach is that there is no need to train huge amounts of people at one time, rather, a small team of people are trained to facilitate the LLIN campaigns in each province and district. As the same people are being used to coordinate the activities in every province, this resulted in a very consistent approach to the distribution of LLINs in PNG.

Rotarians Against Malaria (RAM) had been elected by the National Malaria Control Program (NMCP) National Department of Health (NDoH) to coordinate the distribution of Long Lasting Insecticidal Nets (LLINs) throughout Papua New Guinea (PNG). I was recruited to put the program together and make it work.

Designing a mosquito net program that delivers nets to everyone in an equitable way sounds relatively easy until you try doing it! I have had thirty years' experience of distributing mosquito nets, but it was only in the last 17 years or so that I started to really understand the practicalities of doing so at massive scale. PNG was a challenge in every respect.

The overall aim of the PNG malaria program was to ensure that every person affected by malaria in the country was protected by an LLIN. The LLINs would protect householders who sleep under the nets and also protect those who, for whatever reason, do not sleep under them.

Basically, the program can be divided into phases which include the following.

1) Deciding which populations to target with nets.
2) Estimating populations at national, district and health centre level.
3) Procurement, importation, and storage of LLINs.
4) Transport of LLINs to each province and district and final storage of nets.
5) Pre-planning of operations in each province through provincial visits
6) Preparation of all materials and logistics needed in each province
7) Arrival In a province

8) Micro-planning in participating health centres.
9) Program Implementation – training of survey volunteers, carry out village surveys, verification of surveys and distribution of nets.
10) Reporting of all activities carried out.

Deciding which populations to target with nets

The initial target of the LLIN program from 2007 to 2014 was to distribute nets to every household in every village of PNG every three years. At this time, it was assumed that that the whole population of PNG was affected with malaria.

Referring to Chapter One, and the relationship of malaria with temperature and altitude, it was eventually possible to subdivide PNG into difference epidemiological zones and reduce the areas in which LLINs were delivered to.

1) Above 2000m is considered too cold for malaria transmission,
2) From 1600-2000m, is a zone in which only *P. vivax* might be transmitted but at very low levels,
3) From 1200-1600m, a zone in which malaria is epidemic as malaria only appears in certain hotter or wetter years.
4) Below 1200m, malaria is considered endemic i.e. malaria can be found year-round, but in practical terms, the lower the altitude, that higher the malaria transmission.

These predictions changed the way LLINs were later distributed around PNG. After 2014, targeted villages were reduced, particularly in localities of high altitude where malaria transmission was unlikely to occur and therefore distribution of nets was restricted to below 2000m in altitude.[4] However, due to lack of funds, in 2015 to 2016, areas between 1600-2000 metres, LLINs were only given to under-fives in mass campaigns similar to vaccination campaigns. In 2017, this changed again, with household distribution in the 1600-2000m zone when Against Malaria Foundation (AMF) started to supply nets. From 2018, however, AMF decided only to supply nets to areas below 1600m while the Global Fund supplied nets from 1600 to 2000m. Once again, due to shortage of funds and further stratification, from 2022 onwards, the distribution of nets was restricted to areas below 1600m only.

The only places where the altitude rule became flexible was in extremely remote areas with little or no access to the rest of the world. The National Census of 2000 was not always accurate in where villages existed, and the population living in these very remote areas (some at high altitude) are often only accessible by air and often with additional trekking as well. Therefore, for the most part, RAM continued to supply these areas with nets, because if a malaria outbreak ever occurred, it would be logistically very difficult and expensive to reach such locations again. The other issue, also relevant in these areas, is that high altitude villages were often adjacent to low lying areas to which residents from the higher areas might visit to carry out farming and where they might catch malaria.

The real challenge was trying to decide which villages existed at different altitudes. The problem was that no such data previously existed and I had to make altitude maps using Geographical Information System (GIS) programs of the whole country. This program allowed mapping of each village to see at

[4] The district with the highest altitude in PNG is Kandep and is located in Enga Province. Practically every household in Kandep District is above 2000 metres where malaria transmission was unlikely to occur. However, in 2014, Kandep District received nets, but thereafter never received again. Similar scenarios occurred in many other areas of the Highlands except that logistically, it was often difficult to know which villages were below and which were above 2000m.

what altitude they were located.[5] From this, it was therefore easy to allocate nets to villages at different altitudes in each of the provinces.

Estimating Populations at National, District and Health Centre Level

In PNG, we were very lucky, referring back to Chapter Two, in 2000 there had been a very good national census carried out. The data of the National Census was recorded into a public data base which, theoretically, anyone could access and gave data down to village level. Using this data, and accounting for annual growth rates, this allowed the number of nets required to be calculated and to be ordered for each province and broken down to each district, health centre and ultimately village. After 2013, the calculations for each province were based on the population surveyed in each province in the last LLIN distribution three years previously, and then calculating the growth rate for each subsequent year. This could then be applied to every village in the province[6].

This information could then be used to plan where all nets were sent when they arrived in the county, first down to provincial level, and then down to each district and health centre. This information made the PNG program very manageable and achievable.[7] The only complication was that after 2014, nets had to be allocated by altitude in the highland regions to different altitude zones.

With this high level of information being readily available in PNG, it was then easy to order the mosquito nets for the country, and once in country, allocate the nets to each district.

Procurement, importation and storage of nets

From 2010 to 2012, Global Fund procured nets for the PNG program. From 2012 to 2018, annual tenders were put out for nets. RAM organised international tenders of all LLIN companies willing to participate. This could be a long process and could add another two months or more to the procurement process. These LLIN tenders were closely monitored by the Global Fund and nets were procured on the lowest landed price into PNG. No technical preference was allowed for any LLINs, as based on WHOPES, all LLINs were equal. Out tenders were very successful and it was reported that RAM managed to procure nets at equal to the prices that the Global Fund did.

To plan effectively, LLINs needed to be ordered at least 12 months before they're needed in the field. Manufacturing and shipping to Papua New Guinea alone could take 6 months. Once the nets arrive at port, it can take another 3 months or more to reach remote provinces. And that is assuming everything goes smoothly, which it rarely does. With everything that can go wrong, and often does, giving ample time for delivery was most important.

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[5] Fortunately, in about 2013, I decided to stop smoking. I desperately needed to keep my brain occupied to take my mind off smoking and making altitude maps assisted with this aim. Fortunately, one of the chief scientists at PNG IMR gave me gave me a file of all the altitude contour lines in the country which I needed to convert into shapes which represented different altitudes zone. This job took endless hours of work in the evenings but it kept me from thinking of cigarettes. Finally, after a couple of months, I managed to make maps which showed the altitude zone of every village in the country. The exercise also helped my smoking habit, as I have never smoked again, though, I still get the urge to smoke occasionally.

[6] One of the indications that the RAM program was doing a very good job is that when RAM returned every three years to a district, the population growth rates would be very consistent between successive LLIN campaigns. However, this did not apply to individual villages whose populations often changed from one census to the next due to movement of people between villages.

[7] In Mozambique where I worked previously, we had data for provinces and districts, but below this level, there was no public information available, or at least none that we could find. In Mozambique we literally had to go to each local level government office and ask them for their village estimations which was time-consuming and often their data was inaccurate. For all its faults, PNG was very well organised in this respect.

Once the containers of nets arrived at the port of entry, these nets were customs cleared, and sometimes fumigated by health inspectors even though the containers were full of insecticide treated nets.

Before I arrived in PNG, Ron Seddon, the director of RAM, had already ordered all the mosquito nets for each province for 2010. As stated, the number required for each province were taken from the 2000 National Census and these nets were all PermaNet 2.0 from Vietnam which had been used previously in PNG since 2006. For the most part, these nets for 2010 were already delivered to ports in PNG, or were in the process of being delivered to each port and arrived in Shipper Owned Containers (SOC).

SOCs were a godsend to the PNG program. Normally when goods arrive in a county in containers, companies are given 30 days to clear the nets and return the container. Having SOC containers, meant that the program could keep these containers as long as we wanted. This suited the program well as there were no convenient warehouses to temporarily store the nets for onward locations in other provinces, nor did RAM have the institutional capacity to be managing multiple temporary warehouses around the country.

In 2010, after customs clearance, the containers were initially left at the port storage areas as there was nowhere else to leave them at the time. Some were transhipped immediately to provinces, and if the province was an island, they also remained at the ports as there was nowhere to easily store the nets at this time.

Ordinarily, storing nets at the port would attract substantial fees. However, Ron Seddon had a personal connection with the CEO of the PNG Port Authority, which allowed him to secure waivers for storage costs, regardless of how long the containers remained, sometimes for several months. This arrangement changed when a new CEO took over at PNG Ports, making it increasingly difficult to obtain such waivers. As a result, RAM was forced to explore alternative storage solutions.

For the two main PNG ports at Port Moresby and Lae, based on the charity status of the program, RAM managed to negotiate very low storage rates with two large haulage companies. From these locations, the containers would be shipped by sea or road to the respective province and eventually be stored free of charge within provincial or hospital grounds where they would be secure. Throughout the years, RAM was distributing over one million nets a year which equated to over fifty shipping containers a year.

PNG has often been criticized for using containers as storage for LLINs, but in reality, there was little option, and, there were other great advantages in this approach. The reality is that outside of the large cities, large storages spaces to rent or use at provincial level were practically non-existent. Even when they did exist, or were available, the rental costs for short periods of time were prohibitive. More importantly, for such a small organization such as RAM, organizing the management of many storage locations in different provinces would have taken a large team of people in Port Moresby. It should be remembered that it takes a lot of time and effort to set up a warehouse and then make sure that the warehouse was being managed well and there were no security risks. In the case of RAM, these warehouses would only be needed for short periods of time.[8]

[8] In Mozambique where I had previously worked, it was possible to operate large warehouses, and from these warehouses, send out nets by road to the respective distribution points. Also in Mozambique, the program was lucky in that in one location, World Vision already had a huge warehouse so it was possible to piggy back on their warehousing operations. No such similar arrangements were possible in PNG and each warehouse, had they existed, would have only served one province each and only for a small period of time.

The other problem not appreciated, is that due to the poor road network and many islands, getting the LLINs from a central warehouse is usually not possible as containers of LLINs would have to be moved or repacked more than once through different locations to arrive at their end destination. Security of nets is also a huge problem in warehouses and requires many security guards, who in turn, need a lot of monitoring to make sure that they do not steal (or arrange to be stolen) the nets themselves.[9]

Similarly, in other warehouses where thousands of bales of nets are being kept, constant stock checks are required to make sure that the nets do not go missing which they frequently do, albeit usually in small numbers which are not immediately noticeable. Pilferage of small numbers of nets or bales always remains a problem, even in PNG, when it was necessary to store nets in temporary locations.

Keeping nets in containers was very secure and drastically reduced costs. Containers could be stored anywhere, and when normally stored in the grounds of provincial health authorities, they would be stored at no cost. The containers also remained sealed, and were only opened and the contents verified just before the containers would be emptied and the nets taken away. Therefore, unless someone took a big can opener, the contents of the containers remained very safe when stored in secure areas.

This is not to say things could not go wrong. In the provincial capital of Tari, of what is now Hela Province, in 2011, four containers of nets which had been stored in one location for two years in the local hospital premises, were attacked by impatient locals who wanted their nets. The end result was that a large group of people broke into the hospital grounds and opened the containers and distributed about 80,000 nets overnight. These nets fortunately were not the responsibility of RAM, but of the old Global Fund, National Department of Health program. The important lesson that RAM learnt from this incident was not to leave nets in storage for long periods of time in case the local population take the distribution of nets into their own hands. Fortunately, during the program of RAM, no similar incident has ever happened again.

Overall, the use of SOC containers saved the program a lot of money against the use of warehouses, even when the containers were donated to province at the end of each provincial distribution. It cost more to return the containers to a central place for sale, and storage was a chronic problem in most provinces, so donating them away made sense.

As a comparison, using warehouses in PNG for the storage of loose bales of nets would have required multiple warehouses, repacking the nets into containers to take to other maritime provinces, and huge expensive administration costs to ensure that all the warehouses were secure and being run properly. SOC containers avoid all these costs.

Overall, RAM had adopted a cheap, secure and easy way of managing nets. The nets remained in containers until the last possible moment, resulting in no stock checks being needed as the containers remained with their original seals. The only exception to this would be that one random container would be opened on arrival for collecting net samples for quality assurance evaluation. When these containers were opened, the stock in the container was verified and then the container would be immediately resealed.

[9] An incident in Liberia serves as a good example. A local NGO had a warehouse of nets in Monrovia the capital of Liberia. The guards, or their accomplices in this warehouse, had built a large wire cage in a mountain of mosquito nets. They removed the number of bales of nets that would have fitted into the cage, and then built the rest of the nets around the cage to make the mountain of nets appear to be there. It took sometime before anyone realized that anything was missing.

However, criticism of the use of SOC intensified when RAM began raising concerns about the deteriorating quality of the nets. Experts from both the scientific community and net manufacturing industry argued that prolonged storage inside containers exposed to direct sunlight led to overheating, which compromised the nets' integrity and effectiveness.

While there might be some merit to these complaints, the following can be noted:

- Using temperature probes, it was possible to verity that only the edges of the containers which were in direct exposure to sunlight became very hot. Away from the edges, the temperatures within the containers remained at acceptable stable temperature levels.
- Work in PNG suggests that even when LLINs are exposed to high temperatures, they will remain effective.
- There is no evidence from the field that containers left in the sun for long periods during the period 2010 to 2013 had any less effect on malaria than those nets stored for shorter periods.
- Containers rarely remained completely exposed in the sun. Containers are normally stacked up together so it is rare that all sides of the container and the roof would all be exposed to the sun at one time.
- Even if containers were fully exposed on all sides, it is likely that only 15% of the nets might be exposed to higher temperatures.

It should also be noted that PermaNet 2.0 which had been stored in people's homes for up to ten years under uncontrolled conditions still performed exceptionally well in laboratory tests. This indicated that storage, while potentially reducing efficacy slightly, was not a major factor in declining LLIN performance.

Transport of LLINs to each province and district and final storage of nets.

Once nets arrived at Port Moresby or Lae, they were transported to other province for final storage. For all provinces, this would be by road or by ship for maritime provinces. For maritime provinces, the SOCs were stored at ports initially, but after 2011, all nets were stored on arrival in provincial health grounds such as the provincial office or provincial hospitals. From these locations, containers might be sent to other districts where possible.

For a number of provinces, the containers of nets were not stored at one location. Where possible, particularly in the highland provinces, containers were sent directly to the districts in which the nets would be distributed. This reduced time and costs.

The major task was deciding how to get the LLINs from the containers to all the respective locations where they were needed. Easy places could be reached by road, and more difficult places by boat and in the worst-case scenarios, by airplane or in the extreme scenarios by helicopter. The other logistic option was trekking nets into remote areas, but for nets in large quantities, helicopters generally proved cheaper and safer from a security point of view. One only has to imagine hiring 300 trekkers to carry nets for four days through a mountain range. 300 trekkers could carry about four tons of nets, and to pay and feed these trekkers, let alone supervise them to make sure that they would not run away with the nets, would cost anything up to US$16,000. For this price you could hire an old Russian Mil 8 helicopter and get the nets to the location cheaper and faster and without all the hassle. Nevertheless, RAM did have to use trekkers all the time to reach small locations, but for large scale movements of nets into remote areas, it was always cheaper to use airplanes and if necessary, helicopters where airplanes could not land.

Pre-planning of operations in each province through provincial visits.

RAM had already recognized that the provincial health authority staff were the most suitable partners to implement the LLIN programs. However, within this broader group, it was necessary to pinpoint exactly who would be responsible for carrying out the work at the community level. Therefore, once mosquito nets were in country, it was necessary to start working with the individual provinces and to decide who was going to do what.

At least two months before operations would take place in a province, senior RAM staff, usually including myself, would visit each provincial health authority. The major aim of such visits was to introduce ourselves and explain how operations would take place and define who would do what during the operations. This also included discussions on budgets, payment rates for volunteers and health staff assisting the program, and allocation of villages to health centre catchments areas.

It has been recognised that the most suitable health staff to carry out LLINs distributions were those who worked in the communities to be served. Therefore, the first detailed planning exercise was to allocate villages to the catchment areas of each health centre. In this task, RAM came prepared with village lists of each province, and from this, each village was allocated to a health centre. This task was primarily done by provincial staff but where possible, this was also verified by district and health facility health staff as provincial health staff could sometimes give misleading information.[10]

The only limitation to this approach, is that in many health facilities in PNG, there were simply not enough staff who could carry out all the functions of the LLIN distribution program. When this situation occurred, local capable people, nominated by the health staff were also recruited to assist. However, at all times, these additional staff operated under the direct guidance of both the RAM field officers and health staff. The health facility staff who worked with the project were known as DHT (District Health Team) and those nominated outside of the health service were known as Team leaders. Team Leaders were often school teachers or local church ministers who had almost the same responsibilities as the DHT in terms of what they were expected to do, except in verifying activities carried out by others. The most important aspect of both DHTs and the Team Leaders is that they knew well the communities and the areas they were to work in.

However, for all other functions, local people were also recruited to carry out any additional work. Surveys were carried out by appropriately educated villagers from their own village and who were ultimately nominated by village elders or by health staff. In the latter case, these were volunteers from villages who normally worked with the health staff on outreach programs and who had ultimately been chosen by their respective communities to represent them.

There were other tasks that needed to be carried out. In many cases, nets needed to be trekked into remote areas, and for this, villagers from remote area receiving the nets would be chosen to trek the nets to their respective villages at a cost to the program.

There were always lots of other jobs such as security guards for nets at health facilities or simply getting labour to move the nets from vehicles or airplanes to the places of storage. In all cases, “volunteers” required payment for the day whether they spend one hour or ten hours. The basic rate in PNG was 20 kina a day, which in US dollar terms (in 2010) was about US$8. In my mind, this was a huge amount

[10] Provincial staff in PNG, like in many other countries I have worked in, do not know their provinces well, particularly at village level. Provincial staff could therefore assist in the organization of mosquito net distributions but they could not directly carry them out. For this, the most appropriate people to organize the distribution of mosquito nets were the health staff at each health centre where villages are situated.

of money compared with what organizations would pay volunteers in Africa and other developing countries. The only defence for this high price was that the cost of living in PNG was huge and the currency overvalued.

From this planning exercise with provincial staff, RAM was able to determine how to fulfil all the tasks for the provincial LLIN distribution.

Preparation of all materials and logistics to the provinces

Before deploying a RAM team to a province, extensive preparations were required, involving both field and administrative staff. Everyone in RAM worked together to ensure all necessary arrangements were in place before departure. This coordination was crucial, as field staff had to travel with all essential supplies and equipment.

The involved the following components:

- Ensuring that all the logistics were in place to deliver the LLINs to the provinces and from the provincial centre, down to each central location (usually a health centre) from where the LLINs would be delivered to the villages.
- Prepare field budgets for operations for each officer and health facility.
- To streamline operations, RAM field officers were assigned to a specific health centre before arriving in the province. This ensures that they were fully prepared for their responsibilities and requirements.
- Field staff also had to carry out substantial preparatory tasks, including submitting cash requests to secure the funds needed for their work. These financial requests were based on predetermined budgets outlined below.
- Preparation of all the documentation and equipment needed for each provincial distribution which included items such ball point pens, permanent markers, staplers together with all forms needed to complete all task.

Logistics

For all intended deliveries to and within provinces, RAM needed to identify suitable service providers in advance and look for quotations from as many suppliers as possible. Transport options included road, boat to airplanes and sometime helicopters in extreme circumstances. However, getting many quotations and keeping financial controller happy was often elusive as service providers were few in most provinces.

Road transport to provinces was the best where possible. Containers would be moved on big trucks. However, moving containers into rural locations, Papua New Guinea featured a type of vehicle I had never encountered elsewhere, the side lifter.

Side lifters are specialized trucks equipped with hydraulic arms that allow them to park next to a container, lift it onto the truck bed, and unload it in the same manner upon arrival at the destination. These trucks proved invaluable, enabling the program to place containers in remote locations where conventional loading equipment was unavailable[11].

[11] I often wondered why I had never seen such trucks in the United Kingdom or other developed countries. They likely exist in Europe, but they are rarely needed because, in most cases, forklifts or other lifting machinery are readily available for loading and unloading containers. In Papua New Guinea, however, side lifters provided a practical and efficient solution for container transportation in challenging terrains.

Side lifter trucks were very important in our first operational areas. As the nets were in containers, we could preposition them securely in advance in the grounds of local hospitals or participating health centres (where accessible by trucks) where they would be secure and cared for. The only problem with side lifters compared with bigger trucks is that they were expensive to use, so generally were used only for shorter journeys into rural locations.

In many locations transportation by road or ship was not possible so smaller boats had to be used. This was necessary in Gulf Province in 2010 where the provincial capital and the district of Kikori were not easily accessible by road and everything had to go by barge (looks like a landing craft). For these types of barges, all LLINs had to be put onto pallets before loading onto the barges which was a specialised task in its own rights.[12]

While putting bales on nets onto a pallet may not seem like a particularly critical skill at first glance, over the course of the project, only two staff members ever learned this skill and became the program logisticians. This simple expertise played a vital role in ensuring the smooth transportation and distribution of nets, highlighting the importance of specialized logistical knowledge in large-scale health initiatives[13].

Side lifter truck in Rigo District of Central Province delivering a container of LLINs

Aircraft had different logistical requirements. In 2010, there were many places that could only be reached by air. All the preparations in terms of goods, food money etc had to be ready before the RAM team left for these fly-in areas. Once staff boarded a plane for a remote fly-in area, there was no further support until they had completed their work and were picked up, normally about ten days later. The only exception to this, was if there was an emergency, normally a medical emergency, and RAM would have to fly back into the area to assist.

Modes of Transport

[12] In the early days of the program, there were no staff exclusively assigned to logistics. However, RAM was fortunate to have a staff member called Jerry Leva, who had previously worked with RAM before it secured a Global Fund grant. Jerry possessed valuable skills, he was familiar with local transportation companies, experienced in handling containers, and, most importantly, knew how to stack bales of nets onto pallets for shipment by boat when necessary. For this skill alone, he eventually became the official program LLIN logistician.

[13] While the barge could be directly loaded in Port Moresby, once it reached its destination, the nets and other essential supplies, including fuel for boats and vehicles, had to be offloaded by hand, onto land, using small dinghies. Off loading big boats onto dinghies was a common method of delivery in many locations in the country as there was no landing place to dock the bigger boats.


Coastal shipping in barge like boats (Morobe Province) or dinghies (Manus Province)

Budgeting

Once the transportation of nets and boat and vehicle fuel was organised, the next step was the organisation of all other necessary paperwork and equipment, but most importantly, to estimate the amount of funds needed for each location. This latter element was particularly difficult in fly-in areas as there was little latitude for getting it wrong, and if staff did run out of funds, the only way this could be replenished was at the end of the program when airplanes returned to pick up staff.

Budgeting became an art form. We needed, in advance, often without any help from the people in the areas to which we were travelling, to calculate the potential costs the program would face. For fly-in areas, together with the population data, all the villages came with Geographical Position System (GPS) coordinates, and from the maps made, the program could make out some basic type of assessments about how much funding would be needed for trekking in remote areas. Trekking could be very expensive so it was important that each officer had adequate funds to move nets around by trekking if necessary.

Another aspect that helped budgeting and planning a lot in the early days was fixed prices organised for certain services such as boat hire. The National Department of Health (NDoH), through Australian grants, had set the price at which various services could be hired for. In 2010, it was possible to hire local boats at an agreed rate of 200 kina a day without much trouble. This was good for the program and for possible corruption, as staff knew that they had to remain within these rates when accounting for funds. Sadly, this latter system has not remained, and as the program carried on, service providers would ask for higher and higher rates when hiring out their boats or other services.

Cars also remained a headache. At first, hired cars from international companies like Hertz and Avis were used, but as time went on, these companies were not available in remote areas and also the program received rental better rates from other companies. Probably one of the notable aspects of the RAM program, is that RAM hired vehicles at much better rates than any other organisation in the country. This was done through developing good relations with a number of hire car companies who have remained with the program since 2010. Like boat rates, car hire rates become fixed.

Assigning Staff To Health Facilities

One of the rules the program developed, is that where possible, the program always sent a field officer to an area where he had never been before, and if going to the same province for a second time, he

was not allowed to return to the health centre he had previously worked in. This was based on experience, as officers, who thought they knew an area, would direct activities in the way they thought fit, and worse still, would employ people that they already knew which created conflicts of interest. It was therefore expected, using local expertise, that RAM officers would facilitate the most efficient way to carry out a program. This meant that all the micro planning would ultimately be jointly done by local health staff and other local expertise but ultimately, all activities carried out under the watchful eye of the RAM officer who was responsible to getting the program completed in good time.

Paperwork and Equipment

In the office, all field staff, apart from helping out when needed to load nets or other activities, had to manage a huge variety of paperwork to complete their work. This included paperwork which included vehicle log books, survey books, planning documents, micro planning documents, payment vouchers for different types of activities, cash book and the very important reconciliation forms. To remember everything, there was a "field needs" check list which also included items like life jackets, thumb pads, carbon paper and all the other items that they would need to give to survey volunteers such as biros (ball point pens) and for the health staff, staplers, markers and T-shirts. The biggest challenge was getting the field officers to read the "needs check list" before they left as inevitably, they left something behind.

Once everything was arranged, the staff would travel to the province and from there, to their respective health centres. RAM Field Staff were allocated, in some cases two health centres with small catchment areas, to coordinate and manage all activities.

Arrival in a Province

When a RAM distribution team first arrived in a province, they immediately had a meeting with the provincial health staff to discuss plans and decide who would go to which health centres. Provincial officers were encouraged to join RAM officers in the field, but sadly few did, and would only monitor the program at intervals together with team leaders.

Prior to leaving the provincial capital and heading to health centres, the RAM field staff would pick up their hire vehicles and fuel, and buy all the rations (food) they needed when away from the provincial capital. All RAM officers were expected to remain at the health facilities they were working with, unless they needed to replenish funds, and then only with prior permission to travel from their operational area. However, some officers sneaked out when they got the opportunity to do so.

Containers being transported to provinces and local aeroplanes taking nets to remote areas

Micro-planning in participating health centres.

On arrival at a health centre, RAM officers needed to introduce themselves to the health staff. Once done, the first priority was to have a micro planning meeting with all staff to be involved in the forthcoming distribution program.

During this meeting, the first issue to decide was which health staff can assist and whether it is necessary to recruit additional team leaders. The second important task was to make a map of all the villages under the catchment area of the health centre. From this map, it could be calculated the best way to reach all the villages and, from this, set out a timetable of events. This resulted in a plan of how every village would be visited, village volunteers trained, village surveyed and then finally, allocation of nets and the nets distributed to each village.

The micro-planning process required a lot of skill to do well, and some RAM field officers were much better making then than others, but ultimately, they needed to create a daily plan of who was doing what with themselves included.

This micro-plan would guide all the activities and each RAM officer was given 20 days maximum to complete the areas they had been given. If staff took longer than 20 days, which was often the case, they had to have a good explanation why this occurred.

One of the important aspects of the micro-plan is to make sure that the villages allocated to the health centre come under that specific health centre, and more importantly, make sure that no other villages had been left out of the list that RAM had for planning purposes. Over the years, RAM has discovered many new villages which were not included in the 2000 Census and RAM had to make sure that all villages in any given catchment area were covered.

Program Implementation and Field Process

Household Surveys - Reaching Village Population with the Correct Number of Nets

It was quickly understood that relying solely on village estimates from the 2000 national census would not be enough to assess current needs. By the time RAM launched the program, the census data was already 10 years old, and many residents had relocated between villages. As a result, the information had to be verified to ensure each village received the appropriate number of nets before distribution began.

The second problem was, even when the number of nets required was known, how best to make sure every household received the nets they needed. It is easy to imagine that simply delivering sufficient number of nets to a village will not result in an equitable distribution if left to their own devices.

The challenge was to provide each village with the correct number of nets and ensure every household received a fair share. To achieve this, a census had to be conducted in each village. Unlike the previous Global Fund round from 2006 to 2010, it was decided that the census would be carried out by individuals chosen by the village itself, i.e. people who lived there and knew every family, making them best suited for the task.[14]

[14] As a reference to this, I had worked in flood emergencies in Mozambique. In this instance, I discovered that many organizations simply relied on the village chief to supply the information needed on every household. In other country programs, volunteers (not from the community) go to each household and ask for the number of people in the household. Both approaches in my experience led to a lot of creativity of numbers.

In previous LLIN programs in PNG, provincial staff conducted village censuses themselves. Not being familiar with the villages, they reportedly excluded many households, and their population estimates were often inaccurate.

One other major issue was that extended families were often very large, and when householders were asked how many people lived in their homes, they felt pressured by survey volunteers and gave quick guesses, often overestimating to ensure everyone was covered[15].

In PNG, it was therefore necessary to create a village census system that could accurately count the population and ensure each household received the right number of nets. The program also needed a way to prevent false reporting of household members.

To achieve this, survey volunteers were recruited from within each village who knew every household personally. To ensure accurate data, volunteers recorded the name, sex, age, and relationship to the head of household for every individual. After completing the census for each home, they provided the household with a duplicate white receipt of the information collected which was to be presented when collecting nets.

Training of Survey Volunteers

As emphasized earlier, all survey volunteers had to be residents of the village they were assigned to. Many already had established connections with local health centres through previous health programs. In cases where no such volunteers were available, RAM worked closely with village elders and leaders to select someone who was literate and widely accepted by the community.

In areas with good road access, or proximity to health centres, volunteers could be trained in groups of up to twenty volunteers. However, for remote villages, especially those requiring health staff to travel on foot, survey volunteer training was conducted individually at the village level.

The village survey volunteers were expected to survey about 25 households a day. For this they were given survey books which had duplicate copies for 50 households. These survey books were expected to be completed within two days. As households averaged about five people per household, one survey book was normally enough for villages of about 200-250 people. If villages were much larger than this, often more than one survey volunteer per village was recruited so that the survey could occur quickly. In these circumstances, two or more volunteers needed to decide which houses were done by whom. This was when the verification process became very important (see below) to ensure that no household was surveyed more than once.

After completing the village survey, volunteers returned their survey books to the health centre team. If the surveys were properly conducted and the data recorded correctly, the volunteers received their payment.

The collected data was then compared against the projected population figures. If there were significant discrepancies between the expected and actual numbers, the RAM officer, together with health centre staff, would investigate to ensure the data was accurate. For instance, in cases of tribal

[15] In Mozambique's flood emergencies, I saw similar problems. Whenever teams distributed nets, they often had to flee as the supply was too limited and crowds kept arriving, expecting to receive nets. Another challenge arose when village chiefs were responsible for listing households; they sometimes exaggerated the size of their own families. I recall a troubling incident where a village chief in Mozambique was attacked by his community after falsely claiming he had four wives and many children, when he actually had only two wives.

conflict, residents might relocate from one village to another, leading to a drop in population in one area and a rise in another.

Verification of Data

To prevent cheating, RAM initially required village volunteers conducting the survey to read aloud the list of families and the number of people in each household to a gathered crowd. This allowed villagers to know that they had been included in the list and that families were not giving false information.

This method was later replaced with a written list using a standardized template. On this template, every family in the village was recorded along with the number of people in each household. The completed list was displayed in a public area for 24 hours so the entire village could confirm their inclusion in the survey. More importantly, it allowed families to see how many people others had reported, helping to maintain transparency.

Although this process was time-consuming, it helped prevent situations where individuals claimed they had been left out after nets were distributed. Those excluded were often the most vulnerable, such as people with physical or mental disabilities, and when this happened, it was deeply embarrassing for everyone involved.

Despite all the precautions, an additional verification system was later introduced in 2017 when Against Malaria Foundation (AMF) became a donor. Around 6% of households were revisited for spot checks to confirm that village survey volunteers had completed their work properly. Each survey book covered 50 households, and it was expected that three households per book would be randomly checked by a RAM staff member or a DHT from the local health facility to ensure the data was accurate.

This 6% system was not feasible for all villages in remote locations and only applied to for villages accessible by vehicle or within a two-hour walk from a road or river. In the remoter areas, surveys were usually coordinated by local health staff, and the program had to rely on their diligence and integrity. These villages received their mosquito nets either by sending trekkers from the respective village to the health centre or by villagers in remote coming to collect them directly. It was understood that if insufficient nets had been supplied, complaints from these communities would likely have followed, serving as a natural check on the accuracy of the data and distribution.

With these safeguards in place, the goal was to ensure the village population data was reliable. Once the methodology was finalized and the survey books confirmed, the RAM team was ready to begin the distribution process.

Allocation of Nets

In PNG, the nets were ordered at a ratio of 50 nets to every one hundred people (one net for two people) which is much less than other countries. Nets in PNG, unlike most countries, were allocated based on sleeping patterns[16].

[16] The system of using sleeping places was developed by myself in Mozambique though sleeping patterns differ in the two countries. One fundamental difference between PNG and Mozambique (and much of Africa), is that children in PNG sleep with their parents until the age of six and then are separated into boys and girls sleeping areas. In Mozambique, children remain sleeping with the parents until the next child is born and then pass onto a communal sleeping area for children. Only when the boys reach puberty at about eleven or twelve years of age, do the male children separate and sleep with the single men. I recently discovered that Mozambique had continued net allocation based on sleeping place for many years after I had left. I was also informed that eventually Mozambique had to abandon the methodology as villagers worked out how to manipulate the census to get more nets. I believe, due to the verification processes put in place, this has not occurred yet in PNG.

In many countries, nets are allocated to households at a rate of one net to every two people in a household. If a family has an odd number of people, they get an extra net. This means that when ordering nets, programs have to order about 55 nets for every one hundred people (or one net for every 1.8 people). Even with this ratio, some families will get too many nets and other too few depending on who sleeps with who in a family.

Basically, RAM staff and DHTs trained by RAM staff, literally reviewed every household in every survey book, and allocated nets to each household depending on the household makeup. This system allocated one net for the parents and two children below six years of age, and then one net for every three girls (ladies) and one net for every three boys (men) residing in the household.

Once all the nets are allocated, then the total number of nets was added up for each village. If the number of nets allocated is less than the number of nets allocated to the health centre, then extra nets might be given out to families with old men. Grandmothers seemed happier to sleep with other girls and ladies in the house, but the men are fussier. However, RAM officers were encouraged to save nets where possible as there might be other locations in the same vicinity or province which have a shortage of nets.

Occasionally, nets allocated to a health centre were not enough and exchanges needed to be made with other health centres where there were savings, or in extreme cases with other provinces though this was rare. The only time when the situation was desperate was in locations where the team had to fly in and there were not enough nets to go around and no way to resupply easily. In this latter situation, the nets available had to be distributed as equally as possible to the families surveyed. I am happy to say, that this very rarely occurred and for the most part, the logistic estimates were very good.

In fact, the logistic estimates improved after the first three years. After three years, the RAM program no longer relied on the 2000 Census but on the figures collected by the RAM team distributions in the previous three years. These figures were to prove surprisingly good, and provincial estimates generated were consistently good enough to use for the following three years. This was perhaps one of the greatest successes of this program, as was the consistent generation of population data in provinces and which many provinces would use in future.[17]

Distribution of Nets

Distribution of nets to communities is as much an art as a science.[18] It sounds easy giving out mosquito nets to communities, but it reality, distributions can be chaotic and very much dependent on the staff organising the distributions. In this respect, I learnt a lot from Mozambique, not only in emergencies, but also in National Campaigns which were organised by UNICEF in Mozambique, where LLINs,

[17] The use of population data was always politically driven. RAM did produce good population data which many provinces did not have, and they were thankful to RAM for sharing this with them. However, many of the provinces had much higher population estimates than those generated by RAM, and preferred to use these estimates, as these generated more money. For example, when there was an EPI (Expanded Program of Immunisation) or more commonly known in PNG as SIA (Supplementary Immunisation Campaign), provinces would be awarded a budget for these campaigns based on the population of children they had. Therefore, in many cases, the RAM estimates of the population were often lower than those of the provinces, so they would use their greater estimates in order to attract more funding for their activities.

[18] Observation of distribution points was always interesting, and in many cases, very saddening. Some distributions in Mozambique were extremely orderly with very few organisers involved, while others, with many people supervising, could be chaotic and frightening. In some cases, there would be large groups of women and their children, being patrolled by men wielding sticks and beating anyone who stepped out of place. In comparison, I still remember one location with a huge crowd, and only one health staff member present who kept the whole crowd in order in a peaceable manner.

together with other interventions such as Vitamin A were distributed to all the children in Mozambique at the same time.

Organisation is everything in a distribution. For the distribution to go quickly, it requires consistent order and planning. Fortunately for RAM, the program never had a shortage of nets when carrying out distributions, but there were many other things that could go wrong.

For the most part, distributions were carried out in central places, and if the villages were big, in the centre of the village. Alternatively, where there were a number of villages close together, a central place might be chosen which all villagers can reach. The timing was important, as it is necessary to choose a time and day when most of the villagers would be able to attend the distribution.

During these distributions, in theory, householders would be organised into villages or into groups represented in each survey book. Normally they would be asked to sit separately so it was easier to communicate with them. Ideally, the householders would then be called out one at a time using the names from the survey books. Each villager would bring the white receipt that they originally received when being surveyed, and exchange the nets allocated to them for the receipt. If the householder had lost their receipt, they were then generally asked to wait until the end of the distribution. This allowed the nets to be allocated after all other receipts had been collected and it was easy to see which households had not yet received nets in the survey book. This was always important, as sadly, there were many people who are inclined to cheat and use any opportunity to get extra nets.

For remote villages, irrespective of size, if they could be reached by vehicles, individual distributions would be carried out in each village. This would also apply to villages on rivers which could only be reached by boat.

In remote villages that required trekking, those located relatively close to a health centre often had a health staff member accompany the trekkers to oversee and confirm that the net distribution was done correctly.

For villages situated much farther away, the ideal approach was for health staff to visit once to conduct the survey. After the survey, they would return with village trekkers who would collect the mosquito nets and carry back a detailed allocation list showing how the nets were to be distributed among households. In these cases, villagers needed to choose trekkers they trusted to deliver the nets fairly and reliably.

This was the basics of LLIN distribution, but different areas had different challenges and required different approaches. In many remote areas, field staff would reach the villages by foot or boat, and carry out a survey and distribution at the same time as it was too expensive to return a second time. In other instances, where markets were taking place, distributions could occur at the market as householders from certain villages would be known to attend the markets in mass and this was a good time to meet the villagers in places they would normally visit.

For all these reasons, the RAM staff had to be well trained to work with the local health staff to find the best ways of reaching all the remotest areas and making sure that each village and every householder in each village received their nets.

Other Notes

At the end of each distribution cycle, it was important to collect all the data and send a report to each province on the number of villages reached, the population of each village, and most importantly how

many nets each village received. This was important for verification purposes, so in the event of a complaint or query, the program manager was in a position to answer any questions posed.

The most important thing about the RAM program was that RAM field officers were given very strict instructions that they could not leave their project areas without reaching every village on their list. They also had to confirm whether any villages had been left out. For each provincial report, there are normally a few new villages identified that need to be included in future distributions.

The most successful part of the program, is that since its inception, there is a distribution report for every distribution done in every province for every year in which a distribution has taken place. These are accessible to anyone who wants them as the reports outline the successes and challenges of each distribution that has taken place.

PNG Population Figures

The National Statistics Office (NSO) was the official voice of the population of PNG. As far as we know, the population census done in 2000 was very good, and for the most part, served as an excellent guide to the number of nets required in 2010. However, there were some errors, and some of the estimates of population growth made were too high in some cases resulting in RAM ordering too many nets in few highland provinces, particularly Southern Highland and Hela. Nevertheless, without the data supplied by the 2000 Census, the PNG LLIN program could potentially have been a logistical nightmare.

After the first three years, in 2013, RAM no longer used the 2000 Census Data but used its own previous data for planning purposes and in almost all cases, this was an accurate predictor of the needs of each province in the future. However, strangely in 2011, another census was held by the NSO, and while their overall countrywide population estimates were the same as RAM, data in some provinces and districts was completely different to those RAM had calculated.

The issues of actual population figures became particularly contentious in 2021. With support of UNFPA (United National Population Fund), Southampton University from the United Kingdom and funding from the Australian Government, the NSO commissioned a population estimate of PNG using satellite imaging of different criteria and other factors. The NSO even took into consideration RAM data and downloaded much of this into their own data bases. However, at the end result of this exercise, many districts and provinces had projected population figures similar to RAM, but other provincial estimates were significantly different. In the end, the NSO together with their UK consultants, estimated the population of PNG in 2021 as being two million more people than estimated by RAM. In some provinces, the populations estimated were two to four times higher than those estimated by RAM.[19]

The whole story of NSO, UNFPA, AUSAID and Southampton University had also caused much controversy earlier on. Someone (rumoured to be from the Australian High Commission) had leaked that the initial estimated for the population for 2021 was 17 million people. This caused huge alarm bells, as the country was working on estimates which were half of this. It was fortunate, that after reviewing their data, including that of RAM's, that the estimate for 2021 was reduced to only 11.7 million people though RAM was still estimating about 9.7 million for the same year.

[19] I asked those involved with the 2021 census the simple question, if RAM had arrived in these provinces with only half or a quarter of the nets required, would they not think that the local population would have been up in arms and accusing RAM of undersupplying nets. This question fell on deaf ears and the population of PNG officially is two million more people than estimated by RAM. Only time will tell if RAM population surveys were more accurate than estimations based on satellite images.

The only way to reach much of the remoter part of PNG
This was in Sandaun Province on the boarder with Indonesia

CHAPER FIVE - The Malaria Program Partners

Chapter Summary

- Introduces each of the partners involved in the PNG LLIN distribution program.
- This includes the National Deportment of Health (NDoH), National Malaria Control Program (NMCP), Global Fund, Rotary International and the Rotary Club of Port Moresby, Against Malaria Foundation (AMF), PNG Sustainable Development Program (PNG SDP) and the PNG Institute of Medical Research (PNG IMR)

There have been a large number of partners involved with malaria control directly and indirectly in PNG. However, there are several which have significantly contributed in terms of finance, implementation and technical support of the LLIN distribution program.

For coordination and implementation, the Rotarians Against Malaria (RAM) (together with the National Malaria Control Program of the National Department of Health) has been the major partner of the LLIN distribution program. RAM however, is a project of the Rotary Club of Port Moresby which in turn falls under Rotary International.

For financing, the program has had three major contributors. The initial and major donor who started the LLIN distribution program since 2006 (RAM from 2010) has been the Global Fund, but also importantly, significant contributions were made by Against Malaria Foundation (AMF) from 2017 to 2020 and PNG Sustainable Development Program (SDP) from 2018 to 2026. In terms of AMF contributions were made in kind with the supply of LLINs, while PNG SDP funded most of the malaria activities carried out from 2018 onwards in Western Province. The program was indebted to Global Fund, but the financial interventions of AMF and PNG SDP allowed RAM to maintain a national program throughout PNG which might not have occurred had the AMF and PNG SDP not stepped in when they did.

However, other partners should be mentioned who contributed greatly to the program over the years. The most important of which is the National Malaria Control Program (NMCP) of the National Department of Health (NDoH). For the NMCP, its senior officer Mr Leo Makita deserves special mention as he remained in this position from about 2000 to his death in 2024 and was probably, together with Ron Seddon the director of RAM, instrumental in assisting in setting up RAM to be part of the Global Fund Malaria Control Program.

RAM also worked closely with other organisations who were carrying out different aspects of the malaria program in the past. The most important perhaps was the PNG Institute of Medical Research (IMR) which carried out malaria research alongside the malaria program, particularly having three-year audits of the program which became known as Malaria Indicator Survey (MIS). IMR were also later instrumental in the discovery of poor-quality nets in 2018. Without the IMR, it would have been very difficult to gauge the impact and success of the program from year to year.

One other partner with RAM throughout, was the World Health Organisation (WHO) who remained the technical advisor to the malaria program. Other implementing partners in malaria included Population Services International (PSI) and Oil Search Foundation (OSF) which implemented other aspect of the malaria control program up until 2018 after which RAM took over their roles. There were other organizations involved in malaria in smaller ways such as the Malaria Trilateral Project which was a joint venture between China, Australia and PNG and concentrated on improving microscopy in the country together with the Central Public Health Laboratories (CPHL) and the Pharmaceutical Services

Standards Branch (PSSB) of the NDOH. All these partners were important in their respective roles to make the PNG program a very well-coordinated and national program.

The background on each of the major partners follows.

Rotary International

Rotary International is one of the largest service organizations in the world coming only second after the Lion's Club International. The mission of Rotary, as stated on its website, is to "provide service to others, promote integrity, and advance world understanding, goodwill, and peace through [the] fellowship of business, professional, and community leaders". It is a non-political and non-religious organization. Membership is by application or invitation and based on various social factors. There are over 46,000 member clubs worldwide, with a membership of 1.4 million individuals. For administrative purposes, the more than 46,000 clubs worldwide are grouped into 529 districts, and the districts into 34 zones which include over 200 countries. PNG Rotary Clubs belong to an Australian Rotary District.

Rotary started with the vision of a man called Paul Harris. He was an attorney from Chicago who, on 23 February 1905, together with three colleagues, formed the Rotary Club of Chicago. The name of Rotary came from the habit of having weekly meetings in different member's offices i.e. rotating venues according to the members in the club. However, membership grew so quickly, that soon they had to elect for one meeting place only which is the common practice of Rotary Clubs today.

The initial purpose of the club, was that professionals with diverse backgrounds could exchange ideas and form meaningful, lifelong friendships. Over time, Rotary's reach and vision gradually extended to humanitarian service.

The Rotary idea quickly took on, and soon other clubs were formed in other parts of the United States such as San Francisco, Oakland and Los Angeles and in 1910, a new club was formed outside of the USA in Winnipeg in Canada. From there, Rotary Clubs started to be formed in other countries such as Ireland in 1911, followed shortly by a club in London in 1912. In recognition that the Rotary Clubs were no longer only in the USA, the organisation changed its name to the International Association of Rotary Clubs in 1912 and eventually to Rotary International in 1922.

Rotary International began expanding globally in its early years but faced several challenges. In 1919, the first Rotary Clubs in Asia were established in Manila, Philippines, and Shanghai, China, but they appeared to accept only white members. To promote inclusivity, Rotary's headquarters in Chicago encouraged the Shanghai Club to welcome Chinese members. This approach met resistance in 1920 from clubs in Kolkata (then Calcutta), India, and Tokyo, Japan. As a result, Rotary formally addressed the issue of racial exclusion and decided that such restrictions would not be allowed. In June 1921, Rotary officially ruled against racial discrimination, and by 1922, all member clubs were required to adopt a constitution that supported racial equality.

Although Rotary International had begun embracing racial inclusivity, women were still excluded from membership from its founding in 1905 until the 1980s. During that time, wives and daughters of Rotarians, including Paul Harris's wife, often joined the "Inner Wheel" club, created specifically for female relatives of Rotary members.

The question of allowing women into Rotary was debated for years, but real change began in 1976 when the Duarte Club in California admitted three women. Rotary International responded by revoking the club's charter in 1978. In protest, the club sued in California, arguing that Rotary Clubs

were business establishments and were subject to the Unruh Civil Rights Act which prohibits discrimination based on race, gender, religion, ethnicity, or sexual orientation.

Rotary International appealed to the U.S. Supreme Court, but momentum for change grew. In 1986, a Seattle club voted unanimously to admit women. Then, on May 4, 1987, the Supreme Court upheld the California ruling in *Board of Directors, Rotary International v. Rotary Club of Duarte*, affirming women's right to join. That same year, the first woman was elected president of a Rotary Club.

While Rotary was becoming more inclusive, it wasn't until the 1990s that the organization began welcoming gay members and not until 2018 that the LGBTQ community was officially recognized as part of the Rotary Family.

Women now account for about 22% of Rotary membership worldwide and the change of the second Rotarian motto in 2004, from "He profits most who serves best" to "They profit most who serve best", 99 years after its foundation. This illustrates the move to general acceptance of women members in Rotary. Still, in Port Moresby of Papua New Guinea in 2024, there are two Rotary Clubs. One club still steadfastly remains male only.

Rotary International did have other issues. The Catholic Church at one time banned its members from joining Rotary due to its non-religious secular bias and, during the war, Rotary International in Germany was put alongside the Masons as being described as a secret society and only survived after Jewish members were disallowed membership.

Despite its trials and tribulations, Rotary International for all its history is still famous for its good works. The mandate for all Rotary Clubs is to raise funds for local charities and improve communities. While much of the work of Rotary is done at club level, there are other levels at which Rotary International works. Internationally, Rotary is best known for its long support, started in 1985, of the Polio Plus program to immunize all of the world's children against polio. As of 2011, Rotary had contributed more than US$900 million dollars to the polio cause and has seen polio almost eradicated from the world except in isolated areas of Nigeria, Afghanistan and Pakistan.

With Polio now disappearing, there is much pressure for Rotary to start investing in other diseases with malaria being top of the list. In this respect, perhaps Rotarians Against Malaria (RAM) PNG has led the way towards this goal supported by Rotarians Against Malaria (RAM) in Australia.

Rotarians Against Malaria (RAM)

Many believed that Rotarians Against Malaria (RAM) began in Papua New Guinea in 1997. However, it turns out that the PNG initiative was unaware of similar efforts happening elsewhere.

The concept of RAM appears to have originated in Sydney, Australia, through the Rotary Club of Brookdale. In the early 1990s, Dr. Brian Handley, a member of the club, was deeply concerned about rising malaria cases in the Solomon Islands following the end of DDT spraying. Determined to take action, he launched RAM.

Initially managed by the Brookdale Club, RAM was later overseen by Rotary District 9680 to raise funds, especially for Long Lasting Insecticide Nets (LLINs). Though the program aimed to support Vanuatu and the Solomon Islands, its first overseas project began in 1995 on Tulagi Island, Central Province, Solomon Islands. This joint effort between the Honiara Rotary Club and District 9680

involved purchasing netting, which women's groups in Western and Choiseul Provinces sewed into mosquito nets of various sizes.

Over time, the program grew, distributing around 250,000 treated nets before the Global Fund began supplying LLINs nationwide. With the Global Fund covering the country's needs, RAM shifted focus to the Healthy Island initiative, encouraging communities to clean their villages and eliminate mosquito breeding grounds. RAM in Honiara launched the "Adopt a Village" program to support this effort with tools and infrastructure. Notably, the Healthy Island concept had already seen success in Isabel Province, where women's groups led early efforts, and malaria rates still remain low there today. Data suggests malaria began declining in the Solomon Islands from 1995 onward, and RAM likely played a key role in that progress.

In PNG, the story unfolded differently. The Rotary Club of Port Moresby formed RAM in 1997, initially calling it Rotary Against Malaria before adopting the now official name of Rotarians rather than Rotary. Two origin stories exist, both likely true. One recounts how Ron Seddon and fellow Rotarians witnessed a child's death from malaria at a local health facility, prompting them to take action. The other, shared by another founding member Rio Fiocco, tells of a donation of 150,000 insecticide-treated nets from Australian Aid. The club was requested to sell the nets, create a revolving fund, and use the proceeds to purchase more. The club president at the time predicted the project would last over a decade. Whether sparked by tragedy or opportunity, RAM in PNG was born from a shared commitment to fight malaria.

In the early days of RAM in Papua New Guinea, a committee was formed that included Rotary Club members, the head of the National Malaria Control Program (NMCP), and representatives from the World Health Organization. This group helped establish a strong and lasting partnership between Ron Seddon and NMCP's National Manager, Leo Makita.

One of RAM's first tasks, alongside distributing the 150,000 donated mosquito nets, was retreating nets previously handed out by the government. At that time, Long-Lasting Insecticidal Nets (LLINs) weren't available, and regular Insecticide Treated Nets (ITNs) lost effectiveness after washing, requiring retreatment.

To manage distribution, RAM sold the donated nets at nearly cost price. The money raised was used to buy more nets, creating a revolving fund. This initiative, which began in 1997 and sold around 40,000 nets annually before the Global Fund began supporting malaria efforts, has continued successfully into 2025. It stands as a remarkable example of a successful revolving fund and how the private sector can support public health.

To boost mosquito net distribution, it's believed that in 2002, Ron Seddon and the RAM committee launched the Adopt a Village (AAV) program. The concept invited Rotary Clubs, especially in Australia, to sponsor villages in Papua New Guinea. A website featuring a map of PNG made it easy for clubs to choose locations, and RAM PNG would then supply nets to those villages. The Solomon Islands adopted a similar AAV model, though their focus was not on nets.

The program was an effective way to raise funds and support remote communities. However, its momentum slowed significantly once the Global Fund began providing enough resources to supply both countries with all the nets and other resources they needed.

In the Solomon Islands, AAV funds were redirected to support community-led malaria control through environmental cleanup, tool provision, and storage facility construction. In PNG, the strategy differed, funds were saved for future use. It was proposed that when Global Fund support ended, Rotary would

use these funds to resume net distribution. As far as in known, these funds remain unspent as the Global Fund has continued to support the malaria program from 2005 to date.

Over time, RAM's partnership with the National Malaria Control Program (NMCP) in Papua New Guinea grew stronger, especially with the arrival of Global Fund support. Under PNG's first Global Fund grant, the National Department of Health (NDoH) received LLINS to cover the country. While the details of how the collaboration evolved are unclear, RAM became a key service provider to NDoH.

RAM took on the responsibility of managing the importation and distribution of nets, specifically PermaNet 2.0 from Vietnam. RAM handled shipping logistics and ensured delivery to provinces and districts across PNG. To support these efforts, RAM received a modest contract from the Global Fund to cover operational costs.

This close working relationship led to a major milestone in 2009, when the Global Fund awarded the Rotary Club of Port Moresby and RAM a grant of US$55 million to distribute nets nationwide from 2010 to 2014. It was a bold move, especially considering RAM's limited capacity at the time. In 2010, the team consisted of just two people: Director Ron Seddon and a full-time logistician (Jerry Leva mentioned previously), who managed customs clearance and ground operations. The rest of the work was coordinated by Ron and his Rotary colleagues from their offices.

Despite its small size, RAM rose to the challenge, but the scale of the program demanded a new and more robust approach.

RAM, which began in the Solomon Islands and Papua New Guinea, was later adopted across Australia and support expanded to include East Timor (Timor-Leste) in 2004. In the early years, RAM contributed to significant reductions in malaria in both PNG and Solomon Islands. However, some years after the Global Fund took over, malaria levels in both countries began to rise again. The introduction of the Global Fund also shifted focus away from RAM-supported programs, which in some cases were sidelined or seen as unnecessary. In hindsight, RAM could have complemented Global Fund efforts at the community level in the Solomon Islands and PNG, but this opportunity was missed.

East Timor, on the other hand, has been a success story. RAM's consistent support, in partnership with the country's National Malaria Control Program, has helped steadily reduce malaria. While it's hard to measure Rotary's exact impact, its role in East Timor has clearly been positive and constructive.

The most important aspect, is that the idea of RAM has been gaining ground with Rotary International in the United States and there are high hopes, that like the PolioPlus Campaign, this will become a leading focus of Rotary International worldwide in the future.

Global Fund has tended to work on large scale interventions such as LLINs or Indoor Residual Spraying (IRS). Rotary works best at community level. The reality is that both approaches are needed, and in PNG, community level malaria programs in PNG were supported by RAM Australia from 2013 to 2017. The trouble is that with so much funding being supplied by the Global Fund, the appetite to support malaria from Rotary Clubs in Australia diminished and there was never enough money to scale up, and these projects did not expand and other RAM PNG supported malaria program died out.

RAM PNG, with Australian RAM financial support, worked at community level and in schools in Central Province. In this project, school children and communities were taught how to eliminate malaria larval habitats, and therefore reduce local malaria transmission. The program also taught school teachers and villagers in remote areas to test and treat malaria in their respective communities and schools.

In terms of treatment by communities, the community programs conducted by RAM in Central Province from 2013 to 2017, were the precursors of the Home Management of Malaria (HMM) program which were later adopted by the Global Fund in 2020. The HMM program uses village volunteers who are taught to test and treat malaria at community level and this is now being implemented in most low-lying areas in PNG.

Global Fund

It is reported by the Global Fund that in 2000, the challenges faced by HIV/AIDs (Human Immunodeficiency Virus infection and Acquired Immune Deficiency Syndrome), TB (Tuberculosis) and malaria were insurmountable. The HIV/AIDS pandemic was at its peak, and TB was closely associated with HIV/AIDS, as reduced immunity caused by HIV/AIDS, led to an upsurge in TB. In many countries the AIDS epidemic was killing many people leaving countless orphans and shattered communities while malaria continued to kill young children and pregnant women who were unable to protect themselves from mosquitoes or have access to lifesaving medicines. Similarly, TB unfairly afflicted those living in poverty, as it had for centuries, with the HIV/AIDS pandemic fuelling more cases and also under cutting the immunity to malaria.

AIDS, TB and malaria are all preventable and treatable, but solving this problem required huge funding and required concerted commitment, not only of world leaders and decision-makers, but also from the grassroots and others who were working on the ground. In 2000, support for these three diseases was decentralised and spotty, and it was felt a single organisation should be created that could make a difference and specialise only in these three diseases. In reality, malaria was not at first considered for the Global Fund in 2000, but through advocacy, was finally included into the mix.[20]

Following on from advocacy meetings, the concept of the Global Fund was discussed at a G8 summit in Okinawa, Japan, in 2000, but the real commitment began to coalesce at the African Union summit in Abuja, Nigeria in April 2001. The call for action then continued at the United Nations General Assembly Special Session in June of 2001, which called for the formal creation of the Global Fund. This was finally endorsed by the G8 at their summit in Genoa, Italy, in July 2001. After this, a Transitional Working Group was established to determine the principles and working modalities of the new organization, and the Global Fund came into being in January 2002.

The new organisation sought to create a new mechanism that would be leaner, faster, and more "business oriented". The Global Fund was also meant to add to, not duplicate, existing aid and global health institutions including the World Health Organization and UNAIDS. These institutions remain intimately involved in Global Fund activities, providing technical expertise and on-the-ground experience.

The Global Fund operates differently from most other organizations. It focuses solely on financing and does not directly implement programs. Instead, it relies on local experts called Local Fund Agents (LFAs) to oversee and monitor grant activities in each supported country.

[20] The creation of the Global Fund included much grass root advocacy aimed at the global leadership to make things happen. In my case, I attended one such meeting in Brussels, Belgium in May 2021. It was a strange meeting for me at least. I was travelling from Washington DC in the USA back to Geneva via Brussels. On route to Brussels, all my luggage was lost and I was forced to attend the advocacy meeting in the clothes I had travelled in. I was very concerned that I would stand out in the crowd as being under dressed for the occasion. I should not have worried. Half the participants appeared to have come from the gay community and were dressed very flamboyantly. From being underdressed, I ended up being one of the more formally dressed overall despite being in my travel attire.

The Global Fund emphasizes partnership, bringing together governments, civil society, technical agencies, the private sector, and people affected by AIDS, tuberculosis, and malaria. It strategically invests global resources to help eliminate these diseases as public health threats.

A unique feature of the Global Fund is its requirement that all funding proposals be approved by a Country Coordinating Mechanism (CCM). The CCM includes representatives from all sectors of society and meets regularly to develop, review, and endorse proposals. It also monitors funded programs to ensure they reflect the interests of all stakeholders, especially key populations affected by the diseases.

This inclusive approach prevents any single group, such as the government, from dominating program design or implementation. As a result, Global Fund grants are country-led and shaped by broad collaboration, giving all partners a meaningful role in decision-making.

One of the primary roles of a CCM is to choose implementing partners, known as Principal Recipients (PRs), who receive funding directly from the Global Fund. In many countries, these PRs are government bodies, such as ministries of health. In Papua New Guinea (PNG), the National Department of Health (NDoH) served as a PR from 2005 to 2011. However, due to various factors, other organizations were later appointed as PRs. These included RAM, Oil Search, and Population Services International (PSI) for malaria, and Oil Search and World Vision for HIV/AIDS and TB.

Over time, the number of PRs was reduced in PNG. By 2018, RAM remained the sole PR for malaria, while World Vision took on HIV/AIDS and TB. The decision to assign PR roles to non-governmental organizations (NGOs) has been a point of ongoing disagreement with the NDoH, which continues to express a strong desire to resume its role as a PR.

Since its inception, the Global Fund has disbursed over US$75 billion to combat HIV, tuberculosis, and malaria, and to support health system strengthening in more than 155 countries. It also provides regional grants, making it one of the world's largest contributors to global health.

It's now estimated that the Global Fund's targeted health investments have helped save 65 million lives and delivered prevention, treatment, and care to hundreds of millions of people. Alongside its partners, the Global Fund has contributed to revitalizing communities, strengthening health systems, and boosting local economies.

The main donors to the Global Fund include the United States, European countries (with France as the largest contributor), and Japan. Around 6% of funding comes from private organizations, with the Bill and Melinda Gates Foundation providing 75% of that share. If ranked alongside countries, their contribution would place eighth, just after Canada, and would exceed the combined donations of Norway and the Netherlands.

Countries receiving Global Fund support are generally expected to contribute about 15% of their own government budgets toward the same health priorities. This approach encourages increased domestic investment, with the long-term goal of countries eventually managing these programs independently.

In Papua New Guinea, however, domestic funding for malaria has remained stagnant. There's currently no clear sign that PNG is ready to take over full responsibility for these programs. Reaching that point would likely require a significant shift in how health financing is planned and prioritized.

Against Malaria Foundation

RAM and PNG were indebted to the Against Malaria Foundation (AMF) for giving significant funding to support RAM for the period of 2017 to 2020. The funding came in the form of LLINs rather than cash, but this freed up much needed funds for other activities and expansion of the LLIN program throughout the country. Until AMF came onto the scene in 2017, RAM was obliged, due to lack of funds, to carry out LLIN campaigns to only under five year old children in many areas of PNG. During their period of support, AMF contributed most of the LLINs for PNG with their delivery costs being covered by the Global Fund. With AMF, under five campaigns became a feature of the past giving much better malaria control in the all areas concerned.

AMF was the vision of a remarkable man called Rob Mather who lives in London in the United Kingdom. Rob was a strategy consultant who gave advice to companies on how best to run their companies with maximum efficiency and profit.

In 2003, by accident, he ended up watching a television program about a two-year old girl “Terri” who had suffered from 90% burns in a house fire. He was greatly moved by her story and encouraged two friends to carry out a sponsored swim with him to raise some money for her trust fund. Over the next seven weeks, Rob Mather started calling other people, including Speedo the swimwear manufacturer, and the sponsored swim turned into 150 swims in 73 countries and involved 10,000 people with 100% of the money raised going towards the Trust Fund of the small girl Terri.

During the Swim for Terri, a website was created which allowed swimmers to see who was swimming throughout the world. This website built the basis for other future initiatives and activities.

As the first Swim on 6 December in 2003 for Terri was so successful, it was decided to expand this idea with the funds being raised for malaria and the World Swim Against Malaria was born.

Malaria was chosen against many other ideas. Malaria affects those mainly in the developing world which at the time was not well funded. This was preferred, rather than diseases in the first world which were generally well funded. Malaria at the time, in the words of Rob Mather, resulted in the deaths of seven Jumbo jets of children each day.

Also importantly, there was a very clear gap in the needs for malaria in terms of LLINs which was then the latest new approach to malaria control. LLINs in 2003 were costing about US$5 so it was an easy and identifiable target to raise funds for. This new program saw 250,000 people swimming for malaria in 160 countries. Apart from raising a lot of funds, this program improved people’s knowledge about malaria worldwide.

The World Swim Against Malaria was so successful, that people started to ask if they could raise funds in other ways besides swimming. This resulted in a web site called The Against Malaria website which allowed people to fundraise 'against malaria' in whatever way they wished. With this change, the organisation's name was changed to the Against Malaria Foundation (AMF).

The donor base of AMF has grown over the years and now includes organisations such as PwC, Citi, Sumitomo, Vestergaard and Microsoft, with practically all of the funds raised going to the procurement of LLINs. AMF has been so successful, that since they started operating, they probably account for 6% of all the LLINs bought worldwide since 2002. In the last four years from 2020 to 2023, this percentage has increased to 12% of all nets procured worldwide. By the end of 2023, AMF had procured and sent to countries over 176 million LLINs. This achievement is even more remarkable in that AMF does not have an office and all staff work from home.

Sadly, for the Global Fund malaria program in PNG in 2021, AMF decided that there were other countries in more need than PNG and withdrew their support, particularly after the Global Fund increased funding to PNG in 2021. However, it is fair to say that RAM had a very good relationship with AMF and the program was very grateful for the support they gave when they did.

It should also be noted that AMF is also very stringent in following up on their donations for donor accountability. From 2021 to 2024, AMF also supported a small grant to RAM to follow up on all the LLINs that RAM had distributed country wide. In theory, all nets were followed up after 18 and 36 months which allowed both RAM and AMF to see how many nets were actually being used and how many remained after three years. Certainly, the results showed that most the nets which were donated by AMF were used, and much to everyone's surprise, the nets used lasted longer than anyone expected.

Papua New Guinea Sustainable Development Program

The Papua New Guinea Sustainable Development Program (PNGSDP) was the ultimate outcome of an environmental disaster in Western Province. In 1984, a tailing dam collapsed at the Ok Tedi Mine resulting in immediate and long term pollution of the Ok Tedi and Fly River system.

The Ok Tedi Mine is an open-pit copper and gold mine in PNG located near the headwaters of the Ok Tedi River, in the Star Mountains of the North Fly District of Western Province. The Ok Tedi River feeds into the Fly River. The Fly River forms a delta which accounts for much of Western Province, and the pollution of the river has affected the livelihoods 50,000 people or more who live in the delta.

Copper deposits were first discovered in the Star Mountain area in 1963 and copper and gold deposits further discovered in 1968 which led to exploratory drilling. Australian BHP (Broken Hill Proprietary Company Limited) became involved after they secured a mining lease in 1975. This led to feasibility studies culminating in a detailed report to the PNG Government in 1979.

BHP received the mining lease in 1980 to develop the mine which ultimately created Ok Tedi Mine. Ok Tedi Mining Limited was incorporated as the entity to operate the project in 1981 and was formed from a partnership between BHP (as the majority shareholder), the PNG Government, Amoco Corporation and Inmet Mining Corporation. At the beginning, BHP owned a 52% share in the company.

As part of the mine facilities, to avoid environmental pollution, a tailing dam was being constructed to hold processed mine waste in addition to rock dumps for rocks separated from the copper and gold ore. In 1984, when the mine opened, it is reported that an earthquake caused a landslide which destroyed the foundations of the half built tailing dam which subsequently collapsed. Similarly, in 1989, a rock dump was destroyed.

The tailings dam in particular was supposed to separate out toxic waste and release relatively fresh water into the river system, and with its collapse, this separation could not effectively take place. Similarly, the destruction of the rock dumps left the rocks exposed to weathering which also allowed waste to enter the river systems.

The mine had become a major revenue source for the government and there was much pressure to keep the mine open. Therefore, in the end, the mine remained open, and as a result of the destruction of both the tailings dam and the rock dumps, much of the Ok Tedi mine waste was discharged into the

river system without much processing. This caused the huge continual pollution and environmental damage to the Ok Tedi River and Fly River Delta for many years.

In 2001, BHP became BHP Billiton through the merger of the Australian Broken Hill Proprietary Company Limited (BHP) and the Anglo–Dutch Billiton plc. trading on both the Australian and London Stock Exchanges as a dual-listed company.

In 2005, BHP Billiton, fearing litigation for environmental damage against them from local landowners and the government of PNG, wanted to close the mine. The government of PNG did not want to close the mine due to high earnings, so an unusual agreement was made. Instead of handing over the BHP Billiton shares to the government, shares of Ok Tedi Mine were given over to a newly formed trust fund based in Singapore. The funds for the trust fund would come from the profit of Ok Tedi shared together with interest raised from the funds received. This agreement was made on the condition that BHP Billiton would not be sued for environmental damage.

This was the birth of PNG Sustainable Development Program Limited which held 52% of the shares of Ok Tedi Mine with the remaining stock and shares being held by the State of Papua New Guinea (30%) and Inmet Mining Corporation (18%). While PNG SDP held a shareholding of Ok Tedi Mine, it was expected that all interest and profits raised were to be used for development projects only.

Since its birth in 2001, PNG SDP has not been without controversy but became the second largest donor in PNG with holdings of about US$ 1.4 billion in 2012. PNG SDP has done some very good work, particularly supporting the cell and communications tower infrastructure in Western Province as well as support for micro financing and other concerns.

In 2013, the government of PNG under the Prime Minster Peter O'Neil tried to nationalise PNG SDP. As a result of this, the organisation was moth balled from 2013 to 2018 and only re-launched after the government failed to nationalise the PNG SDP funds. However, the government did confiscate the PNG SDP shareholding so PNG SDP now works only from the profits of their investment funds which still remain considerable. The new 2018 PNG SDP now restricts its funding of development projects to Western Province where it is making considerable investment in health, agriculture, education, infrastructure and livelihoods. It does this through having its own PNG SDP program as well as supporting other Non-Government Organisation (NGOs) such as RAM with its mandate on efficient use of funds. This can be witnessed by its very small Port Moresby offices.

When the Global Fund grant was reduced for the 2018 to 2021 program, RAM reached out to PNGSDP for support. Fortunately for RAM, PNGSDP agreed to support much of the malaria activities of RAM in Western Province. Through this support, it has freed up funds which allowed RAM to support other parts of the country. PNGSDP has continued to support RAM now for three grants with the latest finishing in 2026.

Papua New Guinea Institute Of Medical Research

The Papua New Guinea Institute of Medical Research (PNGIMR) was established in 1968 as a statutory body. Initially known as the Institute of Human Biology, it was based in Madang before moving to Goroka. In 1975, the institute was renamed the PNGIMR.

The institute has played a crucial role in researching major health issues affecting Papua New Guineans, including kuru, malaria, pneumonia, enteric diseases, and sexually transmitted infections.

Over the years, PNGIMR has expanded its research programs and established branches in Maprik, Wewak, Port Moresby and Lae. The institute has contributed to groundbreaking studies, including research on kuru, which has been linked to two Nobel Prizes. PNGIMR continues to be a leading institution in public health and medical research, working closely with national and international partners to improve health outcomes in Papua New Guinea.

In terms of malaria, the PNG IMR has been deeply involved in malaria research for decades, contributing to national and global efforts to combat the disease. Key aspects include:

- Malaria Control and Surveillance - PNGIMR has played a crucial role in evaluating national malaria control programs, including health facility surveys conducted between 2010 and 2016. These surveys assessed the availability of malaria rapid diagnostic tests (mRDTs) and artemisinin-based combination therapies (ACTs) in health facilities across Papua New Guinea.

- Malaria Indicator Surveys - The institute has conducted Malaria Indicator Surveys every three years since 2009. These surveys, examine malaria prevention strategies, infection prevalence, and treatment-seeking behaviours. These surveys provide valuable data to guide national malaria elimination strategies. In this respect PNGIMR collaborates with global health organizations, including the World Health Organization (WHO), Swiss Tropical and Public Health Institute, and Liverpool School of Tropical Medicine. These partnerships help advance research on malaria transmission, drug resistance, and vector control.

In recent years, PNGIMR has been investigating a number of malaria interventions including special repellents and larvicides. More famously, IMR has had a long relationship with Insecticide Treated Nets (ITN). PNGIMR was one of the first establishments to prove the efficacy of ITNs against malaria in the 1980s, and more importantly, since 2018, the declining efficacy of LLINs which superseded ITNs and about which this story is written.

World Health Organisation

The World Health Organisation (WHO) was formed in 1945 during the formation of the United Nations of which it is a member. The WHO constitution was drafted and agreed upon in 1946.

WHO's stated mission is: "the attainment by all peoples of the highest possible level of health," defining health as complete physical, mental, and social well-being and not just the absence of disease.

WHO is headquartered in Geneva Switzerland, with six regional officer and over 150 country offices. It is answerable to the World Health Assembly.

WHO is the leading agency in all issues on health and had published many guides on the diagnosis, treatment and control of most diseases. WHO has also led the world in various international campaigns again disease such as smallpox, HIV/AIDS, malaria, tuberculosis and non-communicable diseases. It has also led campaigns against global outbreaks of Ebola and Zika and the Covid 19 pandemic.

The WHO office in PNG, together with its dedicated malaria officers, have been an integral part of the National Malaria Control Program (NMCP) and all their partners as technical advisors always guiding the program to attain its goals.

In reference to this story, WHO was also responsible to the quality of insecticides and LLINs through its WHO Pesticide Evaluations Scheme (WHOPES).

The National Department of Health

The National Department of Health (NDoH) was established in 1975 at the PNG Independence and has the responsibility of overseeing health policy, planning and service delivery across PNG. This included, developing national health plans, regulating health standards and coordinating provincial and district health services.

The health system was decentralised in 1995 followed by the Provincial Health Act in 2007 which integrated hospital and public health services under unified provincial health authorities (PHA).

Malaria has always been a problem in PNG, and from 1975, malaria became the responsibility of the NDoH. Within the NDoH malaria was managed by the Public Health Department who had specialised divisions such as the Vector-Borne Disease Control Program (VBDCP). Major investments in malaria were limited at this time due to lack of funds and interventions included presumptive treatment of malaria, vector surveillance and community education. This was also a period of research, PNG being one of the locations in the world where the efficacy of ITNs (Insecticide Treated Nets) was discovered.

It was only in 2004 that the specialised National Malaria Control Program (NMCP) was created as a sign of a renewed commitment by NDoH to malaria. The NMCP was managed by Leo Makia until his untimely death in 2024. He oversaw the Global Fund program and other initiatives during this period including the introduction of LLINs, RDTs (Rapid Diagnostic Teats) for malaria and ACTs (Artemisinin Combination Therapy).

CHAPER SIX - Issues Faced in the Field Operations

Chapter Summary

- Highlights the challenges faced by the LLIN program
- Includes issues with working with provinces, staff discipline, poor service providers and poor roads and other infrastructure

Planning and Collaboration

One of the issues that we learnt early on, was not to ask provincial staff for any assistance before arriving in their provinces. During our preplanning meetings in provinces, which occurred two months before starting our distribution programs, one of the other things we learnt, was to tell provincial staff not to do any preparatory work on behalf of RAM without clear written authority to do so.

In one province, without asking RAM, the provincial staff hired two vehicles with the supposed aim of informing and preparing the districts and health centres of the arrival of the RAM team. The trouble was that they did not inform us that they were doing this.

When the RAM team eventually arrived at this province, the RAM team was presented with an invoice to pay of about US$15,000 with no report on how the vehicles had been used or where they had been. It led to very painful and difficult discussions to resolve their claims which RAM in the end had to partially pay. It also soured relations between this province and the RAM team for some years following. For this reason, RAM could not afford to give any permission to provinces to carry out preparatory work without clear written authority from RAM which was rarely given.

Staff Discipline

It would be good to report that RAM had really disciplined officers. We needed orderly staff who obeyed orders. My first days in PNG were however occupied with stamping my authority. I thought three simple rules would be a good start. Be on time for work, dress well, and if you could not do the first, please inform the office if you were going to be late.

I failed in all three aspects. Public transport in Port Moresby is appalling. Even with the best will in the world, unless you own your own car, and not always even then, it is impossible to arrive every day on time for work. Of course, you can get up at five o'clock in the morning each day to arrive for work at eight, but few of the staff had this mentality, and to be honest, I could not blame them.

Dressing well was a non-starter! After three years we still had not been able to get the RAM staff to dress well in a European sense. There is no role model for this, and the PNG population at large dress in second hand cast offs from Australia[21], a country that cannot also claim to be the best dressed nation on earth. In fact, for PNG men, it was practically impossible to buy good clothes or shoes in PNG though this situation had improved in recent years. However, for most of the population, they live on second hand clothes bought from second hand clothes shops which can be found in all town and cities in the country. For men, the preferred dress style was a shirt, short trousers and boots. The one type of shoes that can be bought new in PNG are working boots often worn by both men and women. When boots

[21] I also assumed that most of the second hand clothes in PNG were coming from Australia. One day, one of my staff put a one trillion dollar note on my table from Zimbabwe. I asked him where he got it from and told me that it was inside a jacket he had just bought from a second hand shop. The only conclusion that I could come up with was that the jacket had originally been owned by a Zimbabwean who had come to Australia and had discarded the jacket after never using it.

are not being worn, most people wear flip flops or thongs as the Australians and people in PNG will call them.

For good communication, all staff had to own a phone. In additional to the phone, we gave all staff members a phone package that is known as a CUG (Common User Group) facility. This allowed all RAM staff to call each other free of charge and talk for as long as they wish. One would think that with such a facility, there would be no problem to ring your boss and tell him you would be late for work. The excuses for not doing so are legion from the phone being stolen, phone not being charged, being destroyed by their children, or one of the best excuses being that it was switched off while the phone was being charged. No amount of haranguing would get them to leave their phone switched on while the phone was being charged.

The aspect of discipline worried me. My personal thoughts were that we needed discipline as westerners perceive it if this project was to succeed.

Another problem was money. “All Papua New Guineans are born thieves” one white man once told me. “Under no circumstances can you trust them with money”.

I thought this was perhaps a little unfair and reflected that the person had not lived much outside of Papua New Guinea. In my experience, few people in this world had respect for other people’s money if they were not carefully monitored. What man or woman did not try to cheat a tax man of his dues, and I had never met a salesman who was not liberal with the way he used his company expense account to entertain himself and his friends? I do not know about other people, but lending money to anyone, from experience, and with few exceptions, I have usually found it a challenge to get the money back.

This was the first big challenge. Our staff had to handle large sums of money. Like banks giving a credit card to their customers, we had to evaluate credit worthiness of our staff by giving increasingly larger sums of money. This is the same way that banks give increasing credit allowances on credit cards based on credit history. We found that whatever we did, some people could not handle money at all, while others were extremely trustworthy with very large sums of money.

It can be argued that PNG still has some of the remotest and inaccessible areas on the globe. Not because PNG has huge expanses of land such as the Amazon Basin, but simply because there is no infrastructure to reach most of the remoter parts of the country. There are three whole districts on mainland PNG that can only realistically be reached by air (Telefomin in Sandaun Province, Middle Ramu in Madang and Kabwum in Morobe Province) but there are many other districts who also have areas only reachable by boat, long treks, small airplanes or helicopters.

Other locations can only be reached by boat. One district in West New Britain (Kandrian Gloucester), most of the health centres can only be reached by boat from the provincial capital except for one location with an air strip. In East New Britain, most of the district of Pomio can only be reached by boat and then by dinghies (small boats), and once again, there is only a single airfield present in the district. Worse still, some of the islands within the territories of PNG are huge distances from their provincial capitals. Two islands in particular, Mortlock and Tasman, are so far away in the ocean they are often left off maps of PNG. Morlock and Tasman are two coral atolls situated about 270 kilometres and 540 kilometres respectively out in the open sea east from their provincial capital of Buka in the Autonomous Region of Bougainville. Similarly, another group of islands known as Wau Wuvulu lie 500 kilometres over the seas from their provincial capital of Lorengau in Manus Island.

These and many other places in PNG have no regular transportation system, and the people who live there have to get to the rest of PNG by their own devices, often by foot, irregular air transport, or in open dinghies. Apart from no public transport, many localities also lack basic facilities such as banks. This means that any activity that is carried out in these areas, everything needs to be taken to carry out the work. To return to base to get more supplies, will often cost much more than the supplies are worth.

This had been one of the best kept secrets of the RAM PNG project. RAM staff often carry around large amounts of cash, and should any of the "rascals" in the districts been aware of this, then perhaps RAM officers would have been robbed and the program would have collapsed. In recent years, some RAM staff have been robbed in the houses they stayed in, but thankfully, for the most part, these incidents were few. However, wherever possible, RAM would look for other means of reducing cash carried in the field.

We did find other ways to get cash. Local shops were often happy to supply cash in remote areas in exchange, with a commission, for depositing funds for their cash in their banks in Port Moresby. In additional to shops or trading posts which were often Chinese owned, some organisations such as the Catholic Provincial Centres were also willing to assist with such arrangements. However, many of the places in which RAM worked had no shops or no organisation which could assist so cash had to be taken in full.

Perhaps one of the most remarkable features of the RAM programme is that very little money was reported stolen, but it did happen. Two examples of this include, one officer who foolishly left some money in a hotel room and a hotel staff member relieved him of it. Similarly, another officer got himself a local girlfriend who dipped into his project funds. Fortunately, in general, it was only small amounts of money. This was a remarkable feature of the project achieved by RAM officers carrying money by stealth and never allowing others to see how much money they were carrying.

This is not to say that other money was not spent by staff members themselves. Temptation, as outlined above, was always present, and at least four staff in the first three years had been terminated for helping themselves to project cash, usually for beer or women.

In general, there was always a reason for borrowing of project funds, and if you could monitor this, you would know who is most likely to give problems in terms of fraud and theft. These factors are what I used to call the six Bs, Buai (betel nut), Booze, Betting, Brus (cigarettes and tobacco), Babes and Bludgers (Australian word for people needing money i.e. in the case of PNG, the extended family).

Many people in PNG smoke or chew betel nut and it is a constant drain on resources and can take up much of your salary. I myself gave up smoking in PNG as it cost me three times more to smoke in PNG than it did in Mozambique where I had come from, and Mozambique was much more expensive than Zimbabwe where I had lived for many years. Similarly betel nut could cost the same or more than smoking as both cigarettes and betel nut are extremely addictive. However, it can be argued that the other B's can be far worse.

PNG probably inherited the cult of binge drinking from their colonial masters. Once a RAM officer started drinking, in many cases, they might not stop. Once on a drinking binge, RAM officers could become very generous with their cash. In one case, an officer managed to spend 5,000 Kina (about US$1500) on drinks in the space of two nights buying everyone in the bar drinks and then finished off the night by crashing a car. A number of other officers also lost their jobs due to driving under the influence, and sometimes crashing a car they were driving.

Betting did not affect that many people, but when it did, it could become disastrous and RAM officers could easily spend their salaries and project funds on bets they had made. One of the worse times of the year was when there was the traditional annual Australian "State of Original" Rugby League competition occurred, and which is avidly followed by many people in PNG. This when the "Maroons" (Queensland) faced off against the "Blues" (New South Wales). In this competition, family members often supported different sides, sometimes resulting in arguments and fights, but the greatest cause of concern, was that many of the staff were waging relatively very large sums of money compared with their salaries on the outcomes of the match. Often when their team lost, they owed their colleagues large sums of money which they could not pay back easily and this often led to a lot of tension between staff in the office.

Family and babes were perhaps were even worse.

Papua New Guineans like most of the rest of the planet never have enough money to make ends meet. There is always a long list of issues and people demanding people's hard earned cash. This is made worse in a society which has an extended family system like Papua New Guinea. Apart from feeding yourself, there is always a queue of relatives who think you have too much money and you should share it around. PNG people, like others in the developing world such as in Africa, all have extended families and traditional commitments to these extended families can be great. In particularly, once a family misfortune occurs, great pressure is put on those with jobs to contribute all their hard earned cash. In these cases, there was no real intention to defraud the project, rather, higher loyalties took precedence.

And yes, the babes; could be male or female but generally female as most of the officers were male. Some, particularly the single men, were in paradise. Wherever they went, there were girls who were ready to share their time and the officers' funds. Some became insatiable girlfriends demanding money at all times, and other just robbed the officers blind when they were sleeping. In a couple of cases, officers got involved with beautiful girls they met on their travels and even married them. These latter girls had very high expectations of their husbands and made constant demands for money which they could not keep up with. Certainly, in one case, it was my unfortunate responsibility to carry out an investigation in a remote part of the country looking for fraud and having to terminate the contract of the officer concerned. His only crime, was trying to keep his young beautiful wife happy.

I have often wondered if we are not all the same, and what the different triggers are to commit fraud or theft. Certainly, I have never met anyone in the world who thought twice about not paying his taxes if they could get away with it, but I have also wondered many times, that, when a person lives under continual demand to spend money and never has enough of it, what the threshold is to start stealing or borrowing money, albeit with intention of returning the funds.

Despite all these temptations, over fourteen years of my tenure, the project has lost very little money as we were able to recuperate the money later when staff contracts were terminated. Those who showed credit worthiness stayed and prospered in the job, and those with weak wills, usually did not last long and lost their jobs.

Accounting and not stealing money was one of the major skills needed by RAM staff, but it was only one of many other skills.

Need to be multi skilled

RAM staff often went into remote areas by boat, trekking or aircraft, and once there, they needed to plan, coordinate, monitor, cajole, be a paymaster and do anything else necessary to survey and

distribute nets in an area together with local health staff. This requires a whole skill set for which few others possess with the exception of the old Australian colonial district officers (Kiaps as they were known locally) who had to administer whole areas alone in the era of Australian colonisation. The parallels to this type of work are many in terms of skill sets.

To succeed, the RAM officer needed to get along with others and lead and or coordinate with the communities to which they were assigned. They had to be prepared to stay for long periods alone, and away from their wives and families. The wives did not always appreciate this, and RAM officers, beside dealing with their work in a remote community, also had to contend with the problems back home. [22]

Good reliable workers

Many people, both locally and from abroad, complain about the local work force, stating that often they were lazy, only turned up for work when they needed to, and needed to be kept under constant supervision. Perhaps the worst example of this, is when something happens in the family, staff often simply lay down tools and head off without making sure that others can cover their work.

It is true, some PNG workers don't always inform their supervisors when they don't come to work, a few, even leave the job and don't tell anyone, a situation which occurred in my first two weeks in PNG. But in my experience, I have found some of the best workers that I have ever dealt with in the world in PNG. The secret I have found, and probably applies to anywhere else in the world, is if you can give a person a job they enjoy, a job that they can feel proud of, they will work very hard and not count all the hours they work to achieve their goals. In this respect, RAM has been very lucky, and some of the staff who I first met in 2010 were still with me fourteen years later.

Service providers

Money, while being one of the biggest issues, was to be only one of our problems that we had to deal with. The second biggest problem was service providers for aircraft, boats and side lifters. In later years, particularly after Covid 19 pandemic, finding small airplanes to carry out work in remote areas became a nightmare.[23]

Much of PNG outside of the major cities is sparsely populated, and similarly, service providers are equally spread thinly on the ground. In general, there would be in many places only one service provider which meant that they had a monopoly on the service they provided. Without competition, many of these service providers were very inefficient and expensive. First of all, this caused constant fights with finance staff who wanted three quotes for everything, and also more importantly, it allowed the service providers to provide very poor and unreliable service at a huge cost.

Apart from having to pay them large sums of money, they often kept the program waiting, sometimes for weeks at a time, before they took off. A good example of this is that RAM had to hire a boat from Port Moresby to take nets to Gulf and Western Provinces in 2013. The boat manager kept promising that they would go the following day but never did. Based on his promises, we had already loaded the boat and I had lost all faith in the boat manager to tell the truth. I therefore had to place all the

[22] Many had frustrated wives and no power to help their families besides sending extra money which was often not possible due to lack of banks or communication. Some wives however could interfere badly with the program. On some occasions they got on planes and joined their husbands whether they liked it or not. In one case, one wife got the police to arrest her husband as he was getting on a plane in Port Moresby: he was on this way to the field which severely disrupted operations in the field as he was one of the project team leaders.

[23] As for Covid, we continued to work through Covid, but every so often, a staff member would be tested at an airport for Covid and found positive. When this occurred, the whole team could be put into quarantine for ten days or more.

respective RAM officers who were going to distribute these nets onto the boat. I did this to make sure that the boat did not go without them (which had happened in other locations) and to make sure that nets would not be stolen. In total, the RAM officers remained on this boat in harbour in Port Moresby for two weeks before the boat finally left.[24]

The provision of services in remote areas was always to prove difficult, and in many cases unnecessarily delayed our program. However, there were a number of other things that happened that equally put a spanner in the works and threatened the program.

Love of driving vehicles

Many people in PNG love cars. They don't understand the need to have a licence or be insured when they drive vehicles, particularly when they are drunk. We lost two vehicles through drunk driving and others through normal negligence and people driving when they should not.

We had to have very strict rules on this very quickly. The worst was when we hired cars. The hire car drivers would often pass the keys onto the RAM staff and ask them to drive which invalidated any insurance that they or we had. We had to make sure that no RAM officer ever drove any vehicle without permission from senior management in Port Moresby.

Drink driving was even a worse issue as it immediately invalidated any insurance you might have. See above

Insurance

In a project the size of RAM's in PNG, there are a huge number of things that have to be covered with insurance. Risk management is a huge undertaking, and making sure that every aspect of the project is properly insured.

With the best intent in the world, things go wrong, and to great cost to RAM, there were a couple of occasions when the administration responsible, forgot to insure some aspect of the program. In one instance, a brand new Toyota Land Cruiser was collected and no one thought to insure it or check it was insured when they picked it up. Three days later, it was stolen in the Highlands of PNG and never see again.

The worst instance was when a shipment of nets from Vietnam was not insured, and the boat carrying the shipment grounded on a reef at the eastern end of the mainland of PNG. Fortunately for RAM, the shipment was recovered but RAM had to pay out quite a lot of money in recovery fees in order to receive the nets saved. Had the ship actually sank, it would have put the whole program out of business as no one would have been able to afford the recovery costs.

Other problematic highlights

In one province in the Highlands, with a reputation for being fierce, we were told that under no circumstances should RAM staff involve themselves in any relationships with the opposite sex. Accordingly, we warned the staff regarding this issue. However, when conveying this information, the staff forgot to inform the drivers.

[24] Ironically, there was a myth in Zimbabwe and reflected also in PNG, that white guys were more honest and reliable. Similarly. In PNG, two service providers, initially favoured for being white, gave us a complete run-around before the service they promised was finally provided.

One driver of a rental car ended up having an affair with a deaf and dumb girl who apparently communicated with everyone through a writing board. When the parents of this girl discovered the affair, all hell was let loose and RAM had to stop their operations in the areas immediately. The parents on the other hand demanded large sums of money before they would allow the RAM officers to return to complete their distribution.

This was an extremely stressful time for me. The director Ron Seddon clearly stated that under no circumstances would RAM pay any compensation, and I on the other hand, had made a promise to myself and my team, that we would never leave any village in PNG not covered with nets.

In the end, fortunately for us, the provincial health director from the province, went and interceded on our behalf. He even paid towards the damages claimed. Fortunately, all the staff in the team also contributed something each from their salaries, and the situation was resolved after the driver, it is rumoured, promised to marry the girl. In the end, I ended up paying personally the funds paid by the provincial medical director, as we could not allow him to pay on RAM's behalf: in all consciousness, I could not let him pay as without his intervention, the problem would not have been resolved.

In the same province in another year, two RAM vehicles were high jacked in a remote village. It was a nightmare getting these vehicles back. RAM had to pay a lot of money to the police to assist, and were never quite sure what we were paying for. In the first instance after paying quite a lot of money to the police, the police returned with only one vehicle and we had to pay again to get the second one returned.

A similar situation occurred in Bougainville. In 2013, an old rebel commander from the Bougainville civil war, hired us a vehicle. Despite his signing an agreement, at the end of the hire, he refuted the rates we had agreed on, and hijacked one the RAM vehicles. This was a very difficult scenario as Bougainville is one province in PNG which insurance companies will not insure vehicles, and secondly, the police were scared to interfere with old rebel commanders. In the end, we did get the vehicle back but after very long discussions through intermediaries. After this incidence, RAM never sent any of its own vehicles to Bougainville again.

Weather, roads and access

I have always said in Africa, that, if possible, you do everything in the dry season. With some exceptions, during the dry season, most places in Africa are accessible by road or dirt tracks. PNG, unlike Africa, has no real rainy or dry seasons. Some months of the year may be relatively drier than other months, some windier that other months, but overall, there is no clear dry season in which to carry out implementation. Therefore, the RAM LLIN program, worked throughout the year irrespective of the weather conditions. The only exception to this, is the Maritime Provinces, whether by accident or otherwise, the team normally arrives in the months when the weather allows boats to travel across open water.

Few places in PNG have good tar roads except for the main roads connecting provinces. All the rest are dirt roads, often in very poor condition. Travelling on these roads required huge skill and more importantly patience and determination to travel along them. In the first distribution of nets in Gulf Province, the RAM team had to drive along a road of 60 kilometres which took them twelve hours or more through constant boggy areas and rivers overflowing. It was this type of determination which has made the RAM program successful, and without this determination to reach these remote areas, the program would have died very early on.

Road conditions were also often compromised further through landslides, broken bridges and other obstacles. When these obstacles occurred, often there would be road blocks of people wanting money to allow you to pass on the pretext that they were sorting out the road obstacle. It might be added, that some locals just created road blocks because they wanted to only to extort money from traffic. This caused huge financial problems for our accounts team: these road blocks did not give receipts and without payment, the team could not pass, so haggling about payments for road blocks with the finance section was always an issue.

The weather also caused great problems for airplanes. Some of the airstrips could only be reach at certain times of the day, or with very clear skies. This meant that teams often had to wait days before conditions allowed the planes to fly, but also importantly, it often resulted in staff being stranded in very remote locations for days on end waiting for the weather to clear up so the planes could land to pick them up.

Overall, the RAM program had to work in often very difficult circumstances and the stories related above are only a sample that occurred. In reality, it was rare that anything worked smoothly, as there was always something to confound whatever plans the team had made. PNG is always advertised as the land of the unexpected, and this applied to positive aspects as well and negative ones.

For the positive side, the RAM staff have found extremely helpful local partners who have been willing to assist the program, often for free, to supply fuel or transport to reach remote areas. This has been particularly true of some of the logging companies, whose roads, are often the only roads that allow access to some areas.

Other companies have also offered help, but often with conditions so strict, that RAM have had to refuse the help offered. For example, some of the oil palm companies have offered their trucks to assist in carrying nets to some locations. But they only offer this when the trucks are running empty and at no particular times, so it is almost impossible to plan distributions with transport whose timetable you have no idea about.

The important issue, is that with all the difficulties confronting the RAM staff, they have continued to reach the remotest areas in the country, and it is only where there are ongoing tribal fights, sadly which are increasing each year, that they fail to reach some of the areas concern.

Gender Equality

Coming from UNICEF and the United Nations I was very aware of gender equality. However, as much we tried as an organisation, the job of a field officer seemed almost exclusively for men. The major reason for this was not that women were less able, but rather, field officers stayed away from Port Moresby and home for six to eight weeks at a time. This was the time it took to carry out a distribution in most provinces.

Few women were prepared to leave their children for so long and there were few husbands who would be prepared to look after the children alone in their stead. There was also a perceived security issue as most field officers worked alone and often in very remote areas. As a result of all these factors, women predominated in the office and men in the field, at least in the initial days.

Eventually we were to identify some very competent female field officers in later years, but for the most part, they were predominantly single when they joined us. However, it is great to report that RAM has employed some very special ladies, some of whom you could send into the remotest places

in PNG, and know they would be able to handle themselves equally, if not better, than their male colleagues.

Over the life of the program, women took over more and more positions in the organisation and came to represent over 40% of the staff employed. However, for LLIN field officers, who often remained in the field for weeks at a time, men still predominated though one or two women have remained in the field teams for most periods of the program. Sadly though, due to security reasons, normally female field officers remained carrying out their duties in perceived safe areas such as urban areas, but there have been a few female officers, who were very strong and self-assured that they could be sent into the remotest communities in the country.


Getting To The Remotest Places With Helicopter And By Trekking

CHAPTER SEVEN - World Health Organisation Pesticide Evaluation Scheme (WHOPES)

Chapter Summary

- WHOPES was responsible for evaluation and qualifying LLINS to be sold and used for public health programs worldwide, from 1960 till 2017
- LLINs were first evaluated on laboratory and small-scale field studies after which they could initially become prequalified and be sold. For full qualification, they would later have to undergo large field trials.
- All laboratory and field trials used two approved laboratory bioassay tests known as cone bioassay and tunnel test. Tunnel tests were used during prequalification when LLINs fail cone bioassay tests.
- All LLINs on the market passed their initial prequalification based on cone bioassay tests but tunnel tests were to be used in early days to back up cone bioassay tests.
- During subsequent WHOPES trials, some LLIN products improved.
- WHOPES was replaced in 2017 by the WHO Prequalification Vector Control Products Unit (PQT-VCP). However, the WHOPES legacy lives on.
- Tunnel tests stop being used in WHOPES prequalification but then reappear in 2018 to justify LLINS with reduced efficacy

WHOPES (Pesticide Evaluation Scheme)

In 1960, the World Health Organization (WHO) established the Pesticide Evaluation Scheme (WHOPES) to support and coordinate the testing and assessment of pesticides used in public health. In 2001, WHOPES partnered with the Food and Agriculture Organization (FAO), which focused on agricultural pesticide use.

WHOPES itself was responsible for evaluating various types of pesticides, including larvicides, insecticides for Indoor Residual Spraying (IRS), household insecticide sprays, repellents, and space sprays. From 2000 onwards, it also began assessing Long-Lasting Insecticidal Nets (LLINs).

Every insecticide underwent a thorough evaluation by WHOPES to **assess its safety, composition, effectiveness, wash resistance, durability, environmental impact, and user acceptance**. To be included in public health programs, both insecticides and Long-Lasting Insecticidal Nets (LLINs) should first receive accreditation known as prequalification from WHOPES. Only after this approval could they be sold, acquired, and distributed for public health use. After prequalification, products were required also to carry out further work, including large scale trials, to verify their long terms efficacy and durability under field conditions before being completely approved.

History of Net Evaluations By WHOPES

The functioning of WHOPES is difficult to judge from 1960 until 1997, until WHOPES published its first annual report in June 1997. These annual reports continued until 2017. Using the annual reports which are available on the internet, anyone can investigate how insecticides and LLINs passed their primary WHOPES prequalification which allowed net to be sold to malaria programs.

The first two LLINs to be evaluated by WHOPES were the Sumitomo **Olyset** net in 2001 and **PermaNet 2.0** in 2003. The Olyset LLIN is made from polyethylene and the PermaNet 2.0 polyester. For Olyset LLINs, the insecticide permethrin is impregnated into the polyethylene fibres, while in PermaNet 2.0,

the insecticide deltamethrin is stuck onto the outside of the polyester fibres with a binder (glue). In both cases, the insecticide is slowly released from the polyethylene fibres in the case of Olyset and through the binder in the case of PermaNet 2.0. (also refer to Chapter One page 14).
Reading through the WHOPES reports for **Olyset** (2001) and **PermaNet** (2003), the evaluations appear like a collection of random experiments or trials carried out in different parts of the world. Each laboratory test or field trial was carried out in a different way, and ultimately it was the judgement of the selected panellists (reputable scientists) who decided what was acceptable and what was not acceptable. Most of the field trials were small, and measured various indicators such as feeding inhibition, repellence, deterrence against mosquitoes entering huts and also other indicators. Other indicators included reduction in parous rates (number of times that the mosquitoes have laid eggs) and reduction of malaria in some cases where the trials were big and lasted long enough.

In the case of Olyset nets, the WHOPES reports indicated that Olyset nets still killed 90% of mosquitoes after 24 washes in cone bioassays, but in the case of PermaNet 2.0, it seems that mortality from 10 washes upwards with cone bioassay tests remained in the region of 30-50% though field trials from other countries showed better results. Interestingly, both Olyset and PermaNet 2.0 reported 100% knockdown after twenty washes using cone bioassays alone, and both were also tested with tunnel tests which they passed easily with 95% mortality and 100% blood feeding inhibition (see below).

2005 WHOPES APPROVED LABORATORY TESTS

All LLINs for public health programs had to be approved by WHOPES using laboratory, hut and field trials. For all three types of trials, to measure long term efficacy, two primary types of laboratory tests were used, the first is known as the cone bioassay test and the second as the tunnel test.

Cone bioassay tests, used in WHOPES evaluations of LLINs, involve placing a cone over the test material such as netting. Mosquitoes are introduced into the cone for three minutes, then removed and transferred to containers. Knockdown is assessed after one hour, and mortality is measured after 24 hours.

To pass the cone bioassay test, the product must achieve at least 80% mosquito mortality after 24 hours or 95% knockdown within 60 minutes. These standards must still be met after the net has been washed 20 times. In field evaluations, for full WHOPES approval, at least 80% of tested nets should meet at least 80% mortality or 95% knockdown criteria.

In tunnel tests, the mosquitoes are potentially exposed to the insecticides for 12-15 hours. The tunnel is basically a tunnel of glass with an additional cage of normal mosquito netting at each end. The glass section is divided into two and separated by the netting to be tested. Into this netting nine holes of 1 cm each are cut out. On one side of the netting is also placed a guinea pig (or another similar animal) in a cage which stops it moving around.

100 unfed mosquitoes are placed into the side of the tunnel without the guinea pig. The guinea pig (or other animal) acts as a bait, but to get through to the guinea pig, the mosquitoes must pass through one of the holes in the treated mosquito netting. When the experiment is finished, the number of fed and dead mosquitoes are counted. To pass the tunnel test, after twenty washes, the test should show greater than 80% mosquito mortality after 24 hours OR more than 90% blood feeding inhibition (i.e. the mosquitoes were unable to feed).

O**lyset** and **PermaNet 2.0** were WHOPES evaluated without any strict set of guidelines. Definitive guidelines for WHOPES prequalification only appear in 2005 after the approval of Olyset and PermaNet 2.0. It can be presupposed any new guidelines were shaped by previous prequalification and would have to include parameters already accepted in the original Olyset and PermaNet 2.0 prequalification.

In April 2005, there was a WHOPES meeting from which clear guidelines were put into place about which bioassay tests would be used for laboratory and also for small and large field trials. These were to become known as the **Guidelines for Laboratory and Field Testing of Long-Lasting Insecticidal Mosquito Nets WHOPES 2005**. These guidelines confirm the use of cone bioassay and tunnel tests and also give guidelines for field trials**.**[25]

In terms of the guidelines, it was decided that for laboratory tests, to pass WHOPES, the cone bioassay test was nominated as the main guide to efficacy with nets being washed up to 20 times. The tested nets, unwashed nets, and washed nets up to twenty washes, had to pass WHOPES criteria and kill at least 80% of mosquitoes within 24 hours of being tested or have a knockdown of 95% within an hour.

One controversial decision perhaps was the inclusion of tunnel test if cone bioassays did not work well. In the 2005 WHOPES guidelines published, the following statement was included under tunnel tests.

> *"The efficacy of treated nets can be underestimated if judged only based on standard cone bioassays. This is specially the case with insecticides that have a high excito-repellency [26] effect, such as permethrin* and etofenprox*."*

Viewed in retrospect, this statement is very curious. Of the two LLINs to have already received their WHOPES prequalification, only the **Olyset**, which contains permethrin, had already passed cone bioassay tests in terms of 80% mortality up to 24 washes. **PermaNet 2.0**, which did not have either permethrin or etofenprox, failed the cone bioassays in terms of mortality in their original 2004 WHOPES prequalification laboratory tests and, ultimately, only passed their WHOPES prequalification with knockdown in cone bioassay tests. They also passed tunnel tests in terms of mortality and blood feeding inhibition.

At the end of the meeting, despite the statement quoted above, the WHOPES LLIN pass criteria for efficacy became:

> *"It was agreed that a net should be considered to have passed Phase I requirements if, after 20 or more washes, mortality is ≥80% OR knockdown is ≥95% in the WHO cone test, or if mortality is ≥80% OR blood-feeding inhibition is ≥90% in the tunnel test. Washing and bioassays should continue until the net falls below these criteria or until the number of washes claimed by the manufacturer is reached."*

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25 The 2005 guidelines also outline a number of other criteria that needed to be tested in experimental huts and larger field trials. For the experimental huts, other characteristics had to be evaluated and these included the efficacy of the LLIN in terms of blood-feeding inhibition, deterrence (the ability to keep mosquitoes from entering the hut compared with control huts), induced exophily (forced to go outside) and mortality. In all these experiments it was expected that the experimenters will use susceptible, free-flying, wild mosquitoes (Anopheline and in addition Culicine where possible). These criteria were used to compare unwashed LLINs and LLINs washed 20 times with normal mosquito nets treated with the same insecticide strength (not long lasting) and lastly, with untreated nets. To ensure that all huts were equal, different huts were used in different rotated combinations on all occasions. People also slept in the huts as baits (regularly rotated also) and then mosquitoes were collected each morning from all the different huts. The experimental huts were also supposed to record any side effects noted when using the nets.

[26] Excito-repellency refers to contact irritability and spatial repellency i.e. moving away when it detects the chemical from a distance.

This guideline basically allowed two vulnerabilities to be introduced into WHOPES testing. Firstly, that cone bioassay "knockdown" by itself was sufficient to get WHOPES approval and, in the final guideline, no further mention of excito-repellency was made. From then on, all future mosquito nets could pass WHOPES using either cone bioassay tests or tunnel test. With this, similar recommendations were made for both small and large field trials.

It should be argued that the tunnel test had given the LLIN world a back door or a "get out of jail free card". This is not to say that the tunnel test is not good, but it is simply not as rigorous as cone bioassay tests, and nets can pass a tunnel test with much lower efficacy as shown in most of the tests carried out in prequalification evaluations and later evaluations mentioned in the next chapter.

The 2005 guidelines also confirmed knockdown.[27] **Some new products were to pass WHOPES criteria based on knockdown alone in cone bioassay test, but in reality, no product ever needed to use tunnel tests to get through WHOPES prequalification after 2005 as they all passed cone bioassays.**

If the laboratory and experimental hut tests were carried out successfully, then the results could be submitted to WHOPES for prequalification, and if they passed, the LLINs could be sold in the public sector while field trials were carried out.

Once prequalified, the LLINs were still subject to large field trials. The purpose of the field trials was to test the **efficacy, longevity and fabric integrity as well as the community acceptance** of the LLIN being tested. The trials had to be randomised, carried out at village level and had to last three years. They also had to be compared with conventionally treated nets using the same insecticide at the same dose as the LLIN being tested.

LLINs only theoretically passed field trials, and WHOPES qualification, if at the end of 3 years, **at least 80% of LLINs tested**, met the cut-off criteria for either the WHO cone bioassay or the tunnel test.[28]

New WHOPES prequalified LLINs 2007 onwards

With the new guidelines in place, at the end of 2006, the process of evaluating and approving new insecticide and net combinations formally began.

The first new products approved were the Interceptor LLIN made by BASF and a self-treatment kit called the **KO Tab 123** made by BAYER that allows users use to treat ordinary mosquito nets and make their own Long Lasting Insecticidal Net. The most important thing to note about both these products, like the **PermaNet 2.0**, both of these products could not pass cone bioassay tests with 80% mortality

[27] Knockdown is a curious indicator as it suggests that the insecticide initially knocks out the mosquitoes but then they come back to life later. Some, like myself, have questioned the value of this indicator as knockdown in itself, does not reduce the population of mosquitoes. However, others have argued, that while mosquitoes are knocked down in the field, they are unlikely to survive, as they would be picked up by ants and other predators while reviving on the floor, therefore knockdown is still effectively killing mosquitoes in the field. However, there are always concerns that if mosquitoes are knocked down but not killed, that they are perhaps already showing early signs of insecticide resistance.

[28] It should also be noted, though not mentioned in the guidelines, that a number of field trials, usually three, were carried out in different locations around the world, and average survival in all field trials evaluated, before LLINs were finally approved as being fully WHOPES compliant.

after twenty washes, but did pass, because they both had good knockdown rates (≥95%) after twenty washes.[29] They also both passed mortality criteria in tunnel tests.[30]

Following the approval of the Interceptor LLIN In 2006, two new LLINs (Net Protect and DuraNet) were approved at the end of 2007. Both these nets were made of polyethylene but Net Protect was treated with deltamethrin while the **DuraNet** with alphacypermethrin. While both these nets showed very good knockdown after twenty washes, the **Net Protect** stopped killing 80% of mosquitoes by 15 washes and DuraNet by 10 washes. However, both passed WHOPES prequalification on knockdown only and no tunnel tests were required. At this same meeting, **Dawa Plus** by Tana Netting was refused prequalification due to variability between nets in terms of insecticidal content.[31]

In 2008, PermaNet 2.0 was evaluated for its field trials alongside two new products: the PermaNet 2.5 and the PermaNet 3.0. The PermaNet 2.0 passed its WHOPES evaluation, though surprisingly not with flying colours. For the other variants of PermaNet, both passed their prequalification evaluations. What is important is that all the PermaNet types all managed to achieve 80% mortality after 20 washes in cone bioassay tests.[32] Importantly, PermaNet 3.0 though, was the first net manufactured to combat insecticide resistance to pyrethroid insecticides.[33]

LLIN Equivalence

Another new development occurred at this time. Presumably to speed things up, a new idea was created in WHOPES called "**equivalency**". Equivalent nets were essentially LLINs which had very similar characteristics to existing approved LLINs on the market. For equivalency, the new nets had to use the same certified insecticide as the insecticides used in other LLINs. Providing the "equivalent" LLIN passed cone bioassay tests against the LLINs which they were considered equivalent to, they would pass their WHOPES prequalification without seemingly any further studies in the field. As a result of equivalency, the Interceptor LLIN would result in the production of its equivalent SafeNet, DuraNet in MAGNet and Royal Sentry and from PermaNet 2.0 came the Yorkool LLIN.

These equivalent LLINs seem to have done much better under WHOPES. They did not need to undergo the more stringent tests of their original "parent products", and none appeared to have been tested by tunnel tests. In reality, Yorkool, MAGNet, Royal Sentry and SafeNet appear to have passed WHOPES

[29] **Interceptor** LLINs could not pass cone bioassays for mortality when new or after any wash, but did have consistently good knockdown results. **KO Tab 123** passed cone bioassays for mortality up to 15 washes.

[30] It can be argued that the malaria world desperately needed more LLINs to supply a bigger and bigger market that RBM and the Global Fund had created. Most of the new nets being tested after 2006 were passing on knockdown criteria only, and the need to use tunnel tests for further support was seemingly abandoned.

[31] The **Dawa Plus** was also a failure in other ways. Dawa Plus was also part of an overall USAID government initiative called NetMark. One of the mandates of NetMark was to find easier way to treat mosquito nets with a long-lasting insecticide than at a factory level. The concept was, that if this methodology worked, it could be used by other factories to produce long lasting nets. The main idea was to use the insecticide treatment kit, the **KO Tab 123**, to treat mosquito nets in bulk in washing machines. This would have been fantastic had it produced good quality LLINs, as there were very large mosquito net factories in Tanzania and Nigeria for example, which had never produced LLINs. The reason this NetMark initiative failed in part was that WHO wanted all new nets to be evaluated, but also realistically, the methodologies to treat the nets being tried out in washing machines, left a lot to be desired. In the case of the Dawa Plus, which only just passed WHOPES prequalification, was later banned by WHO and other agencies due to poor quality control at their factories.

[32] **PermaNet 2.5** is a PermaNet 2.0 with a thicker boarder at the bottom to resist wear and the **PermaNet 3** was also treated with deltamethrin and a synergist, piperonyl butoxide (PBO) which enhances the killing action of the original insecticide. The PermaNet 3 also had a roof made of polyethylene in which the deltamethrin and PBO were treated. The PermaNet 3 was being sold as a net to combat insecticide resistant mosquitoes.

[33] Pyrethroid resistance had been around for a long time, particularly in places such as West Africa where pyrethroid insecticides had been used extensively in agriculture. With the widespread introduction of LLINs worldwide, the resistance by mosquitoes to pyrethroids was increasing worldwide, though whether this was solely the result of LLINs remains controversial, as pyrethroids were also widely used in agriculture.

prequalification only on laboratory tests alone with little other experimental tests, though they appear in a number of scientific publications later.

The first net to pass with equivalency was **Yorkool** LLIN in 2009. Yorkool was the first newly introduced LLIN to be prequalified with gaining 80% mortality in cone bioassays after 20 washes. This was a second attempt for Yorkool to enter the market after being failed by WHOPES in 2006, but realistically, this was also the first product in laboratory trials that passed its cone bioassay mortality for up to 20 washes. During the laboratory tests of Yorkool, they were compared with their equivalent PermaNet 2.0. During these trials, it is interesting to note, that PermaNet 2.0 did much better than its original 2004 WHOPES evaluation, and like the Yorkool net, passed cone bioassay mortality tests after 20 washes.

From 2009 to 2011, there is a period of almost two years when no new products were approved. In 2011, this changed with a number of new nets products, the most interesting being a net called the **LifeNet** made by BAYER. This LLIN was essentially quite different from anything else produced previously. It was made from polypropylene, which apparently is softer, but more durable than polyester, and it passed all its cone bioassay mortality tests easily. The sad side of LifeNet story was that it was more expensive to produce than other LLINs, and the malaria world was not prepared to pay for it. It therefore died a quick commercial death, even though it is rumoured to have had the potential to be a hugely improved product versus other LLINs on the market.

Evaluated with the LifeNet were the **MAGNet** and **Royal Sentry** LLINs, which were equivalents of the DuraNet. They are both made of polyethylene and treated with alphacypermethrin. Most importantly, both these products passed their cone bioassay tests both with mortality and knockdown. Ironically, these two LLINs were also tested alongside their equivalent parent **DuraNet** which also passed the 20-wash bioassay mortality test which it did not do in its original WHOPES prequalification. This suggested that the DuraNet had perhaps improved since it had first been evaluated by WHOPES. In fact, overall, the MAGNet and Royal Sentry performed slightly better than their parent product. Something similar occurred in 2015 where the SafeNet appeared do better than its parent product the Interceptor, at least in laboratory tests.

At the same time as the MAGNet and Royal Sentry in 2011, WHOPES evaluated another LLIN called the **Yahe**. While the Yahe did well in some tests, overall, it was found that results were so variable that it failed to pass WHOPES on their first attempt. Yahe only later passed it prequalification in 2015.

In 2012, Sumitomo net introduced another PBO nets called **Olyset Plus** to combat insecticide resistance. The next PBO would not appear again until 2016 with the name of **Veeralin**. In 2017, the **Dawa Plus 3.0** and the **Dawa 4.0** PBO nets were also approved. The five PBO nets on the market utilised the same technology where a synergist is added to the insecticide mix to augment the efficacy of the LLINs against insecticide resistant mosquitoes.

It was not until 2017, that the **Interceptor G2** was introduced. The G2 had a different kind of insecticide included called chlorfenapyr which belongs to a completely different group of insecticides known as the pyrrols. This has a completely different mode of action to pyrethroids, and it was thought, that if used in combination with alphacypermethrin, this would tackle insecticide resistance. In additional to the Interceptor net, another LLIN known as the **Royal Guard** was introduced in 2018 with another insecticide known as Pyriproxyfen. Pyriproxyfen is also a different approach to mosquito control. Instead of being an insecticide that directly kills insects, it is a hormone that controls the growth of insects and disrupts their early growth.

For a full list of prequalified products and when they were prequalified, see Table One at the end of the chapter.

Other notes

Reading WHOPES prequalification documents can perhaps be described as a mind-numbing experience. Most of the early reports are inconsistent in what they report and often very detailed in what was done, but then very poor in presenting the results in any kind of systematic way.[34]

Perhaps the most frustrating part of the WHOPES reports, is that products seem to vary in their efficacy from one report to another. For example, the **PermaNet 2.0** failed mortality bioassay tests in their 2004 WHOPES evaluations, but when tested against similar products such as the **Yorkool**, they do remarkably well. I.e. there is no consistency of data from one report to another, even when the same species of mosquitoes are being used during testing. This suggests, that the PermaNet 2.0, and probably all the other nets on the market, were being constantly modified and hopefully improved from the version originally prequalified by WHOPES.

When the Global RBM program was launched in 2000, there were no "approved" products available so it can be assumed that WHOPES were pressurised into finding LLIN products that could be promoted for international malaria control as quickly as possible.

Once manufacturers had a licence to sell to public health organisations, there seemed to be little control of changes made to their products. This was fine when products improved, but not when changes are made which had a negative impact. This is the subject of this book, particularly the change in binders which glue the insecticides to polyester nets.

As a final note, it should be noted, that one of the major consequences of WHOPES, is that ultimately it made all products equal. WHOPES would never give an opinion which of any two products was better. Price and delivery times became the only major determinant of which LLIN to procure. [35,36]

The End Of WHOPES

In 2017, WHOPES was replaced by the WHO Prequalification Vector Control Products Unit (PQT-VCP), which has developed and published new LLIN evaluation guidelines over the six years since the original

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[34] As stated previously, the first two nets **Olyset** and **PermaNet** would probably not have been approved so easily if the guidelines for LLINs had come out earlier, but even with the guidelines in place, there is a lot of ambiguity, particularly in the hut experiments and field trials, about what is being measured and why.

[35] Prices of nets could be FOB (Free on board) i.e. price from the factory or CIF (Cost, Insurance and Freight) i.e. landed price in country. In the early days, organisations such as UNICEF, who I worked for at the time, preferred tenders based on FOB prices. I had to argue with UNICEF Procurement Division in Copenhagen that they should be using the landed price in country (CIF), not the FOB price as a cost comparator. This eventually allowed UNICEF to procure Olyset nets which were produced in Tanzania at an overall lower CIF price, even though their FOB price was more expensive than the PermaNet 2.0. Also, to deliver Olyset LLINs from Tanzania took only four days to reach the provinces I was working in in Mozambique. PermaNet 2.0 on the other hand, would take two months to come by ship to Mozambique from Vietnam where they were produced, and then, much more time to move them to other provinces.

[36] The other practical problem of buying PermaNet 2.0 in Mozambique was UNICEF and Mozambican Government agreements stipulated that all health shipments coming into Mozambique had to be custom cleared by government (usually provincial) custom agents. This was fine, though often a slow process, at shipping ports, but the real problem came when trying to move the nets from one province to another. The provinces which cleared and received nets were very reluctant to let those nets go to another province. This was a bureaucratic nightmare and UNICEF did not have any projects in provinces with shipping ports. However, fortunately for UNICEF at least, all the UNICEF LLIN projects were in provinces which had boarders with other countries (Tanzania or Malawi) which allowed us to import the Olyset LLINs from Arusha in Tanzania directly to our project sites within two days of arrival in country. Importing PermaNet 2.0 would have taken anything up to six months from the time they left the factory to where they would be in position for distribution.

concerns of efficacy were raised. While this marks a step in the right director, progress to improving LLINs is very slow and much more is needed to ensure quicker access to effective LLINs and to rebuild trust in a tool that has been losing credibility in malaria control efforts. All LLIN companies now have to submit complete portfolios with exacting standards of their products by the end of 2025. However, prior to this PQT-VCP has been reluctant to judge existing products on the market.

Relevant to this book and covered in the next chapter, it is only in 2019 that tunnel tests alone reappear as a pass mark for LLIN efficacy using WHOPES standards. This only occurred when PNG started to complain about the efficacy of LLINs it had received in country from 2013.

The major issue is that most LLINs on the market cannot pass cone bioassay tests and can now only pass tunnel tests in terms of bioefficacy. Tunnel tests are much less rigorous than cone bioassay tests.

Tunnel tests have now allowed the Global Fund and other agencies to keep procuring these LLINs even though they were not as efficacious or durable as they once were or when first prequalified.

TABLE ONE
Summary of Laboratory Tests on WHOPES Approved LLINs at Time of Their Evaluation

					Cone Test		Tunnel Test		
Net	Manufacturer	Insecticide	Material	Year Of WHOPES Evaluation	20 wash >80% Mortality	20 Wash >95% Knockdown	20 Wash >90 Blood Feeding inhibition	20 Wash >80% Mortality	Qualified By Phases
Olyset	Sumitomo	Permethrin	Polyethylene	2001	Yes	Yes	Yes	Yes	Pass P1
PermaNet 2.0	Vestergaard	Deltamethrin	Polyester	2004	10 Washes	Yes	Yes	Yes	Pass P1
Interceptor	BASF	Alphacypermethrin	Polyester	2006	No	Yes	Yes	Yes	Pass P1
KO Tab 123	Bayer	Deltamethrin	Not Applicable	2006	15 washes	Yes		Yes	Pass P1
Net Protect	Intelligent Insect Control	Deltamethrin	Polyethylene	2007	No	Yes			Pass P1
Duranet	Shobika Impex Pvt., Ltd.	Alphacypermethrin	Polyethylene	2007	No	Yes			Pass P1
Dawa Plus	Tana Netting	Deltamethrin	Polyestster	2007	No	Yes			Not pass P1
PermaNet 2.0	Vestergaard	Deltamethrin	Polyester	2008	Yes	Yes	Yes	Yes	P3 Pass
PermaNet 2.5	Vestergaard	Deltamethrin	Polyester	2008	Yes	Yes			Pass P1
PermaNet 3.0	Vestergaard	Deltamethrin + PBO	Polyester + PBO	2008	Yes	Yes			Pass P1
Olyset	Sumitomo	Permethrin	Polyethylene	2009	No	Yes			P3 Pass
Dawa Plus 2.0	Tana Netting	Deltamethrin	Polyester	2009	No	Yes			Pass P1
Yorkool	Tianjin Yorkool International	Deltamethrin	Polyester	2009	Yes	Yes			Pass P1
Lifenet	Bayer	Deltamethrin	Polypropylene	2011	Yes	Yes			Pass P1
MAGNet	VKA Polymers pvt. Ltd	Alphacypermethrin	Polyethylene	2011	Yes	Yes			Pass P1
Royal Sentry	Disease Control Technologies	Alphacypermethrin	Polyethylene	2011	Yes	Yes			Pass P1
Yahe	Fujian Yamei Iustry	Deltamethrin	Polyester	2011	Yes	Yes			Not pass P1
Olyset Plus	Sumitomo	Permethrin + PBO	Polyethylene	2012	No	Yes			Pass P1
Interceptor	BASF	Alphacypermethrin	Polyester	2012	Yes	Yes	Yes	Yes	P3 Pass
Duranet	Shobika Impex Pvt., Ltd.	Alphacypermethrin	Polyethylene	2013	Yes	No	Yes	Yes	P3 Pass
Net Protect	BestNet	Deltamethrin	Polyester	2013	No	No			Not pass P3
Yahe	Fujian Yamei Iustry	Deltamethrin	Polyester	2013	No	Yes			Not pass P1
Net Protect	BestNet	Deltamethrin	Polyester	2014	No	No			Not pass P3
Miranet	A&Z Textiles	Alphacypermethrin	Polyethylene	2015	15 washes	Yes			Pass P1
Paa Net	Life Ideas Textiles Company	Deltamethrin	Polyethylene	2015	No	Yes			Pass P1
Yahe	Fujian Yamei Iustry	Deltamethrin	Polyester	2015	No	Yes			Pass P1
Safenet	Mainpol GmbH	Alphacypermethrin	Polyester	2015	No	Yes			P3 Pass
Veeralin	VKA Polymers pvt. Ltd	Alphacypermethrin + PBO	Polyethylene	2016	Yes	Yes			Pass P1
Interceptor G2	BASF	Alphacypermethrin + chlorfenapyr	Polyester	2017	10 washes	Yes		Yes	Pass P1
Dawa Plus 3.0	Tana Netting	Deltamethrin + PBO	Polyester/ Polyethylene Roof	2017	Yes	Yes	No	No	Pass P1
Dawa Plus 4.0	Tana Netting	Deltamethrin + PBO	Polyethylene	2017	No	Yes	No	No	Pass P1

Notes: Empty = No data available
Pass P1 = Pass Phase One laboratory and huts trials and approved for sale.
Pass P3 – nets pass all their field trials and are fully approved
PBO = piperonyl butoxide

CHAPTER EIGHT - Signs of Trouble of LLINs in PNG

Chapter Summary

- The impact of the PermaNet 2.0 LLIN on malaria in PNG was tremendous with malaria decreasing from 2007 onwards.
- In 2016, malaria in PNG started to rise and has continued to do so since.
- Pre-Delivery Inspections for PNG continued to show delivered LLINs were good.
- In 2018, it was discovered that PermaNet 2.0 LLINs were not killing mosquitoes well. It was discovered that PermaNet 2.0 had a binder change at the end of 2012 which drastically reduced its efficacy.
- In 2020, due to poor performance, PermaNet 2.0 was replaced in PNG with other brands of LLINs. These brands were also much less efficacious than the pre 2014 PermaNet 2.0 and also believed to be much less efficacious than their respective original LLINs which had been initially prequalified by WHOPES.
- Despite poor efficacy and inability to pass cone bioassay tests, all brands of LLINs continue to be supported by WHO as they pass tunnel tests. During prequalification, most LLINs passed cone bioassay tests which they can no longer do now demonstrating reduced efficacy.
- Chapter concludes with an analysis of malaria trends in PNG versus LLIN distribution plus a list of scientific publications made by PNG IMR.
- Bedbugs are yet another problem which may affect malaria control.

From 2010 to 2015, the RAM program in Papua New Guinea (PNG) achieved remarkable success. Despite the demanding work and frequent challenges, long-lasting insecticidal nets (LLINs) were delivered to households as planned. Most importantly, malaria cases in PNG consistently declined each year during this period. Those involved in malaria control across the country strongly believed that this progress was due solely to the use of PermaNet 2.0 LLINs, as no other significant changes in climate, environment, or other factors were observed.

Before the introduction of PermaNet 2.0, malaria cases in PNG remained steady between 2000 and 2008, with approximately 1.6 million clinical cases reported annually. A noticeable decline began in 2009, following the initial mass distribution of LLINs in PNG in 2007. The rate of decline accelerated from 2010 onward, coinciding with RAM's takeover of LLIN distribution coordination which was a more rigorous and systematic distribution strategy, resulting in improved coverage.

This improvement in malaria rates in 2010 could also be attributed to a higher rate of LLINs being distributed per person. Prior to 2010, the National Department of Health (NDoH) had distributed LLINs at a rate of one LLIN to every 2.5 people. With the new program, this increased to one net for every two people.[37] In many provinces, they also ran out of funds to cover distribution costs before they had covered their target population. These operational challenges were key reasons for transferring the program to RAM, enabling a more reliable and effective distribution approach.[38]

The decrease of malaria after 2010 was so positive, that in 2014, at an annual meeting of the PNG IMR, everyone in the PNG malaria program was congratulating themselves on such a successful impact on

[37] Distributing nets at a rate of one net for every 2.5 people proved to be challenging for Provincial Health Authorities from 2007 to 2010. In most cases, provinces ran out of nets as they did not distribute nets at a rate of one net for every 2.5 people but distributed at a rate of one net for every two people which consequently meant they ultimately ran out of nets before reaching 100% of targeted households.

[38] In reality, implementation of the program prior to 2010 in most provinces was very variable, but it should be noted, that one or two provinces did a very good job following instructions and worked within budget, while many other provinces did not.

malaria. This was also supported by a scientific paper which had been published in 2014, showing that the PermaNet 2.0 being distributed in PNG was lasting up to seven years in the field and was still very effective at killing mosquitoes after all these years. With the results of this scientific paper, and the continuing trend of malaria going down, everyone in the malaria community in PNG in 2014 was convinced that PNG was on its way to malaria elimination throughout the country.

It was during this period of optimism that I conceived the idea for this book and began taking notes. The book was intended to commemorate the decline and anticipated eradication of malaria in PNG. However, those triumphant and self-congratulatory days would soon prove to be fleeting, and ultimately, illusory.

In 2016, reports began to surface of malaria drug shortages in several provinces, accompanied by a noticeable rise in malaria cases. The immediate assumption (but in hindsight probably the wrong conclusion), was that the shortages of antimalaria drugs were driving the resurgence. By early 2017, the situation had worsened to the point that the Global Fund stepped in to procure emergency supplies of anti-malarial drugs and Rapid Diagnostic Tests (RDTs). These were distributed in the final quarter of 2017 by Population Services International (PSI), with support from RAM staff. From 2018 onward, RAM assumed responsibility for antimalaria drug distribution, and up to 2024, there were no further malaria drug shortages.

Although access to malaria drugs improved, the number of cases continued to rise steadily each year. The only notable declines occurred in 2021, likely due to fewer people visiting health facilities during the COVID-19 pandemic, and in 2023, possibly as a result of more effective long-lasting insecticidal nets (LLINs) being distributed in parts of Papua New Guinea in 2022. However, by the end of 2024, the overall upward trend in malaria cases appeared to persist (see Fig. 1).

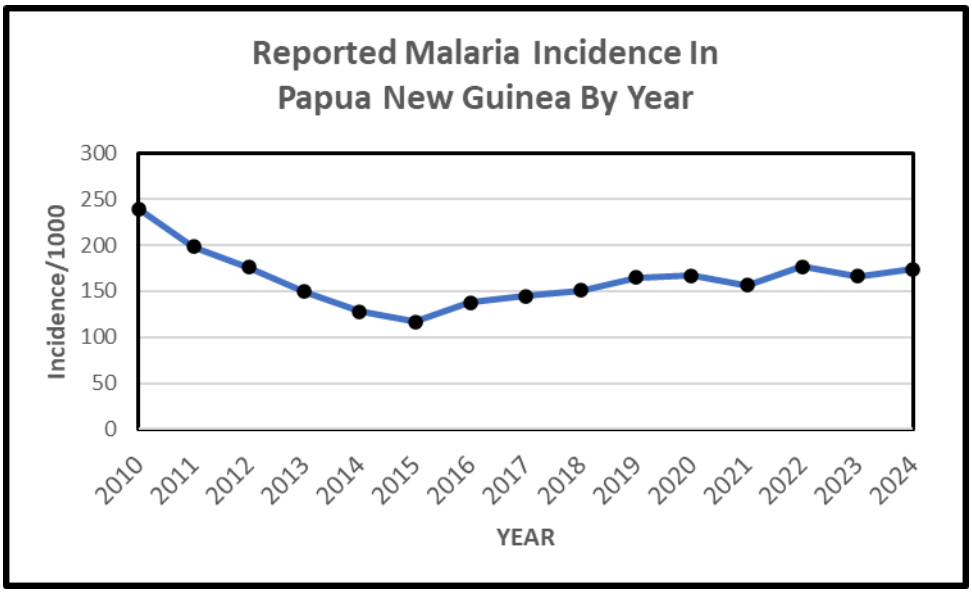

Fig. 1 - Malaria Incidence Trend in Papua New Guinea
(Data Taken From the PNG National Health Information System)

In retrospect, the rise in malaria cases from 2015 to 2016 was not caused by a shortage of procured drugs, but rather by a surge in malaria infections that exceeded the available supply of anti-malarial medications. It's important to acknowledge that the National Department of Health (NDoH), which was responsible for drug procurement at the time, had not maintained sufficient buffer stocks for emergency situations. Their projections were likely based on previous downward trends in malaria, leading to an underestimation of drug requirements in case of emergencies.

Between 2016 and 2018, the true cause of the resurgence remained unclear. The drug shortages in 2016 initially seemed to explain the increase in cases, but this assumption masked other issues.

Until 2018, no one in PNG questioned the efficacy of PermaNet 2.0 LLINs. These nets were WHOPES-certified and consistently passed all Predelivery Inspections (PDIs), which measured insecticide concentration, a metric considered a reliable indicator of mosquito-killing effectiveness.[39]

In August 2018, I received a report that changed everything. It came from Prof. Stephan Karl, a German-Australian entomologist, working at the Institute of Medical Research (IMR) in Madang in Papua New Guinea. He was routinely monitoring LLIN efficacy of the National Malaria Control Program with cone bioassays.

During this evaluation, Stephan Karl's team tested LLINs recently distributed in Madang Province, the same area where insecticide-treated nets were first studied in 1987. The findings were alarming: the 2017 PermaNet 2.0 LLINs showed minimal effectiveness in killing mosquitoes, despite having been distributed less than a year earlier.

The PermaNet 2.0 LLINs distributed in 2017 appeared markedly different from those previously studied and documented by the Institute of Medical Research (IMR) in 2014. Both the 2017 nets and those referenced in the 2014 publication were tested using standard WHOPES cone bioassays (see Chapter Seven). This method was preferred because it was the same test used during the original WHOPES prequalification process for most LLINs.

It was later revealed that the PNG paper published in 2014 was actually based on research conducted in 2011. Fortunately, the PermaNet 2.0 LLINs used in that 2011 study were still stored at the Institute of Medical Research (IMR) in Madang.

In 2018, these 2011 unused PermaNet 2.0 LLINs were retested and, consistent with the original findings, remained highly effective at killing mosquitoes. In contrast, PermaNet 2.0 LLINs distributed in 2017 and recollected from the field in 2018 showed poor efficacy. For further comparison, unused PermaNet 2.0 LLINs delivered in 2017 and 2018, still sealed, unwashed, and in their original packaging, were also tested. These, too, demonstrated low mosquito-killing effectiveness, even when new, compared to the 2011 batch, raising serious concerns about the quality and performance of more recent LLINs even when new.

We anticipated strong resistance to our findings, not only from Vestergaard, the manufacturer that had supplied PermaNet 2.0 LLINs to PNG for over a decade, but also from donors who had invested heavily in the malaria program. This made it essential for PNG to present a robust scientific case, clearly explaining the methodology behind the results.

To strengthen our position, RAM began collaborating closely with the IMR to collect additional samples of unused LLINs from various years and locations across PNG. The goal was to determine whether the LLINs sampled in 2018, both used and unused, from Madang Province, were an isolated anomaly or indicative of a broader issue.

At the time, RAM's standard operating procedures (SOPs) required all distribution staff and volunteers to open LLIN packages before handing them to households, in order to reduce their resale value. Each LLIN was also marked with a permanent marker to indicate the province and year of distribution. These measures were intended to discourage the commercial sale of LLINs.

[39] It is only later that it was discovered that the insecticidal content of the net alone does not confirm efficacy.

However, despite these protocols, many volunteers failed to comply. Often under pressure from recipients, overwhelmed by workload, or becoming confused during distribution, they did not open the packages as required.

Before 2018, many families held onto their previously distributed LLINs, waiting for older nets to wear out before using new ones. This showed RAM that many LLINs were still in use more than three years after distribution. Fortunately, for the investigation, many households had unused LLINs from earlier campaigns still sealed in their original packaging. Additionally, LLINs distributed early in the PNG program were not packed in biodegradable bags, helping them remain in excellent condition for years.[40]

To collect samples for comparison, RAM sent field officers across the country in 2019 to find unused LLINs from earlier distributions still in sealed packaging. The team successfully gathered nets manufactured between 2007 and 2018, which were sent to IMR for testing.

During this testing, Stephan Karl and his team at IMR found that PermaNet 2.0 LLINs manufactured up to 2012 (and still distributed in 2013) met their original WHOPES prequalification standards, achieving 100% mosquito mortality and 95% knockdown. However, LLINs distributed after 2013 failed to kill mosquitoes (less than 80% mortality) when tested unused, according to WHOPES cone bioassay standards. These findings are clearly illustrated in Figure 2, which shows mortality rates by year of manufacture with huge reduction of efficacy in LLINs manufactured after 2012.

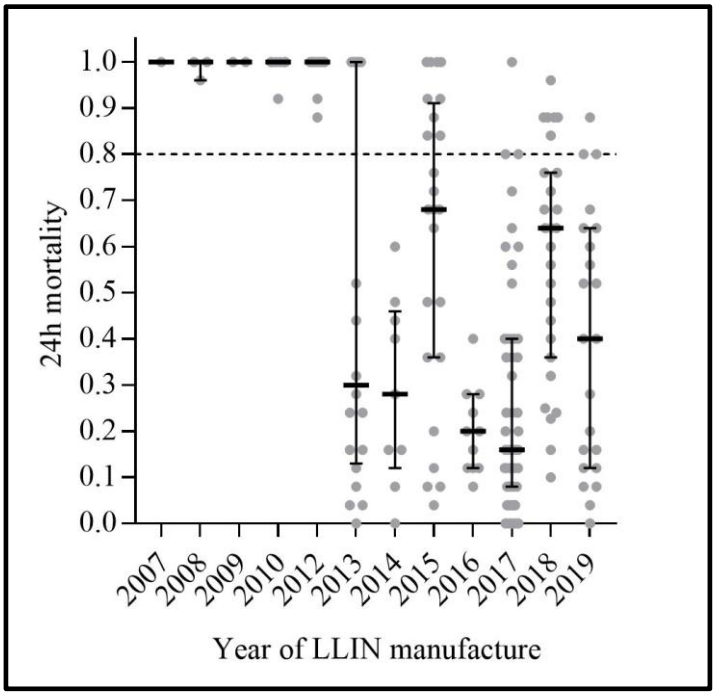

Fig. 2 - Cone bioassay mortality results for unused PermaNet 2.0 manufactured between 2007 – 2019.
https://www.nature.com/articles/s41467-020-17456-2
The results clearly show that unused PermaNet 2.0 manufactured from 2007 to 2019 kill 100% of mosquitoes but those from 2013 could not kill 80% mosquitoes even when new or unused.

[40] Biodegradable bags, which RAM ultimately procured for environmental reasons, proved to be a total nightmare. If kept for a long time in storage, the net packaging would break down and you would be left with lots of tiny bits of plastic from the covers which were almost as difficult to get rid of as the original plastic packaging. Worse still, it left nets without any packaging at all. This meant that retrieving old nets with biodegradable bags in pristine condition very difficult.

Once this finding emerged, we realized the implications were far more serious. It wasn't just a matter of one defective production year; it pointed to a change that had long-term consequences for malaria control in PNG and potentially worldwide. If compensation were pursued, the manufacturer could face costs covering at least five years of underperforming nets. More critically, the reputational damage would extend beyond the PermaNet 2.0 manufacturer to the entire procurement system, which failed to detect the issue sooner.[41]

Stephan Karl and his team conducted extensive investigations and discovered that, at the end of 2012, Vestergaard had changed the binder used to attach insecticide to PermaNet 2.0 LLINs. It would appear that the new binder failed to release the insecticide effectively, leading to a significant drop in performance from 2013 onward. As a result, measuring insecticide content during Pre-Delivery Inspections no longer reflected the true efficacy of the LLINs.

CHANGE IN LLIN BINDER OF PERMANET 2.0

The mosquito net binders used in **PermaNet 2.0 before 2013**, were a group of chemicals known as PFAS (polyfluoroalkyl substances) or more commonly known as Forever Chemicals. PFAS are found in a huge variety of products including packaging, clothing and non-stick pan surfaces as they are very resistant to breakdown but the substance has increasingly been linked to health and environmental issues. PFAS binders for insecticides were expensive, and when the European Union amongst others started expressing reservations about PFAS in about 2009, it is believed that some LLIN companies quietly changed their PFAS binders without informing anyone. This also coincided with increased pressure from donors for cheaper nets. Identifying cheaper alternatives therefore made sense economically. The issue is, that while binders were being changed, no one appears to have tested the new binders to see if they were as efficient as the old ones in terms of their insecticidal efficacy during 20 washes or three years of use.

The result was a significant drop in LLIN performance, which went unnoticed for years. It's comparable to replacing a turbocharger in a sports car without telling customers, only to discover later that the car no longer performs the same.

In addition to chemical changes, the physical durability of the nets also declined. Between 2016 and 2019, the weight of PermaNet 2.0 nets supplied to PNG by Vestergaard dropped from 500 grams to around 400 grams. Although Vestergaard claimed this did not affect durability, field observations in 2019 suggested that these lighter nets did not last as long as those distributed between 2007 and 2012.

PNG was fortunate in the type of analysis that could be done on LLINs. PNG is perhaps unique in the world, as having only one type of LLIN (PermaNet 2.0) distributed in the country for twelve years from 2007 to 2019 which allowed comparison of performance of the nets from one year to the next.

In 2020, when it was realized that PermaNet 2.0 were no longer working well, PNG made the decision not to procure any further PermaNet 2.0 LLIN.

[41] It's important to note that defective LLINs were not uncommon. Several brands were found to be faulty in other countries, though typically only for a single year, making the issue easier to manage and explain. Notable examples include the distribution of 3.5 million NetProtect nets in Rwanda in 2014, and 15 million Dawa Plus nets supplied to Kenya in 2018 and 2019, which were also sent to other countries. In both cases, it's believed that no compensation was received, as the manufacturers went out of business.

As mentioned in the previous chapter, WHOPES in effect, made all LLINs equal. LLINs could only be selected in tenders based on price. With PNG refusing to receive PermaNet 2.0 nets, this now precluded the possibility of having a tender based on price, and therefore, from then on, RAM requested the Global Fund procurement division to procure other brands of LLINs on RAM's behalf in the future. The request for new LLINs came with clear instructions that under no circumstances should the Global Fund (and our other donor Against Malaria Foundation) send any more PermaNet 2.0 LLINs to PNG. It was in this way; RAM came to receive almost all the different types of single AI (active ingredient) insecticide LLINs on the market over the next few years.

From 2020 onward, various types of LLINs were procured and distributed across different regions of PNG. Upon arrival in PNG, RAM officers collected samples from the coolest part of the shipping containers (see Chapter Four). These samples were sent to IMR, where they underwent cone bioassay testing to assess their efficacy both when new and up to twenty washes.

Through systematic sampling, RAM and IMR collected a wide range of LLINs from different consignments and batch numbers, allowing PNG to build a comprehensive database of net types. **When testing showed that none of the polyester LLINs on the market outperformed the original pre-2013 PermaNet 2.0, and were similar in efficacy to the post-2012 PermaNet2.0 version, a decision was made in 2021 to trial polyethylene LLINs.** These LLINs are heavier and bulkier, increasing distribution costs, especially when airlifting is required. Also, the program remained cautious, as polyethylene nets are also less popular among communities due to their stiff texture, unlike the soft and flexible feel of polyester nets. Additionally, polyethylene nets are often repurposed as fishing nets.

Polyethylene LLINs were introduced in late 2021 and distributed through 2022. They proved more efficacious than polyester nets, contributing to PNG's first nationwide decline in malaria cases in 2023, though modest. However, lab tests showed these nets were less effective than their WHOPES prequalification results suggested. Overall, none of the LLINs used in PNG matched the efficacy of earlier versions, such as the pre-2013 PermaNet 2.0.

Overall, based on observed data, both in the laboratory and on malaria in the field, it would seem that that **PermaNet 2.0 LLINs prior to 2013 were better (much more efficacious and durable) than PermaNet 2.0 LLINs being distributed after 2013 and all other LLIN brands distributed in the last few years in PNG.**

It's likely that changes made to PermaNet 2.0 in 2013 were also applied to other polyester LLINs, reducing their effectiveness compared to when they first passed WHOPES prequalification. Although polyethylene nets lack binders, they too seem to have undergone changes, as none have matched their original prequalification performance.

International reaction

Our prediction that we would have problems getting acceptance of our results turned out to be an understatement. From the first day that we noted a problem with PermaNet 2.0 in 2018 in PNG, we informed our donors Global Fund and our other donor Against Malaria Foundation (AMF) of our concerns. The project managers in both Global Fund and Against Malaria Foundation, were very receptive and supportive of our reports. Other key stakeholder representatives, particularly those in procurement, were a different story and PNG results were to become very controversial. Overall, IMR and RAM received a lot of negative comments regarding the PNG findings from others within the Global Fund, WHO and other organisations.

In early 2019, RAM and IMR were asked to send samples of PNG's PermaNet 2.0 to both the manufacturer, Vestergaard, and a laboratory in Belgium. The results took a long time to be released.

In July 2020, IMR published the first finding on this subject (Fig. 2) showing that PermaNet 2.0 was much more efficacious before 2013 than those LLINs produced from 2013 afterwards. This was circulated to all concerned. As a result of this, we eventually received a copy of the Vestergaard report

Vestergaard's results released in mid-2020 confirmed IMR's findings: LLINs manufactured before 2012 performed well and passed cone bioassay tests with flying colours, while those from 2018 and 2019 showed very poor efficacy in cone bioassay tests. The real shock came when Vestergaard, backed by the Global Fund Quality Assurance team, stated that the nets were still WHOPES compliant based solely on tunnel test results. **This meant no action would be taken, despite the fact that post-2013 PermaNet 2.0 nets were significantly less effective than those received before 2012, and even less so than the original 2004 PermaNet 2.0 WHOPES prequalification standard.** WHOPES compliance at this time now appeared to depend only on passing tunnel tests, regardless of the decline from their former efficacy or their original prequalification performance.

After IMR's first publication in July 2020, a number of other publications followed in July 2021, December 2021, July 2022 and in November 2022 where it was shown conclusively that the problem with the PermaNet 2.0 was caused by a change in binder (See end of chapter for references).

Although PNG's IMR published its concerns, no one seemed to listen. The PNG team reached out widely, but most responses dismissed the issue as unique to PNG. Many claimed that local practices, especially storing nets in containers, were responsible for reduced effectiveness in PNG while the storing practices in PNG did not change pre and post 2013.

In other countries, particularly in Africa, poor LLIN performance was blamed on insecticide resistance whereas PNG has no insecticide resistance in local mosquito vector. Despite our efforts to explain that resistance was masking the LLINs' low efficacy, these arguments were largely ignored. PNG was treated as an exception, both in findings, cause and context.[42]

Despite earlier setbacks, PNG continued to press the Global Fund for action. In early 2023, the Global Fund sponsored an appraisal in Tanzania, testing three LLIN brands: **PermaNet 2.0**, **SafeNet**, and **Yahe**. As expected, all three failed cone bioassay tests but passed tunnel tests, and were therefore deemed compliant with WHOPES standards. PNG highlighted that these nets had previously met higher WHOPES benchmarks, including cone bioassay performance. However, it appeared that as long as the LLINs met the minimum requirements of the 2005 WHOPES Guidelines, reduced efficacy over time was not considered grounds for concern.

Despite mounting evidence, few were willing to acknowledge a problem. Key figures in the global malaria community, including WHO, maintained that LLINs were performing well worldwide, suggesting that the concerns raised in PNG were isolated and not representative of broader issues.

In February 2024, Bloomberg News published an article that briefly brought global attention to the LLIN efficacy issue in PNG. For reasons unclear to us, Bloomberg became interested in the problem of LLLIN efficacy towards the end of 2023. Most notably, they succeeded in getting Vestergaard to acknowledge that the binder in PermaNet 2.0 was changed in 2012. However, Vestergaard downplayed

[42] Durability was also to become a major reason to explain poor net efficacy. Nets were simply not lasting as long as they used to. In PNG, the research work has shown that durability is not the issue, as the insecticidal efficacy of the LLINs finishes long before the physical life of the net. This was not recognised as a problem in Africa.

the significance of this change, claiming it did not affect LLIN efficacy and that they were not obligated to inform WHO.

The Bloomberg article was published while I was attending an LLIN conference in Nairobi, Kenya, alongside representatives from many African National Malaria Control Programs (NMCPs). A key takeaway from the meeting was a recommendation to the Global Fund and WHO to consider distributing nets every two years instead of three, as current LLINs were not lasting the full three years in terms of durability and hence efficacy.

An unpublished 2024 study in PNG, funded by AMF, found that LLINs are physically lasting much longer in the field than previously expected. However, their insecticidal efficacy declines rapidly. This suggests that in Africa, where similar single-insecticide nets are used, the reduced performance may not solely be due to insecticide resistance and short lived LLINs, but to the short life of insecticidal effectiveness.[43]

Since the Bloomberg article, scepticism around LLIN efficacy has diminished. However, a significant number of stakeholders still either deny the issue or genuinely believe LLINs remain effective, despite rising malaria cases in PNG and elsewhere. In May 2023, an international malaria conference held in PNG was attended by the Chairman of the Roll Back Malaria (RBM) initiative. During the event, Stephan Karl and I delivered a passionate presentation highlighting the global decline in LLIN efficacy over the past decade. This led to the formation of a special RBM group to investigate the issue.

Unfortunately, during the group's second Zoom meeting, one group member again framed the problem as unique to PNG. I had to reiterate that this is a global concern: LLINs today which once passed cone bioassay tests can no longer do so and only pass tunnel tests. Regrettably, the group now appears to have stopped pursuing the matter further.

Change In Malaria Incidence in PNG Over Time Due to Changing Efficacy of LLINs

As reflected in Fig. 1 and 3, the **incidence of malaria** in PNG went down annually from 2010 and then started to rise again in 2016 and still continues to rise until 2024. It is believed that this rise is a result of LLIN manufacturing changes in PermaNet 2.0 at the end of 2012, and the new 2013 manufactured PermaNet 2.0 LLINs with the new binder being distributed in PNG in 2014. This ultimately caused the rises of malaria in 2016 and it is important to understand the dynamics of this.

As mentioned previously, PNG has rolling LLIN distribution campaigns. LLIN distributions do not occur at one time, and are continuously being carried out at district level so that all districts and provinces receive LLINs at three-year intervals at approximately the same time of year. As the LLINs are distributed at different times of the year, it is good to investigate the impact of individual distributions of LLINs over time rather than annual changes in malaria which can mask performance of LLINs depending on what time of year the distributions were carried out.

In total, between 2010 and 2019, there were 171 separate district LLIN distribution campaigns in the low-lying malaria endemic areas of PNG. There were also a further 183 district LLINs distribution campaigns in the highland areas of PNG during the same period. These distributions are not included

[43] Recent multi-country studies have tested new LLINs that use two insecticides, also called "novel insecticide combinations". These trials typically compare the new nets with single-insecticide LLINs. Unsurprisingly, the older brands of single Active Ingredient (AI) LLINs brands perform poorly in comparison to new brands for LLINs with PBO or new insecticides. What many observers overlook is that these single-insecticide LLINs, like those used in PNG, can still initially kill insecticide-resistant mosquitoes. The real issue, as seen in both Africa and PNG, is their short-lived efficacy. In Africa, this decline has often been misinterpreted as physical deterioration, with little recognition that the nets lose their insecticidal potency far earlier than their physical integrity (durability).

in the following analysis as it is now believed that malaria is not endemic in these areas and malaria has now practically disappeared.

For each of the 171 separate LLIN district distribution campaigns carried out in malaria endemic areas, malaria incidence (cases of malaria per 1000 people) was calculated for one year before each LLIN distribution in each district. In addition to this, the malaria incidence was calculated for each of three years following each LLIN district distribution as a comparison of performance of the LLINs against the previous year when the LLIN distribution was carried out. For example, if a LLIN distribution was carried out in June of a 2018, the malaria incidence would be measured for the period of June of 2017 to May 2018. Incidence would then also be calculated for the period June 2018 to May 2019, June 2019 to May 2020 and lastly from June 2020 to May 2021. This allows comparison of the malaria incidence one year before and for three years after each district LLIN distribution.

For malaria incidence, **Suspected Malaria Incidence** was chosen. Suspected malaria includes all cases of malaria which are treated presumptively (i.e. no testing carried out) and all cases which are suspected of malaria and tested by microscopy or malaria Rapid Diagnostic Tests (RDTs). However, it should be noted that similar results as shown below occur when incidence per 1000 of presumed malaria cases (not tested) + positive cases is used. This latter incidence is often used by WHO in their reports.

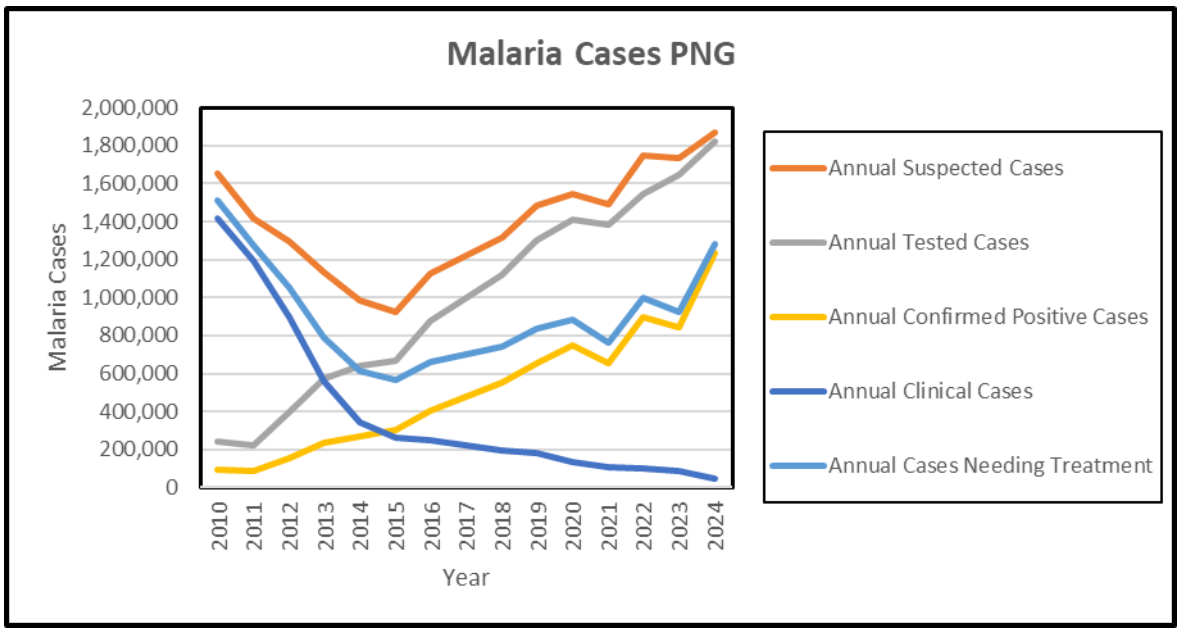

Fig. 3 – Change of Types of Recorded Malaria over Time from 2010 to 2023. (PNG NHIS)

Notes
1. Annual Suspected Cases - cases treated presumptively and those tested by microscopy or RDT (Lines 2 + 4).
2. Annual Tested Cases - cases tested by microscopy or malaria RDT.
3. Annual Confirmed Positive Cases – cases actually recorded positive by microscopy or RDTs (around 50%)
4. Annual Clinical Cases – cases that are suspected of malaria but presumptively treated without testing
5. Annual Cases Needing Treatment – all malaria cases, either suspected presumptively or test positive, treated with antimalaria drugs (Lines 4 +5)

The reason why the suspected malaria criteria is used rather than confirmed positive cases is that prior to 2010, in PNG, practically all cases of malaria were treated presumptively i.e. without any type of testing. Referring to Fig.3, this shows that after 2012, malaria cases are increasingly diagnosed (mainly with RDTs) which allows more positive cases of malaria to be confirmed. However, throughout the history of PNG, when malaria cases are tested, roughly 50% of tested cases have been considered

microscopy or RDT positive, so the idea of using suspected malaria cases allows us to roughly compare malaria data from 2000 to 2024 for periods with and without testing [44,45].

Malaria outcomes from LLIN distributions varied widely. Between 2010 and 2013, 61 out of 71 district distributions led to positive results—defined as a lower malaria incidence three years after distribution compared to the year before distribution. In contrast, from 2014 to 2019, only 29 of 100 distributions showed improvement (see Table One).

Table One compares malaria incidence one year before LLIN distribution with incidence three years after. Before 2014, LLIN distributions typically reduced malaria by up to 30% in year three. After 2014, all distributions saw increases, ranging from 17% in 2018 to as high as 60% in 2015 and 2017. These trends align with annual LLIN efficacy results shown in Fig. 2 and annual malaria increases in Fig. 4.

Table One

Percentage of Successful LLIN Distribution Campaigns in Low-Lying PNG Malaria Endemic Areas

Year Of Distributions	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Number Of District LLIN Distributions	19	16	16	20	16	14	17	19	16	18
Number Of District Distributions With Positive Outcomes	16	15	14	16	6	3	6	4	6	4
Percentrage Of Distributions Which Were Successful in Reducing Malaria	84.2	93.8	87.5	80.0	37.5	21.4	35.3	21.1	37.5	22.2

Note – A successful LLIN distribution outcome is when the malaria incidence after three years of a LLIN distribution is less that the malaria incidence prior to the LLIN distribution.

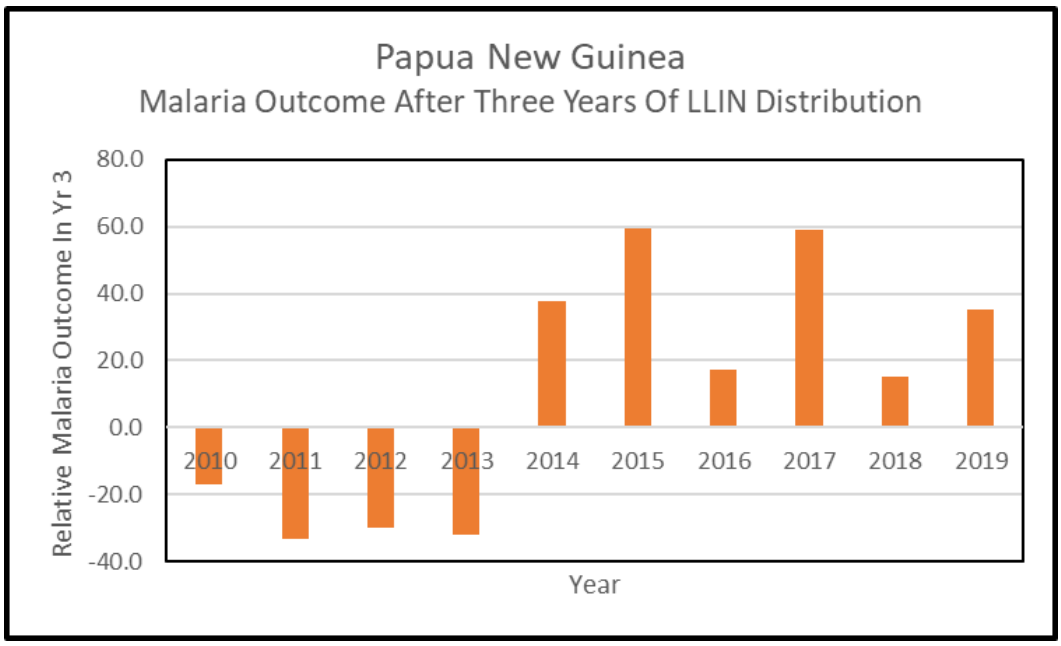

Fig.4 - Average Reduction of Suspected Malaria per Year Following District LLIN Distributions in Low-Lying PNG Malaria Endemic Areas

[44] Malaria positivity has changed a little over time. In 2009, it was about 48% and after RDTs were introduced, it dropped down to as little as 39% from 2010 to 2014 as RDTs were introduced and clinical staff started to test all fever cases for malaria. However, from 2015 positivity rates rose to 45% and increased continually to be about 50% in 2023. Factoring in positivity rates would not change the trend of malaria reducing until 2015 and malaria continually rising in 2016.

[45] It should be noted that clinical malaria is being reported from about 822 health centers. The data does not include data from about 3000 Aid Posts (many of which are closed at any given time) which probably account for about 60% of the malaria cases treated in the country. However, it is considered that the number of families who visit health centers remain constant, so the data presented can be a reflection of malaria trends but not absolute figures in terms of malaria cases in PNG.

It can be assumed that the binder was changed in the PermaNet 2.0 at the end of 2012 and whose LLINs were first used in PNG in 2014. If we therefore investigate how malaria is affected each year after a distribution, we can get the graph in Fig. 5 which shows the combined change in malaria by year after LLIN distributions for the periods 2010-2013 and for 2014-2019. This can be further broken down to annual reductions by year (Fig. 6), which shows consistent annual results for the two periods: before (till 2013) and after the binder change (2014 distributions onwards).

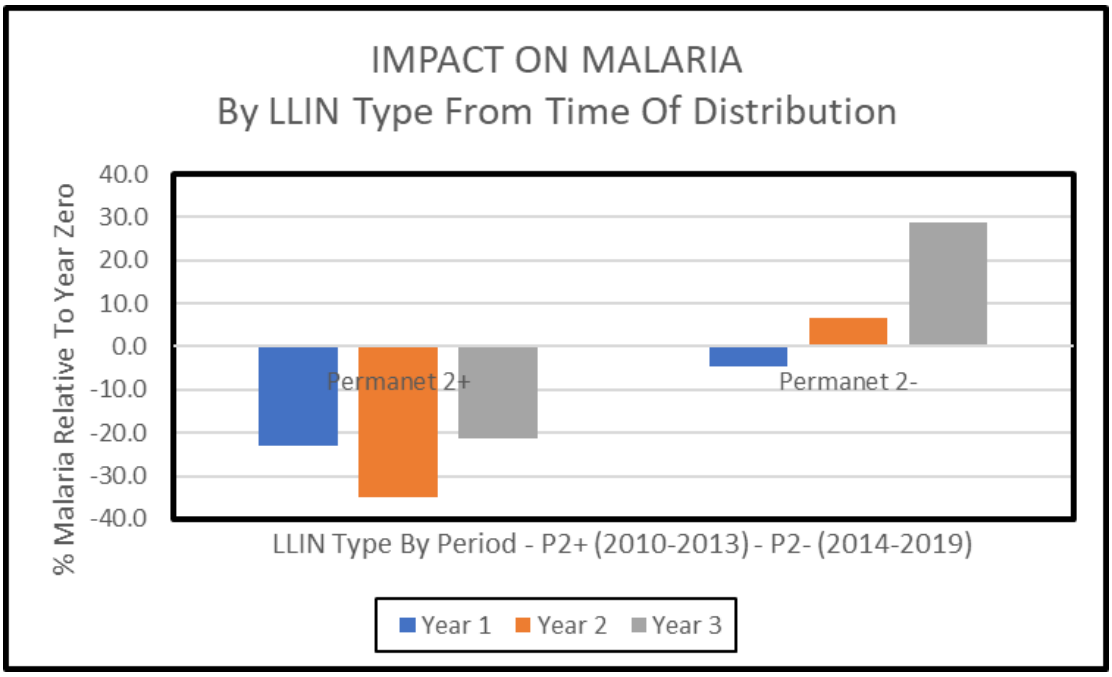

Fig. 5 Combined Suspected Malaria Change in Low-Lying PNG Malaria Endemic Areas For Different Quality PermaNet 2.0 Nets Before And After Binder Change At End Of 2012

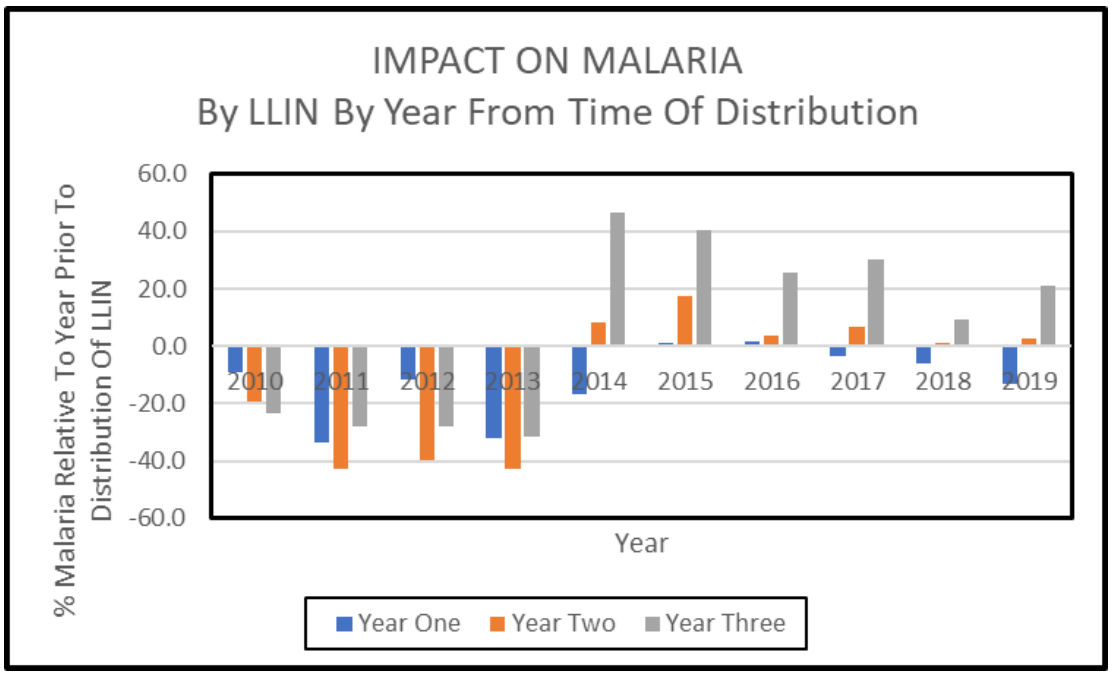

Fig. 6 - Changes by Year to Malaria Following LLIN Distributions in Low-lying PNG Malaria Endemic Areas
(Malaria incidence in year three post distribution compared with incidence in year before net distribution)
It can be noted that in 2015 and 2016, there was practically no reduction of malaria even in Year One.

From 2014 to 2019, data from Fig. 5 and Fig. 6 shows that LLINs had little to no impact beyond the first year, and in 2015 and 2016, not even during the first year. This suggests, as seen in Africa, that shortening the physical lifespan of LLINs is unlikely to affect their overall efficacy. While reduced durability is often blamed for poor performance in Africa, the real issue appears to be the short-lived insecticidal effectiveness. Evidence from PNG indicates that the insecticidal potency of LLINs fades well before the LLINs physically wear out.

PNG 2020 onwards

Since 2020, PNG has distributed a number of different LLIN brands including SafeNet, Yahe, Yorkool, Royal Sentry, MAGNet and DuraNets. PNG IMR does not have complete data sets for all of these products, but from what can be observed, SafeNet worked very well for two years but by year three, malaria has increased again above base line. A similar scenario is seen for Yahe though the impact of Yahe nets on malaria in year one and two has been much less than SafeNet. It is expected that Yorkool and Interceptor, as polyether LLINs, will also have similar performance.

The only nets showing any type of efficacy similar to that of the original 2010-2013 **PermaNet 2.0** is the **Royal Sentry**. For the rest, we have to wait until more data is collected, but it is likely that all LLINs on the market (with perhaps the possible exception of the **Royal Sentry**) are worse than the **pre 2013 PermaNet 2.0** and the prequalification performance of their own brands which were first approved by WHOPES.

Therefore, with the quality of nets presently available, there is little likelihood of reduction of malaria using LLINs alone. While **Royal Sentry** shows great promise, it is a polyethylene net which is not favoured by communities, as like all polyethylene nets, it does not hang well and needs to be weighted down to keep it on the floor. Monitoring Royal Sentry net usage like other polyethylene LLIN therefore needs to be monitored and special education given in their use to communities.

Challenges with pre-delivery inspections

The experience in Papua New Guinea (PNG) has revealed an additional issue. Pre-delivery inspections often rely on measuring insecticide concentration as a proxy for the efficacy of long-lasting insecticidal nets (LLINs). However, insecticide content alone does not reliably correlate with LLIN insecticide effectiveness.

Between 2010 and 2019, the concentration of deltamethrin in PermaNet 2.0 nets delivered to PNG remained consistent. This indicates that measuring insecticide content alone is insufficient to assess LLIN insecticidal efficacy as seen in Fig. 2. While testing the insecticide content of new LLINs is still important, it is equally essential to conduct cone bioassays on a sample of LLINs from each shipment to confirm their effectiveness. This is best done predelivery inspections but also prior to distribution to ensure no degradation of insecticide or performance during shipment.

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YET ANOTHER POSSIBLE PROBLEM

If LLIN efficacy is not enough, another factor has been introduced in PNG which makes malaria control even more difficult.

The tropical bedbug *Cimex hemipterus*, is related to the European bedbug *C. lectularius* which has become an increasing problem in Europe, particularly well reported in France. Bedbugs are parasites on humans which come out, mainly at night, to bite their human hosts. When bitten, people experience itchiness, swelling around the bites, and lesions around the affected areas on the skin. The Tropical Bedbug is now becoming a problem in PNG and other parts of the world where it has been reported in several countries in Africa.

Both species of bedbugs have become resistant to the pyrethroid insecticides which are used for treating mosquito nets. This means that LLINs no longer kill bedbugs.

Bedbugs are supposed to hide away during the day time in nooks and crannies. Reports are being received of Tropical Bedbugs being found in day light resting on mosquito netting in PNG. In fact, reports are being received that villagers in many places are complaining that the bedbugs are being distributed with the LLINs. The end result is that reports have been received that many people have abandoned their nets and in extreme cases, have burnt their nets to destroy the bedbugs.

This creates a real problem to compound the issues of efficacy. There is no easy way to get rid of bed bugs, particularly in a rural setting. The bedbugs are completely resistant to many insecticides and the only way to clear them from urban homes is using steam machines which are impractical for use in rural settings.

CHAPTER NINE - Public Private Partnerships

Chapter Summary

- Examines the probable Conflict of Interest between the public and private sector and how perhaps this has affected the declining efficacy of LLINs
- Regulations are now in place to improve LLINs, but it might take years to see better LLINs.

In the 1990's, it is probably fair to say that malaria control had come to a standstill in most countries with a few exceptions like Zimbabwe where I was living at the time. Zimbabwe still had a national Indoor Residual Spraying (IRS) campaign to control malaria.

At this time, worldwide, it was estimated that over 300 million people were suffering acute illness from malaria each year, together with, about one million malaria deaths of which 75% were children or pregnant women, most of which occurred in Africa.[46] It was also estimated that in countries with a heavy malaria burden, malaria accounted for 40% of public health expenditure, 30-50% of inpatients and up to 50% of outpatient consultations.[47] It was also known that children who did not die of malaria could also suffer brain damage or experience cognitive and learning deficiencies in later life.

As no new initiatives or funding were available at the time for malaria, in October 1998, the WHO, World Bank, UNDP (United Nations Development Program) and UNICEF (United Nations Children's Fund) conceived and partnered together to create the Roll Back Malaria (RBM) movement. The ambitious goal of RBM was to halve malaria deaths by 2010 and then halve malaria deaths yet again by 2015.[48] The main aim of RBM was to raise funds for malaria control worldwide and promoting good practices in tackling malaria such as emphasising early treatment and use of Insecticide Treated Nets (ITNs).[49]

To achieve its ambitious aims, RBM used advocacy directed at many partners looking for joint approaches to tackling the malaria problem at all levels. These included international partnerships between donors, to country level and even community level partnerships. There was also a huge emphasis on public private partnerships as it was felt that the private sector had a lot to contribute, particularly in the areas of developing new drugs and insecticides, and later on, the development of LLINs. It was recognised that very few people in the malaria public health community had the expertise to develop these commodities. RMB also emphasised country design and ownership of their malaria programs[50].

It is also good to note, that even before RBM came into existence, the private sector was already well ingrained into the malaria world, so these types of "partnerships" were already in existence. The big

[46] WHO 1990 Malaria Reports

[47] Roll Back Malaria Partnership - Economic costs of malaria

[48] Roll Back Malaria - The scarcity of international aid for malaria control, Vasant Narasimhan & Amir Attaran *Malaria Journal* volume 2, Article number: 8 (2003).

[49] As a historical perspective, at the start of RBM, the British Department for International Development (DFID) were the main funder of RBM and donated about US$90 million towards RBM movement. It can also be noted that the first Executive Director of RBM in 1999 was David Nabarro who was formally the Director for Human Development in DFID from 1997–1999. In fact, the British were to remain one of the biggest donors to malaria control in the early days of RBM and ironically also funded a number of US NGOs in the malaria sphere until the US government became more involved in the malaria world through the President's Malaria Initiative (PMI) and other US initiatives and interventions.

[50] One of the mantras of the early RBM advocacy was that countries should design their own malaria programs. I commented and actually wrote to David Nabarra at the time that this was like asking malaria experts to design a new type of sports car as countries per se did not have the expertise within country to solve their malaria problems, as malaria experts did not have the expertise to design a car.

question was whether they were true partnerships or simply the private sector selling their wares to the public sector is open to debate. Certainly, in Zimbabwe when I was first working in malaria, the local insecticide companies were always present at any national malaria meeting, and always, supplied at least one evening each of free food and drinks to all the participants of these meetings.

However, it is also fair to say that these interactions were not completely commercial. Through these interactions genuine friendships were formed and to this day, I still have good colleagues and friends from the private sector, as we used to sit, talk and drink with each other (albeit often with their money) at these meetings, often to early hours in the morning. There were always rumours that favours were exchanged behind closed doors, but it is something nobody could ever prove. I had nothing to sell or buy from my side though there were always stories of inducements paid to others and just occasionally, the suspects were caught[51].

The private sector was also active at international level. I had the luck to attend a Ministerial Meeting on malaria in Amsterdam in October 1992 where I met international representatives from various companies including pharmaceutical and insecticide companies. The person I remember most was the international representative from Zeneca who came to me out of the blue and publicly accused me of not being sympathetic to his particular insecticide product. These meetings however, allowed the private sector to directly engage with influential people, such as in my case, I attended the meeting with the Zimbabwean Minister of Health and the Director of the Blair Institute (now the National Institute of Health Research) who I worked for at the time.

Selling LLINs was certainly more pronounced when I reached Mozambique. This is where I worked for UNICEF and was often visited by salesmen of both IRS (indoor Residual Spraying) and LLINs companies. One salesman in particular, from Vestergaard Frandsen, would complain bitterly that I was the only person in Africa that was not buying PermaNet 2.0, even though I explained to him at length, that I could get his opposition Olyset LLIN (the Olyset net) at a much cheaper landed price and more quickly delivered from Tanzania.

In all fairness though, many of the company representatives were technical people who knew their business and taught me a lot of technical aspects of insecticides and LLINs. They were always at pains to tell me that it was not their job to sell their products, though indirectly they did by simply being there and building up friendships. I am personally however, grateful to many of them as they helped me navigate the world of insecticides. I might add, that in my case, these interactions never amounted to any procurement from my side! Fortunately for me, except in the case of UNICEF in Mozambique, I had little influence on products purchased in any country.

Overall, however, the lines of engagement between the public sector and private sector remained murky. There were no clear lines of engagement, with relationships and friendships being built in areas where professionally there were many potential conflicts of interest. This situation should have resulted in clear rules of engagement for both parties, particularly those doing the buying. Temptation to be helpful to colleagues was always there, whether it might have been through monetary or other inducement, or simply because people were good friends and colleagues. In this respect it was always easy to step over an invisible line of what was acceptable and what was not.

[51] In 2014, both Vestergaard Frandsen and Sumitomo had to pay huge fines to the Global Fund when both companies were found to have been paying bribes to Cambodian officials from 2006 to 2011. It was reputed that they paid out over US$400,000 to Cambodian officials to ensure that contracts were awarded to them. Both companies were suspended from supplying nets in November 2013 but by February 2014 they were back in business based on a package of conditions including the donations of one million nets to the Global Fund program.

For the most part, research into new health products is paid for by private sector companies, and in this respect, the malaria world needed the expertise of the private sector to develop new tools. RBM perhaps made the situation worse: in terms of potential conflicts of interest, the private sector was invited to be part of every aspect of RBM meetings including assisting finalising technical requirements for new products such as the new Long Lasting Insecticidal Nets (LLINs). In this respect, it might be argued, that the private sector had too much influence, and decisions were made, that were not necessarily always in the best interest of customers worldwide, be it a malaria donor, or simply the end user in the field.

Perhaps one of the most controversial involvements of the private sector is when in WHO decided that they should standardise the way in which LLINs were evaluated. In April 2005, there was a WHOPES meeting from which clear guidelines were put into place about which bioassay tests would be used for laboratory and also for small and large field trials. The most important part relevant to this story, is that the meeting was attended by twenty-one people, eleven of which were from the private sector: Syngenta (1), Bayer (2), Sumitomo (2), Vestergaard Frandsen (2), Siam Dutch (1), BASF (2), and another scientist who was working closely with Vestergaard at the time. In fairness, the meeting was four days long and the private sector were allowed to be there for only two days, but within that time, they had plenty of time to share their views and make suggestions.

Nevertheless, the 2005 Guidelines produced, can arguably be accused of having undue influence of the private sector. Not only were the guidelines put together which would include the criteria already used to judge the Olyset Net and PermaNet 2.0, it can be argued that it left the LLIN guideline very weak for the future which has proved to be the case.[52]

The bottom line was that the relationship with the private sector and public sector has perhaps been too cosy, and if manufacturers could change their products without the need to tell anyone, this suggested a very lax relationship between the public and private sector. In the case of LLINs, it has literally taken years to note the change in performance, and even now, there are many that still believe that the 2013 to 2019 PermaNet 2.0 was working well.

Manufacturers can argue as much as they wish, but changes made to their products, particularly crucial components such as binders, without testing the consequences of their actions, could be considered unethical even if they were acting within their legal rights. The problem is that now, the benchmarks on which original the LLINs could be prequalified was in fact quite low. After 2005, the performance of many LLINs improved, but later on, probably due to pricing pressure from the donors, future changes resulted in reduction of performance below the level at which they had been originally prequalified. The worst of the story, as mentioned previously, is that even with a large reduction of efficacy, theses LLINs were still considered WHOPES compliant due to tunnel tests, and continued to be sold.

Apart from changing the chemical properties, it would seem that the physical life of mosquito nets has got much shorter too. Certainly, in the case of PNG, the PermaNet 2.0 received from Vestergaard reduced in weight during the period 2016 to 2019 from 500 grams per net down to almost 400 grams. RAM was assured by Vestergaard that this did not reduce the durability of the net, but nets in 2019, did not appear to last in the field as long as the ones we received prior to 2013.

[52] I confess I found LLIN sales people often irritating and pushy, but the real reason for choosing Olyset against PermaNet 2.0 was simply because the landed price of Olyset was cheaper and very much quicker to procure. Ironically, once I reached Papua New Guinea, the same rules applied, and for all future distributions in PNG, PermaNet 2.0 were to win tenders until 2019: Olyset took a very second place and were never procured in PNG due to high landed prices and higher potential distribution costs in PNG, due to bulkiness and weight.

As this section has looked at potential conflicts of interest, it is of interest that it is only in 2011 that all the panellists of the WHOPES evaluations needed to declare their conflict of interests. From 2011 onwards, conflicts of interest are outlines in all future WHOPES evaluations.

This introduces another area of concern. Most laboratories who carry out work on insecticides, also rely heavily on grants from the private sector for their survival, meaning, that there is constant dialogue, and probable friendships, between the laboratories and the private sector companies they deal with. This is not to say that the laboratories are not reputable, only that through these relationships, they may not always be as unbiased as they should or wish to be.

It is probably fair to say, that the relationship between the private and public sector is complicated and intertwined. The public sector and donors on their part, are constantly wanting cheaper and cheaper nets but make no allowances how those cost cutting efforts may come about. Certainly from 2010, the price of mosquito nets reduced from about US$4.00 in 2010 to about US$1.70 for the same nets in 2014. People like myself naively believed that this reduction in price was due to mass production like the fabled mass production of the Model T Ford. While mass production no doubt contributed to a reduction of price, it is more than likely that the reduction in price also resulted in the reduction of quality, and consequently, a reduction in efficacy and durability.

One of the conundrums of WHOPES and the evaluation of LLINs is the power of laboratory tests. Certainly, for equivalent LLINs, laboratory tests alone have sufficed for them to pass WHOPES. This approach, and probably rightly so, supposes that if a net can do very well in the laboratory, it should theoretically do well in the field, though laboratory tests will not give information about their durability.

However, if LLIN efficacy is considered a priority, it should be recommended that all LLINs brands should be immediately tested together under the same conditions in the laboratory for wash resistance. It is likely that those who have high mortality after 20 washes in the laboratory will also have high efficacy in terms of mortality in the field. The trouble is that no agency is willing to do this. LLINs are not equal, and the world continues to procure and give out poor quality nets which in terms of WHOPES, are all equal which they are not. The world needs to invest in better quality and more efficacious nets if the malaria world is ever to improve net quality.

This is in fact happening but at a very slow rate. The public sector has always relied on LLIN manufacturers to come up with new products. The last WHOPES report was published in 2017 and then WHOPES was disbanded and taken over by WHO Prequalification Unit Vector Control Products Assessment (PQT-VCP). The WHO PQT-VCP originally re-prequalified all old LLINs based on WHOPES but in recent years has required LLIN manufacturers to show much better testing of their products. This is a great new initiative but still relies of the private sector to come up with ideas to make better products. This will ultimately result in better products, but sadly, this could result in better LLINs only being available in many years in the future. Somehow, the process, needs to be kick started to produce better nets more quickly.

Price will also remain an issue. Like the Bayer LifeNet, the donors might have to consider once more paying for the extra costs for more efficacious LLINs. Certainly, this would be much cheaper than distributing nets every two years rather than three years which many people in Africa are advocating for.

CHAPTER TEN - The Hare and the Tortoise

Chapter Summary

- Single, quick acting malaria "magic bullet" interventions do not work in the long run
- Environmental development and multiple interventions may work more slowly but more effectively

Magic Bullets

People often seek quick solutions and lose patience when progress is slow. Malaria control, especially in tropical regions, was proving to be very difficult. By the 1990s, efforts at controlling malaria were failing. After nearly a century of global strategies, like Indoor Residual Spraying (IRS) with DDT, results were disappointing. Mosquitoes had developed resistance to insecticides, communities were less cooperative, and donor support was fading. There was no clear path forward.

Long-Lasting Insecticide Nets (LLINs) offered a new promising approach in the first decade of 2000. People sleeping within LLINs attracted mosquitoes and the LLINs killed 100% of the mosquitoes that touched them. This not only protected those using the LLINs but also reduced the overall mosquito population and thereby lowering the risk of malaria for others in the community who were not sleeping under the nets.

What could be better? LLINs also had a major advantage over IRS. The principals and use of LLIN can be easily understood by communities, and should funding cease for any reason, communities in theory could purchase LLINS at retail outlets.

In contrast, IRS programs required well-organized and disciplined teams, along with significant funding. When the money ran out, the IRS programs often collapsed. Communities were also rarely involved in IRS efforts, except to leave their homes during spraying or when a few locals were hired to help. Once IRS programs ended, communities lacked the knowledge and/or resources to continue them. In many cases, people didn't even understand the purpose of the spraying.[53]

Therefore, once it was decided that LLINs were an ideal tool for malaria, all efforts were put into promoting this new intervention, particularly as it was shown that the cost of implementation would be the same or less than IRS.

The biggest issue was that even before the ideal LLIN had been fully developed, both the Roll Back Malaria (RBM) initiative and the Global Fund needed huge numbers of LLINs to fuel their new strategic approach. To do this, they were continually pushing to get lower and lower prices, particularly when the LLIN program became more global.

For example, from 2010 to 2014, LLIN prices dropped from over US$4 to below US$1.75. No one seemed concerned about how this happened, or perhaps no one wanted to ask. By then, the global malaria program built around LLINs had expanded massively and was worth billions of dollars. It supported thousands of jobs, from net manufacturers to staff at donor organizations like the Global Fund, UNICEF, DfID, and USAID, as well as numerous NGOs and their teams.

[53] I recall working with an IRS team in Zimbabwe in 1992 and asking an elderly woman what she thought the spray team was doing. She said they were there to kill cockroaches, completely unaware that the goal was to fight malaria.

In addition, many malaria control workers at national, provincial, and local levels relied on the malaria program for their livelihoods. With so many people and organizations benefiting, few were willing to question the details, especially since early results, when LLINs were more expensive, showed real success in places like Papua New Guinea to dramatically reduce malaria.

It obviously cannot be proven, but continual pressure put on LLIN manufacturers by donors to reduce costs probably resulted in cost cutting measures put in place, some, like the Permanet 2.0 binder, would have resulted in reduced efficacy and life span of the nets. However, many like me, assumed that the massive cost reductions were a result of mass production.

History shows that single malaria interventions, while impactful initially, like LLINs and IRS, are not always effective long-term. Achieving elimination requires a mix of strategies tailored to diverse environments, vector species, and transmission patterns. Global efforts also demand substantial coordination and funding.

Apart from the reduced efficacy issues as highlighted in this book, single "magic bullet" interventions also result in donor fatigue, particularly when the programs take too long or begin to fail. Ironically, donors also often move on when programs are successful and donors no longer think their inputs are necessary.

Development, community involvement and multiple interventions

Perhaps one of the main observations in history, is that improved social development usually eliminates malaria. Better housing, better sanitization, drains which remove standing water, all reduce malaria indirectly. Good housing stops mosquitoes entering into houses and good sanitation reduces the places where mosquitoes can breed. Urban areas often also create polluted water in which Anopheline vector mosquitoes do not thrive.

Other than development, the early days of mosquito control, used a variety of methods to control malaria, and in some places, by ensuring that no stone was left unturned. The best example still has to be the elimination of malaria and Yellow Fever from the Panama Canal Zone. During the control of Yellow Fever and Malaria in the Panama Canal, every conceivable scenario was considered and taken care of, even to the extent of having teams who walked around dormitories and houses swatting any mosquitoes found resting during the day. It is this attention to detail that controls malaria, not having a single control methodology.

Single interventions such as IRS and LLINs cannot cover all ecological niches. Despite this, donors will continue to put their faith in single interventions and even prevent any other approaches being implemented at the same time. For example, the Global Fund (GF) would not fund any other malaria control intervention other than LLINs or IRS. Generally, if other interventions such as larval control were included in a GF proposal, the likely result was that the proposal would be rejected.

There are two aspects of this. Unlike the RBM approach of being country led, Global Fund often ends up dictating the type of interventions being implemented and the type of LLIN being distributed. The second problem is that this approach using the "hare" scenario kills off innovation which often promotes a slow and steady community based "tortoise" approach which takes time, but, at the end of the day, may result in long term achievements in terms of elimination.

Perhaps a good example of this can be seen in the Solomon Islands and in Papua New Guinea. Isobel Province in the Solomon Islands has one of, if not the lowest, malaria incidence rate in Solomon Islands. It is reputed that in the 1980's a healthy island program was implemented. In this healthy island

program, women's groups, particularly the Mother's Union groups, led villages to clear up their environments in terms of getting rid of all potential mosquito larval habitats. While the rest of Solomon Islands have undergone many other types of malaria control activities in recent years, particularly LLIN distribution, Isobel Island has remained low in terms of malaria transmission throughout the last thirty years.

Near to, and north of Isobel Province lies the Autonomous Region of Bougainville (ARoB) which lies in Papua New Guinea. In the district of South Bougainville in 2006, a healthy island program was started. Ironically, the healthy island concept in South Bougainville made little or no mention of malaria, but households were expected to tidy up their villages, seal their houses with mosquito netting, and most importantly, remove all standing water in the village. One of the other ways of doing this was to put pigs in pens. Pigs in Oceania are like cattle in Africa. Anopheles mosquitoes in Africa often utilize the foot prints made by cattle to breed, while in the Solomon Islands and Papua New Guinea, pigs are always grubbing and create large holes everywhere where Anopheles mosquitoes can lay their eggs and develop. By putting the pigs into pens, pigs can no longer make holes and local mosquito larval habitats may be drastically reduced.

The healthy island program in South Bougainville slowly expanded into Central and North Bougainville but failed to get community acceptance except in a few places. Today, South Bougainville has the lowest malaria incidence of anywhere in coastal PNG despite the rest of PNG having successive LLIN campaigns every three years for a period of 18 years. No other coastal district has reduced malaria so much and almost to the point of elimination. Similarly, like the highlands in PNG, most of the malaria cases in South Bougainville are adults which suggest that most of the malaria cases (which are very few) have been imported from elsewhere. In North Bougainville, which ecologically and environmentally is very similar to South Bougainville, continue to have relatively high levels of malaria in many places as they reputedly do not follow the teaching of the healthy island village concept.

I was lucky to go to ARoB and investigate their healthy islands program. Before going to ARoB, I had been able to make a map of all the villages in ARoB showing how much malaria each village had. This was possible as PNG has what is known as the Electronic National Health System (eNHIS). The eNHIS allowed for health centre staff to input all the individual malaria cases in their catchment area into a data base and indicate exactly which village they came from. This made it very easy to make maps showing where malaria was most common.

On arrival in Buka, the capital town of ARoB, we were taken to visit some ideal demonstration villages which followed the healthy island concept. These villages were to immaculately kept where all the pigs were penned, the houses all screened and there was no surface water to be found lying around. When looking at the data base, it was obvious that these villages did not have any malaria problem as few or no malaria cases were recorded from these villages.

After reviewing the database, we visited villages with high malaria incidence. The contrast between healthy and unhealthy communities was striking. In affected villages, little effort was made to reduce mosquito breeding. Homes had broken screens, litter was widespread, and stagnant water, especially in communal washing areas, provided ideal conditions for mosquito larvae. It was clear how easily residents could contract malaria in such environments.

The other issue also highlighted from the examples made from the Solomon Islands and ARoB is the crucial importance of community involvement. While LLINs are mooted to have a community approach, like IRS, the reality is that community involvement is still very poor. Other than health education given about the best use of nets, the community are not really involved, and worse still,

probably expect donors to supply more LLINs rather than them taking ownership of the program and buying their own LLINs in the future.

This is where the conundrum becomes worse. Even if communities could be encouraged to buy their own nets, the global LLIN program has in fact almost completely destroyed local commercial endeavours to stock LLIN in local stores. In PNG, it is always possible to find small quantities of poor quality Chinese untreated nets, but the reality is, that the world malaria program has left little in place to encourage the local supply of LLIN nets and let communities take over control of their own futures.

There are no clear answers to this problem, but the reality is that the malaria program has left an environment of dependency, and even if communities can be empowered, the world has left nothing in its place for the community to take over, even when the dependency has been removed. How can any trader make money selling nets when organizations keep coming around to give them away for free? This is an area of potential investment, supply nets through commercial outlets, either as subsidised or non-subsidised products. Personally, I prefer the latter as this ultimately makes the program more sustainable.

Ultimately, this is a transition the world must make. The world community cannot continue to indefinitely fund malaria control for long periods into the future, particularly when LLINs are not as efficacious as they should be. It could be postulated that villagers would be fussier about what LLINs they would buy than donors have been. Donors don't have to use the products they supply but villagers do. If villagers were allowed to choose which products they would prefer, the issue of poor-quality and inefficacious LLINs would likely soon disappear.

I strongly believe that eliminating malaria depends not just on community acceptance, but on active community participation in control efforts. I was personally involved in such programs in Zimbabwe and PNG. In PNG, the malaria program, like in Bougainville, school children have been taught to eliminate mosquitoes from their schools and home. Similarly, 1996, communities and schools in Zimbabwe's Zambezi Valley were taught how to eliminate mosquito breeding sites. The results in Zimbabwe were remarkable and people (including myself), could sleep outdoors during the rainy season without being bitten by mosquitoes.

One good example of community participation occurred during a malaria outbreak in 1997 in the Zambezi Valley in Zimbabwe. While most health centres were overwhelmed with patients, one had none. The Environmental Health Officer (EHO) there had taken steps to mobilise communities to eliminate all major mosquito larval habitats in his catchment area. When I visited the health centre, I was surprised to find the clinic staff calmly reading newspapers, while staff at other clinics in the district were overwhelmed and struggling to manage huge queues of malaria cases. The difference was clear: where communities were mobilised, mosquito breeding was controlled and malaria cases were nearly non-existent.

This is not an advertisement for larvicides or mosquito habitat control alone, it's about the power of community-driven interventions. When communities are fully engaged, the results can be extraordinary but developing these skills takes time.

Future LLIN Interventions

The reality remains, unless long-lasting insecticidal nets (LLINs) are significantly improved from what they are now, both in terms of efficacy and durability, malaria reduction will remain out of reach in many countries without significant investment in other interventions.

It's uncertain whether current LLINs can be enhanced enough to reclaim their former reputation as “magic bullets.” The irony is that we had very good LLINs before prices were reduced. Perhaps the simplest option is to pay more and get the old LLINs back into production.

Perhaps it's time to also reconsider our reliance on such tools and focus more on empowering communities to take charge of their own health. If LLINs are to play a meaningful role, they must be efficacious and consistently available at the local level worldwide.

The story of LLIN distribution could mirror the global promotion of tea by the British, initially driven by commercial interests and fuelled by aggressive marketing, including free giveaways, tea became staple household drink. Similarly, LLINs have been distributed freely in massive quantities. Maybe the time has come to shift toward encouraging people to purchase nets by ensuring they are readily available in local markets by good marketing and efficient supply chains.

Before the Global Fund era, particularly between 1997 and 2007, Social Marketing was the primary strategy to promote net usage. ITNs and LLINs were sold at subsidized prices to boost uptake. However, due to slow sales of nets, unless prices were extremely low, free distribution became the dominant model, and Social Marketing faded. While a full return to that model is not being proposed, a hybrid approach may be more effective. The world has moved away from Social Marketing to free distribution, but perhaps it's time to embrace mixed models. Selling health products to low-income populations fell out of favour, yet a balanced approach should be more sustainable.

One other emerging idea is to distribute nets every two years instead of three. While this may improve coverage, it would increase costs by 50%, as nets would be distributed three times over six years instead of twice. Perhaps a more economical solution would be to produce higher-quality nets in terms of durability and long lasting efficacy, like those available in 2010. In the context of PNG, paying double the price for a good LLINs would cost less than having distributions every two years. However, if in some countries with easy road access the price of distribution of nets is much less, then perhaps having distributions might make economic sense, but still, if nets are only efficacious for one year, then distributions every two years might still not reduce malaria sufficiently!

If the observed reduction of malaria from 2010 to 2015 was continued, PNG would have got to elimination levels within 10 years. Surely, it is better to pay for better efficacious LLINs like those that existed before rather than increasing the distribution rates of poorly efficacious nets over much longer periods of time which ultimately is much more expensive and likely not achieve its objectives.

Similarly, LLIN durability varies widely depending on care. Increasing the life of the net requires better **Behaviour Change Communication** (BCC). This however, does not solve the problem of reduced efficacy.

In Papua New Guinea, another targeted approach is being used: new LLINs are given to individuals who test positive for malaria. This assumes that sick beneficiaries either lack a net or live in high-transmission areas. It’s a practical method for continuous distribution, avoiding the inefficiencies of mass giveaways that often reach people who do not need them. Unfortunately, when this strategy was proposed to the Global Fund as a cost-saving measure, it was rejected, but other donors fortunately accepted.

One oversight in the LLIN program has been insecticide resistance. Resistance to pyrethroids is not new. West Africa had already seen it due to agricultural use before LLINs were introduced. Initially, resistance in Anopheles mosquitoes was low, but it surged after LLINs became widespread. By 2005, in West Africa, 5% of mosquitoes showed resistance; by 2017, that figure had climbed to 98%. Whether

this is a result of LLINs alone, reduced efficacy of LLINs or increased agricultural use of insecticides is open to debate.

Moving forward, we need a diverse mix of interventions tailored to specific ecological and environmental contexts. One-size-fits-all solutions rarely succeed, and quick fixes often yield inconsistent long-term outcomes. To truly control malaria, we must revisit strategies from the past, engage communities deeply, and adopt approaches that have proven effective, even those from a century ago.

A lingering question remains in terms of LLINs. Fifteen years ago, LLINs were highly effective. Today, we struggle to produce nets of comparable quality. Have we lost the technology, or are we simply unwilling to invest in it by allowing the LLIN prices to be the only criteria to rank biddings?

In the end, we must ask ourselves: will we follow the hare, chasing quick wins, or the tortoise, moving steadily toward lasting success? Ideally, we need both. We need good efficacious LLINs plus investments in other interventions and most importantly, in community involvement and mobilisation.

RAM Team distributing LLINs in the Highland of PNG

CHAPTER ELEVEN - Future Malaria Control Recommendations

Chapter Summary

- WHOPES approved nets are not the same in terms of efficacy and durability. It is time to prove this in all countries through having comparative laboratory trials and testing nets which last more than three years in the field to record if they are still efficacious.
- Pre-Delivery Inspections (PDIs) should include cone bioassays rather than relying on insecticide concentration alone. Cone bioassays should be done before delivery and a small quantity retested in country with cone bioassay tests.
- For malaria intervention to occur, LLINs need to become more efficacious and implemented together with other strategies to achieve elimination in all scenarios.
- No single intervention works alone but only with other interventions at the same time to cover all environmental and ecological niches. Behaviour Change Communication (BCC) and community mobilization are most important.
- Marketing of LLINs, repellents and other interventions such as spatial repellents should be considered.
- Malaria control can be successful if having a diverse approach to the problem and applied in a disciplined way.

Testing Efficacy Of LLINs Received And After Three Years

This book will likely be very contentious. The malaria community has continually supported the idea that overall LLINs are still affective. The efficacy statements claimed in this book can easily be disproved or proved by carrying out comparative laboratory trials using cone bioassay tests against all LLIN products up to 20 washes. It is likely that most products will fail cone bioassay tests even though most products passed cone bioassay tests in their original WHOPES prequalification. Tunnel tests can also be carried out if they want to see if they can pass basic WHOPES prequalification benchmarks.

There is also another simple test that can easily be carried out by all countries. Carry out cone bioassay tests after LLINs have been used for three years in the field. If you can do this after each year, even better to see when efficacy no longer exists.

In PNG only two nets have passed cone bioassay tests after three years in the field that we know of. Permanet 2.0 produced before 2013, and recently, tests on Royal Sentry nets showed greater than 80% mortality in cone bioassay tests after the LLINs had been in the field for three years. It is likely, that the rest of the LLIN products will have much less that 80% mortality in cone bioefficacy tests after three years (generally much less than three years) rendering them ineffective in the later life of the LLINs.

As mentioned earlier, Insecticidal efficacy may not be based on the insecticide concentration in a LLIN. All nets before being delivered to countries, should undergo cone bioassay tests if they had passed their original WHOPES prequalification with cone tests (or other test for efficacy in cone bioassay tests are not appropriate). As with the pre 2013 PermaNet 2.0, this will clearly show if LLINs are efficacious when new.

Importance Of Coordination And Lessons For Papua New Guinea And Other Countries

My visit to Cambodia in March 2025 was a powerful reminder that well-coordinated malaria control can be highly effective. By the time I left Cambodia on March 10, only six cases of *Plasmodium vivax* malaria had been reported nationwide since the start of the year. Cambodia is expected to declare malaria elimination later this year.

This marks a dramatic decline from the 63,186 cases reported in 2018. The success is largely due to consistent efforts targeted at grassroot communities in forested regions, where malaria is most prevalent. Key interventions included chemoprophylaxis, repellents and LLINs which were distributed in both standard and hammock types. These interventions are also backed up by a grassroot testing and treatment program at community level. In additional to this, this is supported by an elaborate reporting system that allows all malaria cases countrywide to be reported immediately to all levels of the health system. This has allowed rapid follow up of all malaria cases that occur nationwide.

Cambodia's journey began with reducing malaria to low levels starting from 2000, primarily through LLINs. Based on the lessons learned in PNG about efficacy decrease, it's reasonable to assume that these LLINs were used effectively before their performance declined to achieve a reduction in malaria.

In contrast, PNG is far from achieving malaria elimination. Despite ongoing challenges, PNG has been proposing malaria elimination, even though previous strategies have failed to reduce malaria or stop the upward trend of the last ten years.

Unlike Cambodia, where malaria is confined to forested zones, PNG faces widespread transmission across most regions except the highlands. Many affected areas are also remote and difficult to access, and the primary intervention, LLINs, is underperforming because of the decreased efficacy of LLINs described in this book.

Financial constraints are another major hurdle. A large portion of PNG's Global Fund budget goes toward drug supply and LLIN distribution. Yet, with declining LLIN quality and no viable alternatives, progress is limited.

To make meaningful strides, PNG needs significantly more funding and a shift in strategy. Highly efficacious LLINs like those used in 2012, could reduce malaria to manageable levels, but elimination would still require major improvements in the health system overall, as well as new multi-strategy malaria interventions. These include strengthening the health information system, which currently does not include data from around 3,000 Aid Posts, private sector and community initiatives (using Community Malaria Volunteers) where malaria is already being tested and treated.

With expanded budgets, other interventions should be considered. Indoor Residual Spraying (IRS) is often proposed, but it is hugely expensive and difficult to implement in a country like PNG with very poor road infrastructure and, as a result, might likely not have the impact required.

WHO has also recently recommended the use of spatial repellents. Spatial repellents are strips of material impregnated with insecticides which are released into the air to kill mosquitoes, and prevent the mosquitoes from entering, locating and biting human hosts. It is recommended that these spatial repellents are used together with LLINs or IRS and this will enhance the reduction of malaria.

Other tried and tested interventions also include the control of mosquito larval habitats. Such approaches are relatively cost effective in urban areas where populations are high, but very expensive in rural areas unless the use of communities is considered.

BCC is often limited to how populations can protect themselves on a self-protection basis using repellents, mosquito coils, treated and untreated mosquito nets, screen houses and ensuring there is no mosquito breeding around the houses. However, if malaria control programs extend their reach to mobilise communities, miracles can happen as mentioned in Bougainville in PNG, the Solomon Islands and PNG.

Community involvement is also essential, not just for local testing, treatment and reporting, but for broader public health initiatives like the Healthy Islands program which should include the reduction of mosquito larval habitats by communities themselves. All these, and other interventions, must be in place before elimination becomes a realistic goal.

Ultimately, for countries like PNG, highly efficacious and durable LLINs still remain critical. The global malaria community should prioritize improving this intervention to bring down malaria to manageable level. With highly efficacious LLINs, successes like Cambodia's could become far more common.

For this to happen, the malaria community and manufacturers need to recognise that the LLINs on the market are not as efficacious as they once were. If they are able to do so, one quick fix is to revert to the products that were produced in the late first decade of 2000, 15 years ago. On the other hand, surely, 15 years later, the malaria community should be able to find experts to develop products which outperform their predecessors both in terms of durability (extended durability of the netting) and find ways to ensure that insecticide treatments not only last three years but also much longer! Thinking outside of the box would be the key requisite.

For elimination of malaria, the following interventions are recommended.

- **Detailed epidemiological data of malaria** which reaches down to village and community level. Like Cambodia, have information systems in place which allow all malaria cases to be recorded immediately (or at least on a monthly basis) so that interventions can be prioritised. Electronic systems are best which use phones or tablets with internet access. Such systems should include regular monitoring of malaria outbreaks combined perhaps with dengue, chikungunya and other mosquito borne outbreaks.
- **Setting up testing and treatment** of malaria in all remote communities which are far from a health facility
- **Good national mosquito control strategy – e**.g. mix of LLINs, IRS, larval control, spacial repellents, genetically modified mosquitoes, etc
- **Behaviour Change Communication** (BBC) in the areas of:
    - Improved care and repair of existing nets.
    - Personal protection including sleeping under LLINs and using screens and when outside using personal protection from mosquito bites using **mosquito repellents, fumigants, spatial repellents and treated clothing and screens.**
    - For mosquito nets which are durable but no longer efficacious, returning to ways of having individual treatment kits such as the KO Tab 123.
    - Breaking the life cycles of mosquitoes including destroying all mosquito larval habitats around the home.
- **Mobilisation of communities, including schools and churches,** to act and reduce mosquito breeding habitats, using a Healthy Island or similar approach.
- **Building markets –** have marketing campaigns together with logistic supply chains to supply additional LLINs, retreatment kits, repellents, special emanators and other health products on a full cost recover basis to increase sustainability of interventions.
- **Monitoring and Evaluation –** all malaria control programs require monitoring and evaluation to ensure that programs are efficiently carried out and to monitor both drug and insecticide resistance which can severely handicap a program.

The most important lesson, is that whatever interventions are introduced, they must be implemented in a systematic, continuous and disciplined manner

ACKNOWLEDGEMENTS

This book has been a long journey in the making. The idea first took shape in 2014, inspired by the rapid decline, and hopeful elimination, of malaria in Papua New Guinea. Yet, the demands of work left little time to write, and as the years passed, the narrative shifted from one of triumph to one of disappointment.

Ironically, it was only after I left my position with Rotarians Against Malaria (RAM) that I found the time to reflect, research, and write. What emerged was a story, not just of malaria control setbacks in PNG, but of a global struggle against malaria, one not born of negligence, but of circumstances beyond our control. The declining efficacy and durability of Long-Lasting Insecticidal Nets (LLINs) from 2012 onward marked a turning point, derailing progress towards malaria elimination in many countries.

I owe immense gratitude to my long-time partner, Lorrie Tapora. Her patience and support, especially over the past year, were invaluable. While we once commuted to work together daily, from July 2025 onward she made the journey alone, allowing me the space to write. Without her understanding and encouragement, this book would never have come to life.

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Most of all, I want to acknowledge the local RAM staff whose dedication made the program possible. Their tireless efforts, often spending weeks away from home to reach remote communities, were the backbone of our work. These colleagues became more than coworkers; they became my family in PNG.

Today, RAM employs 120 staff. Many played pivotal roles, and while it's difficult to single out individuals without honouring them all, two deserve special mention: Hebou Ranu, my trusted deputy for many years in operations, and Rebecca Ani, our program secretary. Rebecca’s photographic memory and her endless cups of tea kept me grounded and smiling through it all. I have tried many times to make a special list of others staff members, but all the staff were important in their own way, and to pick out one or two more, does not do justice to the rest. They were all special in their own rights,

Importantly, I must recognize Prof. Stephan Karl and his team at PNG IMR. Stephan Karl is an entomologist formerly based at the Institute of Medical Research (IMR) in Madang. His curiosity and commitment helped uncover the issues with LLINs, sparking a wider understanding of the problems involved and its causes. Stephan became a close friend and a steadfast ally in our fight against the seeming indifference of donors, the WHO, and research institutions that dismissed our findings as a uniquely PNG problem.

I need to acknowledge the PNG Global Fund Country Team who were very supportive throughout the time I spent at RAM. They also allowed us to discontinue with Permanet 2.0 nets and to procure other brands of LLINs which allowed an oversite of the overall problems.

DEDICATION TO DUTY

Crossing the Markham River

An example of team leaders taking the lead in difficult circumstances. Nets had to cross the wide Markham Rive in Morobe Province where there were no roads. Each bale weighed 50 kg and had 100 nets

The late Helmut Magino (in front) who later became the chief team leader of RAM LLIN teams

Michael Kalal – a HEO and one of the first team leaders in RAM. He always led from the front.

RAM TEAM

RAM TEAM 2011

RAM TEAM 2023