VANUATU 2007

ELECTIVE REPORT

JASON ALI
Vanuatu is a Y shaped chain of islands in the South Pacific. It is located 1750km east of Australia, 500km north-east of New Caledonia, 800km west of Fiji and 170km south of the Solomon Islands. Its land area comprises 83 islands, most of which are the summits of mountain ranges rising from the deep ocean floor. The largest islands are Espirito Santo, Malekula and Efate.

Vanuatu is on the Pacific ‘Ring of Fire’ and as such, there are frequent earthquakes (two tremors were experienced during my elective period) and volcanic eruptions.

History

Vanuatu was thought to be first inhabited by Melanesian people around 1400BC. European explorers such as the Portuguese Pedro Fernandez Quiros discovered the area in the 17th century. Europeans began to settle in the late 18th century. In 1906 Britain and France officially claimed the country, jointly managing it through a British-French Condominium, as the New Hebrides (named by James Cook 1774). An independence movement was established in the 1970’s, and the Republic of Vanuatu gained independence on the 30th July 1980.

Population
In April 2007, the population was estimated to be 221,506. All but 3500 are Melanesian - Ni Vanuatu ('of Vanuatu'). The remainder includes Europeans, Asians and other Pacific Islanders. 80% of the population lives in rural areas. In 2006 the New Economics Foundation and Friends of the Earth environmentalist group rated Vanuatu as the happiest place to live out of 178 nations all over the world using the Happy Planet Index!

**Economy**

The economy is based primarily on subsistence or small scale agriculture, which provides a living for 65% of the population. Fishing, tourism and offshore financial services (Vanuatu does not release account information to other governments making it a tax haven for many overseas businesses) make up the rest of the economy. Agriculture earns >85% of the countries export income: Copra (dried coconut meat), beef and cocoa being the main exports.

**Language**

Bislama is the most widely spoken and is a pidgin language that uses Melanesian grammar with English and French vocabulary. There are said to be fewer than 8000 words. Consequently Bislama is relatively easy to pick up and understand, and is a very colourful, descriptive language with some amusing terms:

- “basket blong pikinni” (basket belonging to a child) – uterus
- “sit sit wota” – diarrhoea
- “ples wea man I put wot blong him” – vagina!
- “Mix-master blong Jesus Christ” – helicopter!

**Why Vanuatu?**

In choosing an elective destination, I had several criteria:

- Developing country, which would allow opportunity for hands on experience and responsibility. Giving an insight into medicine with limited resources.
- English speaking in order that communication difficulties would be minimal.
- Low levels of blood borne viral disease, particularly HIV, as I wanted a surgical elective but with risks minimised.
- Experience a new culture.

From my research, Northern District Hospital in Vanuatu seemed to fulfil all my criteria.

**Health in Vanuatu**

The life expectancy of children born today is: 65.6 and 69 years for males and females respectively. Health services suffer from a lack of facilities, but more importantly, trained staff. The WHO quotes there being just 20 doctors, being 0.11 per 1000 population, compared to 2.3 in the UK.

There are three hospitals in Vanuatu:

- Vila Central Hospital – in Port Vila the capital – the settlement with the largest population in Vanuatu, on the Island Efate
- Northern District Hospital – In Luganville – the second largest settlement – on the island Espirito Santo
- Norsup Hospital – on the island Malekula – Currently there are no doctors at this hospital, which is able only to provide very basic nurse led care.

In addition to the three hospitals, there are a range of rural clinics which travel around islands visiting villages and providing care such as maternal care, immunisations for children, health education, as well as being able to perform simple interventions for minor complaints. Some of these clinics are able to perform malaria films, and prescribe a limited range of medication.

The main health problems in Vanuatu include both chronic disease as well as infectious diseases.

Diabetes is seen to be a significant problem. WHO estimated the prevalence as being 6000 in 2000, and predicted to triple to 18,000 by 2030. The reliability of these estimates is questionable and are most likely underestimates. There is no screening for diabetes, or any other chronic illness such as hypertension, and such disease is usually diagnosed upon presentation to the health services with a complication of the disease, such as gangrenous ulceration of the lower limb.

Malaria is Vanuatu’s major infectious health risk. *Plasmodium falciparum* and *Plasmodium vivax* are endemic, and there are believed to be over 10,000 cases per year. As a result, there is much emphasis on educating the population with regard to reducing risk of infection, such as the use of mosquito nets.

Tuberculosis is another infectious health problem. The incidence is in the order of 60 per 100,000 population per year. The patients are commonly admitted for long periods for administration of medication. The WHO quotes the DOTS treatment success rate as being >90% for Vanuatu.

**Northern District Hospital, Espirito Santo**

The northern district hospital (NDH) serves the northern islands of Vanuatu. There are four very capable Ni-Van doctors – trained in Fiji and five Chinese doctors. There are also 5 nurse practitioners who effectively have responsibility for the running of the hospital. An agreement with the Chinese government sees the Chinese doctors spending two years in Vanuatu to work (in exchange for fishing rights), but often they speak limited English and no Bislama and at times have been known to make questionable medical decisions (including giving warfarin to an acute stroke patient).
However, the hospital is able to provide a surprising level of care despite a limited level of supplies and investigations available.

The hospital comprises:
- 20 bed Medical ward
- 20 bed surgical ward
- 20 bed paediatric ward
- Maternity ward with nursery
- 10 bed TB ward
- Emergency department
- Ophthalmology department
- Outpatients department
- 2 surgical operating theatres
- Radiology
- Pathology laboratory

I spent my time predominantly in the surgical department of the hospital. I will give a brief overview of some of the other departments.

Medical Ward

The medical ward rarely approached capacity, with very few patients remaining admitted for more than a few days. The ward was typical: often crowded with relatives of the patients sleeping on the floor, questionable levels of hygiene and observations involved using equipment of doubtful reliability – such as urinalysis dip sticks which went out of date 5 years ago, and upon reading had colours that didn’t match those present on the bottle to compare to!

The wall of the medical ward was painted with a range of public health posters with the aim of educating:

Public health posters in the medical ward

Tuberculosis ward

There are 10 isolation rooms forming the TB ward. The patients included both children and adults. Because of the public health implications of allowing partially treated patients back into the community – spread of disease, as well as multiple drug resistant TB, the patients remained admitted for the duration of their treatment. This was necessary because of the poor compliance with the treatment once the patients left the hospital – more so for patients coming from other islands and the villages. The treatment involved the same regimen as for the western world –
involving quadruple therapy for two months of rifampicin, isoniazid, pyrazinamide and ethambutol, followed by double therapy of rifampicin and isoniazid for 4 months.

There were patients presenting with classical pictures of night sweats, weight loss, haemoptysis and pulmonary disease, with diagnostic upper lobe cavitation on chest radiographs; but there were also rarer presentations such as with spinal TB, and even a presumed intussusception caused by small bowel TB.

The strictness of the isolation was relative, with the TB children often seen running around the hospital, usually playing with the children from the paediatric ward!

Radiology

The radiology department was run by two radiographers. There is an x-ray machine, with facilities for automated film processing. To complete the department, there is an old ultrasound machine with no Doppler. However, there was nobody trained on performing more detailed analysis than measuring size of kidneys and a basic look at abdominal structures.

One notable example of the reliability of this service, was when there was a patient who had fallen out of a coconut tree, hypotensive and tachycardic, haemoglobin falling. The ultrasound report read: ‘spleen normal, small amount of fluid in abdomen’. When the abdomen was opened, 2 litres of blood were suctioned, and the ruptured, grossly enlarged spleen removed!

Emergency Department

The emergency department (ED) is where those with acute problems presented. It is through here that patients were admitted to the various wards, however, most were sent away with appropriate advice and medication. The department was open 24 hours a day and was run by a single nurse practitioner, although there was usually a nurse around during the day. The department was quite busy, with a continuous
trickle of patients from first thing in the morning until eleven at night. There were occasional patients arriving during the night. For patients not living in or around Luganville, it often required a significant journey to arrive at the ED. Because of this, it was rare that a true emergency presented as the patient would most likely succumb before arriving at hospital unless they lived close by.

The ED was relatively small, comprising a small consultation area and three trolleys. The equipment in the ED was variable, and in particular cardiac arrest is not a presentation one wants to see there as the defibrillator is faulty, causing a arc of electricity to pass between the two paddles, not through the patient, but through the air above the patient’s chest with a large spark leading to electrocution of the last user! Needless to say, this machine is not used currently. As with the other departments, disposables were usually out of date having been donated from developed nations.

It was interesting to see that in contrast to the UK, an important non medical question often determined the management of the patient. This question is: ‘where do you live?’. The importance of this is recognising that some patients have travelled a long distance to attend the hospital. Indeed, there was a much lower threshold for admitting patients who lived further away from the hospital, as it was felt that with local patients it could be relied upon that if there was deterioration they would return quickly, however, for those living further away, if their condition worsened they were less likely to return in time. As such, the medical ward was often relatively full in the morning of patients from outer villages, admitted overnight as a safety measure. Most were discharged after an uneventful night in the hospital at the medical ward round the following morning.

Patients attended the department with a wide range of complaints. However, notably, a few presentations were particularly common:

- **Bush knife injuries** – These were very common. Bush knives were very prevalent throughout Vanuatu. It was often a sight, seeing young children walking around with very large bush knives. The typical patient would be a young male, attending having cut himself with a bush knife whilst working. Sometimes the injuries were relatively superficial, requiring simple cleaning and suturing. However, there were often also very deep injuries. One example involved a man who had managed to completely sever his patella tendon with a bush knife. In addition to accidents, bush knives can also
be involved in assault. Several children attended having sustained such cuts having been fighting with other children with bush knives.

- **Fractures** – Traumatic fractures were also common. Patients ranged from young children with fractured femurs, to middle aged women with fractured humerus. The fractures were often sustained during sport or other physical activity. A typical patient was a young man who arrived at the ED having travelled for just under a week from another island with a bamboo cast. He had sustained a suspected fracture playing football. The radiograph showed an undisplaced comminuted fracture involving both the tibia and fibula.

- **Malaria** – malaria is a significant health problem in Vanuatu. There were several presentations during my time in the ED. Most usually young patients presenting with swinging fevers, malaise and a range of other symptoms. It became apparent that a patient presenting with fever was malaria until proven otherwise, which involved taking thick and thin blood films which could be analysed relatively quickly during daytime hours.

As medical students, we were called upon to do shifts in the department during the evening, when there were relatively few other staff in the hospital. This was a good opportunity to practice our Bislama, but also use our clinical and diagnostic skills, with relatively little supervision (and practically no investigations). The nursing staff greatly trusted our opinions/decisions on the management of the patients, and it was up to us whether the patient was admitted to the hospital or sent home.

It was an interesting feeling to be in such a position of responsibility at this stage of our careers. It was alarming, realising that were a significant emergency to occur, we would be the most senior people present. Although it made us feel that we were helping the hospital, we used our new found powers with great caution, for it would be devastating to our confidence, were something to go wrong at this stage in our medical lives.

For the most, the shifts were uneventful, and involved assessing patients as they arrived, examining them, and prescribing the appropriate medication. For those requiring admission, it was a good opportunity to practice venesection, canulation, putting up IV fluids and catheterisation. One aspect that was particularly difficult, was the fact that there was no radiologist. This meant that usually, it was the medical student that read radiographs, and then decided on the management. During the day it was sometimes possible to get the opinion of one of the doctors!
Surgery at Northern District Hospital

I spent the majority of my elective with the surgical department, with the aim of getting some experience of surgery in the developing world.

A typical day would involve arriving for the ward round at 8:30 in the morning. The ward round involved reviewing patients admitted the day before – deciding who would be going to theatre that day, and the post-operative patients. The ward round covered both adult and paediatric surgical patients. The surgical ward was the most populated ward, often at capacity.

The surgical team comprised a Ni-Van doctor: Dr Wari, trained in Fiji as a general surgeon; and a Chinese gastrointestinal surgeon: Dr Zhang, coming towards the end of a two year placement in Vanuatu. Between them, these two surgeons were responsible for performing procedures on any cases that came through the doors – true general surgeons! I undertook a role similar to that of a surgical FY1. I was responsible for writing in the notes any decisions made on the ward round. Before my arrival no notes were written. The nurses were most thankful for my contribution. In addition, I was responsible for requesting all of the blood and radiological tests, and ensuring that the results were prepared for the ward round the following day. I was also responsible for reviewing patients on the ward if there were any problems. Once the ward round was complete, we would then head for theatre to perform any procedures that were decided on the ward round.

Surgical ward

Ward life was very different to that in the UK. Patients seemed not to like being on the wards, even if they were requested to stay by the doctors. Although having great respect for doctors and generally taking a very passive role in the management decisions, this was something that they did not seem to like being asked to do. It was not uncommon to encounter inpatients in the town for example! As long as they were in their beds for the ward round, nothing more was said.

The wards were divided into rooms with four patients in each, single sex. The room was usually quite crowded and hot. The patients usually had one member of family who stayed with them and slept on the floor. This was allowed, as usually the patients came from far, and so it would not be possible for them to ‘commute’. The hospital supplied food, however, this was usually supplemented by the family – or the patient, going shopping in town.

Nursing staff were caring and very capable. They performed observations regularly – at least whilst the patients were in their beds, and performed the routine tasks such as changing dressings. They ensured that patients were prepared for theatre and completed the tasks delegated to them during the ward round.
It was interesting to see that often patients were kept in hospital for longer than would be the case in the UK. It was explained to me that for conditions such as abscesses and other infections, patients were kept in hospital until the infection had completely cleared. The reason is that the compliance is so poor when patients leave the hospital. With their experience, the surgeons knew that if partially treated and sent home they would return with severe consequences – such as osteomyelitis as a complication of partially treated abscess not previously involving the bone. This was particularly the case for those living far away, as they would be less likely to return until the problem was serious, and then too late to treat without significant intervention such as amputation – as in a case discussed below.

Theatres

The theatre department included two operating theatres, a changing area, dirty area for cleaning instruments and a clean area where there was an autoclave. The operating theatres themselves were quite small and very basic. There was an anaesthetic machine of sorts, overhead light and an operating table. They were air conditioned however. There were three theatre nurses whose roles included cleaning instruments, sterilisation and assisting in theatre. In addition there was an anaesthetist and an anaesthetic assistant.

The supplies of the theatre department were variable. The hospital is able to purchase some supplies, but relies on donations from other countries such as Australia and China. This meant that supplies, including anaesthetic drugs, were out of date. One notable example was an endo-tracheal tube that was found to have a ‘use by’ date of February 1980! There was also a limited range of sutures, which was often testing for the surgeons. Many of the sutures too were out of date, and it was seen that some of the sutures were very brittle, and often broke during surgical knot tying which was most frustrating. The surgical instruments were quite old, and most scissors were blunt! It soon became apparent that surgery in the developing world involved making the most of what you have. It also made me realise how we take so much for granted in the UK. For example, an operation would never be cancelled because there were no surgical gloves. Even more illustrative was the fact that during my time at NDH the oxygen supply of the hospital ran out twice, meaning that no surgery was performed for almost a week on each occasion.
The vast majority of cases were local infections and abscesses that required debridement or drainage. Because most patients lived in extremely rural areas they would either leave their wounds until they had deteriorated enough to require surgical attention or would simply have to travel for several days for medical attention. Debridement was also required for many of the patients who had suffered bush knife injuries, as they often presented late, when the risk of infection is such that it is safer to get the wound cleaned properly in theatre, rather than simply washing with saline and suturing closed. Dr Wari and Dr Zhang were more than happy to allow me to perform a lot of the minor procedures such as incision and drainage of abscesses and debridement on my own, and I became quite proficient at doing so as a result.

Performing an abscess drainage

Open appendicectomies were relatively common. As were repair of inguinal and paraumbilical hernias – however, they had run out of mesh and so were suturing the defects – usually with non-optimal sutures, and so there were recurrences. One memorable experience on a ward round involved a patient with an inguinal hernia. An unusual technique was employed to demonstrate the hernia. The patient was asked to jump up and down. Initially this seemed not to work. Rather than using the more conventional method of coughing, the patient was asked to continue jumping, and that the ward round would return shortly. The patient duly continued to jump on the spot for around 10 minutes before we returned – by which time the hernia had still not come down!

Three open prostatectomies were performed during my time at the NDH. It was interesting to see how often a patient would be admitted from clinic or ED one day and would proceed to theatre the next day, even for large procedures such as open prostatectomies.
Medicine is very paternalistic in Vanuatu. Patients accept what a doctor tells them, and goes along with whatever is proposed. As such, consent is relative. Although there were consent forms, these were not usually completed. On occasion it was amusing to see that the form was completed after the patient had already signed it, and was on the way to theatre after very little discussion. The patients rarely asked questions about procedures, other than how long it would be for their recovery which was a stark contrast to the UK.

Orthopaedics

The other bulk of the surgical cases at NDH are orthopaedic in nature. Many fractures of forearms, tibias, femurs and hands present to the ED, often after a week or so with no attention. The majority of management for such cases is conservative, consisting of manipulation under anaesthesia and application of plaster casts or backslabs. There is some limited provision for operative orthopaedics, including the insertion of Kirchner wires or intra-medullary pins for forearms fractures. I was taken aback when first assisting in one of these cases, however, when the theatre staff produced a Black and Decker power drill for the operation. It was wrapped in sterile towels and had the chuck swabbed with iodine and declared sterile and ready for use! Needless to say, it was not a sight I was expecting to see but one that sums up the Ni-Van attitude to many things!

It was often disheartening to see young patients presenting with fractures that you knew would be operated upon in the UK, and would leave the patient with no decreased function. However, because of absence of equipment and expertise, many patients with severe fractures were managed with manipulation and plaster alone. Often the post manipulation radiograph showed such severe angulation and displacement that it was almost certain that the patient would be left with reduced function and mobility.

During my time at NDH, there were three fractures of the shaft of femur in young patients. There is no provision at the hospital for surgical management of these patients. They were placed in traction for long periods with varying results.

There is some provision for patients to be flown to Vila Central Hospital which is better equipped to deal with the more complex cases, although it too suffers from limited resources as is demonstrated by the following case. A 28 year old male was admitted with a subcapital neck of femur fracture acquired in a motorcycle accident. Unfortunately Vila Central Hospital had run out of pins for such a case, and so he was placed in skeletal traction (using the aforementioned drill) to manage his injury.
This is obviously a sub-optimal form of management, and it is hoped that the dreaded complication of avascular necrosis will not occur in this case.

As diabetes is so prevalent in Vanuatu, there are a lot of presentations with gangrenous ulcers and necrotic digits in the lower limb. As a result there were a lot of toe amputations performed during my time at NDH, and debridement of diabetic foot ulcers. Such patients were often inpatients for a prolonged period as healing was so poor because of the poor, or in most cases, non-existent blood glucose level control.

Another notable case was that of a 14 year old boy who had cut his finger on a bottle several months earlier, resulting in infection. He had not attended the hospital because of the distance. However the infection progressed and he presented with gross osteomyelitis and a hugely swollen and deformed finger. This required amputation, and a wedge amputation was performed with a remarkable result. He retained normal function in the other fingers. The cosmetic result was very good, with it not being obvious in passing that he was missing a digit.

One sad case poignantly illustrating the impact resources has on third world medicine involved a 16 year old boy who presented in excruciating pain in his right thigh. The pain required morphine to become tolerable. On palpation there was a mass that was fixed to surrounding structures. There is no histology service in Vanuatu, and as such there was no way of assessing what this mass was. It was highly likely to be a tumour of some kind. However, the surgeon felt it beyond his expertise to excise the mass. As such, he attempted to organise the patient to be sent to Vila Central Hospital. However, they declined the patient, partly based on the issue of funding. The patient was treated with prednisolone, which significantly reduced the pain. However, with no opportunity for surgical management, the patient was discharged back to his village, with the expectation that he would not live for much longer with the likely malignant nature of his disease.
My experience

I thoroughly enjoyed my time in NDH, and was welcomed into and felt an important part of the surgical team. I was able to assist in most procedures, and got the opportunity to close the incision on many occasions which allowed plenty of opportunity to develop my suturing technique. Towards the end of my time at the hospital, the surgeons gave much more responsibility to me. As mentioned, many of the minor procedures such as drainage of abscesses as well as manipulation under anaesthesia of fractures, were left for me to do alone. In addition, myself and a colleague were left on several occasions to perform the ward round on our own, which demonstrated the degree of trust that the surgeons had in our clinical ability and judgement.

Activities outside the hospital

Vanuatu, and particularly Espirito Santo, provides much opportunity for exploration and to experience a tropical island in all its splendour.

Champagne beach
Champagne Beach is arguably one of the most beautiful beaches in the South Pacific. It has amazing white sands and crystal blue water. Because of the poor roads, you can almost guarantee that you will have this amazing beach all to yourself! A sunny day at Champagne Beach is one you will never forget.

Tasiriki
The majority of the population live in rural villages, and so it is only right that you go and see how these people live. Tasiriki is one such village that has built a guesthouse to attract tourists to create an income for the village. Seeing how self-sufficient and rural these villages are helps you appreciate the culture of Vanuatu. They live in self-built huts, with hole in ground toilets. They have livestock – mainly cattle and chickens that provide food and they grow root vegetables which forms the basis of their diet. They have a coconut plantation which is where the majority of their income comes from. It was an amazing experience to interact with these people, if only for a short while. The black sand beach is an additional reason to pay a visit.

There are plenty of other amazing things to be seen in Vanuatu on other islands. On the island of Pentecost, is the only place where you can see land diving, a primitive form of bungee jumping. On Tanna, is the most accessible active volcano in the world.
Conclusion

Going to Vanuatu for my elective was an amazing experience. I had the privilege of experiencing life in another culture, and had the opportunity of helping those who were unwell. Seeing how doctors cope in the developing world with limited resources and minimal investigations allowed me to realise how important the basic clinical skills of history and examination are to making a diagnosis. Observing how surgeons operated with the most basic of equipment, but yet able to perform complex operations was fascinating. It really makes you appreciate how lucky we are in the UK, where it would be unheard of to run out of oxygen. It was satisfying to be given the responsibility to conduct a ward round, perform minor operations and run an emergency department at this stage in my medical career. I believe that the experience will be of immense value to me in the future, as I have learnt from very experienced and capable doctors that you don’t always need to have the most advanced imaging, or the most detailed pathological investigation to make a diagnosis. Dr Wari said to me as I departed, ‘medicine is all about using your coconut’ – a sentiment that will stay with me forever.

Special thanks to Dr Santus Wari, Lester Evans-Dingley and the staff and patients of Northern District Hospital.

During my time at the Northern District Hospital, I conducted a small study analysing the results of their malaria films over the last 5 years. This report is included should this be of interest.
Retrospective audit of positive thick and thin malaria films conducted by the Northern District Hospital, Luganville, Vanuatu

Jason Ali\textsuperscript{1} and Samuel Kamuel\textsuperscript{2}

\textsuperscript{1}University of Cambridge, UK. \textsuperscript{2}Northern District Hospital, Luganville, Espirito Santo, Vanuatu

Abstract

Malaria is a global public-health issue that has been targeted by the WHO for elimination on several occasions, most recently with their: Roll Back Malaria campaign. Vanuatu, in the South West Pacific, is a group of islands, on many of which malaria is endemic. Because of the rural nature of much of the population, it has been difficult to gain a full picture of the extent of the disease. In order to contribute a little towards this, a retrospective audit was conducted using the malaria slide results from the Northern District Hospital on the island of Espiritu Santo. Five years worth of data was collected and analysed. It was seen that \textit{Plasmodium vivax} and \textit{Plasmodium falciparum} were both prevalent in the region. The seasonality of the disease was confirmed with peak incidence occurring during the wet season. The population are significantly more susceptible to the disease during their first two decades, with no significant difference between males and females. This audit gives a good idea of the caseload of malaria that presents at the Northern District Hospital, Vanuatu. A more complete understanding of the epidemiology of the disease is the first step towards considering the best way of intervening with the goal of elimination.

Introduction

The Republic of Vanuatu is located 1750km east of Australia, 500km north-east of New Caledonia, west of Fiji and South of the Solomon Islands. It is made up of 83 islands which are mostly mountainous and volcanic and has a tropical climate. Port Vila, on the island of Efate, is the capital and the largest settlement in Vanuatu and Luganville, on the island of Espiritu Santo is the second largest. Vanuatu was once named New Hebrides when it was settled and run as a colony in the late 18\textsuperscript{th} century by both England and France. In 1980 Vanuatu achieved freedom and was named a Republic. Vanuatu currently has a population of 205,754 (as of 2006) with much of the population living rurally\textsuperscript{1}. The population is mostly of Melanesian (Ni-Vanuatu) make-up but there are a small number of Europeans, Asians and other Pacific Islanders living in Vanuatu.

In Vanuatu the life expectancy of children born today are: 65.6 and 69 years for males and females respectively\textsuperscript{2}. Health services suffer from a lack of facilities, but more importantly, trained staff. The WHO quotes there being just 20 doctors, per 0.11 per 1000 population, compared to 2.3 in the UK\textsuperscript{2}.

Despite many decades of malaria control efforts, malaria remains one of the main global public health issues. In 1998, the WHO global initiative, Roll Back Malaria, was instituted\textsuperscript{3}. Malaria is Vanuatu’s major infectious health risk\textsuperscript{1}. \textit{Plasmodium falciparum} and \textit{Plasmodium vivax} are endemic, and there are believed to be over 10,000 cases per year\textsuperscript{2}. The disease is seasonal with peak incidence in cases said to occur during the rainy season (December to May)\textsuperscript{4}. As a result, there is much emphasis on educating the population with regard to reducing risk of infection, such as the use of insecticide-impregnated mosquito nets. For much of Vanuatu there are no data collated in order to understand the patterns of the disease due to the rural nature of
the island life. Such data could be useful, for example, in knowing which areas of Vanuatu have higher incidence of malaria. The hospital has been donated mosquito nets, but without the relevant information, there is no way of deciding which areas would be best served by the nets. It is known that successful malaria control requires an understanding of the local epidemiological characteristics.

Analysis of thick and thin slides for *Plasmodium* parasites is one of the most commonly conducted pathological tests at Northern District Hospital (NDH). Such test is requested for all patients who present with fever, and other combinations of suggestive symptoms. NDH serves the northern islands of Vanuatu and is on the island Espirito Santo. There are two further hospitals: Vila Central Hospital (the largest hospital, serving the southern islands) in the capital on the island Efate; and Norsup hospital on the island Malekula (which currently has no doctors).

Due to the country being divided into 83 islands, and there being poor transport links between them – few boats and expensive flights – it is probable that only a small proportion of patients from the more distant islands attend hospital other than in emergencies – and even then, it can take up to a week for patients from the distant islands to reach NDH. In addition, there are rural health services on the islands, some of which can interpret malaria slides in order to diagnose malaria and allow for appropriate treatment. Even on the island of Espirito Santo, the largest island, where NDH is, there are rural health clinics, which travel around the island and are able to perform such slides. There is no collation of the data from all of the health professionals that perform malaria slides, which prevents public health analysis of the extent of the disease and patterns of its occurrence to be considered, such as relative prevalence of *Plasmodium falciparum* and *Plasmodium vivax*, which may better assist interventional strategies. As a result of these factors, despite NDH being the largest laboratory in the northern islands performing the slides, their data is far from complete as a full record of the extent of malaria in northern Vanuatu.

**Background to study**

The pathology laboratory of the NDH, records the results of the malaria slides written in books. These contain the following information: date, age, name, sex, origin, residence of the patient, as well as the species of *Plasmodium* parasites and the size of the parasitaemia. Such data is not analysed in any way, and remains in the record books on the shelf in the laboratory.

It was thought that it may be useful to collate the data in order that trends and prevalence information may be generated that may assist the NDH in targeting its interventional public health measures. As malaria is such an important infectious disease in Vanuatu, having a better understanding of the annual trends in case load, will be of use to the Northern District Hospital. They have an allocation of funds towards targeting reducing the incidence of this disease however, they are unsure of how the funds could be put to best use.

In addition, by setting up the spreadsheet and computing this data, there is the potential that the staff may take the opportunity of inserting future data, such that the spreadsheet constructed is used in the future for further data analysis of a similar kind.
Methods

Primary data collection

Due to some books missing, there was only complete data from April 2002 of all malaria slides performed at the NDH.

Due to time constraints it was decided that the following data would be recorded

- April 2006 – April 2007
  - In depth analysis of the data, recording: age, sex, residence and *Plasmodium* species. This may provide some information about the distribution amongst the population of the disease demographically, including their residence within Vanuatu. In order to complete the analysis such information such as the populations of the villages will be important to assess the relative density of the prevalence of the cases.

- April 2002 – April 2007
  - Count the monthly totals of *Plasmodium vivax* and *Plasmodium falciparum* – the species of *Plasmodium* most frequently present in Vanuatu. This will allow the temporal patterns of the incidence each month to be graphically represented, looking for recurrent trends over the years. This will be enhanced by looking at the rainfall each month, as there is an association of cases of malaria and rainfall which leads to increased breeding potential for the *Anopheles* mosquito that is responsible for the transmission of the parasites.

All positive malaria slides recorded in the results books were recorded in the manner described above. Consequently the data was tabulated and graphical manipulation of the data was performed in order that the trends be better visualised.

Secondary data collection

In order to conduct a more complete analysis of the data, it was obvious that rainfall data would be required. Mr Jotham Napat, the director of the Vanuatu Meteorological Society was contacted with the request of providing rainfall data for the region over the period of investigation.

Data from Pekoa Airport, the closest recording station to the Northern District Hospital were kindly provided.
Results

*Five year data analysis:*

- **Monthly frequency of positive slides**

![Graph showing monthly frequency of positive slides](image)

*Figure 1.* Frequency of positive slides over the data collection period separated by species. May 2002 until April 2007

Figure 1 is a graph of the relative frequency of positive slides with *Plasmodium falciparum* and *Plasmodium vivax*. It shows that *Plasmodium vivax* is more prevalent than *Plasmodium falciparum* at all time points except the first point, May 2002. The lines for each species follows much the same pattern. There are peaks each year: July 2002, February 2003, February 2004, November 2005, January 2006. This would suggest that there is a cyclical pattern to the incidence of cases. There are repeated peaks between November – February each year except 2007, however, data only extends to April, so presence of a late peak cannot be excluded. In addition, an earlier higher peak in early 2002 cannot be excluded also, as data was not present. Thus, although not conclusive, it would appear that there is an annual cyclical pattern to the incidence of the cases, which is followed by both species.

It may also be suggested that there is a downward trend in the incidence of malaria, with much lower peaks in 2005 and 2006, with no apparent winter peak in 2007. This may reflect an increase intervention over this period. Indeed this is confirmed when considering the totals for the years spanning May to April. The total number of detected cases fell as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Positive Slides</th>
<th>Total Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002/03</td>
<td>3219</td>
<td>2230.7</td>
</tr>
<tr>
<td>2003/04</td>
<td>2216</td>
<td>2332.8</td>
</tr>
<tr>
<td>2004/05</td>
<td>1749</td>
<td>2835.6</td>
</tr>
<tr>
<td>2005/06</td>
<td>1729</td>
<td>2029.1</td>
</tr>
<tr>
<td>2006/07</td>
<td>1014</td>
<td>2697.3</td>
</tr>
</tbody>
</table>
Figure 2. Incidence of positive slides and rainfall over the five years of retrospective study. Years from May to following April.

- **Rainfall**

One hypothesis would be that the incidence would follow the rainfall levels, as high rainfall, created an increased habitat for the *Anopheles* mosquito, which are responsible for the transmission of the *Plasmodium* parasites.

![Rainfall graph](image)

Figure 3. Rainfall levels at Pekoa, with frequencies of malaria cases over the same period.

The climate in Vanuatu is tropical, and typically there is a dry season centred upon the summer months of May –November, and the wet season centred upon the winter months December - May. The rainfall levels collected at Pekoa over the period of investigation as shown in figure 2, tend to support this picture. There are troughs in the level of rainfall recorded over the summer months during all years, except 2002. Interestingly, Summer 2002 also saw a high level of cases of malaria, being the first peak on the graph. As expected, there are generally peaks in rainfall over the winter months. Of note is the observation that there was a peak in rainfall over winter 2007, which was not accompanied by a peak in cases of malaria over that period. This data supports the suggestion that for the most, the trend in malaria cases follows that of the level of rainfall – apart from the notable exception of winter 2007.

**One year detailed data**

- **Frequency of different Plasmodium species by age**

<table>
<thead>
<tr>
<th>Count of Month</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>both</td>
</tr>
<tr>
<td>0-9</td>
<td>3</td>
</tr>
<tr>
<td>10-19</td>
<td>9</td>
</tr>
<tr>
<td>20-29</td>
<td>1</td>
</tr>
<tr>
<td>30-39</td>
<td>1</td>
</tr>
<tr>
<td>40-49</td>
<td>1</td>
</tr>
<tr>
<td>50-59</td>
<td>8</td>
</tr>
<tr>
<td>60-69</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure 4. Table displaying the frequency of cases by age divided by species of Plasmodium.

<table>
<thead>
<tr>
<th>Age</th>
<th>Species</th>
<th>both</th>
<th>f</th>
<th>v</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-79</td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>80-89</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>unknown</td>
<td></td>
<td>2</td>
<td>51</td>
<td>113</td>
<td>166</td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td>17</td>
<td>295</td>
<td>702</td>
<td>1014</td>
</tr>
</tbody>
</table>

Figure 5. Graph demonstrating the frequency of cases by age divided by species of Plasmodium.

These data present the trend in frequency of positive slides versus age of patient. It is clear that there is an almost exponential decrease in case frequency with age. *Plasmodium vivax* is more prevalent at all age groups than *Plasmodium falciparum*. Indeed, in the first two decades, *Plasmodium falciparum* accounts for around a third of cases, a proportion which appears to be true for all ages.

- **Frequency by age and sex**

<table>
<thead>
<tr>
<th>Count of Month</th>
<th>Species</th>
<th>both</th>
<th>f</th>
<th>v</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-9</td>
<td>f</td>
<td>1</td>
<td>40</td>
<td>133</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>2</td>
<td>47</td>
<td>120</td>
<td>169</td>
</tr>
<tr>
<td>0-9 Total</td>
<td></td>
<td>3</td>
<td>87</td>
<td>253</td>
<td>343</td>
</tr>
<tr>
<td>10-19</td>
<td>f</td>
<td>5</td>
<td>42</td>
<td>87</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>4</td>
<td>42</td>
<td>97</td>
<td>143</td>
</tr>
<tr>
<td>10-19 Total</td>
<td></td>
<td>9</td>
<td>84</td>
<td>184</td>
<td>277</td>
</tr>
<tr>
<td>20-29</td>
<td>f</td>
<td>1</td>
<td>17</td>
<td>36</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>2</td>
<td>22</td>
<td>38</td>
<td>60</td>
</tr>
<tr>
<td>20-29 Total</td>
<td></td>
<td>1</td>
<td>39</td>
<td>74</td>
<td>114</td>
</tr>
<tr>
<td>30-39</td>
<td>f</td>
<td>1</td>
<td>2</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>1</td>
<td>10</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>30-39 Total</td>
<td></td>
<td>1</td>
<td>12</td>
<td>30</td>
<td>43</td>
</tr>
<tr>
<td>40-49</td>
<td>f</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>6</td>
<td>16</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>40-49 Total</td>
<td></td>
<td>1</td>
<td>13</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>50-59</td>
<td>f</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>m</td>
<td>6</td>
<td>8</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Age Group</td>
<td>Count of Cases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50-59 Total</td>
<td>8</td>
<td>13</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-69</td>
<td>f</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>60-69 Total</td>
<td>1</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>70-79</td>
<td>f</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>70-79 Total</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80-89</td>
<td>m</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>80-89 Total</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>unknown</td>
<td>f</td>
<td>1</td>
<td>25</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m</td>
<td>1</td>
<td>26</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>unknown Total</td>
<td>2</td>
<td>51</td>
<td>113</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>Grand Total</td>
<td>17</td>
<td>295</td>
<td>702</td>
<td>1014</td>
</tr>
</tbody>
</table>

**Figure 6.** Data table describing the frequency of cases by age and sex, divided by species of Plasmodium.

**Figure 7.** Graph demonstrating the frequency of cases by age and sex, divided by species of Plasmodium.

These data assess the presence of a trend in case prevalence by age and sex. Indeed it can be seen that there is almost an exponential decrease in frequency with age. There are substantially more cases in the 0-19 age group than older age groups with a decreasing trend throughout. With regard to sex difference by age, it does not seem that there are significant differences between the sexes although statistical analysis has not been performed as the data is only from one year. If anything, it may be suggested that there may be a slight increase in male prevalence versus female.

When this is broken down by species of *Plasmodium*, it can be seen that the decreasing trend with age, of frequency of cases, is found within each of the species. In both cases, there is not a great difference between the 0-9 and 10-19 age group in prevalence. It is notable that in these age groups there are a number of individuals that appear to have been infected with both species, a phenomenon that was barely observed beyond this age group.
- **Monthly trend in frequency divided by species of Plasmodium**

<table>
<thead>
<tr>
<th>Count of Month</th>
<th>Species</th>
<th>f</th>
<th>v</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>May-06</td>
<td>both</td>
<td>3</td>
<td>35</td>
<td>122</td>
</tr>
<tr>
<td>Jun-06</td>
<td></td>
<td>3</td>
<td>55</td>
<td>109</td>
</tr>
<tr>
<td>Jul-06</td>
<td></td>
<td>2</td>
<td>23</td>
<td>67</td>
</tr>
<tr>
<td>Aug-06</td>
<td></td>
<td>1</td>
<td>18</td>
<td>48</td>
</tr>
<tr>
<td>Sep-06</td>
<td></td>
<td>2</td>
<td>13</td>
<td>40</td>
</tr>
<tr>
<td>Oct-06</td>
<td></td>
<td>2</td>
<td>12</td>
<td>42</td>
</tr>
<tr>
<td>Nov-06</td>
<td></td>
<td>1</td>
<td>23</td>
<td>51</td>
</tr>
<tr>
<td>Dec-06</td>
<td></td>
<td>1</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td>Jan-07</td>
<td></td>
<td>1</td>
<td>23</td>
<td>47</td>
</tr>
<tr>
<td>Feb-07</td>
<td></td>
<td>2</td>
<td>21</td>
<td>39</td>
</tr>
<tr>
<td>Mar-07</td>
<td></td>
<td>1</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td>Apr-07</td>
<td></td>
<td>1</td>
<td>28</td>
<td>57</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td></td>
<td>17</td>
<td>295</td>
<td>702</td>
</tr>
</tbody>
</table>

**Figure 8.** Table displaying the frequency of cases each month, divided by species of Plasmodium.

These figures present data from a perspective of the number of cases by month. It has already been seen that the rainfall during this year appeared to follow the expected cycle of wet (winter) and dry (summer) season, but that there was no peak in cases of malaria during this peak, unlike that observed in previous years. Thus it is seen that there was a large number of cases in May and June of around 160, but for the remainder of the year of observation, the case frequency has been between 50 and 80 cases. *Plasmodium falciparum* is less prevalent each month then *Plasmodium vivax.*
Because of the atypical nature of the beginning of 2007 with regard to cases, a graph was constructed with the average number of cases per calendar month for the five year period, to see if the suspected seasonality was observed.

This graph does display the seasonality of the cases. There is a clear peak observed over the wet season, and a trough over the summer months verifying the reported seasonality is present in the Northern islands of Vanuatu. However, the standard error bars are wide suggesting significant overlap.
Discussion

As malaria is such an important infectious disease in Vanuatu\(^2\), having a better understanding of the annual trends in case load, will be of use to the Northern District Hospital. They have an allocation of funds towards targeting reducing the incidence of this disease however, they are unsure of how the funds could be put to best use.

This study aimed to create an electronic database of the positive blood films from the previous year, with the aim that this will be maintained as a sustainable project, thus allowing manipulation of the data in the future. Hopefully this aim has been achieved successfully.

Analysis of the data has interestingly shown that there has been a decrease in the incidence of cases over the retrospective study period. Over a three fold decrease was observed over the five years from 3219 to 1014 positive slides. This is despite the absence of significant change in the rainfall over this period. This could be explained by several reasons. First, there may be a reduction in the number of patients attending the NDH with fever, because of the increase in development of rural health care with increased clinics and nominated individuals in villages who are able to perform malaria slides and prescribe the medication when appropriate – thus diverting patients from attending the hospital. This could be verified by counting the total number of slides performed to see if there has been a significant fall in the number performed over the years. If there was not a significant decline in number performed, then this suggests that the proportion of those positive must have fallen significantly, which may be due to the increasing presence of another febrile condition that leads to the request for a malaria slide. Alternatively, this may represent a real decline in the incidence of the disease due to the increased awareness and public health moves that are directed at reducing the incidence of this major public health issue.
The data also confirms that *Plasmodium vivax* is the most prevalent species of *Plasmodium* detected, with *Plasmodium falciparum* the other main species detected. There were also two cases of *Plasmodium malariae* during this period of study.

The cyclical nature of the disease is also confirmed by this study, with peaks occurring in the wet season, which is confirmed by the simultaneous analysis of rainfall data over the period of investigation. The peaks in incidence corresponded with the peak in rainfall, except for the wet season of this year, 2007.

When looking in more detail at the demographics of those inflicted by malaria, it is seen that there is no significant difference between male and females, albeit a tendency for more cases in males. In addition, it was clearly seen that those in the first two decades of life are inflicted far greater than at any other time in life, with an almost exponential decrease in cases with age observed, a pattern observed for both sexes. This is in keeping with previous work in endemic areas, which proposes that in such areas, repeated inoculation with parasites leads to a state of humoral immunity with age. However, this immunity is short lived, and if people move away for a significant period from an endemic area, they are rendered susceptible to the disease upon remigration to the endemic area.

Understanding of the lifecycle of any parasite is required in order to interrupt, and reduce the incidence of disease. The lifecycle of malaria is well characterised, and in Vanuatu involves the female *Anopheles farauti* mosquito as vector in Vanuatu. Upon taking a bloodmeal this vector is able both to pick up Plasmodial gametocytes, and transmit sporozoites.

Three main targets for interrupting the transmission of malaria have been tried previously in Vanuatu. 1) widespread treatment with fansidar (pyrimethamine and sulphadoxine) 2) Permethrin treated bednets (with annual treatment) 3) introduction of the lavivorous fish (*Gambusia spp*) into water sources identified as breeding places for *A. farauti*. Indeed, this interventional study involving one of the smaller islands: Aneityum in 1991, discovered that with this intensive regime involving all inhabitants, they were effectively able to disrupt the transmission of these parasites, such that over the nine year period of study there were no outbreaks of malaria. *Plasmodium falciparum* was reportedly eradicated by 1992, and *Plasmodium vivax* disappeared from 1996 onwards. This was a very positive result, and demonstrates that the idea that if malaria is hit hard enough it can be eliminated is true. The authors identified that to be effective, elimination intervention must be employed over the entire area of transmission, and risk of importation of malaria is controlled.

The danger of incomplete interruption and subsequent reintroduction have been seen before. Reintroduction into an area where the natural immunity level has fallen due to reduced exposure, has lead to severe outbreaks with increased morbidity and mortality. This is an important consideration in any attempt to disrupt the transmission cycle of this endemic disease. Thus, a half hearted attempt may do more harm than good. However, it is recognised that it is a difficult task to simultaneously cover a large population with mass drug administration and proper surveillance for a sufficient amount of time. The quest still continues in the search for a vaccination for malaria, which would make this task immeasurably easier with population cooperation.
Limitations and further work

1) Time constraints meant that data over the period of one year only could be analysed in more depth. This meant that there was insufficient data to perform statistical manipulation to look for significance.

2) It is recognised that the data collected is not a complete representation of the cases of malaria in the northern islands. As discussed, there are rural clinics, which are able to conduct malarial slides, whose data is not incorporated in this study. It would most likely be extremely difficult to collect data from all sources that perform blood films, and even more unlikely that they would have records going very far in time. In addition, many would not have the ability to attend the hospital as they live far away, with very poor transportation links.

3) It would have been useful to compare the data to the southern islands, looking at the data from Vila Central Hospital to see if the trends suggested in this data are found at other locations within Vanuatu.

4) For every case recorded within this dataset, the place of origin of the patient is recorded. This data included a large amount of names of villages within the northern islands. In order to organise this data, it was decided that the villages should be grouped into regions, to reduce the number of possible variables. Once such data has been collated, in order to make it meaningful, the population of these regions will be needed in order to assess the relative density of cases within each region, in order to generate an idea of regions in which there is a high density of cases. These tasks form the basis of further work.

5) With the observed decrease in cases, suspected to be due to intervention, it would be interesting to see if there is any change in the outcome of these cases in terms of morbidity and mortality, with the knowledge that interrupting transmission can lead to decreased immunity and more severe morbidity.

Conclusion

This study has confirmed that there is a seasonal variation in incidence of malaria. The incidence has been falling over the last years suggesting that current efforts may be having effect. However, it would seem that much more intensive efforts are required if elimination is to realistically be achieved.

With malaria being the major infectious health problem in Vanuatu, it would seem that performing a more comprehensive analysis of the caseload in Vanuatu would be a very useful study. In order to be complete, this would be a large undertaking, most likely requiring a prospective study to ensure that all records are complete and contain the required information for the study. However, with more comprehensive information, the Vanuatan department of health would be in a better position to target interventions and public health strategies.

References
   accessed 14/09/2007