A Collaborative Telepathology Network Project (CTNP) for the Sustainable Capacity Building of Pathology and Cancer Services in Papua New Guinea and the Pacific

An architecture for inclusive action

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Collaborative Telepathology Network Project (CTNP)
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Abstract

An Innovative Collaborative Telepathology Network Project (CTNP) to accelerate pathology diagnostic services in Papua New Guinea

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There is a rapidly growing global mandate for the use of eHealth, that is, Information Communication Technologies (ICT) to transform health care. This was made explicit by the World Health Assembly resolution 58.28 in 2005 to grasp this evolution in technology and apply it to make a difference to patient care.

A World Health Organisation sponsored survey in 2005 by the newly created Global Observatory for eHealth (GOe) demonstrated that for the non-OECD countries surveyed, the vast majority placed great value on the development of telehealth.

Papua New Guinea stands on the brink of this huge opportunity as it starts to increase its ICT diffusion through satellite, land line, fibre optic and mobile networks which are bridging the gaps created by its remote geography and the relative isolation of the Capital where its pathological expertise is concentrated. The National Government, in its pacific digital strategy has seized this opportunity with programs such as the Rural Internet Connectivity System (RICS) and the Oceania One Laptop Per Child (OLPC) initiative.

With a predicted rise of cancer in PNG of 40%; a robust and sustainable digital pathology program is advocated to lay the foundation for an unrivalled communication network throughout its base hospitals to facilitate the training and education of its doctors, nurses and scientists to transform this future.

In the abstract: “A Retrospective Comparative Analysis of Turnaround Time (TAT) for Pathology Samples at Port Moresby General Hospital”, evidence is provided for the possibility of using eHealth technology to create a phased program of telepathology. This uses the technique of digital image capture of a microscope image at a set magnification and its transmission to a virtual platform where experts are able to make diagnoses through internet connectivity.

Successful programs have been established in the Pacific, for example, the Solomon Islands Telepathology Program 2, the U21/Swinfen Charitable Trust/Queensland Centre for Online Health collaboration at Tabubil 3 and the Fiji School of Medicine Telepathology Program. All of these have demonstrated both efficacy and workability combined with realistic principles that can be applied to the context in Papua New Guinea.

For example the Solomon Islands program achieved a mean turnaround time of 12 hours after image submission. In Papua New Guinea, with tissue processing at the originating hospital and digital transmission, all the costs and delays in physical transport may be rendered obsolete.

The CTNP is currently in the planning phase and we require a broad base of representation to initiate the program and to guarantee maximal participation of all parties. Your participation is vital. The Medical Symposium also sees the first ever eHealth survey in Papua New Guinea which will inform the CTNP. Please complete this during the week.

Introduction

Papua New Guinea, a low income developing country, currently has limited comprehensive access to pathological diagnostic services. As a country with difficult geographical terrain, a rural based population with a relatively isolated capital city where much of the diagnostic expert human resources are concentrated and a developing telecommunications network, unique challenges exist.

This context has had a direct impact on the delivery of healthcare; great health disparities are experienced by its citizens, who often face a clinical diagnosis and therapy of cancer without confirmatory histopathology or metabolic disturbances without resource to biochemical testing. When combined with the current challenging level of service for the sector wide healthcare framework, there is a great capacity for development and opportunity for innovative solutions through partnership and advocacy.

This proposal presents such an innovative strategy to provide a rapid and expert pathological diagnostic service by using the vehicle of telepathology through digital imaging and internet technology.

In essence it will enable the transmission of digital images of histology specimens over the internet by email, to give provincial hospitals access to rapid and accurate pathology reporting.

There is a both a global recognition and mandate for eHealth, that is the use of information communication technology for healthcare, to be integral to any health care program, precisely because of the usefulness of Information Communication Technologies (ICT) to deliver quality patient care.

The World Health Assembly and the World Health Organisation have created enabling environments for the design and implementation of the many formulations of eHealth, including telehealth, “...to develop the infrastructure for information and communication technologies for health as deemed appropriate to promote equitable, affordable, and universal access to their benefits.” (1)

Likewise, nationally in PNG, the Medium Term Development Strategy (MTDS) 2005-2010, places great value on the development of ICT: “Under the MTDS, the promotion of economic growth and social development will be greatly assisted by a vastly improved telecommunications network and a program to bridge the digital divide that is limiting the opportunities available to ordinary Papua New Guineans.” (2) The government in 2003 thus created the Department of State Enterprises and Information to take on this agenda.

This has led to the PNG government formulation of the pacific digital strategy and a new national ICT policy document in May 2007 (3). Initiatives such as the Rural Internet Connectivity System (RICS), the Oceania One Laptop Per Child (OLPC) and mobile telephony deregulation have seized this digital agenda. The National Department of Health (NDoH) in their corporate plan 2009-2013 have focussed on “…looking at new and better models of support for service delivery including innovative partnerships with other providers and moving resources out into the regions…” (4).

Similarly the Australian Agency for International Development (AusAID), in their recent cooperative strategy document have focussed on service delivery as one of four framework pillars as: “…improving the delivery of services in education and health
improves the living standards and productivity of people, their access to markets and information, and their contribution to economic growth.” (5)

The Collaborative Telepathology Network Project (CTNP) is such a delivery model to fulfil on this new focus. It represents a medium term strategy to accelerate the capacity of pathology services to develop the maximum potential of the human resources already in place and facilitate training and education by utilising rapidly developing ICT.

With the signing of a Memorandum of Understanding to create the PNG Academic Research Network (PNGARNet) and many pacific based telepathology models, (6) which have demonstrated both efficacy and workability combined with realistic principles, the stage is now set for the implementation of CTNP in PNG.

**The core of the CTNP proposal details the rationale for the implementation of telepathology, to make rapid and accurate pathological diagnosis accessible to all hospitals in Papua New Guinea and achieve the aim of quality patient care that includes all members of society, especially the rural poor and women. The paradigm of eHealth is one of radical inclusion, so that none are left behind.**

The program is also anticipated to provide an enabling environment to other parallel health prevention, education and curative programs.

This proposal will systematically:

- review current pathology and cancer services in PNG
- present new data on turnaround time for histology and bone marrow samples
- review current global eHealth developments
- review eHealth and telepathology initiatives in the Pacific region
- present data from the first ever eHealth survey 2008 for PNG
- demonstrate telepathology as part of the solution for the challenges in pathology services, cancer services and sample turnaround time in PNG
- detail a comprehensive telepathology strategy, CTNP, for PNG
- outline a randomised controlled trial to be undertaken within the CTNP

This overview of the current configuration of pathology and cancer services will be performed to show how a telepathology strategy such as CTNP could re-orientate this service provision to deliver improvement in the:

- coordination and quality of services
- time to diagnosis and health intervention
- patient mortality
- patient morbidity
- education and training of health workers

These will form some of the key indicators for the measuring the impact of the project and will focus on patients in rural areas in order to conform to the strategic direction set by the National Department of Health and the scope of the millennium development goals.
An Introduction to Papua New Guinea

Papua New Guinea is in the southern hemisphere at between 0 and 10 degrees latitude. It occupies the eastern half of the second largest island in the world, New Guinea, the western half constituting Indonesia. Papua New Guinea covers an area of 462,840 square Km, with forest covering 64% (294, 400 square Km), which are mostly unexplored due to the remote and inaccessible geography.

Figure 1: Map of Papua New Guinea

Papua New Guinea is one of the most linguistically diverse countries in the world with over 800 indigenous languages. Papua New Guinea became an independent state on 16, September 1975 from Australian territorial administration, and hence it still has close ties with Australia.

Papua New Guinea, as an island nation along with many other island states within the Pacific region, has in common their relative isolation and challenging geography in making health care access to rural communities difficult, where 87% of the population live (7).

Papua New Guinea is within the Western Pacific WHO region and is a constitutional monarchy administered by a national parliament with 109 members. Total Population, in 2005, was estimated to be 5.9 million with a population growth rate of 2%, Gross Domestic Product (GDP) being US $3.9 billion (8). Papua New Guinea is rich in natural resources and the mining and petroleum sector accounts for an estimated 28.8% of GDP and 77.3% of total exports (9).

Papua New Guinea is ranked 139th in the Human Development Index, 2006 (which is a composite measure of 3 dimensions of human development: living a long and healthy life (measured by life expectancy), being educated (measured by adult literacy

7
and enrolment at primary, secondary and tertiary institutions) and having a decent standard of living (measured by purchasing power parity in US dollars). In the Human Development Report 2007, through 2004, Papua New Guinea has fallen in ranked overall human development and since 1995 there has been stagnation in the trend (10). This is illustrated well in Figure 2.

**Figure 2: Human Development Index 1975-2005 and GDP per capita 2005 for Papua New Guinea from reference (9)**

Selected measures for Papua New Guinea include; Life expectancy at birth (2000-2005) 55.1 years, Adult literacy is 57.3%, with combined primary, secondary and tertiary enrolment in education 41% and health expenditure as a proportion of GDP is 3.8%.

Gross National Income per capita is US$660 and is therefore characterised as a low income country, with a GDP per capita of US$2,543 (in Purchasing Power Parity with the US$ ) (7, 8).

Papua New Guinea presents specific development challenges in:
- Geography
- Communication
- Technology
- Climate
- Language

The power of this program will be to utilise the inherent strengths within these challenges to build sustainability, to find uniquely Papua New Guinean solutions as enshrined in the National Principles.
Overview of current specialist pathology services in Papua New Guinea

Pathology services have developed, through resource constraint, in a non-comprehensive manner and are often limited to the provincial base hospitals and the tertiary centre at Port Moresby General Hospital (PMGH). This has instead led to a comprehensive referral network. The key block within this network is the relative isolation of PMGH from the rest of the country. This creates financial barriers to accessible health care for PNG citizens outside of National Capital District (NCD).

Most base hospitals and faith based hospitals are able to provide some basic biochemical, microbiological, haematological and blood transfusion services with varying degrees of technological and human resource expertise.

PMGH, in collaboration with the University of Papua New Guinea, provides the only post mortem, histopathological and haemato-oncological diagnostic service for Papua New Guinea. The service, in 2007, received 4515 samples and of these processed; 83 post mortems, 4515 histopathology specimens, 1535 fine needle samples, 174 gynaecology cytological samples and 315 non-gynaecology cytological samples. With a backlog of work from 2006, the total workload was 11,997 samples (11). The system of referral in operation at present is that all specimens from hospitals and clinics outside of Port Moresby are transported by air, road or sea to the pathology department. The following departments provide a service:

- clinical biochemistry
- haematology
- anatomical pathology
- cytology
- forensic pathology
- microbiology
- immunology
- blood transfusion services
- central public health laboratory

The total human resources are illustrated in tables 1 and 2. Nationally there are over 200 registered pathology technicians. These undergo training at a variety of courses at the University of Papua New Guinea in the Division of Health Sciences.

Table 1: Total pathology workforce at PMGH

<table>
<thead>
<tr>
<th>Work role</th>
<th>Number of staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientists/Technicians/Technologists</td>
<td>36</td>
</tr>
<tr>
<td>Secretaries</td>
<td>4</td>
</tr>
<tr>
<td>Accounts clerk</td>
<td>1</td>
</tr>
<tr>
<td>Cleaner/Ancillary</td>
<td>2</td>
</tr>
<tr>
<td>Pathologists</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total human resources</strong></td>
<td><strong>52</strong></td>
</tr>
</tbody>
</table>

Table 2: Summary of pathologists working at PMGH and University of Papua New Guinea

<table>
<thead>
<tr>
<th>Pathology Specialty</th>
<th>NDoH</th>
<th>UPNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomic Pathology</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Microbiology</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Haematology</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Blood Transfusion</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chemical pathology</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CPHL</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Trainees</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

The service is run by a dedicated team of technicians and a clinical staff of 9 consultant pathologists, however the service is experiencing major delays in its turnaround time to issue expert reports in comparison to the previous decade as shown in table 3. This has been comprehensively analysed recently and will be presented at the Pathology Update 2009 and the World Congress of Pathology and Laboratory Medicine in March 2009. It is presented here for the first time (11).

It clearly demonstrates both the major decay and delay in pathology turnaround times over time. The mean TAT is given, however the range extends to well over 6 months (180 days) for some samples. Currently there is also a 1 year backlog of samples, especially large organ specimens. This has a major impact on clinical management of patients. For example a paper presented in the Annual Medical Symposium in 2007, indicated that virtually all head and neck surgery is performed without reliance on histopathology at Goroko Base Hospital (12). The tabulated results of this study are shown in table 4.

Table 3: Comparative mean turnaround times (TAT) for pathology samples analysed by Port Moresby General Hospital department of anatomical pathology in 1997 and 2007 (11)

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean TAT (days)</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>23</td>
<td>229</td>
</tr>
<tr>
<td>2007</td>
<td>115</td>
<td>240</td>
</tr>
</tbody>
</table>
Table 4: Results of a retrospective study of the management of head and neck malignancy at Goroka Base Hospital 2002-2006 (12)

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>% patients pre-operative histology unavailable</th>
<th>Average waiting time for histology</th>
<th>% patients post-operative histology confirms malignancy</th>
<th>% patients whose tumour became inoperable in waiting time</th>
<th>% error of clinical diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>98.5</td>
<td>4-5 months</td>
<td>95</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

This delay is also replicated in the turnaround time for bone marrow analysis; in a similar abstract, to be presented at Pathology Update 2009, for bone marrow aspirate and trephine samples derived outside of Port Moresby results may take between 6-12 weeks (13).

The relative contribution of the three major process delays are shown in Figure 3, the majority of delay occurring in slide production, yet significant, was the delay incurred by transportation to PMGH Pathology. The significant contributors to this observation have been identified to be:

- the supply of reagents and technical breakdown,
- transportation of specimens,
- insufficient human resources for slide production/reporting due to joint duties bringing heavy workload commitment,
- inadequate prioritisation system of analysis
- communication of result to submitting hospital

Therefore solutions that would make the need for transport of the primary specimen obsolete would have a major impact on the turnaround time. It is only telepathology that could provide an interim solution until enough human resources are trained and are resident in each base hospital.

In terms of human resources there are currently 8 working national pathologists and 2 UPNG overseas pathologists in specialities of haematology and academic immunology respectively.

Currently there are 2 trainees; in years 1 and 5 respectively of the Master of Medicine (MMed) Pathology training program. There will be a significant deficit between 2009 and 2012 with no new graduating pathologists. With an estimated attrition rate of one specialist every 3 years and an estimated single new trainee annually; there will be a slow rise in the total number of specialist pathologists, to an expected 16 specialists by 2020. This represents a doubling of the total specialist pathology workforce over that 12 year period. These figures are represented graphically and tabulated in figure 4 and table 5 respectively.
The current distribution of the pathology workforce creates a major impact on health care. All of the specialist human resources and therefore expertise is concentrated in Port Moresby. It can be expected this has had, and whilst it remains, continue to have a major impact on the distribution, accessibility of services and the education and training of the healthcare workforce outside of Port Moresby. It is precisely these rural areas where need is greatest for pathological services to transform service delivery in accordance with the country demographics.

In these rural areas of PNG most pathology services are provided by technical staff and turnaround times are much longer for rural areas due to the necessity of transportation and its nominal costing. Often hospitals delay sample delivery to send as a bulk delivery. A sub group analysis of 2008 data demonstrates that for samples received within Port Moresby in table 6 (11).

Table 6: Subgroup analysis of 2008 turnaround time (TAT) data (11)

<table>
<thead>
<tr>
<th>Mean TAT within Port Moresby area</th>
<th>Mean TAT outside of Port Moresby</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 days</td>
<td>67 days</td>
</tr>
</tbody>
</table>

Insightful programs, such as the MMed in Rural Health have sought to redress this balance by training doctors with a broad scope of knowledge, including pathology, to work in rural areas with laboratory staff. Ultimately, the goal is to have pathologists based in each provincial hospital and a rotational system may be a workable solution and one which will aid a phased introduction of the CTNP, a system that is currently being implemented by the National Department of Health (14).
Figure 4: Human resource projection for total number of specialist pathology staff 2008-2020

![Bar chart showing projected human resources of specialist pathologists from 2008 to 2020.](image)

Table 5: Analysis of human resource trends in specialist pathologists 2008-2020

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Number of MMed Pathology Trainees Assuming 1 new trainee recruited per year (+)</th>
<th>Annual Number trainees graduating as MMed Pathology Specialist</th>
<th>Total Projected Specialist Pathology Human Resource Capacity Assuming 1 specialist loss every 3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>2</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>2009</td>
<td>5 (+3 new trainees)</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>2010</td>
<td>5(+1)</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>2011</td>
<td>6(+1)</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>2012</td>
<td>6(+1)</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>2013</td>
<td>6(+1)</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>2014</td>
<td>4(1)</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2015</td>
<td>4(1)</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2016</td>
<td>4(1)</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2017</td>
<td>4(1)</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>2018</td>
<td>4(1)</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2019</td>
<td>4(1)</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2020</td>
<td>4(1)</td>
<td>1</td>
<td>16</td>
</tr>
</tbody>
</table>
Overview of current cancer services in Papua New Guinea

Cancer is an important cause of mortality and morbidity in Papua New Guinea yet must be contextualised within the prevalent health climate facing Papua New Guinea. Current overall health indicators give a frank illustration of the great challenges and key constraints present within the Papua New Guinea health service presently.

Table 7: Key health indicators for Papua New Guinea (15)

<table>
<thead>
<tr>
<th>Health indicator</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy Years</td>
<td>60</td>
<td>64</td>
</tr>
<tr>
<td>Infant mortality rate Per 1000 live births</td>
<td>58</td>
<td>51</td>
</tr>
<tr>
<td>Under 5 mortality rate Per 1000 live births</td>
<td>77</td>
<td>69</td>
</tr>
<tr>
<td>Adult mortality rate Between 15-60 per 1000</td>
<td>303</td>
<td>243</td>
</tr>
<tr>
<td>Maternal Mortality per 100,000 live births</td>
<td></td>
<td>470</td>
</tr>
<tr>
<td>Age standardised cancer mortality rate per 100,000</td>
<td>118</td>
<td></td>
</tr>
</tbody>
</table>

Cancer in Papua New Guinea is recognised in both the National Health Plan 2001-2010 (16) and “The Hidden Burden; Cancer in Papua New Guinea” (17) as a major affliction carried by many citizens and those who care for them. Yet the provision of a comprehensive service is in its infancy, a challenge the health institutions of the country are facing currently.

Although the National Health Plan 2001-2010 places cancer 7th in the overall cause of mortality per 100,000 population, an iceberg model illustrates well the features of cancer registration in PNG, as in Figure 5. It is created by the presence of major limitations to the collection of accurate cancer related statistics, such as:

- Cultural values and taboos
- Geography
- Lay knowledge and referral patterns
- Health care access
- Health care costs and user fees
- Health care professional training and education
- Transportation costs
- The effective use of a cancer registry
- Histopathology expertise
There have been previous comprehensive reviews of the tumour registry in PNG from a range of authors published in the literature over a time period, 1979-1992 (18, 19, 20, 21, 22, 23) within these limitations.

It is readily acknowledged that any data produced in the absence of a population based registry is bound to be an underestimate, with the true burden of cancer being much higher and therefore more profound the impact on any community.

Many estimates do exist in the cancer literature, both for overall and tumour specific data. Table 8 summarises overall cancer incidence and mortality data from a number of sources. In table 9 the current data on breast cancer is presented to illustrate the rising incidence of many tumours.

This is in line with global predictions of rising cancer incidence. Of an estimated 7.6 million cancer deaths in 2005, over half occur in low and middle income countries. This is expected to rise to 70% by 2020 if remedial measures are not taken (24). It is precisely these countries, such as Papua New Guinea, who are least prepared to deal with this scenario.

For example radiotherapy provision throughout the Asia-Pacific region, where 3.8 million cases of cancer occur, is limited. Unfortunately, Papua New Guinea did not take part in an Asia-Pacific regional cooperative audit of radiotherapy in 1999, which revealed great disparities in radiotherapy services throughout the region. For example Indonesia, PNG’s immediate neighbour, has only 10% of the predicted number of radiotherapy machines it requires for an adequate cancer service (25). The UICC world cancer declaration (26) demands investment in health to reverse this trend.
Table 8: Summary of the sources and estimates of cancer data in PNG

<table>
<thead>
<tr>
<th>Source of estimate</th>
<th>Publication date of source estimate</th>
<th>Reference</th>
<th>Cancer data for PNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Hidden Burden Report</td>
<td>April 2001</td>
<td>(28)</td>
<td>Cancer admissions 204/100,000 in PMGH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cancer incidence 300/100,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cancer mortality 250/100,00</td>
</tr>
<tr>
<td>WHO executive report</td>
<td>August 2006</td>
<td>(29)</td>
<td>Cancer incidence 120/100,000</td>
</tr>
<tr>
<td>WHO world health statistics</td>
<td>2008</td>
<td>(15)</td>
<td>Cancer mortality rate 118/100,00</td>
</tr>
<tr>
<td>NDoH Discharge reports</td>
<td>2004</td>
<td>(30)</td>
<td>2213 new cancer cases 215 deaths</td>
</tr>
<tr>
<td>IARC Globocan 2002 database</td>
<td>2002</td>
<td>(31)</td>
<td>Age standardised cancer incidence/100,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Female: 165</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male: 148</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Age standardised mortality rate/100,00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Female: 103</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male: 104</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5 year prevalence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Female: 6067</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male: 3761</td>
</tr>
<tr>
<td>Western Pacific Regional Office</td>
<td>1990</td>
<td>(32)</td>
<td>Age standardised cancer incidence/100,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Female: 186</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male: 186</td>
</tr>
</tbody>
</table>
Table 9: The rising incidence of breast cancer in PNG, 1958-1998, adapted from (33)

<table>
<thead>
<tr>
<th>Year</th>
<th>Female population</th>
<th>Incidence per 100,000</th>
<th>Age standardised incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958-1961</td>
<td>856,909</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>1,364,200</td>
<td>3.5</td>
<td>2.3</td>
</tr>
<tr>
<td>1978-1987</td>
<td>1,364,200</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>1,642,238</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>2,070,404</td>
<td>4.8</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Data represented in figure 6 from the Globocan international cancer database of the International Agency for Research on Cancer (IARC) demonstrates the age standardised rate per 100,000. The bulk of cancers in PNG are oral cavity, cervical, liver and breast, the burden of which disproportionately affects women.

Table 10 collates all the incidence data from these four highest rate cancers and demonstrates that assuming a PNG population of 6 million then 9,204 annual cancers will occur. Of these four highest incidence cancers in PNG, three are potentially preventable with the implementation of management strategies, including:

- tobacco and betelnut control
- hepatitis B virus (HBV) vaccination
- human papilloma virus (HPV) vaccination combined with cervical cancer screening by a variety of techniques

Whilst breast cancer cannot be prevented it can be impacted with education and screening, allowing early detection and better survival outcomes. Figure 7 demonstrates the overall female cancer incidence from Globocan 2002 database in graphic format.

Papua New Guinea has already become a signatory to the Framework Convention on Tobacco Control (FCTC) and implemented a nationwide hepatitis B vaccination program in childhood. The future is exciting with the forthcoming possibility of the implementation of a phased, nationwide implementation of a cervical screening and vaccination program against the human papilloma virus. With these programs in place the majority of cancers could be prevented or detected early to allow greater survival.

The outlook may appear full of challenge, yet there is good reason for optimism; overall nearly 50% of cancer is potentially preventable and there are many examples of successful programs that have overcome great constraints in low income/resource countries. For example:

- Visual Inspection with Iodine (VIA) Cervical Cancer program in Kenya (34)
- Single visit prevention schemes for cervical cancer in Thailand (35)
- Breast Cancer Pilot Project in Ethiopia (36)
- Glivec International Patient Assistance Program (GIPAP) (37)
The bases for these and many other interventions have been known for many years. The challenge is now to translate this into effective actions that will make a difference, as noted: “The Medical Symposium in Lae in 2001 reminisced of how well things worked in the past and produced a new blueprint for resurrecting the situation (The Burden of cancer in PNG). Little action has eventuated to date, except the Department of Health has recognised cancer services as a priority” (38).

Figure 6: Age-standardised incidence rate per 100,000 of various cancers in Papua New Guinea (31)
Table 10: Incidence rate per 100,000 of the highest rate cancers in PNG according to Globocan 2002 data (31)

<table>
<thead>
<tr>
<th>Site of cancer</th>
<th>Incidence rate /100,000</th>
<th>Combined incidence/100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Oral cavity</td>
<td>40.9</td>
<td>26.3</td>
</tr>
<tr>
<td>Cervix</td>
<td>40.4</td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td>19.4</td>
<td>10</td>
</tr>
<tr>
<td>Breast</td>
<td></td>
<td>17.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59.4</strong></td>
<td><strong>94</strong></td>
</tr>
</tbody>
</table>

Cancer services in PNG declined overall in the period from 1998, since the scaling down of the cancer centre in Lae. Lack of coordination, provision of awareness and preventative strategies, training and the provision of expert human resources, diagnosis, treatment and nursing care have all become determinants to diminish an effective cancer response (39, 40). In parallel, cancer has remained a key potentially preventable disease that potentially may claim 12,750 lives and produce an estimated 15,000 new cases annually (41). Illustrative of this situation in PNG are for example:

- the 5 year survival rate for paediatric acute leukaemia at the Kudjip Nazarene Hospital in Western Highlands Province is currently negligible (42)
- in Port Moresby a study in 2001 of 58 cases of paediatric leukaemia comments “…treatment and survival rates are low…” (43)
- recurrence of head and neck cancer following surgery is 100% at Goroka Base Hospital (12)
- nationally patients face a disease course without access to effective analgesia for severe pain (44)

The National Health Plan in addressing the challenge of malignant disease has as its goal; “To reduce illness, suffering and deaths by preventing cancers and improving treatment and palliative care.” (45).

This vision was re-emphasised and further clarified in 2001 by both; “The Hidden Burden, Cancer in Papua New Guinea” and the Annual Medical Society Symposium having its theme of Cancer. The Hidden Burden Cancer report advocated the creation of a national cancer control program and recommended a timetable in which transformation of services was to take place within.
This was not wholly adopted by the Department of Health in 2001, which rather followed the National Health Plan priorities of:

- Improve community awareness and education
- Strengthen screening, diagnostic, treatment and palliative services
- Review the Tobacco Products (Health Control) Act (1987) and regulations
- Increase the Hepatitis B vaccination coverage, particularly in the Highlands
- Update the knowledge and skills of health care workers
- Improve surveillance and reporting (46)

Subsequently the mainstay of all cancer treatment in Papua New Guinea has been surgical. This is available at most government provincial base hospitals and many faith based hospitals. Chemotherapy is only available a limited number of centres: Port Moresby General Hospital, Port Moresby, Angau Memorial Hospital, Lae and some faith based hospitals, for example Kudjip Nazarene Hospital. Radiotherapy had been unavailable in-country since the decommissioning of the radiotherapy unit in 1998.

Key Elements of the Hidden Burden report recommendations were not implemented, progress and direction remaining piecemeal until, in 2007, the National Department of Health created the National Cancer Committee. This committee was formed with a remit...
to coordinate the comprehensive development of cancer services. The outcome of this process 2007-2008, has been to:

- Rejuvenate cancer planning and create a national cancer control program
- Country membership of the International Atomic Energy Agency (IAEA)
- Rebuilding of the cancer centre at Lae and the creation of a National Cancer Institute at Lae and Port Moresby General Hospital
- Purchase and installation of a new MDS-Nordion Cobalt-60 radiotherapy machine
- Reworking of cancer chemotherapy drug supply
- Provision of human resources with the appointment of an Australian radiation oncologist

With this development in Lae, it is now an imperative to coordinate and re-establish pathology services in Lae and establish a link facility with the histology services at Port Moresby General Hospital. This is to facilitate the provision of expert malignant diagnosis to enable the cancer unit to function effectively.

It is here where the possibility of this telepathology proposal, creating such a link between the two hospitals, would impact the management of cancer patients within such a system.

**eHealth as a global strategy**

With the advent of major advances in information communication technology (ICT) and the world wide web there is an unprecedented level of global connectivity. Within a healthcare context this has had and will continue to have a profound effect on the future of healthcare delivery and how systems of healthcare are created.

The overall term applied to this combination of technology and health is eHealth, and defined simply as, “The use of information and communication technologies for health…” (47). eHealth has great potential for the transformation of health systems and services, as recognised at the 58th session of the World Health Assembly, where eHealth resolution 58/28 was passed securing the focus of Information and Communication Technology (ICT) as a key strategy in the drive for improved health care. The resolution stated:

“(1) to consider drawing up a long term strategic plan for developing and implementing eHealth services that includes an appropriate legal framework and infrastructure and encourages public and private partnerships;
(2) to develop the infrastructure for information and communication technologies for health as deemed appropriate to promote equitable, affordable, and universal access to their benefits, and to continue to work with information telecommunication agencies and other partners to strive to reduce costs to make eHealth successful… (4) to endeavour to reach communities, including vulnerable groups, with eHealth services appropriate to their needs” (1)

The World Health Organisation (WHO) subsequently formed the Global Observatory for eHealth (GOe) in February 2005, in recognition of the importance of the
diverse electronic developments and the critical present and future role they will play in the delivery and improvement of healthcare services.

Indeed, the findings of the Report for the World Summit on the Information Society, 2005, comments: “Advances in ICT have yielded substantial dividends to individual and public health. From the local level to the national level, ICT is changing how health care is delivered and how health care systems are run. Today, ICT is fundamental for health systems to meet obligations to deliver care, pursue research, educate students, treat patients and monitor public health” (48).

This has led to the design and implementation of eHealth strategies that can be at the international, national, provincial, local or institutional level. The power of eHealth paradigms is that they have no borders and in connecting, create unique networks of relationships that can transform healthcare delivery.

The Global Observatory on eHealth has structured eHealth strategies into:

- Electronic Health Records
- Patient Information Systems
- Hospital Information Systems
- General Practice Information Systems
- National Electronic registries
- National Drug registries
- Decision Support Systems
- Telehealth
- Geographical Information Systems

Many worked out examples exist that exemplify the combination of technology and health; the eHealth strategy of British Columbia in Canada (49) and St Jude Children’s Hospital in Memphis, USA has an international outreach eHealth arm (50). This institute has formulated an online eHealth strategy to assist the development of paediatric oncology- cure4kids. With an online “oncopedia” available through a website and innovative twinning partnerships, major breakthroughs in healthcare are possible. Numerous other global projects exist (51, 52, 53, 54)

These programs proliferate as countries recognise their inherent potential and allocate resources to utilise this technology, as illustrated in figure 8 (55). This can then be measured in terms of a Technology Achievement Index (TAI). The leaders in TIA are Finland, United States and Sweden with TAI values over 0.7 (56), whilst Papua New Guinea has a value less than 0.1.

Many of these programs involve telehealth, which focuses on health programs utilising distance bridging technologies. In a recent global survey of eHealth within non-OECD countries, by the GOoe (57), telehealth was rated as extremely useful or very useful by over 75% of the countries surveyed, as demonstrated in figure 9. This indicates there is a growing interest globally in applying telehealth technologies to health care delivery models. Telepathology is one form of telehealth, where image rich digital media are transmitted through a variety of means to afford second opinion, diagnosis or education

This usefulness is illustrated well by global telehealth projects that have been successful. For example a recent paper by Kvedar et al (58), describes the implementation of “operation village health” in remote rural Cambodia. This was a
collaborative partnership between two institutions in the USA (Brigham and Women’s Hospital and the Massachusetts General Hospital) and two non-profit organisations; the Sihanouk Hospital Center of Hope and American Assistance for Cambodia (based in Phnom Penh, the capital city).

Figure 8: Global expenditure on ICT as a proportion of Gross Domestic Product (55).

Patients at either two remote sites have access to a national nurse and assessments and digital photography are performed and relayed through satellite internet connectivity to the participating partners, 90% of which are oncological in nature and showing: “This pilot project has demonstrated that telemedicine can have a positive impact on the public health of very remote communities in the developing world” (59). Likewise in an urban setting in Brazil, an internet linked network has been created to establish a national hospital-based cancer registry and database (60).

The potential and powerful value of connectivity provided by ICT and the use of electronic databases to aid the health planning process, facilitate clinical research and give essential outcome measures to the effectiveness of treatment or preventative strategies is clear. Given the situation in Papua New Guinea with malignant disease registration such an ehealth integrated national registration system of malignancy would give more accurate incidence figures; with the possibility of follow up data for the reporting of mortality and morbidity figures.

The technology, both hardware and software, remains important but crucial is the:

- infrastructure in which the technology is placed
- the human resources who are to operate it
- the policies and standard operating procedures that govern usage
• the evaluation and measurement tools which will be used
• the leadership and political commitment that back up the whole effort

When these operate in an integrated way then maximum impact can be created and sustainability generated by a systematised process, that builds a new model of operating.

Figure 9: Response ratings of non-OECD countries for a variety of eHealth tools (57)

Such a framework for the development of ICT, within a health care structure composed of these differing elements, need to be integrated. Certain factors assist this integration and certain others retard this. For example internet usage is one such key element, and its penetration through a culture and population will parallel the applicability of ICT solutions. This penetration has occurred unevenly and mirrors the prevalent development factors, just as other health and socio-economic disparities do.

This can be represented graphically in a Lorenz curve, and is essentially a representation of the degree of inequality for any chosen parameter. For example in internet usage, as shown in figure 10 (61), in 1997 most internet usage was restricted to 20% of the world population, however by 2004 the proportion had widened to 60%,
demonstrating the advancing equality. Other indexes for modelling this transitional process have been created for ICT, such as the ICT diffusion index and Technology Achievement Index. These take into account a wide scope of factors and are a useful tool to track changes within and between countries and the impact of a variety of technologies as they are introduced, as discussed next.

**Figure 10: Lorenz curve showing variation of proportion of internet users to proportion of population 1997-2004 (61)**

![Lorenz curve](image)

**eHealth strategies in the Pacific**

The Pacific is a widely dispersed group of small and large island nations within the Western Pacific region of the World Health Organisation. It is a diverse region and the most populous region of all WHO regions, principally because of the presence of China. There are wide disparities in the region in health and ICT and to enable the design of strategies which gain the benefit of advancing technology; researchers have modelled the key elements that are required to allow diffusion of ICT. In this way eHealth can progress and become accessible to those communities that need a particular service.

This model is called the ICT diffusion index (ICTDI) and it is both a measurement and comparison tool to evaluate the penetration of ICT within a country and between countries. Its calculation is based on two indicators; connectivity and access. These are each measured according to the following parameters:

**Connectivity**
- Number of internet hosts per capita
- Number of personal computers per capita
- Number of telephone mainlines per capita
- Number of mobile subscribers per capita

Access
- Estimated internet users
- Adult literacy rate
- Cost of a local call
- GDP per capita (in Purchasing Power Parity with US dollar)

The index value is between 0 and 1, with a higher index indicative of more diffusion of ICT. The ICT diffusion indexes for the Western Pacific region are shown graphically in figure 11. The data is taken from the recent “Digital Divide Report”, published by the United Nations Conference of Trade and Development in 2006.

Figure 11: ICT Diffusion Indexes (ICTDI) for the Western Pacific Region 2005 (62)
There is a clear relationship between the GDP per capita of a country and its ICT diffusion index, this is illustrated well in figure 12. There are a large proportion of countries at the 0.2 index and around a GDP of 1000 PPP US$. However, this is not the only determinant as certain countries with much higher GDP have a relatively low ICT diffusion index, for instance Equatorial Guinea.

Papua New Guinea is a good case of ICTDI development. Its current position in 2005 was within the low band of low ICTDI and low GDP. The PNG government in May 2007 released a new ICT policy (amended version released in October 2007). This paved the way for the breakage of the monopoly of Telikom PNG on mobile subscription, with the introduction of Digicel provider of mobile telephony. The consequence of this was that “…the Department of Treasury has indicated that the start-up of Digicel has added 0.7% to this year’s gross domestic product growth of 6.2%.” (63). This will have a significant effect on the ICT diffusion index due to its calculation based on mobile subscribers and GDP. When combined with extension of VSAT technology to rural areas the effects will be considerable.

It is this implementation from policy which will provide a sound foundation for eHealth strategies to penetrate effectively throughout countries in the Pacific.

Figure 12: Variation of ICT diffusion Index (ICTDI) with Gross Domestic Product (GDP) for a range of countries, Papua New Guinea illustrated (64)
Historically there have been many strategies of eHealth in the Pacific region including:

- **The Pacific Public Health Surveillance Network (PPHSN)**
  This was established in 1995 by the Secretariat of the Pacific Community with its telehealth arm, PACNet, being launched in April 1997. This network was created to rapidly disseminate information for public health. It has internet accessible arm called PACNet (65).

- **The Western Pacific Health Net (WPHNet)**
  This was founded by the Pacific Basin Medical Association in 1995 to coordinate regional consultation and distance learning. It is currently not operational (66).

- **Pacific Island Health Care Project.**
  This project, initiated by the Tripler Army Medical Center in Hawaii, has served patients from the United States Associated Pacific Islands (67).

- **Armed Forces Institute of Pathology (AFIP)**
  This US institute is a centre of excellence in telehealth and telepathology research. It has a dedicated global telepathology service (68).

- **WHO Fiji distance learning network.**
  This network of some 19 centres offer diploma, undergraduate and postgraduate courses in medical laboratory technology, pharmacy, pharmacology, public health, mathematics, science and English language (69).

- **Swinfen Charitable Trust telehealth network**
  This is a charitable network and operates globally assisting doctors in developing countries (70).

- **Queensland Centre for Online Health**
  This is based in Brisbane and coordinates eHealth projects and research throughout the Pacific (71).

The first Pacific telehealth conference was held in Noumea in 1998 (72), which reviewed promising and innovative solutions to the physical and professional isolation and distance related limitations of education and consultation in the Pacific region. The conference had participants and papers presented from:

- Fiji
- Federated States of Micronesia
- Marshall Islands
- Tonga
- New Caledonia
- Tokelau
- Republic of Palau
- Solomon Islands
These covered telehealth, distance education and telecommunications. In 2000 these were subsequently published in an entire volume of the Pacific Health Dialog devoted to telehealth in the Pacific.

It can be seen that despite the low ICTDI, remarkable and sustainable eHealth strategies have evolved in the Pacific region to serve its people. Therefore the proof of concept exists for the advocacy of eHealth solutions and systems to improve health delivery.

Key to the support for the creation of a telepathology network such as CTNP, in Papua New Guinea, is whether eHealth projects have been trialled in the Pacific region. These can then serve as useful models for the design and implementation of CTNP, noting those elements that contributed to their success or failure.

The Swinfen Charitable Trust in the United Kingdom in collaboration with the Queensland Centre for Online Health organised a global telehealth network for the support of doctors working in hospitals in the developing world (70). This has been facilitated by medical students participating in the four U21 universities, and the project occurred at sites in Papua New Guinea, Sri Lanka and Pakistan.

In Papua New Guinea, at Tabubil, 30 patients were referred to the network for opinions from project inception in June 2005. Overall 9 out of 67 queries were pathological in nature however most, 26 cases, were related to internal medicine. The mean response time to any e-referral was 20 hours (inter-quartile range 5-85 hours).

The results of 785 e-referrals for the whole of the Swinfen Charitable Trust telepathology network from June 2005- May 2007 demonstrated a similar pattern to the PNG eHealth study. Medical students were able to overcome potential e-barriers, such as technological knowledge, time and resource constraints to provide a useful service that was valued as a learning experience. Sustainability criteria were identified as the key risk for the projects success or failure. The outcomes of the project are reported fully by Wootton et al (73).

The project’s success at this remote location indicates the eminent transferability of the technology to diverse locations within Papua New Guinea. It is clear that there is abundant evidence to establish the proof of concept of eHealth strategies directly appropriate for Papua New Guinea. We now consider telepathology itself, the key paradigm of eHealth for the CTNP, and the parallel evidence to validate its introduction.

Telepathology as an eHealth strategy in the Pacific

The term telepathology was coined by Weinstein in 1986 (74), and referred to the use of the emerging information and communication mediums to advance the field of pathology, which at its heart, is reliant on image rich formats. This historically has been through the use of the light microscope. A complex technology-led evolution of both imaging technology and its global transmission by digital image capture and the world wide web respectively has transformed the practice of pathology.

Telepathology enabled the separation of the patient and the sample from the diagnostic process, enabling global consultation, especially helpful in geographically remote contexts and where pathological human resources are constrained. Since the inception of telepathology there has been a rapid proliferation of global institutions that
use this technology in the developed world (75, 76, 77, 78) and the developing world (79, 80, 81, 82) and telepathology is considered a powerful application of eHealth.

Initially the developments in teleradiology led the way with formulations of international interoperable systems such as DICOM with the support of large corporations and their investment. Telepathology, although it has proceeded in a more diffuse approach with a lack of standardised interoperable systems, has never the less made great strides in digitally representing a pathology sample. The three basic operating models have been created in both parallel and series:

- Static image
- Dynamic image
- Virtual slide imaging

In static systems, images are captured by digital or video mediums and then stored until viewed or transmitted (often called store and forward). In more developed systems single images can be fused together to gain an image of the whole slide at various magnifications. Dynamic imaging is in real time and utilises robotic or non-robotic means to control the image production. Both the operator and the viewer can then be physically distant from each other.

The most advanced development is the production of virtual slides; technology digitises the entire slide at all magnifications, dispensing with all physicality. Modern slide processors through array technology can perform this task rapidly and at high quality to produce memory dense files. Each technology has hybrids and variations and the systems have been classified by Weinstein et al (83), adapted in table 11.

Telepathology has a wide range of proven applications:

- intra-operative frozen sections
- routine surgical pathology
- second opinions, consultations and expert review
- quality assurance programs
- distance education.

Surgical pathology can be provided with differing levels of service also classified by Weinstein, from basic, simple to complex and compound (84). Though these systems have been designed in the developed world, where facilitating telecommunications are present, the opportunity was seen for the application in developing countries. As clearly evidenced, developing countries have both pathology, cancer services and ICT that are resource constrained and projects have been pioneered to apply this technology, within these limitations.

The diagnostic process is an essential focus of telepathology, as accuracy and precision are required in order to give the best diagnosis. The true diagnosis for comparison is always the conventional light microscopy of the slide. In this process of diagnosis with telepathology as experience grew it became clear there were different levels of diagnostic certainty (85) and this process was termed concordance. Different coding schemes have been proposed and most defer accuracy to clinical impact, table 12 gives an example from reference (86). For instance if the telepathologic diagnosis differed from the standard diagnosis by a minor degree such that no clinical difference is
made to the patient then this is considered tolerable. Obviously if a major discrepancy is found then this has significance for the system.

Table 11: Classification of telepathology technology (83)

<table>
<thead>
<tr>
<th>Class of technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dynamic/real time (non-robotic or robotic)</td>
</tr>
<tr>
<td>2</td>
<td>Store and forward (robotic, non-robotic and stitch)</td>
</tr>
<tr>
<td>3</td>
<td>Hybrid (dynamic and store and forward)</td>
</tr>
<tr>
<td>4</td>
<td>Virtual slide (non-robotic/robotic processor)</td>
</tr>
<tr>
<td>5</td>
<td>Virtual slide with varying degrees of rapidity</td>
</tr>
</tbody>
</table>

Diagnostic accuracy is dependent on several factors (86):

1. Image production technology:
   - image selection,
   - focus
   - resolution
   - poor staining
   - inadequate range of magnification
   - inadequate illumination
   - thick section
   - corrupted images
   - pixellated image
   - poor preservation
   - tangential section
2. Storage technology, eg memory capacity
3. Transmission technology, eg internet speed for upload and download
4. Practice model; virtual academy, triage, super-specialist
5. Human performance: attitudes, training, performance

In the replacement of any previous technology with a new approach, the diagnostic accuracy should ideally not be compromised. Diagnostic accuracy studies are summarised in table 12, all of which use a static image based technology, which would be used in CTNP. The clinical acceptability of the results are well above 80%, and in a clinically constrained environment, as in most developing countries, a basic level 1 or 2 diagnosis is satisfactory.

In the literature there are few examples of randomised controlled trials of telepathology with standard techniques, which would be a definitive test of the technique. However in a landmark study by Furness et al (87), which was been performed using
virtual slide technology in a quality assurance context there was no detectable diagnostic difference between virtual and conventional slides. In this paper a preliminary proposal is suggested for this innovation to take place within the context of a randomised controlled trial to provide further accumulating evidence of efficacy and impact.

Table 12: Quality diagnostic codes used by AFIP to compare telepathologic and manual slide diagnosis (86)

<table>
<thead>
<tr>
<th>Quality code</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No diagnosis given by referring hospital</td>
</tr>
<tr>
<td>2</td>
<td>Complete agreement</td>
</tr>
<tr>
<td>3</td>
<td>Minor discordance with no clinical impact</td>
</tr>
<tr>
<td>4</td>
<td>Major disagreement with clinical impact</td>
</tr>
<tr>
<td>5</td>
<td>Diagnosis deferred</td>
</tr>
</tbody>
</table>

Table 13: Summary of diagnostic accuracy of static imaging telepathology studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Diagnostic accuracy</th>
<th>Clinically insignificant</th>
<th>Clinically Major discrepancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Williams et al (86)</td>
<td>73.7%</td>
<td>97.3%</td>
<td></td>
</tr>
<tr>
<td>Brauchli et al (88)</td>
<td>69.1%</td>
<td>89.3%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Brauchli et al (89)</td>
<td>84.8%</td>
<td>95.7%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Fisher et al (90)</td>
<td>47%</td>
<td>88%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Throughout the Western Pacific region there are many examples of telepathology projects (67, 68, 70, 77, 88, 91, 92, 93). These are summarised in Table 14 and geographically mapped on figure 13.

The Solomon Islands telepathology project (88), serves as a model that closely resembles the context in Papua New Guinea, as opposed to the more advanced institutes that undertake to accept referrals from other developing nations. During its life cycle it produced histopathology results within 12 hours of submission and an acceptable level of accuracy, in comparison with conventional histopathology performed at a reference centre at the Royal Brisbane Hospital in Queensland (88).
Table 14: Summary of telepathology projects in the Western Pacific

<table>
<thead>
<tr>
<th>Telepathology Project Source</th>
<th>Countries served</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armed Forces Institute of Pathology (AFIP), USA</td>
<td>China, Korea, Philippines, Guam</td>
<td>(68)</td>
</tr>
<tr>
<td>Fiji School of Medicine</td>
<td>Fiji</td>
<td>(91)</td>
</tr>
<tr>
<td>Pacific Island Health Care Project Tripler Army Medical Centre</td>
<td>Federated States of Micronesia, Republic of the Marshall Islands, American Samoa, Republic of Palau, Guam, Commonwealth of the Northern Mariana Islands</td>
<td>(67)</td>
</tr>
<tr>
<td>Peking University Health Science Center</td>
<td>China</td>
<td>(92)</td>
</tr>
<tr>
<td>Solomon Islands Telepathology Project</td>
<td>Solomon Islands</td>
<td>(88)</td>
</tr>
<tr>
<td>Swinfen Charitable Trust/ Queensland Centre for Online Health</td>
<td>Papua New Guinea, Solomon Islands</td>
<td>(70)</td>
</tr>
<tr>
<td>Sihanouk Hospital Centre of Hope</td>
<td>Cambodia</td>
<td>(89)</td>
</tr>
<tr>
<td>Kyoto University</td>
<td>Japan</td>
<td>(77)</td>
</tr>
<tr>
<td>New Caledonia Territorial Hospital</td>
<td>New Caledonia</td>
<td>(93)</td>
</tr>
</tbody>
</table>
Figure 13: The WHO Western Pacific region illustrating geographic sites of telepathology projects
The system was a collaboration between the National Referral Hospital (NRH) in Honiara and the University of Basel, Switzerland. Pathology specimens were cut up and processed by a surgeon at the hospital and 2 laboratory technicians in order to produce embedded paraffin blocks that could be sectioned into 4-6 micron slices, mounted on glass slides and stained with haematoxylin and eosin (H&E). The slide images could then be captured with an Optiphot 2 Nikon microscope and Nikon coolpix digital camera. This produced 640 x 480 pixel images of .jpg file size 20-70Kb. These were then transferred by a telephone modem dial up connection with a speed of 33Kb/s.

A dedicated telemedicine platform had been created at the University of Basel and incoming email was received by the server then redirected to a confidential group. The on call pathologist was then alerted by email and could access the site from any location, view and report the images and a final diagnostic email was returned to the email account of the sender in Solomon Islands. If the case was not directly reportable it could be referred to a Virtual Institute for group consultation and final diagnosis.

The results of this two year project 2002-2004 have been reported and are summarised in table 13. The project is currently not operationally. This gives valuable insight and lesson into the sustainability of such technology based projects.

Table 15: Key indicators of telepathology in the Solomon Islands adapted from reference (88)

<table>
<thead>
<tr>
<th></th>
<th>Phase I</th>
<th>Phase II</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of consultations</td>
<td>73</td>
<td>260</td>
<td>333</td>
</tr>
<tr>
<td>Median time to first response (hours)</td>
<td>28</td>
<td>8.5</td>
<td>12</td>
</tr>
<tr>
<td>Consultation possible</td>
<td>93%</td>
<td>94%</td>
<td>94%</td>
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The results indicate the possibility of gaining very fast turnaround times with this basic technology system of tissue processing, image capture and transmission. If this can be replicated and translated to Papua New Guinea the difference will be a vast improvement of the turnaround times currently reported (11, 13) and will make a profound difference to all dimensions of patient care.

As mentioned, the Solomon Islands project utilised a virtual institute. This is demonstrated symbolically in figure 13. The non-expert located in the Solomon Islands prepared a tissue sample taken from the patient and then captured the image and transmitted this to the University of Basel server. From here it is directed into a confidential group solely for the use of the project and its participants. An on call pathologist is then alerted by email that a request and its images have arrived. The reporting pathologist can then access the confidential server, view the images from any
global location, make a telepathology diagnosis and report it in written form, or if the case is complex and a full diagnosis cannot be made then refer it to the expert group. The final report is then entered into the system by the on call pathologist or the expert group, and emailed back to the Solomon Islands. This process is facilitated by the ipath software, which is open source and free of charge to use. The American Forces Institute of Pathology (AFIP) use a similar system and it is described at length by Williams (86), including the outcome measures of the project.

The Solomon Islands Project using very simple technology and store and forward image capture and dial up transmission achieved impressive outcomes. With its demonstrable efficacy the Collaborative Telepathology Network Project will follow this model and utilise the same ipath software in collaboration with the University of Basel.

The integral elements of the CTNP will now be presented as an adaptation to this version, given the unique circumstances in PNG, with the presence of automated tissue processors and histopathologists.

Figure 13: Composition of the Virtual Pathology Institute in the Solomon Islands Telepathology Study (94)
The Collaborative Telepathology Network Project

Foundational principles

Pioneering ICT and eHealth solutions, as envisioned by many development and policy proposals (1, 2, 3, 4, 5), are required to improve healthcare delivery of both pathology and cancer services in PNG, and evidence for this need has been carefully reviewed:

- The current level and quality of pathology and cancer services,
- Current data, recently analysed, on the prolonged histopathology and haematopathology turnaround time
- Poor indicators of patient survival with malignant disease, which disproportionately affects the rural poor and women
- Impact of current global, regional and national eHealth strategies to healthcare in both developed and developing country settings

It is clear that eHealth strategies have the potential to achieve this goal of health advancement in the area of pathology and cancer care, and this paper has evaluated in some detail global, regional and local eHealth strategies and their basis, together with the general principles and specific practical examples of telepathology as a mechanism to meet this overarching purpose.

The Collaborative Telepathology Network Project (CTNP) is advocated as a powerful mechanism to recover the healthcare parameters in Papua New Guinea and address the health measures within the pathology service, utilising the ICT models that have been explored. The aim being, of CTNP, to **provide a rapid, accurate and quality assured telepathology service to transform the healthcare of patients in remote, rural Papua New Guinea.**

This project is an innovative strategy to provide a rapid and expert pathological diagnostic service by using the vehicle of telepathology through digital imaging and internet technology, which has been thoroughly reviewed and demonstrated to be an eminently workable solution both in-country, regionally and internationally.

This possibility was presciently described by Ross Humphries, the then president of the PNG Cancer Relief Society in 2001, in regard to recruitment solutions; “The problem of recruiting of a Specialist Oncology Doctor (and they do not come cheap) could be overcome by linking up again with an Oncology Department in Australia and then introducing new technology that is now quite common to remote areas and countries such as PNG. This technology is linking up with medical establishments and specialist in Australia or other overseas countries via the internet.” (39)

It is essential that this proposal runs parallel to a medium term solution to the current human resource shortage in pathology in Papua New Guinea. It is envisioned that within a 15 year period more nationally trained histopathologists will commence work within the Government Health Service, as is occurring in the National Department of Health vision for training in other specialties such as Surgery and Internal Medicine at the post-graduate level, as demonstrated earlier in figure 4 and table 5.

Likewise it is imperative that the CTNP facilitates this human resource process and does not de-skill and out-source and hence degrade this development. Rather the
CTNP will enhance the training and education of all current and future pathologists, be a valuable resource for communication and collaboration between pathology specialists globally and inspire quality teaching of pathology to medical students both in the School of Medicine and Health Sciences in PNG and potentially throughout the Western Pacific region. Like all technologies it is also anticipated to have a cross-cutting effect through many health disciplines in a diverse range of institutions both rural and urban, effectively building capacity in a sector wide approach and suggested by the medium term development strategy (MDTS).

The WHO has established key principles for the design and implementation of any ICT based eHealth strategy (95). For the CTNP these have been adapted and are demonstrated in figure 14. These will flow through all elements of the project.

Figure 14: Core Principles of CTNP

- Sustainable life cycle
- Reliable
- Create measurable impact
- Quality
- Ethical
- Accessible
- Transparent
Sustainability of the CTNP is crucial throughout its life cycle; five criteria will be considered in its creation:

1. ecologically sustainable  
2. economically viable  
3. socially fair  
4. culturally acceptable  
5. institutionally or systems integrated

With any technology there is a carbon footprint and this will be taken into account with the choice of infrastructure, the supply of power demanded by the operation of electrically dependent equipment and that it is the best value for reliability, maintenance, particularly durable for the conditions in PNG and disposal characteristics when worn out. The whole aim of the project is focused on the marginalised rural poor who are disadvantaged by the current configuration of pathology services and therefore in essence is participatory in nature and is a good example of a justice-orientated program that empowers the poor toward health.

With the growing familiarity and diffusion as demonstrated of ICT through developing country economies, as previously illustrated, this feature will be the case for PNG due to the progressive ICT government strategy, which will promote their growing uptake. Critical to this process is the status of ICT knowledge and perceptions in PNG and in anticipation of the creation of CTNP, the first ever eHealth survey was carried out at the Annual Medical Symposium in 2008 (96), to gain an understanding of current perceptions to both ICT and telepathology in healthcare workers.

Figure 15: eHealth Survey 2008 responses to whether telepathology would be useful in PNG (96)
There was a 50% response rate, with 206 responses, allowing information gathering from a wide range of participating health care professionals spread throughout the nation. The findings of the survey, represented graphically in figure 13, closely mirror the results of the GoE survey (57) with 76.4% of respondents indicating that telepathology would be very or extremely useful, and a similar percentage (64%) would value email access to histopathology results as shown in figure 16.

The eHealth survey also recorded that seventeen of the nineteen provinces of Papua New Guinea have health care institutions with internet access and email; however this may be under-reporting within the limits of the survey. This demonstrates the sound foundation for the promotion of a digital eHealth network and hence CTNP to advance healthcare in a sustainable way.

Figure 16: eHealth Survey 2008 responses to the usefulness of histopathology result availability through email (96)

Furthermore the CTNP will operate within a governance framework of transparency, quality and ethical standards, with due attention to legal implications of this technology. The development of regulatory ethics is vital for CTNP in terms of:

- confidentiality
- use of the internet for transmission of sensitive data
- consent
- clinical research

This is echoed the telepathology literature (87), and a development process will be undertaken reflective of the ethical and legal principles in PNG and approval from those research bodies, such as the SMHS Research Committee, sought. The utilisation of clinical research is imperative for CTNP in order to:

- evaluate health and project outcomes in a standardised way
monitor and evaluate quality
assess impact and impact trajectory over time

This is particularly important with the use of a randomised controlled trial as a building block in CTNP. With the paucity of such research data in the world literature, there is a great opportunity to use the platform of CTNP to perform this study. This will be completed with international collaborative assistance in the setting of doctoral research to encompass quality, collaboration, education, training and most importantly the capacity building of Papua New Guinean researchers.

**Aims, objectives and functions of the CTNP**

The aim of CTNP is: **to provide a rapid, accurate and quality assured telepathology service to transform the healthcare of the patients in remote, rural Papua New Guinea.**

To achieve this aim the following objectives will be met:

- Create a sustainable national and pacific wide telepathology service
- Create a Virtual Pathology Academy of the Pacific (VPAP)
- Expand microscope and computer literacy and training for health care workers
- Perform a prospective randomised controlled trial of telepathology in the Pacific
- Expand and strengthen the knowledge and awareness of the community, health care workers and doctors to cancer and its treatment

This process is road mapped in figure 17, and is envisioned to occur over an 18 month timeline, which is represented in figure 18.

The role of the telepathology service will be multi-fold:
1. primary diagnosis of tissue specimens sent from provincial hospitals by in-country or international pathologists
2. provision of second opinion consultation by international pathologists
3. expert to expert collaboration
4. quality assurance of the histopathology and haematopathology service
5. video-conferencing
6. undergraduate and postgraduate education and training in pathology using digital images
7. ePBL (electronic problem based learning) a curriculum development for the Master in Medicine in Pathology program

After launch of this concept document and the enrollment of health institutions, the next step will be to demonstrate the efficacy of a working telepathology centre within the context of PNG.

This working telepathology centre in a pilot setting, with small volume funding, will be located at the SMHS/PMGH and connect to Angau Memorial Hospital (AMH) in Lae with an aim to provide second opinion consultations on histopathology and haematopathology specimens.
Figure 17: Overview road map of CTNP

- CTNP launched
  - Institutional endorsement: SMHS/UPNG, NDoH, PMGH, Provincial hospitals, faith based hospitals

- Establish telepathology centre at SMHS/PMGH/AMH
  - Pilot operation
  - Establish Virtual Academy of Pathology of the Pacific (VPAP) with international collaborators
  - ipath at the University of Basel with Professor Hurwitz

- Site visit and comprehensive assessment of those hospitals expressing an interest
  - Site Analysis

- Full costing and tender process
  - Formal submission document completed

- Project implementation in three phases:
  - I national telepathology network
  - II pacific telepathology network
  - III randomised controlled trial
Figure 18: TIMELINE FOR CTNP IMPLEMENTATION

2009

J
Telepathology proposal launched

F
Disseminate CTNP to key stakeholders in SMHS, PMGH, and NDoH

M
Establish telepathology (TP) centre at SMHS/PMG

A
Specialist knowledge visit to collaborators in UK, Australia & Switzerland

M
Establish VPAP

J
Site Assessment to interested hospitals

J
Installation of SMHS internet connectivity

2010

S
Site analysis Report efficacy of TP centre

O
Full costings and tender process

N
Formal full proposal written & submission for funding

D
Project preparation

2010

J
Project implementation

F
Launch of PNG telepathology network

M
Launch of Pacific telepathology network

A
Randomised controlled trial

M

Phase I Phase II Phase III
This service will be provided by established collaborations with principally, the University of Basel in Switzerland using the *ipath* system under the supervision of Professor Hurwitz.

The process map for a single sample through the CTNP is shown in figure 19. The sequence of events to produce a telepathology diagnosis once the sample is sent to a telepathology centre is illustrated. Once both the usefulness of both the concept and praxis are combined in a functional system, it will be a powerful advocacy tool to empower the further development of the program.

The priority thereafter is to garner the expression of interest of both provincial and faith based hospitals who would participate in the creation of a national telepathology network. Each prospective participant hospital would require to be visited and the administration of a comprehensive assessment for the installation of a telepathology centre.

The elements involved in this installation are:

- **Technological infrastructure**
- **Sustainable human resource capacity**
- **Training and educational potential**
- **Data collection, storage and research**

Guidelines for this assessment process are already in existence, both from the WHO and other institutions (95, 97) and will be used, along with health technology assessment tools (98).

This process will then enable the effective creation of the national telepathology network (NTN). Linking each regional centre and the hub at SMHS/PMGH, will be the internet with World Wide Web connection via satellite and this is illustrated in figure 20. The University of Papua New Guinea is a signatory to a memorandum of understanding in the participation of the PNG Academic Research Net (PNGARNet) along with many other academic institutes in PNG.

This PNGARNet network, along with UPNG’s open college network and the growing diffusion of internet access across all provincial hospitals and rural villages (through the RICS program), as evidenced in the eHealth survey 2008, will form an excellent platform to support the necessary internet connectivity for CTNP.

UPNG has also chosen the SMHS site as a model for its future ICT connectivity. A detailed schematic of the proposed for SMHS is illustrated in figure 21, taken from reference (99). It uses a diverse combination of linkage technologies that will facilitate gigabit speeds for intranet and internet capability throughout SMHS. For CTNP this will raise the possibility of real time consultation using the stored images over such technology as Skype (an internet telecommunication tool), which is free of cost implications to UPNG and any user.

This technology has already been pioneered by Professor Hurwitz in a program of telepathology in Cambodia (100), utilising the Skype program. This has enabled the training of a haematopathologist through this formally arranged mentor program.
Figure 19: Total process map of CTNP operation for a single patient experience

Patient presentation

Healthcare worker assessment

Health care worker recognition

Healthcare worker referral

Doctor assessment and/or referral to Hospital

Lesion biopsy

Tissue processing and embedding

Production of slide & analysis at telepathology centre

Digital image production by microscope and camera

Patient healthcare intervention

Doctor reviews patient

Doctor receives email and diagnosis

Email from ipath to referrer

Pathology diagnosis

VPAP pathology consultation via ipath

Email via internet to ipath server

Digital picture storage and forward as email attachment
Each of these elements will now be analysed in more detail with objectives for consideration:

**Technological Infrastructure**

To create the national telepathology service the following technological components are required and each will be addressed. At the initial site visit the capacity of each component will be investigated and recorded. A manual will be produced that will document a telepathology kit list that can be replicated at any site. This will be linked into a standard operating manual and when combined with training workshops will ensure a standardised competency for system operation of all technology. A troubleshooting and maintenance guide will also be incorporated in the manual to minimise operation downtime.

1. **Internet connection**

The geographic location of the national network will first be between SMHS, UPNG in Port Moresby and Angau Memorial Hospital (AMH) in Lae. This is because the National Cancer Institute at Lae will be operational in 2009 and will need access to rapid histological diagnosis. It is anticipated pathologists will be resident in Lae to facilitate the introduction and smooth transition of the project.
Figure 21: Schematic of the proposed connectivity at SMHS
At SMHS there will be a new internet network installed with a timeline of next 6 months and the detailed schematics of this network are shown in figure 21. This is anticipated to be a broadband ADSL network with speeds of up to 1 gigabit per second.

2. **Digital microscope**

Microscopes will be of good quality and reliability. Previous models trialled have been the Nikon Optiphot and the Olympus BH-2 with a digital camera attachment, either built in or detachable. This must be able to produce .jpg files of at least 700 x 500 pixels. With an ADSL/broadband network speed of at least 100kb/s, higher image quality can be afforded. There should be a maintenance contract in place to deal with breakdown and keep the microscopes sustainable.

3. **Image capture and field selection**

This is often a limiting factor in telepathology diagnosis if done poorly. Therefore training and experience is required to select the best images under the microscope for diagnostic yield. This will be facilitated by the pathologist, and thereafter this becomes a key element of the training program for regional centres where there is no resident pathologist.

4. **Computer**

This will be sustainably purchased for both initial sites. It will be able to:

- Utilise software for image capture
- Store images in a suitable program
- Access the internet by wireless or cable
- Have appropriate security measures to ensure confidentiality
- Possess removable back up storage

5. **Standard operating procedures**

There will be software that enables the division of responsibility and management of:

1. Data flow and data storage
2. Human resources
3. Technology
4. Security
5. Breakdown procedures

5. **Integrated patient registration and management software**

A robust system is required to handle all the data manipulation and storage needs. This will form the backbone of a cancer registration mechanism, to

- assist in data retrieval and
- new national reporting for up to date cancer data research
To facilitate this process an electronic health record would be useful to parallel the introduction of the project.

6. Collaboration with ipath

Following initial collaboration with the University of Basel in Switzerland, this link requires to be formalised with the setting up of a confidential group for the operation of the project, within the ipath network.

**Sustainable human resource capacity**

A priority is to utilise the human resources that are already in place at the various hub and regional centres, until newly trained pathologists are trained. In order to create this the following need to be implemented:

1. Pathology technicians identified to collaborate with the project.
2. Technology training to implement digital image capture, software and internet links and to train all professionals involved to be fully conversant with the technology and its operation
3. Identify a group of national and international histopathologists familiar with telepathology reporting to participate in a Virtual Pathology Academy of the Pacific (VPAP). These pathologists will generate the histopathology reports.
4. Mapping of human resources throughout all participating centres in site visit schedule
5. Human performance analysis. It is well known that telepathology has a learning curve just as any new technology
6. Identify all skill sets needed to complete a successful outcome and form a training manual and design training workshops
7. Ongoing training program to extend and consolidate capacity

**Training and educational potential**

1. Education for medical students, residents and postgraduate specialists through the use of virtual education sessions and clinico-pathological conferences. This will enable the sharing of current advances and introduce younger doctors to the nature of cancer and palliative care strategies
2. The starting of virtual clinico-pathological conferences for specialist clinicians and resident doctors and medical students to enhance knowledge of histopathology, cancer diagnosis and therapy
**Data collection, storage and research**

The importance is to develop elements that:

1. Develop a clear ethical basis for the project to operate within and to describe and implement culturally appropriate notions of consent and confidentiality to those patients participating in the program
2. The collection of baseline data especially to demonstrate current levels of key indicators will be important to then be in a position to judge the efficacy of the program by those same indicators
3. Data will be compatible with the national tumour registry facilitating data entry and the implementation of an electronic health record is advocated to facilitate data collection
4. Utilisation of standard data collection forms and appropriate software to analyse patient outcomes of morbidity and mortality, with use of an electronic health record

Upon completion of this rigorous site visit and assessment based on these outlined criteria a comprehensive analysis of each potential participating site can be performed. The strengths, weaknesses, opportunities and threats (SWOT) will be considered in a robust risk analysis.

Following this a full costing and tender process will be undertaken to include all the necessary budgets for every aspect of the program. A formal submission can then be composed for funding and when approved implementation can go ahead. This implementation will be in three phases:

- Phase I; the setting up of telepathology centres at the participating hospitals to launch the national telepathology network, as seen in figure 23 (faith based hospitals are in a purple colour, government in red)
- Phase II; the linking in with international centres in the Pacific. The Republic of Palau, Fiji and Solomon Islands have all expressed an interest to participate (101, 102, 103)
- Phase III; to commence a randomised controlled trial

Once introduced and operational the CTNP will undergo regular monitoring and evaluation against indicators. The following describes a list of possible indicators of the impact of the project:

1. Pathological diagnostic correlation comparing digital and conventional interpretation
2. Turnaround time (from sample acquisition to clinical decision for patient intervention)
3. Patient Outcome- Mortality and Morbidity
4. Level of community cancer awareness
5. Level of HCW knowledge and skill
Figure 22: Possible participant hospitals in the National Telepathology Network
6. Level of doctor knowledge and skill
7. Implementation of Palliative care approaches determining for example patient’s experience of pain
8. Clinician satisfaction with the program
9. Clinical research paper publication in peer reviewed journal

The CTNP needs to be both flexible and adaptable as it implements to meet the needs of its core principles, and therefore requires a leadership team who will oversee all aspects of the project and be responsive to leaders in each of the regional centres and internationally during this phase.

The importance of the clinical trial aspect has been emphasised and there is a need for further research in the literature for clinical trials in telepathology especially in low resource settings.

Much of the research data that has been reviewed is concordance data via a comparison of mean results in specifically designed coding to ensure there are no clinically significant errors in reporting; however this has been rarely linked to patient outcome.

The aims of commencing a prospective randomised controlled trial are to determine:

- The equivalence of using telepathology versus a conventional histopathological and haematopathological approach for pathological diagnosis
- Determine the equivalence of patient outcomes with each diagnostic methodology.

It is a key element of the overall structure of CTNP, as it affords an important opportunity to assess the efficacy and safety of telepathology in low resource settings. At present in the literature there is only one such randomised trial, and in a developed country setting (87). The trial will facilitate this contribution to global knowledge and for this reason it will form an excellent proposal for a doctoral thesis.

At its essence the trial will determine the non-inferiority of the telepathology mode of diagnosis in comparison to the standard technique. This type of clinical trial is called an equivalence trial, and therefore the null hypothesis is reversed to express a difference and the alternative hypothesis expresses no difference.

To determine the truth or falsity of the null hypothesis, confidence intervals are calculated and an equivalence range predicted which corresponds to an area of no difference. If the confidence interval of the telepathology dataset lies within this equivalence range then the null hypothesis is disproved and there is no difference between telepathology and the conventional diagnostic mode.

Uniquely in this trial, the data will also be linked to patient clinical outcome as again the world literature rarely provides prospective randomised trials in telepathology with this data. A summary of the study format is shown in figure 23. This trial will take place as a third phase after operation of all centres is confirmed.
Figure 23: Outline of a prospective randomised controlled trial for phase III of the implementation of CTNP

International multi-centre prospective randomised controlled equivalence trial

Patient clinical and demographic data
Histopathology Specimen

RANDOMISATION

Telepathology (TP)
Histopathology/ Haematopathology diagnosis

Conventional (C)
Histopathology/ Haematopathology diagnosis

TP vs C
Diagnostic concordance
Statistical analysis
Confidence intervals
Equivalence range

Patient outcome follow up data to compare mortality/morbidity
TP vs C
Summary

ICT is a powerful tool and its use in healthcare has had great proven benefits and has even greater potential for escalating future healthcare improvements. This potential for breakthrough in healthcare outcomes for patients has been seized by the government of Papua New Guinea and many other health institutions within the country and region. Policy documents advocate for the creation of innovative models of healthcare to improve service delivery.

A comprehensive plan for a Collaborative Telepathology Network Project is presented as such a model to fulfil the need for sustainable capacity building of pathology and cancer services in PNG. This is advocated based on a thorough review, including the presentation of first time research on turnaround times in both the histopathology and haematopathology service at the Port Moresby General Hospital, of the current state of pathology and cancer services in PNG.

The growing diffusion of ICT-based eHealth strategies is illustrated at all levels from global, international, regional, national, institutional and local and its scope defined, with multiple examples of key stakeholders and working, successful programs.

The architecture behind the creation of telepathology as an eHealth strategy is meticulously explored, to demonstrate the nature of this strategy, since its inception in the 1980’s. Telepathology programs within the Western Pacific region are summarised and how technological developments have evolved and impacted both the programs themselves and the healthcare outcomes.

A working telepathology model, pioneered in the Solomon Islands, is used to inform the structure of the CTNP. A comprehensive overview of the principles, aims, objectives, functions, funding and operation of the CTNP is presented. The requirement for clinical research is emphasised and a randomised controlled trial is advocated to potentially demonstrate any inferiority linkages between mode of diagnosis and patient outcome for the first time in the reported literature.

This document provides the conceptual and evidence based platform to proceed with the CTNP in PNG at this time. This process is to be seen as a unique opportunity for PNG and the Pacific, to make a profound difference to the healthcare of its citizens and in a global perspective to advance our understanding of the use of this powerful technology in low resource countries.

In essence, upon implementation, quality and rapid pathology diagnosis, both malignant and benign, will be delivered. The project will impact patient care in a way that is inclusive of the rural poor and women precisely because of their disproportionate experience of malignancy. With a growing scope, the CTNP will be launched in other states within the Western Pacific region to distribute these health benefits and enable collaboration between pathologists.

It will have this architecture due to the inclusive paradigm of eHealth, which is able to transcend many barriers to health potential, and the immense geographic limits within the Pacific region.
References

11. Tiu’amoa D, Garbett IK. A Retrospective Comparative Analysis of Turnaround Time (TAT) for Pathology Samples at Port Moresby General Hospital (PMGH). Poster number 93 at the Royal College of Pathologists of Australasia- Pathology Update 2009 Conference March 13-15th.
27. National Health Plan 2001-2010, Volume III National Health Profile, part 1. page 34.
42. Personal Communication: Dr Bill McCoy MD, Hospital Administrator Kudjip Nazarene Hospital.
45. National Health Plan 2001-2010, Volume II Program Policies and Strategies, p38
46. National Health Plan 2001-2010, Volume II Program Policies and Strategies, p38
49. www.health.gov.bc.ca/ehealth/. British Columbia eHealth strategy
50. www.cure4kids.org/
52. Chung HS, Choa M, Kim SY, Cho JH, Yoo SK. A comprehensive telemedicine system for remote guidance of emergency airway management. 7th International Conference on Successes and Failures in Telehealth. August 2007; p 51.
60. Moretto EG, Alegro MC, Hira A, Mello AN, Kondo MSK, Camanho P, Leitao A, Zuffo M. A Web-based system for the consolidation of hospital-
based cancer registries in Brazil. 7th International Conference on Successes and Failures in Telehealth. August 2007; p125.


71. www.uq.edu.au/coh


91. www.fsm.ac.fj


94. Contained in doctoral thesis by Dr K Brauchli, 2006, University of Basel, Switzerland.


98. www.hta.nhsweb.nhs.uk/


100. Hurwitz N. Personal communication 2008.

