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# Leprosy-tuberculosis Co-infection: A case report in Papua New Guinea

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## ABSTRACT

***Background:*** *The re-emergence of leprosy has been recently reported in Papua New Guinea, raising a public health concern about the neglect of this endemic infectious disease in the health and epidemiological transition of the country.*

***Method:*** *We describe a rare case of leprosy-tuberculosis co-infection using the patient history and medical records extracted from the Comprehensive Health and Epidemiological Surveillance System, operated by Papua New Guinea Institute of Medical Research.*

***Result:*** *A 25-years old male patient with co-infection of multi-bacillary leprosy and tuberculous lymphadenitis was reported for the first time in literature in Goroka, Eastern Highlands Province, Papua New Guinea. The review identifies key challenges in drug treatment regimens, tracing contacts and patient follow-up as major concerns, which can increase the risks of incomplete treatment, transmission of the diseases in the community.*

***Conclusion:*** *Our case study reports a rare patient with co-infections of primary Multi-Bacillary Leprosy plus TB Lymphadenitis in PNG. Throughout the process of diagnosis, treatment and follow-up with the patient, we highlight the key challenges in the implementation of the national leprosy elimination programme at the local level. Understanding of these challenges would help to design effective interventions to improve the performance of national leprosy control programme.*

## Keywords

Leprosy-tuberculosis co-morbidities, Comprehensive Health and Epidemiological Surveillance System, Papua New Guinea.

## Key points

Leprosy re-emerges in PNG and possibly links with tuberculosis.
Major challenges at the local level include contact tracing and patient follow-up.

New approaches are needed to strengthen community-based modality for effective management and control of leprosy-tuberculosis co-infections in PNG.

## Background

Despite improvements in treatment and poverty, there were still more than 200,000 new leprosy cases registered globally in 2018, with a prevalence rate of 0.2 per 10,000 population, according to official data from 159 countries around the world [1,2]. Leprosy remains endemic among estimated 10-15 million people, mostly living in developing countries, in clusters of poor settings.

Leprosy is a chronic, infectious, systemic disease caused by the *Mycobacterium Leprae (M. Leprae) bacillus,* which multiplies slowly. The disease has an insidious onset with the incubation period of about 5 years on average. *M. Leprae* is for the most part contained within the skin, but the bacteria transmit from person to person by nasal secretions or droplets of moisture passed through the air from the upper respiratory tract, nasal mucosa and mouth, during close and frequent contacts with someone who has leprosy but has not yet started treatment. It takes years before the disease develops, but a person can be infected within months of living with an untreated patient [2,3]. Leprosy is curable with multi-drug therapy (MDT) [1]. Untreated leprosy can cause progressive and permanent damage to the skin, nerves, limbs, and eyes, and resulting in disabilities and deformities [2]. Even patients who have been treated for leprosy can still develop new disabilities due to leprosy reactions. These reactions can lead to permanent damage before, during and after treatment. An evaluation of the microcirculation function *in vivo* suggested that the leprosy cutaneous lesions have a significant impairment of tissue perfusion, which aggravates the peripheral nerve degeneration [4].

The disease mainly affects the skin, the peripheral nerves, mucosa of the upper respiratory tract, and the eyes. The clinical presentations are characterised by hypo pigmented skin lesions with reduced sensation or cutaneous lesions called plaques. Leprosy patients are clinically classified into two types: Pauci-Bacillary (PB) and Multi-Bacillary (MB) based on the number of skin lesions, the presence of nerve damage and the presence of M. Leprae in a skin smear (Table 1) [3]. In 1966, Ridley and Jopling further classified leprosy patients into five subtypes: Tuberculoid Tuberculoid (TT), Borderline Tuberculoid (BT), Borderline Borderline (BB), Borderline Lepromatous (BL), and Lepromatous Leprosy (LL) [5]. According to this classification, PB includes TT and BT, and MB covers BB, BL, and LL. While classifying leprosy patients, it is important to ensure that patients with MB leprosy are not treated with the regimen for the PB form. The presence of acid-fast bacilli (AFB) in tissue specimens is regarded as a gold standard for confirming the diagnosis of leprosy [6]. A skin lesion with loss of sensation is also a definite confirmation of the diagnosis leprosy, as is an enlarged nerve with motor or sensory loss [2].

| Clinical symptom and sign | Pauci-Bacillary (PB) | Multi-Bacillary (MB) |
|---|---|---|
| Skin lesions (macula, papules, nodules) | • 1-5 lesions<br>• Well defined borders<br>• Asymmetrically distributed<br>• Loss of sensation | • More than 5 lesions<br>• Distributed symmetrically<br>• May or may not have loss of sensation |
| Nerve Damage:<br>• Loss of sensation<br>• Thickened nerves<br>• Weakness of muscles | • None or only one nerve involved | • More than one nerve involved |
| • Skin smear | • All negative | • One or more positive |

**Table 1: C**lassification of Leprosy, Standard Treatment Guidelines for Common Illnesses of Adults in Papua New Guinea, the National Department of Health, 2012.

We report the case findings from patient with Leprosy-TB co-morbidities in Goroka district, Eastern Highlands Province (EHP). We analyse key challenges in treatment, management and follow up with the patient. We raise concerns about the re-emergence of leprosy concomitant with tuberculosis from a health surveillance perspective, and highlight challenges in management of the patient in the local context of PNG. Finally, we discuss a new approach to developing a community-based modality for effective management and control of leprosy towards eliminating this neglected endemic infectious disease in PNG.

## Data source

Information and data used in this report were extracted from the morbidity data component of the Comprehensive Health and Epidemiological Surveillance System (CHESS), operated by the Papua New Guinea Institute of Medical Research (PNGIMR). The CHESS approach was first discussed in 2015 [7] and the PNGIMR's CHESS methodology has been discussed elsewhere [8].

CHESS clinical team is mostly based in primary health facilities within the surveillance sites, and provides healthcare services to the population. In addition, the team collects morbidity data from the patients, who seek services at the health facilities. The clinical team conduct individual face-to-face interviews with consenting patients, using a Morbidity Questionnaire. This questionnaire is based on various data collection tools, which are currently in use within the PNG public health system, including the Patient Card [9]. It comprises six data modules: (i) Patient identification information; (ii) Patient background information; (iii) Patient general health status; (iv) Clinical signs and symptoms of the current illness; (v) Laboratory investigations; and (vi) Diagnosis, treatment and management of the current illness. The patient's identification information and medical records are kept confidential in PNGIMR Main Office in accordance with the institution's Standard of Operation Procedures.

## Case characteristics

On 25$^{th}$ of February 2020, a 25-years-old male patient visited North Goroka Urban Clinic for the first time. The patient is originally from *Ieu* village, Gulf Province, but currently lives in *Masumave* village of *Ungai Bena* district, Eastern Highlands Province (EHP) for five years. With the patients consent, CHESS clinician conducted examinations and interviewed the patient.

## Clinical signs and symptoms

The patient was in good general health status, with overall health status indicators such as body temperature, heart and respiratory rates, Body Mass Index (BMI) and blood pressure in the normal range. The gastro intestinal tract, respiratory system, cardio vascular system and genital urinary system were all functioning well. The ears and eyes were well functioning. In the past 24 hours prior to the consultation, he had night sweats, joint ache and weakness, but no coughing symptom.

The patient had low muscle tone with swollen joints, numbness, and amyotrophic sclerosis and deformed clawing of the right

hand (Figure 1). He also had a swollen right elbow with enlarged nerve (Figure 2). There were several patches with typical signs of MB leprosy on the back (Figure 1), the left cheek (Figure 3), the left thigh and both legs (Figure 4). These patches appeared first on the face and the back three years ago and it was diagnosed as skin infection. The peripheral lymphoid nodes were enlarged, especially the nodes on the left neck and under the left armpit with scars and pus, indicating TB lymphadenitis (Figure 5). The patient has BCG scar on the left upper arm. He had a family history of leprosy and a personal medical history of TB.

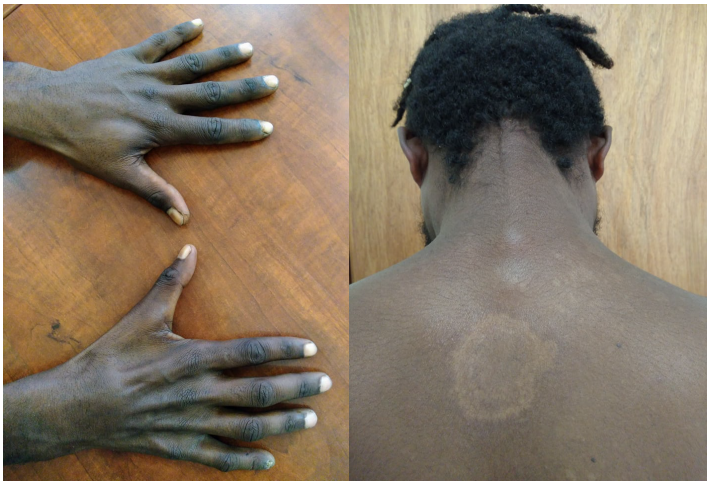

**Figure 1:** Patient's right hand with patches, numb, amyotrophic sclerosis and deformed clawing, and a Borderline Lepromatous (BL) skin lesion on the back, Leprosy-TB co-morbidities case study, PNGIMR's CHESS, 2020 (photo taken on 2 June 2020).

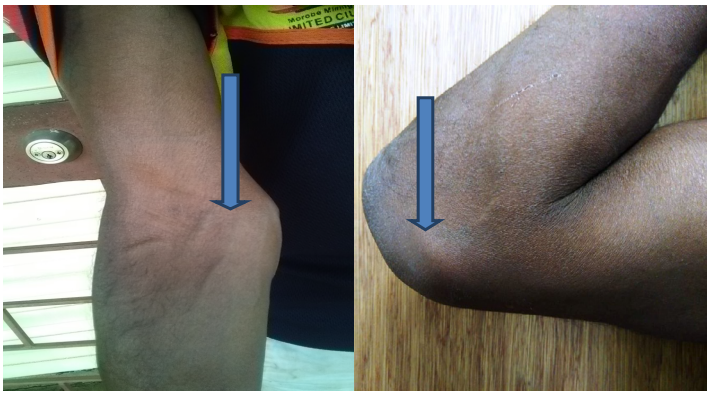

**Figure 2:** Swollen right elbow with enlarged nerve, Leprosy-TB co-morbidities case study, PNGIMR's CHESS, 2020 (the left photo taken on 7th April and the right photo taken on 2 June).

## Clinical diagnosis

Upon the clinical examination and given the typical signs and symptoms, the patient was diagnosed with Leprosy (MB) and extra-pulmonary TB (Lymphadenitis). He was referred to the Infectious Diseases Control Unit, Eastern Highlands Provincial Hospital for further investigation.

**Figure 3:** Borderline Borderline (BB) skin lesion on the left cheek, Leprosy-TB co-morbidities case study, PNGIMR's CHESS, 2020 (the left photo taken on 7th April and the right photo taken on 2 June).

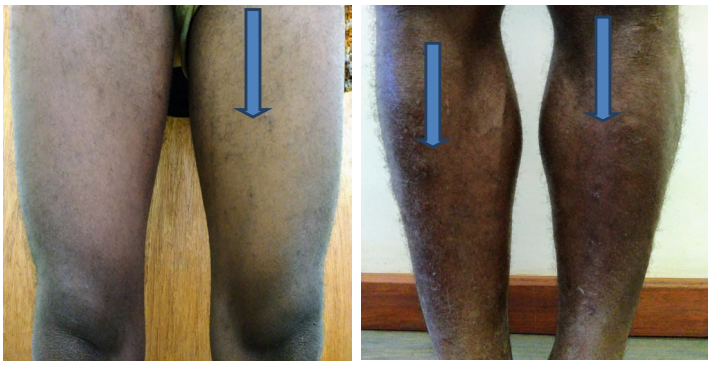

**Figure 4:** Borderline Lepromatous (BL) skin lesions on the left thigh and both legs, Leprosy-TB co-morbidities case study, PNGIMR's CHESS, 2020 (photos taken on 2 June).

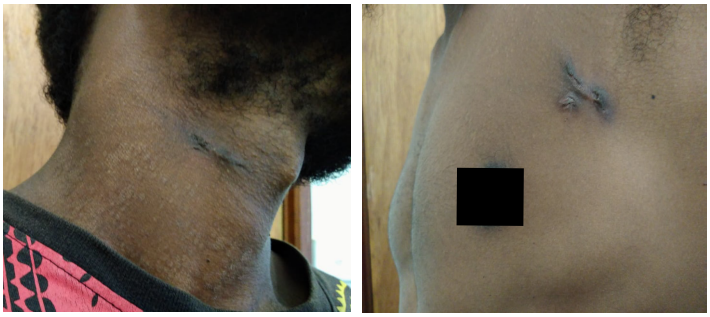

**Figure 5:** Scars with pus on the right neck and under the left armpit, and Borderline Tuberculoid (BT) skin lesions on the neck, Leprosy-TB co-morbidities case study, PNGIMR's CHESS, 2020 (photos taken on 2 June).

## Laboratory tests

As shown in Table 2, a chest X-Ray was performed on the 26th February 2020 confirming the patient had no pulmonary TB. Sputum sample was not taken and no lymph node specimen was collected for biopsy test to reconfirm clinical diagnosis of TB lymphadenitis as the patient had lymph nodes burst and healed up leaving clear scars at the neck and under the left armpit. Mantoux test was no longer conducted in PNG since the 2010s,

as recommended by PNG National Department of Health because of the high prevalence of TB in the country, resulted in many fault positives [10,11]. GeneXpert or TB culture services are currently not available in the hospital. Sputum samples of pulmonary TB suspected patients are often sent to the Central Public Health Laboratory in Port Moresby for GeneXpert testing, and to laboratories in Brisbane, Australia for TB culture, as needed. Since the patient has no pulmonary TB, sputum sample was not collected. No microscopy, GeneXpert or TB culture was conducted for this patient. Hence, TB-*Rifampicin* resistance status is not confirmed at this point of time. The HIV test is not done in the meantime, but it has been scheduled as soon as the patient revisits the hospital in the next time. No skin smear sample was taken for testing AFB. As recommended by the PNG National Department of Health, this patient has clear clinical signs of MB, detected by an experienced leprosy specialist, he commences straightforward the leprosy treatment without delay [12].

## Treatment

The patient took the Directly Observed Therapy Short Course (DOTS) for TB control with two phases of treatment [13]. The intensive treatment was a combination of four anti-tuberculosis drugs: *Rifampicin, Isoniazid, Pyrazinamide,* and *Ethambutol* for two months, which was completed in April. He then moved to the continuation treatment, where he was given two anti-TB drugs: *Rifampicin* and *Isoniazid* on daily basis for 4 months, plus *Pyridoxine* (Vitamin B6 for preventing peripheral nerve disorder such as impairment of hearing capacity caused by *Isoniazid)*. In addition, the patient took *Dapsone* and *Clofazimine* as part of the MDT treatment regimen for leprosy. It is noted that the MDT also includes *Rifampicin* with a dose of 600mg once a month but this dosage was already covered in the DOTS (Table 3).

## Management

There are a number of public health concerns arising from management of our patient in the local context of PNG. There is the potential for loss to follow up with patients who are treated with endemic infectious diseases in public health facilities in PNG. Currently, leprosy treatment has been integrated into general healthcare services; hence leprosy patients are treated as part of the out-patient service [12]. From our observation, some patients borrow health record books from other people, who live in the catchment areas of the CHESS, while others use different names or resident locations when attending health facilities for different health matters. These factors complicate the potential for health workers to effectively manage leprosy patients, resulting in low treatment completion rate, reported as low as 50% [12].

There is potential for the patient's non-adherence to the treatment therapy. We have observed that some leprosy patients stop their medication once they experience clinical improvement. In our case, the patient was provided a two-month supply of medication (April and May) as he was on expecting to travel to another location for personal reasons, which meant that he missed a scheduled re-examination.

| General health status | Clinical signs and symptoms | Family and medical history | Laboratory tests |
|---|---|---|---|
| • Body Temperature: 36.5 degree Celsius<br>• Pulse/Heart Rate: 86 beats / minute<br>• Respiratory rate: 20 breath/ minute<br>• Weight: 62Kg<br>• Height: 167cm<br>• Body Mass Index: 22Kg/m2<br>• Systolic blood pressure: 112mmHg<br>• Diastolic blood pressure: 80mmHg | • Patches on the cheek, back, legs and left thigh<br>• Swollen left elbow with tender enlarged nerve<br>• Swollen enlarged neck and axilla glands with scars of pus<br>• Loss of sensation of right hand (numbness) with amyotrophic sclerosis and wasting/clawing (first degree disability)<br>• Weakness of joints of the limbs | • Patient had a history of TB when he was 12 years old residing in Gulf province<br>• Patient reported completing TB treatment and tested negative in 2006<br>• Grandmother had leprosy and died before he was born<br>• Elder brothers had leprosy and on treatment in 2005, currently live in Port Moresby without any major disability<br>• Younger brother has leprosy, but not on treatment<br>• Patient had BCG vaccination scar | • Chest X-Ray: No pulmonary TB<br>• Mantoux: non-available (N/A) Microscopy: N/A<br>• GeneXpert: N/A<br>• TB culture: N/A<br>• HIV test: N/A<br>• AFB test: N/A<br>• Lymph node biopsy: N/A |

**Table 2:** General health status, clinical signs and medical history on admission, Leprosy-TB case study, PNGIMR's CHESS 2020.

| | Treatment phase | Medications | Fixed Dose Combination |
|---|---|---|---|
| Treatment for TB (DOTS) | Intensive treatment phase [a] | Rifampicin | 1 capsules (600 mg) per day and every day |
| | | Isoniazid | 1 tablets (300 mg) per day, and every day |
| | | Pyrazinamide | 1 tablets (2000 mg) per day and every day |
| | | Ethambutol | 1 tablets (800 mg) per day and every day |
| | Continuation phase treatment [b] | Rifampicin | 1 capsules (600mg) per day and every day |
| | | Isoniazid | 1 tablets (600mg) per day and every day |
| Treatment for Leprosy (MDT)[c] | | Dapsone | 1 tablet (100mg) per day, every day for 12 months |
| | | Clofazimine | 1 capsule (50mg) per day, every day for 12 months |
| | | Rifampicin [d] | 1 tablets (600 mg) once a month under supervision of health worker for 12 months |

**Table 3:** Medications for treatment of Leprosy-TB co-infection case study, PNGIMR's CHESS 2020.
*Note: [a] Revisit health clinic once a month for two months*
*[b] Revisit health clinic once a month for four months*
*[c] Revisit health clinic once a month for 12 months*
*[d] This dosage is not administered as Rifampicin has been included in DOTS*

The cost for transportation to attend monthly health service appointments is another concern. Our patient reported paying 5 PNG kinas (about 2 US dollars) for a trip on public bus between his village and the hospital. In addition, public transportation was particularly difficult during the corona virus outbreak as the country was in lockdown for several periods between 20 March to 1 September 2020 [14,15].

Toxicity has been previously reported in Leprosy-TB co-morbidity treatment therapies. Our patient was prescribed four anti-tuberculosis drugs: *Rifampicin, Isoniazid, Pyrazinamide,* and *Ethambutol*, plus *Dapsone*, and *Clofazimine* for treatment of leprosy, with fixed dose combination (one tablet per day for every drug). These treatment regimens for leprosy-TB concomitant contain *Rifampicin* and *Clofazimine*, which are both active against the two mycobacterial species and may cause some side effects. After one month on the therapies, the patient demonstrated red eyes and loss of vision, which is a known critical side effect of *Ethambutol* and requires immediate drug stoppage to aid reversal of ocular symptoms [2]. On the re-examination on the 2nd June, the patient's overall health status and many clinical signs were improved.

## Patient follow-up

In our case, the patient lived in his village, 30 km away from the hospital and he was advised to revisit health workers at least once a month for 12 months in order to complete both MDT and DOTS. However, the health workers had no contact with the patient, neither telephone nor social network, hence all follow-ups depend on the patient's cooperation. With a wide network of community health workers (CHW) based in villages, CHESS offers a link between healthcare facilities and the communities in follow-up with leprosy patients [8]. In our case study, a CHW was assigned to follow up with the patient. Living in the village and speaking the local language, the CHW has sound local knowledge of the health of the people, and also on to people moving in and out of the village. The CHW actively traced the patient's contacts, screened household members, and detected suspected leprosy and TB cases in the community and he identified an additional leprosy case, which is young bother of the patient. As this suspected case moved to Port Moresby, we advised him to register at Port Moresby General Hospital.

The CHW provided counselling to the patient on adherence to therapy, compliance to the prescriptions, and consumption of daily doses, as prescribed. The patient was advised to take note of any change in the colour of urine, tears, faeces, saliva, sputum and sweat into red or orange, and report any side effect of the medications such as high fever, itching and skin rashes, pain and swelling hands and feet, vision gets worse, yellowing of the skin and eyes (jaundice), stomach pain, loss of appetite, nausea and vomiting, or losing hearing capacity, and seek medical help from the health workers, as needed. The CHW also conducted health education sessions on measures for preventing the transmission of leprosy and TB, raising the public awareness of leprosy and TB issues. The CHW regularly checked the patient's condition and medication regimes, and encouraged the patient to revisit the hospital for re-examination on schedule and provided transportation, as needed.

## Discussion

### Leprosy-Tuberculosis Co-infection

Historically, archaeological evidence, post-mortem findings and retrospective analysis of leprosy data demonstrates that the observed incidence of concomitant infection of leprosy and tuberculosis (TB) is high [16]. However, this concomitant infection is reportedly very low in the modern literature, with estimates of annual new case detection rates at approximately 0.02 cases per 100,000 population [17]. The explanation for this rare observation is because leprosy is a rare disease, even in most endemic countries. The chance of having leprosy and TB at the same time is therefore small. The mechanism for leprosy-TB concomitant infection remains unclear and the relationship between the two mycobacterial diseases continues to be largely unknown. Modelling studies of the interactions of the two organisms suggest that the decline in observed concomitant infection may be due to an antagonism between the two mycobacterials and the protective effects of cross immunity [17]. However, other studies suggest that leprosy would predispose to TB, raising the question of whether this synergistic effect would lead to an increased death rate among the host patients [18].

Research on the concomitant presence of these mycobacterial infections has remained relatively neglected and hardly reported in literature over the last decades. The fact that such a co-infection is rare is part of the explanation that few reports can be found. In a review of 156 dual infections cases reported in the period 1968-2007, leprosy was found in 90% of all dual infections and more than 50% of the dual infection's cases had lepromatous leprosy, and tuberculosis occurred in 2.5-13.5% of the lepromatous leprosy patients [19].

Both leprosy and tuberculosis are known to have similar geographic endemicity and are both endemic in several populous countries including India and Brazil. Mangum and colleagues conducted a literature review of leprosy-TB co-infections and found that only 13 cases were published over the 15 years period 2003-2017, and most cases had borderline lepromatous and pulmonary tuberculosis. Extra-pulmonary tuberculosis, including cutaneous, lymph node, and central nervous system was reported in only 3.2% of leprosy cases [17-19]. The study in India in 2011 suggesting both TB and leprosy remain endemic with the detection rate of concomitant infection at only 0.019 cases per 100,000 population [20]. A review of medical records of patients at the Dermatology Clinic at São Paulo University Medical School in the period 2004-2011 showed only two leprosy patients with TB co-infection: one with pleural TB and another with pulmonary TB [21].

From epidemiological, public health, and clinical perspectives, better understanding of co-infections and leprosy-TB co-

morbidity in particular are important even though there is not much incidence. Co-morbidity conditions predispose patients to developing tuberculosis and the dual infections are associated with high mortality (37.2%) of the patients [18]. Previous studies have highlighted several under-investigated areas, including: (i) the host immune-genetics involved in concomitant infection; (ii) the relation between prolonged courses of high dose steroids for leprosy and TB infections; and (iii) the development of *rifampicin* resistance in leprosy patients in co-infection with TB and other infections. Longitudinal works are therefore, needed to characterize the temporal relationships between leprosy and TB, adding to the current lack of literature on these subject matters [17].

### Epidemiology of leprosy in PNG

Leprosy control in PNG dates back to the 1960s and leprosy was announced as being successfully eliminated in PNG in 2000. However, the number of new leprosy cases was reportedly on increase in recent times, from 281 in 2010 to 540 in 2014, 658 in 2015 and 356 in the first quarter of 2017 [12,22]. The National Leprosy Elimination Programme (NLEP): Strategic Plan 2016-2020 shifts from a medical, hospital-based perspective to training of health workers in leprosy awareness and setting up field control programmes to reduce the medical, social and economic burden of leprosy [12]. The recommended MDT for treatment of leprosy includes a combination of *rifampicin* and *dapsone* for PB patients and a combination of *rifampicin*, *clofazimine* and *dapsone* for MB patients [2]. In PNG, all the medicines are available and provided free of charge to leprosy patients [23]. Recently, Australian Government committed to provide 608 million Australian dollars to PNG for the period 2019–2020, with some of that fund going towards the public health system and non-government organisations involved in containing leprosy [22].

It is noticeable that 90% of the new cases since 2010 were reported in six provinces, which are the Western, Gulf, West Sepik, East New Britain, Central provinces, and National Capital District in Port Moresby. These were classified as high endemic provinces with the prevalence rate of above 1 per 10,000 population. Western Province is one of the hot spots of endemic leprosy in PNG with approximately 100 new cases registered per year at Daru General Hospital (DGH) since 2017 [24]. The first TB-leprosy concomitant was officially reported by the DGH in 2019 in a patient who was under treatment for multidrug-resistant TB and observed to also have leprosy [25].

Our leprosy-TB co-morbidities patient is among few cases of such concomitant infection reported worldwide. A critical finding is that this 25-year old patient is considerably younger than the average age of the leprosy patients, 37.8 years reported worldwide previously [18], providing new evidence on the recent re-emergence of leprosy among the young population in PNG. This is the second leprosy-TB concomitant reported in PNG [25] and could be the first case of co-infections of primary MB leprosy and TB lymphadenitis reported in literature. Most of the previously reported co-infection cases are between lepromatous leprosy and pulmonary tuberculosis, in contrast to this case of extra-pulmonary tuberculosis. To the best of our knowledge there has been no previous leprosy-TB co-infections reported in other Pacific Islands Countries and Territories [19,20]. A previous study of a woman presenting with leprosy, HIV and active pulmonary TB suggests that co-existence of mycobacterial infections is emerging with retrovirus [26]. The recent global pandemic of novel corona virus disease (COVID-19) could pose a significant threat for new co-infections.

The recent economic growth and mortality decline across PNG suggest the country has entered into a health and epidemiological transition, characterised by a reduction in infectious diseases and growing non-communicable diseases (NCDs) [9]. A cause of death analysis using mortality surveillance data in the periods 1970-2001 and 2010-2015 shows a large decrease in endemic infections across the rural areas [27]. The challenging terrain of PNG across the islands and highlands regions makes leprosy service difficult to deliver to the population in need. Leprosy is likely to be neglected in the context of global health priorities such as HIV/AIDS, TB and malaria, and even diluted within the country' responses to the outbreaks of childhood preventable communicable diseases such as polio, measles, and COVID-19 recently. Hence, new strategy to establish a community-based modality for management of leprosy-TB patients with interdisciplinary approach is much needed.

As part of the NLEP, a final review is scheduled in 2020 [12]. This evaluation needs to assess a comprehensive model for effective management of leprosy in the community, in which new approaches are needed to address major challenges at the local level as discussed above. The manifestation of leprosy in PNG today is likely complicated with TB. These community-based approaches should assist patients to comply with MDT, keep patients safe while maintaining their family and social supports and reduce social stigma and discrimination in the village. These are key principles for an effective community-based management of leprosy and crucial for a successful national leprosy control programme in PNG.

## Limitation

There were elements missing in the differential diagnostic process because key laboratory tests, including TB sputum microscopy, GeneXpert and TB culture were not conducted, hence no result was available to support clinical diagnosis and confirm the *rifampicin*-resistance status of the patient. HIV test is not conducted yet although it has been scheduled in the next revisits of the patient to the hospital.

## Conclusion

Our case study reports a rare patient with co-infections of primary Multi-Bacillary Leprosy plus TB lymphadenitis in PNG. Throughout the process of diagnosis, treatment and follow-up with the patient, we have highlighted the key challenges in the implementation of the national leprosy elimination programme at

the local level. Understanding of these challenges would help to design effective interventions to improve the performance of national leprosy control programme, toward eliminate leprosy in PNG.

## Ethics approval

The CHESS was granted ethics approvals from Internal Review Board of PNG Institute of Medical Research (IRB Approval No. 18.05) and the Medical Research Advisory Committee of Papua New Guinea (MRAC Approval No. 18.06). These approvals covered all the data components under the CHESS, including morbidity data which were used in this manuscript. Informed consent was sought from patients and caregivers of child patients. Participants were informed about their right to withdraw from the study at any stage.


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