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Serei Vatana Nath   Date

Treatment Outcomes of Pulmonary Tuberculosis at Population Services International Clinic Networks, Myanmar: A Retrospective Cohort Study, 2012-2016

By
SEREI VATANA NATH

Master of Public Health
Hubert Department of Global Health
Rollins School of Public Health
Emory University

_____

Kenneth G. Castro, MD, FIDSA
Committee Chair

_____

Sarita Shah, MD, MPH
Committee Member

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International University
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Thesis Committee

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Sarita Shah, MD, MPH
Committee Member

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Abstract

Treatment Outcomes of Pulmonary Tuberculosis at Population Services International Clinic Networks, Myanmar: A Retrospective Cohort Study, 2012-2016

Introduction: Myanmar is among the 30 highest tuberculosis (TB) burden countries globally, with an estimated TB prevalence of 467/100,000 population in the National TB Prevalence Survey (2017-2018). Activities to reach, cure, and prevent tuberculosis have been implemented through Public-Public Mix and Public-Private Mix Models (PPM). In 2016, the National TB Program (NTP) and Population Services International (PSI) contributed 82.5% and 11.6% of bacteriologically confirmed TB patients, respectively. We sought to examine the TB trends and treatment outcomes of patients diagnosed and treated within the PSI network of clinics.

Methods: This is a retrospective cohort study examining TB treatment outcomes and risk factors associated with unsuccessful outcomes using clinical and public health data collected by PSI Myanmar from 2012 to 2016. Public health and sociodemographic risk factors were examined using multivariate regression. Multinomial regression models were used to examine independent variables with more than two categories of dependent outcomes and give both crude and adjusted Relative Risk or Risk Ratio (RR).

Results: A total of 62,664 tuberculosis patients were seen in PSI Myanmar facilities (93.4% new patients and 6.6% re-treated patients) from 2012 to 2016. A majority, or 38,848 (62%) were male. Patients who were 35-54 years old (38%), and male gender had highest percentage of TB compared to other age groups and sex. Smear positive, negative, and smear not done accounted for 31,679 (50.6%), 29,889 (47.7%), and 1,096 (1.7%), respectively. Of all patients, 31,433 (50.2%) had negative HIV test, 1,871 (2.9%) had positive test, and 29,360 (46.8%) had an unknown HIV test result. There were 58,544 (93.4%) new patients, and 4,120 (6.6%) re-treated patients. Among all patients treated at PSI, 90.9% were successfully treated (35.1% cured and 53.4% completed), and 9.1% were unsuccessfully treated (0.5% lost to follow-up during the initial phase of treatment, 7.1% lost to follow-up during the continuation phase, and 4.0% failed treatment). The risk factors statistically associated with unsuccessful treatment outcomes included male sex (aRR=1.41, CI:1.33-1.50), age over 55 years old (aRR=1.25, CI:1.17-1.34), smear-positive TB (aRR=1.03, CI:0.98-1.10), HIV positive status (aRR=1.65, CI:1.42-1.85), and those who sought retreatment after initial loss to follow-up (aRR=1.99, CI:1.14-3.49). Nutrition support was found to significantly decrease the risk of having unsuccessful treatment (aRR=0.91, CI:0.86-0.96).

Conclusions: During the five-year study period, PSI achieved considerably high treatment success rate in the context of the PPM model where PSI provided diagnosis and treatment services for people with TB (Scheme III) and reached a large number of patients with the use of incentive and support programs, such as nutritional and travel support. These findings suggest that the PPM model used by PSI can successfully implement the NTP goals and significantly contribute to successful treatment outcomes for most people served.

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Glossary of Terms [1]

Pulmonary tuberculosis: any bacteriologically confirmed or clinically diagnosed case of tuberculosis (TB) involving the lung parenchyma or the tracheobronchial tree.

Extrapulmonary tuberculosis any bacteriologically confirmed or clinically diagnosed case of TB involving organs other than lungs such as pleura, lymph nodes, abdomen, genitourinary tract, skin, joints and bones, meninges.

New patients: patients who have never been treated for TB or have taken anti-TB drugs for less than 1 month.

Previously treated patients: patients who have received 1 month or more of anti-TB drugs in the past.

Relapse patients: patients who have previously been treated for TB, were declared cured or treatment completed at the end of their most recent course of treatment and are now diagnosed with a recurrent episode of TB (either a true relapse or a new episode of TB caused by reinfection).

Treatment after failure patient (failure): patients who have previously been treated for TB and whose treatment failed at the end of their most recent course of treatment.

Treatment after loss to follow-up patients (defaulter): patients who have previously been treated for TB and were declared lost to follow-up at the end of their most recent course of treatment.

Defaulted before 2 months: TB patient lost to follow-up during the Initial Phase (2 months) of treatment.

Defaulted before 6 months: TB patient lost to follow-up during the Continuation Phase (last 4 months) of treatment.

HIV-positive TB patient: any bacteriologically confirmed or clinically diagnosed case of TB who has a positive result from HIV testing conducted at the time of TB diagnosis.

HIV-negative TB patient: any bacteriologically confirmed or clinically diagnosed case of TB who has a negative result from HIV testing conducted at the time of TB diagnosis.

HIV status unknown TB patient: any bacteriologically confirmed or clinically diagnosed case of TB who has no result of HIV testing.

Multidrug resistant tuberculosis (MDR-TB): resistance to at least both isoniazid and rifampicin.

Rifampicin resistant tuberculosis (RR-TB): resistance to rifampicin with or without resistance to other anti-TB drugs.

Treatment outcomes for TB patients (excluding patients treated for RR-TB or MDR-TB): all bacteriologically confirmed or clinically diagnosed TB cases assigned an outcome, excluding those with RR-TB or MDR-TB, who required a second-line drug regimen.

> **Cured:** a TB patient with bacteriologically confirmed TB at the beginning of treatment who was smear- or culture-negative in the last month of treatment and on at least one previous occasion.

> **Completed**: a TB patient who completed treatment without evidence of failure BUT with no record to show that sputum smear or culture results in the last month of treatment and on at least

one previous occasion were negative, either because tests were not done or because results are unavailable.

Failed: a TB patient whose sputum smear or culture is positive at month 5 or later during treatment.

Died: a TB patient who dies for any reason before starting or during treatment.

Lost to follow-up: a TB patient who did not start treatment or whose treatment was interrupted for 2 consecutive months or more.

Not evaluated: a TB patient for whom no treatment outcome is assigned. This includes cases "transferred out" to another treatment unit as well as cases for whom the treatment outcome is unknown to the reporting unit.

Treatment success: the sum of cured and treatment completed cases

Treatment success rate: percentage of treatment success

Abbreviations

AIDS: Acquired Immunodeficiency Syndrome

aRR: adjusted Relative Risk or Risk Ratio (RR)

CI: Confidence interval (95%)

DoH: Myanmar Department of Health, Ministry of Health and Sport

DoPH: Department of Public Health, Ministry of Health and Sport

HIV: Human Immunodeficiency Virus

IOM: International Organization of Migration

LTBI: Latent Tuberculosis Infection

MDR-TB: Multi-drug resistant Tuberculosis

MMA: Myanmar Medical Association

MoHS: Ministry of Health and Sport of Myanmar

MSF: Medecin Sans Frontiere /Doctors without Border

NTP: National Tuberculosis Program of Department of Health, Ministry of Health and Sports

NTRL: National Tuberculosis Referral Laboratory

PPM Model: Public-Private Mix model

PPM-DOTS: Public-Private Mix-Direct Observed Therapies

PSI: Population Services International

RR: Relative Risk or Risk Ratio

RR-TB: Rifampin-resistant Tuberculosis

SD: Standard deviation

SPH: PSI's franchise "Sun Primary Health" for primary health care

SQHC: PSI's franchise "Sun Quality Health Care" for specialized and standard care

TB: Tuberculosis, Pulmonary Tuberculosis

TB/HIV: Tuberculosis and HIVco-infection

TSR: Treatment Success Rate

WHO: World Health Organization

WHO SEAR: South-East Asia Regional Office, World Health Organization

Chapter I: Introduction

1.1 Tuberculosis clinical presentation

Tuberculosis is one of the top 10 leading cause of death in low- and middle-income countries. In 2019, tuberculosis cases were estimated to be 10 million (95% confidence interval 8.9 – 11 million) globally. WHO aims to reduce TB incidence by 80% by 2030 [2]. Tuberculosis is an airborne disease of the lungs and other organs caused by *Mycobacterium tuberculosis* complex. It is mainly classified into; 1) pulmonary tuberculosis, which typically causes the disease in the lungs and accounts for nearly 80% of the total tuberculosis cases, and 2) extrapulmonary tuberculosis that affects other organs such as lymph nodes, pleura, bones, and tissues other than lungs [3].

The airborne infection is commonly transmitted through respiratory route, and it occurs when a person inhales aerosolized droplets containing *Mycobacterium tuberculosis* generated during coughs, sneezes, talking, or singing by another person with tuberculosis (TB) disease affecting the respiratory system. These inhaled bacteria travel through the respiratory tract and reach the alveoli (air-containing sacs), where they settle, multiply, and establish latent TB infection (LTBI). In some people, this infection can progress to cause pulmonary TB, and in some cases, small number of bacteria are disseminated through the bloodstream to other organs and causes the extrapulmonary tuberculosis [4]. By definition, people with LTBI have no symptoms and are not considered infectious to their close contacts; a systematic review and meta-analysis estimated that nearly ¼ of the world population has LTBI [5]. A small proportion (5-15%) of these people are at risk of developing TB disease during their lifetime, but the risk is higher among individuals with known risk factors such as HIV/AIDS and other immunocompromising diseases, under-nutrition, diabetes, smoking, and chronic lung diseases [6, 7].

The clinical presentation of TB commonly includes respiratory signs and symptoms such as coughing, production of sputum (with or without blood) that lasts three or more weeks, chest pain, and difficulty breathing. Other generalized symptoms such as fever, night sweats, chills, loss of appetite, and weight loss are commonly seen in TB patients [3]. Diagnosis of TB can be laboratory confirmed with rapid molecular tests (e.g., GeneXpert or TruNat), sputum smear microscopy, and culture [4, 8]. Both LTBI and TB disease are treatable, and various TB treatment guidelines have been developed and specifically aim to treat different forms of LTBI and TB, including drug-resistant TB, and multidrug resistant TB [7, 9-11].

1.2 Myanmar: Country Profile

Myanmar, officially the Republic of the Union of Myanmar, and formerly known as Burma, is the largest country in Southeast Asia, shown in the adjacent map. The history of Myanmar dates back over one thousand years when the kingdom rose and collapsed overtime. From 1824 to 1886, under the British rule, Burma was incorporated into India and was administered as a province of India. In 1948, Burma attained independence from the British Empire, but the internal conflicts, insurgence, and rebellions continued, which contributed to collapses of the economy, infrastructure, education and healthcare system, and other aspects of daily life.

Populations are concentrated along the coastal areas and in general proximity to the shores of the Irrawaddy River; the extreme north is relatively underpopulated. Ethnic groups consist of Burman (68%), Shan (9%), Karen (7%), Rakhine (4%), Chinese (3%), Indian (2%), Mon (2%), and other (5%). In total, the government recognizes 135 indigenous ethnic groups [12, 13].

The total population from the last census in 2014 was **51,486,253** people (24,824,585 male, and 26,661,667 female). The total number of people aged 0-14, 15-64, and over 65 were 14,399,369 (27.9%), 32,982,768 (64.1%), and 2,897,563 (5.6%), respectively. From 2012 to 2016, the population increased from 51,413,698 people in 2012 [12] to 53,045,226 people in 2016, for an approximate 3.1% increase [14]. The majority of the population lives in rural areas (70%), while only 30% reside in urban areas [12].

According to the WHO Global Tuberculosis Report, from 2000 to 2019, Myanmar has remained in the list of 30 highest TB burden countries, meeting all three criteria of high TB burden, high multi-drug resistant TB burden, and high HIV-associated TB burden [2, 15]. The Myanmar National TB Prevalence Surveys estimated the prevalence to be 603/100,000 population and 467/100,000 population in the first survey (2009-2010) and in the second survey (2017-2018), respectively. TB incidence in Myanmar in 2019 was estimated to be 322 per 100,000 population [16].

1.3. Study Objective

A survey showed that about 73% of TB patients in Myanmar first sought care from private health care providers before reaching public TB centers. The Public-Private Mix model TB guideline initiative was developed in 2003 by the Myanmar NTP, and these partnerships with private sector were key components in implementing National TB strategies country-wide [17]. Public-Private Mix DOTS (PPM-DOTS) partnership has contributed about 20% of total case notification, and the various models of expanded TB control activities filled the small gap of TB control, and strengthened the case finding and treatment outcomes [18, 19].

In 2016, NTP and PPM-PSI contributed 82.5% and 11.6%, respectively, of bacteriologically confirmed TB patients, and 80.9% and 11.6%, respectively, of all forms of TB, ranking PSI as the second largest contributor to Myanmar's diagnostic and treatment services for TB [19, 20].

This specific project sought to examine the PPM model for TB delivery of services, evaluate TB trends and treatment outcomes of patients who received treatment and care at the largest PPM contributor, PSI Myanmar, between 2012 and 2016.

Objective 1: to examine the trends of tuberculosis notified from PSI Myanmar for a five-year period, from 2012 to 2016.

Objective 2: to assess the outcome of tuberculosis treatment at PSI Myanmar TB centers from 2012 to 2016.

Objective 3: to identify factors associated with unsuccessful treatment at PSI Myanmar TB centers from 2012 to 2016.

Chapter II: Literature Review

2.1. Public-Private Mix model (PPM) and Population Services International

Tuberculosis control and prevention in Myanmar is supervised by the central unit called National Tuberculosis Program (NTP) under Department of Health, Ministry of Health and Sport of Myanmar, and led by the Director-General of Department of Health, Director-General and Deputy Director-General of Disease Control of Department of Health [19, 21].

A survey showed that about 73% of TB patients in Myanmar first sought care from private health care providers before reaching public TB centers. Public-Private Mix model TB guideline initiative was developed in 2003 by the Myanmar NTP, and these partnerships with private sector were key components in implementing National TB strategies country-wide [17]. Public-Private Mix DOTS (PPM-DOTS) partnership has contributed about 20% of total case notification, and the various models of expanded TB control activities filled gaps in TB control, and strengthened case finding and successful treatment outcomes [18].

PPM models developed by the NTP were categorized into 3 schemes:

- Scheme I: PPM partners refer presumptive TB patients to the NTP for diagnosis and treatment.

- Scheme II: PPM partners provide additional supervision of directly observed treatment (DOT) services.

- Scheme III: PPM partners have additional capability and permission from NTP to initiate diagnosis and treatment services for people with TB.

PSI was founded in 1970 and has worked with and for the people to build sustainable solutions for serious health issues. Its commitment is not limited to health, but its mission includes improving gender equality, diversity and inclusion, environmental sustainability, revolutionize youth engagement, and unlock domestic financing. PSI Myanmar was founded in 1995 and aimed to demonstrate how the private sector contributed to improved universal healthcare in Myanmar through focus on HIV prevention and rapidly expanded to the treatment of reproductive health and sexually transmitted diseases, malaria, and tuberculosis [20, 22]. PSI's TB activities operate in 272 out of 330 townships across Myanmar through its network of clinics at Scheme III level. In 2016, PSI Myanmar had 855 health clinics capable of providing standard TB diagnosis and treatment, including MDR-TB and TB/HIV treatment care [23].

PSI has maintained the standard of care through monthly field visits to all registered clinics by PSI field inspectors to provide technical support and continuous training on updated TB guidelines and treatment protocols, and patient health data are sent to PSI for generating various reports. PSI has demonstrated its support to NTP through its TB REACH project initiative to promote TB Active Case Finding (ACF), providing diagnostic tests and free TB medication, and playing a role as observers of directly observed therapy, short course (DOTS) to ensure that TB patients adhere to recommended treatment. PSI promotes ACF using two approaches; detecting TB in urban poor area through Sun Primary Health Providers (SPHP) providers and in rural community through its Interpersonal Communicators (IPCs) across the country; another approach is promoting referrals of presumptive TB cases from local pharmacies and other nearby PSI's SQHC through incentive programs rewarding an amount of US$5 after diagnosis and $5 after treatment completion [24], which sums up to US$10 in total for each patient referred and

successfully treated. Also, with this incentive program, the patients receive US$1.50

compensation for travel costs to the PSI TB diagnosis center.

2.2. TB Case detection and notification

National TB prevalence rate (per 100,000/year) in Myanmar between 2012 and 2016 were 489

and 463, respectively. The national prevalence of TB patients co-infected with HIV (TB/HIV)

was 9.7% (2012) and 8.5% (2016). The notified multi-drug resistant TB (MDR-TB) was 833

(27%) and Rifampicin-resistant TB (RR-TB) was 259 (9%) in 2012, and in 2016, the case

detection and notification capacity has been supported by international partnerships, public, and

PPM DOTS Tuberculosis centers; therefore, more cases of MDR-TB were reported 29,169

(44%) but a decrease of RR-TB percentage 3,095 (5%) was reported. Overall, the total case

notification of all forms of TB decreased from 148,149 in 2012 to 139,625 in 2016, in which

35% of new TB cases were bacteriologic confirmed [19, 20]. The proportion of TB cases

reported by NTP and PPM partners is shown in the chart below.

Chart: Proportion of all forms of TB patients contributed by NTP and PPM Partners (2016)
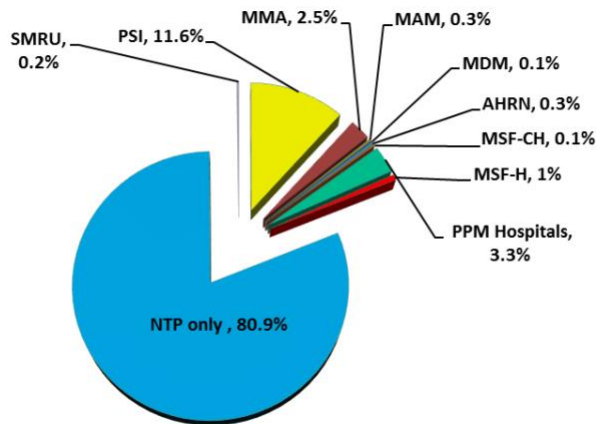
Source: Annual Report 2016, NTP Myanmar, page 50 [25]

2.3. TB Diagnosis

In the first National TB Survey, 134,023 tuberculosis cases were notified, and smear-positive cases accounted for about 31%. Among all smear-positive TB cases, males had 2 times higher ratio of having smear-positive disease than female (2:1). The high-risk groups were those aged between 25 – 54 years old, and those who tested HIV positive. National HIV prevalence trends in people with TB are shown in the graph below for 2005 through 2016. During the years covered by our assessment, HIV prevalence in TB patients decreased from 9.7%, in 2012 to 8.5% in 2016, as shown in the graph below [19, 26].
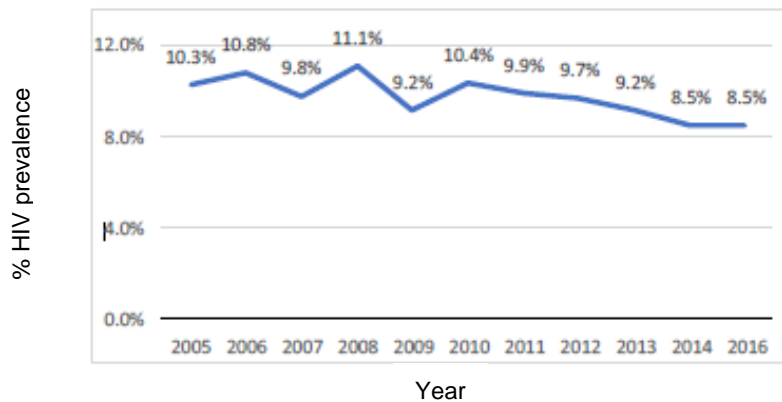
Trend of HIV prevalence among new TB patients (2005-2016)

Source: Annual TB Report 2016, NTP, page 28 [26]

In a 2013 study by the Myanmar Medical Association (MMA), the third largest Publix-Private Mix contributor following NTP and PSI, of 20,603 TB patients, 62% were male, and 38% female; among three age groups, the highest proportion (74%) occurred in those aged between 15-64 years old; pulmonary smear-positive TB accounted for 39% of cases, 52% had pulmonary smear-negative TB, and 9% had extra-pulmonary TB. Among all TB cases diagnosed and treated at PPM-MMA during the studied period, 95% were new cases, and 5% were retreated cases [27].

A previous study at PSI specifically focused on treatment outcomes among re-treatment patients reported from 2004-2010: 69% of all TB patients were male, and 46% and 33% were aged

between 35-54 years old and 15-34 years old, respectively. These were the two highest proportions among the four age groups examined. Approximately 54% of retreatment cases were those who had a history of relapse, and 28% had treatment failure. Ten percent were those who had been previously lost to follow-up, and 7% represented other type of retreated patients [28].

2.4. TB Treatment Outcomes

Myanmar maintained the Treatment Success Rate of all forms of TB above 85% from 2012 to 2016, with the rate slightly increasing from 85% to 87%, respectively, in those years [19, 29]. In 2016, about 68% of national bacteriologically-confirmed TB cases were cured, 17% completed treatment, 6% died, 6% were lost to follow-up, 2% failed treatment, and 1% were not evaluated [16, 19].

PPM-Myanmar Medical Association (MMA), reported in its study in 2013 that 92% of their TB patients had a successful treatment outcome, of which 32% were cured and 60% completed, and 8% were unsuccessfully treated, of which 2.9% died, 2.5% lost or defaulted, 1.9% failed treatment, and 0.6% were transferred out. Among patients with unsuccessful outcomes, females had 35% increased risk compared to males, those who were more than 65 years old had 4 times higher risk compared to reference group aged 15-64 years old, and re-treated patients had 3.16 risk of having unsuccessful outcomes compared to new patients [27].

The PSI study which only focused on retreated TB patients diagnosed from 2004 to 2010 classified these into the following categories: relapse, failure, return after lost to follow-up, and other. Of 3,643 retreated patients, 73% received successful treatment (cured, completed), and 27% were unsuccessfully treated (lost to follow-up, died, failed, and transferred out). Among relapsed patients (retreated patients), 75.8% were successfully treated (69% cured, 6.8%

completed), 3.5% were lost to follow-up, 7.4% died, 7.6% failed treatment, and 5.2% were transferred out. Among those who failed previous treatments and were retreated, 65.2% attained successful treatment (58.2% cured, 7% completed), 8.7% were lost to follow-up, 4.6% died, 13.5% failed treatment again, and 8% transferred out. For those who returned after loss to follow-up (previously classified as "defaulter"), 73.7% were successfully treated (67.8% cured, 5.9% completed), 10.7% lost to follow-up again, 5.4% died, 4.6% failed treatment, and 5.6% transferred out. Treatment failure among retreated TB patients was higher in females (RR=1.04, CI: 0.83-1.31) compared to male as reference group, and among retreatment cases, those who failed treatment before had the highest risk of retreatment failure again (RR=1.76, CI:1.42-2.2) compared to relapse patient as reference group [28].

2.5 Gaps in Knowledge and the Impact of this Study

Myanmar is a high burden TB country, but only outdated or limited data are available on TB treatment delivery, treatment outcomes, and risk factors for poor outcomes to guide how to improve or target our interventions. Myanmar provides TB services through its national program (NTP) and through partnership with private organizations. Review of available publications suggests that PPM models have been important contributors to TB control, and PSI is by far the largest contributor to PPM in Myanmar. The last assessment of PSI TB services was in 2010 but those findings are outdated and of limited value because they only assessed retreated TB patients. To bridge this information gap, we sought to evaluate the treatment outcomes of all TB patients receiving care through PSI network of clinics during a more recent 5-year interval (2012-2016), with sufficient time elapsed to accurately assess treatment outcomes. The analysis of this study is intended to provide public health and clinical information, characterize key

outcomes associated with tuberculosis treatment service delivery at PPM-PSI, and to inform-

decisions and policies aimed at optimizing TB treatment outcomes.

Chapter III: Manuscript

Abstract

Treatment Outcomes of Pulmonary Tuberculosis at Population Services International Clinic Networks, Myanmar: A Retrospective Cohort Study, 2012-2016

Introduction: Myanmar is among the 30 highest tuberculosis (TB) burden countries globally, with an estimated TB prevalence of 467/100,000 population in the National TB Prevalence Survey (2017-2018). Activities to reach, cure, and prevent tuberculosis have been implemented through Public-Public Mix and Public-Private Mix Models (PPM). In 2016, the National TB Program (NTP) and Population Services International (PSI) contributed 82.5% and 11.6% of bacteriologically confirmed TB patients, respectively. We sought to examine the TB trends and treatment outcomes of patients diagnosed and treated within the PSI network of clinics.

Methods: This is a retrospective cohort study examining TB treatment outcomes and risk factors associated with unsuccessful outcomes using clinical and public health data collected by PSI Myanmar from 2012 to 2016. Public health and sociodemographic risk factors were examined using multivariate regression. Multinomial regression models were used to examine independent variables with more than two categories of dependent outcomes and give both crude and adjusted Relative Risk or Risk Ratio (RR).

Results: A total of 62,664 tuberculosis patients were seen in PSI Myanmar facilities (93.4% new patients and 6.6% re-treated patients) from 2012 to 2016. A majority, or 38,848 (62%) were male. Patients who were 35-54 years old (38%), and male gender had highest percentage of TB compared to other age groups and sex. Smear positive, negative, and smear not done accounted for 31,679 (50.6%), 29,889 (47.7%), and 1,096 (1.7%), respectively. Of all patients, 31,433 (50.2%) had negative HIV test, 1,871 (2.9%) had positive test, and 29,360 (46.8%) had an unknown HIV test result. There were 58,544 (93.4%) new patients, and 4,120 (6.6%) re-treated patients. Among all patients treated at PSI, 90.9% were successfully treated (35.1% cured and 53.4% completed), and 9.1% were unsuccessfully treated (0.5% lost to follow-up during the initial phase of treatment, 7.1% lost to follow-up during the continuation phase, and 4.0% failed treatment). The risk factors statistically associated with unsuccessful treatment outcomes included male sex (aRR=1.41, CI:1.33-1.50), age over 55 years old (aRR=1.25, CI:1.17-1.34), smear-positive TB (aRR=1.03, CI:0.98-1.10), HIV positive status (aRR=1.65, CI:1.42-1.85), and those who sought retreatment after initial loss to follow-up (aRR=1.99, CI:1.14-3.49). Nutrition support was found to significantly decrease the risk of having unsuccessful treatment (aRR=0.91, CI:0.86-0.96).

Conclusions: During the five-year study period, PSI achieved considerably high treatment success rate in the context of the PPM model where PSI provided diagnosis and treatment services for people with TB (Scheme III) and reached a large number of patients with the use of incentive and support programs, such as nutritional and travel support. These findings suggest that the PPM model used by PSI can successfully implement the NTP goals and significantly contribute to successful treatment outcomes for most people served.

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SEREI VATANA NATH

Background

According to the WHO Global Tuberculosis Report, from 2000 to 2019, Myanmar has remained in the list of 30 highest TB burden countries, meeting all three criteria of high TB burden, high multi-drug resistant TB burden, and high HIV-associated TB burden[2, 15]. The Myanmar National TB Prevalence Survey estimated the prevalence to be 603/100,000 population and 467/100,000 population in the first survey (2009-2010) and in the second survey (2017-2018), respectively [15]. TB incidence in Myanmar in 2019 was estimated to be 322 per 100,000 population (Total) and 10 per 1,000 population (MDR/RR-TB), the prevalence among incident TB cases was 7.8%, and the incidence was higher in urban population and in male [16].

A survey showed that about 73% of TB patients in Myanmar first sought care from private health care providers before reaching to public TB centers. Public-Private Mix model TB guideline initiative was developed in 2003 by the Myanmar NTP, and partnerships with private sector were key components in implementing National TB strategies country-wide [17]. Public-Private Mix DOTS (PPM-DOTS) partnership has contributed about 20% of total case notification, and the various models of expanded TB control activities filled the small gap of TB control, and strengthen the case finding and treatment outcomes [18, 19].

In 2016, NTP and PPM-PSI contributed 82.5% and 11.6%,respectively, of bacteriologically confirmed TB patients, and 80.9% and 11.6%, respectively, of all forms of TB, ranking PSI as the largest PPM contributor [19, 20].

This specific project sought to examine the PPM-PSI TB delivery services and evaluate TB trends and treatment outcomes of patients who received treatment and care at PSI between 2012 and 2016.

Methods

This study was a retrospective cohort study to analyze TB treatment outcomes and risk factors associated with unsuccessful outcomes using secondary and de-identified data from Myanmar Population Services International (PSI Myanmar) from 2012 to 2016. PSI Myanmar is a Public-Private Mix DOTS contributor in delivering tuberculosis diagnosis, care, and prevention activities. PSI's TB activities operates in 272 out of 330 townships across Myanmar through its franchise "Sun Quality Health Clinics (SQHC)" for providing high standard of healthcare, and "Sun Primary Health (SPH)" for primary care. Data were collected from all PSI's SQHC and SPH affiliated clinics in those 272 townships, across the countries.

Data and Data Source

Data for this analysis was a PSI tuberculosis patient registry database that contained de-identified information related to diagnosis and treatment at PSI from 2012 to 2016 and contained 62,644 observations of pulmonary tuberculosis patients from all 272 PSI's affiliated clinics throughout the country during the studied period. Data were retrieved from Harvard Dataverse with permission from original owner PSI's Ye Kyaw Aung [30].

This analysis was exempted from IRB review because it relied on a secondary analysis of an existing database from PSI patient registry that was made available in a de-identified format and the analysis posed no risk or harms to human subjects.

Data were cleaned to exclude duplicate reports and to generate variable labels using R programming version 4.0.3 and STATA 16. New composite variables were generated to answer

research questions. The list of Variables, descriptions, and values are found in the appendix section.

Statistical Analysis

Individual patient records showed only information at the day of diagnosis and at the day that outcomes were assessed, and the duration of treatment and year treatment started and ended. Drug susceptibility results were not available for stratified analyses of treatment outcomes by drug-resistance status.

Descriptive results of categorical variables are presented using frequency and percent, and Chi-square test were used to compare categorical variables. Continuous variables were presented using mean, median, and standard deviation (SD). Type I error (alpha) was at 0.05, and the test is considered statistically significant if p-value <0.05.

Potential risk factors in this study were examined in STATA 16 using multivariate logistic regression models. Multinomial logistic regression was also used to analyze independent variables that have more than two categories of dependent outcomes, check for collinearity and calculate the Relative Risk or Risk Ratio (RR). Both Crude and Adjusted Relative Risk for age, gender, and bodyweight, also 95% confidence interval were presented.

Results

Characteristics of TB patients

Table 1. Characteristics of Tuberculosis Patients by Years of Treatment Start (column % for each characteristic)

Characteristics	N (%) 2012 = 13,474 (21.5%)	N (%) 2013 = 14,730 (23.5%)	N (%) 2014 = 13,042 (20.8%)	N (%) 2015 = 11,329 (18.1%)	N (%) 2016 = 10,089 (16.1%)	Total 62,664	chi2 (p-value) 25.0554 (<0.001)
Demographic characteristics							
Sex							
Male	8,281 (61.46%)	9,088 (61.7%)	8,064 (61.83%)	7,065 (62.36%)	6,350 (62.94%)	38,848 (61.99%)	104.4944 (<0.001)
Female	5,193 (38.54%)	5,642 (38.3%)	4,978 (38.17%)	4,264 (37.64%)	3,739 (37.06%)	23,816 (38.01%)	
Age, years							
15 - 34	4,904 (36.4%)	5,228 (35.49%)	4,692 (35.98%)	4,350 (38.4%)	3,695 (36.62%)	22,247 (35.5%)	
35 - 54	5,269 (39.1%)	5,646 (38.33%)	4,859 (37.26%)	3,033 (26.77%)	2,917 (28.91%)	23,819 (38.01%)	64.2832 (<0.001)
>= 55	3,301 (24.5%)	3,856 (26.18%)	3,491 (26.77%)	3,033 (26.77%)	2,917 (28.91%)	16,598 (26.49%)	
Bodyweight, kg							
Average	44.6 (SD = 8.7)	45 (SD = 8.6)	45.1 (SD = 8.7)	45.6 (SD = 8.9)	45.6 (SD = 9)		
Under 15kg	12 (0.09%)	5 (0.03%)	3 (0.02%)	6 (0.05%)	7 (0.07%)	33 (0.05%)	
16 - 29kg	279 (2.07%)	269 (1.83%)	223 (1.71%)	196 (1.73%)	190 (1.88%)	1,157 (1.85%)	
30 - 39kg	3,074 (22.81%)	3,071 (20.85%)	2,782 (21.33%)	2,342 (20.67%)	2,076 (20.58%)	13,345 (21.3%)	114.5016 (<0.001)
40 - 54 kg	8,559 (63.52%)	9,531 (64.7%)	8,369 (64.17%)	7,173 (63.32%)	6,295 (62.39%)	39,927 (63.72%)	
55 - 70kg	1,434 (10.64%)	1,734 (11.77%)	1,549 (11.88%)	1,494 (13.19%)	1,398 (13.86%)	7,609 (12.14%)	
> 70kg	116 (0.86%)	120 (0.81%)	116 (0.89%)	118 (1.04%)	123 (1.22%)	593 (0.95%)	
Clinical characteristics							
Nutrition support							
No	9,521 (70.66%)	9,687 (65.76%)	8,657 (66.38%)	6,910 (60.99%)	6,451 (63.94%)	41,226 (65.79%)	275.2171 (<0.001)
Yes	3,953 (29.34%)	5,043 (34.24%)	4,385 (33.62%)	4,419 (39.01%)	3,638 (36.06%)	21,438 (34.21%)	
Sputum Smear							
Positive	7,281 (54.04%)	7,323 (49.71%)	6,558 (50.28%)	5,759 (50.83%)	4,758 (47.16%)	31,679 (50.55%)	
Negative	5,943 (44.11%)	7,200 (48.88%)	6,237 (47.82%)	5,336 (47.1%)	5,173 (51.27%)	29,889 (47.7%)	147.2202 (<0.001)
Not Done	250 (1.86%)	207 (1.41%)	247 (1.89%)	234 (2.07%)	158 (1.57%)	1,096 (1.75%)	
HIV status							
Negative	4,992 (37.05%)	6,356 (43.15%)	7,376 (56.56%)	6,622 (58.45%)	6,087 (60.33%)	31,433 (50.16%)	
Positive	437 (3.24%)	420 (2.85%)	395 (3.03%)	278 (2.45%)	341 (3.38%)	1,871 (2.99%)	2200 (<0.001)
Unknown	8,045 (59.71%)	7,954 (54%)	5,271 (40.42%)	4,429 (39.09%)	3,661 (36.29%)	29,360 (46.85%)	
Type of TB							
New patient	12,556 (93.19%)	13,813 (93.77%)	12,133 (93.03%)	10,527 (92.92%)	9,515 (94.31%)	58,544 (93.43%)	25.0554 (<0.001)
Re-treated patient	918 (6.81%)	917 (6.23%)	909 (6.97%)	802 (7.08%)	574 (5.69%)	4,120 (6.57%)	
Lost to follow-up							
Initial phase**	19 (0.14%)	92 (0.62%)	72 (0.55%)	65 (0.57%)	67 (0.66%)	315 (0.5%)	46.6494 (<0.001)
Continuation phase***	881 (6.54%)	1,120 (7.6%)	1,055 (8.09%)	825 (7.28%)	661 (6.55%)	4,542 (7.25%)	

*p-value < 0.05 considered significant

** Initial Phase: first 2 months of treatment

*** Continuation Phase: last 4 months of treatment

For five years period from 2012 to 2016, there were 62,664 tuberculosis patients diagnosed and treated at PSI Myanmar. The numbers of all types of tuberculosis patients decreased in the early studied period from 13,474 patients (2012) to 10,089 patients (2016) at the end of studied period. Among these 5 years, in 2013, PSI cared for 14,042 patients (24% of total cases) diagnosed and treated, and this was the highest number and proportion within the studied years **(Figure 1)**. The decrease in number and proportion of TB cases is statistically significant, based on Chi Square analysis for linear trends (chi2=25.0554, p<0.001).

Figure 1. Number and Percent of National (Myanmar) TB cases cared by PSI by year, 2012-2016
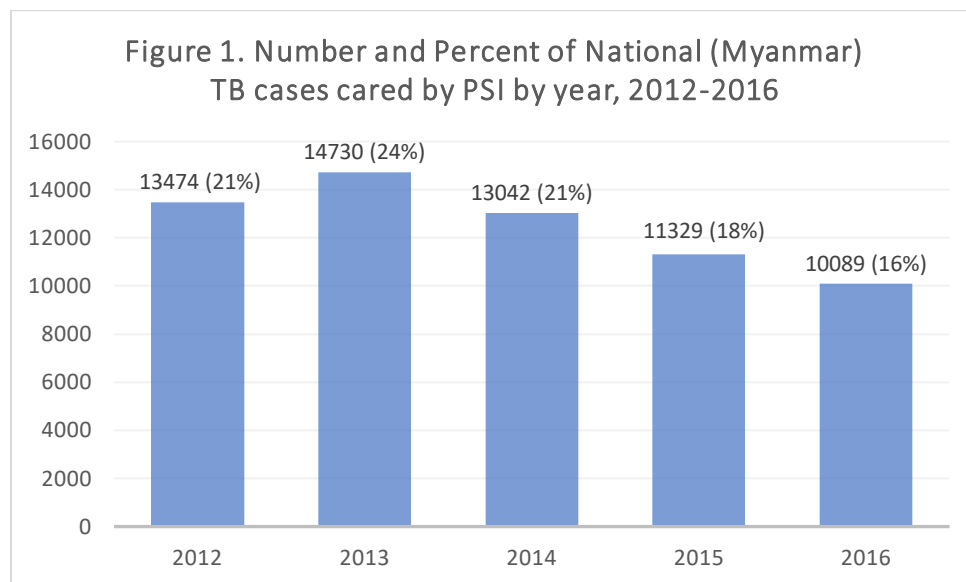
The demographic characteristics of patients during this five-year period show that males (38,848 patients, 61.9%) represented a higher proportion than females (23,816 patients, 38.0%) (**Table 1**). The highest number (23,819, or 38.0%) of patients were in the age group 35-54 years, followed by those aged below 34 years (22,247, or 35.5%), and the lowest number were those aged over 55 years (16,598, or 26.5%) (**Table 1**).

There were 31,679 (50.6%) patients with smear-positive TB, while 29,889 (47.7%) had smear-negative TB, and another 1,096 (1.8%) patients had no sputum smear microscopy. Of all TB patients diagnosed at PSI, 31,333 (50.2%) had negative HIV test, another 1,871 (3.0%) patients tested HIV positive, and 29,360 (46.9%) patients had unknown HIV test status (**Table 1**). Of all 62,664 tuberculosis patients, 93.4% were new patients and 6.6% were re-treated patients, and those who returned after lost to follow-up before 2 months and 6 months of previous treatment accounted for 315 (0.5%) and 4,542 (7.3%), respectively. Patients who received nutritional support while receiving treatment accounted for 34.2%, lower than those who did not receive nutritional support (65.8%).

Treatment Duration and Treatment Outcomes

Table 2. Average Treatment Duration and Treatment Outcomes by Different Characteristics of Tuberculosis Patients

Characteristics	Treatment Interval Mean in Days	in Weeks	Successfully Treated = 56,951 (90.88%)* Cured = 22,603 (35.11%)* N (%)	Completed = 34,348 (53.36%)* N (%)	Unsuccessfully Treated = 5,713 (9.12%)* Loss to follow-up during initial phase = 315 (0.49%)* N (%)	Loss to follow-up during continuation phase = 4,542 (7.06%)* N (%)	Failure = 2,564 (3.99%)* N (%)	Total = 62,664 (100%) N (%)
Demographic characteristics								
Sex								
Male	171.54	24.51	14,576 (64.49%)	20,377 (59.33%)	208 (66.03%)	3,019 (66.47%)	1,800 (70.20%)	38,848 (61.99%)
Female	169.97	24.28	8,027 (35.51%)	13,971 (40.67%)	107 (33.97%)	1,523 (33.53%)	764 (29.8%)	23,816 (38.01%)
Clinical characteristics								
Nutrition support								
No	170.18	24.31	13,055 (57.76%)	24,303 (70.76%)	198 (62.86%)	3,118 (68.65%)	1,651 (64.39%)	41,226 (65.79%)
Yes	172.40	24.63	9,548 (42.24%)	10,045 (29.4%)	117 (37.14%)	1,424 (31.35%)	913 (35.61%)	21,438 (34.21%)
Sputum smear								
Positive	175.43	25.06	22,560 (99.81%)	6,276 (18.27%)	124 (39.37%)	2,060 (45.35%)	2,050 (79.95%)	31,679 (50.55%)
Negative	166.49	23.78	42 (0.19%)	27,131 (78.99%)	180 (57.14%)	2,350 (51.74%)	496 (19.34%)	29,889 (47.7%)
Not done	162.85	23.26	1 (0.00%)	941 (2.74%)	11 (3.49%)	132 (2.91%)	18 (0.7%)	1,096 (1.75%)
HIV status								
Negative	172.09	24.58	12,772 (56.51%)	16,506 (48.06%)	153 (48.57%)	1,692 (37.25%)	1,419 (55.34%)	31,433 (50.16%)
Positive	168.32	24.05	455 (2.01%)	1,213 (3.53%)	11 (3.49%)	162 (3.57%)	78 (3.04%)	1,871 (2.99%)
Unknown	169.88	24.27	9,376 (41.48%)	16,629 (48.41%)	151 (47.94%)	2,688 (59.18%)	1,067 (41.61%)	29,360 (46.85%)
Categories of patients								
New patient	167.88	23.98	20,413 (90.31%)	32,903 (95.79%)	304 (96.51%)	4,210 (92.69%)	0 (0.00%)	58,544 (93.43%)
Failed previous treatment	170.24	30.43	575 (2.54%)	313 (0.91%)	4 (1.27%)	99 (2.18%)	0 (0.00%)	1,025 (1.64%)
Return after Loss to Follow-up	124.09	17.73	38 (0.17%)	27 (0.08%)	0 (0.00%)	12 (0.26%)	0 (0.00%)	77 (0.13%)
Relapsed	214.52	30.65	2,190 (9.69%)	1,445 (4.21%)	11 (3.49%)	332 (7.31%)	2,564 (100%)	4,120 (4.8%)
Treatment Outcomes								
Cured	179.49	25.64						
Completed	173.11	24.73						
Lost to follow up during Initial Phase	40.82	5.83						
Lost to follow up during Continuation Phase	103.49	14.78						
Failure	215.74	30.82						

*N and % in the header by Row, below is by Column

Table 3.0 Weight group of TB patients stratified by Age Group

Weight group	Age Group				
	15-19 years old	20-34 years old	35-54 years old	over 55 years old	Total
under 15 kg	7 (21.21%)	9 (27.27%)	12 (36.36%)	5 (15.15%)	33 (100%)
16-29 kg	105 (9.08%)	153 (22.30%)	247 (21.35%)	652 (56.35%)	1157 (100%)
30-39 kg	965 (7.23%)	3383 (25.35%)	4266 (31.97%)	4731 (35.45%)	13345 (100%)
40-54 kg	2236 (5.6%)	12974 (32.49%)	15,512 (38.85%)	9205 (23.05%)	39205 (100%)
55-69 kg	181 (2.38%)	2102 (27.63%)	3464 (45.53%)	1862 (24.47%)	7609 (100%)
over 70 kg	6 (1.01%)	126 (21.25%)	318 (53.63%)	143 (24.11%)	593 (100%)

Table 3.1. Proportion of Smear Microscopy by HIV Status

Smear Result	HIV Status		
	Negative	Positive	Unknown
Positive Smear	16,280 (51.79%)	699 (37.36%)	14,700 (50.07%)
Negative Smear	14,833 (49.63%)	1,107 (59.17%)	13,949 (47.51%)
Not Done	320 (1.02%)	65 (3.47%)	711 (2.42%)
Total	31,433	1,871	29,360
Chi2 (p-value)	332.67 (<0.001)		

Table 3.2. Proportion of Successful treatment by Weight Group, stratified by Age Group

Weight group	Age group							
	15-19 years old		20-34 years old		35-54 years old		over 55 years old	
	successful*	unsuccessful**	successful	unsuccessful	successful	unsuccessful	successful	unsuccessful
under 15 kg	7 (0.22%)	0	8 (0.05%)	1 (0.06%)	11 (0.05%)	1 (0.05%)	5 (0.03%)	0
16-29 kg	100 (3.08%)	5 (1.95%)	146 (0.85%)	7 (0.43%)	218 (1%)	29 (1.39%)	571 (3.84%)	81 (4.64%)
30-39 kg	889 (27.40%)	76 (29.69%)	3,099 (18.09%)	284 (17.54%)	3,845 (17.7%)	421 (20.13%)	4,163 (28.03%)	568 (32.51%)
40-54 kg	2,079 (64.09%)	157 (61.33%)	11,867 (69.28%)	1,107 (68.38%)	14,197 (65.34%)	1,315 (62.89%)	8,309 (55.95%)	896 (51.29%)
55-69 kg	163 (5.02%)	18 (7.03%)	1,893 (11.05%)	209 (12.91%)	3,166 (14.57%)	298 (14.25%)	1,679 (11.31%)	183 (10.48%)
over 70 kg	6 (0.18%)	0	115 (0.67%)	11 (0.68%)	291 (1.34%)	27 (1.29%)	124 (0.83%)	19 (1.09%)
Total	3,244	256	17,128	1,619	21,728	2,091	14,851	1,747
Chi2 (p-value)***	4.6137 (0.465)		8.2247 (p=0.143)		10.9653 (p=0.052)		22.3367 (<0.001)	

* Successful treatment = cured + completed cases

** Uncessful treatment = Loss to follow-up + failure + relapsed

*** p-value >0.05 is considered not significant

Of 62,664 tuberculosis patients treated at PSI, 56,951 (90.9%) were successfully treated (35.1% cured and 53.4% completed), and 5,173 (9.1%) had unsuccessful treatment outcomes (0.5% defaulted before 2 months of treatment, 7.1% defaulted before 6 months of treatment, and 4.0% failed treatment) (**Table 2**).

The demographic characteristics of TB patients included 38,848 (62.0%) males, and 23,816 (35.5%) females. A total of 21,998 out of 23,816 (92.4%) females were successfully treated (cured, or completed), compared with 34,953 out of 38,848 (89.9%) of males (**Table 2**). Males had higher proportion of unsuccessful treatment outcomes, with 66.0% loss to follow-up during initial phase of treatment, and 66.5% loss to follow-up during continuation phase of treatment (**Table 2**).

Among HIV positive cases, the proportion of smear-positive (37.4%) was lower than smear-negative and not done, 59.2%, and 3.5%, respectively, but there were noticeably a large number 29,360 (46.9%) of total TB cases with unknown HIV status (**Table 3.1**). TB patients with known HIV negative status had higher proportion of successful treatment outcomes (56.5% of cured cases, and 48.1% of completed cases) compared with those who had HIV positive test results (**Table 2**).

With age group stratification, the proportion of successful treatment by weight group was seen highest in patient aged between 35-54 years old (21,728/56,951, 38.2%) compared to other three age groups, and those who weighted between 40-54kg (65.3%) (**Table 3.2**). Data were not available to examine treatment outcomes by body mass index (BMI). Of all successfully treated cases, proportion of patients who received nutritional support were 42.2% of cured cases, and 29.4% of completed cases, a smaller proportion than those who did not attain successful

treatment outcomes. (**Table 2**). Also, of TB patients who failed current treatment, 100% had previous relapse history (**Table 2**).

Treatment Interval

The standard treatment interval for Initial Phase (the first 2 months) is 60 days (8.5 weeks), another 120 days (17 weeks) for Continuation Phase (the next 4 months), and the complete interval for tuberculosis treatment is 180 days (27.7 weeks) (**Table 2**).

The mean of treatment interval for tuberculosis patients at PSI was 171 days (iqr=8) or 24.4 weeks (iqr=1.14). The minimum interval was 1 day, or 0.14 week (defaulted) and the maximum interval was 336 days, or 48 weeks (until completed) (**Table 2**).

Among all diagnostic categories of tuberculosis patients, those who previously relapsed spent the longest duration of treatment, with mean of 214 days (30.65 weeks) until attainment of observed treatment outcomes. In contrast, new patients spent average of 168 days (23.98 weeks) until attaining observed treatment outcomes; those who returned after loss to follow-up (124 days or 17.73 weeks) had shorter treatment interval than the standard treatment interval of 180 days or 27.7 weeks for the combined treatment phases, which could reflect default before completing the re-treatment regimen. (**Table 2).**

When the average treatment interval was stratified by treatment outcomes, patients who completed the treatments spent an average of 173 days (24.73 weeks), those who were cured spent an average of 179 days (25.64 weeks), those who lost to follow-up before 2 months and 6 months spent 41 days (5.83 weeks) and 103 days (14.78 weeks) in treatment, respectively, and those who failed the re-treatment spent the longest duration of 216 days (30.82 weeks) under treatment (**Table 2).**

Newly and Re-treated Cases, and Risk Factors of Being Re-treated

Table 4. Characteristics of Patients between Newly and Re-treated Cases, and Associated Risk of Being Retreated (column % for each characteristic)

Characteristics	N (%) New Patients= 58,544 (93.43%)*	N (%) Re-treated Patients= 4,120 (6.57%)*	N (%) Total = 62,664 (100%)*	Relative Risk (CI)	p-value	adj. Relative Risk (CI)**	p-value***
Demographic characteristics							
Sex							
Male	35,986 (61.47%)	2,862 (69.47%)	38,848 (61.99%)	1.43 (1.33 - 1.53)	<0.0001	1.44 (1.35 - 1.55)	<0.0001
Female	22,558 (38.53%)	1,258 (30.53%)	23,816 (38.01%)	reference group		reference group	
Age, years							
15 - 34	21,271 (36.33%)	976 (23.69%)	22,247 (35.50%)	reference group		reference group	
35 - 54	21,905 (37.42%)	1,914 (46.46%)	23,819 (38.01%)	1.90 (1.76 - 2.06)	<0.0001	1.87 (1.73 - 2.02)	<0.0001
>= 55	15,368 (26.25%)	1,230 (29.85%)	16,598 (26.49%)	1.74 (1.60 - 1.90)		1.71 (1.57 - 1.87)	
Clinical characteristics							
Nutrition support							
No	38,652 (66.02%)	2,574 (62.48%)	41,226 (65.79%)	reference group	<0.0001	reference group	
Yes	19,892 (33.98%)	1,546 (37.52%)	21,438 (34.21%)	1.17 (1.09 - 1.25)		1.16 (1.09 - 1.25)	<0.0001
Sputum Smear							
Positive	28,607 (48.86%)	3,072 (74.56%)	31,679 (50.55%)	3.06 (2.85 - 3.30)		3.08 (2.87 - 3.32)	
Negative	28,876 (49.32%)	1,013 (24.59%)	29,889 (47.7%)	reference group	<0.0001	reference group	<0.0001
Not Done	1,061 (1.81%)	35 (0.85%)	1,096 (1.75%)	0.94 (0.67 - 1.32)		0.99 (0.71 - 1.40)	
HIV status							
Negative	29,297 (50.04%)	2,136 (51.84%)	31,433 (50.16%)	1.25 (1.02 - 1.53)		reference group	
Positive	1,768 (3.02%)	103 (2.50%)	1,871 (2.99%)	reference group	<0.02	1.17 (0.96 - 1.44)	<0.0001
Unknown	27,479 (46.94%)	1,881 (45.66%)	29,360 (46.85%)	1.17 (0.96 - 1.44)		1.1 (0.89 - 1.34)	

*N and % in the header by Row, below is by Column

**Relative Risk or Risk Ratio adjusted for Age Bodyweight and Gender,with 95% Confidence Interval (CI)

*** Two-sided chi-squared, p-value < 0.05 considered significant

All values rounded to 2 decimals

Among new patients diagnosed at PSI, a higher proportion were male (61.5%) than female, those aged between 35-54 years old (37.4%) were more common than the other two age groups. Patients who did not receive nutritional support accounted for 66.02% compared to 34.0% who received nutritional support. Among newly treated patients, a relatively larger proportion had smear-negative results (49.3%), compared with those who had smear-positive results (48.9%) and those who had no sputum smear microscopy (1.8%) (**Table 4**).

Among patients who sought re-treatment, a higher proportion were male (69.5%), and in the age group of 35-54 years old (46.46%) compared with the other two age groups. In addition, those who did not receive nutritional support accounted for a majority (62.5%), compared to those who received nutritional support (37.5%). In contrast to new cases, re-treated cases had far higher proportion of patients who had smear-positive (74.6%) compared to smear-negative (24.6%) and those who had not smear microscopy (0.9%) (**Table 4**).

When adjusted for age group and sex, the risk of being re-treated for males was 1.44 (aRR=1.44, CI:1.35-1.55) times higher than in females. Compared to the reference age group of younger than 34 years, there was an 87% higher risk of being re-treated among patients in the age-group 35-54 years (aRR=1.87, CI:1.73-2.02), and 71% increased risk in patients aged over 55 years (aRR=1.71, CI:1.57-1.87). Compared with smear-negative cases, smear- positive cases had 3 times higher risk (aRR=3.08, CI:2.87-3.32) of being re-treatment TB cases (**Table 4**). In addition, patients with negative HIV status had 1.17 risk of being re-treatment cases compared with patients who had HIV positive status, but this result could be influenced by the small number of patients (103, 2.5%) with positive HIV test results (**Table 4).**

FIGURE 2. TREATMENT OUTCOMES BY DIFFERENT CATEGORIES OF PATIENTS (%)

Legend: Cured | Completed | Defaulted before 2 months | Defaulted before 6 months | Failure

NEW PATIENT: 35.3, 56.9, 0.53, 7.27, 0
FAILED PREVIOUS TREATMENT: 58.02, 31.58, 0.4, 10, 0
RETURN AFTER LOSS TO FOLLOW-UP: 49.35, 35.06, 0, 15.59, 0
RELAPSED: 33.48, 22.01, 0.17, 5.07, 39.19
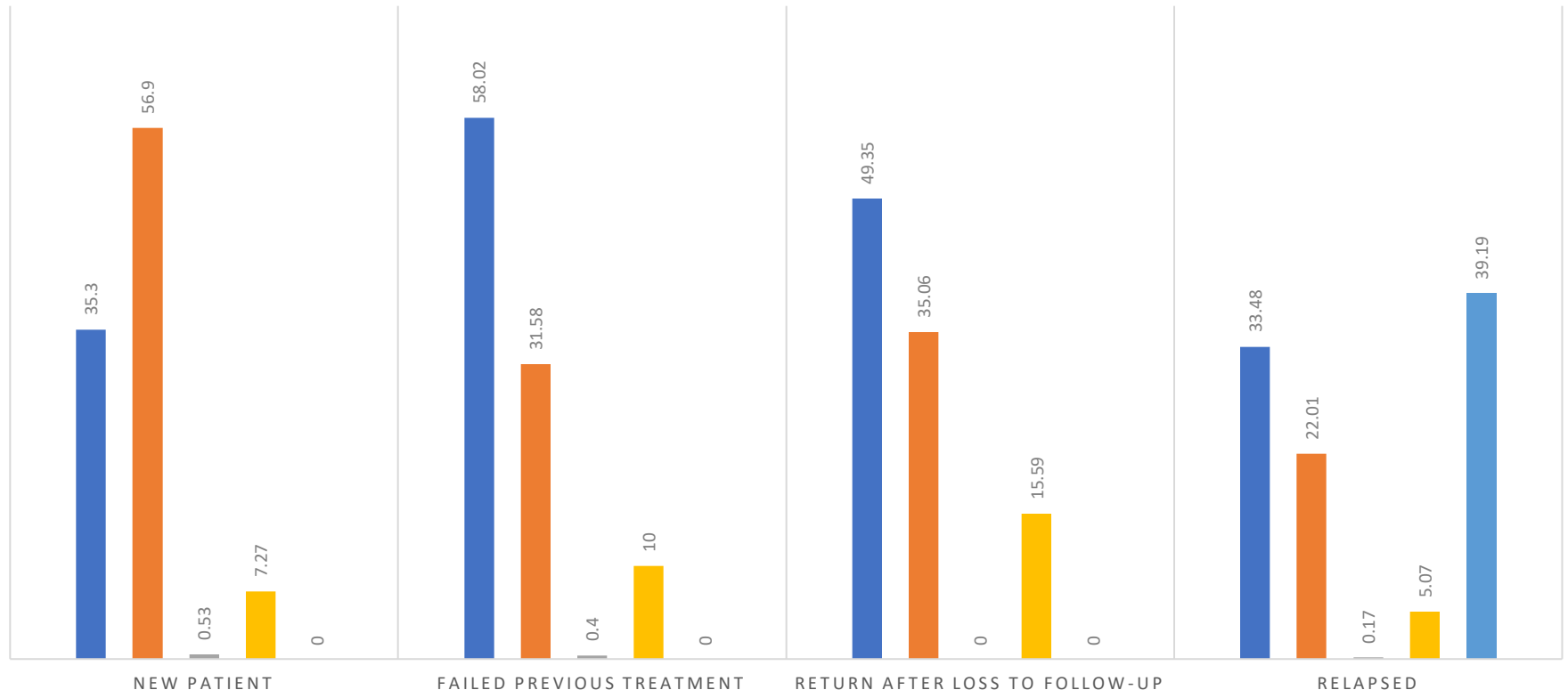
Of all 62,664 tuberculosis patients treated at PSI, 90.9% had successful treatment outcomes, and 9.1% had unsuccessful outcomes.

Among new patients successfully treated at PSI, 92.2% had successful outcomes (56.9% completed and 35.3% cured). Among patients with unsuccessful outcomes, 0.53% and 7.27% were lost to follow-up during the initial phase (before 2 months) and continuation phase of treatment, respectively, and none met treatment failure criteria (***Figure 2***).

Among patients who failed previous treatment and were served at PSI, 89.6% achieved successful treatment outcomes (31.6% completed, and 58.0% cured). Unsuccessful treatment outcomes included 0.4% and 10.0% lost to follow-up during the initial phase and during the continuation phase of treatment, respectively, and none met the criteria of failed re-treatment (***Figure 2***).

Among patients who returned to PSI for TB care after loss to follow-up for previous treatment, 84.4% attained successful treatment outcomes (35.1% completed, and 49.4% cured). Of unsuccessfully treated patients, 15.6% were lost to follow-up during the continuation phase of treatment, and none met treatment failure criteria or were lost to follow-up during the initial phase of treatment *(**Figure 2**)*.

Among relapsed patients who received re-treatment, 55.5% were successfully treated (22.0% completed, 33.5% cured). Of the remainder, 0.2% and 5.1% were lost to follow-up during the initial phase and during the continuation phase of treatment, respectively, and 39.2% met treatment failure criteria after re-treatment *(**Figure 2**)*.

Treatment Success Rate

The overall Treatment Success Rate at PSI for this five-year period from 2012 to 2016 was at 91% *(**Figure 3**).* However, the Treatment Success Rate by year fluctuated between 89.2% (2012) to 88.03% (2013), 86.25% (2014), 90.96% (2015), and 88.35% (2016) *(**Figure 4**).*

FIGURE 3. TREATMENT SUCCESS RATE AT PSI

■ Successful   ■ Unsuccessful

5,713 (9%)

56,951 (91%)

Figure 4. Treatment Outcomes and Success Rate by Year at PSI Myanmar

■ Completed   ■ Cured   ■ Defaulter before 2 months   ■ Defaulter before 6 months   ■ Failure   ■ Treatment Success Rate
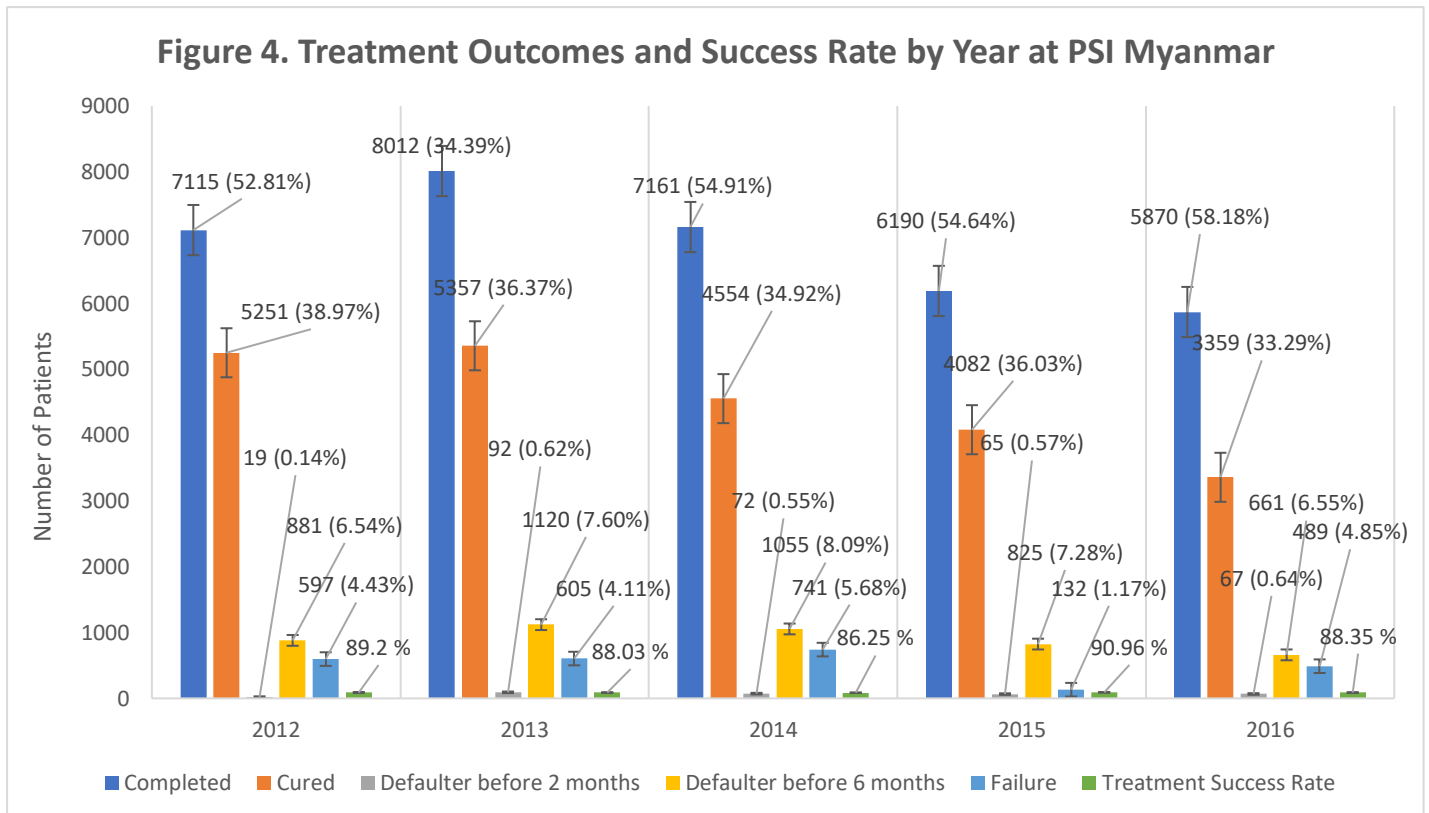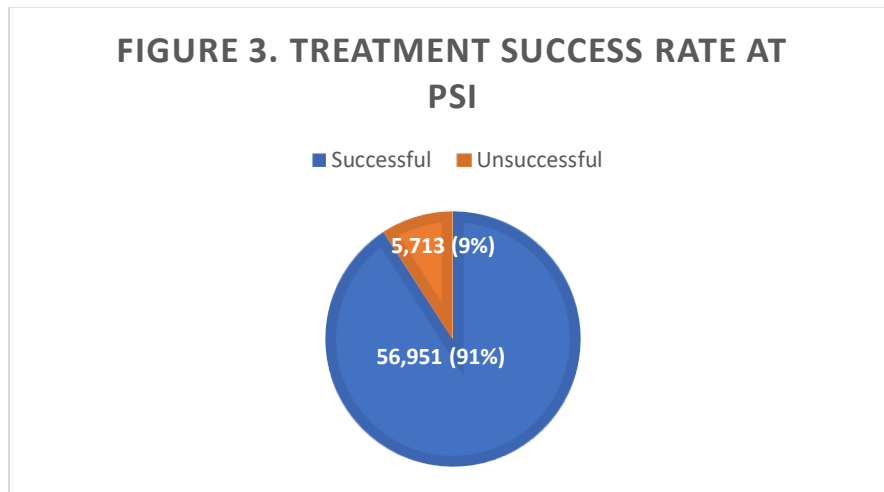
Risk Factor Associated with Unsuccessful Treatment

Table 5. Characteristics of Patient, and Risk Factors Associated with Unsuccessful Treatment (column % for each characteristic)

Characteristics	N (%) Successfully Treated= 56,951 (90.88%)*	N (%) Unsuccessfully Treated= 5,713 (9.12%)*	N (%) Total = 62,664 (100%)*	Relative Risk	p-value	adj. Relative Risk (CI)**	p-value***
Demographic characteristics							
Sex							
Male	34,953 (61.37%)	3,895 (68.18%)	38,848 (61.99%)	1.35 (1.27 - 1.43)	<0.0001	1.41 (1.33 - 1.50)	<0.0001
Female	21,998 (38.63%)	1,818 (31.82%)	23,816 (38.01%)	reference group		reference group	
Age, years							
15 - 34	20,372 (35.77%)	1,875 (32.82%)	22,247 (35.5%)	reference group	<0.0001	reference group	<0.0001
35 - 54	21,728 (38.15%)	2,091 (36.6%)	23,819 (38.01%)	1.05 (0.98 - 1.11)		1.03 (0.96 - 1.10)	
>= 55	14,851 (26.08%)	1,747 (30.58%)	16,598 (26.49%)	1.28 (1.19 - 1.37)		1.25 (1.17 - 1.34)	
Clinical characteristics							
Nutrition support							
No	37,358 (65.6%)	3,868 (67.71%)	41,226 (65.79%)	reference group	<0.0001	reference group	<0.0001
Yes	19,593 (34.4%)	1,845 (32.29%)	21,438 (34.21%)	0.91 (0.86 - 0.96)		0.91 (0.85 - 0.96)	
Sputum Smear							
Positive	28,836 (50.63%)	2,843 (49.76%)	31,679 (50.55%)	0.99 (0.93 - 1.04)		1.03 (0.98 - 1.10)	
Negative	27,173 (47.71%)	2,716 (47.54%)	29,889 (47.7%)	reference group	<0.0001	reference group	<0.0001
Not Done	942 (1.65%)	154 (2.7%)	1,096 (1.75%)	1.64 (1.37 - 1.95)		1.74 (1.46 - 2.07)	
HIV status							
Negative	29,278 (51.41%)	2,155 (37.72%)	31.433 (50.16%)	reference group		reference group	
Positive	1,668 (2.93%)	203 (3.55%)	1,871 (2.99%)	1.65 (1.42 - 1.93)	<0.0001	1.69 (1.45 - 1.96)	<0.0001
Unknown	26,005 (45.66%)	3,355 (58.73%)	29,360 (46.85%)	1.75 (1.66 - 1.85)		1.75 (1.66 - 1.85)	
Categories of patients							
New patient	53,316 (92.09%)	5,228 (89.12%)	58,544 (93.42%)	0.79 (0.70 - 0.89)		0.83 (0.74 - 0.93)	
Failed previous treatment	888 (1.54%)	137 (2.34%)	1,025 (1.64%)	1.24 (1.00 - 1.54)	<0.0001	1.26 (1.02 - 1.56)	<0.0001
Return after Loss to Follow-up	65 (0.12%)	16 (0.27%)	81 (0.13%)	1.99 (1.14 - 3.48)		1.99 (1.14 - 3.49)	
Relapsed	3,635 (6.25%)	485 (8.27%)	4,120 (4.81%)	reference group		reference group	

*N and % in the header by Row, below is by Column

**Relative Risk or Risk Ratio adjusted for Age Bodyweight and Gender,with 95% Confidence Interval (CI)

*** Two-sided chi-squared, p-value < 0.05 considered significant

Among unsuccessfully treated cases, a higher proportion were male (68.2%) compared to the proportion of female (31.8%), those in the age-group of 35-54 years old had the highest proportion (36.6%) among the three age groups (**Table 5**). Of patients served at PSI, 67.7% did not receive nutritional support, and 32.3% received nutritional support. Sputum smear-positive cases accounted for 49.8% and smear-negative cases accounted for 47.5%, and those who had no sputum smears accounted for 2.7% of cases (**Table 5**). Of all unsuccessfully treated cases, 89.1% were new patients, 2.3% were those who failed previously treatment, 0.3% were those who had been lost to follow-up, and 8.3% were those who relapsed after previous treatment (**Table 5**).

When adjusted for age group and sex, the risk of having unsuccessful outcomes in males was 1.41 (aRR=1.41, CI:1.33-1.50) times the risk in females (**Table 5**). The risk of having unsuccessful outcomes among those in age group of 35-54 years old (aRR=1.03, CI:0.96-1.10) was similar to the risk observed in the reference age-group below 34 years old. However, the risk of unsuccessful treatment was 25% among those in the age-group over 55 years old (aRR=1.25, CI:1.17-1.34) (**Table 5**). Those patients who received nutritional support had a 9% (aRR=0.91, CI:0.85-0.96) lower risk of having unsuccessful outcomes compared to those who did not receive the nutritional support. Those who had smear-positive disease only had 3% increased risk of unsuccessful outcomes (aRR=1.03, CI:0.98-1.10) compared to those who had smear-negative result, but this difference was not statistically significant (**Table 5**). Patients who return after lost to follow-up had the highest risk of having unsuccessful outcomes (aRR=1.99, CI:1.14-3.49), and the risk among those who failed previous treatment was 1.26 (aRR=1.26, CI:1.02-1.56). Although not statistically significant, there was a 17% decreased risk of having unsuccessful outcomes among those who were new patients (aRR=0.83, CI:0.74-1.96) compared to those who relapsed previous treatment as reference group (**Table 5**).

The risk factors for having unsuccessful treatment outcomes among tuberculosis patients seen at PSI from 2012 to 2016 were those who were male, patients aged over 55 years old, smear-positive, HIV positive, and those who return for re-treatment after lost to follow up.

Discussion

This assessment provides descriptive information about TB patients in Myanmar cared for at PSI from 2012 to 2016 and identified risk factors related to unsuccessful treatment outcomes. Using Chi Square test for linear trends, we observed a statistically significant reduction in the annual number and proportion of Myanmar TB patients treated by PSI, peaking at 14,730 (24%) in 2013 and decreasing to 10,089 (16%) in 2016. The limited available information does not provide insights to explain this decrease over time.

Among the population served by PSI during the study period, we found a higher tuberculosis diagnosis in male patients and those in the age group of 35-54 years old. These findings were similar to the previous study at PSI analyzing data for retreatment cases from 2004 to 2010, with a predominance of males, and in the age group of 35-54 [31]. Contrasting the demographic characteristics of NTP patients with those served by PSI, in both settings a similarly higher proportion of TB were seen in males, but a larger proportion of NTP patients were in the age group over 65 years old [19].

In addition, we observed that sputum smear results reflected that half of these TB patients had a higher bacillary load, as suggested by sputum microscopy. Compared with new TB cases, previously treated TB cases also had a statistically higher relative risk of sputum smear positive results, also suggesting more extensive pulmonary disease. Previous PSI study [28] and NTP

results [19] have shown that HIV positive status was associated with a higher proportion of smear-positive results. In contrast, our study could not confirm that association, yet was limited by having nearly half of the TB cases with unknown HIV status, and a small proportion of HIV positive cases.

Not surprisingly, we observed that PSI retreatment TB cases experienced a higher risk of unsuccessful treatment outcomes and required longer duration (previously relapsed had a mean of 214 days/30.65 weeks) than new TB patients (average of 168 days/23.98 weeks) to attain the observed treatment outcomes. The longer need for medications and supportive care are important considerations when planning delivery of future services that target the subpopulation of retreatment TB patients. These will need enhanced patient education and extended treatment supplies.

The sputum smear findings in new TB patients also imply that exclusive reliance on sputum microscopy would have missed a large fraction (nearly half) of people determined to have TB disease at the sites served by PSI in Myanmar. Both PSI and MMA had very high successful treatment outcomes, possibly associated with implementation of diagnosis and treatment using national standards, as well as their provision of support and incentives to facilitate TB patients' access to treatment services and reduce the loss to follow-up [18]. However, the treatment success rate at the two largest PPM, which accounted almost 20% of national TB cases, had 91% and 92% treatment success rate [18], which contrast favorably with the NTP [19] and WHO [2] estimated Myanmar TB treatment success rate of 85% and 88%, respectively, in the studied period. We also observed that those patients who received nutritional support had a statistically significant lower risk of unsuccessful treatment outcomes, suggesting that this form of incentive promotes treatment adherence.

NTP had no specific criteria for the provision of nutritional support for TB patients while receiving treatment, but some large PPMs, such as PSI and MMA target the provision of social and nutritional support to TB patients with HIV positive status [27]. PSI and other PPMs should consider expanding their nutritional support for other patients, especially those found to have a high risk for unsuccessful treatment outcomes, such as those aged over 55 years old, having smear-positive disease, and those who came for re-treatment. Other areas deserving future targeted attention and not examined by this evaluation include children with TB, and those who experience barriers to access to TB diagnosis and treatment services [3, 20, 28].

A systematic review which examined TB control in 12 high burden countries, including Myanmar, reported that Public-Private Mix sectors made significant contributions to expanding access to TB services, and most countries achieved high treatment success rate, ranging 85% to 90% [18, 32]. The annual treatment success rates at PSI from 2012 to 2016 were maintained at about 90%. Considering that at least one or two of every 10 TB cases in Myanmar were cared for at PSI, this achievement probably contributed to increases the national treatment success rate of all forms of TB. Nationally, annual treatment success has remained at 85% to 87% from 2012 to 2016 [19, 29].

In the absence of information during the same study period for other small PPMs and public sectors to allow for correlation of observed treatment outcomes, identifying risk factors for poor outcomes, or exploring the role of incentives and enablers – such as nutritional support – it is unclear how these other entities would have fared in their TB treatment success rates. The findings provided by this assessment can now be used by other Public-Private Mix TB contributors, such as PPM-Myanmar Medical Association (MMA), to contrast their treatment outcomes during those same years.

Limitations

This dataset contains many observations and variables useful to for analysis, but it lacked drug-resistance status, other clinical measures (such as chest radiographs), specific treatment regiments, or detailed treatment history. Our analysis was thus restricted to the programmatic data collected by PSI, which also limited the variables to be mined and analyzed. Specific concerns include the inability to examine or compare treatment outcomes stratified by the types of drug resistances such as RR- or MDR-TB, impact of HIV status, or use of body mass index (BMI) as indicators of patients' nutritional status. In addition, patients served by PSI sites are not necessarily representative of other TB patients seen by NTP or all Public-Private Mix in Myanmar. Future studies should consider a full-scale prospective collaboration between NTP, PSI, MMA, and other smaller PPMs to gather additional clinical, laboratory, and specific treatment regimen data to more precisely inform future measures aimed at reducing unsuccessful TB treatment outcomes.

Consolidated Data Appendices

Tables

Table 1. Characteristics of TB Patients

Table 1. Characteristics of Tuberculosis Patients by Years of Treatment Start (column % for each characteristic)

Characteristics	N (%) 2012 = 13,474 (21.5%)	N (%) 2013 = 14,730 (23.5%)	N (%) 2014 = 13,042 (20.8%)	N (%) 2015 = 11,329 (18.1%)	N (%) 2016 = 10,089 (16.1%)	Total 62,664	chi2 (p-value) 25.0554 (<0.001)
Demographic characteristics							
Sex							
Male	8,281 (61.46%)	9,088 (61.7%)	8,064 (61.83%)	7,065 (62.36%)	6,350 (62.94%)	38,848 (61.99%)	104.4944 (<0.001)
Female	5,193 (38.54%)	5,642 (38.3%)	4,978 (38.17%)	4,264 (37.64%)	3,739 (37.06%)	23,816 (38.01%)	
Age, years							
15 - 34	4,904 (36.4%)	5,228 (35.49%)	4,692 (35.98%)	4,350 (38.4%)	3,695 (36.62%)	22,247 (35.5%)	
35 - 54	5,269 (39.1%)	5,646 (38.33%)	4,859 (37.26%)	3,033 (26.77%)	2,917 (28.91%)	23,819 (38.01%)	64.2832 (<0.001)
>= 55	3,301 (24.5%)	3,856 (26.18%)	3,491 (26.77%)	3,033 (26.77%)	2,917 (28.91%)	16,598 (26.49%)	
Bodyweight, kg							
Average	44.6 (SD = 8.7)	45 (SD = 8.6)	45.1 (SD = 8.7)	45.6 (SD = 8.9)	45.6 (SD = 9)		
Under 15kg	12 (0.09%)	5 (0.03%)	3 (0.02%)	6 (0.05%)	7 (0.07%)	33 (0.05%)	
16 - 29kg	279 (2.07%)	269 (1.83%)	223 (1.71%)	196 (1.73%)	190 (1.88%)	1,157 (1.85%)	
30 - 39kg	3,074 (22.81%)	3,071 (20.85%)	2,782 (21.33%)	2,342 (20.67%)	2,076 (20.58%)	13,345 (21.3%)	114.5016 (<0.001)
40 - 54 kg	8,559 (63.52%)	9,531 (64.7%)	8,369 (64.17%)	7,173 (63.32%)	6,295 (62.39%)	39,927 (63.72%)	
55 - 70kg	1,434 (10.64%)	1,734 (11.77%)	1,549 (11.88%)	1,494 (13.19%)	1,398 (13.86%)	7,609 (12.14%)	
> 70kg	116 (0.86%)	120 (0.81%)	116 (0.89%)	118 (1.04%)	123 (1.22%)	593 (0.95%)	
Clinical characteristics							
Nutrition support							
No	9,521 (70.66%)	9,687 (65.76%)	8,657 (66.38%)	6,910 (60.99%)	6,451 (63.94%)	41,226 (65.79%)	275.2171 (<0.001)
Yes	3,953 (29.34%)	5,043 (34.24%)	4,385 (33.62%)	4,419 (39.01%)	3,638 (36.06%)	21,438 (34.21%)	
Sputum Smear							
Positive	7,281 (54.04%)	7,323 (49.71%)	6,558 (50.28%)	5,759 (50.83%)	4,758 (47.16%)	31,679 (50.55%)	
Negative	5,943 (44.11%)	7,200 (48.88%)	6,237 (47.82%)	5,336 (47.1%)	5,173 (51.27%)	29,889 (47.7%)	147.2202 (<0.001)
Not Done	250 (1.86%)	207 (1.41%)	247 (1.89%)	234 (2.07%)	158 (1.57%)	1,096 (1.75%)	
HIV status							
Negative	4,992 (37.05%)	6,356 (43.15%)	7,376 (56.56%)	6,622 (58.45%)	6,087 (60.33%)	31,433 (50.16%)	
Positive	437 (3.24%)	420 (2.85%)	395 (3.03%)	278 (2.45%)	341 (3.38%)	1,871 (2.99%)	2200 (<0.001)
Unknown	8,045 (59.71%)	7,954 (54%)	5,271 (40.42%)	4,429 (39.09%)	3,661 (36.29%)	29,360 (46.85%)	
Type of TB							
New patient	12,556 (93.19%)	13,813 (93.77%)	12,133 (93.03%)	10,527 (92.92%)	9,515 (94.31%)	58,544 (93.43%)	25.0554 (<0.001)
Re-treated patient	918 (6.81%)	917 (6.23%)	909 (6.97%)	802 (7.08%)	574 (5.69%)	4,120 (6.57%)	
Lost to follow-up							
Initial phase**	19 (0.14%)	92 (0.62%)	72 (0.55%)	65 (0.57%)	67 (0.66%)	315 (0.5%)	46.6494 (<0.001)
Continuation phase***	881 (6.54%)	1,120 (7.6%)	1,055 (8.09%)	825 (7.28%)	661 (6.55%)	4,542 (7.25%)	

*p-value < 0.05 considered significant

** Initial Phase: first 2 months of treatment

*** Continuation Phase: last 4 months of treatment

Table 2. Treatment Duration and Treatment Outcomes

Table 2. Average Treatment Duration and Treatment Outcomes by Different Characteristics of Tuberculosis Patients

Characteristics	Treatment Interval Mean in Days	Treatment Interval Mean in Weeks	Successfully Treated = 56,951 (90.88%)* Cured = 22,603 (35.11%)* N (%)	Successfully Treated = 56,951 (90.88%)* Completed = 34,348 (53.36%)* N (%)	Unsuccessfully Treated = 5,713 (9.12%)* Loss to follow-up during initial phase = 315 (0.49%)* N (%)	Unsuccessfully Treated = 5,713 (9.12%)* Loss to follow-up during continuation phase = 4,542 (7.06%)* N (%)	Unsuccessfully Treated = 5,713 (9.12%)* Failure = 2,564 (3.99%)* N (%)	Total = 62,664 (100%) N (%)
Demographic characteristics								
Sex								
Male	171.54	24.51	14,576 (64.49%)	20,377 (59.33%)	208 (66.03%)	3,019 (66.47%)	1,800 (70.20%)	38,848 (61.99%)
Female	169.97	24.28	8,027 (35.51%)	13,971 (40.67%)	107 (33.97%)	1,523 (33.53%)	764 (29.8%)	23,816 (38.01%)
Clinical characteristics								
Nutrition support								
No	170.18	24.31	13,055 (57.76%)	24,303 (70.76%)	198 (62.86%)	3,118 (68.65%)	1,651 (64.39%)	41,226 (65.79%)
Yes	172.40	24.63	9,548 (42.24%)	10,045 (29.4%)	117 (37.14%)	1,424 (31.35%)	913 (35.61%)	21,438 (34.21%)
Sputum smear								
Positive	175.43	25.06	22,560 (99.81%)	6,276 (18.27%)	124 (39.37%)	2,060 (45.35%)	2,050 (79.95%)	31,679 (50.55%)
Negative	166.49	23.78	42 (0.19%)	27,131 (78.99%)	180 (57.14%)	2,350 (51.74%)	496 (19.34%)	29,889 (47.7%)
Not done	162.85	23.26	1 (0.00%)	941 (2.74%)	11 (3.49%)	132 (2.91%)	18 (0.7%)	1,096 (1.75%)
HIV status								
Negative	172.09	24.58	12,772 (56.51%)	16,506 (48.06%)	153 (48.57%)	1,692 (37.25%)	1,419 (55.34%)	31,433 (50.16%)
Positive	168.32	24.05	455 (2.01%)	1,213 (3.53%)	11 (3.49%)	162 (3.57%)	78 (3.04%)	1,871 (2.99%)
Unknown	169.88	24.27	9,376 (41.48%)	16,629 (48.41%)	151 (47.94%)	2,688 (59.18%)	1,067 (41.61%)	29,360 (46.85%)
Categories of patients								
New patient	167.88	23.98	20,413 (90.31%)	32,903 (95.79%)	304 (96.51%)	4,210 (92.69%)	0 (0.00%)	58,544 (93.43%)
Failed previous treatment	170.24	30.43	575 (2.54%)	313 (0.91%)	4 (1.27%)	99 (2.18%)	0 (0.00%)	1,025 (1.64%)
Return after Loss to Follow-up	124.09	17.73	38 (0.17%)	27 (0.08%)	0 (0.00%)	12 (0.26%)	0 (0.00%)	77 (0.13%)
Relapsed	214.52	30.65	2,190 (9.69%)	1,445 (4.21%)	11 (3.49%)	332 (7.31%)	2,564 (100%)	4,120 (4.8%)
Treatment Outcomes								
Cured	179.49	25.64						
Completed	173.11	24.73						
Lost to follow up during Initial Phase	40.82	5.83						
Lost to follow up during Continuation Phase	103.49	14.78						
Failure	215.74	30.82						

*N and % in the header by Row, below is by Column

Table 3. Weight Group, Smear, HIV, Successful Treatment

Table 3. Weight group of TB patients stratified by Age Group

Weight group	Age Group				
	15-19 years old	20-34 years old	35-54 years old	over 55 years old	Total
under 15 kg	7 (21.21%)	9 (27.27%)	12 (36.36%)	5 (15.15%)	33 (100%)
16-29 kg	105 (9.08%)	153 (22.30%)	247 (21.35%)	652 (56.35%)	1157 (100%)
30-39 kg	965 (7.23%)	3383 (25.35%)	4266 (31.97%)	4731 (35.45%)	13345 (100%)
40-54 kg	2236 (5.6%)	12974 (32.49%)	15,512 (38.85%)	9205 (23.05%)	39205 (100%)
55-69 kg	181 (2.38%)	2102 (27.63%)	3464 (45.53%)	1862 (24.47%)	7609 (100%)
over 70 kg	6 (1.01%)	126 (21.25%)	318 (53.63%)	143 (24.11%)	593 (100%)

Table 3.1. Proportion of Smear Microscopy by HIV Status

Smear Result	HIV Status		
	Negative	Positive	Unknown
Positive Smear	16,280 (51.79%)	699 (37.36%)	14,700 (50.07%)
Negative Smear	14,833 (49.63%)	1,107 (59.17%)	13,949 (47.51%)
Not Done	320 (1.02%)	65 (3.47%)	711 (2.42%)
Total	31,433	1,871	29,360
Chi2 (p-value)	332.67 (<0.001)		

Table 3.2. Proportion of Successful treatment by Weight Group, stratified by Age Group

Weight group	Age group							
	15-19 years old		20-34 years old		35-54 years old		over 55 years old	
	successful*	unsuccessful**	successful	unsuccessful	successful	unsuccessful	successful	unsuccessful
under 15 kg	7 (0.22%)	0	8 (0.05%)	1 (0.06%)	11 (0.05%)	1 (0.05%)	5 (0.03%)	0
16-29 kg	100 (3.08%)	5 (1.95%)	146 (0.85%)	7 (0.43%)	218 (1%)	29 (1.39%)	571 (3.84%)	81 (4.64%)
30-39 kg	889 (27.40%)	76 (29.69%)	3,099 (18.09%)	284 (17.54%)	3,845 (17.7%)	421 (20.13%)	4,163 (28.03%)	568 (32.51%)
40-54 kg	2,079 (64.09%)	157 (61.33%)	11,867 (69.28%)	1,107 (68.38%)	14,197 (65.34%)	1,315 (62.89%)	8,309 (55.95%)	896 (51.29%)
55-69 kg	163 (5.02%)	18 (7.03%)	1,893 (11.05%)	209 (12.91%)	3,166 (14.57%)	298 (14.25%)	1,679 (11.31%)	183 (10.48%)
over 70 kg	6 (0.18%)	0	115 (0.67%)	11 (0.68%)	291 (1.34%)	27 (1.29%)	124 (0.83%)	19 (1.09%)
Total	3,244	256	17,128	1,619	21,728	2,091	14,851	1,747
Chi2 (p-value)***	4.6137 (0.465)		8.2247 (p=0.143)		10.9653 (p=0.052)		22.3367 (<0.001)	

* Successful treatment = cured + completed cases

Table 4. Risk Factor of Being Re-treated

Characteristics	N (%) New Patients= 58,544 (93.43%)*	N (%) Re-treated Patients= 4,120 (6.57%)*	N (%) Total = 62,664 (100%)*	Relative Risk (CI)	p-value	adj. Relative Risk (CI)**	p-value***
Demographic characteristics							
Sex							
Male	35,986 (61.47%)	2,862 (69.47%)	38,848 (61.99%)	1.43 (1.33 - 1.53)	<0.0001	1.44 (1.35 - 1.55)	<0.0001
Female	22,558 (38.53%)	1,258 (30.53%)	23,816 (38.01%)	reference group		reference group	
Age, years							
15 - 34	21,271 (36.33%)	976 (23.69%)	22,247 (35.50%)	reference group		reference group	
35 - 54	21,905 (37.42%)	1,914 (46.46%)	23,819 (38.01%)	1.90 (1.76 - 2.06)	<0.0001	1.87 (1.73 - 2.02)	<0.0001
>= 55	15,368 (26.25%)	1,230 (29.85%)	16,598 (26.49%)	1.74 (1.60 - 1.90)		1.71 (1.57 - 1.87)	
Clinical characteristics							
Nutrition support							
No	38,652 (66.02%)	2,574 (62.48%)	41,226 (65.79%)	reference group	<0.0001	reference group	
Yes	19,892 (33.98%)	1,546 (37.52%)	21,438 (34.21%)	1.17 (1.09 - 1.25)		1.16 (1.09 - 1.25)	<0.0001
Sputum Smear							
Positive	28,607 (48.86%)	3,072 (74.56%)	31,679 (50.55%)	3.06 (2.85 - 3.30)		3.08 (2.87 - 3.32)	
Negative	28,876 (49.32%)	1,013 (24.59%)	29,889 (47.7%)	reference group	<0.0001	reference group	<0.0001
Not Done	1,061 (1.81%)	35 (0.85%)	1,096 (1.75%)	0.94 (0.67 - 1.32)		0.99 (0.71 - 1.40)	
HIV status							
Negative	29,297 (50.04%)	2,136 (51.84%)	31,433 (50.16%)	1.25 (1.02 - 1.53)		reference group	
Positive	1,768 (3.02%)	103 (2.50%)	1,871 (2.99%)	reference group	<0.02	1.17 (0.96 - 1.44)	<0.0001
Unknown	27,479 (46.94%)	1,881 (45.66%)	29,360 (46.85%)	1.17 (0.96 - 1.44)		1.1 (0.89 - 1.34)	

Table 4. Characteristics of Patients between Newly and Re-treated Cases, and Associated Risk of Being Retreated (column % for each characteristic)

*N and % in the header by Row, below is by Column

**Relative Risk or Risk Ratio adjusted for Age Bodyweight and Gender,with 95% Confidence Interval (CI)

*** Two-sided chi-squared, p-value < 0.05 considered significant

All values rounded to 2 decimals

Table 5. Risk Factor of Unsuccessful Treatment

Table 5. Characteristics of Patient, and Risk Factors Associated with Unsuccessful Treatment (column % for each characteristic)

Characteristics	N (%) Successfully Treated= 56,951 (90.88%)*	N (%) Unsuccessfully Treated= 5,713 (9.12%)*	N (%) Total = 62,664 (100%)*	Relative Risk	p-value	adj. Relative Risk (CI)**	p-value***
Demographic characteristics							
Sex							
Male	34,953 (61.37%)	3,895 (68.18%)	38,848 (61.99%)	1.35 (1.27 - 1.43)	<0.0001	1.41 (1.33 - 1.50)	<0.0001
Female	21,998 (38.63%)	1,818 (31.82%)	23,816 (38.01%)	reference group		reference group	
Age, years							
15 - 34	20,372 (35.77%)	1,875 (32.82%)	22,247 (35.5%)	reference group	<0.0001	reference group	<0.0001
35 - 54	21,728 (38.15%)	2,091 (36.6%)	23,819 (38.01%)	1.05 (0.98 - 1.11)		1.03 (0.96 - 1.10)	
>= 55	14,851 (26.08%)	1,747 (30.58%)	16,598 (26.49%)	1.28 (1.19 - 1.37)		1.25 (1.17 - 1.34)	
Clinical characteristics							
Nutrition support							
No	37,358 (65.6%)	3,868 (67.71%)	41,226 (65.79%)	reference group	<0.0001	reference group	<0.0001
Yes	19,593 (34.4%)	1,845 (32.29%)	21,438 (34.21%)	0.91 (0.86 - 0.96)		0.91 (0.85 - 0.96)	
Sputum Smear							
Positive	28,836 (50.63%)	2,843 (49.76%)	31,679 (50.55%)	0.99 (0.93 - 1.04)		1.03 (0.98 - 1.10)	
Negative	27,173 (47.71%)	2,716 (47.54%)	29,889 (47.7%)	reference group	<0.0001	reference group	<0.0001
Not Done	942 (1.65%)	154 (2.7%)	1,096 (1.75%)	1.64 (1.37 - 1.95)		1.74 (1.46 - 2.07)	
HIV status							
Negative	29,278 (51.41%)	2,155 (37.72%)	31.433 (50.16%)	reference group		reference group	
Positive	1,668 (2.93%)	203 (3.55%)	1,871 (2.99%)	1.65 (1.42 - 1.93)	<0.0001	1.69 (1.45 - 1.96)	<0.0001
Unknown	26,005 (45.66%)	3,355 (58.73%)	29,360 (46.85%)	1.75 (1.66 - 1.85)		1.75 (1.66 - 1.85)	
Categories of patients							
New patient	53,316 (92.09%)	5,228 (89.12%)	58,544 (93.42%)	0.79 (0.70 - 0.89)		0.83 (0.74 - 0.93)	
Failed previous treatment	888 (1.54%)	137 (2.34%)	1,025 (1.64%)	1.24 (1.00 - 1.54)	<0.0001	1.26 (1.02 - 1.56)	<0.0001
Return after Loss to Follow-up	65 (0.12%)	16 (0.27%)	81 (0.13%)	1.99 (1.14 - 3.48)		1.99 (1.14 - 3.49)	
Relapsed	3,635 (6.25%)	485 (8.27%)	4,120 (4.81%)	reference group		reference group	

*N and % in the header by Row, below is by Column

**Relative Risk or Risk Ratio adjusted for Age Bodyweight and Gender,with 95% Confidence Interval (CI)

*** Two-sided chi-squared, p-value < 0.05 considered significant

Figures

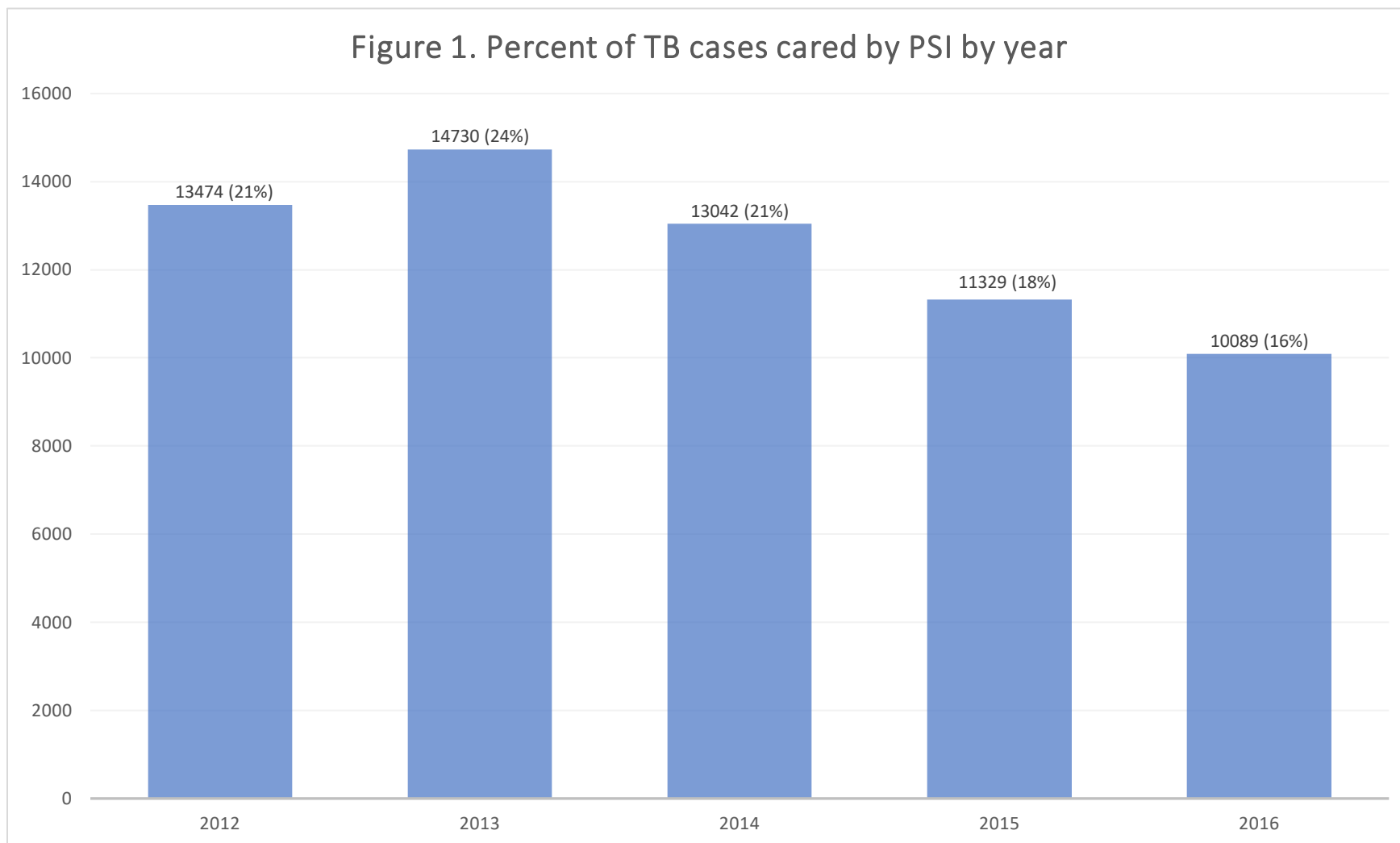**Figure 1. Percent of TB cases cared by PSI by year**

Figure 1. Percent of TB cases cared by PSI by year

Figure 2. Treatment Outcomes by Different Categories of Patients

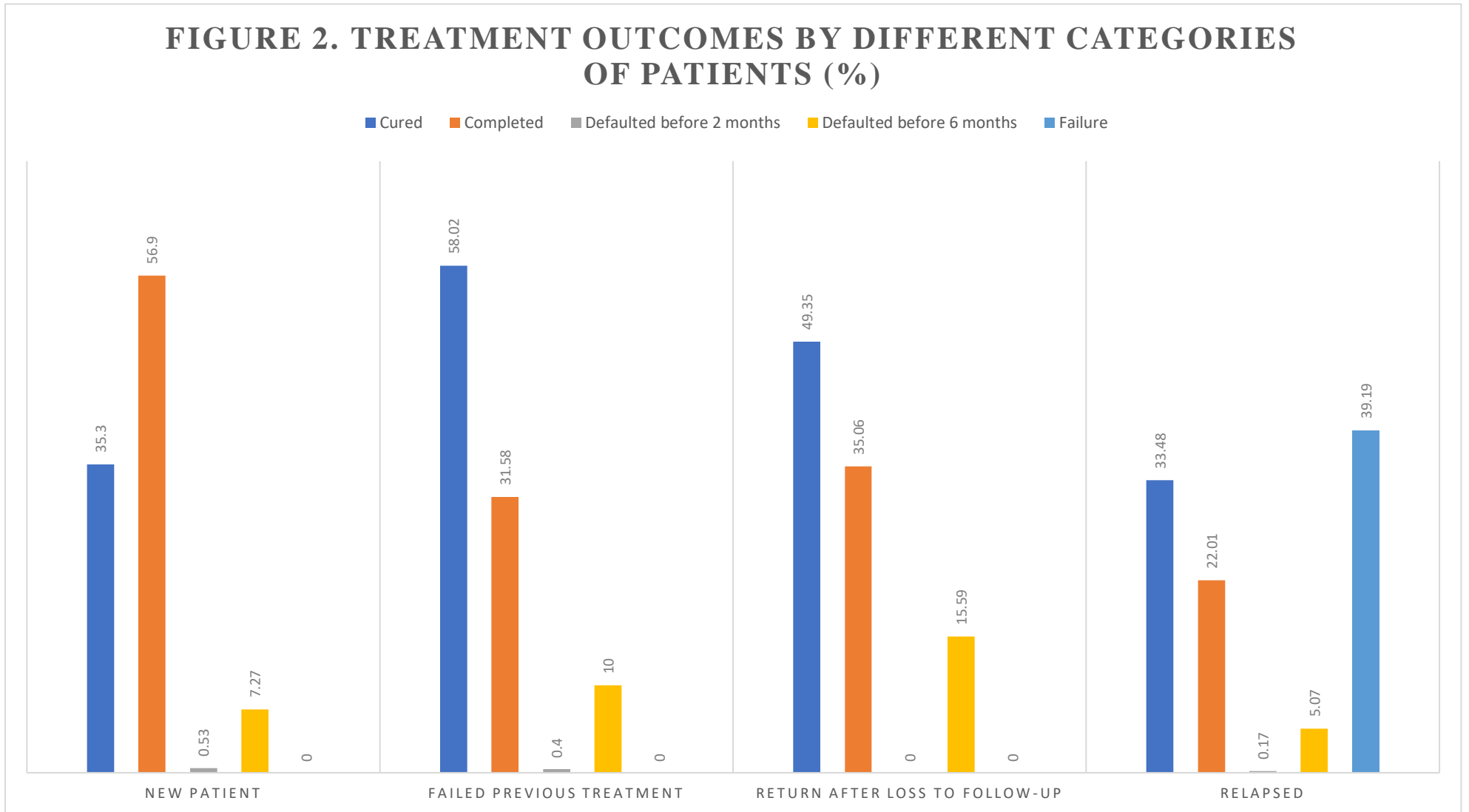FIGURE 2. TREATMENT OUTCOMES BY DIFFERENT CATEGORIES OF PATIENTS (%)

- Cured
- Completed
- Defaulted before 2 months
- Defaulted before 6 months
- Failure

NEW PATIENT
- Cured: 35.3
- Completed: 56.9
- Defaulted before 2 months: 0.53
- Defaulted before 6 months: 7.27
- Failure: 0

FAILED PREVIOUS TREATMENT
- Cured: 58.02
- Completed: 31.58
- Defaulted before 2 months: 0.4
- Defaulted before 6 months: 10
- Failure: 0

RETURN AFTER LOSS TO FOLLOW-UP
- Cured: 49.35
- Completed: 35.06
- Defaulted before 2 months: 0
- Defaulted before 6 months: 15.59
- Failure: 0

RELAPSED
- Cured: 33.48
- Completed: 22.01
- Defaulted before 2 months: 0.17
- Defaulted before 6 months: 5.07
- Failure: 39.19

Figure 3. Treatment Successful Rate at PSI

FIGURE 3. TREATMENT SUCCESSFUL RATE AT PSI

■ Successful   ■ Unsuccessful

5,713 (9%)

56,951 (91%)

Figure 4. Treatment Outcomes and Success Rate by Year

Figure 4. Treatment Outcomes and Success Rate by Year at PSI Myanmar
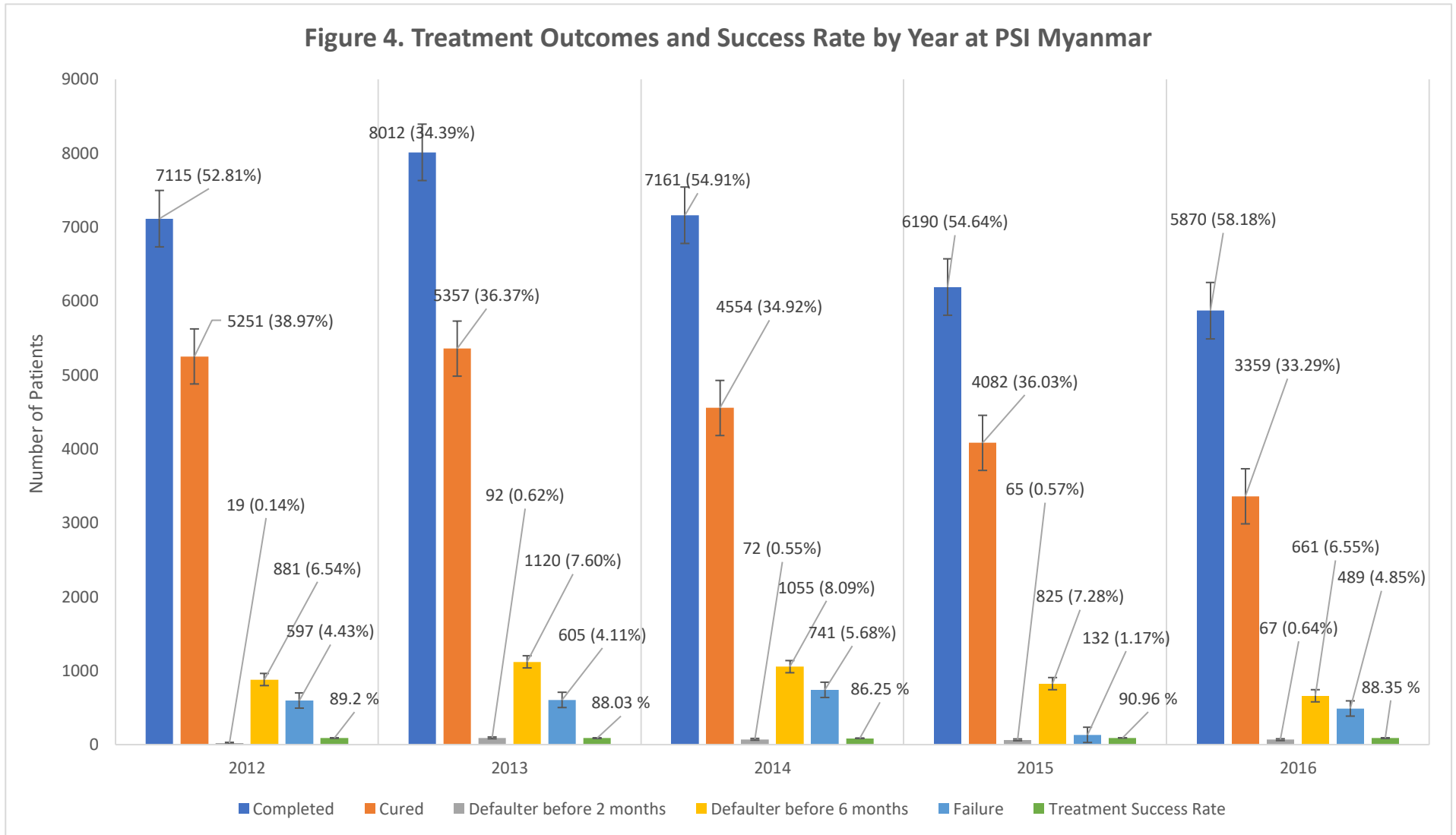
List of Variables

List of Variables	type	Descriptions	Values
clientsr	num	Generated Serial number of client	
clientage	num	Patient age	
clientage_10yr	num	10 years increased in Age	
agegroup	cat	patient's age group	15-34, 35-54, over 55
gender	cat	patient sex	Male, Female
bodyweight	num	patient bodyweight	
bodyweight_10kg	num	10kg increased in bodyweight	
weightgp	cat	patient weight group	under 15, 16-29, 30-39, 40-54, 55-70, over 70
weightgp_n	cat	patient weight group	under 25, 25 and above
client region	cat	patient region	Delta, Hilly, Plain, Coastal region
state_region	cat	patient state	!!!!
category_n	cat	patient category	
casetype	cat	patient type	New, re-treated
smear	cat	smear result	Positive, negative, Not done
txstartyr	cat	treatment start year	2012, 2013, 2014, 2015, 2016
outcome_n	cat	treatment outcomes	completed, cured, defaulted
outcomeyr	cat	treatment outcome year	2012, 2013, 2014, 2015, 2016
nutrition_n	cat	receive nutrition support	No, yes
transport	cat	receive transport support	no, yes
referal channel	cat	PSI's referal channel	walk-in, SPH, IPC
acf	cat	active case finding	no, yes
tx_interval	num	number of days treated	
tx_interval_week	num	number of weeks treated	
tx_interval_month	num	number of months treated	
retrostatus_r	cat	HIV status	no, yes, unknown
pro_gender	cat	provider's gender	male, female, health facility
proderage	num	provider's age	
pro_agegp	num	provider's age group	26-40, above 40, unknown
pro_experience	num	provider's experience	
pro_experience_gp	cat	provider's experience group	0-5, 6-10, >10 years
defaulter	cat	lost to follow up	no, yes
defaulter_2mnth	cat	lost to follow up before 2 month (initial phase)	no, yes
defaulter_6mnth	cat	lost to follow up before 6 month (continuation phase)	no, yes
male	cat	if male	no, yes
casetype_new	cat	if new case	no, yes
pt_new	cat	if new case	no, yes
pt_failure	cat	patient who failed previous treatment	no, yes
pt_relapse	cat	patient who failed the retreatment	no, yes
pt_ltfu	cat	patient who lost to follow up for previous treatment	no, yes
tx_completed	cat	patient who completed retreatment	no, yes
tx_cured	cat	patient who were cured for retreatment	no, yes
tx_defaulted	cat	patient who defaulted during retreatment	no, yes
tx_success	cat	patient who were successfully treated (cured, completed)	no, yes
tx_relapse	cat	patient who relapsed the retreatment	no, yes

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