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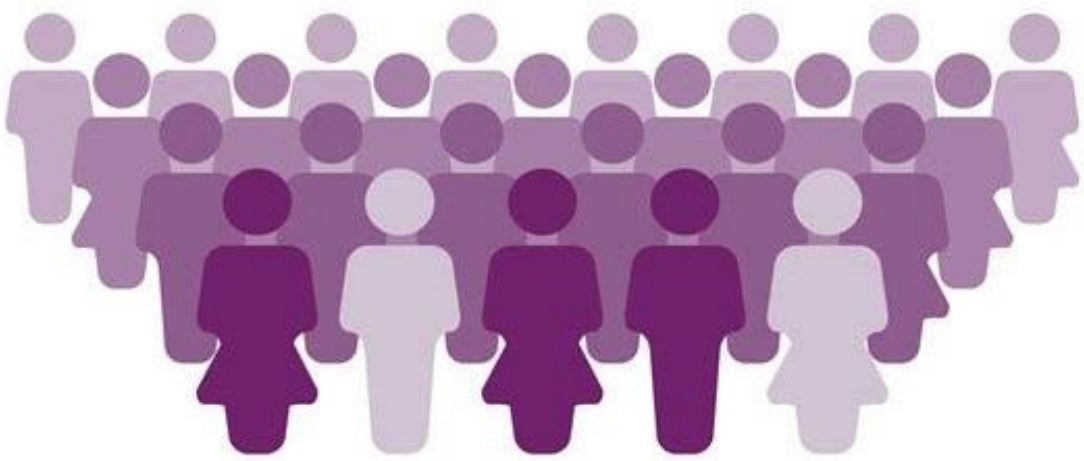
Tuberculosis and Undernutrition in India

2018 - 19



Population Research Centre

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**A Report prepared for the Ministry of Health and Family Welfare,
Government of India, New Delhi**

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Tuberculosis and Undernutrition in India

1. Background

A healthy population is a critical component for the development of any nation, and the health status of any country is mirrored by the levels of morbidity and treatment seeking behavior of the population. With the ongoing demographic and epidemiological transition in India, non-communicable diseases are now taking more of a toll on the health of the Indian population, while the problem of endemic and re-emerging infectious diseases persists, Tuberculosis is one of them. Tuberculosis has re-emerged as a major public health problem in many parts of the world, often as a concomitant illness to HIV/AIDS and undernutrition. TB is not just the chronic morbidity but also a hindrance in the socio-economic development of the country. It is believed to be nearly as old as human history. Traces of it in Egyptian mummies dating back to about 7000 years ago, when it was described as phthisis (pulmonary tuberculosis) by Hippocrates. In India, it has also been referred to in the Vedas and Ayurvedic Samhitas. In the eighteen and nineteen centuries, tuberculosis became knowns as 'consumption' and recently in developing world, the word 'slim disease' has been used for both tuberculosis and HIV infection interchangeably, because of the wasting effect of the disease. It was declared a public health emergency in the African Region in 2005 and has since continued to be a major cause of disability, co-morbidities and death (Loto, & Awowole, 2012). Tuberculosis, once also known as the 'White Plague', is contagious and spreads through droplets that can travel through the air when a person with the infection coughs, talks, or sneezes.

Globally, Tuberculosis is one of the top 10 causes of death and the leading cause of a single infectious agent. Every year millions of people continue to fall sick with TB. About 10 million people fell ill with Tuberculosis, and 1.6 million died from the disease (including 0.3 million among people with HIV) in 2017 worldwide. In 2017, the largest number of new TB cases occurred in the South-East Asia and Western Pacific regions, with 62% of new cases, followed by the African region, with 25% of new cases. In 2017, 87% of new TB cases occurred in the 30 high TB burden countries. Eight countries accounted for two-thirds of the new TB cases: India, China, Indonesia, the Philippines, Pakistan, Nigeria, Bangladesh and South Africa. Although, at a global level recently TB incidence is showing the declining trend at about 2% per year (WHO, 2018). But, along with the decline trends, TB remains a leading cause of death in the world.

In India, many efforts have been made to control the tuberculosis in the past. As in most nations, the initial anti-TB measures implemented in India was unplanned and ad hoc in nature, confined mainly to the setting up to the hospitals and clinics. Attempts to tackle the problem of TB through organized efforts actually had their origin in the late 1930s. From that time to 1961 a number of TB dispensaries and societies launched a

campaign against TB to educate people about the cause and prevention from TB. Effective drugs against TB began to be available only during the time India got independence. In addition to mass BCG campaign started in 1951, 165 million vaccinated children were also administered tuberculin tests. Thereafter, The National TB Programme (NTP) was launched by the Government of India in 1961, keeping the loses and expansion of Tuberculosis in India. After the three decades of the National Tuberculosis Program, the Revised National TB Control Program (RNTCP-1) was launched all over India in 1993 to deal with some of the shortcomings of the earlier National Tuberculosis Programme (NTP) highlighted by the 1992 Joint Review by the Government of India and other partner agencies. After the five year of RNTCP a new large scale programme, based on DOTS – the internationally-recommended strategy, Indian Government's revised National TB Control Program (RNTCP) (sometimes known as RNTCP-I) was started in 1997. The Programme was then expanded across India until the entire nation was covered by the RNTCP in March 2006. At this time the RNTCP also became RNTCP II, and in RNTCP II under the 2012-17 strategic plan, the more emphasis was given to achieving universal access to quality diagnosis and treatment. Although the tuberculosis program has clearly covered a long way but the journey is still far from over.

The past evidence shows that there are several socioeconomic, demographic factors associated with tuberculosis (Leung. et al., 2004; Dheeraj et al. 2004; Kennedy et al. 1996; Van Lettow et al. 2004; Harries et al. 1998). Furthermore, there are also several factors that contribute to the enormous mortality caused by tuberculosis, including malnutrition, tobacco smoking, underinvestment, implementation failure, a weak health system, and poor quality of tuberculosis care in the private sector. Malnutrition and HIV are the two major pathways through which tuberculosis lead the individual to mortality. However, the direct evidence of an effect of nutrition on tuberculosis is difficult because of the whole complex of concurring environmental determinants. Notwithstanding these limitations, the weight of evidence still favours the view that malnutrition may be a critical factor in the high mortality and morbidity from tuberculosis in the population subjected to food shortage. Moreover, Semba et al., in 2010 found that among the known risk factors for active tuberculosis (undernutrition, HIV infection, diabetes, cancer), under-nutrition has the highest population attributable fraction of 27 %. Evidence suggests that the relationship between tuberculosis and malnutrition is bidirectional. Undernutrition increases the risk of Tuberculosis which in turn, can lead to malnutrition. Most individuals with active Tuberculosis are in a catabolic state and experience weight loss, and change in feeding practices (Zachariah et al. 2002; Dodor, 2008). Weight loss among those with TB can be caused by several factors, including reduced food intake due to loss of appetite. Additionally, protein-energy malnutrition and deficiencies in micronutrients such as iron, vitamin A and Zinc are known to affect immunity unfavorably. Iron and other nutrient deficiencies together with chronic

disease such as tuberculosis and HIV infection may cause anemia. Therefore, anemia may perhaps be seen as both an outcome and marker of malnutrition.

2. Rationale of the study

India is one of the countries with the highest burden of TB in the world, accounts for approximately one-fifth of the global incidence. World Health Organization (WHO) estimates that in India approximately 300,000 people die from TB each year. It is also estimated that Tuberculosis and undernutrition are both problems of considerable and magnitude. In India, many patients with active TB, have coexisting undernutrition, which can be severe and life-threatening. Undernutrition and tuberculosis have a bidirectional correlation, which is particularly relevant in the Indian setting. Undernutrition contributes to an estimated 55% of annual TB incidence in India at the population level (Central TB division, 2017). TB leads to weight loss, wasting and worsening of nutritional status.

Tuberculosis is still one of the prime cause of wasting worldwide. Though, the undernutrition in tuberculosis yet not completely understood (Schwenk & Macallan, 2003). Studies on the nutritional status of TB patients in India have shown high levels of moderate to severe undernutrition in both women and men. According to programme data, the median weights in men and women are 43 kg and 38 kg, respectively. Even lower weights have been documented in patients from rural areas, the poor and marginalized communities (Central TB division, 2017). The direct fact of the consequence of nutrition on tuberculosis or vice versa is challenging due to complete multifarious of coincident environmental causes.

3. Objective

This study is an attempt to find out the gap in the current situation of undernutrition and Tuberculosis in India and also searching the path to deal with this double burden of the country. The main objective of this study is:

1. To study the level trend and pattern of Tuberculosis in India and its states
2. To study the level and pattern of undernutrition in India
3. To examine the morbidity status of tuberculosis patient with undernutrition in India.

4. Data source and methodology

The fourth round of National Family Health survey and Revised National TB Control Programme (RNTCP) data have been used to fulfil the study objectives. The RNTCP data have been used to study the trends of Tuberculosis in India and its states in the past five years. Data from the NFHS has been used to estimate the BMI and other indicators of undernourishment and its association with Tuberculosis.

4.1 Revised National Tuberculosis Control Program

The Revised National Tuberculosis Control Program (RNTCP) is state-run tuberculosis (TB) control initiative of the Government of India. As per the 12th five-year plan 2012–17, the program has a vision of achieving a "TB free India" by 2025 and aims to achieve Universal Access to TB control services. The program provides, various free of cost, quality tuberculosis diagnosis and treatment services across the country through the government health system. It seeks to employ the WHO-recommended tuberculosis control strategy, DOTS (Directly Observed Treatment, Short Course) to the Indian scenario through five components of strong political will and administrative commitment, diagnosis by quality assured sputum smear microscopic, uninterrupted supply of quality assured short course chemotherapy drugs, directly observed treatment (DOT) and systematic monitoring and accountability. Moreover, National Strategic Plan for 2012–17 government of India hopes to achieve the detection of at least 90% the total estimated cases and a cure rate of 90% in new and 85% in re-treatment cases through the rigorous implementation of Case finding and diagnostics, Patient friendly treatment services, Scale-up of Programmatic Management of Drug-Resistant TB, Scale-up of joint TB-HIV collaborative activities, Integration with health systems.

4.2 National Family Health Survey

The National Family Health Survey is a large-scale, multi-round survey conducted in a representative sample of households throughout India. Four rounds of the survey have been conducted since 1992-93 and the fourth round of the survey was conducted in 2015-16 covering the 99% of India's population. NFHS is in the similar line with the other demographic and health survey. The first three survey provides the information at state and national and the fourth survey provides the information at the district level covering the information on fertility, mortality, practice of family planning methods, maternal and child health services, reproductive health, nutrition, anemia, communicable and non-communicable disease etc. The NFHS was conducted by the International Institute for Population Sciences, Mumbai under the stewardship of the Ministry of Health and Family Welfare (MoHFW), Government of India and funded by many international agencies and Government of India. It employed a multistage stratified probability proportional to size sampling design. Systematic random sampling was adopted to select the households. The fourth round of survey covers a representative sample of about 699,686 ever-married women in the age group 15–49 and 112,122 men aged 15-54 from 601,509 Household.

For the study purpose, member file of the NFHS-4 data has been utilized. For the tuberculosis, during the survey respondent of the household interview were asked 'Does any usual resident of your household suffer from tuberculosis?' Moreover, for each household member identified as suffering from TB, the respondent was asked: 'Has She/he received medical treatment for the tuberculosis?'

The survey also collected information on the height and weight of women age 15-49 and men age 15-54. The height and weight measurements provide an estimate of the body mass index (BMI), a measure of nutritional status. The BMI is defined as weight in kilograms divided by height in meters squared (kg/m2). Here for the study purpose, a cut-off point of <15 is defined as seriously thin, BMI above 15 and less than 18.5 defined as underweight, and a BMI of 18.5 or above considered as normal or overweight.

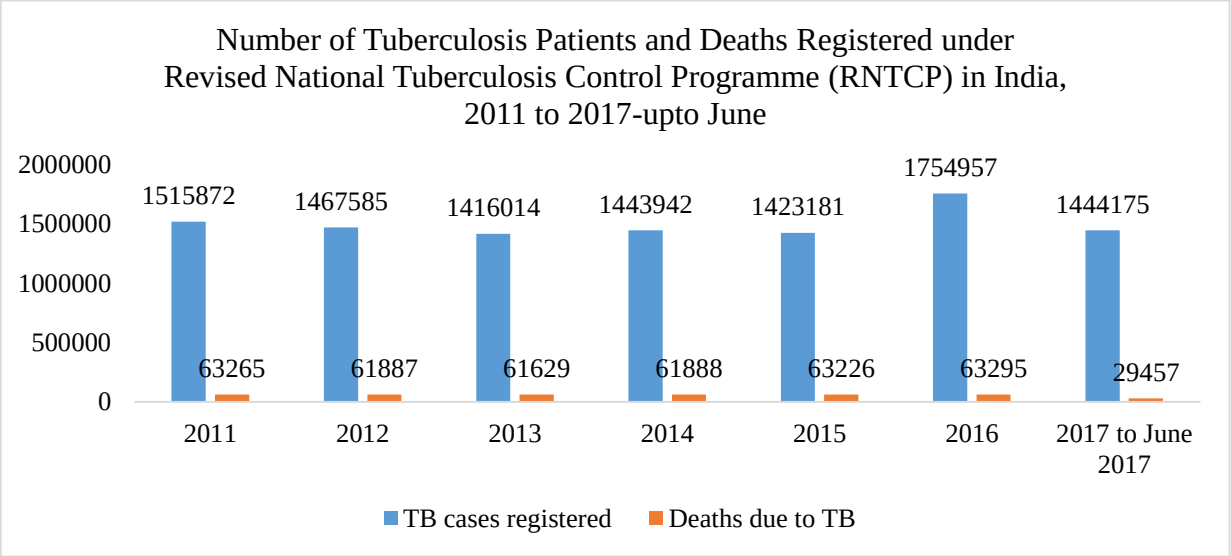
STATA 14 software has been used to analyzed the data. Simple frequency distribution and Cross-tabulation has been done to see the differential in prevalence of Tuberculosis and BMI status. Chi-square test has been applied to see the significant association between predictor and outcome variable.

The first three Sustainable Development Goals (SDGs 1, 2 and 3) deal with action on poverty, hunger and ensuring healthy lives and well-being of people. Action on chronic undernutrition and nutritional support to TB affected households are consistent with the SDGs and have a potential for a significant impact on TB incidence, especially in poor and marginalized communities.

5. Results

5.1 Trends of Tuberculosis and TB attributable death in India

The data from RNTCP during 2011-17, shows the almost stagnated trend in the number of TB Patient. However, the number of registered patient under RNTCP has increased in 2016 and it has decline in 2017. Figure 1 depicts the number of TB patient registered under RNTCP and number of death due to TB in India during 2011 to 2017. In 2011 total 1515872 TB patients were registered under RNTCP and out of the that total 63265 death occurred due to the TB. During 2012-2015 the number of TB case patients showing the almost stagnated trend with slight decline from 1467585 to 1423181. However, 61887 patients in 2012, 616229 in 2013, 61888 in 2014, 63226 in 2015, 63295 in 2016 TB patient deaths occurred. Suddenly in 2016, about 23 % increased has been observed in the TB patients, total 1754957 TB patient were register under RNTCP, and during the same year 63295 TB patient death occurred. Moreover, 17 percent decline in the TB cases has been observed in the 2017, the number of TB patient were decline to 1444175, and till June 2017, total 29457 TB patients' deaths were reported.



Note: Source- RNTCP annual report, 2012-2018 and indiastate.com In 2017, the number of deaths due to TB is up to June, 2017.

5.2 State wise variation in the number of TB patient and death of TB patient

There is huge variation in the number of TB patients at the state level during 2011-17 (**table A1**). All the bigger state has more number of TB patient than smaller state, and it is obvious because of large population size in that states. Further, from the table we can see that the decline in the TB patients during 2011 to 2017 is about 44% (26126-14522) in the Kerala, 40% (111915-67074) in Andhra Pradesh, 28% (76484-54995) in the Bihar, 24 % (112504-84774) in Rajasthan, 17% (99829-82209) in west Bengal, 14.6 % (285884-244074) in Uttar Pradesh and 7% (135281-124900) in Maharashtra. However, some of the state and UTs showing the increasing trend in the TB patients. For illustration about 123% (2537-5664) has increased in Chandigarh, 46% (74867-109422) in Gujarat, 37% (48970-67162) in Odisha, 36% (2311-3139) in Arunachal Pradesh, 29% (90764-117583) in Madhya Pradesh, 18% (51645-60772) in Delhi and 13% (27118-30593) increased of the TB patients has been observed in Chhattisgarh during 2011-2017. Punjab is showing almost constant trend in the TB patient during 2011-2017. State wise number of death due to TB during 2011 to 2014 is given in the table 2. We restricted our analysis up to 2014 due to unavailability of data on death of TB patients. From the tables, bigger states such as Uttar Pradesh, Maharashtra, Bihar, Andhra Pradesh, Madhya Pradesh, Karnataka have reported more number of deaths of TB patients under the RNTCP out of total registered TB cases (**table A1**), though it has showing the decline trends. 8221 TB patients in 2011, and 7946 TB patients in 2013 has died in Uttar Pradesh. 6735 to 7716 in Maharashtra, 1972 to 2139 in Bihar, 4676 to 4356 in Karnataka, 5371 to 5169 in Andhra Pradesh death of the TB patients occurred during 2011- 2013. Maharashtra, Gujarat, Karnataka, Uttarakhand has reported the higher number of deaths due to TB up to first two quarters in 2014. Even though lakswadeep is an union territory with a

very small population as compared to other states and union territories of India it is quite notable the no. of deaths is negligible.

5.3 Prevalence of Tuberculosis in India, evidence from NFHS, 2015-16

Table 3 shows the number of persons per 100,000 usual household residents suffering from any tuberculosis in India and its states during 2015-16. In overall, 316 persons per 100000 populations are suffering from any kind of TB at the time of survey. Moreover, the highest prevalence of TB found in North East state of Arunachal Pradesh (846/100000), Manipur (717/100000) followed by Bihar (661/100000), Nagaland (657/100000) and Andaman and Nicobar Island (615/100000). The lowest cases found in Daman diu (51/100000), Goa (76/100000), followed by Chandigarh (89/100000), Puducherry (137/100000) and Himachal Pradesh (148/100000).

The number of persons suffering from TB differs prominently by age, gender, place of residence, level of education, wealth status of the household. Overall, the risk of TB is much higher among older person. From the table we can see that the number of persons suffering from TB increases with increase in the age. The risk of Tuberculosis is higher for men (402/100,000) than women (229/100,000), and much higher for rural residents (345/100,000) than urban residents (259/100,000). Further, the prevalence of Tuberculosis is much higher in not educated category (500/100,000) than other education category. The economic status of the household also showing the significant differentials in the prevalence of TB. As wealth status of the household increases the prevalence of TB decreases. The prevalence of tuberculosis for poorest 542, poorer 371, middle 293, richer231, richest 146 per one lakh population, respectively (**Table 4**).

Table 5 depicts the prevalence of TB by household crowding (the number of persons per room used for sleeping) and the type of cooking fuel, the place for cooking, and the type of fire or stove among households using solid fuel. The prevalence of TB is increases as person per sleeping room increases. As expected the prevalence of TB is higher among smoker (465/100,000) compared with non-smoker (234/100,000). Use of solid fuels (wood, animal dung, crop residues/grasses, coal, and charcoal) expose people to high levels of toxic air pollutants, which have been linked with serious health consequences. There is a great deal of variation in prevalence of TB according to the type of cooking fuel the household uses. The prevalence TB is low (212/100,000 in household which use smokeless fuel (electricity, LPG, natural gas, or biogas etc.) than which use smoke full (straw, shrubs, or grass etc.) fuel (388/100,000).

It is also found a higher TB prevalence in households cooking in the house (without having a special room or not) but TB prevalence among households cooking indoors is lower than among households cooking

outdoors (440/100,000). The lower prevalence of tuberculosis is found among households utilizing a other type of fire (147/100,000) followed by open fire (389/100,000).

5.4 Nutritional level among the population in India

Below table showing that more than fourteen percent of the population are in the risk of starvation/seriously thin, about one fourth of the population are in the risk of underweight (**Table 6)**. Further, **table 7** shows that BMI status of the population by background characteristics. From the table in overall, about 14.3%, 24.3% of the population was seriously thin (BMI<15 kg/m2) and underweight (BMI 15 kg/m2-18.5 kg/m2), respectively. About 31% of young adults in the age group 15-25 are at the risk of underweight. Considering the young population who most probably are either pursuing education or working population needs immediate attention. The risk is higher among male than female for both (Seriously thin and underweight). It is also observed that the risk of undernutrition is higher than urban area. More than fourth percent of rural population either seriously thin or underweight than urban counterparts (30%). The prevalence of seriously thin and undernutrition is concentrated among non-educated. We can see that as the education level increases, the risk of seriously thin or underweight decreases. The wealth status of the household is a strong predictor of BMI level. Result depicts that the wealth status of the household is negatively associated with the BMI level. As the wealth status of the household increases the level of undernutrition is decreases.

5.5 Nutritional level among person with tuberculosis and person with no tuberculosis

Table 8 depicts the underweight among the person with tuberculosis and among the person with no tuberculosis. In overall, 45.2 percent of the people with tuberculosis were suffering from underweight, while 38.5 percent of the people with no tuberculosis was suffering from underweight. From the table we can see that the risk of underweight was higher in the elder persons compared with younger persons in the tuberculosis persons, and in the non-TB persons the results was completely inverse. Sixty-one percent of the persons were underweight in the age category aged 45 or above whereas, fourth-five percent of the persons were underweight in the age category aged 15-24 years. Gender is also showing similar kind of results, however the prevalence of underweight was higher in the male with no-TB. This may be due to the small sample size of the male TB patient. As far as place of residence concern we can also see that the prevalence of underweight was higher among the persons with TB compared to persons with no TB in both urban and rural area. Moreover, level of education showing the negative relation with the underweight among both persons with TB and person without TB. However, the prevalence of underweight is higher among the person having TB than person without TB. Similar kind of results have been observed in the wealth status of the household. The prevalence of underweight was higher in the Poorest wealth quintile

than richest in the both (person with TB, and person without TB). For illustration the prevalence of underweight in the richest was 21.1 percent, while in the richest it was 57.8 percent in among the person with TB, and among the non-TB person the prevalence of underweight was 25.1 percent in the richest, while it was 52.7 percent in the poorest.

The difference in underweight and normal persons was comparatively less among persons who are diagnosed with TB as to non TB persons. Notable difference was observed in 35-44 years of age wherein among TB persons the number of underweighed persons was almost double as compared to normal weighed persons whereas among non TB persons the number of normal weighed persons were almost six times more than under weighed persons. Further, irrespective whether TB or non TB persons the number of under weighed persons are more than the normal weighed persons among persons with no educational level, and from the poorest wealth index. Although the number of normal persons who are more than underweight persons was observed both among TB and non TB persons it was prominently seen among non TB persons and among females, persons residing in rural and urban areas, persons with educational level primary, secondary and higher secondary and among middle wealth index.

5.6 Morbidity status among the person with tuberculosis and with and without underweight

Evidence shows that persons with tuberculosis has higher risks of the other morbidities compared with the person with no-tuberculosis. Here we also tried to investigate the prevalence of morbidities in the tuberculosis patient with underweight and without-underweight. The study found that the prevalence of anemia was higher in the person with underweight compared to normal among the TB patient. As far as diabetes is concerned, results reveals that the prevalence of Diabetes was higher (71.4%) among those TB patient who were underweight compared to those TB patient whose BMI was normal (28.6%). Moreover, analysis also found that the prevalence of asthma was higher (57.6%) among the TB patients who were underweight, compared to those whose BMI was normal (42.4%). Additionally, clear difference has been observed in the prevalence of morbidities between persons with TB and without TB. The prevalence morbidities were higher in the persons with Tuberculosis compared to the persons with no Tuberculosis. Further, the prevalence of anemia, diabetes, and asthma was comparatively higher among persons with TB who were under weighed as compared to non TB persons where the normal weighed outweighed under weighed in terms of prevalence of these morbidity issues.

6. Conclusion and Discussion

A healthy population of any country is the backbone of socio-economic development. Health is an indicator through which development measured and the prevalence of the disease or morbidity reflects the health

status of the population. In the last few decades, the prevalence of lifestyle disease increase and at the same time the life threating communicable disease persist. However, the effort has been made at global as well as the national level to eradicate or eliminate such type of disease but that is not sufficient. Tuberculosis is one of them, which is a cause of millions of death and morbidities in each year at global as well as national level. It is not only responsible for death but also responsible for different type of co-morbidities such as HIV, anaemia, malnutrition, diabetes etc. results million of the people forces to live with Disability Adjusted Life Year (DALY). It is continued to remain a major public health problem in India.

The prime aim of this study was to estimate the prevalence of Tuberculosis and malnutrition in India and the subsequently to see its association with other morbidities. For that purpose, data from RNTCP report and fourth round of the national family health survey have been utilized. The result of the study shows that the prevalence of the Tuberculosis is 316/100,000 population and the risk is higher in the northeastern states, i.e. Arunachal Pradesh, Manipur, Nagaland and Bihar. Moreover, there is a vast socio-economic differential is the prevalence of Tb in India. The Study has found that age is one of the most critical determinants of Tuberculosis. The prevalence of TB is higher in the older population than the younger one.

Gender emerges as a powerful determinant of tuberculosis in this study. Gender is a social determinant of health that interacts with other variables such as, age, family structure, income, education and social support, and with a variety of behavioural factors (WHO, 2004). Globally, significant excess cases of men over women are reported with TB each year including India (Khatri, 1999; Tuberculosis Research Centre, 2001; WHO, 2001 and 2003). Our study also in the similar line of previous studies.

It has also found that the prevalence of tuberculosis is higher in rural than its counterpart. The probable reasons behind that the rural population are in disadvantage position of access to health care services and lack of knowledge about the illness and its symptom. Also, the rate of ignorance of the symptoms of the disease is higher in the rural area. The stigma related to tuberculosis persists in the rural area which leads to the incidence of tuberculosis. It is also overserved that as education increases the prevalence of TB decreases.

We have also observed that the economic status of the household is negatively associated with the tuberculosis. This may be because of people with low economic status live in poor housing and environmental conditions, have greater food insecurity and have less access to quality health care compare to higher economic status groups (Lonnrot et al., 2010; Oxlade & Murry, 2012). Further, the result shows that overcrowding increases the risk of disease. Overcrowding is directly linked with the poverty and sanitation,

which are a risk factor of Tuberculosis. Moreover, as tuberculosis is primarily an airborne dis-ease, over-crowding decrease the degree of air space that is shared, results in increased exposure to tuberculosis (Gupta et al., 2004).

We also found that the of Tuberculosis is higher among the smoker than non-smokers. The previous evidence also shows the similar kind of results (Maurya et al., 2002; Yanbaeva et al., 2007; Bates et la., 2007). The biological explanation may be that consumption of the nicotine affect the mucosal secretion, reduced phagocytic ability of the alveolar macrophages and decrease in the immune response and/or CD4 + lymphopenia, which increased the susceptibility to pulmonary tuberculosis (Houtmey-ers et al., 1999; Sopori, 2002; Wang et al., 2003; Arcavi & Benowitz, 2004). Moreover, our study also found that those household uses full smoke fuel (firewood, animal dunk, crop residual, coal etc.) are in higher risk of Tuberculosis than those households use smokeless fuel (LPG, CNG, electricity etc.). In the other study smoke full fuel recognized as an independent risk factor for Tuberculosis (Mishra et al., 2004; Perez-Padilla et al., 2001). Interestingly, the risk of Tuberculosis is higher in among those who cooking food outside. The higher prevalence among households cooking outdoors may be related to outdoor cooking being more likely than indoor cooking to be done with solid fuels. Among user of smoke full fuel, those who are using a stove for cooking have more prevalence of TB than those who use an open fire or other fire. The study conducted by Pokhrel et al in 2009 also found a similar kind of results.

Our study further found that undernutrition is highly correlated with tuberculosis. Previous studies have also suggested that person with the TB has higher risk of being malnourished due to various causes including loss of appetite. Undernutrition is usually connected with sickness and infections such as gastrointestinal disorders and malabsorption, pneumonia, TB and HIV (WHO, 1999). Tuberculosis makes undernutrition worse, and undernutrition weakens immunity, thereby increasing the likelihood that latent TB will develop into the active disease (Cegielski & McMurray, 2004).

TB is not only the illness but also the root cause of the multiple life-threatening comorbidities. We found that the prevalence of anaemia, Diabetes and asthma is higher among the person with TB. Anaemia is a common morbidity at tuberculosis patient (Van et al., 2005). The possible cause of anemia among the TB patients may be an absence of bone marrow iron, which is also observed in the iron-deficiency anemia (Cameron & Horne, 1971; Baynes et al., 1986). The result of this study is in the similar line with the study conducted in the Tamil Nadu, which found that about half of the Tb patient either have Diabetes or pre-Diabetes (Viswanathan et al., 2012). A study shows that diabetes is an important risk factor for TB (Jeon & Murray, 2008). However, it is also possible that TB can induce glucose intolerance and also deteriorate glycemic control in subjects with diabetes (Dooley & Chaisson, 2009). We also found that the prevalence

of asthma is higher among TB patients. Certain factors can lead to the tendency of bronchial asthma in patients of tuberculosis and vice versa. The use of inhaled corticosteroids in a patient with chronic respiratory diseases is one of the factors to increase the risk of tuberculosis (Ni, et al., 2014). Besides this, in the patients of tuberculosis, the risk of asthma is higher due to the Loeffler's syndrome being caused due to a usage of paraamino salicylic acid (PAS) and drug allergy or broncho pulmonary damage (Garg & Karahyla, 2017).

In conclusion, the study demonstrated the high prevalence of TB in India. Malnutrition and indoor air pollution are recognized risk factors which are confounded with the socioeconomic status. The prevalence of undernutrition among TB patients was very high. Despite the attempts made by Revised National Tuberculosis Programme (RNTCP) to make people aware about the availability of free treatment and symptoms of tuberculosis, community-based nutritional interventions for such patients in India, require further investigation, particularly in rural areas. Interventions by different stakeholders should be targeted considering the patient's nutritional state. Tuberculosis care providers should receive training which focuses on dietary counselling for TB patients.

References

Arcavi, L., & Benowitz, N. L. (2004). Cigarette smoking and infection. *Archives of internal medicine*, *164*(20), 2206-2216.

Bates, M. N., Khalakdina, A., Pai, M., Chang, L., Lessa, F., & Smith, K. R. (2007). Risk of tuberculosis from exposure to tobacco smoke: a systematic review and meta-analysis. *Archives of internal medicine*, *167*(4), 335-342.

Baynes, R. D., Flax, H., Bothwell, T. H., Bezwoda, W. R., Atkinson, P., & Mendelow, B. (1986). Red blood cell distribution width in the anemia secondary to tuberculosis. *American journal of clinical pathology*, *85*(2), 226-229.

Cameron, S. J., & Horne, N. W. (1971). The effect of tuberculosis and its treatment on erythropoiesis and folate activity. *Tubercle*, *52*(1), 37-48.

Cegielski JP, McMurray DN. (2004) The relationship between malnutrition and tuberculosis: evidence from studies in humans and experimental animals. *Int. J. Tuberc. Lung Dis.* 8:286–98.

Central TB Division. (2017). *Guideline: nutritional care and support for patients with tuberculosis*. Director General of Health Services, Ministry of Health and Family Welfare, Government of India. http://yenepoya.edu.in/downloads/Guidance%20Doc_Final.pdf

Dheeraj G, Kshaunish D, Balamughesh T, Ashutosh N, Surinder K. (2004). The role of socio-economic factors in tuberculosis prevalence. *Indian J Tuberc*. 51:27–31. 10.

Dodor E. Evaluation of nutritional status of new tuberculosis patients at the effiankwanta regional hospital (2008). *Ghana Med. J, 42*(1): 22–8

Dooley, K. E., & Chaisson, R. E. (2009). Tuberculosis and diabetes mellitus: convergence of two epidemics. *The Lancet infectious diseases*, *9*(12), 737-746.

Garg, K., & Karahyla, J. K. (2017). Association between tuberculosis and bronchial asthma. *International Journal of Research in Medical Sciences*, *5*(8), 3566-3569.

Gupta, D., Das, K., Balamughesh, T., Aggarwal, N., & Jindal, S. K. (2004). Role of socio-economic factors in tuberculosis prevalence. *Indian Journal of Tuberculosis*, *51*(1), 27-32.

Harries, A. D., Nkhoma, W. A., Thompson, P. J., Nyangulu, D. S., & Wirima, J. J. (1988). Nutritional status in Malawian patients with pulmonary tuberculosis and response to chemotherapy. *European Journal of Clinical Nutrition*, *42*(5), 445-450.

Houtmeyers, E., Gosselink, R., Gayan-Ramirez, G., & Decramer, M. (1999). Regulation of mucociliary clearance in health and disease. *European Respiratory Journal*, *13*(5), 1177-1188.

Jeon, C. Y., & Murray, M. B. (2008). Diabetes mellitus increases the risk of active tuberculosis: a systematic review of 13 observational studies. *PLoS medicine*, *5*(7), e152.

Kennedy, N., Ramsay, A., Uiso, L., Gutmann, J., Ngowi, F. I., & Gillespie, S. H. (1996). Nutritional status and weight gain in patients with pulmonary tuberculosis in Tanzania. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *90*(2), 162-166.

Leung, C. C., Yew, W. W., Tam, C. M., Chan, C. K., Chang, K. C., Law, W. S., ... & Au, K. F. (2004). Socio-economic factors and tuberculosis: a district-based ecological analysis in Hong Kong. *The International Journal of Tuberculosis and Lung Disease*, *8*(8), 958-964.

Lonnroth K, Castro KG, Chakaya JM, Chauhan LS, Floyd K, et al. (2010) Tuberculosis control and elimination 2010–50: cure, care, and social development. Lancet 375: 1814–1829

World Health Organization. (1999). Management of severe malnutrition: a manual for physicians and other senior health workers.

Maurya, V., Vijayan, V., & Shah, A. (2002). Smoking and tuberculosis: an association overlooked. *The International journal of tuberculosis and Lung Disease*, *6*(11), 942-951.

Mishra, V. K., Retherford, R. D., & Smith, K. R. (1999). Biomass cooking fuels and prevalence of tuberculosis in India. *International Journal of infectious diseases*, *3*(3), 119-129.

Ni, S., Fu, Z., Zhao, J., & Liu, H. (2014). Inhaled corticosteroids (ICS) and risk of mycobacterium in patients with chronic respiratory diseases: a meta-analysis. *Journal of thoracic disease*, *6*(7), 971.

Oxlade O, Murray M (2012) Tuberculosis and Poverty: Why Are the Poor at Greater Risk in India? PLoS ONE 7(11): e47533.

Perez-Padilla, R., Perez-Guzman, C., Baez-Saldana, R., & Torres-Cruz, A. (2001). Cooking with biomass stoves and tuberculosis: a case control study. *The International Journal of Tuberculosis and Lung Disease*, *5*(5), 441-447.

Pokhrel, A. K., Bates, M. N., Verma, S. C., Joshi, H. S., Sreeramareddy, C. T., & Smith, K. R. (2009). Tuberculosis and indoor biomass and kerosene use in Nepal: a case–control study. *Environmental health perspectives*, *118*(4), 558-564.

Semba, R. D., Darnton-Hill, I., & De Pee, S. (2010). Addressing tuberculosis in the context of malnutrition and HIV coinfection. *Food and Nutrition Bulletin*, *31*(4_suppl4), S345-S364.

Sopori, M. (2002). Effects of cigarette smoke on the immune system. *Nature Reviews Immunology*, *2*(5), 372.

Van Lettow, M., Harries, A. D., Kumwenda, J. J., Zijlstra, E. E., Clark, T. D., Taha, T. E., & Semba, R. D. (2004). Micronutrient malnutrition and wasting in adults with pulmonary tuberculosis with and without HIV co-infection in Malawi. *BMC infectious diseases*, *4*(1), 61.

Van Lettow, M., West, C. E., van der Meer, J. W. M., Wieringa, F. T., & Semba, R. D. (2005). Low plasma selenium concentrations, high plasma human immunodeficiency virus load and high interleukin-6

concentrations are risk factors associated with anemia in adults presenting with pulmonary tuberculosis in Zomba district, Malawi. *European journal of clinical nutrition*, *59*(4), 526.

Viswanathan, V., Kumpatla, S., Aravindalochanan, V., Rajan, R., Chinnasamy, C., Srinivasan, R., ... & Kapur, A. (2012). Prevalence of diabetes and pre-diabetes and associated risk factors among tuberculosis patients in India. *PloS one*, *7*(7), e41367.

Wang, H., Yu, M., Ochani, M., Amella, C. A., Tanovic, M., Susarla, S., ... & Al-Abed, Y. (2003). Nicotinic acetylcholine receptor α7 subunit is an essential regulator of inflammation. *Nature*, *421*(6921), 384.

Yanbaeva, D. G., Dentener, M. A., Creutzberg, E. C., Wesseling, G., & Wouters, E. F. (2007). Systemic effects of smoking. *Chest*, *131*(5), 1557-1566.

Zachariah, R., Spielmann, M. P., Harries, A. D., & Salaniponi, F. M. L. (2002). Moderate to severe malnutrition in patients with tuberculosis is a risk factor associated with early death. *Transactions*

Annexure

Table 1: State-wise total register TB patients under Revised National Tuberculosis Control Program (RNTCP) in India, 2011-17

States/UTs	2011	2012	2013	2014	2015	2016	2017
A & N Islands	908	844	738	756	584	534	270
Andhra Pradesh	111915	108727	103707	88638	61758	74373	67074
Arunachal Pradesh	2311	2357	2500	2691	2748	2788	3139
Assam	37841	35788	35624	38317	38014	40851	36720
Bihar	76484	73537	67020	67991	64928	97001	54995
Chandigarh	2537	2807	2890	2869	3143	3413	5664
Chhattisgarh	27118	27160	25889	28864	29950	39484	30593
Dadra and Nagar Haveli	419	415	411	450	487	552	893
Daman and Diu	313	330	742	279	284	487	381
Delhi	51645	52006	50727	54037	55260	62706	60772
Goa	1982	1950	1778	1660	1599	1966	1563
Gujarat	74867	72554	74086	77395	82585	126665	109422
Haryana	37913	38036	38104	39498	40913	47545	34104
Himachal Pradesh	13501	13615	13691	14441	14333	14961	15715
Jammu and Kashmir	13473	12662	11038	10243	9873	9937	9420
Jharkhand	38574	36666	34941	35907	34792	39515	36861
Karnataka	70595	67572	61446	61328	59932	68462	69199
Kerala	26126	25917	24204	23439	22785	47293	14522
Lakshadweep	17	20	23	27	40	23	46
Madhya Pradesh	90764	89545	92420	100034	103108	129915	117583
Maharashtra	135281	136045	137237	135465	130874	195139	124900
Manipur	3080	2744	2329	2198	1881	2393	1691
Meghalaya	5079	5114	5002	4944	4674	4586	3353
Mizoram	2304	2337	2005	1993	2088	2205	2201
Nagaland	3722	3525	3339	3298	3316	2821	2284
Odisha	48970	49191	45269	45777	45814	43851	67162
Puducherry	1568	1430	1458	1409	1288	1421	1601
Punjab	39206	39569	37258	38152	38625	39836	38977
Rajasthan	112504	100966	94698	94908	90296	106756	84774
Sikkim	1631	1832	1637	1630	1400	1539	1232
Tamil Nadu	79830	79576	80407	84570	80543	96079	74256
Telangana	-	-	-	18655	39498	45003	31828
Tripura	2798	2557	2540	2507	7394	2374	1685
Uttar Pradesh	285884	271678	256733	255364	246589	297746	244074
Uttarakhand	14883	15239	13700	14429	14317	15081	13012
West Bengal	99829	93274	90423	89819	87468	89656	82209

Source: RNTCP annual reports, 2012-2018

Table 2: Number of death due to TB among the tuberculosis patients

States/UTs	2011	2012	2013	2014
Andaman and Nicobar Islands	43	34	18	22
Andhra Pradesh	5371	5439	5169	1605
Arunachal Pradesh	79	65	67	37
Assam	1586	1648	1678	884
Bihar	1972	2125	2139	1003
Chandigarh	56	82	65	23
Chhattisgarh	988	1085	782	707
Dadra and Nagar Haveli	21	12	15	6
Daman and Diu	59	7	8	4
Delhi	1503	1241	1316	725
Goa	168	75	76	25
Gujarat	3950	3808	4094	2172
Haryana	1400	1649	1628	935
Himachal Pradesh	630	521	518	283
Jammu and Kashmir	468	337	303	166
Jharkhand	1431	1341	1332	777
Karnataka	4676	4542	4356	2203
Kerala	1002	1205	1158	547
Lakshadweep	3	1	1	1
Madhya Pradesh	4079	2966	3174	1769
Maharashtra	6735	7687	7716	3889
Manipur	167	72	73	39
Meghalaya	177	213	202	92
Mizoram	76	79	77	50
Nagaland	135	91	201	54
Odisha	2424	2405	2332	1262
Puducherry	72	78	66	35
Punjab	1875	1925	1678	1002
Rajasthan	4134	3592	3599	1792
Sikkim	164	82	47	18
Tamil Nadu	3794	3865	4005	2206
Telangana	-	-	-	-
Tripura	292	150	106	1121
Uttar Pradesh	8221	7866	7946	66
Uttarakhand	823	552	500	4189
West Bengal	4691	5047	5184	285

Source: indiastate.com; data up to 2014 has been provided for the first two quarters.

Table 3: Prevalence of Tuberculosis in India and in its states (per 100,000), 2015-16, NFHS

India/States/UT's	Prevalence of TB	Sample
India	**316**	**2748327**
Bigger States		
Andhra Pradesh	320	112307
Assam	311	66871
Bihar	661	240047
Chhattisgarh	167	62049
Delhi	211	40756
Gujarat	181	131413
Haryana	234	62778
Jammu and Kashmir	165	26235
Jharkhand	328	73543
Karnataka	180	133698
Kerala	374	78951
Madhya Pradesh	224	177753
Maharashtra	245	266244
Odisha	338	93735
Punjab	156	60466
Rajasthan	222	150096
Tamil Nadu	360	179369
Telangana	308	83773
Uttar Pradesh	346	426076
Uttarakhand	257	22599
West Bengal	356	206553
Smaller State		
Arunachal Pradesh	846	2364
Goa	74	3245
Himachal Pradesh	148	14506
Manipur	717	4887
Meghalaya	549	6418
Mizoram	253	2318
Nagaland	657	3289
Sikkim	475	1137
Tripura	256	7956
Union Territories		
Andaman & Nicobar Islands	615	804
Chandigarh	89	2150
Dadra and Nagar Havel	156	706
Daman and Diu	51	406
Lakshadweep	391	162
Puducherry	137	2667

Table 4: Prevalence of Tuberculosis by background characteristics (per 100,000), 2015-16

Background Characteristics	Prevalence of TB	Chi Square	Sample
Age Group			
0-5 Years	33		291,369
6 – 14 Years	73		487,513
15 – 25 Years	143		567,594
26 - 35 Years	287	$\chi2 = 6000$**	431,113
36 - 45 Years	448		339,694
46 – 55 Years	590		275,485
56 – 65 Years	841		218,367
66+ Years	880		137,193
Gender			
Female	229	$\chi2 = 640.7$**	1,360,364
Male	402		1,387,963
Place of Residence			
Urban	259	$\chi2 = 149.2$**	911,099
Rural	345		1,837,229
Education level			
No education, Preschool	500		826422
Primary	269	$\chi2 = 1100$**	633726
Secondary	244		1031685
Higher	128		250549
Wealth Index			
Richest	146		549,681
Richer	231	$\chi2 = 1200$**	549,541
Middle	293		549,687
Poorer	371		549,681
Poorest	542		549,737
Total	**316**		2,748,327

Note: **Significant at 99% CI

Table 5: Prevalence of tuberculosis by persons per sleeping room and cooking fuel/ cooking arrangements (per 100,000)

Sleeping and Cooking Practices	Prevalence of TB	Chi Square	Sample
Persons per room used for sleeping			
< 3 persons	297	$\chi2 = 20.9$**	1169483
3 - 4 persons	311		906497
> 4 persons	358		654582
Smoking Status		$\chi2 = 1100$**	
Non-Smoker	234		1768472
Smoker	465		979855
Cooking fuel			
Smokeless fuel	212	$\chi2 = 497.1$**	1116826
Smoke full fuel	388		1631501
Place for cooking			
In the house	303		2237576
In a Separate building	315	$\chi2 = 51.8$**	270745
Outdoors	440		236,694
Other	121		862
Type of fire			
Open fire	389	$\chi2 = 0.52$	1572115
Stove	412		38879
Other	147		1628
Source of Drinking Water			
Safe water	319	$\chi2 = 18.1$**	2548602
Unsafe water	284		199725
Total	**316**		**2,748,327**

Note: **Significant at 99% CI

Table 6: Level of BMI of the population of India, 2015-16.

Nutritional Status	Percent
Starvation/Seriously Thin (BMI<15kg/m2)	14.3
Underweight (BMI 15-I8.5 kg/m2)	24.3
Others (BMI>18.5 kg/m2)	61.5
Total	991633

Table 7: BMI Status of the persons by background characteristics in India, 2015-16

Background Characteristics	Nutritional Status			Sample
	Seriously thin (BMI<15kg/m^2)	Underweight (BMI 15-I8.5 kg/m^2)	Others (BMI>18.5 kg/m^2)	
Age Group				
15 - 25 Years	2.0	31.0	67.1	295428
26-35 Years	0.9	16.3	82.9	228601
36- 45 Years	0.9	12.8	86.3	184050
46 - 55 Years	0.8	12.3	86.9	61691
Gender				
Female	9.8	22.7	67.4	769476
Male	29.5	29.6	40.8	222157
Place of Residence				
Urban	11.8	18.4	69.8	323006
Rural	15.4	27.1	57.5	668627
Education level				
No education, Preschool	32.3	30.2	37.6	411534
Primary	2.6	20.5	77.0	104706
Secondary	1.4	21.7	77.0	374863
Higher	0.7	13.7	85.6	99102
Don't Know	0.8	20.9	78.3	1428
Wealth Index				
Richest	9.7	15.4	74.9	191847
Richer	12.1	20.0	67.9	202254
Middle	13.8	24.2	62.0	203212
Poorer	16.0	28.8	55.2	201131
Poorest	19.7	33.0	47.3	193189
Total	**14.3**	**24.3**	**61.5**	**991,633**

Table 8: percentage distribution of Underweight (BMI<18.5 kg/m^2) in the person with TB and Without TB by background characteristics, 2015-16

Background Variables	TB Patients			Non-TB		
	Underweight	Normal	Sample	Underweight	Normal	Sample
Age Group						
15 - 24	45.1	54.9	338	34.2	65.8	262,325
25 - 34	53.9	46.1	567	18.0	82.0	227,703
35 - 44	61.4	38.6	637	13.9	86.1	186,833
45+	61.5	38.5	441	13.3	86.7	90,927
Gender						
Female	44.0	56.0	1,592	32.6	67.4	767,884
Male	50.3	49.7	454	59.2	40.8	221,703
Place of Residence						
Urban	36.2	63.8	588	30.2	69.8	322,417
Rural	48.9	51.1	1,458	42.5	57.5	667,169
Education level						
No education	52.5	47.5	1,002	62.5	37.5	410,532
Primary	42.5	57.6	267	23.0	77.0	104,438
Secondary	37.9	62.1	689	23.0	77.0	374,174
Higher	28.6	71.4	87	14.4	85.6	99,015
Wealth Index						
Richest	21.1	79.0	200	25.1	74.9	191,647
Richer	34.3	65.8	285	32.1	67.9	201,969
Middle	44.2	55.8	372	38.0	62.0	202,841
Poorer	44.3	55.7	487	44.9	55.2	200,644
Poorest	57.8	42.3	703	52.7	47.3	192,486
Total	**45.2**	**54.8**	**2047**	**38.5**	**61.5**	**989586**

Table 9: Morbidity status among the person with tuberculosis and with and without underweight, 2015-16

Morbidities	TB Patients			Non-TB Patients		
	Underweight (BMI<18.5 kg/m^2)	Normal	Sample	Underweight (BMI<18.5 kg/m^2)	Normal	Sample
Anemia						
No	60.3	39.7	955	31.9	68.1	470,851
Yes	50.9	49.1	1063	41.9	58.1	461,609
Diabetes						
No	55.3	44.8	1856	22.3	77.7	732,116
Yes	71.4	28.6	60	7.7	92.3	13,174
Asthma						
No	55.6	44.4	1691	22.1	77.9	735,865
Yes	57.6	42.4	231	17.3	82.8	14,130
Total	**45.2**	**54.8**	**2047**	**38.5**	**61.5**	**989586**