PREVALENCE OF TUBERCULOSIS AND DIABETES MELLITUS COMORBIDITIES IN JEMBER: AN ECOLOGICAL ANALYSIS

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Abstract. Tuberculosis (TB) is a communicable disease primarily linked to diabetes mellitus (DM) comorbidity. Jember is a district with the second highest TB burdens in East Java Province. It was important to understand the prevalence TB-DM comorbidities in order to develop a strategic program to eliminate TB in Jember. The objective of this study was to identify the prevalence of TB and DM comorbidity in areas of Jember. The study used ecological analysis of the Jember District's health profile in 2020 which involved 50 public health centers across 31 sub-districts. The data contained the number of TB prevalence, DM prevalence, and TB-DM comorbidities prevalence while the ecology variables were the aggregate of poor households, population density, Posbindu or the integrated development post, health sanitary access, adult health screening, and elderly health screening per sub-district of Jember. The highest prevalence of TB was found in the Kaliwates Sub-district which is the downtown Jember District. Another area with a high prevalence of DM cases was Sumbersari which was also an urban area. Notably, the lowest prevalence of TB and DM cases was found in Jelbuk which was in a rural area in the north of Jember. The study concluded there were strong correlation between DM and TB prevalence, population density and TB, and both health sanitary access and adult health screening with TB, DM, and adult health screening was correlated with TB-DM comorbidities. It was necessary to screen DM patients using a chest x-ray or rapid molecular test method to detect TB and treat its symptoms early.

Keywords: diabetes mellitus, ecological analysis, tuberculosis

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INTRODUCTION

Tuberculosis (TB) is a communicable disease caused by Mycobacterium tuberculosis infecting lungs and other organs (WHO, 2021). About a quarter of the world's population has been infected with TB, and the disease is one of the leading causes of global mortality with a single infectious agent (WHO, 2021). Indonesia was positioned third for having a high TB burden (443,235 reported cases) after India and China in 2021 (WHO, 2021). However, since the coronavirus disease 2019 (COVID-19) pandemic hit worldwide in 2020, the number of reported cases dropped more (14%) in 2020 compared to 2019 (WHO, 2021). Indonesia was one of the countries with the most shortfall number of TB reports after India in 2020 due to shrinking health supply and demand which affect TB diagnostic and treatment services (WHO, 2021).

Diabetes mellitus (DM) is a non-communicable disease that causes a chronic body condition characterized by raised levels of blood glucose because the body cannot produce any or enough of the hormone insulin or cannot effectively use the insulin it produces (International Diabetes Federation, 2022). DM remains a well-known risk factor for TB besides human immunodeficiency virus (HIV) (Alisjahbana *et al*, 2007). Currently, DM prevalence has globally increased from year to year and contributed to the rise of TB transmission. People with diabetes are more susceptible to acquiring TB, developing TB diseases, and being re-infected by TB bacteria (Stevenson *et al*, 2007). TB-DM comorbidity will occur in several developing countries such as Indonesia where TB is highly endemic (Awad *et al*, 2022). Indonesia is one of the countries with the highest number of DM cases predicted to be approximately 19.5 million DM cases in 2021 (International Diabetes Federation, 2022).

Jember District, located in the east part of East Java Province, had the second highest number of TB reported cases and the fifth highest number of DM cases in 2020 (East Java Provincial Health Office, 2021). Since Jember has a high burden of both TB and DM, the interplay between these diseases becomes a public health concern. It was estimated there were 5,578 TB incidents in 2020, but the COVID-19 pandemic which occurred in the same year affected the reports. Meanwhile, routine treatment for people with diabetes declined during the pandemic which also caused a delay in the screening of TB for diabetic patients. The Ministry of Health of Republic Indonesia stated the bi-directional screening TB and DM has been regulated but the implementation in the districts mostly has been not fully applied so the notification of TB-DM comorbidities were found under-reported (MOH RI, 2022). Therefore, it was necessary to assess the prevalence of TB and DM comorbidities and its associated factors in Jember in order to develop a strategic program in preventing and eliminate TB.

MATERIALS AND METHODS

The study was cross-sectional research using ecological analysis to analyze TB and DM patients. The research secondary data of the patients were obtained from the 2020 Health Profile of Jember District that has been published reports by Jember Health Office (Jember Health Office, 2021). The study took place in Jember District, East Java Province, Indonesia. There were 50 primary health facilities across 31 sub-districts of Jember. The population was all Jember residents in 2020. The data of TB and DM patients were aggregated data without the name patients and publicly accessible (Jember Health Office, 2021).

The data contained the number of TB, DM, and TB-DM patients in each sub-district and each primary health facility. The prevalence of TB, DM, and TB-DM cases was classified into three categories, namely low, medium, and high based on the frequency distribution of each variable. The TB prevalence was categorized as low if number of cases ranged between 47-114, moderate if

it ranged between 115-182 cases and high if it ranged between 183-250 cases. As for DM prevalence, it was categorized as low if number of cases ranged between 493-979, moderate if it ranged between 980-1465 cases and high if it ranged between 1466-1952 cases. In addition, in TB-DM prevalence was low when number of cases ranged between 0-6, moderate when it ranged between 7-12 cases and high if it ranged between 13-19 cases.

The research used an ecological analysis approach focusing on comparisons between groups in district level (Morgenstern, 1995). Since the data was large scale in aggregates so the ecological study was used to assess the population-level effect of exposures on TB and DM prevalence (Munnangi and Boktor, 2022). The variables of ecological analysis in this study were socio-economic factor, health access factor, and other public health measurements. The variables were poor household data, and population density, the integrated development post or "The Integrated Health Services Post for Non-Communicable Disease Screening and Treatment", health sanitary access, adult health screening, and elderly health screening per sub-district of Jember. The poor household data were the numerical data of several households in all sub-districts collected from the Central Statistical Bureau. Jember population density was counted as people per square kilometer. The integrated development post was one of the innovative health services conducted by all primary health care in Indonesia and involved public routine participation in the early detection of illness, especially non-communicable diseases in periodic events (Sudharma *et al*, 2016). The integrated development post data were collected as units per sub-district. Health sanitary access was the number of households that has sanitation standard and applied Open Defecation Free (ODF). The data for adult health screening included the number of people aged 19-59 years old who obtained standard health screening by the primary healthcare centers, while the data for elderly health screening were gathered from people aged >60 years old. The data were analyzed in MsExcel (Microsoft, Redmond, WA). The statistical analysis used the correlation Pearson test to identify the correlation between TB and DM cases along with the ecologic variables in Jember.

RESULTS

The prevalence of TB in Jember amounted to 3,200 cases in 2020. The highest TB burden was found in the Kaliwates sub-district (248 cases) which was an urban area and the downtown of Jember District. Results showed that 35,951 people experienced diabetes in 2020. The highest DM prevalence was found in the Sumbersari Sub-district (1,950 cases), an urban area or downtown in Jember. The lowest both TB and DM prevalence was found in the Jelbuk Sub-district, a rural area in the north of Jember. The prevalence of TB-DM comorbidities was reported in 290 patients in 2020. The highest prevalence of TB-DM comorbidity was found in Bangsalsari and Tanggul sub-districts (17 cases), both sub-urban areas in Jember.

Most sub-districts reported a low number of TB passive cases in 2020. The contribution of DM cases was similar to TB prevalence in that most sub-districts found low and moderate DM cases from Posbindu or the integrated development post (a health program intended for hypertension and DM patients in the primary health center area). The study analyzed the Pearson correlation coefficient test results between TB and DM prevalence, and the test showed a p-value of 0.78. Thus, there was a strong correlation between TB and DM to form comorbidity. However, the data did not show the tracking results of TB-DM comorbidities in all sub-districts of Jember (Table 1).

Pearson correlation coefficient test showed a weak correlation between the prevalence of TB cases, DM cases, and TB-DM comorbidities with poor household variables (Table 2). A strong correlation was shown between population density and health sanitation access with the TB prevalence. Meanwhile, DM prevalence had a strong correlation with health sanitation access and adult health screening. The prevalence of TB-DM comorbidities only had a moderate correlation with adult health screening.

Table 1
Prevalence of tuberculosis (TB), diabetes mellitus (DM), and TB-DM comorbidities in 31 sub-districts of Jember, 2020

Variable	Category	Number of cases in the category	Number of sub-district
TB prevalence	Low	47-114	20
	Moderate	115-182	9
	High	183-250	2
DM prevalence	Low	493-979	12
	Moderate	980-1465	11
	High	1466-1952	8
TB-DM comorbidity prevalence	Low	0-6	8
	Moderate	7-12	14
	High	13-19	9

DISCUSSION

The contribution of TB reported cases in 2020 dropped more dramatically by 19% compared to 2019 due to the COVID-19 pandemic. The COVID-19 pandemic has constrained progress in providing essential TB services and reducing the TB disease burden (WHO, 2021). The numbers of both active and passive TB cases in 2020 were very low due to the lockdown policy causing barriers to accessing comprehensive TB services (Widiadana, 2020). The impact of the COVID-19 pandemic on TB services was experienced by the health staff and healthcare providers since the job tasks and financial budget were reallocated from TB services to the COVID-19 response (Castro, 2021). Thus, case finding, data collection, and reporting systems were negatively impacted during the pandemic.

The prevalence of DM cases was associated with more people living with diabetes in Jember in 2020 compared to 2019 (35,395 cases) (East Java

Table 2

Proportion and Pearson correlation tests between tuberculosis, diabetes mellitus, tuberculosis-diabetes mellitus comorbidity, and all ecologic variables

Variable	Tuberculosis prevalence				Diabetes Mellitus prevalence				Tuberculosis-Diabetes Mellitus comorbidity prevalence			
	Low (%)	Moderate (%)	High (%)	Coefficient*	Low (%)	Moderate (%)	High (%)	Coefficient*	Low (%)	Moderate (%)	High (%)	Coefficient*
Poor households	67.33	28.00	4.67	-0.22	39.72	31.90	28.39	0.12	34.61	32.48	32.55	0.01
Population density	45.61	34.59	19.80	0.79	26.79	38.84	34.37	0.39	35.63	34.05	30.32	0.08
The integrated development post units	62.50	31.45	6.05	0.08	35.48	36.29	28.23	0.38	35.08	33.06	31.85	0.10
Health sanitation access	51.41	39.00	9.60	0.67	24.86	38.18	36.96	0.90	33.25	28.10	38.65	0.42
Adult health screening	50.58	39.13	10.29	0.56	22.28	38.01	39.71	0.71	29.40	27.30	43.30	0.50
Elderly health screening	51.04	43.89	5.06	0.18	21.93	36.56	41.51	0.44	31.61	32.94	35.45	0.21

*Pearson correlation coefficient

Notes: (1) Tuberculosis prevalence is considered low when there were 47-144 cases; moderate when 115-182 cases and high when 183-250 cases.

(2) Diabetes mellitus prevalence is considered low when there were 493-979 cases; moderate when 980-1465 cases and high when 1466-1952 cases.

(3) Tuberculosis- diabetes mellitus comorbidity prevalence is considered low when there were 0-6 cases; moderate when 7-12 cases and high when 13-19 cases.

Provincial Health Office, 2020). Even though there were a large number of DM patients found, the International Diabetes Federation (IDF) stated that Indonesia was still one of the countries with the highest number of people with undiagnosed diabetes (International Diabetes Federation, 2022). Thus, the prevalence of DM during the COVID-19 pandemic did not show the real number of diabetic people in Jember. In 2020, less than 80% of people with diabetes were able to access the standard health care provided by the primary health center as the restricted protocol was implemented during the pandemic (Jember Health Office, 2021). Providing early DM detection is important to rectify poor health access which would reduce the quality of life since DM is one of the top 10 causes of mortality worldwide (International Diabetes Federation, 2022).

The TB prevalence was lower in rural than urban areas because there was more access to health services in urban areas where strategic places were located there (Noviyani *et al*, 2021). TB screening activity was mostly contributed by the passive TB case detection method whereas the TB suspects went to the primary health centers or any health facility when they showed positive screening symptoms (Noviyani *et al*, 2021). On other hand, the lowest TB and DM prevalence did not indicate the real situation of morbidity in the population of rural areas. There were some determinants of that condition such as low TB case detection, poor DM screening tool resources in each village, and the inability of health access by the rural community due to distance from their home to the health care provider. In addition, the COVID-19 pandemic has led to further setbacks in health services (Castro, 2021).

Very low TB-DM comorbidity prevalence indicated poor TB screening in diabetic people and likewise. A study calculated the increased prevalence of DM in urban areas was associated with greater TB incidence compared to rural areas (Stevenson *et al*, 2007). In the TB national program, the Indonesian Government has launched a TB screening program for risk populations, particularly people living with diabetes and HIV, using chest X-ray and a quick blood glucose test for all TB patients. The objective of TB and

DM screening in both DM and TB patients was to detect the comorbidity early and give the standard comorbidity treatment such as glycemic control on TB treatment and outcomes. Likewise, TB screening in DM patients and DM screening in TB patients were also negatively impacted by the COVID-19 pandemic as the strict health protocols prohibited face-to-face services. Even though there was innovative telemedicine for routine treatment, most people were afraid to report whether they had cough symptoms. Thus, the situation makes it for health workers difficult to give sufficient treatment via telemedicine services.

A study showed DM has a large impact on TB incidence for both the indirect effect (ie, increased transmission of TB) and direct effect (ie, increased risk of TB disease onset) (Pan *et al*, 2015). In Indonesia with a large DM prevalence, one out of five TB cases and one out of four TB-related deaths were attributed to DM in 2020 (Awad *et al*, 2022). The proportion of type 2 DM patients with TB was found significant in Indonesia (Alisjahbana *et al*, 2007). DM was associated with more symptoms but not with increased severity of TB (Alisjahbana *et al*, 2007). Another study revealed that the global prevalence of TB among people living with DM was low, but there was a high burden of DM among TB patients (Workneh *et al*, 2017).

Adult health screening was a public health program in Indonesia that was conducted regularly every month by the front-line health workers in sub-districts. The activity of adult health screening was consisted of early detection of hypertension, diabetes mellitus, TB, and measurements of body mass index (BMI). The target population of this screening activity are people in age group of 15-59 years who attend the primary health care or the integrated development post. The benefit from adult health screening especially for DM patients was TB screening and glycemic control. A study stated poor glycemic control at the time of TB diagnosis was identified as a risk factor for the development of TB-DM comorbidities (Webb *et al*, 2009). In summary of few articles, the risk factors for TB-DM comorbidity were socio-demographic and economic factors (ie, older age and urban residence), behavioral factors (*ie*, illicit drug use, cigarette smoking, sedentary lifestyle),

clinical factors (ie, BMI, HIV coinfection, hypertension, poor glycemic control, and patient with liver cirrhosis), history of DM, TB treatment, and other factors (ie, contact with TB patient in the family and patient imprisonment) (Workneh *et al*, 2017).

Contrary to this study, socio-economic deprivation continuously contributes to the TB epidemic. For example, people living in overcrowded dwellings and having poor nutritional status are associated with a higher risk of TB infections (Nguipdop-Djomo *et al*, 2020). The highest population density indicated the highest prevalence rate of TB particularly in urban slum dwellings (Lansang *et al*, 2021). The high density of the population will allow direct exposure to TB germs and TB patients, thus, the prevalence of TB increased higher in urban areas which are densely populated than in rural areas (Noviyani *et al*, 2021).

The evidence showed a similar finding of previous research that there was a strong correlation between poor sanitation and TB incidence(Wu and Dalal, 2012; Ma'rufi *et al*, 2018). A study conducted in Jember and Situbondo showed the majority of TB patients lived in low bedroom conditions (no ventilation and poor sunlight), sewerage system, and waste management (Ma'rufi *et al*, 2018). Poor sanitation and hygiene are common causes of diseases and productivity loss; hence, sanitation improvement will have significant impacts not only on health but also on social and economic development (Bartram *et al*, 2005; Mara *et al*, 2010).

The role of the integrated development post is to promote community participation in the early diagnosis and prevention of diseases, particularly non-communicable diseases. The integrated development post primarily focused on the elderly community and geriatric social healthcare. The health services of the integrated development post included screening for early detection of non-communicable diseases through an interview, measurement of BMI, abdominal circumference, blood pressure, health counseling, health education, blood examination (blood glucose test, cholesterol test, triglyceride test), spirometry, urinary amphetamine, blood alcohol test, visual

acetic acid inspection, and breast cancer screening. Currently, the utilization of the integrated development post services was accessible not only to the geriatric population but also to individuals of productive ages (15-59 years old). Thus, both adult health screening and elderly health screening can be performed in the integrated development post besides primary health centers and reached by groups with lower education levels (Sudharma *et al*, 2016). However, the integrated development post was known inaccessible and yielded some practical barriers (capability, resources, and protocols) (Widyaningsih *et al*, 2022).

Health screening performed by the health workers to specific age groups, 15-59 years old and >60 years old, was aimed to detect non-communicable diseases early through interviews, blood tests, and necessary certain health measurements. These health services were accessible both in the primary health centers and outside healthcare providers such as the integrated development post. The community used mobile health screening provided by the integrated development post, and those, particularly in remote areas, accessed the service from the primary healthcare center. However, the daily operational hours of the integrated development post were limited similarly to work shift hours. As a result, the majority of adult participants as the target population less visited the healthcare providers. Nevertheless, many participants confirmed the benefit of attending health screening. They obtained a health check result and free counseling, raised their awareness about non-communicable diseases, and a healthy lifestyle, and use the benefit of health insurance membership towards universal health coverage (Sudharma *et al*, 2016; Widyaningsih *et al*, 2022).

In summary, the prevalence of TB and DM grew year by year, and there were strong correlations between DM and TB prevalence; population density and TB prevalence; and both health sanitation access and health screening with TB and DM prevalence. On the other hand, the shortfall of TB case reports and DM routine treatment during the pandemic needs a further evaluation from the government. This study suggests the Government should

implement strategies in overcoming TB cases in their respective district by 1) implementing active and passive case finding, especially for DM patients, HIV patients, and other risk groups; 2) improving contact tracing for all TB patients; 3) implementing Public-Private Mix (PPM) and patient-centered care to treat TB patients. Society and the Government should improve access to health sanitation, optimize health screening outside the primary health center to detect diseases early, and promote health awareness in the community. Further studies are needed to assess other variables and to elaborate the individual variables from TB and DM patients through questionnaire interviews.

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CONFLICT OF INTEREST DISCLOSURE

The authors declared no conflicts of interest.

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