

# World Journal of *Diabetes*

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*WJD* mainly publishes articles reporting research results and findings obtained in the field of diabetes and covering a wide range of topics including risk factors for diabetes, diabetes complications, experimental diabetes mellitus, type 1 diabetes mellitus, type 2 diabetes mellitus, gestational diabetes, diabetic angiopathies, diabetic cardiomyopathies, diabetic coma, diabetic ketoacidosis, diabetic nephropathies, diabetic neuropathies, Donohue syndrome, fetal macrosomia, and prediabetic state.

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## Case Control Study

# Analysis of the influencing factors and clinical related characteristics of pulmonary tuberculosis in patients with type 2 diabetes mellitus

Han Shi, Yuan Yuan, Xue Li, Yan-Fang Li, Ling Fan, Xue-Mei Yang

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## Abstract

### BACKGROUND

In China, the prevalence of type 2 diabetes mellitus (T2DM) among diabetic patients is estimated to be between 90%-95%. Additionally, China is among the 22 countries burdened by a high number of tuberculosis cases, with approximately 4.5 million individuals affected by active tuberculosis. Notably, T2DM poses a significant risk factor for the development of tuberculosis, as evidenced by the increased incidence of T2DM coexisting with pulmonary tuberculosis (T2DM-PTB), which has risen from 19.3% to 24.1%. It is evident that these two diseases are intricately interconnected and mutually reinforcing in nature.

### AIM

To elucidate the clinical features of individuals diagnosed with both T2DM and tuberculosis (T2DM-PTB), as well as to investigate the potential risk factors associated with active tuberculosis in patients with T2DM.

### METHODS

T2DM-PTB patients who visited our hospital between January 2020 and January 2023 were selected as the observation group, Simple DM patients presenting to our hospital in the same period were the control group, Controls and case groups were matched 1:2 according to the principle of the same sex, age difference ( $\pm 3$ ) years and disease duration difference ( $\pm 5$ ) years, patients were investigated for general demographic characteristics, diabetes-related characteristics, body immune status, lifestyle and behavioral habits, univariate and multivariate analysis of the data using conditional logistic regression, calculate the odds ratio (OR) values and 95%CI of OR values.

## RESULTS

A total of 315 study subjects were included in this study, including 105 subjects in the observation group and 210 subjects in the control group. Comparison of the results of both anthropometric and biochemical measures showed that the constitution index, systolic blood pressure, diastolic blood pressure and lymphocyte count were significantly lower in the case group, while fasting blood glucose and high-density lipoprotein cholesterol levels were significantly higher than those in the control group. The results of univariate analysis showed that poor glucose control, hypoproteinemia, lymphopenia, TB contact history, high infection, smoking and alcohol consumption were positively associated with PTB in T2DM patients; married, history of hypertension, treatment of oral hypoglycemic drugs plus insulin, overweight, obesity and regular exercise were negatively associated with PTB in T2DM patients. Results of multivariate stepwise regression analysis found lymphopenia (OR = 17.75, 95%CI: 3.40-92.74), smoking (OR = 12.25, 95%CI: 2.53-59.37), history of TB contact (OR = 6.56, 95%CI: 1.23-35.03) and poor glycemic control (OR = 3.37, 95%CI: 1.11-10.25) was associated with an increased risk of developing PTB in patients with T2DM, While being overweight (OR = 0.23, 95%CI: 0.08-0.72) and obesity (OR = 0.11, 95%CI: 0.02-0.72) was associated with a reduced risk of developing PTB in patients with T2DM.

## CONCLUSION

T2DM-PTB patients are prone to worse glycemic control, higher infection frequency, and a higher proportion of people smoking, drinking alcohol, and lack of exercise. Lymphopenia, smoking, history of TB exposure, poor glycemic control were independent risk factors for T2DM-PTB, and overweight and obesity were associated with reduced risk of concurrent PTB in patients with T2DM.

**Key Words:** Type 2 diabetes; Pulmonary tuberculosis; Blood sugar; Infection; Risk factors

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**Core Tip:** Diabetes mellitus is a metabolic disorder resulting from a combination of genetic factors, environmental influences, and lifestyle choices, which lead to impairments in insulin secretion or function. In recent times, there has been a significant increase in the incidence of diabetes accompanied by hyperglycemia as its primary manifestation. By conducting case-control studies within hospital settings, we aim to examine the distinctive features of patients with type 2 diabetes mellitus and pulmonary tuberculosis and investigate the potential risk factors associated with the development of tuberculosis in this specific population.

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## INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder caused by genetic factors, environment and lifestyle caused by defects in insulin secretion or function. In recent years, the prevalence of DM, the main manifestation of hyperglycemia, has risen sharply, reaching 9.7%[1]. In China, type 2 DM (T2DM) accounts for 90%-95% of in all diabetic patients[2]. Tuberculosis (TB) is a chronic infectious disease caused by *Mycobacterium tuberculosis* (*M. tuberculosis*)[3], most of latent tuberculosis infected people have no obvious clinical symptoms. Patients with latent TB, when body resistance decreases or cell-mediated allergy increases, develop active TB, with pulmonary tuberculosis (PTB) being the most common[4]. China is one of the 22 countries with high TB burden with about 4.5 million active TB patients[5]. As many as 130000 TB patients die each year, more than twice the total number of other infectious diseases in China[5]. T2DM is one of the risks of developing TB, and the incidence of T2DM with PTB (T2DM-PTB) increased from 19.3% to 24.1%. These two diseases are closely related and mutually promote[6]. On the one hand, due to the high tissue sugar content, metabolic disorder and decreased immune function, *M. tuberculosis* increases the production of resistant strains, and affects the prognosis of T2DM-PTB patients; on the other hand, TB will aggravate the glucose metabolism disorder of T2DM patients, increase the incidence of ketoacidosis, and present a dangerous prognosis[7]. T2DM-PTB faces new challenges in the world public health field due to its severity, treatment difficulties, and poor prognosis.

China is in a period of rapid growth in the incidence of DM, and the burden of tuberculosis is serious. DM combined with tuberculosis has become a major public health problem and the rising prevalence of DM is a potential threat to TB control. Based on this, World Health Organization recommends a collaborative framework for clinical management and control of DM with TB. Therefore, this study conducted a hospital-based case-control study to observe the characteristics of T2DM-PTB patients and explore the risk factors for pulmonary TB in T2DM, providing a scientific basis for the prevention and control of T2DM-PTB.

## MATERIALS AND METHODS

### General information

In this study, cases (observation group) of selected tuberculosis patients with T2DM from January 2020 to January 2023 were randomly selected in our hospital, and compared with diabetic patients without tuberculosis in the same period (control group).

### Selection of the cases

**Inclusion criteria for the observation group:** (1) DM diagnosis earlier than PTB; (2) active tuberculosis (never received anti-tuberculosis chemotherapy or received chemotherapy for 1 month); (3) lived locally for more than 1 year, age > 18 years old; and (4) was aware of the study and signed informed consent.

**Exclusion criteria for observation group:** (1) Recovered PTB patients, disseminated PTB, tuberculosis pleurisy, and other extrapulmonary tuberculosis; (2) has other endocrine diseases, such as hyperthyroidism, systemic lupus erythematosus, rheumatoid arthritis; (3) has diseases that can affect immune function such as acquired immunodeficiency syndrome (AIDS), malignant tumor, chronic hepatitis, cirrhosis, primary kidney disease, renal failure, blood disease, renal transplantation, gastrectomy; or (4) study subjects have used hormones and immunosuppressants within 4 months.

### Selection of control group

The control group was patients with T2DM in our hospital at the same time. Two controls were matched for each case by the principle of equal gender, age difference ( $\pm 3$ ) years and disease duration difference ( $\pm 5$ ) years.

**Inclusion criteria for the control group:** (1) DM patients aged > 18 years who had lived locally for more than 1 year; and (2) were aware of the study and signed informed consent.

**Exclusion criteria for the control group:** (1) Now have other endocrine diseases, such as hyperthyroidism, systemic lupus erythematosus, rheumatoid arthritis, *etc.*; (2) now has diseases that can affect the immune function, such as AIDS, malignant tumor, chronic hepatitis and cirrhosis, chemical, primary renal disease, renal failure, hematological disorders, post-renal transplantation, gastrectomy, *etc.*; or (3) patients with pulmonary infection, or patients with tuberculosis lesions or suspicious lesions after chest X-ray examination.

### Diagnostic criteria

**Diagnostic criteria for T2DM[8]:** Patients presented with typical T2DM, abnormal glucose test (random glucose 11.1 mmol/L or fasting glucose 7.0 mmol/L; or oral glucose tolerance test 2h glucose 11.1 mmol/L).

**Diagnostic criteria for PTB[9]:** (1) Clinical symptoms such as cough, expectoration and fever, typical PTB findings combined with chest X-ray and chest computed tomography; (2) tuberculin skin test (PPD) reaction 10 mm; (3) positive TB antibody or  $\gamma$ -interferon release test; (4) positive mycobacterium smear culture; and (5) histopathology consistent with positive tuberculous change and acid fast staining.

### Sample size calculation

The sample size was calculated according to the sample size of the paired case-control study (number of cases: number of controls = 1: r):

$$n = [Z_{\alpha}\sqrt{(1+1/r)\bar{p}(1-\bar{p})} + Z_{\beta}\sqrt{p_1(1-p_1)/r + p_0(1-p_0)}]^2(p_1 - p_0)^2$$

$$p_1p_0p_0 = OR/[1 + (OR-1)]$$

$$\bar{p}p_1p_0 = (+r)/(1+r)$$

$p_1p_0Z_{\alpha}$  and  $Z_{\beta}$  are the exposure rate of a major risk factor in the observation group and control group, respectively. OR represents the odds ratio of the risk factor, the standard normal cut-off for the type I error probability  $\alpha$  and the standard normal cut-off for the type II error probability  $\beta$ . The literature shows that the glucose control level of T2DM patients is closely related to the occurrence of PTB[10], poor glucose control can increase the risk of PTB, its OR value is about 3[11], the incidence of poor glucose control in T2DM patients in China is about 60% [12], namely = 0.60, this study took  $\alpha = 0.05$  (bilateral),  $\beta = 0.10$ ,  $r = 2$ . The observation group should be more than 81 cases and more than 162 cases in the control group. A total of 105 patients in the observation group and 210 patients in the control group were included in this study, which met the study requirements.

### Questionnaire survey

Using uniform questionnaire and inquiry, the questionnaire mainly included: general demographic characteristics: age, gender, marital status, educational level, work and monthly income, DM related characteristics: family history of DM, course of disease, diet control and blood glucose monitoring; body immune status: whether the subjects had upper respiratory tract infections (such as cold, sinusitis, tonsillitis, otitis media, *etc.*), bronchitis or pneumonia, skin infections (lip herpes, genital herpes, warts, furuncle or abscess) in the last year. The questionnaire was adapted from the immune system assessment questionnaire developed by the Chronic Immunodeficiency Center of the University Medical Center in Freiburg[13]; Lifestyle and behavioral habits: smoking, alcohol consumption, physical exercise, sleep status, tuberculosis exposure history, per capita living area, dust exposure history and contact personnel, *etc.*

### Physical examination

**Measurement of height and weight:** After calibrating the instrument, the patient is required to take off his shoes and coat according to the standard method. During the measurement, feet are tight, back straight and eyes straight forward.

**Blood pressure measurement:** Blood pressure is measured by desktop mercury column sphygmomanometer. The respondent needs to rest for at least 5 min in a quiet state, and can be measured after the mood is stable. During the measurement, the respondent was exposed to his right arm, the arm was placed flat on the table and heart, and the feet were placed flat on the ground to relax. Select the appropriate cuff, record the systolic blood pressure and diastolic blood pressure in the first and fifth tone of Korotkoff, measuring three times, at least one minute between each two times, and averaging the three readings.

### Laboratory examination

Fasting blood was drawn and sent to the clinical laboratory, Timely centrifugation, Isolate the serum, Hitachi 7180 was used to determine fasting blood glucose, total cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), albumin; separated plasma, A SYSMEX XE-2100 hematology for hemoglobin, lymphocyte count, *etc.* Glycated hemoglobin was determined by Alometric.

### Quality control

Before the formal investigation, the pre-investigation should be conducted in a certain group of people to find out the problems and deficiencies in time, adjust the design of unreasonable items, and improve the content of the questionnaire. All the investigators have received systematic and unified professional training, and can participate in the project research only after passing the examination. Inform the research subjects before the investigation, and sign the informed consent form. Investigators in strict accordance with the requirements of the training inquiry and physical examination, not induced questions, truthfully fill in the questionnaire, to ensure the authenticity and reliability of the data, and in the survey by personnel audit questionnaire, unified number and corresponding records, the unqualified questionnaire check or remove as far as possible. Data entry was conducted by uniformly trained researchers. The double data entry method was adopted, and the data was checked after entry. When the two questionnaires were inconsistent, the original data were checked, and errors were found and re-entered.

### Statistical analysis

Data were entered and statistically analyzed using SPSS 20.0 software. If the quantitative data conforms to the normal distribution, the mean standard deviation; the non-normal data adopts the median and the interquartile spacing; the qualitative data is represented by the frequency (percentage). For quantitative data satisfying the normal distribution, non-parametric test for non-parametric data; and test for comparison between groups. Univariate analysis screened the potential risk factors for concurrent PTB in DM patients, multivariate conditional Logistic regression analysis (fitting by Cox model in survival analysis) screened the independent influencing factors of concurrent PTB, using the stepwise method, and 0.05 and 0.10 were used as the significance level of introduced and excluded variables, respectively. The strength of the association of the various influencing factors with PTB was measured by the odds ratio (OR) and its 95%CI. Before the analysis, all the variables were checked for collinearity. The test level shall be taken as  $\alpha = 0.05$ .

## RESULTS

### General demographic characteristics

A total of 105 eligible T2DM-PTB patients and 210 patients with T2DM alone were collected during the study period. The age range of the observation group was 26-86 years, and the mean age was  $55.3 \pm 11.5$  years; the control group was 26-83 years,  $55.7 \pm 11.4$  years, gender, marital status, educational level, occupational and worker's insurance ( $P > 0.05$ ), as shown in [Table 1](#).

### DM-related characteristics

The mean duration of DM in the observation group was  $6.8 \pm 5.7$  years,  $7.4 \pm 5.6$  years, with no statistical difference ( $P > 0.05$ ); the proportion of history of hypertension was lower than the control group ( $P < 0.05$ ), but no significant difference in family history of DM ( $P > 0.05$ ); the incidence of poor glucose control in the observation group was 77.9%, significantly higher than 56.5% ( $P < 0.001$ ). In both groups, drugs were the main way to control blood glucose, accounting for 45.7% and 43.8%, respectively, but the proportion of the observation group using oral medicine and insulin was significantly lower than that of the control group (10.5% *vs* 24.8%,  $P < 0.05$ ). There were significant differences between the two groups, and the proportion was 43.8%, while the control group was 43.3%, statistically different ( $P < 0.05$ ); there was no significant difference in the family history of DM and regular blood glucose monitoring ( $P > 0.05$ ; [Table 2](#)).

### Test results of laboratory indicators

Systolic BP, diastolic blood pressure, body weight, body mass index (BMI), and lymphocyte count were lower than the control group, while fasting glucose and HDL were higher than the control group ( $P < 0.05$ ). Serum cholesterol and triglyceride levels may differ between the two groups ( $P = 0.052$ ), but not in height, glycated hemoglobin, hemoglobin, albumin and LDL ( $P > 0.05$ ; [Table 3](#)).

**Table 1** General demographic characteristics of the observed and control groups, *n* (%)

Characteristics	Observation group ( <i>n</i> = 105)	Control group ( <i>n</i> = 210)	$\chi^2/t$	<i>P</i> value
Age (yr)	55.3 ± 11.5	55.7 ± 11.4	-0.254	0.800
Gender			0.009	0.926
Male	80 (76.2)	159 (75.7)		
Female	35 (23.4)	51 (24.3)		
marital status			7.307	0.007
Unwed/divorced/widowed	14 (13.3)	27 (12.9)		
Married	91 (86.7)	183 (87.1)		
Educational level			0.335	0.163
Illiteracy	13 (12.4)	32 (15.2)		
Primary school	18 (17.1)	32 (15.2)		
Middle school	62 (59.1)	126 (60.0)		
College degree or above	12 (11.4)	20 (9.5)		
Occupation			6.491	0.261
Housework and unemployed	34 (32.4)	65 (30.9)		
Peasant	22 (21.0)	65 (30.9)		
Office worker	13 (12.4)	27 (12.9)		
Self-employed worker	12 (11.4)	23 (11.0)		
Worker	14 (13.3)	21 (10.0)		
Other	10 (9.5)	9 (4.3)		
Worker's insurance			2.293	0.130
Yes	45 (42.9)	109 (51.9)		
No	60 (57.1)	101 (48.1)		

### Nutritional status

In terms of nutritional status, clear differences between the rates of overweight, obesity, hypoproteinemia and lymphopenia, as detailed in [Table 4](#). The incidence of overweight and obesity was 29.5% and 8.6%, respectively, significantly lower than the control group 47.0% and 17.5%, and the incidence of hypoproteinemia and lymphopenia was 24.2% and 74.2%, respectively, both higher than 11.4% and 45.1% in the control group, while neither group was statistically different between the incidence of hyperlipidemia and anemia, shown in [Table 4](#).

### Immunological status of the body

In the case of the observation group, upper respiratory tract infection was 69.5% in the past year, which was significantly higher than 47.1% of the control group. Both the observation and control groups were lower in the incidence of bronchitis or pneumonia, gastrointestinal infection, and skin infection, and there was no significant difference between the two groups. There were significant differences between high infection in the two groups, with the proportion of high infection in 70.5% in the observation group and 54.3% in the control group. The difference was statistically significant ( $P < 0.05$ ). However, there was no statistical difference in the incidence of herpes between the two groups, as detailed in [Table 5](#). The rates of pharyngeal, tonsillectomy, nasal polypectomy, and appendectomy were low in both groups (< 2%, not listed).

### Lifestyle and behavior habits

The comparison of lifestyle and behavioral habits between the two groups are shown in [Table 6](#). The proportion of participants with a history of TB contact was significantly higher than the control group (21.0% vs 6.7%), while the kitchen was less well-ventilated than the control group (61.9% vs 81.2%). More than 70% of the patients in both groups were able to do indoor ventilation regularly, but the proportion of people in the observation group without ventilation habits was higher than that in the control group. There were no statistical differences in dust contact history, migrant work history, contact situation and per capita living area. A comparison of the distribution of smoking between the two groups found that the proportion of current smokers in the observation group was the highest, 49.5%, while the proportion of non-smokers in the control group was 50.0%. The proportion of current smokers in the observation group was significantly higher than that in the control group ( $P < 0.05$ ). 39% and 18% of the observation and control groups were current drinkers, and 2.9% and 10.0% were previous drinkers. The proportion of patients in the observation group was 40%, significantly

**Table 2 Comparison between the observed and control groups in diabetes-related characteristics, *n* (%)**

Characteristics	Observation group ( <i>n</i> = 105)	Control group ( <i>n</i> = 210)	$\chi^2/t$	<i>P</i> value
Disease course (yr)	6.8 ± 5.7	7.4 ± 5.6	-0.863	0.389
Family history of diabetes			1.585	0.208
Yes	31 (29.5)	77 (36.7)		
No	74 (71.5)	133 (63.3)		
History of hypertension			4.123	0.042
Yes	34 (32.4)	93 (44.3)		
No	71 (67.6)	117 (55.7)		
Poor glycaemic control			12.281	< 0.001
Yes	74 (77.9)	100 (56.5)		
No	31 (22.1)	110 (43.5)		
Regular blood glucose monitoring			0.135	0.713
Yes	25 (23.8)	54 (25.7)		
No	80 (76.2)	156 (74.3)		
Diabetes treatment modality			10.285	0.016
Unregular treatment	24 (22.9)	36 (17.1)		
Oral hypoglycaemic agent	48 (45.7)	92 (43.8)		
Insulin	22 (20.9)	30 (14.3)		
Oral antidiabetic drugs + insulin	11 (10.5)	52 (24.8)		
Diet control attitude			7.141	0.028
Think it's very important	29 (27.6)	53 (25.3)		
Think it is generally important	30 (28.6)	91 (43.3)		
Think it's not important	46 (43.8)	66 (31.4)		

lower than 61% in the control group. According to the sleep status analysis, the proportion of people with difficulty falling asleep and habitual snoring was higher than that of the control group, while the drug sleep assistance and sleep duration was not significantly different between the two groups.

### Univariate analysis of the risk of patients with T2DM-PTB

Using univariate condition logistic regression analysis, 12 factors at  $\alpha = 0.05$ , including marital status, history of hypertension, poor blood glucose control, DM treatment, BMI grouping, hypoproteinemia, lymphopenia, TB exposure, high infection, smoking, drinking, and regular exercise. The relative hazards of each contributing factor are shown in Table 7. The analysis found that poor glycaemic control, hypoproteinemia, lymphopenia, history of TB exposure, high infection, smoking, and alcohol consumption were the risk factors for T2DM-PTB. In this study, non-smokers, former smokers, and passive smokers were combined as current non-smokers, With it as a reference group, univariate logistic regression analysis found that T2DM patients had more than five times higher risk of smoking PTB than non-smokers (OR = 5.12, 95%CI: 2.61-10.7;  $P < 0.001$ ); Combining non-drinkers and previous drinkers as current non-drinkers, With it as a reference group, The univariate results showed that the risk of PTB in T2DM patients was 3.39 times higher than that in current non-drinkers (OR = 3.39, 95%CI: 1.88-6.12;  $P < 0.001$ ). Regarding nutritional status, hypoproteinemia (OR = 2.48, 95%CI: 1.21-5.09) and lymphopenia (OR = 3.91, 95%CI: 2.12-7.21) were both risk factors for T2DM-PTB; while overweight (OR = 0.38, 95%CI: 0.22-0.66;  $P = 0.001$ ) and obesity (OR = 0.32, 95%CI: 0.14-0.70;  $P = 0.005$ ) than T2DM with normal weight, and patients had a lower risk of concurrent PTB. Unmarried (OR = 0.29, 95%CI: 0.12-0.73), history of hypertension (OR = 0.59, 95%CI: 0.36-0.98), oral medication and insulin (OR = 0.31, 95%CI: 0.13-0.73), and regular exercise (OR = 0.34, 95%CI: 0.20-0.58) were protective factors for T2DM-PTB.

### Multivariate logistic regression analysis of the risk of patients with T2DM-PTB

Before the multivariate condition logistic regression analysis, the univariate analysis of OR is significant, marital status, high blood pressure, poor blood glucose control, DM treatment, BMI group, low proteinemia, lymphopenia, TB exposure history high infection, smoking, drinking, regular exercise 12 factors for collinear diagnosis. The results show that the tolerance is between 0.746 and 0.924, and the variance expansion factors are less than 10, and there is no collinearity problem. The possible risk factors selected by the results of univariate analysis were used as independent variables, and

**Table 3 Test results of observation and control groups**

Items	Observation group (n = 105)	Control group (n = 210)	$\chi^2/t$	P value
Height (cm)	169.52 ± 8.81	168.68 ± 7.54	0.881	0.379
Weight (kg)	66.53 ± 13.62	71.75 ± 12.08	-3.249	0.001
Body mass index (kg/m <sup>2</sup> )	23.00 ± 3.30	25.18 ± 3.40	-5.377	< 0.001
Systolic blood pressure (mmHg)	129.00 ± 20.00	134.00 ± 24.00	-2.544	0.011
Diastolic blood pressure (mmHg)	80.00 ± 10.50	83.00 ± 14.00	-2.504	0.012
Hemoglobin A1c (%)	8.85 ± 2.15	8.90 ± 2.80	-0.873	0.382
Fasting blood glucose (mmol/L)	10.54 ± 3.43	7.83 ± 2.81	-4.517	< 0.001
Hemoglobin (g/L)	136.50 ± 27.00	138.00 ± 21.00	-0.295	0.768
Albumin (g/L)	40.20 ± 8.40	39.68 ± 5.80	-0.247	0.805
Lymphocyte count (10 <sup>9</sup> /L)	1.65 ± 0.78	2.08 ± 0.94	-4.168	< 0.001
Triglyceride (mmol/L)	1.28 ± 0.31	1.47 ± 0.36	-1.940	0.052
Cholesterol (mmol/L)	4.68 ± 1.13	4.39 ± 1.62	-1.870	0.061
High-density lipoprotein (mmol/L)	1.20 ± 0.47	1.10 ± 0.39	-2.032	0.042
Low-density lipoprotein (mmol/L)	2.85 ± 1.08	2.70 ± 1.30	-0.713	0.476

**Table 4 Comparison of nutritional status between the observed and control groups, n (%)**

Items	Observation group (n = 105)	Control group (n = 210)	$\chi^2/t$	P value
BMI divide into groups			19.702	< 0.001
Normal	65 (61.9)	71 (35.5)		
Overload	31 (29.5)	94 (47.0)		
Fat	9 (8.6)	35 (17.5)		
Anemia	18 (18.4)	28 (15.2)	0.465	0.495
Hypoproteinemia	24 (24.2)	20 (11.4)	7.702	0.006
Lymphocytopenia	72 (74.2)	83 (45.1)	21.773	< 0.001
Hyperlipidemic and hyperlipidemia	46 (50.0)	98 (58.7)	1.812	0.178
Simple hypertriglyceridemia	13 (14.1)	38 (22.8)	2.790	0.095
Simple hypercholesterolemia	8 (8.7)	9 (5.4)	1.057	0.304
Combined hyperlipidemia familial	3 (3.3)	7 (4.2)	0.138	0.710
Simple low HDL cholesterolemia	22 (24.7)	44 (26.7)	0.114	0.736

BMI: Body mass index; HDL: High-density lipoprotein.

the conditional logistic regression analysis was performed with PTB as the dependent variable (the control group was 0), and 0.05 and 0.10 as the significance level of the introduced and excluded variables. The assignment method for each variable is shown in [Table 8](#).

The statistically significant 12 factors were analyzed by multivariate Logistic regression, which showed that five factors entered the model, as detailed in [Table 9](#). Among them, lymphopenia, poor glycemic control, history of TB exposure and smoking were risk factors for T2DM-PTB, while overweight and obesity were protective factors. Patients with T2DM-PTB with OR lymphopenia (17.75,  $P = 0.001$ ) and smoking (OR = 12.25,  $P = 0.002$ ) had more than ten times the risk of TB. Being overweight (OR = 0.23,  $P = 0.011$ ) and obesity (OR = 0.11,  $P = 0.021$ ) reduced the risk of PTB in T2DM by 77% and 89%, respectively.

**Table 5 Comparison of body immune status between the observed and control groups, n (%)**

Items	Observation group (n = 105)	Control group (n = 210)	$\chi^2/t$	P value
Upper respiratory tract infection	73 (69.5)	99 (47.1)	14.145	< 0.001
Bronchitis or pneumonia	5 (4.8)	12 (5.7)	0.124	0.724
Gastrointestinal infection	9 (8.6)	20 (9.5)	0.076	0.783
Skin infection	3 (2.9)	9 (4.3)	0.390	0.532
High infection	74 (70.5)	114 (54.3)	7.626	0.006
Bleb	16 (15.2)	26 (12.4)	0.495	0.482

**Table 6 Comparison of lifestyle and behavioral habits between the observed and control groups, n (%)**

Items	Observation group (n = 105)	Control group (n = 210)	$\chi^2/t$	P value
History of tuberculosis contact	22 (21.0)	14 (6.7)	14.113	< 0.001
History of dust contact	7 (6.7)	15 (7.1)	0.024	0.876
Smoke			29.017	< 0.001
Current smoker	52 (49.5)	48 (22.8)		
Non-smoker	33 (31.4)	105 (50.0)		
A former smoker	13 (12.4)	18 (8.6)		
Passive smoker	7 (6.7)	39 (18.6)		
Drink			18.924	< 0.001
Current drinker	41 (39.0)	38 (18.1)		
No drinkers	61 (58.1)	151 (71.9)		
A former drinker	3 (2.9)	21 (10.0)		
Whether you exercise regularly			16.625	< 0.001
Yes	42 (40.0)	128 (61.0)		
No	63 (60.0)	82 (39.0)		

## DISCUSSION

This paper compared the characteristics of the two groups, and the results showed that there were obvious differences in marriage, education, low protein, *etc.* Our previous study found that the proportion of unmarried (unmarried, divorced, widowed) in T2DM-PTB patients was significantly higher. Part of this is that a person has a great relationship between their physical and mental health. The ability to care for each other and support each other is very important for maintaining mental and physical stability between couples[14]. However, the older unmarried, divorced, widowed, often have loneliness, anxiety, anger, sadness and other bad psychological state. This bad mood and mood, it is likely to affect the body's metabolic function and immunity, thus making the body more susceptible to *M. tuberculosis* infection. Moreover, it is also possible that it is related to the poor family income of PTB patients, with some impact on their marriage.

T2DM-PTB is a common chronic wasting disease, patients often lead to nutritional deficiency, and then lead to body injury, and then lead to disease recurrence, affecting the prognosis[15,16]. The incidence of T2DM-PTB is as high as 45%-78.3%[17]. The occurrence of T2DM-PTB is associated with multiple causes[18]. T2DM has high blood sugar levels in the body, but due to the lack of insulin, the body cannot convert blood sugar into energy, and can only use protein, fat and other metabolites as energy sources, resulting in malnutrition[19]. T2DM is a serious risk of human health disease. In addition, because the body is in a state of consumption for a long time, PTB will also cause the body's catabolism abnormalities, thus reducing the body's protein and fat reserves, resulting in the body's malnutrition. The T2DM-PTB group had higher hypoproteinemia than the T2DM group. It is possible that protein deficiency reduces the cellular immune function of the body, which further improves the body's sensitivity to infection, leading to the infection aggravating[20]. Another reason may be that in the chronic process from *M. tuberculosis* infection to TB, the metabolism of the patient will accelerate and the production of interleukin-6 and tumor necrosis factor- $\alpha$  may lead to fever, liver synthesis of acute phase reaction protein and inhibit the production of serum albumin[21,22]. PTB is a chronic wasting disease that is prone to anemia. At the same time, *M. tuberculosis* proliferation in the patient's body tissue can cause a large amount of nutrients to be consumed, including hematopoietic substances, and eventually lead to anemia in the patient. About 16%-94% of PTB patients will develop anemia[23]. Our previous study found that there was no significant

**Table 7 Results of the univariate conditional logistic regression analysis**

Variable	Odds ratio	95%CI	P value
Married	0.29	0.12-0.73	0.009
Poor glyceimic control	2.36	1.32-4.22	0.004
Diabetes treatment modality			
Unregular treatment	1.00	-	-
Oral hypoglycaemic agent	0.76	0.41-1.44	0.401
Insulin	0.98	0.45-2.14	0.960
Oral antidiabetic drugs + insulin	0.31	0.13-0.73	0.007
History of hypertension	0.59	0.36-0.98	0.040
Body mass index divide into groups			
Normal	1.00	-	-
Overload	0.38	0.22-0.66	0.001
Fat	0.32	0.14-0.70	0.005
Hypoproteinemia	2.48	1.21-5.09	0.013
Lymphocytopenia	3.91	2.12-7.21	< 0.001
History of tuberculosis contact	4.49	1.97-10.23	< 0.001
High infection	1.95	1.21-3.15	0.006
Smoke	5.12	2.61-10.7	< 0.001
Drink	3.39	1.88-6.12	< 0.001
Regular exercise	0.34	0.20-0.58	< 0.001

**Table 8 Assignment statement in the multivariate logistic regression analysis of the risk in type 2 diabetes mellitus with pulmonary tuberculosis patients**

Items	Assignment method
Marital status	Unmarried, divorced and widowed = 1, married = 2
Hypertension	No = 0, Yes = 1
Poor glyceimic control	No = 0, Yes = 1
Diabetes treatment methods	Oral medication = 1, insulin = 2, oral medication and insulin simultaneously = 3, no regular treatment = 4
BMI grouping	BMI < 24 = 1, BMI: 24.0-27.9 = 2, BMI ≥ 28 = 3
Hypoproteinemia	No = 0, Yes = 1
Lymphocytopenia	No = 0, Yes = 1
History of tuberculosis contact	No = 0, Yes = 1
High infection	No = 0, Yes = 1
Smoke	No = 0, Yes = 1
Drink	No = 0, Yes = 1
Regular exercise	No = 0, Yes = 1

BMI: Body mass index.

relationship between T2DM-PTB and the incidence of diabetic TB, and the incidence of T2DM-PTB will gradually increase with the development of the disease.

Our multifactorial study found that in patients with T2MD, having lymphopenia, smoking, a history of TB, and failure to control their blood sugar increase the risk of TB. In the execution of cellular immunity, lymphocytes are the most important effector cells, which can not only reflect the immune status of the human body, but also be used as a new index

**Table 9** Multivariate conditional logistic regression analysis of risk factors for type 2 diabetes mellitus with pulmonary tuberculosis

Variable	$\beta$	SE	Wald	P value	Odds ratio (95%CI)
BMI divide into groups					
Normal	-	-	-	-	1.00
Overload	-1.457	0.573	6.475	0.011	0.23 (0.08-0.72)
Fat	-2.182	0.943	5.357	0.021	0.11 (0.02-0.72)
Poor glycemic control	1.215	0.568	4.581	0.032	3.37 (1.11-10.25)
Lymphocytopenia	2.876	0.844	11.622	0.001	17.75 (3.40-92.74)
History of tuberculosis contact	1.882	0.854	4.849	0.028	6.56 (1.23-35.03)
Smoke	2.506	0.805	9.686	0.002	12.25 (2.53-59.37)

BMI: Body mass index.

to evaluate the protein reserve of the human body internal organs. By measurement, it can also indirectly evaluate the nutritional status of the human body. The previous study of our group found that T2DM was accompanied by lymphocyte decline, and the incidence of PTB was 10 times higher than that of T2DM. The decrease in lymphocyte number indicates a weakening of cellular immune function as an anti-tuberculosis immune mechanism, which leads to the development of TB[24]. After extensive research, it has been proved that balanced nutrition and proper body weight can ensure the normal metabolic activities and immune function of the body. Malnourished people often reduce the total number of T lymphocytes, the function of the decline, but also can make the mechanical barrier of the body is damaged, mucosal resistance decreased, resulting in immune dysfunction, which is easy to cause a variety of infection[25,26].

A large number of studies have shown that smoking can improve the risk of TB. Preliminary meta-analysis showed that the risk of TB in smokers is twice that of non-smokers[27]. The previous study of our research group found that the risk of TB in diabetic patients is 10 times that of non-smokers. This suggests that among diabetics, smoking causes a much greater risk of TB than the average patient. Smoking can damage airway epithelial cilia, inhibit lung phagocytosis by macrophages, reduce the removal of lung, and increase the risk of lung infection. There are also reports that nicotine in cigarettes directly damage macrophages, killing *M. tuberculosis*[28]. Smoking for a long time leads to a decrease in the expression of surface proteins associated with antigen presentation in lung macrophages. After the pathogen enters the body, some of them cannot be presented to the immune system, leading to a decrease in the killing of pathogenic bacteria [29]. Our study showed that smoking and alcoholism is a risk factor for TB, while smoking and alcohol abuse is also a risk factor for TB in African population[30]. Smoking and passive smoking are closely linked to drinking, this is because drinking has a special social environment, drinking and smoking and passive smoking often coexist, thus improving the risk of infection. Previous studies have shown that the risk of active pulmonary TB with over 40 g of daily drinking significantly increases[31], and the univariate analysis of our research group also indicates that alcohol consumption is an important cause of T2DM-PTB. Some scholars believe that excessive drinking will cause TB, and alcohol will cause direct toxicity to the body's immune system, making the body more susceptible to TB[32,33]. Animal experiments have shown that chronic and acute alcohol intake can directly damage macrophages and cellular immunity, leading to the development of PTB[34].

BMI is a comprehensive index of long-term lack of energy. Previous studies[35,36] found that BMI (BMI < 18.5 kg/m<sup>2</sup>) is closely related to TB incidence, but the proportion of people with BMI < 18.5 kg/m<sup>2</sup> is low (3.5%), and the statistical significance is unclear, so further expansion of the sample is needed.

Previous studies have shown that the risk of developing TB gradually increases with increasing age, and men are more likely to develop TB[37,38]. Since age is proportional to sex, its relationship with T2DM-PTB cannot be evaluated.

This project intends to use a 1:2 ratio case-control design to obtain more valuable data with a smaller sample size, especially in a small number of diabetic patients with active TB. Using conditional logistic regression analysis, the deficiency of increased required sample content due to stratification avoided previous univariate stratification analysis. In addition, this study uses a matching case-control study, which enables the matching factors to reach a balance between the case group and the control group. In the comparative analysis, the influence of these factors can be excluded, so it has a high accuracy in the estimation of the model. Combining a 1:2 ratio of case-control trials with conditional Logistic regression can improve the detection efficiency of clinical trials and ensure the quality of the trials with a smaller sample size.

However, this paper also has some shortcomings. Since the samples in this study were collected from hospitals, there are certain limitations in the selection of samples, so it is inevitable that selective bias will occur.

## CONCLUSION

In conclusion, T2DM-PTB patients are prone to worse glycemic control, higher infection frequency, smoking, drinking and lack of exercise; lymphocytopenia, smoking, exposure to TB history, and poor glycemic control are independent risk

factors for T2DM-PTB, overweight and obesity, T2DM, and decreased risk of concurrent PTB.

## ARTICLE HIGHLIGHTS

### Research background

The characteristics of patients with type 2 diabetes (T2DM) were clarified, and the risk factors of active tuberculosis (TB) in T2DM were explored to provide scientific basis for the prevention and control of the disease.

### Research motivation

In China, T2DM accounts for 90%-95% of all diabetic patients, and China is one of the 22 countries with high TB burden, with about 4.5 million active TB patients; T2DM is one of the risks of developing TB, and the incidence of T2DM with TB (T2DM-PTB) increases from 19.3% to 24.1%. These two diseases are closely related and mutually reinforcing.

### Research objectives

Clarify the characteristics of patients with T2DM complicated with TB, and explore the risk factors of active tuberculosis in T2DM patients, so as to provide a scientific basis for the prevention and control of diseases.

### Research methods

T2DM-PTB patients in our hospital were selected as the observation group, and simple T2DM patients in our hospital at the same time were selected as the control group. The general demographic characteristics, diabetes-related characteristics, body immune status, lifestyle and behavioral habits were investigated, and the data were analyzed by conditional logistic regression.

### Research results

The results found that the physical index, systolic blood pressure, diastolic blood pressure and lymphocyte count were significantly lower than the control group, while fasting blood glucose and high-density lipoprotein cholesterol levels were significantly higher than the control group, poor glucose control, hypoproteinemia, lymphopenia, TB exposure history, high infection, smoking, alcohol consumption were positively associated with PTB in T2DM; married, history of hypertension, treatment of oral hypoglycemic agents + insulin, overweight, obesity and regular exercise were negatively associated with concurrent PTB in patients with T2DM.

### Research conclusions

Patients with T2DM-PTB are prone to worse glycemic control, higher infection frequency, and a higher proportion of people smoking, alcohol consumption, and lack of exercise. Lymphopenia, smoking, history of TB exposure, and poor glycemic control were independent risk factors for T2DM-PTB, and overweight and obesity were associated with a decreased risk of concurrent PTB in patients with T2DM.

### Research perspectives

The empirical and comparative perspectives.

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## FOOTNOTES

**Co-first authors:** Han Shi and Yuan Yuan.

**Author contributions:** Shi H and Yuan Y designed the research; and Shi H and Yuan Y contributed equally to this work as co-first authors equally to this work; Li X, Yuan Y, Li YF, Fan L, Yang XM and Shi H contributed new reagents/analytic tools; Yuan Y, Li X, Li YF, Fan L, Yang YM and Shi H analyzed the data; Shi H and Yuan Y wrote the paper; and all authors were involved in the critical review of the results and have contributed to, read, and approved the final manuscript.

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## REFERENCES

- 1 **Refardt J.** Diagnosis and differential diagnosis of diabetes insipidus: Update. *Best Pract Res Clin Endocrinol Metab* 2020; **34**: 101398 [PMID: 32387127 DOI: [10.1016/j.beem.2020.101398](https://doi.org/10.1016/j.beem.2020.101398)]
- 2 **Hua KF, Zhang MY, Zhang Y, Ren BJ, Wu YH.** Characteristics of OGTT and Correlation Between the Insulin to C-Peptide Molar Ratio, HOMA-IR, and Insulin Antibodies in T2DM Patients. *Diabetes Metab Syndr Obes* 2022; **15**: 2417-2425 [PMID: 35971523 DOI: [10.2147/DMSO.S373475](https://doi.org/10.2147/DMSO.S373475)]
- 3 **Natarajan A, Beena PM, Devnikar AV, Mali S.** A systemic review on tuberculosis. *Indian J Tuberc* 2020; **67**: 295-311 [PMID: 32825856 DOI: [10.1016/j.ijtb.2020.02.005](https://doi.org/10.1016/j.ijtb.2020.02.005)]
- 4 **Fei S, Feng X, Luo J, Guo L, Pan Q.** Obesity and Coronavirus Disease 2019. *J Transl Int Med* 2022; **10**: 207-218 [PMID: 36776236 DOI: [10.2478/jtim-2022-0020](https://doi.org/10.2478/jtim-2022-0020)]
- 5 **Cook JA.** Associations between use of crack cocaine and HIV-1 disease progression: research findings and implications for mother-to-infant transmission. *Life Sci* 2011; **88**: 931-939 [PMID: 21219914 DOI: [10.1016/j.lfs.2011.01.003](https://doi.org/10.1016/j.lfs.2011.01.003)]
- 6 **Ugarte-Gil C, Curisínche M, Herrera-Flores E, Hernandez H, Ríos J.** Situation of the tuberculosis-diabetes comorbidity in adults in Peru: 2016-2018. *Rev Peru Med Exp Salud Publica* 2021; **38**: 254-260 [PMID: 34468572 DOI: [10.17843/rpmesp.2021.382.6764](https://doi.org/10.17843/rpmesp.2021.382.6764)]
- 7 **Armstrong LR, Kammerer JS, Haddad MB.** Diabetes mellitus among adults with tuberculosis in the USA, 2010-2017. *BMJ Open Diabetes Res Care* 2020; **8** [PMID: 32641300 DOI: [10.1136/bmjdr-2020-001275](https://doi.org/10.1136/bmjdr-2020-001275)]
- 8 **Ru N, Zou WB, Wu H, Hu LH, Li XB, Liu GF, Li ZS, Liao Z;** Chronic Pancreatitis Group of Chinese Medical Doctor Association. Chinese guidelines for the diagnosis and treatment of pancreatic exocrine insufficiency (2018 edition). *J Dig Dis* 2019; **20**: 567-571 [PMID: 31006979 DOI: [10.1111/1751-2980.12753](https://doi.org/10.1111/1751-2980.12753)]
- 9 **Bureau of Disease Prevention and Control,** Ministry of Health, Department of Medical Administration, Chinese Center for Disease Control and Prevention. Technical Specifications for Tuberculosis Prevention and Control in China, 2020 edition. Beijing: Peking Union Medical College Press, 2020
- 10 **van 't Riet E, Dekker JM, Sun Q, Nijpels G, Hu FB, van Dam RM.** Role of adiposity and lifestyle in the relationship between family history of diabetes and 20-year incidence of type 2 diabetes in U.S. women. *Diabetes Care* 2010; **33**: 763-767 [PMID: 20067970 DOI: [10.2337/dc09-1586](https://doi.org/10.2337/dc09-1586)]
- 11 **Leung CC, Lam TH, Chan WM, Yew WW, Ho KS, Leung GM, Law WS, Tam CM, Chan CK, Chang KC.** Diabetic control and risk of tuberculosis: a cohort study. *Am J Epidemiol* 2008; **167**: 1486-1494 [PMID: 18400769 DOI: [10.1093/aje/kwn075](https://doi.org/10.1093/aje/kwn075)]
- 12 **Wang L, Peng W, Zhao Z, Zhang M, Shi Z, Song Z, Zhang X, Li C, Huang Z, Sun X, Wang L, Zhou M, Wu J, Wang Y.** Prevalence and Treatment of Diabetes in China, 2013-2018. *JAMA* 2021; **326**: 2498-2506 [PMID: 34962526 DOI: [10.1001/jama.2021.22208](https://doi.org/10.1001/jama.2021.22208)]
- 13 **Hope AA, Hsieh SJ, Petti A, Hurtado-Sbordoni M, Verghese J, Gong MN.** Assessing the Usefulness and Validity of Frailty Markers in Critically Ill Adults. *Ann Am Thorac Soc* 2017; **14**: 952-959 [PMID: 28358584 DOI: [10.1513/AnnalsATS.201607-538OC](https://doi.org/10.1513/AnnalsATS.201607-538OC)]
- 14 **Gao J, Lu Y, Gokulnath P, Vulugundam G, Li G, Li J, Xiao J.** Benefits of Physical Activity on Cardiometabolic Diseases in Obese Children and Adolescents. *J Transl Int Med* 2022; **10**: 236-245 [PMID: 36776239 DOI: [10.2478/jtim-2022-0041](https://doi.org/10.2478/jtim-2022-0041)]
- 15 **Traub J, Reiss L, Aliwa B, Stadlbauer V.** Malnutrition in Patients with Liver Cirrhosis. *Nutrients* 2021; **13** [PMID: 33562292 DOI: [10.3390/nu13020540](https://doi.org/10.3390/nu13020540)]
- 16 **Taylor R.** Type 2 diabetes: etiology and reversibility. *Diabetes Care* 2013; **36**: 1047-1055 [PMID: 23520370 DOI: [10.2337/dc12-1805](https://doi.org/10.2337/dc12-1805)]
- 17 **Santoro A, Kahn BB.** Adipocyte Regulation of Insulin Sensitivity and the Risk of Type 2 Diabetes. *N Engl J Med* 2023; **388**: 2071-2085 [PMID: 37256977 DOI: [10.1056/NEJMra2216691](https://doi.org/10.1056/NEJMra2216691)]
- 18 **Kichloo A, Shaka H, El-Amir Z, Wani F, Singh J, Velazquez GR, Edigin E, Dahiya D.** In-patient outcomes of patients with diabetic ketoacidosis and concurrent protein energy malnutrition: A national database study from 2016 to 2017. *Postgrad Med* 2021; **133**: 854-859 [PMID: 33858299 DOI: [10.1080/00325481.2021.1916231](https://doi.org/10.1080/00325481.2021.1916231)]
- 19 **Fu L, Ramos-Roman MA, Deng Y.** Metabolic Adaptation in Lactation: Insulin-dependent and -independent Glycemic Control. *J Transl Int Med* 2022; **10**: 191-196 [PMID: 36776235 DOI: [10.2478/jtim-2022-0036](https://doi.org/10.2478/jtim-2022-0036)]
- 20 **Pike J, Chandra RK.** Effect of vitamin and trace element supplementation on immune indices in healthy elderly. *Int J Vitam Nutr Res* 1995; **65**: 117-121 [PMID: 7591530]
- 21 **Hullalli R, Gudadinni, Motappa R.** WITHDRAWN: Prevalence of Diabetes Mellitus among Newly Detected Sputum Positive Pulmonary Tuberculosis Patients and Associated Risk Factors: A Cross-sectional Study. *Curr Diabetes Rev* 2023 [PMID: 37138479 DOI: [10.2174/1573399819666230501195227](https://doi.org/10.2174/1573399819666230501195227)]
- 22 **Karyadi E, Schultink W, Nelwan RH, Gross R, Amin Z, Dolmans WM, van der Meer JW, Hautvast JG, West CE.** Poor micronutrient status of active pulmonary tuberculosis patients in Indonesia. *J Nutr* 2000; **130**: 2953-2958 [PMID: 11110853 DOI: [10.1093/jn/130.12.2953](https://doi.org/10.1093/jn/130.12.2953)]
- 23 **Lee SW, Kang YA, Yoon YS, Um SW, Lee SM, Yoo CG, Kim YW, Han SK, Shim YS, Yim JJ.** The prevalence and evolution of anemia associated with tuberculosis. *J Korean Med Sci* 2006; **21**: 1028-1032 [PMID: 17179681 DOI: [10.3346/jkms.2006.21.6.1028](https://doi.org/10.3346/jkms.2006.21.6.1028)]
- 24 **Pavan Kumar N, Nair D, Banurekha VV, Dolla C, Kumaran P, Sridhar R, Babu S.** Type 2 diabetes mellitus coincident with pulmonary or latent tuberculosis results in modulation of adipocytokines. *Cytokine* 2016; **79**: 74-81 [PMID: 26771473 DOI: [10.1016/j.cyto.2015.12.026](https://doi.org/10.1016/j.cyto.2015.12.026)]

- 25 **Black RE**, Morris SS, Bryce J. Where and why are 10 million children dying every year? *Lancet* 2003; **361**: 2226-2234 [PMID: [12842379](#) DOI: [10.1016/S0140-6736\(03\)13779-8](#)]
- 26 **Nobs SP**, Zmora N, Elinav E. Nutrition Regulates Innate Immunity in Health and Disease. *Annu Rev Nutr* 2020; **40**: 189-219 [PMID: [32520640](#) DOI: [10.1146/annurev-nutr-120919-094440](#)]
- 27 **Lin HH**, Ezzati M, Murray M. Tobacco smoke, indoor air pollution and tuberculosis: a systematic review and meta-analysis. *PLoS Med* 2007; **4**: e20 [PMID: [17227135](#) DOI: [10.1371/journal.pmed.0040020](#)]
- 28 **Qiu F**, Liang CL, Liu H, Zeng YQ, Hou S, Huang S, Lai X, Dai Z. Impacts of cigarette smoking on immune responsiveness: Up and down or upside down? *Oncotarget* 2017; **8**: 268-284 [PMID: [27902485](#) DOI: [10.18632/oncotarget.13613](#)]
- 29 **Bothamley GH**. Smoking and tuberculosis: a chance or causal association? *Thorax* 2005; **60**: 527-528 [PMID: [15994256](#) DOI: [10.1136/thx.2004.036012](#)]
- 30 **Tekkel M**, Rahu M, Loit HM, Baburin A. Risk factors for pulmonary tuberculosis in Estonia. *Int J Tuberc Lung Dis* 2002; **6**: 887-894 [PMID: [12365575](#)]
- 31 **Lönnroth K**, Williams BG, Stadlin S, Jaramillo E, Dye C. Alcohol use as a risk factor for tuberculosis - a systematic review. *BMC Public Health* 2008; **8**: 289 [PMID: [18702821](#) DOI: [10.1186/1471-2458-8-289](#)]
- 32 **Szabo G**. Alcohol's contribution to compromised immunity. *Alcohol Health Res World* 1997; **21**: 30-41 [PMID: [15706761](#)]
- 33 **Greenberg S**, Xie J, Kolls J, Nelson S, Didier P, Mason C. Ethanol suppresses Mycobacteria tuberculosis-induced mRNA for nitric oxide synthase in alveolar macrophages, in vivo. *Alcohol Clin Exp Res* 1995; **19**: 394-401 [PMID: [7542849](#) DOI: [10.1111/j.1530-0277.1995.tb01521.x](#)]
- 34 **Mellencamp MA**. Effects of ethanol consumption on susceptibility to pulmonary and gastrointestinal factors. *Alcohol Clin Exp Res* 1996; **20**: 192A-195A [PMID: [8947263](#) DOI: [10.1111/j.1530-0277.1996.tb01774.x](#)]
- 35 **Lönnroth K**, Williams BG, Cegielski P, Dye C. A consistent log-linear relationship between tuberculosis incidence and body mass index. *Int J Epidemiol* 2010; **39**: 149-155 [PMID: [19820104](#) DOI: [10.1093/ije/dyp308](#)]
- 36 **Lönnroth K**, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. *Soc Sci Med* 2009; **68**: 2240-2246 [PMID: [19394122](#) DOI: [10.1016/j.socscimed.2009.03.041](#)]
- 37 **Buskin SE**, Gale JL, Weiss NS, Nolan CM. Tuberculosis risk factors in adults in King County, Washington, 1988 through 1990. *Am J Public Health* 1994; **84**: 1750-1756 [PMID: [7977912](#) DOI: [10.2105/ajph.84.11.1750](#)]
- 38 **Hussain H**, Akhtar S, Nanan D. Prevalence of and risk factors associated with Mycobacterium tuberculosis infection in prisoners, North West Frontier Province, Pakistan. *Int J Epidemiol* 2003; **32**: 794-799 [PMID: [14559752](#) DOI: [10.1093/ije/dyg247](#)]



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