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# Changes in the rate of bacillus tuberculosis infection in health workers in the first year of the COVID-19 epidemic in Kashan- Iran

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A R T I C L E I N F O

*Keywords:*
Tuberculosis
Tuberculin skin test
Medical personnel
TST
PPD test

A B S T R A C T

*Objective:* This cohort study aimed to determine the prevalence and risk factors of latent tuberculosis infection among healthcare workers during the COVID-19 pandemic.
*Methods:* A one-year cohort study was conducted in a referral hospital in Kashan, involving 176 medical, educational, and cleaning personnel. Initial evaluations and tuberculin skin tests were performed, followed by a one-year follow-up period. Data were analyzed using SPSS version 26 software.
*Results:* Among the participants, 26.1% (46 individuals) tested positive for latent tuberculosis infection. Age was a significant risk factor, with a 3.6% increase in latent tuberculosis infection risk with each advancing year. Men had 2.19 times (1.10–4.35) the chance of having a latent infection compared to women. Hospital staff were 3.7 times more at risk of tuberculosis infection than students. Among the hospital job categories, nursing assistants had the highest chance of tuberculosis infection, 6.77 times higher than medical students, followed by cleaning staff and nurses. The ICU, General, and Obstetrics and Gynecology departments had an infection chance of 2.46 (1.11–5.46) compared to other departments. No new positive cases were detected during the follow-up period.
*Conclusion:* This study contributes to the understanding of latent tuberculosis infection prevalence and its risk factors among healthcare workers during the COVID-19 pandemic. The findings highlight the importance of infection control measures and targeted interventions to protect healthcare workers from occupational tuberculosis exposure.

## 1. Introduction

Tuberculosis (TB) is a global health problem, with an estimated incidence of 10 million cases and 1.2 million deaths annually [1]. Despite a decline in prevalence and death rates, approximately one-third of the world's population is infected with Mycobacterium tuberculosis [2]. In Iran, the incidence of smear-positive TB was 5.7 per 100,000, and the overall prevalence of different forms of TB was 11.4 per 100,000 [3].

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A systematic review was conducted to assess the relative efficacy of Tuberculin Skin Test (TST) and interferon-gamma release assays (IGRA) in predicting the occurrence of new cases of active tuberculosis. IGRA, unlike TST, remains unaffected by Bacillus Calmette-Guérin (BCG) vaccination or the majority of Nontuberculous Mycobacteria (NTM) infections (except for Mycobacterium Kansasii, Marinum, and Szulgai). Consequently, IGRA is anticipated to enhance diagnostic specificity. IGRA appears to have higher predictive performance than the TST in low TB incidence countries (<100 per 100,000 population), but the difference was driven by a single study. Any advantage in clinical performance may be small, given the numerically similar positive and negative predictive values. Both IGRA and TST had lower performance in countries with high TB incidence. Test choice should be contextual and made considering the operational and likely clinical impact of test results [4]. According to WHO guidelines, TST or IGRA can be used to detect LTBI in high-income and upper-middle-income countries with TB incidences below 100 per 100,000 population [5]. It is worth noting that approximately 90% of individuals with latent tuberculosis infection (LTBI) do not develop active TB symptoms [6].

TST is the most widely used and accessible diagnostic tool for identifying TB infection [6]. LTBI refers to the presence of TB bacillus without evidence of active TB disease. The risk of latent TB progressing to active disease is approximately 5–10% over a person's lifetime, with the highest risk occurring in the first five years after infection. However, this risk can be significantly reduced by 60–90% through prophylactic treatment [7]. However, due to side effects, drug resistance, and costs, preventive treatment is limited to specific high-risk groups [7,8].

Health care workers (HCWs) are particularly vulnerable to TB infection, posing a risk of transmission to patients and other HCWs. The prevalence of TB among HCWs, based on positive TST results, has been reported as 29.94%, while the global burden of latent TB infection was estimated to be 23.0% in 2014 [9]. Risk factors among HCWs include aging, longer duration of employment, nursing professionals, lack of BCG vaccination, and a low body mass index. The tuberculin skin test plays a vital role in identifying high-risk groups as part of TB control strategies [10,11]. However, TST results can be influenced by previous contact with Mycobacterium bovis or non-tuberculous mycobacteria vaccination, and false-negative results can occur due to immunosuppression caused by HIV infection, active tuberculosis, autoimmune diseases, or immunosuppressive drugs [12–15].

In Iran, the prevalence of LTBI among healthcare personnel is reported at 27.13%, with the highest prevalence observed in the north and west regions (33.8% and 41.4%, respectively) and the lowest prevalence in the south (18.2%) till January 2019 [16].

Therefore, this study aims to assess the prevalence of latent TB infection and identify the risk factors among HCWs in a referral hospital. By examining the specific departments and levels of education, employment duration, and job position, we can gain insights into the risk factors of latent TB infection among HCWs and the conversion rate among them.

## 2. Method

### 2.1. Population

This is a prospective cohort study from February 2019 for one year within the population of students and medical personnel of Shahid Beheshti Hospital in Kashan, the largest hospital in the region with a population of about 500,000 people in the Kashan region, which is a part of Isfahan province in the center of Iran. Personnel with at least 12 months of work experience and medical students with at least 12 months left in their studies were included.

### 2.2. Sampling method

The sampling was done using proportional stratified simple random sampling. By estimating the conversion rate at 18% [17] and the positive test ratio at 30%, and accounting for a loss to follow-up of about 30% of cases, and estimating the accuracy at = 4 d and the confidence level at 95%, the sample size was calculated as 450 people. After the beginning of the COVID-19 epidemic in the region, it was not possible to complete the sample size, and the delay in starting the study could distort the results; since then, the study was conducted on 176 people.

The non-participation rate in the study across various subgroups (hospital departments and study groups) was nearly equal, and the rigorous examination of the characteristics of participants and non-participants revealed no statistically significant differences. Thus, there was no apparent evidence of selection bias.

To assess the potential for sampling bias, we thoroughly examined individuals who did not take part in the study. This is because the non-participation of some individuals under the study conditions could be influenced by various confounding factors, such as the presence of a disease or differences in risk factors. Therefore, individual data of those who were listed in the hospital but did not participate in the research were extracted concerning occupation, gender, department, and duration of hospitalization from the hospital's database. They were compared with the group that participated in the study using the Chi-square test, and no significant difference was observed between these limited items in the two groups. This comparison does not rule out sampling bias, but to the best of our knowledge, the evidence suggests that this bias was not significant. Informed consent was obtained from all individuals participating in the study, ensuring their comprehension of the data collection and testing procedures, as well as the utilization of gathered information for managerial decision-making and anonymous publication. Their profile, demographic information, details about their history of contact with a confirmed TB patient, educational or occupational history, ethnicity, and state of residence were collected using a questionnaire. Subsequently, a tuberculin skin test (TST) was conducted during phase I of the study.

Tuberculin Test Method: The tuberculin test is administered intradermally using an insulin syringe following proper preparation. A volume of 0.1 cc of tuberculin is injected into the anterior aspect of the forearm at a midpoint of 2/1. The injection site is marked with a blue marker for result identification.

Tuberculin Characteristics**:** Tuberculin used in the study is produced by the Razi Institute, with each vial contains 5 mL. It is in the form of a solution and should be stored at a temperature of 4° Celsius. Once opened, the vial can be utilized for up to one month.

The test result was recorded by measuring the induration from two directions and documenting the highest diameter within 48–72 h after the injection. To investigate the booster effect in individuals with negative TST results, the test was repeated one week later. In the case of non-referral, a follow-up was conducted within 72 hourse to read the test result.

The method of performing the tuberculin test was as follows: the tuberculin (Razi Institute, 5 ml) was injected intradermally using an insulin syringe, with an amount of 0.1 cc applied in the middle anterior.

Over twelve months (Feb 2019–Nov 2020), participants were closely monitored for ward changes, ensuring ongoing engagement through tri-monthly SMS/phone updates. All 130 participants with negative PPD remained engaged for over a year. In the short time since the completion of the study's first phase, which ended in February 2019, the COVID-19 epidemic started in the region and the country. Shahid Beheshti Hospital, where this research was conducted, became an exclusive referral center for COVID-19 patients since March 2019. It was nearly entirely dedicated to providing medical services to COVID-19 patients during various epidemic peaks. While interns returned to work after a month of vacation, stagers were exempted from hospital attendance for several months.

Throughout the specified period, all hospital personnel, including nurses and cleaning staff, maintained 8-h shifts to address critical circumstances, except on days when they were unwell. Amidst the COVID-19 pandemic, infectious disease residents conterrupted continued uninterrupted shifts, whereas other residents were granted a break for the initial four months of the pandemic before resuming their duties.

During this one-year-long period, all personnel and students were provided with N95 and surgical masks.

After one year, in November 2020, all subjects in the first phase that had negative initial TST (<10 mm) were called to perform the TST again, and After 48–72 h, their results were examined. Information about their career and position, contact with a patient with TB diagnosis, and trips made during the last year was also gathered. The criterion for diagnosing LTBI was TST with induration greater than or equal to 10 mm. In addition, changes in TST size were also calculated and analyzed. Further follow-up, chest X-ray, and prophylactic treatment were suggested if the test result was greater than 10 mm in the first stage.

Inclusion and exclusion criteria: The inclusion criteria were the individual's consent to cooperate and to be in one of the target groups. The exclusion criteria were not coming for the tuberculin test after being invited and not participating in follow-up appointments.

### 2.3. *Statistical analysis*

The data collection tool was a checklist, and the data from this study were analyzed using IBM SPSS Statistics v21.0. Central and peripheral indicators were described according to the variable type with mean, median, mode, percentage, standard deviation, and IQR, and presented with tables and graphs. A one-year incidence rate was calculated.

The Chi-square test and Fisher's exact test were used in data analysis. The incidence rate was compared with the Risk Ratio index, and the differences in various confounders were evaluated using logistic regression analysis The significance level was considered to be less than 0.05.

### 2.4. *Ethical approval*

The authors of this article have addressed all ethical considerations, including non-plagiarism, duplicate publication, data distortion, and data fabrication. This project has been registered with Kashan University of Medical Sciences under the ethical code IR. KAUMS.MEDNT.REC.1398.080.

**Table 1**
Comparison of the characteristics of health workers in Kashan Hospital based on gender.

| | | Male, N (%) | Female, N (%) | Total, N (%) | *P*-value |
|---|---|---|---|---|---|
| Age group | 15–24 | 23 (28.0%) | 28 (29.8%) | 51 (28.0) | 0.195[a] |
| | 25–49 | 47 (57.3%) | 60 (63.8%) | 107 (60.8) | |
| | 50–70 | 12 (14.6%) | 6 (6.4%) | 18 (10.2) | |
| | | 82 | 94 | 176 | |
| Employment duration | <5 years | 15 (39.5%) | 16 (28.6%) | 31 (33.0%) | |
| | 5–14.9 | 18 (47.4%) | 24 (42.9%) | 42 (44.7%) | 0.190 |
| | 15 and more | 5 (13.2%) | 16 (28.6%) | 21 (22.3%) | |
| job | Medical students | 19 (23.1%) | 27 (28.8%) | 46 (26.1%) | |
| | Nurses | 19 (23.2%) | 40 (42.6%) | 59 (33.5%) | 0.013 |
| | Cleaning staff | 19 (23.2%) | 10 (10.6%) | 29 (16.5%) | |
| | Nurse Assistance | 25 (30.5%) | 17 (18.1%) | 42 (23.9%) | |
| Ward Level of Risk | Low | 62 (78.5%) | 77 (82.8%) | 139 (80.8%) | 0.474 |
| | High | 17 (21.5%) | 16 (17.2%) | 33 (19.2%) | |
| Job Position | Students | 19 (23.2%) | 27 (28.7%) | 46 (26.1%) | 0.403 |
| | Staff | 63 (76.8%) | 67 (71.3%) | 130 (73.9%) | |

[a] All of the p-value in this table are based on the Pearson Chi-square test.

## 3. Results

176 individuals participated in this study. The average age of the participants was 33.5 (95% CI: 32.0–34.9). The average working experience of the personnel was 9.11 (95% CI: 7.7–10.4) years. The workplace of only 33 people (19.2%) was in high-risk departments, including internal emergency, infectious diseases, chemotherapy, dialysis, and general departments. Forty-six individuals were students (26.1%), and the remaining were hospital employees. The ethnicity of the majority of the studied individuals was Fars. While the majority of job groups were nurses and nursing assistants, the frequency of female nurses was almost twice that of males, and the majority of nursing assistant roles were held by men (Table 1).

Out of the total of 176 individuals in the initial TST, 130 people (73.9%) had negative test result, and 46 people (26.1%) tested positive for tuberculin. The average age of tuberculin-negative people was 32.5 (SD 0.87), nearly 4 years less than of those who tested positive 36.2 (SD 1.46) ($P < 0.016$). The logistic regression model indicated a 3.6% increase in the chance of a positive TST for each year of age increase in the subjects under study, and this relationship was statistically significant ($P = 0.036$) (Table 2). According to Table 2, the chance of a positive tuberculin test result was more than twice as high in men compared to women ($P = 0.025$). Nursing assistants and hospital cleaning staff had the highest percentage of positive TST results, with 45.2% and 31%, respectively. The lowest proportion of positive tuberculin tests was observed in medical students (10.9%). The difference among occupational groups was statistically significant ($P = 0.007$). In the high-risk departments of the hospital (ICU, General, and Obstetrics and Gynecology), compared to the low-risk departments (the other departments), the chance of being positive for TST increased by 2.46 (1.11–5.46) times ($P = 0.02$). Among hospital personnel, the positive test rate was 3.7 times higher than that of students ($P = 0.009$). A history of contact with an infected patient was associated with a 2.06 (1.04, 4.08) times higher chance of testing positive for the tuberculin test ($P = 0.038$) (Table 2).

Only 130 out of the 176 individuals who had initially tested negative were willing to return for a retest. The mean of the first TST was 1.55 mm (SD 1.93), while the mean of the second TST increased to 1.60 mm (SD 1.95). However, this increase did not reach statistical significance ($P = 0.083$). The most substantial increase in TST size, approximately 0.14 mm, was observed among individuals with less than 5 years of work experience. These changes exhibited a decreasing trend with increasing work experience. Additionally, a higher rate of increase was observed within older age groups. Similar patterns of change were observed across different hospital departments. The magnitudes of these changes are presented in Table 3.

## 4. Discussion

This study assesses the prevalence and one-year conversion rate of TB infection among hospital personnel, who are at a heightened

**Table 2**
Risk factors associated with tuberculin skin test result among health workers on univariate analysis.

| Variables | | TST Positive N (%) | TST Negative N (%) | Total N | OR (95%CI) | *P*-value |
|---|---|---|---|---|---|---|
| Sex | male | 28 (34.1) | 54 (65.9) | 94 | 2.19 (1.10–4.35) | 0.025[a] |
| | female | 18 (19.1) | 76 (80.9) | 82 | 1 | |
| | total | 46 (26.1) | 130 (73.9) | 176 | | |
| Age group | 15–24 | 8 (15.7) | 43 (84.3) | 51 | 1 | |
| | 25–49 | 31 (29.0) | 76 (71.0) | 107 | 2.19 (0.93–5.19) | 0.74[a] |
| | 50–70 | 7 (38.9) | 11 (61.1) | 18 | 3.42 (1.02–11.49) | 0.47[a] |
| Mean (sd) | | 36.2 (9.8) | 32.5 (10.1) | 176 | 1.04 (1.00–1.07) | 0.036[b] |
| Employment duration | <5 years | 10 (32.3) | 21 (67.7) | 31 | 1 | |
| | 5–14.9 | 15 (35.7) | 27 (64.3) | 42 | 2.02 (0.54–7.61) | 0.393[a] |
| | 15 and more | 4 (19.0) | 17 (81.0) | 21 | 2.36 (0.67–8.31) | |
| Job | Medical students | 5 (10.9) | 41 (89.1) | 46 | 1 | |
| | Nurses | 13 (22.0) | 46 (78.0) | 59 | 2.317 (7.06) | 0.139[a] |
| | Cleaning staff | 9 (31.0) | 20 (69.0) | 29 | 3.69 (1.09–12.46) | 0.035[a] |
| | Nurse Assistance | 19 (45.2) | 23 (54.8) | 42 | 6.77 (2.23–20.54) | 0.001[a] |
| Ward Level of Risk | Low | 32 (23.0) | 107 (77.0) | 139 | 1 | 0.024[a] |
| | High | 14 (42.4) | 19 (57.6) | 33 | 2.46 (1.11–5.46) | |
| Job Position | students | 5 (10.9) | 41 (89.1) | 46 | 1 | 0.006[a] |
| | Staff | 41 (31.5) | 89 (68.5) | 130 | 3.74 (1.39–10.26) | |
| Scar | Yes | 44 (27.2) | 118 (72.8) | 162 | 2.24 (0.48–10.4) | 0.304[a] |
| | No | 2 (14.3) | 12 (85.7) | 14 | 1 | |
| BCG | Yes | 46 (26.4) | 128 (73.6) | 174 | 1 | 0.899[a] |
| | No | 0 (0) | 2 (100.0) | 2 | – | |
| Tuberculosis | Yes | 28 (33.3) | 56 (66.7) | 84 | 2.06 (1.04–4.08) | 0.038[a] |
| Contact History | No | 18 (19.6) | 74 (73.9) | 92 | 1 | |

OR: Odds Ratio.
TST: Tuberculin Skin Test.
[a] All of the p-value in this table are based on the Pearson Chi-square test.
[b] Linear regression test.

**Table 3**
Association of changes in tuberculin skin test results after one year with characteristics of health workers in Kashan Hospital.

| characteristics | | first TST | | Second TST | | TST diff | | *P*-value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | |
| Ward Level of Risk | Low | 1.56 | 1.94 | 1.61 | 1.98 | .05 | .29 | 0.939 |
| | High | 1.21 | 1.36 | 1.26 | 1.24 | .05 | .40 | |
| Scar | No | .75 | .97 | .75 | .97 | .00 | .00 | 0.580 |
| | Yes | 1.64 | 1.99 | 1.69 | 2.01 | .05 | .32 | |
| Age group | 15–24 | 1.47 | 1.88 | 1.49 | 1.88 | .02 | .34 | 0.772 |
| | 25–49 | 1.62 | 2.08 | 1.67 | 2.10 | .05 | .28 | |
| | 50–70 | 1.45 | .93 | 1.55 | 1.04 | .09 | .30 | |
| Sex | female | 1.42 | 2.02 | 1.49 | 2.09 | .07 | .34 | 0.352 |
| | Male | 1.74 | 1.80 | 1.76 | 1.75 | .02 | .24 | |
| Employment duration | <5 years | .95 | 1.47 | 1.10 | 1.48 | .14 | .36 | 0.710 |
| | 5–14.9 | 1.37 | 2.31 | 1.44 | 2.38 | .07 | .38 | |
| | 15 and more | 1.71 | 2.02 | 1.76 | 2.05 | .06 | .24 | |
| BCG | No | 1.50 | 2.12 | 1.50 | 2.12 | .00 | .00 | 0.828 |
| | Yes | 1.55 | 1.94 | 1.60 | 1.96 | .05 | .30 | |
| Tuberculosis | No | 1.43 | 1.78 | 1.47 | 1.78 | .04 | .31 | 0.808 |
| Contact History | Yes | 1.71 | 2.13 | 1.77 | 2.17 | .05 | .30 | |

TST: Tuberculin Skin Test.

risk due to their proximity and frequent contact with infected individuals. By determining the level of TB infection and identifying associated risk factors, this study provides valuable insights into the epidemiology of TB transmission in healthcare settings.

In this study, the prevalence and one-year conversion rate of TB infection among hospital personnel were assessed, revealing a prevalence of 26.1%. Age, gender, job position, TB contact history, and ward level of risk were identified as factors associated with TB infection among HCWs. The study found a higher chance of a positive TST with increasing age, and men had a 2.19 times higher chance compared to women. Certain hospital departments, such as the ICU, General, Obstetrics, and Gynecology departments, showed a higher number of positive TST cases. Healthcare personnel, in general, face a higher risk of TB, with rates reported to be 3 to 6 times higher compared to the general population. The study also found that a history of contact with TB patients increased the odds of a positive TST, while scars and a history of BCG vaccination did not significantly correlate with TST size. These findings emphasize the importance of implementing preventive measures and highlighting the risks faced by HCWs in TB transmission.

In our study, the prevalence of TB infection among hospital personnel was 26.1%. This rate is lower than the prevalence reported in Afghanistan (47.2%) [18] and India (30%) [19], but higher than in Riyadh hospitals (4.9%) [20] and Turkey (1.7%) [21]. The prevalence in EMRO member countries in 2021 was 41.78% [22], while among medical personnel in low- and middle-income countries, it was 54% [23]. The prevalence of LTBI among medical personnel in various regions of Iran has ranged from 7% to 63% [24,25]. In the Doosti study conducted in Iran, Golestan province exhibited the highest incidence rate of new TB cases at 35.9 per 100,000, followed closely by Sistan and Baluchestan with a rate of 34.2 per 100,000. On the other end of the spectrum, Chaharmahal and Bakhtiari provinces reported the lowest incidence rate at 3.06 per 100,000, while Fars province had a slightly higher rate of 3.2 per 100,000 [3]. Inadequate implementation of TB control programs in different regions and personnel's reluctance to disclose their TB diagnosis due to stigma has led to delays and disparities in the diagnosis and treatment of TB [26].

The results of this study indicate that the chance of a positive tuberculin test (TST) increases significantly with each year of advancing age. Similar findings were reported in a study conducted in Qazvin, where age and an increasing history of contact with leprosy patients were associated with an enlarged TST size in students [27]. However, no significant relationship was found between age and LTBI among Khorramabad nomads [28]. The prevalence of LTBI was found to be 0.44% in children, 3.37% in adolescents, and 43.81% in adults [22].

In the present investigation, a 2.19-fold higher susceptibility to a positive tuberculin test was observed in males compared to females, consistent with the findings from the Kermanshah study [29]. Conversely, the investigation conducted in Tehran failed to establish a significant association between gender and tuberculosis (TB) infection [30]. The heightened incidence of TB infection among males can be attributed to a complex interplay of determinants. Biological dissimilarities, including hormonal fluctuations, immune responses, and gender-specific occupational contexts contribute to this observed disparity. Furthermore, broader socio-cultural influences also play a role. Inadequate emphasis on preventive measures targeted towards males, coupled with behaviors such as tobacco and alcohol usage, serves to exacerbate this epidemiological trend. The outcome disparity observed in the Tehran study may potentially arise from factors including sample size limitations, subject heterogeneity, inaccuracies in measurements, and unaccounted for confounding variables [22,23,29].

Regarding hospital departments, this study revealed that the ICU, General, and Obstetrics and Gynecology departments had a higher number of positive TST cases compared to other departments. A systematic review study identified higher TB transmission risks among HCWs in various settings, including inpatient centers of TB patients, laboratories, internal medicine departments, emergency centers, and among radiology technicians, patient attendants, nurses, paramedics, and clinical staff [23]. In Hamedan, the rate of Mycobacterium tuberculosis infection was 54.27% among medical personnel compared to 32.17% among administrative personnel, with more than 6 months of experience in infectious departments increasing the likelihood of a positive tuberculin skin test (TST) [31]. The Tehran study revealed that infection rates among medical personnel were 2–5 times higher than in the general population and correlated significantly with employment duration [32]. A study in Morocco found that working in the pulmonary department increased the risk of a positive TST approximately fourfold [33]. Healthcare personnel, overall, face a higher risk of TB, with rates reported to be 3 to 6 times higher compared to the general population [34,35]. It is worth noting that administrative personnel also face a significant risk of infection, as evidenced by a study showing a twofold higher prevalence of LTBI among TB laboratory personnel in Iran compared to medical personnel in less hazardous departments [36].

We found the odds of positive TST were 2.06 times higher in individuals with a history of contact with TB patients compared to others. A study conducted in 2020 among Indonesian medical personnel showed that those with more than 5 years of experience had a 4-fold increased risk of LTBI compared to those with less experience [37]. Another study in South Africa found a high annual rate of TB infection among HCWs, which was significantly higher than among non- HCWs in the same population. Factors associated with the annual changes in TB infection included working with TB patients, counseling tubercular patients, and having an initial positive TST [38].

This study did not find any statistically significant changes in the results of the tuberculin test after one year based on age, gender, contact history, department type, work history, scar, or history of BCG vaccine. In a study conducted in South Africa, the annual test-specific conversion rate, TST 38%; QuantiFERON-TB Gold-In-Tube 13–22%; and T-SPOT.TB 18–22%. Annual reversion rates were 4, 7, and 16%, respectively. Factors associated with conversion (any test) included the healthcare sector of employment, counseling of TB patients, and a baseline positive TST [37]. The presence of scars and a history of BCG vaccination showed no significant correlation with the size of the TST in this study, aligning with the findings of previous studies conducted in Hamadan, Urmia, and Kermanshah [31,39].

The observed disparity in the conversion rate could be attributed to the specific conditions related to the COVID-19 pandemic throughout the one-year study duration. It is noteworthy that during the study period, participants were also at risk of COVID-19, and mandatory mask usage was implemented, potentially reducing the risk of TB transmission. This study emphasizes the significance of compulsory mask use among medical personnel and individuals in contact with TB patients, underscoring the need to reevaluate and reinforce the importance of masks in preventing TB transmission.

## 5. Conclusion

Male HCWs are at a significantly higher risk of TB infection compared to their female counterparts. Although employment duration may have some influence on the level of TB exposure, our study revealed that age plays a more crucial role in TB infection. Furthermore, the specific department and occupational category within the healthcare setting demonstrated a substantial correlation with the risk of TB infection, emphasizing the need for targeted preventive measures, particularly in high-risk departments and occupations such as nursing assistants. Over the course of a year, spanning the duration of the COVID-19 pandemic, there were no reported cases of TB bacillus infection, possibly attributed to the adoption of preventative measures, notably the consistent utilization of masks among the personnel, resulting in a conversion rate of zero. This finding is noteworthy considering the reduced hospitalization of TB patients and diminished direct contact with infectious individuals during the pandemic period. Implementing preventive measures is crucial for protecting HCWs from TB transmission.

Hospital cleaning staff encountered tuberculosis bacillus at comparable or higher rates than medical personnel. Hospital administrators should prioritize educational programs for cleaning staff, emphasizing care and prevention. Notably, work experience and age warrant attention as TB risk factors in specialized care units.

Preventive measures, like mask use, local exhaust ventilation, UV germicidal rays, general ventilation, Control of airflow patterns in rooms, Monitoring negative pressure, Air-cleaning methods, Negative pressure isolation room, and Personal Protection regular TST, and latent tuberculosis infection treatment, are recommended for high-risk personnel. Commencing professional engagements with TST and periodic retesting aids early TB detection and effective prophylaxis [40–42].

## 6. Limitations and benefits

The spread of coronavirus during the implementation of this project, along with the presence of COVID-19 patients in the hospital where the research was conducted, and the utilization of masks and social distancing both within the hospital and the community, as well as varying levels of exposure within the hospital, may have influenced thee study results. This was acknowledged as one of the limitations of the study.

The constrained sample size resulting from limited enrollment and sampling opportunities constituted a notable limitation in this study. Nonetheless, we posit that the absence of selection bias is plausible, considering the proportional distribution of sampling across subgroups.

Another constraint of this study pertains to the utilization of the TST as a means to assess LTBI.

Conversely, studying the hospital population, particularly during the COVID-19 epidemic, and observing high compliance with preventive measures among individuals and personnel, can be viewed as an opportunity to evaluate the spread and containment of a respiratory disease.

## Author contribution statement

Mojgan Sehat: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Reza Razzaghi; Mark Ghamsary; Monireh FaghirGanji: Analyzed and interpreted the data. Wrote the paper.

Mojtaba Sehat: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

## Data availability statement

Data will be made available on request.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Abbreviations

| | |
|---|---|
| TB | Tuberculosis |
| TST | Tuberculin Skin Test |
| IGRA | Interferon-gamma release assays |
| NTM | Nontuberculous Mycobacteria |
| WHO | World Health Organization |
| LTBI | latent tuberculosis infection |
| HCWs | Health care workers |
| BCG | Bacillus Calmette-Guérin |
| NTM | Nontuberculous Mycobacteria |

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e20560.

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