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# Disparities in tuberculosis diagnostic delays between native and migrant populations in Italy: A multicenter study

Francesco Di Gennaro[1,#], Sergio Cotugno[1,#,*], Giacomo Guido[1], Francesco Cavallin[2], Mariantonietta Pisaturo[3], Lorenzo Onorato[3], Federica Zimmerhofer[4], Luca Pipitò[4], Giuseppina De Iaco[1], Giuseppe Bruno[5], Massimo Fasano[6], Agostina Pontarelli[7], Annarita Botta[7], Tiziana Iacovazzi[6], Rossana Lattanzio[1], Virginia Di Bari[8], Gianfranco Panico[9], Raffaella Libertone[8], Caterina Monari[3], Alessia Musto[10], Mariangela Niglio[11], Federica De Gregorio[11], Loredana Alessio[3], Gina Gualano[8], Salvatore Minniti[10], Giovanni Battista Buccoliero[5], Teresa Santantonio[11], Sergio Lo Caputo[11], Sergio Carbonara[9], Antonio Cascio[4], Roberto Parrella[7], Fabrizio Palmieri[8], Nicola Coppola[3], TB Delay Working Group[1,9,11,12], Annalisa Saracino[1]

[1] *Department of Precision and Regenerative Medicine and Jonian Area (DiMePreJ), Clinic of Infectious Diseases, University of Bari Aldo Moro, Bari, BA, Italy*
[2] *Independent Statistician, Solagna, Italy*
[3] *Department of Mental Health and Public Medicine, Section of Infectious Diseases, University of Campania Luigi Vanvitelli, Naples, Italy*
[4] *Department of Health Promotion, Mother and Child Care, Internal Medicine and Medical Specialties "G D'Alessandro", Infectious and Tropical Disease Unit, University of Palermo, Palermo, Italy*
[5] *Infectious Disease Department, Saint Giuseppe Moscati Hospital, Taranto, TA, Italy*
[6] *UOC Malattie Infettive, ASL BA, PO Della Murgia "Fabio Perinei", Altamura, BA, Italy*
[7] *Respiratory Infectious Disease Unit, AORN dei Colli, Cotugno Hospital, Naples, NA, Italy*
[8] *Respiratory Infectious Diseases Unit, National Institute for Infectious Diseases Lazzaro Spallanzani-IRCCS, Rome, RM, Italy*
[9] *UOC Malattie Infettive, Ospedale Vittorio Emanuele II, ASL BT, Bisceglie, BT, Italy*
[10] *UOC Malattie Infettive, Ospedale Antonio Perrino, Brindisi, BR, Italy*
[11] *Department of Medical and Surgical Sciences, Infectious Diseases Unit, University of Foggia, Foggia, FG, Italy*
[12] *Microbiology and Virology Unit, University of Bari, University Hospital Policlinico, Bari, Italy*

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ABSTRACT

*Background:* Tuberculosis (TB) remains a Global Health challenge, with diagnostic delays contributing significantly to its spread. This study investigates the differences in diagnostic delays between native and migrant TB patients in Italy, examining patient-related diagnostic delay (PDD), health system-related diagnostic delay (HDD), and total diagnostic delay (TDD).

*Methods:* We conducted a retrospective, multicenter, cross-sectional study of TB cases in 10 Italian hospitals from 2018 to 2023. We compared PDD, HDD, and TDD between native and migrant populations. Socio-demographic data and clinical histories were analyzed to identify factors contributing to diagnostic delays.

*Results:* We included 669 TB patients (390 migrants and 279 natives). Migrants experienced significantly longer PDD (median 90 vs 10 days, $P < 0.0001$) but shorter HDD (median 5 vs 40 days, $P < 0.0001$) compared to natives, resulting in a longer TDD (median 96 vs 65 days, $P < 0.0001$). Furthermore, migrants had higher Timika scores, longer sputum conversion times, and were more frequently lost to follow-up.

*Conclusion:* Migrants face longer PDD, emphasizing substantial barriers to healthcare access. Natives experience longer HDD, reflecting neglect of TB in low-endemic regions. Future research should focus on

* Corresponding author: Sergio Cotugno, Department of Precision and Regenerative Medicine and Jonian Area (DiMePreJ), Clinic of Infectious Diseases, University of Bari Aldo Moro, Piazza Giulio Cesare 11, Bari 70124, Italy.
*E-mail address:* sergio.cotugno@gmail.com (S. Cotugno).
# Equally contributed.

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the impact of social determinants and training for healthcare providers on TB diagnosis and develop strategies to reduce diagnostic delays.



## Introduction

For centuries, tuberculosis (TB) has posed a significant global health challenge due to its widespread and persistent presence. The subacute and chronic nature of TB facilitates its spread within communities, as infected individuals often continue their daily activities without seeking medical attention. Diagnostic delay is a critical factor in the fight against TB and may be a major contributor to the TB pandemic [1]. Social and cultural factors play a significant role in enhancing diagnostic delays. Low income often leads to overcrowded living conditions with poor air circulation, allowing *Mycobacterium tuberculosis* bacilli to persist indoors. Moreover, low income is frequently associated with social marginalization, creating barriers to accessing healthcare. Consequently, those most affected by TB are often excluded from healthcare services [2].

Migrants are a prominent social group within the low-income population. Displacement from their social context and limited resources from their countries of origin increase their risk of poverty and social vulnerability [3]. Additionally, migrants often come from high TB burden countries and have a higher premigration risk of TB exposure compared to the host population [1]. These factors make migrants a target population in TB control efforts [1].

In low-endemic countries like Italy, another factor influencing diagnostic delays is the perception of TB risk. According to the latest WHO TB Report, the incidence of TB in Italy is 4.6 for 100,000 people [5]. Still, the migrant population is disproportionately more affected and represents almost 60% of total cases notified in Italy [6]. Furthermore, data suggest that migrants more promptly require hospitalization [7]. For this reason, native Italians are often perceived as being at low risk, while migrants are generally considered at risk for TB. TB is commonly viewed as an exotic and outdated disease, not posing a significant threat to the general population [8]. This perception can lead to healthcare workers deprioritizing TB in differential diagnoses, even when symptoms are indicative [8]. Recognizing these factors, the WHO has refined the definition of diagnostic delay, differentiating between patient-related diagnostic delay (PDD) and health system-related diagnostic delay (HDD). PDD refers to the time between symptom onset and the patient's first medical consultation, while HDD refers to the time between the initial medical visit and the commencement of antitubercular treatment (ATT) [9]. The total diagnostic delay (TDD) encompasses both PDD and HDD, providing a comprehensive measure that requires multifaceted evaluation to understand various aspects of TB.

This study aims to compare TB diagnostic delays between migrant and native patients in Italy, with the goal of improving case detection and management for these two groups.

## Materials and methods

### *Study design*

This was a retrospective, multicenter, cross-sectional study on the diagnostic delay of migrant and native patients with TB in Italy from 2018 to 2023. The study was approved by the local Ethics Committee (number 9128, November 21, 2023), which waived the need for written consent from the patients given the retrospective design and the use of anonymized data.

### *Subjects*

All migrant and native patients who were diagnosed with TB in the participating centers between 2018 and 2023 were eligible for inclusion in the study. Only patients aged 18 and older were included. Both hospital and outpatient clinic settings were considered. The diagnosis of TB was made according to one of the following criteria: (1) microbiological confirmation through microscopy, culture, or molecular test; (2) TB-associated histological finding on biopsy; (3) clinical and radiological suspicion without microbiological confirmation. Patients with unavailable information on the diagnostic delay were excluded.

### *Study setting*

The study was conducted in the Infectious and Tropical Disease Unit of 10 hospitals in Middle and Southern Italy. The participating centers were: "Azienda Ospedaliero-Universitaria Consorziale Policlinico di Bari" in Bari; "Ospedale Vittorio Emanuele II" in Bisceglie, Bari; "Ospedale della Murgia Fabio Perinei" in Altamura, Bari; "Ospedale Cotugno—Azienda Ospedaliera dei Colli" and "Azienda Ospedaliera Universitaria Vanvitelli" in Napoli; "Ospedali Riuniti" in Palermo; "Ospedali Riuniti" in Foggia; "INMI Lazzaro Spallanzani" IRCCS in Roma; "Ospedale Santissima Annunziata" in Taranto; "Ospedale Perrino" in Brindisi. These hospitals operate in four of the 10 most populated Italian Regions which host about 27% of migrants being resident in the country [10]. This figure underestimates the real situation due to the high presence of *sans-papier(undocumented migrants)* and migrants with no registration in the Italian National Registry, which predisposes them to higher risk of social marginalization [11]. Moreover, about 28% of families with at least one migrant component live under poverty, which is about fourth times the percentage among native families [12]. In Italy, the access to the Health System is guaranteed free of charge and without Health Insurance in case of acute conditions. Some Regions provide legal forms of registration for undocumented migrants. The postacute and outpatient access for specific conditions such as TB is provided for free for the main diagnostic procedures and visits required for TB work-up. Although private Health facilities are allowed to provide infectious diseases consultations in Italy, TB is mostly managed in public hospitals. Our study included the most important Referral Hospitals of Apulia, Campania, Lazio, and Sicily, hence, they served almost the whole TB population in their territories. Such background highlights the importance of investigating TB outcomes in migrants and natives in this setting.

### *Endpoints*

***E***ndpoints were the PDD, the HDD, and the TDD. PDD was defined as the time interval from the onset of symptoms to the access to the health care service. HDD was defined as the time interval from the access to the health care service to the start of ATT. TDD was defined as the time interval from the onset of symptoms to the ATT initiation.

*Data collection*

All data were extracted from the hospital charts, the documentation acquired during the visits, or the medical history collection made by clinicians, and collected in an anonymized database for the analysis. Data collection included demographics and clinical characteristics, WHO region of migrant patients, information on the delays, clinical characteristics and medical history, radiological findings (Timika score), microbiological data, length of hospital stay, discharge information, and outcome. Timika score is an internationally recognized imaging score that evaluates the grade of pulmonary involvement in some conditions [13]. Adverse events (AEs) included hepatitis, gastrointestinal issues, cutaneous reactions, neuropathy, visual impairment, hearing impairment, renal failure, multiple symptoms, QT prolongation, and generalized malaise. The grade of AEs was defined as mild (minimal alteration of laboratory data with patient asymptomatic or presenting minor signs/symptoms requiring no medical intervention), moderate (presence of signs/symptoms requiring noninvasive medical intervention), or severe (significant symptoms requiring hospitalization). Patients have been included in the migrant population based on this definition: any individual born outside of the country where the study was conducted or any second-generation individual.

*Statistical analysis*

Numerical data were summarized as median and interquartile range (IQR), while categorical data as absolute and relative frequency (percentage). Data were compared between migrant and native patients using Mann–Whitney test (continuous data) and Fisher's test or Chi-square test (categorical data). Trends over time for the delays and the difference in delays between migrant and native patients were assessed using linear regression models including the time (year of diagnosis from 2018 to 2023), the group (migrant vs native patients), and the interaction term time × group. The probability of migrant and native patients being diagnosed at different time intervals was calculated using Kaplan–Meier survival curves and compared using the log-rank test. All tests were 2-sided and a *P*-value <0.05 was considered statistically significant. Statistical analysis was carried out using R 4.3 (R Foundation for Statistical Computing, Vienna, Austria) [14].

## Results

*Demographics and clinical characteristics*

We evaluated for inclusion all 674 TB cases diagnosed between 2018 and 2023. After excluding five subjects due to unclear information about the delay, 669 subjects (497 males and 172 females; median age 40 years, IQR 25-60) including 390 migrants (58.3%) and 279 native patients (41.7%) were analyzed. Most TB were microbiologically confirmed TB (529/669, 79.1%), while one-fifth (140/669, 20.9%) were presumptive TB. Positive sputum smear was found in 122 out of 390 migrants (31.3%) and 98 out of 279 natives (35.1%) ($P = 0.34$).

Demographics and clinical characteristics are summarized in Table 1. Extrapulmonary TB was more frequently diagnosed in migrant patients compared to native patients (18.9% vs 9.6%, $P = 0.001$). Overall, the proportion of migrant and native patients did not change over time ($P = 0.51$). Migrant patients were younger ($P < 0.0001$) and included a higher proportion of males ($P = 0.02$) and underweight subjects ($P = 0.003$) compared to native patients. Employment status and higher educational levels were more common among native patients ($P < 0.0001$). Alcohol consumption was more common among migrant patients ($P = 0.04$), while smoking were more common among native patients ($P = 0.002$). HIV infection was more frequent among migrant patients ($P < 0.05$), whereas hypertension, COPD/bronchiectasis, and cancer were more frequent among native patients ($P < 0.05$). Migrant patients more frequently reported symptoms such as fever, weight loss, and dyspnea ($P < 0.05$), while native patients more frequently reported night sweats and chronic cough ($P < 0.0001$).

*Patient delay, health system delay, and total delay*

Table 2 summarizes PDD, HDD delay, and TDD. Compared to native patients, migrant patients had longer PDD (median 90 vs 10 days, $P < 0.0001$) but a shorter HDD (median 5 vs 40 days, $P < 0.0001$), resulting in an overall longer TDD (median 96 vs 65 days, $P < 0.0001$) (Table 2).

The curves of the delays in migrant and native patients are displayed in Figure 1. The probability of accessing the health system within 28 days from symptom onset was 25% in migrant patients and 84% in native patients. The probability of being diagnosed within 28 days after accessing the health system was 86% in migrant patients and 39% in native patients. The probability of being diagnosed within 28 days since symptom onset was 16% in migrant patients and 25% in native patients. Overall, it took up to 372 days from symptom onset for 90% of migrant patients with TB to be diagnosed, compared to 190 days for 90% of native patients.

The delays did not show any significant trend over time (PD $P = 0.19$, HDD $P = 0.70$; total delay $P = 0.14$), as well as the difference in delays between migrant and native patients (patient delay $P = 0.55$, health system delay $P = 0.95$; total delay $P = 0.75$). The curves of the delays in migrant and native patients stratified by year are displayed in Supplementary Figures 1 and 2.

Among migrant patients, the delay curves did not differ significantly by WHO Region (Supplementary Table 1). The delay curves in migrant TB patients by WHO Region are displayed in Supplementary Figure 3.

*Disease severity and outcome*

Disease severity and outcome are summarized in Table 3. At diagnosis, migrant patients had higher Timika score and longer time to sputum conversion compared to native patients ($P < 0.0001$). Drug resistance was more common among migrant patients ($P = 0.0002$). The occurrence of AEs was comparable between migrant and native patients ($P = 0.24$), but the severity of the AEs was different ($P = 0.02$). Migrant patients experienced longer length of hospital stay and were more frequently delayed in discharge due to social reasons ($P < 0.0001$). These social reasons included homelessness, delayed admission to postacute care, impossibility of isolation, or other reasons. The outcome was different between the two groups ($P < 0.0001$): a large proportion of migrant patients were lost to follow-up (38.4%), while most native patients completed the treatment (86.7%). Among migrants, the median PDD was 90 days (IQR 25-200) for those who completed the treatment and 90 days (IQR 30-180) in those who were lost to follow-up ($P = 0.64$). Similarly, the median TDD was 96 days (IQR 34-205) for those who completed the treatment and 97 days (IQR 46-202) in those who were lost to follow-up ($P = 0.92$).

## Discussion

The diagnostic delay in TB patients provides critical insights into the disparities between native and migrant populations. Each aspect of this parameter (PDD, HDD, TDD) offers valuable information for understanding both Migration Medicine and TB.

Our study observed a longer TDD among migrants, which could be related to different aspects of the quality of access to the

**Table 1**
Demographics and clinical characteristics of migrant and native TB patients who were diagnosed in 2018-2023.

| | Migrant patients ($n$ = 390) | Native patients ($n$ = 279) | $P$-value |
|---|---|---|---|
| WHO region: | | - | - |
| African Region (AFR) | 163 (41.8) | | |
| Region of the Americas (AMR) | 9 (2.3) | | |
| South-Eastern Asian Region (SEAR) | 50 (12.8) | | |
| European Region (EUR) | 98 (25.1) | | |
| Eastern Mediterranean Region (EMR) | 63 (16.2) | | |
| Western Pacific Region (WPR) | 7 (1.8) | | |
| Year of diagnosis: | | | 0.51 |
| 2018 | 63 (16.2) | 43 (15.4) | |
| 2019 | 59 (15.1) | 49 (17.6) | |
| 2020 | 26 (6.7) | 26 (9.3) | |
| 2021 | 60 (15.4) | 45 (16.1) | |
| 2022 | 70 (17.9) | 52 (18.6) | |
| 2023 | 112 (28.7) | 64 (23.0) | |
| Age, years (median) | 30 (22-44) | 58 (39-72) | <0.0001 |
| Males | 303 (77.7) | 194 (69.5) | 0.02 |
| BMI: | | | 0.003 |
| Underweight | 173/357 (48.4) | 102/255 (40.0) | |
| Normal weight | 172/357 (48.2) | 129/255 (50.6) | |
| Overweight/obese | 12/357 (3.4) | 24/255 (9.4) | |
| Worker: | 105 (26.9) | 192 (68.8) | <0.0001 |
| Educational level: | | | <0.0001 |
| None | 42 (10.8) | 6 (2.1) | |
| Primary school | 124 (31.8) | 98 (35.1) | |
| Secondary school | 26 (6.7) | 105 (37.6) | |
| University | 2 (0.5) | 13 (4.6) | |
| Not declared | 196 (50.2) | 57 (20.4) | |
| Smoking habits | 77 (19.7) | 86 (30.8) | 0.002 |
| Alcohol drinking | 36 (9.2) | 13 (4.7) | 0.04 |
| Diabetes | 54 (13.8) | 48 (17.2) | 0.28 |
| Hypertension | 27 (6.9) | 69 (24.7) | <0.0001 |
| COPD/bronchiectasis | 6 (1.5) | 43 (15.4) | <0.0001 |
| Chronic renal disease | 9 (2.3) | 15 (5.4) | 0.06 |
| Liver disease | 17 (4.4) | 12 (4.3) | 0.99 |
| PLHIV | 14 (3.6) | 1 (0.4) | 0.01 |
| Cancer | 1 (0.3) | 11 (3.9) | 0.001 |
| Previous TB | 14 (3.6) | 5 (1.8) | 0.25 |
| Cough | 189 (48.5) | 142 (50.9) | 0.59 |
| Chronic cough (at least 8 weeks) | 62 (15.9) | 139 (49.8) | <0.0001 |
| Fever | 122 (31.3) | 47 (16.8) | <0.0001 |
| Weight loss | 122 (31.3) | 32 (11.5) | <0.0001 |
| Night sweats | 25 (6.4) | 46 (16.5) | <0.0001 |
| Chest pain | 72 (18.5) | 47 (16.8) | 0.66 |
| Dyspnea | 49 (12.6) | 19 (6.8) | 0.02 |
| Hemoptysis | 42 (10.8) | 18 (6.4) | 0.07 |
| Diagnosis: | | | 0.20 |
| Presumptive TB | 81 (20.8) | 49 (17.6) | |
| Histological | 8 (2.1) | 2 (0.7) | |
| Confirmed TB | 301 (77.2) | 228 (81.7) | |
| Positive sputum smear | 122 (31.3) | 98 (35.1) | 0.34 |
| Pulmonary TB | 318 (81.1) | 255 (90.4) | 0.001 |
| Extrapulmonary TB | 74 (18.9) | 27 (9.6) | |

Data summarized as $n$ (%) or median (IQR).
BMI, Body mass index; PLHIV, People living with HIV.

**Table 2**
Patient delay, health system delay, and total delay in migrant and native TB patients who were diagnosed from 2018 to 2023.

| | Migrant patients ($n$ = 390) | Native patients ($n$ = 279) | $P$-value |
|---|---|---|---|
| Patient diagnostic delay, days | 90 (30-198) | 10 (5-18) | <0.0001 |
| Health system diagnostic delay, days | 5 (2-15) | 40 (11-90) | <0.0001 |
| Total diagnostic delay, days | 96 (39-202) | 65 (29-108) | <0.0001 |

Data summarized as median (IQR).

healthcare system for foreign-born patients. Many studies have highlighted the association between migration status and barriers to healthcare, driven by nonmedical factors such as language, cultural beliefs, low income, and fear of legal authorities [15,16]. These barriers result in significant PDD. In our study, such delay was ninefold longer for migrants compared to natives, suggesting that the Italian healthcare system struggles to offer easy access for the most vulnerable populations [17]. This finding aligns with Peri et al. [18], who noted that migrants living in Italy for less than 5 years faced longer PDD.

In contrast, HDD were eight times longer for natives. This suggests that healthcare providers in low TB burden countries might often overlook TB in their differential diagnoses, even when symptoms are indicative [8,18]. This might be related to the miscon-

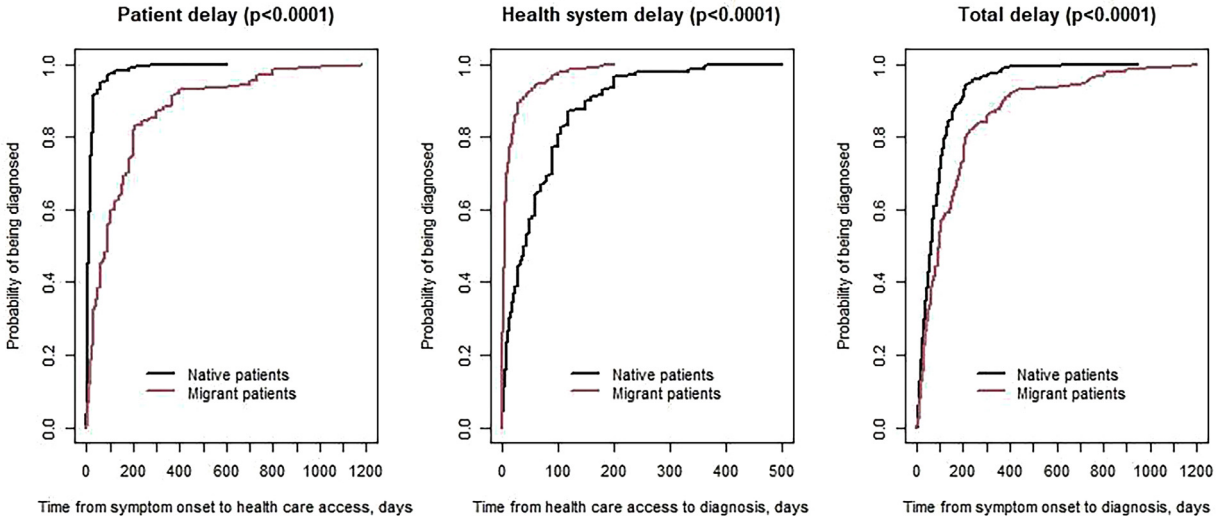


**Figure 1.** Curves of patient delay, health system delay, and total delay in migrant and native TB patients who were diagnosed from 2018 to 2023.

**Table 3**
Disease severity and outcome in migrant and native TB patients who were diagnosed from 2018 to 2023.

| | Migrant patients ($n$ = 390) | Native patients ($n$ = 279) | $P$-value |
|---|---|---|---|
| Timika score[a] | 80 (40-100) | 40 (40-80) | <0.0001 |
| Pansusceptible TB | 319/383 (82.3) | 259/276 (93.8) | 0.0002 |
| Single drug resistance | 54/383 (14.1) | 14/276 (5.1) | |
| Multidrug resistance | 10/383 (2.6) | 3/276 (1.1) | |
| Adverse events | 124 (31.8) | 76 (27.2) | 0.24 |
| Time of sputum conversion[b] | 24 (14-110) | 14 (14-22) | <0.0001 |
| Severity of the adverse events: | | | 0.02 |
| Mild | 25 (20.2) | 7 (9.2) | |
| Moderate | 58 (46.8) | 50 (65.8) | |
| Severe | 41 (33.1) | 19 (25.0) | |
| Length of hospital stay, days[c] | 36 (22-66) | 21 (14-32) | <0.0001 |
| Late discharged due to social reasons | 212 (54.4) | 17 (6.1) | <0.0001 |
| Outcome: | | | <0.0001 |
| Dead | 7 (1.8) | 5 (1.8) | |
| Complete treatment | 182 (46.7) | 242 (86.7) | |
| Lost to follow-up | 150 (38.4) | 5 (1.8) | |
| Under treatment or transferred | 51 (13.1) | 27 (9.7) | |

Data summarized as $n$ (%) or median (IQR). Data not available in [a]110, [b]159 and [c]49 patients. Adverse events included: hepatitis ($n$ = 128), gastrointestinal ($n$ = 13), cutaneous ($n$ = 18), neuropathy ($n$ = 6), visual impairment ($n$ = 5), hearing impairment ($n$ = 2), renal failure ($n$ = 7), more than one symptom ($n$ = 11), QT prolongation ($n$ = 7) and generalized malaise ($n$ = 3). Social reasons included lack of home, delayed admission to postacute care, impossibility of isolation, or other reasons. Adverse events were classified as mild (minimal alteration of laboratory data with patient asymptomatic or presenting minor signs/symptoms requiring no medical intervention), moderate (presence of signs/symptoms requiring noninvasive medical intervention), or severe (significant symptoms requiring hospitalization).

ception of TB as an outdated or exotic disease in regions with high-quality healthcare systems [8]. Authors also reported shorter HDD among migrants, which aligns with our findings [19]. Interestingly, Pezzotti et al. [20] found lower PDD and TDD in migrants compared to natives, hypothesizing that individuals from high TB burden countries might have greater awareness of TB symptoms due to previous personal and familial experiences. Nonetheless, the heterogeneity of the results on TB outcomes in migrants between different Italian studies could depend on the nonuniformity of rule and bureaucracy for the access to Health System for migrants through the different Italian regions. This feature of the Italian Health System leads to diagnostic delay and worse outcomes for non-native population [21].

Our study supports the role of social determinants and health system preparedness in shaping diagnostic delays. Migrants were more likely to be unemployed, consume alcohol, and be underweight, all of which are identified as specific TB risk factors in the literature [21,22]. In addition, several authors confirmed the strong correlation between PDD and social frailty such as unemployment and low income [22] with reflection in worse outcomes and onset on MDR [23]. Additionally, the high proportion of unemployed migrants in our study favors a further comment concerning the demographic characteristics of foreign-born patients of our centers. In fact, we observed that our migrant population was mainly African, male, young, and unemployed. This might be related to an overrepresentation of young African men who moved to South Italy as agricultural migrant workers but still did not manage to find regular jobs [24]. Furthermore, the cities involved in our study have hosted a large number of African people moving to Europe in the last decades through the Mediterranean Sea [25]. Regarding medical history, native patients had a higher prevalence of conditions like COPD, bronchiectasis, and smoking habits, which often present with chronic cough and could confound the diagnosis of TB [26]. Chronic cough was more common among patients with longer HDD in our study, highlighting the need for better awareness among health operators about

TB in patients from nonendemic countries. The authors reported longer HDD among TB patients with previous treatment attempts, which may correlate with COPD exacerbations in our native patient group [18].

Our data revealed significant differences in clinical presentation between groups. Migrants exhibited a higher prevalence of fever, which typically prompts quicker medical attention. However, advanced disease indicators such as higher Timika scores, dyspnea, and longer sputum conversion times were more prevalent among migrants. These findings are consistent with studies reporting increased diagnostic delays and worse baseline radiographic findings among migrants, particularly during the COVID-19 pandemic [27,28]. For migrant patients, the delay in seeking medical care might lead to more advanced forms of disease, making the diagnosis more obvious and contributing to higher proportion of extrapulmonary disease. As observed in other studies, the association between diagnostic delay and advanced disease signs might have been stronger if a different cut-off for diagnostic delay had been used [28].

Communication barriers might explain the lower prevalence of night sweats among migrants, as accurate symptom reporting often requires proficient language skills. HIV co-infection was more frequent among migrants, consistent with European meta-analyses associating higher TB-HIV co-infection rates with migration from high-burden countries [29]. Despite the higher prevalence of HIV and MDR-TB among migrants, other causes of immunosuppression, such as cancer, were more common in natives, reflecting their older median age and different epidemiological profiles [30,31]. Despite the older age profile of the native population, which would typically increase the risk of AEs, our study found no statistically significant difference in AE risk between natives and migrants. This can likely be attributed to the younger age of migrants, which may counterbalance their higher disease severity. Thus, the risk of AEs in the native population, with higher age and pill burden but lower disease severity, was balanced out by the factors affecting the migrant group [32]. Conversely, migrant patients were more prone to discontinued treatment compared to native patients. We believe that this finding remarks the high risk of drop-out among migrants related to the precarious life condition and barriers that we previously discussed. Nonetheless, diagnostic delays were not different between migrants who completed the treatment and those who were lost to follow-up.

Our study highlighted significant disparities in diagnostic delays between natives and migrants. Only a quarter of migrants approached the health system within 28 days of symptom onset, compared to more than three-quarters of natives. Conversely, more than three-quarters of migrants and barely one-third of natives received a diagnosis within the subsequent 28 days. These findings underscore the urgent need to address diagnostic delays to improve TB outcomes for all patients, irrespective of migration status. The WHO recommends a 21-day cut-off for PDD, but no clear guidelines exist for HDD and TDD [11].

Additionally, the study identified social inequalities, with migrants experiencing longer hospital stays and increased discharge times due to social reasons. While disease severity may partially explain the extended hospital stays, the increased discharge times further illustrate the impact of social determinants on healthcare access, outcomes for migrant patients but also on the economic sustainability of healthcare systems.

Finally, we observed an increase in TB diagnosis in 2023 with an uprising rate since 2021. This might be interpreted as the rebound increase of COVID-19 medical crisis for its overcrowding effect on Health System and nonacute condition managements [6], but caution is needed in such interpretation. As the migrant arrivals to Italy and the access of migrant population to the Health System seemed to be more affected by international policy and social events, than from actual COVID-19 pandemics, accurate statements about this topic would require specifically designed studies.

Our study had some limitations. First, the observational design precluded any causal associations and limited the data quality. Furthermore, the PDD was calculated according to medical history collection due to the retrospective design of the study, hence misreporting by the patient should be considered. Second, the lack of social and financial indicators hindered a better profiling of the migrant patients. Third, some countries of origin were underrepresented in our sample, limiting the generalizability of our findings to other settings. Notably, our analysis did not include any adjusting for potential confounding because the study aimed to assess the diagnostic delays in two different profiles of TB patients (migrants and natives). Each profile works as a proxy of a heterogeneous combination of several characteristics, hence limiting the generalizability of the findings to similar profiles. Additionally, the small number of migrants from certain countries precluded a deeper investigation of diagnostic delays stratified according to the WHO Regions. Fourth, data concerning time of arrival in Italy was unavailable, so an important aspect of migration for the effect on social integration could not be assessed.

## Conclusion

Our study provides a comprehensive analysis of diagnostic delays in TB patients, highlighting significant disparities between native and migrant populations in Italy. Migrants face longer PDD, suggesting substantial barriers to healthcare access, such as language and socio-economic disadvantages. Conversely, natives experience longer HDD, implying potential neglect of TB in low-endemic regions. These findings underline the necessity for targeted interventions to improve TB detection and management among migrants, including enhanced social support and streamlined access to healthcare services, together with enforcing prompt screening at the entrance for migrants coming from high-burden TB countries. Additionally, increasing awareness and training among healthcare providers in low-endemic regions may play an important role to ensure timely diagnosis and treatment for all TB patients. Future research should identify the specific causes of diagnostic delay in migrant and native TB patients, in order to plan appropriate interventions to reduce such delay and improve TB outcomes for both native and migrant populations.

## Declarations 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 article.

## Ethical approval

The study was approved by the local Ethics Committee (number 9128, November 21, 2023).

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## Author contributions

1. The conception and design of the study: SC, FDG, G Gacquisition of data: GDI; RL; GP; FZ; MP; LP; GB; MF; AP; AB; TI; VDB; RL; CM; AM; MN; FDG; LA
2. Analysis and interpretation of data: FC; FDG; SC
3. Drafting the article: SC; GG
4. Revising it critically for important intellectual content: GG; GDI; TB Delay Working Group
5. Final approval of the version to be submitted: SeCa; SLC; TS; GBB; SM; GiGu; NC; FP; RP; AC; AS

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijid.2024.107279.

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