Impact of Early Chest Radiography on Delay in Pulmonary Tuberculosis Case Notification in Ethiopia

Hussen Mohammed1,2, Lemessa Oljira3, Kedir Teji Roba4, Esther Ngadaya3, Dagmawit Tesfaye1, Tsegahun Manyazewal2, Getnet Yimer1,4
1Department of Public Health, College of Medicine and Health Sciences, Dire Dawa University, Dire Dawa, 2Centre for Innovative Drug Development and Therapeutic Trials for Africa, College of Health Sciences, Addis Ababa University, 3Ohio State Global One Health Initiative, Office of International Affairs, The Ohio State University, Addis Ababa, 4Department of Public Health, School of Public Health, College of Health and Medical Sciences, Haramaya University, 5Department of Nursing, School of Nursing and Midwifery, College of Health and Medical Sciences, Haramaya University, Harar, Ethiopia, 6Muhimbili Research Centre, National Institute for Medical Research, Dares Saalem, Tanzania

Abstract

Background: One-third of tuberculosis (TB) cases are missed each year and delays in the diagnosis of TB are hampering the whole cascade of care. Early chest X-ray (CXR) in patients with cough irrespective of duration may reduce TB diagnostic and treatment delays and increase the number of TB patients put into TB care. We aimed to evaluate the impact of CXR on delay in the diagnosis of pulmonary tuberculosis (PTB) among people with cough of any duration. Methods: A facility-based cross-sectional study was conducted in four selected health facilities from two regions and two city administrations of Ethiopia. Patients who sought health care were screened for cough of any duration, and those with cough underwent CXR for PTB and their sputum specimens were tested for microbiological confirmation. Delays were followed up and calculated using median and inter-quartile range (IQR) to summarize (first onset of cough to first facility visit, ≥15 days), diagnosis delay (first facility visit to date of PTB diagnosis, >7 days), and total delay (first onset of cough to date of PTB diagnosis, >21 days). Results: A total of 309 PTB cases were consecutively diagnosed of 1853 presumptive TB cases recruited in the study that were identified from 2647 people who reported cough of any duration. The median (IQR) of patient delay, diagnosis delay, and the total delay was 30 (16–44), 1 (0–3), and 31 (19–48) days, respectively. Patients’ delay contributed a great role in the total delay, 201/209 (96.2%). Median diagnosis delay was higher among those that visited health center, diagnosed at a facility that had no Xpert mycobacterium tuberculosis (MTB)/RIF assay, radiologist, or CXR (P = 0.05). Factors associated with patients delay were history of previous TB treatment (adjusted prevalence ratio [aPR] = 0.79, 95% confidence interval [CI]: 0.63–0.99) and history of weight loss (aPR = 1.12; 95% CI: 1.0–1.25). Early CXR screening for cough of <2 weeks duration significantly reduced the patients’ delay and thus the total delay, but not diagnostic delay alone. Conclusion: Early screening using CXR minimized delays in the diagnosis of PTB among people with cough of any duration. Patients’ delay was largest and contributed great role in the delay of TB cases. Screening by cough of any duration and/or CXR among people seeking healthcare along with ensuring the availability of Xpert MTB/RIF assay and skilled human power at primary healthcare facilities are important to reduce patient and diagnostic delays of PTB in Ethiopia.

Keywords: Active case-finding, chest radiography, delay, diagnosis, Ethiopia, screening, tuberculosis, Xpert mycobacterium tuberculosis/ RIF assay, X-ray

Submitted: 17-Oct-2021 Revised: 28-Oct-2021

Introduction

One-third of tuberculosis (TB) cases are missed each year and delays in the diagnosis of TB are hampering the whole cascade of care. The emergence of severe forms of drug resistance and a slower decline of new cases revealed that expanding TB service coverage is not enough to end TB. In Ethiopia, the effectiveness of the national TB program (NTP) calls for an early case finding and treatment of TB and decentralize services to reach the communities at large; however, the program

Access this article online

Quick Response Code:

Website: www.ijmyco.org

DOI: 10.4103/ijmyco.ijmy_216_21

Address for correspondence: Hussen Mohammed, Department of Public Health, College of Medicine and Health Sciences, Dire Dawa University, Dire Dawa, Ethiopia. Centre for Innovative Drug Development and Therapeutic Trials for Africa, College of Health and Medical Sciences, Addis Ababa University. PO Box 1362, Dire Dawa, Ethiopia. E-mail: hus.allya@gmail.com

ORCID:
Hussen Mohammed: http://orcid.org/0000-0003-0625-627X

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPmedknow_reprints@wolterskluwer.com

How to cite this article: Mohammed H, Oljira L, Roba KT, Ngadaya E, Tesfaye D, Manyazewal T, et al. Impact of early chest radiography on delay in pulmonary tuberculosis case notification in Ethiopia. Int J Mycobacteriol 2021;10:364-72.
focusing on passive case-finding that potentially misses many cases to diagnose. A third of TB cases have been missed in Ethiopia and a couple of undiagnosed TB cases are identified in the community that hiddenly transmit the disease.

Realizing early TB case finding and treatment requires, individual’s healthcare-seeking behavior, access to quality diagnostics, and a vigilant healthcare workforce. However, previous studies in Ethiopia reported low healthcare-seeking behavior among presumptive TB cases, poor quality of TB diagnosis and care, and delayed diagnosis and treatment of TB. The use of chest X-ray (CXR) in reducing diagnostic delay in Ethiopia has not been studied well, while available evidence shows variation based on the availability of CXR and other microbiological tools in a facility.

Delay in the diagnosis and treatment of TB cases has several consequences; it leads patients to serious morbidity and death, overburdens healthcare facilities to manage severe cases, and increases disease transmission in the community. The problem is higher in resource-constrained high burden countries as it has an association with the overall burden of TB in a given country and its capacity to early diagnose and treat cases.

For the past 10 years, high burden countries have been implementing TB screening to fill in case detection gaps and reduce diagnostic delays and Ethiopia has been in the loop. Delay in the diagnosis of TB endured obstacles in Ethiopia and health facility-driven delays were frequent among smear-negative, first sought health care, and among rural. A previous study showed that many patients visited several health facilities up to four rounds with a median of two before getting their final TB diagnosis and there have been many challenges that contribute to the low case-finding status of the country. However, evidence and recommendations on how to mitigate the delays are limited. Evidence of how to controlling missed opportunities through active case finding and the early use of CXR is also limited. Some studies reported a reduction in diagnosis delay due to screening of everyone for TB regardless of the duration of cough.

Therefore, this study aimed to evaluate the impact of CXR on delay in the diagnosis of pulmonary tuberculosis (PTB) among people with cough of any duration.

**Methods**

**Study settings and participants**

Health facility-based cross-sectional study was performed in four health facilities that were selected from two national regional states (Oromia and Harari) and two city administrations (Addis Ababa and Dire Dawa) [Figure 1]. These facilities were randomly selected from respective stratified settings by urban and rural. In summary, Chelenko Primary Hospital was from Oromia National Regional State, Hiwot Fina Specialized University Hospital from Harari Regional State, and Zewditu Memorial Hospital and Melka Jebdu Health Center from Addis Ababa and Dire Dawa city administration, respectively. Hiwot Fina Specialized University Hospital and Zewditu Memorial Hospital were from an urban setting. Chelenko Primary Hospital and Melka Jebdu Health Center were from rural settings. A study was conducted from July 2019 to March 2020 and from August 2020 to December 2020. The study was interrupted because of COVID-19 pandemic from April 2020 to July, 2020.

Participants were patients who came to the health care facilities to sought health care at outpatients and those who visited the reproductive and child health units. The patients were screened for cough of any duration, and those with cough underwent CXR for PTB. For individuals such as pregnant women, diabetic patients, and anti-retroviral patients that could not undergo CXR, they were nonchest X-ray group and their screening followed that symptom screening for cough of any duration. Sputum specimens were tested for microbiological confirmation.

To calculate the sample size we made the following assumption: 95% confidence interval (CI), 5% margin of error, 72.3% proportion of total delay in nationwide study survey using single population formula, we calculated 309 PTB cases and included all PTB cases diagnosed from people screened by the cough of any duration and/or CXR at health facilities.

Measurements of delays:
- Patient delay was defined as the time between the first symptom (cough) to date of seeking health care, if ≥15 days, it was taken as patients’ delay
- Diagnostic delay was the interval between the first visits to the health facility to the date of diagnosis for PTB. Time >7 days was considered indicative of delay
- Total delay was defined as the total time interval (days) between the onset of a symptom (cough) related to PTB to date of diagnosis and if >21 days, it was taken as total delay

**Data collection**

A questionnaire was used to collect data by trained data collectors, controlling also recall biases. When patients visited study health facilities, they were screened and recruited immediately for those who fulfilled the eligibility criteria. The date of health facility visit, first dates of symptom (cough), and dates of diagnosis were captured using the study questionnaire. CXR and laboratory findings captured. The duration of delays for patients, diagnosis, and the total delay were calculated using these data.

**Chest X-ray and microbiological diagnosis**

Chest X-ray was offered for the participants. The participants were furthermore stratified by cough duration (<2 weeks and ≥2 weeks). Sputum specimens were collected and microbiological confirmation was performed among those with CXR results of TB suggestive for <2 weeks cough duration and those with CXR results of all types (normal, TB suggestive, and non-TB suggestive) for ≥2 weeks cough.
Figure 1: Map of study sites

Figure 2: Screening by cough of any duration and/or CXR among people sought health care and diagnosis work flow

CXR: Chest X-ray; TB: Tuberculosis; ART: Anti-retroviral therapy; AFB: Acid fast bacillus
A strong emphasis was given to keep the quality of CXR reading and CXRs were read by radiologists. For health centers that lack CXR machine, patients were transported to a nearby public healthcare facility with a CXR machine and the study covers the cost. Microbiological confirmation was as per the national TB guideline which was either Xpert mycobacterium tuberculosis (MTB)/RIF assay or acid-fast bacilli (AFB) microscopy[7] [Figure 2].

Data collection was followed up daily to ensure data quality. The principal investigator verified the data reported on the questionnaires by reviewing study participants’ source documents for completeness and accuracy. Data were stored in key-locked metal cabinets to keep the security.

**Data analysis**

Data was analyzed using Stata version 14.0 (StataCorp, College Station, Texas, USA). Data were summarized in frequencies and median depending on the type of study variables. Median and inter-quartile range (IQR) were used to summarize patient, diagnosis, and total delays among PTB cases. Nonparametric Mann–Whitney and Kruskal–Wallis tests were used for skewed delay data. Based on this, Mann–Whitney test was used to compare delays between two categories of an explanatory variable, and Kruskal–Wallis if a variable had three or more groups,[26] Prevalence ratios were the estimates used with 95% CIs for the modified Poisson regression model,[27] which was used to reveal factors associated with patient’s delay >15 days and total delay >21 days. Statistical significance was determined at \( P < 0.05 \).

**RESULTS**

**Socio-demographic characteristics**

A total of 309 pulmonary tuberculosis (PTB) cases were consecutively diagnosed of 1853 presumptive TB cases recruited in the study that were identified from 2647 people who reported cough of any duration at the study health facilities. Of 309 PTB cases, 163 (52.7%) were males, 176 (57%) married, and 105 (34%) peasant in occupation. The median (IQR) age of TB cases was 27 (20–35) years and with a range from 1 to 80 years. A third of TB cases were in the age group of 25–34 years, 97 (31.4%). Those that never attended education constituted 147 (47.6%) [Table 1]. The majority of TB patients visited at public institutions, 284 (92%). About 1 in 10 PTB cases had a history of previous TB treatment [Table 2].

**Patient delay**

The median (IQR) of patient delay was 30 (16–44) days, ranged from 1 day to 212 days. Of 298 PTB cases, those who visited health facilities to seek care for cough in recognized periods of two weeks were 57 (18.5%). The majority, 252 (81.6%) sought health care after ≥15 days. Median patient delays were higher among rural residents, those who visited hospitals, and were not treated for TB previously (Kruskal–Wallis or Mann–Whitney tests, \( P < 0.05 \)) [Table 2]. Of all, 252 (81.6%) patients’ delay (sought health care after ≥15 days), in which 178/252 (70.6%) delayed for 30 days or more without seeking health care. More than three out of four, 189/252 (83.6%) were from rural.

**Diagnostic delay**

Of all, 301 (97.4%), knew their diagnosis within 7 days (<7 days). The median (IQR) diagnosis delay was 1 (0–3) day, ranged 1–17 days. Following contact with a health care provider, notably, only 8 (2.6%) were diagnosed with diagnostic delay after 7 days (1 week). Zero-day was to mean same day, the difference between visit date and diagnosis completed date, among 86 (27.8%) diagnosis was completed on the same day. Median diagnosis delays were higher among those diagnosed at the facilities that were found at rural, those visited health centers, those diagnosed at the facility that had no Xpert, had no radiologist, or had no CXR (Kruskal–Wallis or Mann–Whitney tests, \( P < 0.05 \)) [Table 3].

**Table 1: Sociodemographic characteristics of pulmonary tuberculosis among people sought health care at health facilities in Ethiopia**

| Characteristics                | Frequency (%) |
|--------------------------------|---------------|
| Gender                         |               |
| Female                         | 146 (47.3)    |
| Male                           | 163 (52.7)    |
| Age groups                     |               |
| 0-14                           | 34 (11)       |
| 15-24                          | 81 (26.2)     |
| 25-34                          | 97 (31.4)     |
| 35-44                          | 51 (16.5)     |
| 45-54                          | 29 (9.4)      |
| ≥55                            | 17 (5.5)      |
| Marital status                 |               |
| Married                        | 176 (57.0)    |
| Single                         | 109 (35.3)    |
| Widowed                        | 13 (4.2)      |
| Divorced                       | 4 (1.3)       |
| Separated                      | 7 (2.3)       |
| Education level                |               |
| Never attended                 | 147 (47.6)    |
| Primary education              | 95 (30.7)     |
| Secondary education            | 40 (12.9)     |
| Tertiary education             | 12 (3.9)      |
| Vocational education           | 5 (1.6)       |
| Adult education                | 2 (0.7)       |
| Religious education            | 8 (2.6)       |
| Occupation                     |               |
| Peasant                        | 105 (34.0)    |
| Housewife                      | 59 (19.1)     |
| Employed                       | 31 (10.0)     |
| Business                       | 25 (8.1)      |
| Student                        | 49 (15.9)     |
| None                           | 28 (9.1)      |
| Not applicable                 | 12 (3.9)      |
The diagnostic delay was varied by health facilities and highest at the health center, 3 (2–4) days that had only smear microscopy. Delays were different by screening algorithms that diagnostic delay was higher among those who screened by symptom followed by chest X-ray (CXR) with cough <2 weeks duration compared with CXR group with cough ≥2 weeks or screened by symptom only but it reduced the patients’ delay significantly [Table 4].

**Total delay**
The median (IQR) of a total delay from the first onset of pulmonary illness (cough) to diagnosis (including patient and diagnostic delays) was 31 (19–48) days, ranged from 2 days to 212 days. Of the total delay longer than 21 days or 3 weeks, 209/309 (67.6%), the patients’ delay contributed 201/209 (96.2%). Patients, diagnostic, and total delay were lowest among antiretroviral treatment (ART) [Table 4].

**Factors associated with delays**
In multivariable analysis, two variables were found statistical significance related to patient and total delays. Those who had a history of previous anti-TB treatment were 21% less likely to delay more than 15 days to be diagnosed when compared with those who had none (adjusted prevalence ratio = 0.79, 95% CI: 0.63–0.99). Those who had a history of weight loss were 12% times more likely to be delayed when compared with those who had not (adjusted prevalence ratio =1.12; 95% CI: 1.0–1.25) [Table 5].

**DISCUSSION**
We found that the median patients’ delay, diagnostic delay, and total delay were 30, 1, and 31 days, respectively. Patients’ delay was longer in duration among rural patients when compared with urban counterparts and those who visited hospitals when compared with those who visited health center. The diagnostic delay was longer among those who visited a health center or primary hospital that were found at rural setting when compared with those who visited at referral hospitals that found at urban and among those screened by symptom followed by chest X-ray (CXR) with cough <2 weeks duration compared with CXR group with cough ≥2 weeks and screened by symptom only.

We found 252 (81.6%) PTB patients who sought health care in ≥15 days, in which more than three out of four, 83.6%, were from rural. The median patients’ delay of our current study was longer when compared with studies done in Ethiopia, at a national level that reported 21 days,[5] 17 days at Addis Ababa,[18] and 25 days in southwestern Ethiopia[24] but comparable with
Table 3: Diagnostic delay of pulmonary tuberculosis among people screened by cough of any duration and/or chest X-ray

| Characteristics | n (%) | Diagnostic delay (day), median (IQR) | P     |
|-----------------|-------|--------------------------------------|-------|
| Delays          | 309   | 1 (0-3)                              |       |
| Gender          |       |                                      |       |
| Female          | 146 (47.3) | 1 (0-2)                              | 0.7105|
| Male            | 163 (52.7) | 1 (0-3)                              |       |
| Residence       |       |                                      |       |
| Rural           | 226 (72.1) | 1 (0-3)                              | 0.6018|
| Urban           | 83 (26.9)  | 1 (0-3)                              |       |
| Facility location |     |                                      |       |
| Urban           | 168 (54.4) | 1 (0-2)                              | <0.0001|
| Rural           | 141 (45.6) | 2 (1-4)                              |       |
| Algorithms      |       |                                      |       |
| Non CXR group   | 14 (4.5%)  | 0 (0-1)                              | 0.0221|
| CXR group <2 weeks cough | 44 (14.2) | 2 (1-3.5)                            |       |
| CXR group ≥2 weeks cough | 251 (81.2) | 1 (0-2.5)                           |       |
| Sputum test results |     |                                      |       |
| Positive        | 185 (62.7) | 1 (0-2)                              | 0.0423|
| Negative        | 110 (37.3) | 2 (1-3)                              |       |
| Previous TB treatment |     |                                      |       |
| Yes             | 38 (12.3)  | 1.5 (0-3)                            | 0.8404|
| No              | 270 (87.7) | 1 (0-3)                              |       |
| Diagnosed at facilities had CXR |     |                                      |       |
| Yes             | 247 (88.7) | 1 (0-2)                              | 0.0001|
| No              | 35 (11.3)  | 3 (2-4)                              |       |
| Diagnosed at facilities had radiologist |     |                                      |       |
| Yes             | 168 (54.4) | 1 (0-2)                              | <0.0001|
| No              | 141 (45.6) | 2 (1-4)                              |       |
| Diagnosed at facilities had GeneXpert |     |                                      |       |
| Yes             | 247 (88.7) | 1 (0-2)                              | 0.0001|
| No              | 35 (11.3)  | 3 (2-4)                              |       |

IQR: Interquartile range, CXR: Chest X-ray, TB: Tuberculosis, PTB: Pulmonary tuberculosis

Mohammed, et al.: Impact of early CXR on delay of PTB in Ethiopia

Further, screening by cough of any duration among people who sought health care reduced diagnosis delay. In this study, the diagnosis delay due to deficiencies of the health system such as lack of CXR, radiologist for CXR reading, and the longer diagnostic pathways was tried to be reduced through, for the health center, without CXR, patients were transported to a public facility with chest X-ray, the costs for transportation, imaging, and CXR interpretation by a radiologist were covered by the research project through agreement entered with the public facility. In Ethiopia, GeneXpert, AFB smear, and ant-TB drugs have been free but CXR has not free.[31] As per NTP guideline, those with smear-negative or GeneXpert negative presumptive TB cases have been provided with antibiotics and appointed and re-checked after 2 weeks[32] but many of the patients might not visit a health facility or select other health facilities that expose them to a longer delay.[30] The majority of total delay was attributable to patients’ delay by reducing diagnostic delay. The median total delay of the current study was 31 days, which was lower than studies done in Ethiopia, at the national level, the median total delay was reported as 33 days[3] and 50 days in the Somali region.[30] It was also lower than studies from sub-Saharan Africa, a study from the Gambia reported 34 days[32] and a study from Uganda reported a median of 13 weeks.[32] In the total delay of the current study, the largest of delay (96.2%) was contributed by patients’ delay. This big contribution for the delay in PTB patients when compared with the health system or diagnostic delay was similarly reported in Ethiopia[30] and in Uganda[32] despite the contribution in our study was higher than other studies due to low diagnostic delay in the current study. This low contribution of diagnostic delay in the current study might be related to the screening for cough of any duration and/or followed by CXR screening we did among health care seekers.

Chest X-ray screening at the hospital with an expert (radiologist) reduced the diagnosis delay. For example, as Table 4 shows, median diagnosis delay at referral hospitals that have chest X-ray machines, GeneXpert, and radiologists was 1 day whereas it was 3 days at health center without studies in the country that reported a median of patients’ delay 30 days at Adama, central Ethiopia,[28] at Gamo zone, south Ethiopia,[29] and Somali region, eastern Ethiopia.[30] The difference might be due to the accessibility to health facilities, socioeconomic factors, and study populations. Besides, the patients’ delay was longer among rural residents. This could be related to the costs of transportation, accommodation, and others such as child care at home.[28,30] Patients’ delay was low among ART patients. This could be due to the existing integrated program to control the TB/HIV co-infection that initiated the screening and diagnosis at an early stage.[31]

We found a very low diagnostic delay (2.6%) in the current study when compared with a study at the national level of Ethiopia that reported a median of 4 days,[3] and a study from Addis Ababa reported 58.8% delayed more than 7 days.[18] The diagnostic delay in the current study was lower than a study done in sub-Saharan Africa countries and other countries. In Uganda, median of 1 week among 44%,[32] median of 1.7 weeks in Zambia,[33] and at China diagnostic delay more than 2 weeks among 23.6%.[34] Indeed, about a third (27.8%) patients were diagnosed in same-day in the current study that patients were very strongly favored in a study at Zambia.[33] This very low diagnostic delay, as low as 2.6% with median of 1 day, in the current study might be related to the screening methods we used cough of any duration among people who sought health care for any reason, which was consistent with a study at Ethiopia,[24] a study at Kenya,[23] and the World Health Organization indicated as cough screening could reduce the delay[31] but in our current study in addition to cough screening, among eligible it was followed by chest X-ray screening that is sensitive and can be detected TB before patients recognized the symptom.[35]
required skills human powers\(^{[21]}\) despite many presumptive TB cases visited the health center at early when compared with hospital as we observed. However, the current finding showed a longer diagnosis delay among the CXR group with cough <2 weeks when compared with their counterpart. The reason might be the waiting for the interpretation of CXR results, to be efficient with the use of GeneXpert for those who had cough <2 weeks, we performed the sputum laboratories only among those who had TB suggestive of CXR results by waiting for the results of CXR reading to perform sputum examination that could be increased the diagnostic delay among them. The algorithm <2 weeks cough duration followed by CXR screening reduced patients’ delay significantly, which is helpful to treat TB patients and

### Table 4: Comparing delays of pulmonary tuberculosis among people screened by cough of any duration and/or chest X-ray

| Facilities, screening algorithms, and units | Patients delay | \(P\) | Diagnostic delay | \(P\) | Total delay | \(P\) |
|-------------------------------------------|---------------|------|-----------------|------|-------------|------|
| Types of health facilities                |               |      |                 |      |             |      |
| Referral hospitals with CXR, GeneXpert, smear microscopy, and radiologist at urban setting | 30 (17-45.5)  | 0.0102 | 1 (0-2)         | 0.0001 | 31 (18.5-48.5) | 0.0243 |
| Primary hospital with CXR, smear microscopy, and GeneXpert at rural | 31 (17-51)    | 2 (1-4) | 34.5 (19-52)    |      |             |      |
| Health center only with smear microscopy at rural | 20 (10-32)  | 3 (2-4) | 22 (14-34)      |      |             |      |
| Screening algorithms                       |               |      |                 |      |             |      |
| Non CXR group                              | 30 (19-31)   | 0.0001 | 0 (0-1)         | 0.0221 | 30 (20-32)   | 0.0001 |
| CXR group <2 weeks cough                   | 7 (6-10)     | 2 (1-3.5) | 10 (7.5-12) |      |             |      |
| CXR group ≥2 weeks cough                   | 31 (22-56.5) | 1 (0-2.5) | 33 (24-58.5)   |      |             |      |
| Departments/units                          |               |      |                 |      |             |      |
| OPD and RCH                                | 31 (16-45.5) | 0.5594 | 1 (0-3)         | 0.0409 | 31 (18-50.5) | 0.4728 |
| Anti-retroviral patients                   | 27 (16-31)   | 0 (0-1) | 27.5 (19-31)    |      |             |      |
| ANC and PMCT                              | 31 (30-32)   | 1 (0-2) | 32 (30-34)      |      |             |      |

CXR: Chest X-ray, TB: Tuberculosis, PTB pulmonary TB, OPD: outpatients department, RCH: Reproductive and child health, ANC: anti-natal care, PMCT: Prevention from mother to child transmission

### Table 5: Factors associated to patients’ delay and total delay among pulmonary tuberculosis, Ethiopia

| Characteristics | Patient delay | Total delay |
|-----------------|---------------|-------------|
|                 | \(n\) | cPR with 95% CI | aPR with 95% CI | \(n\) | cPR with 95% CI | aPR with 95% CI |
| Total           | 252 | | | 209 | |
| Gender          |     |     |     |     |     |     |
| Female          | 124 | 1 | 1 | 100 | 1 | 1 |
| Male            | 128 | 0.92 (0.83-1.02) | 0.92 (0.83-1.02) | 109 | 0.97 (0.83-1.13) | 0.96 (0.82-1.12) |
| Location        |     |     |     |     |     |     |
| Rural           | 189 | 1.1 (0.96-1.26) | 1.05 (0.92-1.17) | 161 | 1.05 (0.00-1.5) | 1.16 (0.95-1.41) |
| Urban           | 63  | 1 | 1 | 48  | 1 | 1 |
| Sputum test results |     |     |     |     |     |     |
| Positive        | 157 | 1.08 (0.96-1.21) | 1.04 (0.92-1.17) | 131 | 1.12 (0.95-1.34) | 1.07 (0.90-1.28) |
| Negative        | 86  | 1 | 1 | 69  | 1 | 1 |
| Previous TB treatment |     |     |     |     |     |     |
| Yes             | 25  | 0.78 (0.62-0.99) | 0.79 (0.63-0.99) | 18  | 0.67 (0.47-0.95) | 0.70 (0.50-0.97) |
| No              | 226 | 1 | 1 | 190 | 1 | 1 |
| History of weight loss |     |     |     |     |     |     |
| Yes             | 83  | 1.11 (1.01-1.23) | 1.12 (1.0-1.25) | 72  | 1.20 (1.02-1.39) | 1.22 (1.04-1.44) |
| No              | 169 | 1 | 1 | 137 | 1 | 1 |

TB: Tuberculosis, PTB pulmonary TB, cPR: Crude prevalence ratio, aPR: Adjusted prevalence ratio, CI: Confidence interval

[Downloaded free from http://www.ijmyco.org on Tuesday, December 14, 2021, IP: 246.195.2.195]
revert the transmission. Screening for anyone regardless of cough duration reduced the delay in line with a study from Kenya.\textsuperscript{[23]}

The strength of this study was executing screening by symptom and/or CXR by changing the usual screening of cough $\geq 2$ weeks to cough of any duration for different target groups at wide-area coverage for both rural and urban settings at both hospitals and health center. However, the patients’ delay might be underestimated due to recall bias of the dates but we tried to control by asking the date at the start rather than the duration and giving appropriate time as they remembered. Besides, when CXR is used, the quality of CXR has to be considered to prevent the consequences of over diagnosis of TB that leads to treating patients without TB and/or under-diagnosis that leads to transmitting TB in the community. Errors and bias could be related to facility arrangements, type and technology of CXR machine used (conventional or digital), and turn-around time of imaging and reading.\textsuperscript{[37-43]} We exerted efforts to undue the challenges, particularly in meeting the quality of imaging and reading to meet the CXR preconditions outlined in a proclamation by the Ethiopian Government.\textsuperscript{[44]} We gave a thorough focus on CXR quality that images were taken by trained and qualified radiographers and read by senior radiologists. With all these considerations, the findings of this study can be evaluated further and implemented for facility-based screening and diagnosis of TB.

**Conclusion**

Early screening using CXR minimized delays in the diagnosis of PTB among people with cough of any duration. Patients’ delay was largest and contributed great role in the delay of TB cases. Screening by cough of any duration and/or CXR among people seeking health care along with ensuring the availability of Xpert MTB/RIF assay and skilled human power at primary health care facilities are important to reduce patient and diagnostic delay of PTB in Ethiopia.

**Ethical clearance and consent to participate**

The study was approved by the Institutional Review Board of the College of Health Sciences, Addis Ababa University (Ref. No. AAUMF 03-008) and Haramaya University, College of Health and Medical Sciences, Institutional Health Research Ethics Review Committee (IHRERC) (Ref. No. IHRERC/004/2019). Letters of permission were obtained from respective health facilities. After enough time is given by responding to any question raised by study participants, interviews and procedures were performed. Informed and written consent or parental consent and/or assent was obtained after information provided for study participants. For illiterate study participants, a witness was attended the process when the form read for them.

**Data availability statement**

All important data used for this article included in the main text. Datasets for the article are available upon reasonable request from the corresponding author.

**Financial support and sponsorship**

The study was financial supported by the EXIT-TB project which is part of the European and Developing Countries Clinical Trials Partnership 2 (EDCTP2) program supported by the European Union (grant number CSA2016S-1608). The authors are thankful to the Center for Innovative Drug Development and Therapeutic Trials for Africa (CDT-Africa), College of Health Sciences, Addis Ababa University for providing technical support and managing the grant. The authors also thank Haramaya University for assisting the implementation of the project, and acknowledge all study participants and the study facilities for permitting to collect the data.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Lönnroth K, Raviglione M. The WHO's new end TB strategy in the post-2015 era of the sustainable development goals. Trans R Soc Trop Med Hyg 2016;110:148-50.
2. WHO. Global TB Report Final. Geneva, Switzerland: WHO; 2020.
3. Cazabon D, Ahsurdf H, Snyatanyaranya S, Nathavitharan R, Subbaraman R, Daffary A, et al. Quality of tuberculosis care in high burden countries: The urgent need to address gaps in the care cascade. Int J Infect Dis 2017;56:111-6.
4. Knuk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Rohde-DerSan W, et al. High-quality health systems in the sustainable development goals era: Time for a revolution. Lancet Glob Health 2018;6:e1196-252.
5. Datiko DG, Jerene D, Suarez P. Patient and health system delay among TB patients in Ethiopia: Nationwide mixed method cross-sectional study. BMC Public Health 2020;20:1126.
6. Ho J, Fox GF, Marais BJ. False case finding for tuberculosis is not enough. Int J Mycobacteriol 2016;5:374-8.
7. Federal Ministry of Health, Ethiopia National Guideline for TB Leprosy and DR TB. 6th ed. Addis Ababa, Ethiopia: Federal Ministry of Health; 2018.
8. Areg A, Tilahun K, Minda A, Agurie A, Menghistu G. Prevalence rate of undiagnosed tuberculosis in the community in Ethiopia from 2001 to 2014: Systematic review and meta-analysis. Arch Public Health 2019;77:33.
9. Getnet F, Demissie M, Assefa N, Mengistie B, Worku A. Delay in diagnosis of pulmonary tuberculosis in low-and middle-income settings: Systematic review and meta-analysis. BMC Pulm Med 2017;17:202.
10. Mbuithia GW, Olingah CO, Ondicho TG. Health-seeking pathway and factors leading to delays in tuberculosis diagnosis in West Pokot County, Kenya: A grounded theory study. PLoS One 2018;13:e0207995.
11. Gambesa DF, Tola H, Mohamed Z, Tesfaye E, Alemu A. Health care seeking behavior among presumptive tuberculosis patients in Ethiopia: A systematic review and meta-analysis. BMC Health Serv Res 2020;20:445.
12. Asemahgn MA, Alene GD, Yimer SA. Geographic accessibility, readiness, and barriers of health facilities to offer tuberculosis services in East Gojjam Zone, Ethiopia: A convergent parallel design. Res Rep Med 2020;11:3-16.
13. Lin CH, Tsai CH, Liu CE, Huang ML, Chang SC, Wen JH, et al. “Cough officer screening” improves detection of pulmonary tuberculosis in hospital-in-patients. BMC Public Health 2010;10:238.
14. Bello S, Afolabi RF, Ajayi DT, Sharma T, Owoye DO, Oduoye O, et al. Empirical evidence of delays in diagnosis and treatment of pulmonary tuberculosis: Systematic review and meta-regression analysis. BMC Public Health 2019;19:820.
15. Veesa KS, John KR, Moonan PK, Kaliappan SP, Manjunath K, Sagili KD, et al. Diagnostic pathways and direct medical costs incurred by new adult pulmonary tuberculosis patients prior to anti-tuberculosis.
Mohammed, et al.: Impact of early CXR on delay of PTB in Ethiopia

...treatment – Tamil Nadu, India. PLoS One 2018;13:e0191591.
16. Mathema B, Andrews JR, Cohen T, Borgdorff MW, Behr M, Glynn JR, et al. Drivers of tuberculosis transmission. J Infect Dis 2017;216:S644-53.
17. WHO. Systematic Screening for Active Tuberculosis Principles and Recommendations. Geneva, Switzerland: WHO; 2013.
18. Adenager GS, Alemseged F, Asefa H, Gebremedhin AT. Factors associated with treatment delay among pulmonary tuberculosis patients in public and private health facilities in Addis Ababa, Ethiopia. Tubere Res Treat 2017;2017:5120841.
19. Zhao F, Zhang C, Yang C, Xia Y, Xing J, Zhang G, et al. Comparison of yield and relative costs of different screening algorithms for tuberculosis in active case-finding: A cross-section study. BMC Infect Dis 2021;21:813.
20. Shimeles E, Tilahun M, Hailu T, Enquselassie F, Asefa A, Meckonnen A, et al. Time interval for diagnosis of tuberculosis and related expenditure in selected health centers in Addis Ababa, Ethiopia. Adv Public Health 2019;2019:4705139.
21. Mohammed H, Oljira L, Roba KT, Ngadaya E, Ajeme T, Haile T, et al. Burden of tuberculosis and challenges related to screening and diagnosis in Ethiopia. J Clin Tuberc Other Mycobact Dis 2020;19:100158.
22. Deribew A, Dejene D, Dafar A, Berhanu D, Biadglegn S, Tekle E, et al. Health system capacity for tuberculosis care in Ethiopia: Evidence from national representative survey. Int J Qual Health Care 2020;32:306-12.
23. Yuen CM, Agaya J, Mchembre W, Okelloh D, Achola M, Opole J, et al. Optimizing the efficiency of tuberculosis active case-finding in health facilities and communities. Int J Tuberc Lung Dis 2019;23:844-9.
24. Asres A, Jerene D, Deressa W. Delays to anti-tuberculosis treatment initiation among cases on directly observed treatment short course in districts of southwestern Ethiopia: A cross sectional study. BMC Infect Dis 2019;19:481.
25. Choi BC, Pak AW. A catalog of biases in questionnaires. Prev Chronic Dis 2005;2:A13.
26. Ali Z, Bhaskar SB. Basic statistical tools in research and data analysis. Indian J Anaesth 2016;60:662-9.
27. Deddens JA, Petersen MR. Approaches for estimating prevalence ratios. Occup Environ Med 2008;65:481, 501-6.
28. Wondawek TM, Ali MM. Delay in treatment seeking and associated factors among suspected pulmonary tuberculosis patients in public health facilities of Adama town, eastern Ethiopia. BMC Public Health 2019;19:1527.
29. Arja A, Godana W, Hassin H, Bogale B. Patient delay and associated factors among tuberculosis patients in Gamo zone public health facilities, Southern Ethiopia: An institution-based cross-sectional study. PLoS One 2021;16:e0255327.
30. Getnet F, Demissie M, Worku A, Gobena T, Tschopp R, Seyoum B. Longer delays in diagnosis and treatment of pulmonary tuberculosis in pastoralist setting, Eastern Ethiopia. Risk Manag Healthc Policy 2020;13:583-94.
31. Xiao W, Huang D, Li S, Zhou S, Wei X, Chen B, et al. Delayed diagnosis of tuberculosis in patients with diabetes mellitus co-morbidity and its associated factors in Zhejiang Province, China. BMC Infect Dis 2021;21:272.
32. Muttamba W, Kyobe S, Komuhangi A, Lakony J, Bureggyeya E, Mabumba E, et al. Delays in diagnosis and treatment of pulmonary tuberculosis in patients seeking care at a regional referral hospital, Uganda: A cross sectional study. BMC Res Notes 2019;12:589.
33. Kerkhoff AD, Kaguji M, Nyanagu S, Matayo K, Sanjase N, Chilukutu L, et al. Pathways to care and preferences for improving tuberculosis services among tuberculosis patients in Zambia: A discrete choice experiment. PLoS One 2021;16:e0252995.
34. Yang Q, Tong Y, Yin X, Qiu L, Sun N, Zhao Y, et al. Delays in care seeking, diagnosis and treatment of patients with pulmonary tuberculosis in Hubei, China. Int Health 2020;12:101-6.
35. WHO. WHO Operational Handbook on Tuberculosis: Module 2: Screening – Systemic Screening for Tuberculosis Disease. Geneva: WHO; 2021.
36. Owolabi OA, Jallow AO, Jallow M, Sowe G, Jallow R, Genekah MD, et al. Delay in the diagnosis of pulmonary tuberculosis in The Gambia, West Africa: A cross-sectional study. Int J Infect Dis 2020;101:102-6.
37. Okhado A, Mercer M, Date T. Does a quality assurance training course on chest radiography for radiological technologists improve their performance in Laos? Int J Mycobacteriol 2017;6:302-6.
38. Okhado A, Mercer M, Date T. Does a quality assurance training course on chest radiography for radiological technologists improve their performance in Laos? Int J Mycobacteriol 2018;7:107-8.
39. Tsegaye Sahle E, Blumenthal J, Jain S, Sun S, Young J, Manyazewal T, et al. Bacteriologically-confirmed pulmonary tuberculosis in an Ethiopian prison: Prevalence from screening of entrant and resident prisoners. PLoS One 2019;14:e0226160.
40. Charlie L, Saidi B, Getachew E, Wanjiru CL, Abebe M, Tesfahuney HA, et al. Programmatic challenges in managing multidrug-resistant tuberculosis in Malawi. Int J Mycobacteriol 2021;10:255-9.
41. Manyazewal T, Woldeamanuel Y, Blumberg HM, Fekadu A, Marconi VC. The potential use of digital health technologies in the African context: A systematic review of evidence from Ethiopia. NPJ Digit Med 2021;4:125.
42. Manyazewal T, Woldeamanuel Y, Blumberg HM, Fekadu A, Blumberg HM, Marconi VC. Electronic pillbox-enabled self-administered therapy versus standard directly observed therapy for tuberculosis medication adherence and treatment outcomes in Ethiopia (SELF8TB): Protocol for a multicenter randomized controlled trial. Trials 2020;21:383.
43. Mohammed H, Oljira L, Roba KT, Yimer G, Fekadu A, Manyazewal T. Containment of COVID-19 in Ethiopia and implications for tuberculosis care and research. Infect Dis Poverty 2020;9:131.
44. Federal Negarit Gazette of the Federal Democratic Republic of Ethiopia. PN. Radiation and Nuclear Protection Proclamation No. 1025/2017. Federal Negarit Gazette, Addis Ababa, Ethiopia. No. 67; 19th July, 2017.