

**Factors Associated with Failure to Diagnose Acute
Pulmonary Tuberculosis
in a Public Emergency Department**

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Dedication

For all those who work tirelessly towards the benefit of others.

Acknowledgements

Modern research is hallmarked by the multidisciplinary approach to data collection and analysis with emphasis on teamwork, specialization and, particularly in the case of this work, excellent mentorship. This work would not have been possible without the guidance of Drs. Maricela Moffitt and Frank LoVecchio and the assistance of Dr. Patrick Godwin, Dr. Ayesha Bashir, Dr. Angelito Bravo, and Travis Powell.

Abstract

Objective: Emergency department presentation of active pulmonary tuberculosis (TB) can be highly variable and atypical. Appropriate patient stratification may require the assessment of non-clinical criteria. The aim of this study was to determine unique presentation, risk factors and outcomes in the population of TB patients that present to a public emergency department (PED), as well as to identify those factors associated with ED discharge without a diagnosis of TB during a potentially contagious visit. **Methods:** Epidemiological characteristics were determined for every patient diagnosed with TB in Arizona for 2000-2008. From these, the 1501 presenting in Maricopa County, Arizona for 2000-2008 were selected for further analysis. Presentation at the only PED in the county was determined by retrospective chart review. Potentially contagious TB patients presenting at the PED were analyzed on the basis of the absence or presence of a TB diagnosis during a potentially contagious visit. **Results:** Of the study population, 150 (12.0% of pulmonary TB patients) presented to the PED within one month of a verified diagnosis of active pulmonary TB. Patients presenting to the public emergency department were more likely to be male, Hispanic, homeless, HIV-positive, current resident of a correctional facility or a long-term care facility, or to have a recent history of substance abuse. Furthermore, PED patients were more likely to have multidrug resistant TB and to die before completion of treatment. Patients reported a median distance of 4.6 miles from their residence to the PED, with only 10.8% reporting a distance of greater than 15 miles. Comparison of potentially contagious TB patient visits demonstrated that patients were significantly less likely to receive a diagnosis of TB when presenting with a traumatic or orthopedic chief complaint, denying cough, hemoptysis, dyspnea, fever or chills, having a normal pulmonary exam and/or chest x-ray, being unresponsive during questioning, or reporting a recent history of both homelessness and excess alcohol use. Baseline sensitivity for the diagnosis of TB during a potentially contagious visit was 78.2%. Modeling revealed an increase in sensitivity to 97.9% if patients were assessed for altered mental status, pulmonary or infectious chief complaint, abnormal vital signs, or history of substance abuse or foreign birthplace. **Conclusions:** In this study, TB patients presenting to the public

emergency department were significantly more likely to have many of the known risk factors for TB, be diagnosed with MDR-TB and die before completion of therapy. Patients with a history of alcohol abuse and homelessness, or lack of signs and symptoms classical for TB were less likely to be diagnosed with TB during a potentially contagious visit. This study adds evidence to the belief that public emergency departments disproportionally care for TB patients and that these patients have a more precarious health status and greater risk for mortality than those who are diagnosed by other facilities.

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Introduction

Background

Public emergency departments face unique challenges when evaluating patients. Public emergency department patients display high rates of substance abuse and psychological symptoms^{1, 2}. The large homeless and other at-risk populations in public emergency departments have a much higher prevalence of certain communicable diseases such as HIV and tuberculosis (TB)². Patients presenting to the ED for diagnosis of TB frequently lack the classic pulmonary and constitutional symptoms, therefore identification and inclusion of relevant epidemiological factors is crucial for risk stratification³.

Determination of relevant risk-factors enables targeted screening and disease identification. Certain healthcare environments, by virtue of being enriched for particular diseases or disease-associated risk factors in their target populations, have the opportunity to employ screening mechanisms that may not be warranted with lower incidence populations. This approach has been adopted for a variety of crucial ED-based public health interventions ranging from vaccination campaigns to identification of patients needing referrals for substance abuse treatment and other services^{6, 7}. Previous efforts to identify and treat TB patients in the ED have demonstrated program feasibility while advocating targeted risk-factor driven approaches to patient identification, likely due to 75% of ED patients having at least one risk factor for TB⁸.

Information about TB incidence, clinical presentation and risk factors is readily available from the Centers for Disease Control and Prevention⁹. However, little is known about the specific subset of the larger population that presents to a public emergency department. This study was conducted to examine the epidemiological determinants of presentation to a public emergency department for diagnosis of TB along with the factors contributing to ED discharge without a diagnosis of TB during a potentially contagious visit.

Significance

Identification of TB patients is a public health priority and the ED visit may be the only interaction with the health care system for

certain groups at high risk for TB such as the homeless and immigrants from TB-endemic nations^{4, 5}.

Aims / Goals / Hypothesis

This work is being conducted to enhance our current understanding of the presentation of tuberculosis in high-incidence Emergency Departments. We hypothesize that the application of clinical and epidemiologic characteristics can enhance detection of TB patients. Specifically, our aims include:

- 1) Characterization of the patient population presenting to our study site, a public emergency department.
- 2) Identification of patients who presented to our study site during a potentially contagious ED visit and the clinical and epidemiological factors distinguishing those patients receiving the diagnosis of active pulmonary tuberculosis from those who did not receive this diagnosis.
- 3) To derive a clinical prediction pathway for the identification of patients at very low risk for active pulmonary tuberculosis.

Research Materials and Methods

Study Design

Reporting of active TB is legally mandated in Arizona. All reported TB cases are verified by the county health department and then compiled and analyzed by the Arizona Department of Health Services (ADHS). Patients in Maricopa County, Arizona with a reported and verified case of TB from 2000-2008 were identified at the only public hospital in the county by electronic medical record search. Patients who accessed the ED during their potentially contagious period were compared with those who did not access the public hospital during this period. Additionally, patients leaving the ED without a diagnosis of TB during a potentially contagious period were compared with those who were admitted or discharged from the ED with a diagnosis of TB. This study was approved by the Institutional Review Board of the Maricopa Integrated Health System (2008-034).

Study Setting and Population

The Maricopa Medical Center emergency department has an annual census of 57,300 patients and also houses an emergency medicine residency program. This emergency department serves the greater Phoenix community while also receiving patients arriving by both air and ground ambulance and patients from county and state correctional facilities. It is located near both the geographic and population center of Maricopa County, a rapidly growing metropolitan area of approximately 3,700,000 (2006). The case rate for TB in Arizona was 5.0/100,000 in 2006.

The study population consists of those patients residing in Maricopa County who were reported to the ADHS as a verified case of tuberculosis from 2000-2008. Potentially contagious ED visits were classified as previously described, with slight modification³. An ED visit was considered to be potentially contagious if any of the following criteria were met: 1) A positive sputum culture for *Mycobacterium tuberculosis* was obtained during the hospitalization that was initiated by this ED visit 2) any visit subsequent to the positive culture or any visit where the patient was known to have a positive smear for acid-fast bacteria but less than two weeks after beginning antimycobacterial therapy 3) any visit within 30 days prior to the eventual initiation of antimycobacterial therapy and eventual confirmation of active pulmonary TB where TB was not ruled out radiographically.

Study Protocol

During the verification of a reported case of tuberculosis, Maricopa County public health workers collected epidemiological data from the patient utilizing the standardized Report of Verified Case of Tuberculosis (RVCT) data collection tool. The CDC criteria for determining a laboratory confirmed case are 1) isolation of *M. tuberculosis* complex from a clinical specimen; or 2) demonstration of *M. tuberculosis* from a clinical specimen by nucleic acid amplification test; or 3) demonstration of acid-fast bacilli in a clinical specimen when a culture has not been or cannot be obtained. A clinically verified case of TB meets all of the following criteria: 1) a positive tuberculin skin test; 2) signs and symptoms compatible with current TB disease, such

as an abnormal, unstable (worsening or improving) chest x-ray, or clinical evidence of current disease; 3) current treatment with two or more antituberculosis medications; and 4) a completed diagnostic evaluation. Multi-drug resistant tuberculosis (MDR-TB) is defined as displaying resistance to both Isoniazid and Rifampin during culture and sensitivity testing.

From the 2000-2008 verified cases of tuberculosis, the subset of patients presenting to the only public emergency department in Maricopa County, Arizona was identified as follows: Electronic medical records were searched by last and first name and confirmed by date of birth. Date of visit to the public emergency department was recorded along with admission status and diagnosis upon discharge from the emergency department or inpatient unit.

Distance from reported residence to the public emergency department was determined as follows: Patient zip codes of current residence (or institution/shelter/long-term care facility) were obtained by Maricopa County public health workers and were utilized to calculate the distance traveled to the public emergency department. Distance was calculated as walking distance along existing roads from the center of the patient zip code to the specific address of the public emergency department. Automobile-related factors such as one-way streets or patients presenting via EMS were not considered.

Clinical data was obtained according to the following procedure: Unique institutional visit identification numbers belonging to patients identified above as presenting to the public emergency department during a potentially contagious period were provided to a PGY-2 EM resident along with a standardized data collection form. This resident was provided with a 1-hour training session in the standardized collection of data for this project. An opportunity to answer questions was provided. The resident was blinded at all times to the specific aims of the study and to individual patient outcomes. Data sheets were then abstracted and entered into Excel (Microsoft) by a separate data assistant who was blinded as above. Entered data was verified in the medical record by the principle investigator (BG). Rare disagreements between data source and PI review were resolved by review of the patient record by a data assistant unfamiliar with the project without pre-review of the patient outcome or other data not contained in the patient electronic medical record.

Data analysis

Descriptive methodology was employed according to the following procedure: Individual RVCT records were entered into a Microsoft Access© database by public health department staff in the course of their standard investigation of reported cases of TB, which was exported for records included in the study period into Microsoft Excel©. Patients presenting at the public emergency department were compared with those who were diagnosed in other facilities. X² test was employed for categorical data and was reported as the odds ratio (95% confidence interval) and p-value (Fishers Exact test). Two-tailed t-test was employed for continuous data and was reported as mean (SEM) and p-value. The threshold for statistical significance was $p < 0.05$.

Results including statistical significance

We identified 1501 reported and verified cases of tuberculosis in Maricopa County, Arizona that were reported to ADHS from 2000-2008 for further analysis due to the quality and ease with which these records could be accessed through the electronic medical record system at the study site. From this pool of 1501 cases, 248 records (16.5%) indicating that the patient did not have pulmonary tuberculosis were removed. The remaining 1253 cases were subjected to medical record search where 378 patients were identified as having been a patient at the study hospital. ED date of service and ADHS-provided date of initiation of antimycobacterial therapy analysis identified 189 patients (15.1% of pulmonary TB cases in study period) who were seen at the study hospital during their potentially contagious period. Of these patients, 39 (20.6%) bypassed the ED and were directly admitted to the inpatient medical unit. The remaining 150 patients were determined to have made a total of 179 potentially contagious visits to the ED. Analysis of the discharge disposition / diagnosis from ED records revealed that 39 of the 179 potentially contagious visits (27.9%) ended with an ED discharge without the diagnosis of TB. The remainder of the cases (72.1%) resulted in hospital admission or ED discharge with a diagnosis of acute pulmonary TB, reflecting a large majority of successful diagnoses.

Epidemiological characteristics for the 150 potentially contagious patients presenting to the ED were compared with the 1064 that sought care at other facilities in the county (Table 1). No significant differences were detected in age at TB diagnosis, rates of foreign-born patients or previous diagnosis of TB. The average time residing in the United States for foreign-born TB patients was 9.7 years, which was not significantly different from the control TB population. However modest differences were detected in birth nation for foreign-born patients, with the public emergency department patients slightly more likely to be from Latin America and less likely to be from Africa or Asia.

The public emergency department TB population was significantly enriched for many traditional TB risk factors including male gender, HIV positive diagnosis, homeless, resident of correctional facility, resident of a long-term care facility, injecting and non-injecting drug use and excess alcohol use in the past year (Table 1). Associated with this increased prevalence of traditional TB risk factors were much higher rates of MDR-TB and increased likelihood of death before TB therapy was completed. All of the MDR-TB patients presenting to the public emergency department were foreign-born. We were unable to identify any covariates from our data set that would explain this finding.

Factors influencing patient presentation at a public emergency department are difficult to determine conclusively. We examined the average distance from the patient's reported residence to the public emergency department for medical care (fig. 2). The median distance reported was 4.6 miles. 54.7% of patients reported a distance of less than 5 miles (46.9% of whom reported homelessness in the past year), while only 10.8% reported a distance of > 15 miles (17% of whom reported homelessness in the past year). Overall, the median distance from patient residence to the public emergency department was 6.9 miles for non-homeless patients and 3.2 miles for those reporting homelessness in the year prior to TB diagnosis.

The 150 public emergency department TB patients in this study made 179 potentially contagious visits to the ED during the study period. We compared the epidemiological characteristics of the patients who were either admitted through the ED or discharged from the ED with a diagnosis of tuberculosis to those patients who were discharged from the ED without a diagnosis of TB. Overall, there were

no significant univariate differences in terms of age or any of the traditional TB risk factors, although there was a trend toward decreased TB diagnosis in those reporting no employment in the past year. Bivariate analysis revealed that those patients reporting both homelessness and excess alcohol use in the year prior to TB diagnosis were significantly less likely to be admitted or to have a known TB diagnosis at the time of ED discharge during a potentially contagious visit.

The failure to diagnose TB during a potentially contagious visit may be driven by an atypical clinical presentation. To examine this possibility, we analyzed the 179 patient visits to our emergency department by chief complaint (figure 4). Patients presenting with TB-related complaints (+PPD, questionable chest x-ray at outside facility, TB clearance for jail, shelter, etc.) or with general pulmonary complaints were more likely to be diagnosed with TB during their potentially contagious visit. Atypical presentations were less likely to be linked to TB, with trauma / orthopedic complaints rarely resulting in TB diagnosis. A detailed analysis of patient clinical data provided an additional level of resolution to this association (Table 3). Patients reporting cough, dyspnea, fever or chills were significantly more likely to be diagnosed with TB than those who denied these classic TB symptoms. In terms of objective clinical findings, there was an increased likelihood of TB diagnosis for patients with an abnormal lung exam or CXR. Interestingly, there was no significant difference in vital signs between patient groups, underscoring the dominant nature of patient history and clinical suspicion in TB diagnosis. This link was reinforced by the significantly reduced rate of TB diagnosis in patients presenting with altered mentation.

There were 39 visits by 29 individual patients included in this analysis of failure to diagnose TB during a potentially contagious visit. 82.1% of the patient visits had a positive interval from ED visit to positive culture sample collection, indicating that they did not have a culture positive sample collected before their ED visit. Most patients made only one visit to the ED that did not result in a diagnosis of TB visit during their potentially contagious period. However, there were four patients who made a combined 13 potentially contagious visits to the ED. This included one patient who visited the ED five times during the nine month period between the collection of a culture positive sample and the eventual initiation of antimycobacterial

therapy. Both the culture collection and eventual diagnosis occurred at another facility. The median time from ED visit to initiation of drug therapy for all patients was 34 days, while the median days from ED visit to obtaining a culture-positive sample was 10 days. Thus there is a segment of the TB population who have produced a sample which will grow *Mycobacterium tuberculosis* yet who are awaiting the initiation of antimycobacterial therapy and are presenting to the ED for evaluation.

As the goal of this study was to increase diagnosis of TB in high-risk populations, we attempted to derive a tool for the identification of patients at very low risk for active pulmonary TB. Using sequential identification of known clinical and epidemiological factors associated with active pulmonary TB we determined a pathway for the identification of patients in whom active TB should be considered (figure 5). By viewing patients with altered mental status, pulmonary or infectious chief complaints, abnormal temperature, heart rate or respiratory rate, history of substance abuse or foreign birth at increased risk for active pulmonary TB we were able to increase the sensitivity for TB suspicion from 78.2% to 97.9%.

Discussion

US incidence of TB is at its lowest level in recorded history at approximately 5/100,000 of the US population¹¹. The public health battle against TB has evolved from a massive nationwide campaign to a targeted attempt to find remaining pockets of infection as TB has become a disease of very specific high-risk groups. These high-incidence TB groups are associated with the markers of low socioeconomic status: crowding and poverty and low education¹². These are also the same groups who predominately access the ED for healthcare^{2, 4, 5}. Thus we undertook what we believe to be the largest epidemiological analysis of ED TB patients to date.

The epidemiological characteristics identified in the public emergency department TB population echo and refine the findings of a smaller study that first identified the unique presentation of ED TB patients³. By following the patient through TB therapy, we were able to demonstrate that a population with increased risk factors was associated with increased mortality. Thus the population of TB

patients presenting to the public emergency department may have more severe disease or increased co-morbidities (such as HIV) which may facilitate negative outcomes. Furthermore, certain subsets of the public emergency department TB population were less likely to receive the diagnosis of TB during a potentially contagious visit, most notably patients who had a recent history of both homelessness and alcohol abuse. Homeless and alcoholic ED patients both utilize ED services more and are more difficult to examine due to intoxication and the potential belief that they may be abusing the system. They are also more likely to present with altered mentation, thus confounding clinical decision making. These data will hopefully raise the suspicion of TB in this population, regardless of presenting complaint.

It is worth noting that our public emergency department has 4.7% of the county ED annual census, yet received 12.0% of the county pulmonary TB cases. There are many reasons why a sick individual may present to a public emergency department and an exhaustive analysis of that question is certainly beyond the scope of this work. We did demonstrate, however, that the overwhelming majority of public emergency department TB patients did not travel a great distance to seek care. The majority of TB patients travelled less than five miles for treatment. 86.1% of our TB patients listed the city of Phoenix for their residence, yet Phoenix contains only 39% of the county population. Thus travel from neighboring cities, which house the majority of the county population, was negligible. The increased Hispanic population in our ED mirrors well a larger Hispanic population in the area immediately surrounding the public emergency department that is 95% greater than the county average¹³. Thus while we are unable to completely explain the disproportionate TB burden experienced by public emergency department s, we can say that this is not the result of movement from disparate areas of the county for issues such as ability to pay, etc. Thus it is acceptable to assume that TB rates at this public emergency department are reflective of the surrounding community, independent of the financial structure or mission of the hospital.

This study demonstrates that the public emergency department patient population displays significantly increased numbers of TB patients. Others have advocated screening in EDs serving specific

high incidence populations while demonstrating that only 54.1% of these high-risk patients follow-up with traditional PPD screening⁸. This conflict between public health priorities and patient compliance in high-risk populations may explain why very little information exists concerning the adoption of ED-based TB screening programs. Recent advances in both the understanding of TB presentation / risk factors and the development of screening tools warrant a reevaluation of this approach. The ED visit may represent a unique opportunity for the application of TB diagnostic testing such as one of the interferon-gamma based TB blood tests. These tests avoid the significant drawback in this high-risk population of having to return to the ED in 48 hours to have the test read. The sensitivity for detecting active TB in HIV negative patients varies compared to PPD testing depending on the particular test system, although in HIV positive patients interferon-gamma based systems display significantly greater sensitivity¹⁴. The latest generation of these systems, with sensitivity for active TB ranging from 83%-97% in immunocompetent patients, displays appropriate utility to be included as an adjunct in the diagnosis of active TB^{15, 16}. While we do not know the true pretest probability for TB in this study population, we can surmise that certain well known high-risk groups (such as the HIV-positive, homeless and chronic alcoholic patients) would have a sufficient likelihood to justify ED-based diagnostic testing. This study contributes to the evidence that other high-risk groups may also be included while suggesting that facilities with disproportionately high incidence of TB may stand to benefit the most.

This study had a number of limitations. The epidemiological patient characteristics were recorded by public health workers during the verification of the TB case. They were not obtained with this study in mind and therefore may not have the validity of a prospective study. The retrospective nature of the medical record review limited the ability to acquire missing data. While the tool we derived to identify very low risk TB patients in a high-risk population where TB is not suspected was very sensitive, it is not to imply that patients not considered low risk should be considered high risk and subjected to costly and potentially harmful testing. There clearly exists a group of moderate-risk patients our analysis did not address.

Additionally, this study did not have a control group of non-TB patients in the public emergency department. Therefore we are unable to determine the prevalence of these risk-factors in the total public emergency department population. Because this was a single-site study, we do not know the characteristics of patients who presented to any other ED in the county. Furthermore, these results may not reflect the state in emergency departments with different patient populations.

We utilized criteria in the definition of “potentially contagious” which could lead to inclusion of some cases that were not actually contagious. While we believe that this accurately reflects the contagious period for a TB patient, some patients who utilize the ED with greater frequency than others (homeless, etc.) may by chance have presented to the ED for another reason, only coincidentally to be diagnosed with TB shortly thereafter. Regardless, these patients would have almost certainly been exposed and therefore positive for any potential laboratory screening that the risk-factor stratification indicated. The identification of associated risk factors and presenting signs / symptoms was performed as a subgroup analysis of the larger data set and therefore should be confirmed by larger prospective studies.

The analysis of predictors of receiving the diagnosis of TB in the public emergency department was conducted by visit, rather than by patient. Thus patients who made multiple visits to the ED will have a greater effect on this analysis than those who presented only once. Nonetheless, this methodology was chosen because it more accurately reflects how patients present in a busy ED ³. To mitigate any potential deleterious effects of this approach, the analysis of baseline characteristics was performed by patient, rather than by visit.

Future Directions

This study has characterized the unique population of TB patients presenting to a public emergency department and identified a potentially useful tool for risk stratification in a high risk population. Expansion of this study to different populations (community

emergency departments, diverse geographical locations) would aid in the assessment of the ability to generalize these findings.

We used univariate modeling to identify risk factors and derive the clinical decision tool. Multivariate logistic regression modeling may reveal new combinations of factors that may be more clinically relevant and increase the sensitivity of the tool.

This analysis was retrospective due to the relatively rare nature of TB presentation. Additionally, the ability to capture a “non-event” would be nearly impossible with other methodology as if was the subsequent diagnosis that defined the patient group. Prospective studies would increase the strength of the evidence, however would likely be difficult due to the large time period required to obtain sufficient sample size.

Conclusions -

This study demonstrates that the population of TB patients presenting to a public emergency department is unique from the larger TB population in that it is enriched for certain risk factors, but that this likely reflects the neighboring community as patients did not travel large distances for treatment. Furthermore, we demonstrated that the subset of homeless alcoholic TB patients and those with atypical presentations were at significantly enhanced risk for being discharged from the ED without a diagnosis of TB during a potentially contagious visit.

Tables and Figures

| <i>Characteristics</i> | <i>PED TB patients</i> (n=150) | <i>Control TB Patients</i> (n=1064) | <i>OR (95%CI)</i> | <i>p value</i> |
|---|-----------------------------------|--|----------------------|----------------|
| Age, years (SD) | 43 (17.9) | 41.8 (23.3) | - | 0.5526 |
| Male | 112/150 (74.7) | 657/1064 (61.7) | 1.826 (1.238-2.692) | 0.0021 |
| Hispanic | 95/150 (63.3) | 579/1064 (54.4) | 1.447 (1.016-2.060) | 0.0397 |
| Foreign Born | 92/149 (61.7) | 619/1050 (59.0) | 1.124 (0.790-1.599) | 0.5161 |
| Birth nation for foreign born (>2%) | | | | |
| Mexico | 73/92 (79.3) | 362/619 (58.5) | - | - |
| Philippines | 5/92 (5.43) | 43/619 (6.95) | - | - |
| Vietnam | <2% | 41/619 (6.62) | - | - |
| India | <2% | 21/619 (3.39) | - | - |
| Sudan | <2% | 16/619 (2.58) | - | - |
| Guatemala | 2/92 (2.17) | 15/619 (2.42) | - | - |
| El Salvador | 3/92 (3.26) | <2% | - | - |
| Mean years in US before TB diagnosis (SD) | 9.70 (12.9) | 9.19 (11.4) | - | 0.7502 |
| Previous diagnosis of TB | 10/150 (6.67) | 81/1053 (7.69) | 0.857 (0.434-1.693) | 0.6567 |
| HIV positive | 28/129 (21.7) | 58/805 (7.20) | 3.571 (2.173-5.867) | <0.0001 |
| Homeless within year before TB diagnosis | 48/145 (33.1) | 98/1033 (9.49) | 4.721 (3.153-7.070) | <0.0001 |
| Resident of correctional facility at time of TB diagnosis | 12/150 (8.00) | 40/1059 (3.78) | 2.215 (1.134-4.326) | 0.017 |
| Resident of long-term care facility at time of TB diagnosis | 8/150 (5.33) | 24/1064 (2.26) | 2.441 (1.076-5.539) | 0.0276 |
| Injecting drug use within past year | 9/138 (6.52) | 20/1006 (1.99) | 3.440 (1.533-7.716) | 0.0015 |
| Non-injecting drug use within past year | 22/138 (15.9) | 68/1007 (6.75) | 2.619 (1.560-4.397) | 0.0002 |
| Excess alcohol use within past year | 39/134 (29.1) | 143/1005 (14.2) | 2.475 (1.638-3.739) | <0.0001 |
| Not employed within past year | 120/151 (79.5) | 675/1064 (63.4) | 2.231 (1.474-3.376) | <0.0001 |
| MDR-TB | 4/124 (3.23) | 7/757 (0.92) | 3.571 (1.030-12.388) | 0.0324 |
| Death before completion of TB therapy | 17/130 (13.1) | 60/916 (6.55) | 2.146 (1.210-3.808) | 0.0077 |

Table 1. Characteristics of PED TB patients

Categorical data are expressed as no. / total no. (%)

TB = tuberculosis

| <i>Characteristics</i> | <i>Received Diagnosis of TB (n=140)</i> | <i>Received Other Diagnosis (n=39)</i> | <i>OR (95% CI)</i> | <i>p value</i> |
|---|---|--|----------------------|--------------------|
| Age, years (SD) | 42.0 (16.7) | 43.8 (18.9) | - | 0.5635 |
| Male | 105/140 (75.0) | 32/39 (82.1) | 0.656 (0.266-1.619) | 0.3581 |
| Hispanic | 87/140 (62.1) | 19/39 (48.7) | 1.728 (0.845-3.532) | 0.1314 |
| Foreign Born | 81/140 (57.9) | 19/39 (48.7) | 1.445 (0.709-2.945) | 0.3094 |
| Previous diagnosis of TB | 9/140 (6.43) | 1/39 (2.56) | 0.864 (0.320-21.273) | 0.3527 |
| HIV positive | 27/118 (22.9) | 9/36 (25.0) | 0.891 (0.374-2.121) | 0.7926 |
| Homeless within year before TB diagnosis | 44/136 (32.4) | 16/39 (41.0) | 0.688 (0.330-1.430) | 0.3145 |
| Resident of correctional facility at time of TB diagnosis | 14/140 (10.0) | 4/39 (10.3) | 0.972 (0.301-3.142) | 0.9624 |
| Resident of long-term care facility at time of TB diagnosis | 6/140 (4.29) | 2/39 (5.13) | 0.828 (0.160-4.277) | 0.8281 |
| Injecting drug use within past year | 11/128 (8.59) | 3/34 (8.82) | 0.972 (0.255-3.699) | 0.9662 |
| Non-injecting drug use within past year | 24/128 (18.8) | 6/34 (17.6) | 1.077 (0.401-2.891) | 0.8830 |
| Excess alcohol use within past year | 38/123 (30.9) | 14/35 (40.0) | 0.671 (0.308-1.459) | 0.3118 |
| Not employed within past year | 84/139 (60.4) | 29/39 (74.4) | 0.110 (0.238-1.167) | 0.1104 |
| Homeless + alcohol abuse within past year | 20/129 (15.5) | 12/35 (34.3) | 0.352 (0.151-0.819) | 0.0129 |

Table 2. Predictors of receiving a diagnosis of TB during a potentially contagious ED visit

| | <i>Received TB Dx (n=140)</i> | <i>Lack of TB Dx (n=39)</i> | <i>OR (95% CI)</i> | <i>p-value</i> |
|------------------------|-------------------------------|-----------------------------|--------------------|----------------|
| Temperature | 37.4 (0.1) | 37.3(0.2) | - | 0.50 |
| Hear Rate | 103.1 (1.9) | 97.6 (3.4) | - | 0.18 |
| Respiratory Rate | 20.6 (0.7) | 17.9 (0.3) | - | 0.06 |
| O2 Sat | 95.5 (0.5) | 97.2 (0.6) | - | 0.11 |
| Cough | 94 of 125 | 10 of 25 | 4.55 (1.85-11.2) | 0.0008 |
| Hemoptysis | 26 of 86 | 0 of 5 | n/a | 0.17 |
| Dyspnea | 60 of 109 | 4 of 19 | 4.59 (1.43-14.7) | 0.005 |
| Subjective Fever | 80 of 125 | 11 of 28 | 4.52 (2.05-9.94) | 0.00009 |
| Chills | 68 of 117 | 8 of 22 | 2.42 (0.95-6.24) | 0.05 |
| Night Sweats | 47 of 86 | 1 of 5 | 4.82 (0.52-44.9) | 0.14 |
| Weight loss | 70 of 100 | 6 of 8 | 0.78 (0.15-4.1) | 0.56 |
| Abnormal lung exam | 72 of 129 | 6 of 31 | 1.33 (1.14-1.56) | 0.0002 |
| Lymphadenopathy | 13 of 72 | 0 of 9 | n/a | 0.18 |
| Abnormal CXR | 112 of 123 | 10 of 17 | 8.71 (2.67-28.4) | 0.0007 |
| --Infiltrate | 75 of 112 | 7 of 10 | 1.16 (0.99-1.37) | 0.04 |
| --Cavitation | 49 of 112 | 1 of 10 | 7.0 (0.86-57.1) | 0.03 |
| --Other | 2 of 112 | 2 of 10 | 0.07 (0.009-0.58) | 0.03 |
| Altered mentation | 11 of 140 | 9 of 39 | 0.28 (0.01-0.74) | 0.01 |
| Left without treatment | 1 of 140 | 2 of 39 | 0.13 (0.01-1.49) | 0.11 |

Table 3. Clinical factors associated with patient presentation during a potentially contagious ED visit

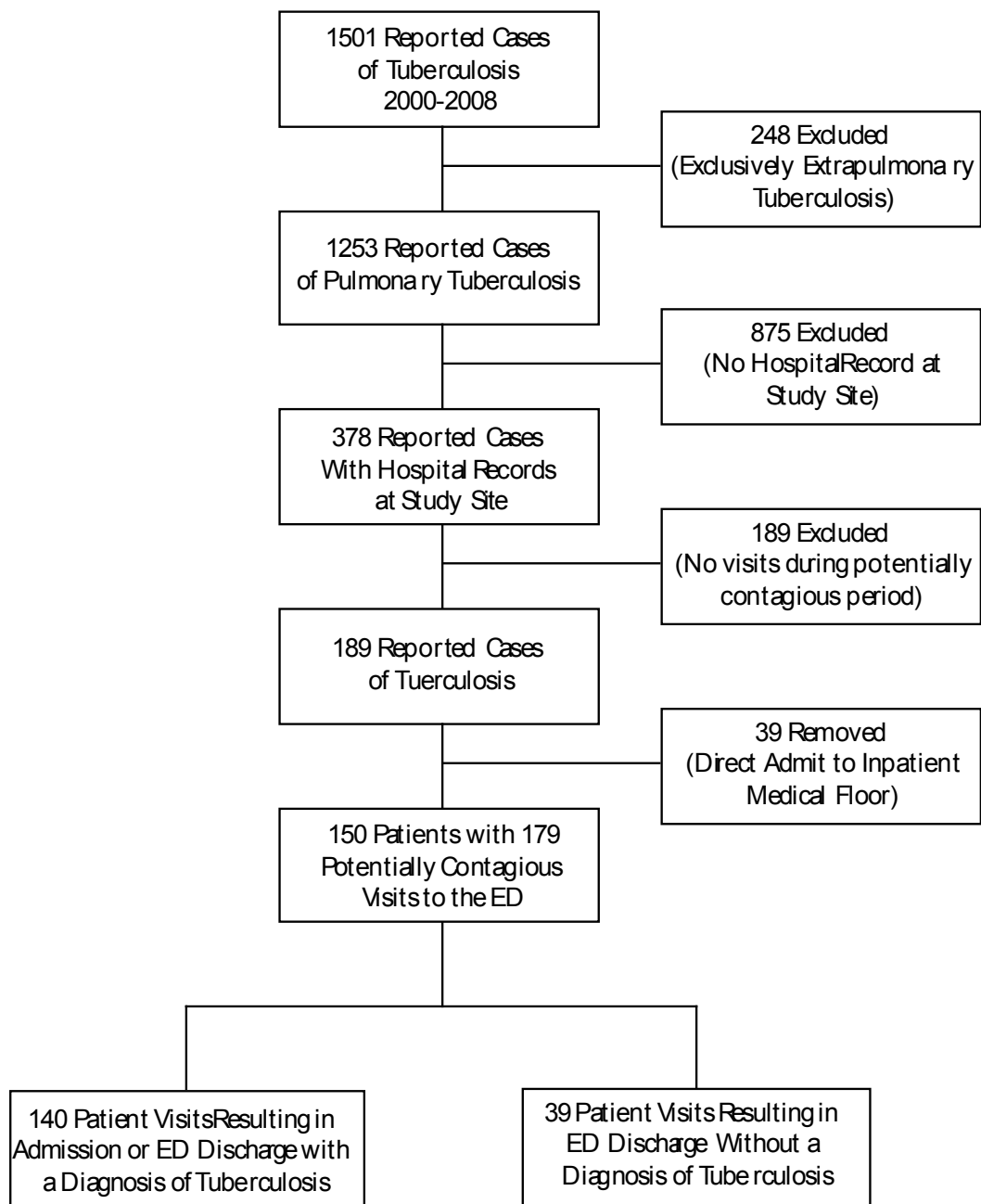


Figure 1. Derivation of study population

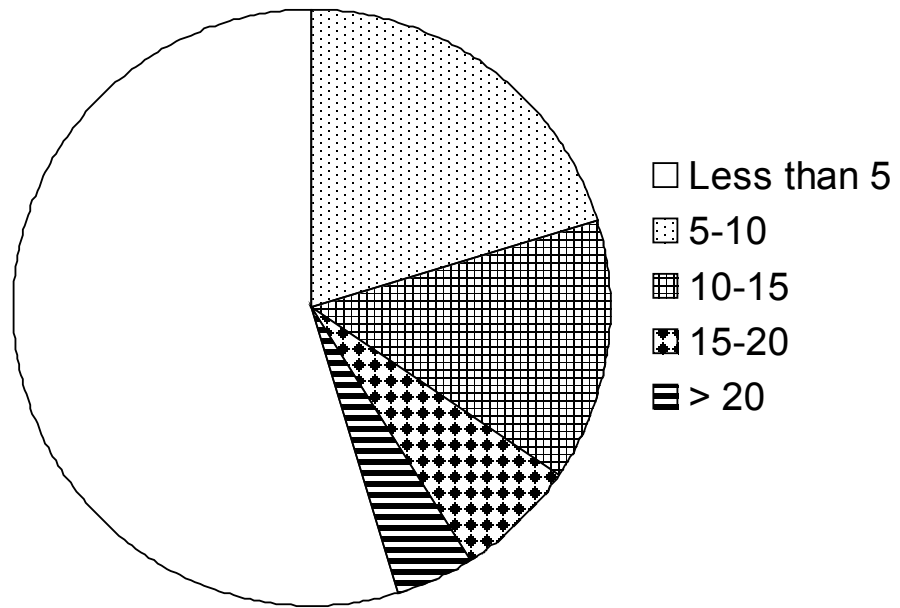


Figure 2. Analysis of distance travelled to seek care at study site

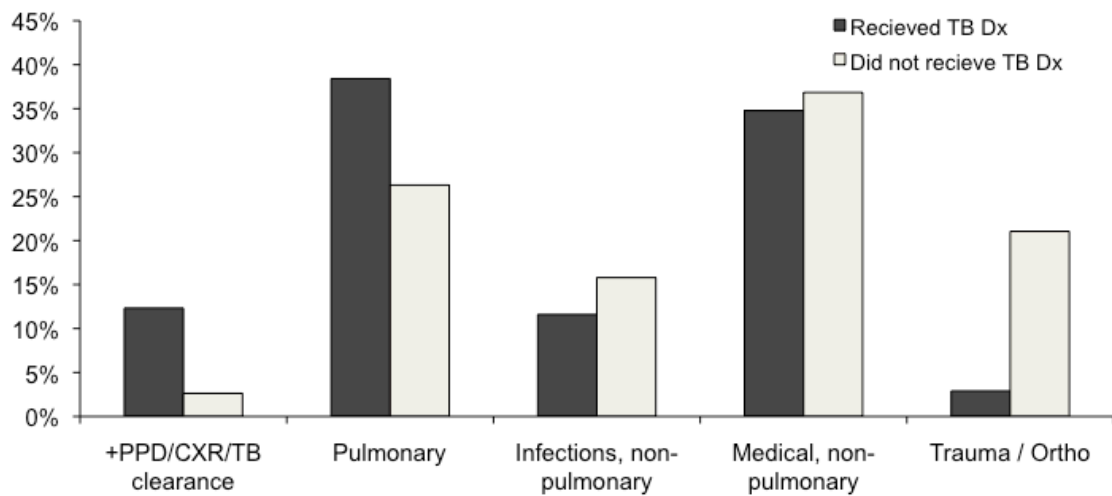


Figure 3. Chief complaint of TB patients during a potentially contagious visit.

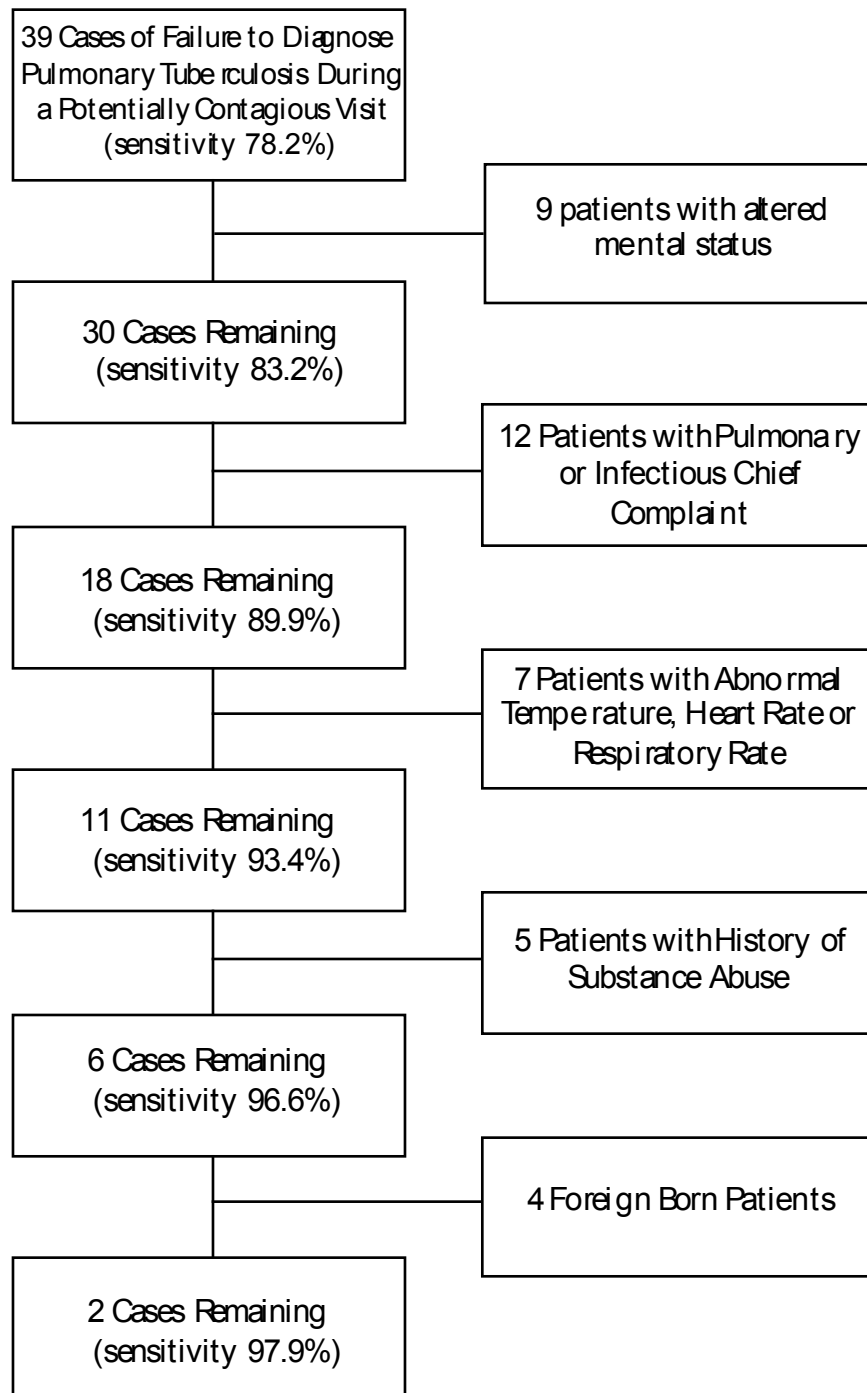


Figure 4. Derivation of a decision tool for identification of patients at very low risk for active pulmonary TB

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Factors Associated with Failure to Diagnose Acute Pulmonary Tuberculosis in a Public Emergency Department

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Objective

Emergency department presentation of active pulmonary tuberculosis (TB) can be highly variable and atypical. Appropriate patient stratification may require the integration of clinical and epidemiological data. The aim of this study was to determine unique presentation, risk factors and outcomes in the population of TB patients that present to a public emergency department (PED), as well as to identify those factors associated with ED discharge without a diagnosis of TB during a potentially contagious visit.

Methods

Epidemiological characteristics were determined for every patient diagnosed with TB in Arizona for 2000-2008. From these, the 1501 presenting in Maricopa County, Arizona for 2000-2008 were selected for further analysis. Presentation at the only PED in the county was determined by retrospective chart review. Potentially contagious TB patients presenting at the PED were analyzed on the basis of the absence or presence of a TB diagnosis during a potentially contagious visit.

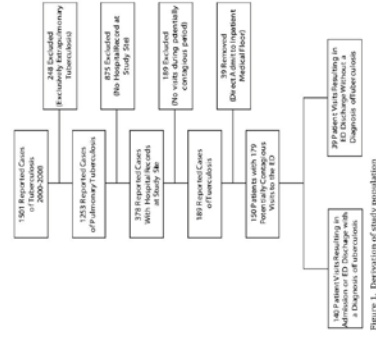


Figure 1. Derivation of study population

Results

Of the study population, 150 (12.0%) of pulmonary TB patients presented to the PED over 179 visits within one month of a verified diagnosis of active pulmonary TB. Patients presenting to the public emergency department were more likely to be male, Hispanic, homeless, HIV-positive, current resident of a correctional facility or a long-term care facility, or to have a recent history of substance abuse or unemployment. Furthermore, PED patients were more likely to have multidrug resistant TB and to die before completion of treatment. Comparison of potentially contagious TB patient visits demonstrated that patients were significantly less likely to receive a diagnosis of TB when presenting with a traumatic or orthopedic chief complaint, denying cough, dyspnea, fever or chills, having a normal pulmonary exam and/or chest x-ray, being unresponsive during questioning, or reporting a recent history of both homelessness and excess alcohol use. Baseline sensitivity for the diagnosis of TB during a potentially contagious visit was 78.2%. Modeling revealed an increase in sensitivity to 97.9% if patients were assessed for altered mental status, pulmonary or infectious chief complaint, abnormal vital signs, or history of substance abuse or foreign birthplace.

Table 1. Baseline sensitivity for the diagnosis of TB during a potentially contagious visit

| Characteristic | Number of TB Patients | Number of Potentially Contagious Visits | Sensitivity (%) | p-value |
|--|-----------------------|---|-----------------|---------|
| Age, years (SD) | 43 (17.8) | 112 (10.7) | 0.9026 | 0.0021 |
| Male | 112 (10.7) | 62 (5.8) | 0.9026 | 0.0021 |
| Hispanic | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Foreign Born | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Homeless | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| HIV positive | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Current resident of a correctional facility or a long-term care facility | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Recent history of substance abuse or unemployment | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Resistant to at least one anti-TB drug | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Resistant to at least two anti-TB drugs | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Resistant to all anti-TB drugs | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Non-infectious chief complaint | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Denying cough, dyspnea, fever or chills | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Normal pulmonary exam and/or chest x-ray | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Unresponsive during questioning | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Recent history of both homelessness and excess alcohol use | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Assessed for altered mental status, pulmonary or infectious chief complaint, abnormal vital signs, or history of substance abuse or foreign birthplace | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |

Table 2. Baseline sensitivity for the diagnosis of TB during a potentially contagious visit

| Characteristic | Number of TB Patients | Number of Potentially Contagious Visits | Sensitivity (%) | p-value |
|--|-----------------------|---|-----------------|---------|
| Age, years (SD) | 43 (17.8) | 112 (10.7) | 0.9026 | 0.0021 |
| Male | 112 (10.7) | 62 (5.8) | 0.9026 | 0.0021 |
| Hispanic | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Foreign Born | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Homeless | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| HIV positive | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Current resident of a correctional facility or a long-term care facility | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Recent history of substance abuse or unemployment | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Resistant to at least one anti-TB drug | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Resistant to at least two anti-TB drugs | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Resistant to all anti-TB drugs | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Non-infectious chief complaint | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Denying cough, dyspnea, fever or chills | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Normal pulmonary exam and/or chest x-ray | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Unresponsive during questioning | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Recent history of both homelessness and excess alcohol use | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |
| Assessed for altered mental status, pulmonary or infectious chief complaint, abnormal vital signs, or history of substance abuse or foreign birthplace | 92 (8.6) | 41 (3.8) | 0.9026 | 0.0021 |

Table 3. Baseline sensitivity for the diagnosis of TB during a potentially contagious visit

| Characteristic | Number of TB Patients | Number of Potentially Contagious Visits | Sensitivity (%) | p-value |
|----------------------------|-----------------------|---|-----------------|---------|
| Temperature | 37.4 (0.3) | 37.3 (0.2) | 0.9026 | 0.0021 |
| Heart Rate | 100.1 (1.2) | 97.4 (1.4) | 0.9026 | 0.0021 |
| Respiratory Rate | 18.1 (1.1) | 17.2 (1.0) | 0.9026 | 0.0021 |
| O2 Sat | 95.5 (0.5) | 97.2 (0.6) | 0.9026 | 0.0021 |
| Cough | 94 (1.25 (25.2)) | 10 (2.2 (46.0)) | 0.9026 | 0.0021 |
| Hemoptysis | 26 (66 (20.2)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Weight loss | 60 (125 (40.0)) | 1 (2.2 (46.0)) | 0.9026 | 0.0021 |
| Chills | 60 (125 (40.0)) | 1 (2.2 (46.0)) | 0.9026 | 0.0021 |
| Subjective fever | 60 (125 (40.0)) | 1 (2.2 (46.0)) | 0.9026 | 0.0021 |
| Abnormal lung exam | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal chest x-ray | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal sputum | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal lymphadenopathy | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal ECG | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal urinalysis | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal blood chemistry | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal social history | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal travel history | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal contact history | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |
| Abnormal treatment history | 70 (100 (70.0)) | 6 (13 (27.7)) | 0.9026 | 0.0021 |

Figure 2. Chief complaint of TB patients during a potentially contagious visit.

Conclusions

In this study, TB patients presenting to the public emergency department were significantly more likely to have many of the known risk factors for TB, be diagnosed with MDR-TB and die before completion of therapy. Patients with a history of alcohol abuse and homelessness, or lack of signs and symptoms classical for TB were less likely to be diagnosed with TB during a potentially contagious visit. This study adds evidence to the belief that public emergency departments disproportionately care for TB patients and that these patients have a more precarious health status and greater risk for mortality than those who are diagnosed by other facilities.

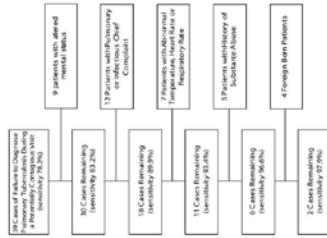


Figure 3. Derivation of a decision tool for identification of patients at very high risk for active pulmonary TB

Limitations

- The epidemiological patient characteristics were not obtained with this study in mind and therefore may not have the validity of a prospective study.
- The retrospective nature of the medical record review limited the ability to acquire missing data.
- This study did not have a control group of non-TB patients in the public emergency department.
- This was a single-site study, therefore these results may not reflect the state in emergency departments with different patient populations.
- Our definition of 'potentially contagious' could lead to inclusion of some cases that were not actually contagious. (It is important to note that the CDC uses the less generous definition of 50 days).
- The analysis of predictors of receiving the diagnosis of TB in the public emergency department was conducted by visit, rather than by patient. Thus patients who made multiple visits to the ED will have a greater effect on this analysis than those who presented only once.
- The proposed decision tool was derived from a very small sample and should be validated in a larger study with a different patient population.

Acknowledgements

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