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The uncertainty, challenges, and variability in tuberculosis congregate setting investigations: The concentric circle model revisited

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ABSTRACT

In the United States tuberculosis programs routinely conduct congregate setting contact investigations in locations such as schools, workplaces, social/recreational sites, nursing homes and prisons. Both documented and anecdotal reports describing these investigations have indicated, in many cases, the unnecessary testing of large numbers of individuals. This article revisits the concentric circle model and its application in congregate setting investigations. In its simplest form this model, despite imperfections, offers tuberculosis programs an opportunity to utilize this approach as a secondary tool to assist in the identification of contacts at both the highest and lowest level of risk due to exposure based on time and place to an infectious or potentially infectious patient. The methodology described here offers a prudent and viable alternative to not allowing a congregate setting investigation to be viewed as a general screening activity where excessive numbers of individuals are needlessly tested.

1. Introduction

Tuberculosis (TB) is an airborne infectious disease produced by the causative agent *Mycobacterium tuberculosis*. Since respiratory TB is communicable, identification of exposed persons plays a pivotal role controlling this disease. A contact investigation (CI) attempts to identify, locate, and refer appropriate contacts for medical evaluation. As such, CIs have been described as a priority activity in TB programs in the United States and represent one of several active case-finding strategies [1,2]. The objective of the CI is to identify and treat TB contacts with infection or disease preventing future disease or further transmission.

As part of the CI process in the United States, TB programs also routinely conduct congregate setting investigations (CSI). A congregate setting is an environment where a number of people reside, meet, or gather in close proximity for either a limited or extended period of time. Examples include prisons, nursing homes, schools, and workplaces [3]. Similar to the CI, the primary objective of the CSI is to identify and prevent additional cases of TB.

There have been reports describing CSIs that have identified hundreds of contacts oftentimes as a result of exposure to a single individual diagnosed with pulmonary TB [4–7]. CSIs have diverse circumstances coupled with their own array of complexities; however, it may be beneficial to highlight core concepts of TB as related to CSIs to better focus the investigation.

Important aspects of CSIs offer distinct variables including the level of infectiousness of the TB patient, the environment where potential exposure occurred, the frequency and duration of the exposure, and additional individual risk factors associated with contacts [8]. As a result of these four primary elements coupled with the absence of a universal, definitive method of contact identification, investigations of congregate setting exposures are reliant upon the experience of local health departments and TB programs for the on-site assessment of exposure environments and the subsequent identification of contacts.

2. Concentric circle model

To assist programs in CSIs, the concentric circle model, despite imperfections and limitations, remains a useful and practical methodology to be considered for application during the process of contact identification [8] (Fig. 1). This approach, although not new, is a method which ideally limits the scope of CIs and helps to establish priorities based on the risk of TB transmission to identified contacts. In general, those contacts with the greatest duration and intensity of exposure are tested first. If there is no evidence of recent transmission in these contacts, expanding the investigation may not be warranted. However, if recent transmission is identified, testing can be extended progressively to lower-risk contacts until the levels of infection approximate

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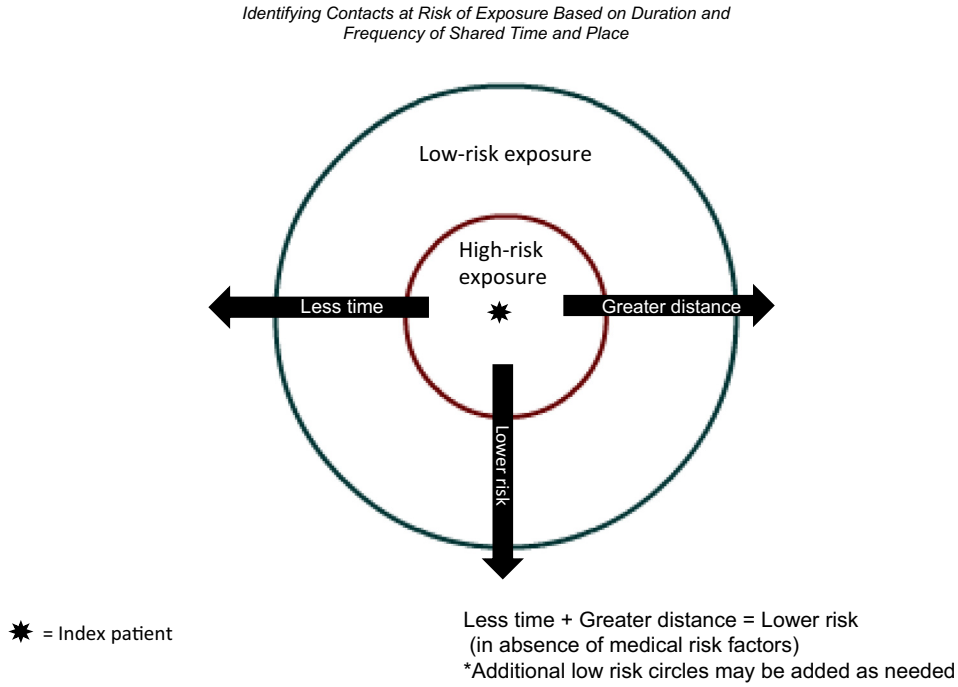

Fig. 1. Concentric circle model in TB control.

the levels of infection in the community where exposure has occurred. Once the infection rate in the group tested does not exceed the infection rate that is generally expected of the local community, testing may stop. The advantage of this approach is its simplicity and the fact that contacts with less exposure are not evaluated until evidence of transmission exists. However, there are disadvantages associated with this model including using household contacts as predictors of transmission for non-household contacts, the vulnerability of lower-risk contacts not fully being considered, and unknown background TB infection prevalence in a community [8]. Additionally, while the concentric circle approach emphasizes levels of exposure in terms of time shared with the TB patient (most to least), TB programs should be careful not to exclude environmental characteristics, such as crowding and poor ventilation, that may contribute to transmission in those contacts who present with less frequent exposure. Similarly, contacts with less exposure but who present with high risk medical conditions should be considered for testing. Despite imperfections, this model places reliance upon individual program standards of practice that are generally applied when identifying contacts in a congregate setting. Once the contact identification process is complete, the concentric circle model lends guidance to public health programs in setting parameters and defining limits of the investigation, assisting in identifying contacts at risk of exposure and allowing the investigation to proceed in an orderly fashion while highlighting the variables of time, place, and space as they relate to exposure from the TB patient. This model is considered a tool to guide CIs while priorities have been established based on the perceived and or observed risk of transmission as determined by a TB program [9]. There is no national standard either in establishing criteria for hours of exposure that places an individual at risk or in differentiating high from low-risk contacts [2]. Therefore, local health departments and state TB programs may address this important element as they deem appropriate within their own standards of practice. While it is presumed that the likelihood of infection depends upon the intensity, frequency, and duration of exposure, no safe exposure to TB has been established and even the briefest exposure potentially may present a theoretical risk [8]. Still, TB programs should focus resources on identifying and testing only those exposed individuals who are more likely to be infected based on investigative findings.

3. Case study

A 20-year-old male college student with confirmed TB had a four-month history of cough. His chest x-ray revealed a cavitary pneumonia in the right upper lobe with sputum smear reported as acid-fast positive (4+). Initial interview identified three household and two social contacts. In addition, school exposure during the estimated infectious period was considered. The university undergraduate enrollment was 13,462. The patient attended 11 classes during the fall and spring semesters which encompassed the infectious period. Two hundred and sixty-five students and 10 faculty members were potentially exposed. A typical class met twice per week for 1.25 hours, for a total of 2.5 exposure-hours per week per class. A schedule of all 11 classes with student and faculty names was requested by the TB program. A review of class rosters revealed names of students and faculty sharing multiple classes with the patient during both semesters. The classrooms ranged from 396–1136 square feet with ceiling heights of 12 feet. During the fall semester, several classrooms were identified as measuring 400 square feet and as spaces where student desks were approximately two feet apart representing a relatively crowded environment. Total classroom exposure hours during the infectious period were calculated ranging from a minimum of 20 to a maximum of 108 hours for each student and faculty member.

4. CI/CSI outcomes

The review of class rosters, hours of exposure, and classroom environments allowed for configuring a concentric circle which categorized layers of exposure of students and faculty ranging from the most to fewest hours exposed. Nineteen students and 1 faculty member with 80–108 exposure hours during the fall semester (16 weeks/106 potential contacts) were identified as high-risk contacts over the spring semester (8 weeks/169 potential contacts) based on overall time shared with the TB patient (Fig. 2).

A frequency distribution based on exposure time was used to identify cut points for the remaining concentric circles.

Two of three household contacts were diagnosed with TB infection and two social contacts were negative for a 40% positivity rate. Of 20