Increasing the efficiency and yield of a tuberculosis contact investigation through electronic data systems matching

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ABSTRACT

Background Electronic health data may improve the timeliness and accuracy of resource-intense contact investigations (CIs) in healthcare settings.

Methods In September 2013, we initiated a CI around a healthcare worker (HCW) with infectious tuberculosis (TB) who worked in a maternity ward. Two sources of electronic health data were employed: hospital-based electronic medical records (EMRs), to identify patients exposed to the HCW, and an electronic immunization registry, to obtain contact information for exposed infants and their providers at two points during follow-up.

Results Among 954 patients cared for in the maternity ward during the HCW’s infectious period, the review of EMRs identified 285 patients (30%) who interacted with the HCW and were, thus, exposed to TB. Matching infants to the immunization registry offered new provider information for 52% and 30% of the infants in the first and second matches. Providers reported evaluation results for the majority of patients (66%).

Conclusion Data matching improved the efficiency and yield of this CI, thereby demonstrating the usefulness of enhancing CIs with electronic health data.

Keywords: contact investigation, electronic medical records, information systems, tuberculosis

BACKGROUND

Transmission of infectious diseases in healthcare settings remains a major risk to the health of patients and healthcare workers (HCWs) in the United States. Despite its steady decline in incidence, transmission of Mycobacterium tuberculosis still occurs in US healthcare facilities, with the potential for numerous HCWs and patients to be exposed. When a person with infectious tuberculosis (TB) exposes others in a healthcare setting to M. tuberculosis, infection preventionists at the facility are expected to lead a contact investigation (CI) in collaboration with state and local health departments.

TB CIs include three major steps: 1) identifying persons exposed to TB (called “contacts”), 2) notifying those who have been exposed and evaluating them for TB infection and disease, and 3) providing such individuals access to appropriate treatment, if necessary. The goals of CIs are to identify infected individuals prior to them developing TB disease and to ensure their completion of preventive treatment. These investigations require partnership and extensive resources, and, despite large investments by healthcare facilities and health departments, the yield of CIs is often low, in terms of successfully locating, evaluating them for TB infection and disease, and treating contacts. Given these concerns, new approaches for conducting CIs more effectively and efficiently are needed.

One method for enhancing CIs involves the use of electronic health data. With increasing availability of electronic data sources, health departments and healthcare providers have examined how this technology can augment infection control practices, including CIs and outbreak investigations. Previously, outbreak investigations of other diseases, such as measles or blood-borne viral infections, have demonstrated how electronic data systems can increase timeliness and precision by providing important medical or demographic history and by rapidly identifying individuals at risk for infection. In this investigation, we report on our use of two systems, hospital-based electronic medical records (EMRs) and an electronic immunization registry, to enhance a TB CI, as well as our subsequent evaluation of these efforts.

METHODS

Investigation Setting

In September 2013, providers diagnosed culture-positive and acid-fast bacilli sputum smear positive pulmonary TB in an individual who worked at Mount Sinai Roosevelt hospital (MSR). During the 3-month infectious period leading up to the diagnosis, the HCW at MSR interacted regularly with newborns and mothers in the hospital’s antepartum and postpartum units. Once infected, infants are at high risk for rapid progression to TB disease; therefore, MSR and the New York City Department of Health and Mental Hygiene’s Bureau of TB Control promptly initiated a CI.

Data Sources

The General Electric Company’s Centricity Enterprise is an integrated EMR that supports clinical, financial, and administrative workflow automation across the continuum of acute care. This particular EMR is commonly called PRISM (Patient Real-Time Information Systems Management) by MSR users. This system tracks patient progress from predmission through discharge, enabling consistent documentation of assessments, progress notes, physician orders, medication administration, treatments, and lab/imaging results. PRISM employs a built-in audit trail that records all users’ documentations and that can be queried by reporting tools in the system.

PeriGen’s PeriBirth® is a multi-disciplinary, highly structured EMR for the obstetrics specialty. This specialized system tracks the
progress of the mother from the start of labor through delivery of the baby and postpartum care. It enables workflow improvements via the use of a standardized risk management system. The PeriBirth® reporting system provides performance tracking, insight into obstetrics trends, and benchmarking capabilities. Similarly to PRISM, a built-in audit trail tracks all users’ documentations and can be retrieved by a reporting tool in the system.

While PRISM and PeriBirth® are robust systems for monitoring all patients’ procedures, including a required newborn evaluation by a pediatrician, while they are receiving care at MSR, information in these records may change after they are discharged. To collect current contact information for exposed infants and their healthcare providers, a match was conducted with data in the New York Citywide Immunization Registry (CIR).

The CIR is a population-based immunization information system maintained at DOHMH that captures birth records and reports of vaccinations administered to patients < 19 years of age by NYC providers. Reporting to the CIR is mandated by New York State and NYC laws. The CIR meets high data quality standards for accuracy, completeness, and timeliness and participates in the Centers for Disease Control and Prevention’s sentinel project. Demographic, contact, and provider information was extracted from the CIR for all infants born at MSR during the HCW’s infectious period.

Data Utilization

MSR staff used PRISM and PeriBirth® to identify patients with exposure to TB, based on a definition developed by personnel from both MSR and DOHMH. To define exposure, a list of services that might involve contact between the HCW and mother only, HCW and mother with infant, or HCW and infant only was created. Built-in audit trails within the EMRs were used to identify patients who received these services from the HCW with TB disease. All HCW services were timed, and patients with a cumulative total of ≥ 30 min of interaction with the HCW with TB disease were considered to have been exposed.

DOHMH matched the records of infants identified as exposed to TB (via the process described above) to CIR data using their first name, last name, date and hospital of birth, home address, and their mother’s first and last name, when needed. Updated contact information from the CIR match was used to notify patients of the TB exposure and to give them instructions for obtaining a TB evaluation. Telephone calls to parents and receipt of notification letters via certified mail were tracked to confirm whether patients were informed of the exposure. In addition, all healthcare practices identified in the CIR as providing care to an exposed infant were notified of the patient’s exposure, given guidelines for conducting a TB evaluation, and instructed to return evaluation forms to DOHMH.

Patients were actively followed for 10 months post-exposure; evaluation results were collected and analyzed at 2-4 months post-exposure for all patients and additionally at 6 months post-exposure for infants (which corresponded with infants turning 6 months of age). This supplementary evaluation was necessary for infants, because TB infection tests may yield a false negative reaction in children younger than 6 months. A final match with the CIR was conducted at 6 months post-exposure, to gather updated information for infants and their providers.

Measures

Descriptive statistics were generated to characterize the sex, age, and borough of residence of the patients. Next, we assessed how electronic health data contributed to the identification, notification, and evaluation of patients in this CI. To evaluate how EMRs helped identify whether TB exposure occurred, the proportion of exposed patients was calculated among all individuals admitted to the units where the HCW with TB disease worked during the infectious period. Next, the proportion of contacts who received notification about the TB exposure was calculated.

Given that the contact information used for notifications was updated using the CIR, we quantified the amount of new information that this database provided. We compared the telephone number, residential address, and healthcare provider and practice listed in the EMRs to the corresponding CIR information for each infant. Infants with a different telephone number, residential address, or provider information were noted. This comparison was conducted again after the final CIR match. Finally, we calculated the proportion of contacts whose provider reported evaluation results to DOHMH. As data were obtained as part of a routine CI, this work was considered a program evaluation and was not subject to review by the DOHMH Institutional Review Board; the MSR Institutional Review Board determined that this work met the criteria for exemption from review.

RESULTS

Identification of Exposed Patients

DOHMH and MSR identified 145 mothers and 140 infants who had been exposed to TB. Exposed patients lived predominantly in the borough of Manhattan; mothers ranged in age from 19 to 44 years, and infants ranged in age from 33 to 114 days at the time of exposure notification (Table 1). These mothers and infants represented only 31% and 29% (respectively) of the patients in these units during the HCW’s infectious period (Figure 1).

Notification of TB Exposure

Nearly all infants with exposure to the HCW with TB disease were identified in the CIR at both matches (Table 2). The initial match of EMR data with the CIR data yielded an updated telephone number and/or address of residence for 49% of infants and a different provider for 52% of infants. Matching with the CIR at 6 months post-exposure provided new information primarily on current healthcare provider, with the CIR identifying a new provider and/or practice location for about one-third of infants.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mothers (n = 145)</th>
<th>Infants (n = 140)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>145 (100)</td>
<td>67 (48)</td>
</tr>
<tr>
<td>Mean age (standard deviation)</td>
<td>33.1 (5.6)</td>
<td>79.2 (19.1)</td>
</tr>
<tr>
<td>Borough of residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brooklyn</td>
<td>29 (20)</td>
<td>30 (21)</td>
</tr>
<tr>
<td>Bronx</td>
<td>18 (12)</td>
<td>17 (12)</td>
</tr>
<tr>
<td>Manhattan</td>
<td>72 (50)</td>
<td>70 (50)</td>
</tr>
<tr>
<td>Queens</td>
<td>14 (10)</td>
<td>11 (8)</td>
</tr>
<tr>
<td>Outside NYC</td>
<td>12 (8)</td>
<td>12 (9)</td>
</tr>
</tbody>
</table>

*aAge in years.

*bAge in days.
Collection of Evaluation Results

DOHMH collected evaluation results for infants and mothers up to 10 months post-exposure. During that time, most mothers (59%) and infants (73%) had evaluation results reported to DOHMH (Figure 1). Providers returned evaluation forms to DOHMH for an additional 10 infants (7%), but the evaluation results were incomplete due to patient refusal or loss to follow-up. None of these infants developed TB disease during the follow-up period.

DISCUSSION

Large CIs in healthcare settings require substantial resources on behalf of the local health department and healthcare facility.\(^5\) Matching with electronic health systems reduced the resource burden in the current CI by enhancing the identification, notification, and evaluation of contacts. Of all the mothers and infants admitted to the antepartum and postpartum units at MSR during the infectious period of the HCW with TB disease, EMRs were used to identify the 31% of mothers and 29% of infants who met the exposure definition. This strategy of using EMRs to assess exposure differs from past CIs, in which all patients attending the facility or unit during the infectious period were considered exposed,\(^14\) an approach that identifies large numbers of contacts who may not have been exposed and generates a substantial workload.\(^14,17\) Restricting this investigation to patients with documented exposure to the HCW with TB disease enabled us to concentrate resources on those at greatest risk for TB infection and decreased the number of patients being screened and treated unnecessarily.

Almost all exposed infants were identified in the CIR, and this surveillance system provided a rich source of contact information. Past investigations in pediatric settings have reported finding only 30–80% of exposed patients.\(^19\) In comparison, DOHMH and MSR notified 100% of infants' parents or guardians about this instance of TB exposure, thereby highlighting the usefulness of the CIR in supplying current and accurate contact information.

In addition to the updated contact information obtained for infants, the CIR also identified new provider information for 52% of infants in

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**Table 2:** Yield of the Initial and Final Matches with the New York Citywide Immunization Registry (CIR) for Infants Exposed to Tuberculosis (TB) at Mount Sinai Roosevelt (MSR) Hospital

<table>
<thead>
<tr>
<th></th>
<th>Initial CIR match(^a)</th>
<th>Final CIR match(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIR match identified</td>
<td>138 (99)</td>
<td>123 (100)</td>
</tr>
<tr>
<td>Updated contact info.</td>
<td>68 (49)</td>
<td>6 (5)</td>
</tr>
<tr>
<td>Updated provider info.</td>
<td>72 (52)</td>
<td>37 (30)</td>
</tr>
</tbody>
</table>

\(^a\)Represents the match completed at 2–4 months postexposure. Includes all 140 infants exposed to TB at MSR.

\(^b\)Represents the match completed at 6 months postexposure. Excludes 17 infants exposed to TB at MSR with addresses outside New York City, who were transferred to other jurisdictions.
the initial match and 30% of infants in the final match. This high proportion of new providers reflects the fact that the pediatrician who evaluates an infant in MSR may not remain the provider after discharge, as well as the lack of continuity that many young children experience in primary care.21

Capturing the change in providers improved follow-up in this investigation. DOHMH staff distributed exposure letters and guidelines to current providers using mailing addresses, fax numbers, and email addresses found in the DOR. Several practices noted distributing these resources to multiple personnel at each practice, increasing the chance that staff performed a TB evaluation for exposed infants. Furthermore, this outreach offered DOHMH an opportunity to provide technical guidance to providers about TB evaluation in infants, which was critical, because many pediatricians have limited experience evaluating and treating young children with recent TB exposure.22

All of these elements—from identifying patients with direct TB exposure to obtaining current contact information for infants and their providers—contributed to a high return of evaluation results for mothers (59%) and infants (73%). The larger proportion of evaluation results among infants reflects our outreach to providers as well as our focus on follow-up in this group, due to their high risk for progression to TB disease. Nevertheless, these results for both mothers and infants represent significant improvements over past DOHMH investigations in maternity wards, in which only 29–43% of exposed patients had evaluation results reported.18,20 Moreover, by enabling MSR and DOHMH to focus on a limited number of patients and to successfully reach infants and providers, these data-matching efforts improved the yield and timeliness of the investigation.

CONCLUSION

This investigation demonstrated the benefits of linking data across electronic health systems during standard CI or outbreak investigations. As the use of electronic health information systems becomes more widespread, health departments and healthcare facilities must continue to explore innovative applications of these data sources, such as identifying and locating contacts and assessing meaningful exposure in epidemiologic investigations, to improve the efficiency and quality of infection control activities.

CONTRIBUTORS

J.M.S. designed the evaluation, conducted all analyses, and led the writing of the article. D.C.P. and L.T. guided data acquisition and analyses, contributed to interpretation of results, and provided critical review on all drafts of the manuscript. E.S. and B.P. acquired data from electronic medical records, drafted all portions of the manuscript related to the electronic medical records, and contributed to article revisions. S.D.A. conceptualized the study, assisted with the acquisition of data and interpretation of the results, and contributed to article revisions. All authors reviewed the final version of the article.

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COMPETING INTERESTS

None.

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REFERENCES


19. Brassard P, Lamarre V. Evaluation of Mycobacterium tuberculosis transmission from a pediatrician and initial compliance to prophylaxis...

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