Infections Acquired in Clinical Laboratories in Utah

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We reviewed laboratory-acquired infections occurring in Utah from 1978 through 1982. Written and telephone interviews of supervisors of 1,191 laboratories revealed an estimated annual incidence of 3 laboratory-acquired infections per 1,000 employees. Infections, in order of frequency, included hepatitis B (clinical cases), shigellosis, pharyngitis, cellulitis, tuberculosis (skin test conversion), conjunctivitis, and non-A, non-B hepatitis. One-half of large laboratories (over 25 employees), but only 12% of smaller laboratories, reported infections. The annual incidence, however, at smaller laboratories was more than three times greater than at large laboratories (5.0 versus 1.5 per 1,000; P < 0.05, chi-square test). Microbiologists were at greatest risk of infection, with an incidence of almost 1%, followed by generalists and phlebotomists. Shigellosis was acquired only by microbiologists and accounted for more than half of their infections. The most common laboratory-acquired infection, hepatitis B, affected a microbiologist, a hematologist, a phlebotomist, a pulmonary blood gas technician, and a blood bank technologist who died from her illness. Clinical cases of hepatitis B occurred at a rate 10 times higher than the rate in the general U.S. population. The incidence of tuberculosis skin test conversion was intermediate between rates reported for hospital employees and for the state of Utah.

Medical laboratories pose some unusual occupational hazards including infections. Many of these infections are serious, and some have resulted in death. Epidemiological analysis of these infections may identify environmental and personal risk factors and lead to appropriate control measures.

A British survey of infections in 21,000 laboratorians (including medical, technical, scientific, and clerical staffs) during 1971 detected acquired cases of tuberculosis, shigellosis, brucellosis, and hepatitis (8). The annual incidence of infection in England and Wales calculated was 4.3 per 1,000 laboratorians. Pike’s review of reported worldwide laboratory-acquired infections over 76 years showed decreasing numbers (14). During the years 1968 to 1977, there were 550 infections compared with 650 during the preceding 10 years, possibly reflecting technological advancements, disposable materials, and increased safety requirements.

We conducted a survey of all clinical laboratory supervisors in Utah to characterize laboratory-acquired infections.

MATERIALS AND METHODS

A written survey and a telephone interview were conducted. Survey forms were sent to supervisors of all 84 Utah clinical diagnostic laboratories. These were the laboratories that perform tests on any body fluid of patients, whether or not the laboratories were located within the hospital. The survey form requested the number of microbiologists, microscopists, hematologists, pulmonary blood gas techni- cians, blood bank technicians, generalists, and phlebotomists employed. Pathologists and histotechnologists were not included. If the written form was not returned, it was completed by a telephone interview. When infections were reported, a follow-up telephone interview confirmed the type, severity, method of confirmation, and the route of transmission. Severity was described by the amount of time lost from work, use of long-term sick leave, permanent disability, or death. Infections were confirmed either by positive culture, serological tests, or physician’s clinical diagnosis. The route of infection was categorized as “working with the culture,” “parenteral inoculation,” “aerosol production,” “labora- tory accident,” or some other “unknown” route.

RESULTS

All 84 clinical laboratory supervisors in Utah participated. The laboratories employed a total of 1,191 people. Part-time employees were included. The totals were rounded off to the nearest whole number. Eighteen infections were reported for the 5-year period. The annual incidence was calculated to be 3 infections per 1,000 laboratorians. Yearly incidence during each of the 5 years was similar.

Hepatitis. The most common laboratory-acquired infec- tions was hepatitis B. Five clinical cases occurred, one each in a microbiologist, a hematologist, a phlebotomist, a pulmonary blood gas technician, and a blood bank technologist who died of her illness. The exact route of infection was unknown in four of the cases. One case was thought to be associated with a needlestick, parenteral inoculation. Of the four surviving patients, three required 2 weeks to 2 months of leave from work. One case involved no loss of work.

One case of non-A, non-B hepatitis diagnosed by a physi- cian occurred in a chemistry technologist. The route of infection was unknown. The illness continued for 6 to 7 months, but involved no time off from work.

Enteric infections. Four cases of shigellosis (two Shigella flexneri, one Shigella sonnei, and one Shigella sp.) were reported. All were among the 149 microbiologists; not surprisingly, all were confirmed by culture. No shigella infections occurred among the 1,042 other clinical laboratorians (P < 0.01, Fisher’s exact test). One case occurred in a microbiologist who remained culture positive and sympto- matic for 6 weeks. She developed her symptoms within 48 h of serotyping an S. flexneri isolate from the Utah Depart- ment of Health proficiency sample test. Another S. flexneri infection acquired from an Analytab Products setup resulted

* Corresponding author.
TABLE 1. Annual incidence of acquired infection by laboratory size

<table>
<thead>
<tr>
<th>Laboratories</th>
<th>Total for 5 yrs in Utah</th>
<th>No. of laboratories</th>
<th>No. of infections</th>
<th>Total no. of laboratorians</th>
<th>Annual rate/1,000 laboratorians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (1 to 25</td>
<td>74</td>
<td>13</td>
<td>521</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>(26 to 112</td>
<td>10</td>
<td>5</td>
<td>670</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>18</td>
<td>1,191</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>

in a 10-day hospitalization. Two others acquired from working with cultures each led to a loss of about 1 week of work. The annual incidence of shigella infection for all clinical diagnostic laboratorians is 0.7 per 1,000. The incidence for microbiologists is 5.4 per 1,000.

Pharyngitis. Generalists who also handled specimens submitted for culture reported three cases of group A streptococcal pharyngitis thought to be acquired in the laboratory, although the exact route of transmission was unknown. The three infections were confirmed by positive cultures. No loss of work time was involved.

Tuberculosis. Tuberculosis purified protein derivative skin test conversion occurred in a generalist and in a microbiologist, both of whom cultured specimens for Mycobacterium tuberculosis. Both used safety hoods. The exact routes of transmission were classified as unknown because the infections could not be associated with any particular culture. The annual incidence in Utah for laboratorians is 0.3 per 1,000.

Cellulitis. Two cases of cellulitis occurred. The first occurred after a phlebotomist was cut by a broken tube. The second, in a generalist, involved three episodes of cellulitis eventually discovered to be self-inflicted. The Staphylococcus aureus isolated from the lesions had an identical sensitivity pattern to a multiply resistant control strain used for laboratory studies.

Conjunctivitis. One case of conjunctivitis occurred. While a microbiologist was inoculating an eye swab on primary plates, a bit of material flipped into his eye. One day later, he developed an eye infection with Hemophilus influenzae, the same organism from the original eye specimen.

Risk factors. We found several apparent risk factors for laboratory-acquired infection. One-half of large laboratories (those with over 25 employees), but only 12% of small laboratories, reported infections. The annual incidence, however, at smaller laboratories was more than three times greater than at large laboratories, 13 infections among 521 laboratorians and 5 infections among 670 laboratorians, respectively (P < 0.05, chi-square test) (Table 1). Microbiologists were at greatest risk of acquiring infection with an annual incidence of 9.4 per 1,000 followed by generalists (5.2 per 1,000) and phlebotomists (3.1 per 1,000) (Table 2). Shigellosis was acquired only by microbiologists and accounted for more than half of their infections. Hepatitis infection, however, was not associated with any particular laboratory specialty.

Of the 18 cases of laboratory-acquired infections we identified, the routes of transmission were unknown in 10, parenteral inoculation in 4, laboratory accident in 2, and self-infected in 1 case (Table 3). None was known to be associated with aerosol production.

TABLE 2. Laboratory-acquired infections by specialty, 1978 to 1982

<table>
<thead>
<tr>
<th>Specialty (n)</th>
<th>Conjunctivitis</th>
<th>Tuberculosis skin test conversion</th>
<th>Cellulitis</th>
<th>Pharyngitis</th>
<th>Shigellosis</th>
<th>Non-A, non-B hepatitis</th>
<th>Hepatitis B</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbiologists</td>
<td>1 (1.3)</td>
<td>1 (1.3)</td>
<td>4 (5.4)</td>
<td>1 (1.0)</td>
<td>1 (1.3)</td>
<td>7 (9.4)</td>
<td>1 (1.0)</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>Chemists (206)</td>
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<td></td>
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<td>Microscopists (21)</td>
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<td>Hematologists (156)</td>
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<td>Phlebotomists (131)</td>
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<td></td>
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<tr>
<td>Blood gas technicians (258)</td>
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<tr>
<td>Generalists (193)</td>
<td>1 (1.0)</td>
<td>1 (1.0)</td>
<td>3 (3.1)</td>
<td>1 (0.8)</td>
<td>1 (2.6)</td>
<td>5 (2.6)</td>
<td>1 (2.6)</td>
<td>5 (2.6)</td>
</tr>
<tr>
<td>Blood Bank technicians (77)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total laboratorians (1,191)</td>
<td>1 (0.17)</td>
<td>1 (0.17)</td>
<td>2 (0.33)</td>
<td>3 (0.50)</td>
<td>4 (0.67)</td>
<td>1 (0.17)</td>
<td>5 (0.84)</td>
<td>18 (3.02)</td>
</tr>
</tbody>
</table>

TABLE 3. Route of acquired infection by laboratory specialty

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Parenteral inoculation</th>
<th>Working with culture</th>
<th>Laboratory accident</th>
<th>Unknown</th>
<th>Aerosol</th>
<th>Intentional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbiologists</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Chemists</td>
<td></td>
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<tr>
<td>Microscopists</td>
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<tr>
<td>Hematologists</td>
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<tr>
<td>Phlebotomists</td>
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<tr>
<td>Blood gas technicians</td>
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<tr>
<td>Generalists</td>
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<tr>
<td>Blood bank technicians</td>
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<td></td>
</tr>
<tr>
<td>Total laboratorians</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
DISCUSSION

Acquired hepatitis B. Parenteral spread of hepatitis was first noted after an accidental inoculation in 1929 in a laboratory employee (14). In 1973, an unusual outbreak was described (13). During a 6-month period, hepatitis developed in five employees of a large, hospital-based clinical laboratory. Risk-factor analysis for ill employees and a control group showed that only a history of sustaining cuts while handling laboratory requisitions was statistically significant. An epidemic of hepatitis B virus infection was associated with computer card handling! Transmission of hepatitis B virus in the clinical laboratory has been shown to be subtle and mainly via hand contact with contaminated items during the various steps of blood processing. Data have supported the concept that the portal of entry of hepatitis B virus is through apparent (and apparent) breaks in the skin and mucous membranes (5, 11). It has been shown that as little as $10^{-8}$ ml of infectious serum can transmit hepatitis (5). Frequently laboratorians with hepatitis B antibody do not have a history of hepatitis.

Hepatitis cases acquired in Utah’s clinical laboratories are similar in type and rate to those reported in the 1971 British survey, 0.8 and 1.7 per 1,000 annually, respectively.

Our estimated annual rate of clinical cases of hepatitis B for clinical diagnostic laboratorians in Utah is 0.84 per 1,000 as compared with 0.06 per 1,000 for the general Utah public (6).

Enteric infection. Reports of typhoid fever, acquired from educational proficiency testing or research specimens, called attention to the fact that laboratory-acquired enteric infections are more common than once realized (2). Two additional cases in Utah (1) were not reflected in our survey because they did not occur in a clinical diagnostic laboratory. These infections resulted when a known educational sample was provided for instructors to be used as an unknown sample. As a result, 59 medical technology students and laboratory personnel were exposed to Salmonella typhi.

Harrington and Shannon reported 37 cases of acquired shigellosis in 21,000 laboratorians in 1971 (8). The rate of 1.8 infections per 1,000 laboratorians is unexplainably higher than Utah’s rate of 0.7 per 1,000. The highest incidence of shigella infection reported in both surveys occurred among microbiologists.

Pharyngitis. The three cases of pharyngitis reported to us may not have been laboratory acquired; however, a 1981 letter to the Lancet described a laboratory-acquired human pharyngitis with group A, type 50 streptococcus (10). This was an experimental strain not previously thought to infect humans and was obviously laboratory-acquired. Utah laboratory supervisors also reported 12 cases of colds, influenza, and sinusitis. Their route of acquisition was uncertain, and they were not included.

Tuberculosis. There were no clinical cases of tuberculosis reported by Utah laboratorians. Harrington and Shannon reported 18 clinical cases of tuberculosis in laboratorians, a 5.4-fold increased risk of acquiring tuberculosis compared with the general population of England and Wales (8). Eight cases occurred among the technical staff, and the remaining 10 occurred among medical, scientific, necropsy, and clerical staff.

Two Utah laboratorians did report skin test conversion. This annual conversion rate of 0.3 per 1,000 laboratorians falls between the 0.9 per 1,000 described in hospital employees (4) and a rate of 0.03 per 1,000 described for the general Utah public (6). The Utah State Code requires tuberculosis skin testing of all new hospital employees.

Cellulitis and intentional infections. Our find that at least one infection was not accidental is not unprecedented. Pike’s survey reported a number of infections as intentional: 10 instances of apparent suicidal attempts, 7 attempts to harm another person, and 2 persons deliberately infected for experimental purposes (15). He also noted 44 cases of S. typhi in Japan when a disturbed bacteriologist inoculated food.

Conjunctivitis. A case of laboratory-acquired gonococcal conjunctivitis occurred when a tuberculin syringe and needle separated, spraying the technician’s face and eye (3). A similar accident reported in 1976 resulted in a case of laboratory-acquired syphilis (7). These accidents led to the recommendation to use syringes with self-locking needle devices. The conjunctivitis case we report, however, was associated with the use of a specimen swab to inoculate media.

Sources of infection. The sources of infection can be difficult to categorize. Broad general categories have been utilized. Sometimes the source of the infection is obscure. Working with the culture was utilized as a category when it was known only that the victim worked directly with the infectious agent.

Recognized accidents accounted for one-fifth of the total acquired infections reported by Pike and included those from needle and syringe, sprays, spills, injury from broken objects, pipette aspiration, bites, and scratches (14, 15).

Syringes and needles continue to be prime offenders; therefore, we distinguished them from other laboratory accidents. A recent survey that included laboratory personnel showed that one-third (35%) of them were injured during the year past, and only one-fourth (8%) of those injured reported the injury and sought treatment (9). Although most of the injuries involved blood contamination, the reason given most frequently for not reporting was an assumption that the injury was unimportant.

In clinical and diagnostic laboratories, another major source of infection is aerosol production associated with procedures. Pike’s study indicated that aerosol was responsible for 13% of the 3,900 cases he analyzed.

Aerosols are particles produced that are 5 µm or less in size. These can penetrate into intraalveolar spaces, but larger aerosols or droplets present a hazard of infection by direct contact.

Stern et al. demonstrated that, with centrifuging, only small amounts of contamination by aerosols actually occur (17). After hand vortex mixing and mechanical vortex mixing, minimal aerosol was detected. Using a paint can shaker for fecal fat analysis produces a vast amount of aerosol when the can is opened. The aerosol persists for more than 1 h within the unopened can. Opening capped specimen containers (Vacutainers), whether or not the tube was inverted to wet the stopper, produced no detectable aerosol. Pouring operations have been shown to produce considerably more aerosol than pipettes. Accidents, such as dropping tubes of blood or spilling serum, produce especially large amounts of aerosols. Aerosols may also be liberated when infectious materials are macerated, ground, and blended and when ampules of lyophilized agents are opened. Plunging a loop into a flame, lyophilization, animal or egg inoculation, and harvesting have all been shown to produce aerosols.

An example of spray of larger aerosol and droplet exposure occurred as early as 1918 when a technician working with an antimeningococcal serum accidentally sprayed her-
Three cases of *Pseudomonas pseudomallei* infection have been recently reported in laboratory workers (16). Review of two of the cases suggested exposure through aerosol. The third case involved a bacteriologist who accidentally spilled the organism during centrifugation. That accident involved larger aerosol and droplet contamination. Bench top and instrument surface contamination with droplets are associated with all procedures (9).

**Compensation.** Several supervisors mentioned compensation for acquired infections to be a problem. Worker’s Compensation laws were passed to provide compensation to workers injured in their work and to provide security to their dependents without the need to resort to personal injury litigation (12). Most cases involving employees’ acquisition of an infectious disease come under these laws. In the past, occupational diseases were handled separately. In interpreting these two categories of law, sometimes the court has looked for an accident to put the injury or disease under Worker’s Compensation laws. Even infections have been designated as accidents. Infections present unusual problems legally because they can be acquired outside employment. To qualify for Worker’s Compensation, there must be a causal relationship between the disease and the employment. This is often established in terms of whether the risk of an employee’s contracting the disease in a particular job is greater than the risk to the general population (12).

Communication between the personnel of the laboratory and the infection control program can affect whether claims concerning laboratory-acquired infections are awarded compensation. Infection control programs should include documentation of whether patients had certain infectious diseases and their location within the hospital. Disease occurring in laboratorians should be reported and recorded. Also, employee health determinations such as skin tests, serum antibody levels, and immunization and infection history may be helpful in determining whether an infection was related to employment.

**Conclusion.** From Pike’s worldwide data, it appears that laboratory-acquired infections may be decreasing. They clearly remain, however, a special occupational hazard for laboratorians. Our calculated incidence of infection is almost certainly an underestimate because of subclinical infections and poor recall.

The difference in rates reported by small and large hospitals is intriguing. Large hospitals may be safer, or it may be more difficult for their supervisors to recall infections occurring among a larger number of employees.

To prevent hepatitis B infection, the use of hepatitis B vaccine in laboratorians should be strongly considered. The high risk of shigellosis infection in microbiologists suggests that gloves and meticulous handwashing should be used when handling pure shigella cultures. The problem of infection acquired from proficiency testing samples has been recognized by Blaser et al. (1, 2) and in our survey and should be addressed by those circulating and handling these specimens.

With over one-half of these infections, the route of transmission was unknown. Assuming that an accident or needlestick would be recalled, many of these may be associated with working with the specimen or possibly aerosol or large droplet inoculation (or both). Meticulous attention to maintaining a clean work site is important. All accidents and injuries should be evaluated, treated, and documented as soon as possible.

Frequent handwashing remains the most important tool in infection control in the laboratory, as it is on the hospital wards.

**LITERATURE CITED**


