Legionnaires’ Disease Outbreak on a Merchant Vessel, Indian Ocean, Australia, 2015

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The risk for Legionnaires’ disease (LD) is known on cruise liners (1–3) and is matched by recommendations for preventive measures (4,5). Environmental sources of *Legionella pneumophila* in ships are prone to transmit LD over several years through resistance to decontamination (6,7). As opposed to cruise liners, there are few reports of LD on working vessels, where occupational health risks differ (8). *Legionella* was detectable in potable water systems on 58% of 350 merchant vessels in a recent survey (9). There was no established precedent for environmental risk assessment or control when 2 LD cases occurred on a merchant ship off the northwestern Australian Indian Ocean coast in 2015. We therefore conducted an extended field investigation.

The Study
The first LD case-patient on the merchant ship sought treatment at the nearest hospital emergency department, and provided no alternative exposure source. After laboratory confirmation of this case, the crew disembarked and the vessel was required to lie at anchor offshore. After using emergency control measures by a private contractor, we obtained information on the ship’s plumbing, including potable, fresh, and hot water systems; water storage; air conditioning; food preparation areas; and sleeping quarters.

We then boarded the ship for environmental investigation on August 27, 2015, to collect samples from potential sources in the ship’s cabins. Modification of maritime regulations for Legionnaires’ disease prevention in commercial vessels is needed for nonpassenger merchant ships.

Two cases of Legionnaires’ disease and 1 of Pontiac fever occurred among the crew of a merchant ship operating off the shores of Australia. PCR assays identified potential sources in the ship’s cabins. Modification of maritime regulations for Legionnaires’ disease prevention in commercial vessels is needed for nonpassenger merchant ships.

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A recent study of nonpassenger merchant vessels (NPMVs) highlighted the risk for *Legionella* contamination of potable water systems (9), but did not establish a link with confirmed infections. Our investigation of *L. pneumophila* serogroup 1 infection in a merchant vessel’s crew highlights the need to control *Legionella* in NPMV water systems, and the challenge of using PCR assays, which do not detect viable bacteria. Culture-dependent methods did not contribute to determination of the environmental source or route of dissemination. Preliminary control measures by external contractors may have prevented *Legionella* isolation from our environmental samples, but have doubtful long-term preventive value without sustained control measures because environmental persistence occurs in ships despite biocide treatment (6).

The survey vessel had a gross tonnage of 2,620, was 64 m long, 16 m wide, a draft of 4.7 m, and a crew of 27. It had 2 water storage tanks with 60,000 L capacity, an ultraviolet water sterilization unit, and 2 hot water gey-

ers. These tanks were refilled from bunkers while in port, and replenished at sea by reverse osmosis. Showers were highlighted in a previous study of NPMV potable water systems (9), and aerator devices have been implicated as bacterial amplification sites in tropical and nosocomial outbreaks (13,14).

Multiple positive PCR results from water outlets in the cabins implicated the showers and faucets as means of respiratory illness (Table 1). Later that day, another crew member, who had symptoms of severe bilateral pneumonia and pneumothorax, arrived at the regional hospital and required aeromedical evacuation for intensive care (case-

patient 2). LD was confirmed by urinary antigen testing and PCR assay on bronchial washings. Other crew members who had nonpneumonic respiratory and other symptoms were investigated for legionellosis by using urinary antigen tests and serologic tests which proved negative, except in case-

patient 3, who had *L. pneumophila* seroconversion and Pontiac fever that did not require hospital admission. The 3 cases all satisfied Australian LD case definitions (12). Case-patients 1 and 2 occupied adjacent cabins and case-patient 3 was 2 cabins away from case-

patient 2 (Figure 2).

*L. pneumophila* was not isolated from any environmental samples. Legionella PCR result was positive in 7/10 cabins tested (13/27 samples) (Table 2). A PCR result was positive for showerheads or residual water from sink faucets in the cabins of 2 LD cases. In 5 other cabins, only faucets were positive (Figure 2). Detection of sludge or biofilm in the showerheads and faucets prompted replacement with better-designed showerheads and removal of faucet aerators. Only 2/79 samples collected on the second visit on September 4 were Legionella PCR positive; a significant reduction ($\chi^2$, Yates’ correction; 15.98, p<0.001). Only 1 of the 58 samples from the third series of samples was clearly PCR positive, from a faucet in a cabin unconnected to LD cases. The in-field PCR results were identical to the confirmatory reference laboratory replicate results. All 10 types of showerhead were rust-stained inside and smelled of chlorine. The most common showerhead types had either 7 silicone rubber O-rings or 1 complex silicone rubber gasket. Showerhead swabs and agar O-ring impressions grew profuse mixed bacteria, commonly *Pseudomonas aeruginosa*. Nonpneumophila *Legionella* sp. was isolated from 1 showerhead. Legionella PCR assays produced unambiguous positives in 13/16 showerheads (19/32 samples). Almost all O-rings from the common showerhead types were *Legionella* positive (Technical Appendix Part 2).

**Table 1. Summary of confirmed legionellosis cases and results of environmental PCR testing in the case-patients’ merchant vessel cabins, August 2015***

<table>
<thead>
<tr>
<th>Case-patient</th>
<th>Age, y</th>
<th>Onset</th>
<th>Infection</th>
<th>Hospital</th>
<th>UAT</th>
<th>Serology</th>
<th>PCR†</th>
<th>Cabin no.</th>
<th>Shower</th>
<th>Showerhead</th>
<th>Bathroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54</td>
<td>Aug 12</td>
<td>Lower respiratory</td>
<td>Regional</td>
<td>+</td>
<td>—</td>
<td>+</td>
<td>22</td>
<td>+</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>55</td>
<td>Aug 19</td>
<td>Lower respiratory</td>
<td>Tertiary</td>
<td>+</td>
<td>—</td>
<td>+</td>
<td>18</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
<td>Aug 10</td>
<td>Mild respiratory</td>
<td>Not required</td>
<td>—</td>
<td>Conversion (0–2,048)</td>
<td>29</td>
<td>NA†</td>
<td>NA†</td>
<td>NA†</td>
<td></td>
</tr>
</tbody>
</table>

* NA, not available; UAT, urinary antigen test; †, positive; —, negative.
†PCR-positive *Legionella pneumophila*.
‡Cabin in use on August 27, 2015. Water from hand basin faucet collected on August 20 by private agency was culture negative.
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infection. All showerheads on the vessel had interior moving parts to control spray settings and were the leading PCR-positive location. A rust-colored biofilm inside most showerheads indicated possible deterioration of iron pipes in the ship’s distribution system, and persistence of Legionella in biofilms (15). The silicone rubber O-rings from the showerheads supported profuse growth of aquatic bacteria and were PCR positive for L. pneumophila. The O-rings formed a permanently wet niche for bacterial growth, and their movement will shear bacteria from biofilms. Faucet aerators also promote turbulent flow by mixing water and air under pressure. These results highlight the potential for Legionella aerosol generation. We recommended replacing the showerheads with a simpler plastic design, more suited to periodic removal, decontamination, and cleaning, and gravity drainage after daily use.

Conclusions
A cluster of L. pneumophila serogroup 1 infections in a vessel working in waters near Australia led to an environmental health assessment in which molecular methods enabled the field investigation team to implicate water outlets in crew quarters and tailor environmental controls. Deployment of quantitative PCR assays extended our investigative reach offshore, enabling faster return of the vessel to active service. The leadership and crew of non-passenger merchant vessels operating in tropical waters need heightened Legionella awareness and require control measures more stringent than those applied in passenger vessels.

Acknowledgments
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T.J.I. and R.J.M. managed the patients and the corresponding clinical laboratory investigations. T.J.I. initiated the public health laboratory investigation in collaboration with G.K.D., who coordinated the public health response to the outbreak, liaised with the shipping company, maritime authorities, and regional public health unit. C.S. assisted with environmental

<table>
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<th>Table 2.</th>
<th>Legionella pneumophila PCR results from environmental samples collected on merchant vessel, Australia, 2015*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample type</td>
<td>August 27</td>
</tr>
<tr>
<td></td>
<td>Reference laboratory testing</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Cabin shower heads</td>
<td>6</td>
</tr>
<tr>
<td>Cabin faucets</td>
<td>14</td>
</tr>
<tr>
<td>Air conditioning</td>
<td>4</td>
</tr>
<tr>
<td>Water supply</td>
<td>2</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
</tr>
<tr>
<td>Total results</td>
<td>27</td>
</tr>
<tr>
<td>PCR controls</td>
<td>Positive, Legionella DNA extract</td>
</tr>
<tr>
<td></td>
<td>Negative, ultrapure water</td>
</tr>
</tbody>
</table>

*NA, not applicable; +, positive.
specimen collection from the start of the investigation and collected subsequent PCR sample series with the support of H.C. The first boarding party comprised T.J.J.I., C.S., and J.D., who together collected, documented, secured, and forwarded environmental samples and their contextual data. M.C. and A.M.-M. conducted the environmental bacteriology, in consultation with and under the guidance of M.H. T.J.J.I. conducted the Legionella PCR assays in the field. A.J.M. verified these in the reference laboratory and conducted the additional PCR analyses. T.J.J.I. collated input from the other authors and wrote the first draft, which was then edited by A.J.M. and G.K.D. before circulation to the other authors. All authors have contributed to this report, and have reviewed and checked its content for accuracy.

About the Author
Dr. Inglis is a medical and public health microbiologist at PathWest Laboratory Medicine WA, Nedlands, Western Australia, who has worked on emerging infectious diseases in Western Australia since 1997. His research interests include bioreconnaissance, melioidosis, and emerging antimicrobial resistance.

References

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