Acinetobacter baumannii is a troublesome and increasingly problematic healthcare-associated pathogen, especially in critical care.\textsuperscript{1-4} It may be associated with hospital-acquired infections with considerable clinical and economic costs. In physiologically compromised patients, morbidity and mortality are common sequelae of hospital-acquired infections.\textsuperscript{4-7} Hence, multiple professional organizations have identified multidrug-resistant (MDR) pathogens as a critical target that requires intervention (Tables 1 and 2).

**Authors**

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Our experience with managing an outbreak of MDR *A baumannii* in a medical intensive care unit (ICU) prompted an evidence-based review of the literature, which resulted in few findings. Key elements of outbreak control and nursing care interventions associated with this resistant strain had not been identified. In this article, we provide a synthesis of the medical literature on *A baumannii*, a chronology of our efforts to control the outbreak, and recommendations for responding to *A baumannii* infections in ICU settings.

### Literature Review

#### Characteristics of *A baumannii* and *A baumannii* Infections

*Acinetobacter baumannii* is a non-fermentative, aerobic, opportunistic, gram-negative coccobacillary rod. Morphological findings vary according to the phase of cell growth and exposure to antimicrobial agents.1,2 Widely distributed in soil and water, *A baumannii* grows at various temperatures and pH environments and uses a vast variety of substrates for growth.3,4,11 The indiscriminate nature of this organism and its recent acquisition of MDR intensify its emergence and significance in healthcare environments.5

*Acinetobacter baumannii* normally inhabits skin, mucous membranes, and soil. The organism can survive for long periods on both dry and moist surfaces.2 A total of 19 strains of *A baumannii* have been identified.12 Although inconsequential to hosts with intact immune systems, *A baumannii* infections may be fatal in those with suboptimal immune defenses. The evolution of this infection commonly occurs in chronically ill patients who have multiple comorbid conditions, are hospitalized for long periods, have multiple invasive procedures, and are of advanced age. Risk factors encompass those for hospital-acquired MDR infections and ventilator-associated pneumonias (Table 3). The role of *A baumannii* in hospital-acquired infections is associated with 3 factors: its diverse reservoir, its association with antimicrobial resistance, and its outbreak potential.

#### Growth Reservoir

Although risk factors for *A baumannii* infection have been well described, the reservoirs of this pathogen are poorly understood.4 *Acinetobacter baumannii* is nonselective in its habitat (Table 4) and can survive indefinitely. The respiratory tract, blood, pleural fluid, peritoneum, urinary tract, surgical wounds, central nervous system, skin, and eyes may be sites of infection or colonization.4,6,13 Invasive devices used to facilitate fluid monitoring, administer medications, and provide lifesaving support may also be sources of colonization. For example, in patients receiving mechanical ventilation, the formation of a biofilm on the surface of the endotracheal tube may be the source of colonization of the lower part of the airway.15 Inert surfaces such as those listed in Table 4 appear to be improbable sources of

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**Table 1** Actions of professional organizations and recommended interventions for outbreaks of infections caused by multidrug-resistant organisms

| Centers for Disease Control and Prevention | • Identified antimicrobial resistance and lack of new drugs coming to market as a major health threat (1997)  
• Created a 12-step initiative to increase awareness of resistance and implement strategies to prevent the development of resistance in various populations4 |
| Infectious Disease Society of America | • Initiated the program Bad Bugs No Drugs10 to enlighten federal policymakers  
• Published A Public Health Action Plan to Combat Antimicrobial Resistance9  
• Cochaired a 10-agency task force (1999) |
| American Society for Microbiology and the Society for Healthcare Epidemiology of America | • Created the Antimicrobial Resistance Prevention Initiative, a program providing ongoing education exploring epidemiology and molecular mechanisms of resistance |
| Clinical and Laboratory Standards Institute | • Developed standard reference methods for antimicrobial susceptibility tests |

**Table 2** Centers for Disease Control and Prevention: 12 steps to prevent antimicrobial resistance among hospitalized adults6

- Prevent infection  
  1. Vaccinate  
  2. Get catheters out  
- Diagnose and treat infection effectively  
  3. Target the pathogen  
  4. Ask the experts  
- Use antimicrobials wisely  
  5. Practice antimicrobial control  
  6. Use local data  
  7. Treat infection, not contamination  
  8. Treat infection, not colonization  
  9. Know when to say no to vancomycin  
  10. Stop treatment when infection is cured, unlikely, or undiagnosed  
- Prevent transmission  
  11. Isolate the pathogen  
  12. Break the chain of contagion
A baumannii, but culturing of specimens obtained from these areas has indicated the prominence of the surfaces in the evolution of A baumannii. Of note, increased incidence of MDR A baumannii in military personnel injured in Iraq, Kuwait, and Afghanistan has been reported. The majority of the injured had had traumatic injuries in the field. Infection with A baumannii was diagnosed after the personnel were transferred to major military hospitals in Western Europe.

Despite the diversity of host sites of A baumannii, inadequate hand hygiene remains a significant factor in the transmission of this pathogen. Cross-transmission of MDR A baumannii occurs via direct contact from hands (especially in persons with damaged skin from chronic dermatitis) and gloves from healthcare professionals to patients. Colonization on the skin and contamination on glove surfaces may be direct or indirect as the healthcare provider touches the patient and/or numerous surfaces in providing care. Acinetobacter baumannii organisms are readily removed by most hand cleansing agents and by the environmental cleaning done in hospital settings.

An Outbreak of MDR A baumannii

In mid-December of 2005, the microbiology specialist at Banner Good Samaritan Medical Center, Phoenix, Arizona, reported that 5 extremely resistant isolates of A baumannii had been cultured during a 2-week period. This number was a dramatic increase. In the previous 6 months, resistant A baumannii had been isolated from only 11 specimens. All of the December isolates were from 5 patients in medical ICUs, and all 5 patients were receiving mechanical ventilation.

Development of Antimicrobial Resistance

Antimicrobial resistance has become a national problem. An organism is considered resistant when its growth in vitro is not inhibited by an antimicrobial agent that has been associated with eradication of the organism in vivo. Causes of resistance vary but are often linked to inappropriate initial antimicrobial therapy, including administration of subtherapeutic doses of antimicrobial agents, drug overuse, abbreviated or interrupted courses of treatment, and poor tissue penetration by the antimicrobial agent.

In A baumannii, antimicrobial resistance probably originated from resistance genes that are transferred between bacterial species. These genes are acquired rapidly and contribute to the development of...
antimicrobial resistance.5 Some of the genes are inherited, some emerge from random DNA mutations in bacteria, and others are imported from related bacteria (Figure 1). Evidence of _Acinetobacter baumannii_ antibiotic resistance may be a harbinger, or indication, of transmission of the organism among patients and may be predictive of an impending outbreak of _A baumannii_ infections.4

**Outbreak Potential**

The evolution of _A baumannii_ infections and their associated relationship with outbreaks correlate with the virulence of the strain. Inherent, unknown mechanisms appear to impede desiccation of this pathogen. Resistant _A baumannii_ often become apparent as a cluster of infections caused by the bacterium.4 Cases are often aggregated by time and place within settings. An outbreak may originate from a single source with widespread environmental contamination or where no reservoir for the contamination can be verified.4,33-37

Most MDR _A baumannii_ outbreaks occur in critical care settings and involve resistance to multiple classes of antimicrobial agents.4,38 Potential sources of _A baumannii_ in the ICU have received close scrutiny. Dust has been identified as a potential vehicle. In one investigation, the outbreak strain of _A baumannii_ was recovered from dust within pneumatic and electronic equipment, in air filters of continuous veno-veno hemodialysis machinery, ventilators, and air conditioner parts despite filters placed at air inlets and outlets. Because of the scope of technological equipment within critical care, this potential source of _A baumannii_ should receive further investigation.

**Antimicrobial Management**

Historically, carbapenems have resulted in the best therapeutic response in infections caused by MDR _A baumannii_.5,25,36 Currently, carbapenems, such as imipenem and meropenem, remain the widely recognized drug of choice for _A baumannii_ infections.13,25,38 Nevertheless, susceptibility testing is still required when this pathogen is identified.

During the time of our outbreak, testing resulted in an unprecedented 38% resistance rate to imipenem (Table 5). Resistance to meropenem for the MDR isolates was close to 100%.

Tests for susceptibility to colistin and tigecycline were also performed. For carbapenem-resistant _A baumannii_, tigecycline and colistimethate are 2 of the most frequently used alternative agents. The Clinical and Laboratory Standards Institute did

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**Table 5** Susceptibility of _Acinetobacter baumannii_ isolates to antimicrobials at Banner Good Samaritan Medical Center and in the United States, January 2005-April 2006

<table>
<thead>
<tr>
<th>Antimicrobial</th>
<th>Medical center (18 isolates)</th>
<th>National (&gt;8000 isolates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amikacin</td>
<td>25.5</td>
<td>80.4</td>
</tr>
<tr>
<td>Ampicillin/sulbactam</td>
<td>47.8</td>
<td>67.1</td>
</tr>
<tr>
<td>Aztreonam</td>
<td>0.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Cefepime</td>
<td>16.3</td>
<td>41.8</td>
</tr>
<tr>
<td>Cefazidime</td>
<td>16.8</td>
<td>39.6</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>15.2</td>
<td>42.0</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>19.6</td>
<td>52.3</td>
</tr>
<tr>
<td>Imipenem</td>
<td>62.0</td>
<td>72.1</td>
</tr>
<tr>
<td>Levofloxacin</td>
<td>16.8</td>
<td>Not available</td>
</tr>
<tr>
<td>Piperacillin/tazobactam</td>
<td>20.2</td>
<td>47.0</td>
</tr>
<tr>
<td>Trimethoprim/ sulfamethoxazole</td>
<td>16.4</td>
<td>52.7</td>
</tr>
<tr>
<td>Tobramycin</td>
<td>23.9</td>
<td>70.1</td>
</tr>
</tbody>
</table>
not provide interpretation of “susceptible,” “intermediate,” and “resistant” for susceptibility to tigecycline because of a lack of correlating clinical data. Without an interpretation, only the size of the area of growth inhibition could be reported. Hence, the interpretation of these findings was left up to individual physicians.

In mid-February 2006, the use of tigecycline E-test strips was implemented by our microbiology laboratory. (E-test strips are impregnated with a predefined antibiotic gradient. They are placed on agar culture plates that have been inoculated with the organism. The goal is to determine the in vitro minimum inhibitory concentration.) Results and interpretations of the E-tests were provided to clinicians according to the Food and Drug Administration’s interpretive guidelines to provide more standardized and informational guidance to physicians. Colistimethate was used clinically because of its proven ability to treat infections caused by MDR A baumannii and other MDR organisms. According to The Surveillance Network, the susceptibility of A baumannii isolates to polymyxin B in the United States is 95.4%. During the outbreak, no polymyxin B–resistant organisms were identified. Tigecycline, a new broad-spectrum minocycline derivative, received approval from the Food and Drug Administration in June 2005.

We subsequently used tigecycline because of the reported in vitro susceptibility of A baumannii to this drug. By the E-test strip method, the susceptibility of MDR A baumannii at the medical center February through June 2006 was 71%. Susceptibility to tigecycline has rapidly declined; only 39% of isolates obtained from July through December 2006 were susceptible, and 22% of those obtained from January through June 2007. Of note, this resistance pattern has emerged despite restriction of tigecycline to treatment of MDR organisms that were sensitive only to colistin and tigecycline. The combination of colistimethate and tigecycline was prescribed for many of our patients because the severity of illness, limited susceptibility information, and lack of clinical outcome data for tigecycline.

Colistimethate Colistimethate is an antimicrobial produced by Bacillus colistinus. It became commercially available in 1959. Use of this agent has been limited because of its nephrotoxicity and the availability of less toxic agents. It is approved by the Food and Drug Administration for treatment of acute or chronic infections due to susceptible gram-negative bacteria. Colistimethate is hydrolyzed to colistin, also known as polymyxin E. Colistin acts as a cationic detergent to damage the bacterial cell wall, resulting in leakage of intracellular substances and cell death. Colistin is eliminated via the kidneys and has a half-life of 1.5 to 8 hours.

The most common dose of colistimethate is 2.5 mg/kg intravenously every 12 hours for patients with normal renal function. Nephrotoxic, neurotoxic, and pulmonary toxic effects are significant adverse events associated with this drug. Dose and interval adjustments are recommended for patients with creatinine clearance less than 75 mL/min. However, dosing modifications for patients with renal impairment are not well established. Colistin is poorly removed by hemodialysis. Patients with renal impairment require monitoring of renal function, and dose and interval adjustments of the drug are recommended. No commercial method for monitoring the therapeutic level of colistin is available in the United States.

Tigecycline Tigecycline, a parenteral broad-spectrum bacteriostatic agent, is approved for treatment of complicated skin and skin structure infections and intra-abdominal infections caused by susceptible organisms. In one study, in susceptibility testing, the minimum inhibitory concentration required to inhibit the growth of 90% of organisms in vitro was 2.0 μg/mL for 739 isolates of Acinetobacter, indicating the potential clinical effectiveness of tigecycline. Tigecycline’s mechanism of action involves binding to the 30S ribosomal subunit and blocking protein synthesis.

Tigecycline has a 7 to 9 L/kg volume of distribution and a half-life of approximately 42 hours. A loading dose of 100 mg is recommended, with a maintenance dose of 50 mg every 12 hours. No dose adjustment is required for patients with renal impairment or mild to moderate hepatic impairment. Major side effects include nausea (29.5%), vomiting (19.7%), and diarrhea (12.7%).

Infection Control Measures

Once the cluster of MDR A baumannii was recognized, discussions occurred between personnel in infection control and the nurse managers of the affected ICUs. Contact precautions were implemented for the patients who had infections caused...
by MDR *A baumannii*, as per hospital policy for any patient with an MDR organism. As new patients continued to be identified, it became apparent that contact precautions were not controlling the outbreak. Nursing staff reported that some colleagues, particularly physicians, but also other staff working on and off the units, had not been following strict contact precautions.

Cohorting or keeping patients who have the same illness together, is a strategic intervention to limit outbreaks of infections caused by MDR organisms.47 The patients were moved to a single ICU, and the unit was closed to other patients. Nursing and respiratory staff were dedicated to that unit; they did not respond to code calls or assist in other units during their shift. Equipment was dedicated to that unit as well (eg, portable x-ray machine). In order to verify that the isolates were related, isolates from 4 patients were sent to the Arizona state laboratory for ribotyping and pulse field gel electrophoresis (PFGE). Results confirmed that the isolates were identical. Recent reports of PFGE testing to prove clonal spread is useful in determining the appropriate actions to control an outbreak.47

The results of our request for PFGE testing prompted the state health department to investigate the prevalence of MDR *A baumannii* throughout Phoenix. The investigation indicated some unrecognized endemcity of this organism in the greater Phoenix area. Of the Phoenix isolates tested, 80% were the same type, and a quarter of those had indications of single point mutations, indicating that although the isolates appeared to come from a single source, this organism had been circulating in the area for a while.

We investigated environmental sources of contamination at the medical center. It was verified that our hospital disinfectant (a quaternary ammonium compound) was effective against *Acinetobacter*. Random specimens for culturing were taken in patients’ rooms from frequently touched surfaces, including beds, bed rails, intravenous pumps, and ventilator faces. Of 13 cultures, 7 were positive for *A baumannii*.

Extensive education was done with the environmental services staff about the importance of attention to detail in room cleaning. Additional education was done with clinical staff (nurses, physicians, and respiratory therapists); data on the positive environmental cultures were used to reinforce the need for strict contact precautions with gowns, hand hygiene, and so on. Later, specimens were obtained from vacant cleaned rooms in the cohort nursing unit and at the nurses’ station (ie, automatic medication-dispensing machines, telephones, and computers). All specimens were negative for *A baumannii*, verifying that the cleaning with our disinfectant was effective.

Of the first 9 cases at the medical center, 6 occurred in patients receiving mechanical ventilation, so attention was focused on the ventilators. It was verified that when mechanical ventilation was discontinued, the circuits on the machine were discarded and the outside of the machine was disinfected. The ventilators used on patients who had *A baumannii* infections were, in addition, sent to the decontamination department for extensive cleaning. Exhalation filters on several random ventilators, ready for use, were cultured; all were negative for *A baumannii*. The respiratory therapy department created a spreadsheet to track specific ventilator use on individual patients. Ventilator use did not explain patient transmission.

Transmission via bronchoscopes was also investigated. Cleaning procedures were reviewed. No new technicians were cleaning the bronchoscopes, and all the technicians were well trained and had received updated annual in-service education. The bronchoscopes were tracked, and their use in patients affected by the outbreak was determined. Only 2 bronchoscopes were used on more than a single patient with MDR *A baumannii*, and in both instances, use of the bronchoscope in patients who became infected with *A baumannii* was separated by at least a 2-week period, and the instrument was used in between on other patients who did not become infected.

A new procedure for active surveillance was initiated. Each time MDR *A baumannii* was isolated from a new patient receiving mechanical ventilation, contact precautions were implemented empirically for all patients in that nursing unit who were receiving mechanical ventilation. The use of the precautions was continued until a sputum specimen negative for MDR *A baumannii* was obtained from each patient. Additionally, for any patient admitted from an outside facility who was receiving mechanical ventilation or had a tracheostomy, contact precautions were implemented empirically until a sputum specimen negative for *A baumannii* was obtained. This precaution has continued. Cohorting was discontinued on March 1, 2006,
when only 2 patients remained in the unit and no new patients had been identified for 3 weeks.

A second cohort unit was started at the end of May 2006, nearly 3 months after the first cohort unit had closed. Intermittent cases of MDR *A baumannii* infections had been identified, but when 8 patients in different ICUs with such infections were identified during the same time frame, the decision was made to open a cohort unit. After 3 weeks, 3 patients remained, and the unit was opened up to patients who did not have *A baumannii* infections. The latter patients had to be at low risk for infection: no mechanical ventilation, no tracheostomies, and no surgical or open wounds. No new clusters of patients infected with this organism have occurred since that time.

**Staffing Impact**

Staffing needs of a cohort unit vary from the usual. As might be expected, challenges during the use of a cohort unit included matching the number and types of staff required with available resources. Most of the patients required a 1 to 1 nurse to patient ratio because of the frequency of treatments, tests, and drug therapies. As isolation precautions intensified, so did patient acuity. Additionally, with this model of cohorting infectious patients, members of the nursing staff were required to assume additional responsibilities. Of note was their need to coach all healthcare workers, including physicians, who interacted with patients to ensure that proper contact precautions were being adhered to during patient contact. The staffing implications also affected respiratory therapy staff, because they were restricted to the cohort unit for the duration of a shift, and often that ICU did not require a respiratory therapist full time. Staffing these cohort units increased the variance between budgeted and actual costs.

**Information: Getting Out a Consistent Message**

During the cohort experience, we used multiple strategies to quickly bring the most current information about the cohorting procedure to the nursing staff. First, the nursing management and infection control teams made rounds at least daily, and at times more often, to update the staff about the situation and to address questions. These rounds provided a time for day and night nursing staff to speak with infection control staff and to inform managerial staff of the nurses’ needs. Second, it was necessary to update all healthcare providers around the clock. Because the members of the nursing staff were the liaisons and primary educators for what was transpiring in the units, these personnel needed more resources to provide ongoing, timely, and accurate information to a variety of colleagues involved in the unit’s functioning. As a result, an “*Acinetobacter* update” flyer (Figure 2) was created. The flyer was updated periodically to keep the staff informed of any new issues or pertinent clinical changes related to *Acinetobacter*. In addition, extensive education was done, on a continuing basis, to increase compliance with contact precaution measures.

**Staff Responses to the Outbreak**

At the beginning of the outbreak, a general sense of fear and uncertainty existed in the unit. *Acinetobacter baumannii* was an unknown organism to the staff, and most of the nurses were unfamiliar with the threat it posed to themselves and their families. The initial days were characterized by questions about what to wear, what not to touch, how often to wash hands, and how long the unit would remain cohorted. One staff nurse said the following:

I remember working on the *A baumannii* unit for the first time: gowns, gloves, booties, and isolation signs covered the entire unit. Everyone seemed to have a fear of working here. Some would refuse. Nurses feared for their health and that of their families. Questions and uncertainties filled the day: Should I shower at work? Should I change my scrubs before going home? Will I become infected?

News of the unit’s cohorting status quickly spread throughout the hospital. The unit became known as the “quarantine” or the “bug unit.” These names created an even deeper sense of isolation for the nursing staff working there. The staff were stigmatized and characterized as being different. Some staff members asked to be transferred. The nurses who remained felt an overwhelming sense of exhaustion as each day the requirement to gown and glove upon entering a patient’s room seemed increasingly burdensome.

As the outbreak continued and core staff began to understand the need and purpose for cohorting, fear dissipated and the staff assumed ownership of this special
Due to the newness of this pathogen and the evolving nursing care requirements associated with this patient population, a periodic newsletter will be sent to critical care areas to ensure all staff have access to updated, timely information. This is the second newsletter in this series of updates.

**Definition:**

Acinetobacter baumannii is a gram-negative bacteria, often found in soil and water and can be isolated readily from many sources in the environment. It can survive for long periods of time in the environment and tolerates both moist and dry conditions. Resistant strains of this bacteria have developed recently throughout the United States and are difficult to treat.

In hospitals, Acinetobacter baumannii is most common in ICU and burn patients. It poses very little risk to healthy people. Patients at highest risk are very ill, on ventilators, have open wounds and/or have many invasive devices.

As of March 1st, we are no longer cohorting patients. Strict adherence to Contact Precautions and optimum hand hygiene remain the standard of care. We are continuing to screen all patients being transferred to us from long term care facilities if they are intubated, have a trach, or have large or draining wounds. Such patients are placed into Contact Precautions upon admission, and remain so until screening cultures are finalized.

These resistant organisms have been found in many hospitals around our valley. The Arizona Department of Health Services has been collecting isolates from hospitals around Arizona and most have turned out to be identical strains. In the long term, this may be an organism that is here to stay. The most recent nosocomial isolates of resistant Acinetobacter were in sputum specimens from 2 of our patients, both collected on 3/22/06. It had been a month since the last one was identified on 2/26/06.

**For patients admitted from LTC with a trach, draining wound, or who are intubated:**

- Immediately upon Admission, place the patient in Contact Precautions;
- Obtain a culture of the site (i.e., trach, draining wound, or ET tube);
- Notify Infection Control x 34390; may leave a message.

**Question of the Week**

What kind of patient can be paired with an Acinetobacter patient?

Ideally, for a patient in an ICU, a 1:1 assignment is preferred. If that is not possible, the nurse should be assigned to a non-ventilated/non-trached patient, one who has not had recent surgery, and one with few invasive devices or draining wounds.

Please call **** (x 34390 or page 555-5555) if you have any concerns and please refer to these evolving updates for continued information.

**Figure 2** Example of an Acinetobacter update flyer.

Abbreviations: ET, endotracheal tube; ICU, intensive care unit; LTC, long-term care; trach, tracheostomy; vent, mechanical ventilation. Reprinted with permission of Banner Good Samaritan Medical Center, Phoenix, Arizona.

population of patients. One nurse remarked as follows:

Core staff became comfortable with the isolated unit. I remember working on the A baumannii outbreak unit for 3 months straight. I became an advocate for proper education to doctors, nurses, and other healthcare providers, compiling education posters for display throughout our hospital so that others could understand more about this bacterial outbreak.

The initial struggle evolved into a shared ownership between the critical care nursing staff, infection control specialists, and nursing management. The need to comprehensively educate the hospital and public became a joint venture. For example, the routine process of sending a patient for a medical imaging procedure became a seemingly unyielding event because of the increased demands for preparation, planning, transportation, and performing the procedure. An added burden was also imposed on staff
who remained in the unit to oversee patient care in the absence of the nurse deemed responsible for care during this time.

Finally, as the decrease in the number of infected patients became obvious, staff realized how the combination of cohorting, effective hand hygiene, and institutional education had worked together to combat the spread of MDR *A baumannii*. Although staff nurses were obviously approaching “burnout” near the culmination of this experience, the support of nursing management and the infection control specialists sustained the core nursing staff by providing daily effective communication and listening to staff members’ concerns about and reactions to this intense experience.

### Clinical Recommendations

The first and foremost clinical recommendation for preventing outbreaks of MDR *A baumannii* infection is early recognition: develop a method to track the incidence and resistance patterns of all *Acinetobacter* isolates in your critical care areas. By the time a patient arrives in the ICU, he or she is often heavily pre-treated and highly compromised and thus vulnerable to a number of potentially fatal sequelae. Patients with known clinical infection most likely represent only a small percentage of microbial colonization/contamination, signifying the

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**Table 6** Recommendations for control of *Acinetobacter baumannii* outbreaks

<table>
<thead>
<tr>
<th>Action</th>
<th>Recommendations</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organize response to outbreak</td>
<td>Start a timeline: include all actions, meetings, education, consultations (eg, health departments) &lt;br&gt;Save emails &lt;br&gt;Start a sequential list of patients</td>
<td>Actions can be reviewed in an organized manner to help determine next steps &lt;br&gt;Organization facilitates financial assessment of outbreak if required at a later date</td>
</tr>
<tr>
<td>Cohort patients, staff, and equipment</td>
<td>Cohort patients, close unit to noninfected and noncolonized patients &lt;br&gt;Cohort staff: respiratory therapists and nurses remain in the cohort unit, do not respond to code calls during shift &lt;br&gt;Cohort equipment (eg, portable x-ray machine) &lt;br&gt;Use active surveillance cultures on admission of high-risk&lt;sup&gt;a&lt;/sup&gt; patients throughout hospital &lt;br&gt;If cohort unit is discontinued, consider active surveillance cultures on all high-risk patients in a nursing unit each time a new patient with resistant <em>A baumannii</em> is identified</td>
<td>Cohorting assists in containing organism &lt;br&gt;Cohorting helps nursing staff enforce meticulous attention to hand hygiene and contact precautions &lt;br&gt;Use of active surveillance cultures facilitates earlier use of contact precautions for colonized and infected patients &lt;br&gt;Use of active surveillance cultures and empiric precautions while awaiting results, when done on inpatients, facilitates earlier uses of contact precautions for colonized and infected patients</td>
</tr>
<tr>
<td>Ensure that staff are all in compliance with preventive procedures</td>
<td>Ventilators: determine cleaning used, type of filters &lt;br&gt;Contact precautions: verify that staff have enough personal protective equipment, are following procedures, have tools to educate and coach other colleagues in complying with precautions &lt;br&gt;Environmental cleaning: verify procedures and education of housekeeping staff; check disinfectant, how it is mixed, and so on &lt;br&gt;Environmental culturing: can be done if for no other reason than to reassure staff &lt;br&gt;Bronchoscopes (if implicated by culture sites): review cleaning and sterilization process, track patient use</td>
<td>Often an outbreak ends without an identified culprit &lt;br&gt;Attention to detail is what is needed</td>
</tr>
<tr>
<td>Educate and communicate with staff</td>
<td>Develop educational programs for all departments: respiratory therapy, medical imaging, environmental services, transport, dietary/nutrition &lt;br&gt;Develop a newsletter or other communication tool to address concerns or information needs &lt;br&gt;Create a question box and post the questions and answers daily</td>
<td>Knowledge equals power &lt;br&gt;All staff must be included to ensure comprehensive team effort &lt;br&gt;Information in writing avoids pitfalls of misinterpretation of answers and missed instructions, giving all staff the benefit of others’ questions</td>
</tr>
<tr>
<td>Provide emotional support for professional caregivers</td>
<td>Anticipate emotional needs of cohort staff: provide food, use chaplaincy or music therapy in-house teams, arrange for times to vent/share frustrations on a regular basis</td>
<td>Emotionally healthy staff can change the experience for patients, physicians and visitors; it can be the difference between success and failure</td>
</tr>
</tbody>
</table>

<sup>a</sup> During the outbreak at Banner Good Samaritan Medical Center, patients from long-term care facilities who were receiving mechanical ventilation or had a tracheotomy and any patient with draining wounds were high risk.

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http://ccn.aacnjournals.org
“iceberg phenomenon.” Prevalence of infection in the setting may be only partially realized.

Our list of recommendations for facilities that must address the management of A. baumannii infections fall into 5 categories (Table 6).

**Consideration of Cost**

The costs associated with a hospital-acquired infection are significant.2,44 In the United States, an estimated 250,000 episodes of hospital-acquired infection occur annually, with a total cost of nearly $5 billion, associated mortality rates of 35%, an extended mean length of hospitalization of 24 days, and added costs exceeding $40,000 per hospitalization of 24 days, and of 35%, an extended mean length of stay of 5% to 10% of inpatient beds, yet account for more than 30% of hospital budgets and 8% of healthcare costs45-47 (Table 7).

According to one estimate,48 the overall cost to contain an outbreak was $220,000 per patient. Additionally, the hospital may lose more than $2 million in potential revenue because of the loss of nearly 300 hospital-bed days because of room closings. Although our review did not include quantification of cost, we recommend the integration of cost data in future analyses of outbreaks.

### Quality Improvement and Nursing Research Indices

Although infection is a nurse-sensitive indicator of quality care,45 personnel from numerous healthcare disciplines interact with patients in the ICU. In order to improve outcomes in patients with MDR and potentially fatal infections, nurse-promoted multidisciplinary inquiries could target the following areas:

- Proactive planning to anticipate the emergence of MDR organisms
- Ongoing collaboration with infection control practitioners regarding trends of outbreaks of infections caused by MDR organisms and prevention strategies
- Providing a forum to enhance staff nurses’ critical thinking
- Identifying the interrelationship of host factors (eg, type, number and severity of comorbid conditions, age, and effect of antibiotic polypharmacy)
- Staff compliance with standard precaution requirements (ie, hand hygiene, gown use)
- Investigation of intervention timing (eg, cohorting patients, staff, equipment) and its impact on the magnitude of the outbreak

Variations in nursing care interventions for ICU patients infected with MDR organisms have not been identified. Frequency of culturing, types of cohorting, communication strategies, prevalence, and intensity of adverse reactions to multiple drug therapies remain unknown. Preventive interventions are difficult to measure, and most researchers did not describe the monitoring of infection control practices.4 We make no recommendations about staffing for patients with MDR pathogens; however, high work load can be a contributing factor for the acquisition of antimicrobial-resistant organisms.18

### Conclusion

A new class of patient has unintentionally evolved in healthcare: the chronically critically ill.22 Increases in the number of such patients will require added nursing resources and expertise. These complex patients also require fine-tuned teams with respect for specialty knowledge. In our experience with an outbreak of infections caused by MDR A. baumannii, a high-quality team effort was responsible for a timely, interdisciplinary, and ultimately successful effort to contain a potentially widespread outbreak.

**Table 7 Costs of an outbreak**

<table>
<thead>
<tr>
<th>Direct</th>
<th>Indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Prolonged length of stay</td>
<td>• Onsite time for chaplain, psychologist unit manager, intensive care nurses</td>
</tr>
<tr>
<td>• Consumption of supplies (eg, personal protective equipment, disposal of supply cart contents after patient is discharged)</td>
<td>• Loss of intensive care unit bed days</td>
</tr>
<tr>
<td>• Use of professional services (eg, consultations with physicians, dedicated respiratory personnel)</td>
<td></td>
</tr>
<tr>
<td>• Dedicated equipment for the unit (eg, portable electrocardiographic and x-ray machines)</td>
<td></td>
</tr>
<tr>
<td>• Pay for nursing full-time equivalents</td>
<td></td>
</tr>
<tr>
<td>• Laboratory services (eg, additional surveillance cultures, environmental and patient screening, pulse field gel electrophoresis testing)</td>
<td></td>
</tr>
<tr>
<td>• Outbreak containment</td>
<td></td>
</tr>
<tr>
<td>• $220,000 per patient48</td>
<td></td>
</tr>
</tbody>
</table>

Financial Disclosures

None reported.

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References


Test ID C081: Acinetobacter baumannii: An Emerging Multidrug-Resistant Pathogen in Critical Care

Learning objectives: 1. Identify factors that contribute to the emergence and significance of Acinetobacter baumannii in healthcare environments
2. Describe the characteristics of A baumannii and the associated risk factors for development of A baumannii infections
3. Discuss nursing interventions, infection control measures, and clinical recommendations for prevention and/or containment A baumannii infections

1. **Acinetobacter baumannii** is a normal inhabitant in which area of the body?
   a. Gastrointestinal tract
   b. Plasma
   c. Lungs
   d. Skin and mucous membranes

2. What is the most significant factor in the transmission of A baumannii?
   a. Widespread overuse of broad-spectrum antibiotics
   b. Direct contact with persons who have contact dermatitis
   c. Inadequate hand hygiene among healthcare providers
   d. The organism’s resistance to multiple hand-cleansing agents

3. How many strains of A baumannii have been identified thus far?
   a. 19
   b. 15
   c. 21
   d. 14

4. Which of the following drug’s associated nephrotoxicity requires that doses and intervals be adjusted for patients with renal impairment?
   a. Tigecycline
   b. Imipenem
   c. Colistimethate
   d. Aztreonam

5. The term “cohorting” refers to which of the following?
   a. Colonization of A baumannii on the skin of susceptible persons
   b. Concurrent use of a combination of 1 or more antimicrobial agents
   c. Implementation of strict contact isolation procedures for patients at high risk for development of multidrug-resistant (MDR) infections
   d. Placement of patients who have the same illness together

6. What is the first and foremost recommendation made by the authors for preventing outbreaks of MDR A baumannii infections?
   a. The use of a multidisciplinary team to establish infection control measures for each healthcare facility
   b. Paying attention to the infection rates specific to critical care settings
   c. Implementation of contact precautions for patients who have infections caused by MDR A baumannii
   d. Extensive education for environmental services staff about the importance of attention to detail in room cleaning

7. **Acinetobacter baumannii** is what kind of bacteria?
   a. Gram-negative, cocobacillary rod
   b. Gram-positive, opportunistic fungi
   c. Gram-negative, nonfermentive spirochete
   d. Gram-positive, anaerobic mycobacteria

8. Which of the following statements about A baumannii is true?
   a. The organism cannot survive on moist surfaces for long periods.
   b. The organism is inconsequential to hosts with intact immune systems.
   c. Infections caused by this organism are preventable when susceptibility results are available.
   d. Rapid understanding and acceptance of the need for cohorting

9. What is an expected outcome of establishing a cohort/isolation unit?
   a. Improved productivity of nursing and respiratory therapy staff
   b. Increased ease of matching the number and types of staff required with available resources
   c. Increased variance between budgeted and actual costs
   d. Use of antimicrobial-treated catheters

10. Successful prevention of the spread of MDR A baumannii infections includes which of the following combinations?
   a. Improved staffing, cohorting, and enhanced infection control practices
   b. Increased interdisciplinary involvement, standardized antibiotic therapy, and review of cleaning procedures
   c. Contact precautions on all mechanically ventilated patients, tracking of specific ventilator use on individual patients, and additional education with all clinical staff
   d. Institutional education, effective hand hygiene, and cohorting

11. Which of the following is a recommendation of the Centers for Disease Control and Prevention’s 12 Steps to Prevent Antimicrobial Resistance Among Hospitalized Adults?
   a. Begin antimicrobial treatment with multiple agents at first and eliminate as soon as possible when susceptibility results are available.
   b. Treat the infection, not colonization of the bacteria.
   c. Treat the infection according to the most recent national data.
   d. Use antimicrobial-treated catheters.

12. Risk factors for acquiring A baumannii include which of the following?
   a. Male sex
   b. Fall or winter season
   c. Depression
   d. Mechanical ventilation

13. What is a recommendation to aid in cohorting patients, staff, and equipment?
   a. Post flyers and informational literature throughout the facility.
   b. Ensure proper cleaning of ventilators and bronchoscopes.
   c. Require that staff on the cohort unit do not respond to code calls during shifts.
   d. Sterilize and disinfect all ventilator circuits used on the cohort unit between patients.

14. What is the estimated cost of outbreak containment per patient?
   a. $40 000
   b. $220 000
   c. $510 000
   d. $730 000

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

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13. a  b  c  d
14. a  b  c  d

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