Molecular Epidemiology of carbapenem resistant Acinetobacter baumannii in the Gulf Cooperation Council States. Dominance of OXA-23-type producers.

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Abstract

The molecular epidemiology and mechanisms of resistance of carbapenem-resistant *Acinetobacter baumannii* (CRAB) were determined in hospitals in the countries of the Gulf Cooperation Council (GCC), namely, Saudi Arabia, United Arab Emirates, Oman, Qatar, Bahrain, and Kuwait. Isolates were subjected to PCR-based detection of antibiotic-resistance genes and repetitive sequence-based PCR (rep-PCR) assessments of clonality. Selected isolates were subjected to multilocus sequence typing (MLST). 117 isolates found resistant to carbapenem antibiotics (either imipenem or meropenem) were investigated. All isolates were positive for OXA-51. The most common carbapenemases were of the OXA-23-type in 107 isolates followed by OXA-40-type (OXA-24-type) in 5 isolates; 3 isolates were found to carry the IS*Abal* element upstream of *bla*OXA-51-type. No OXA-58-type, NDM-type, VIM-type, or IMP-type producers were detected. Multiple clones were detected with 16 clusters of clonally related CRAB. Some clusters involved hospitals in different countries. MLST analysis of 15 representative isolates from different clusters identified seven different sequence types; ST195, ST208, ST229, ST436, ST450, ST452 and ST499, as well as three novel STs. The vast majority of the isolates in this study (84%) were associated with healthcare exposure. Awareness of multidrug resistant organisms in GCC countries has important implications for optimizing infection control practices, establishing antimicrobial stewardship programs within hospital, community, and agricultural settings, and reemphasizing the need for establishing regional active surveillance systems. This will help to control the spread of CRAB in the Middle East and in hospitals accommodating transferred patients from this region.
Introduction

Acinetobacter baumannii is a major pathogen associated globally with hospital acquired infections (HAIs). It was found that 26.5% of ventilator-associated pneumonia in Riyadh, Saudi Arabia, between 2005 and 2009 were caused by Acinetobacter spp (1). The success of this pathogen is partially due to the high prevalence of a multidrug resistant phenotype that A. baumannii now demonstrates (2). In the Middle East, and in particular countries of the Gulf Cooperation Council (GCC) (Saudi Arabia, United Arab Emirates, Oman, Kuwait, Qatar, Bahrain), the prevalence of carbapenem resistant A. baumannii (CRAB) has increased dramatically over the last decade (3). This high prevalence is limiting treatment options, which can lead to increased morbidity and mortality due to infections caused by CRAB.

The phenotypic resistance characteristics of CRAB are mainly due to the expression of class D carbapenemases, called oxacillinases. Moreover, plasmid mediated metallo-β-lactamases (MBL) have also been associated with the resistance phenotype (2). The existence of ISAba1 elements upstream to the blaOXA-51-type gene is also associated with carbapenem resistance phenotype in A. baumannii by over-expressing the intrinsic OXA-51 carbapenemase (4). Previous reports on isolates from the GCC states show that the carbapenem resistance phenotype in A. baumannii is often due to the expression of OXA enzymes, particularly OXA-23 (3). However, MBL encoding genes including the recently emerged New Delhi metallo-β-lactamase (NDM) have been increasingly reported in Acinetobacter spp isolated from different parts of the world (5-7).

Due to the geographical location of the GCC states, and the ethnic relationships of residents, heavy travel occurs between the GCC countries and the Indian Subcontinent, where NDM enzymes are widespread. The current socioeconomic structure of the GCC states relies heavily on an international workforce. For example, about 37% of the total population of the
GCC states are non-national expatriates, mainly from the Indian subcontinent (8). Saudi Arabia receives more than 1.5 million international pilgrims from all over the world to perform Hajj (9). This exemplifies the heavy travel occurring in the GCC region; and travel is known to be a risk factor for spreading/acquiring antimicrobial resistant bacteria (3).

As one of many desperately needed first steps to control the spread of CRAB, we aimed to determine the molecular genetics of CRAB in the countries of the GCC states. To our knowledge no region-wide study on the molecular genetics of CRAB has been undertaken. For this reason, we have performed a “snapshot” analysis of the molecular epidemiology of CRAB in the countries of the Gulf Cooperation Council.

Methods

Bacterial Isolates. Between July 2011 and January 2013, Acinetobacter spp. were collected from seven participating institutes across the GCC states (two hospitals in Saudi Arabia from Riyadh and Khobar, and one hospital from each of the following countries, United Arab Emirates (UAE), Kuwait, Qatar, Oman, and Bahrain) (Table 1). These hospitals are part of a region-wide collaborative study on multidrug resistant Gram-negative bacilli (10). Acinetobacter spp. were identified and tested for their susceptibility to a panel of antimicrobials using semi-automated systems in each clinical microbiology laboratory (Table 1). Isolates were included on the basis of showing decreased susceptibility to imipenem (MIC ≥8 μg/ml), or meropenem (MIC ≥8 μg/ml) using CLSI breakpoints. Only one isolate per patient was included, and isolates originated from a range of clinical specimens.

Isolates were sent to the research laboratory at the University of Queensland Centre for Clinical Research (UQCCR).
Antibiotic Susceptibility Testing. All isolates underwent disk diffusion susceptibility testing following the methodology and the updated breakpoint defined by the European Committee on Antimicrobial Susceptibility Testing (EUCAST) (11) for the following antimicrobial agents: imipenem (10 μg), meropenem (10 μg), gentamicin (10 μg), amikacin (30 μg), ciprofloxacin (5 μg), and sulfamethoxazole/trimethoprim (23.75 μg/1.25 μg). The updated breakpoints defined by the Clinical and Laboratory Standards Institute (CLSI) (12) were also used to assess disk diffusion susceptibility for ceftazidime (30 μg), tetracycline (30 μg), ticarcillin-clavulanic acid (75/10 μg), piperacillin-tazobactam (100/10 μg), and ampicillin-sulbactam (10/10 μg), since these antibiotics do not have EUCAST breakpoints available for Acinetobacter spp.

Polymerase Chain Reaction (PCR) for Carbapenemase Genes. Genomic DNA was extracted using the UltraClean Microbial DNA Isolation kit (MO BIO Laboratories) as recommended by the manufacturer. Species identification was performed using gyrB multiplex PCR as previously described (13). Detection of the intrinsic carbapenemase encoding gene blaOXA-51-type was performed using standard PCR based on the primers listed in table 2 (14). The samples were also screened for the other major groups that confer clinically relevant resistance to carbapenems, blaOXA-23-type, blaOXA-40-type (-24-type), blaOXA-58-type (14, 15) (Table 2). The samples were also screened for the blaNDM-type, blaIMP-type, blaKPC-type in a multiplex reaction (16, 17) and blaVIM-type in a single PCR reaction (18) (Table 2). Isolates not carrying another carbapenemase gene apart from blaOXA-51-type were subjected to PCR screening for ISAba1 element upstream of blaOXA-51-type, (19) and class 1 integron (intI1) as previously described (20) (Table 2). PCR reactions were carried out using GoTaq® Green Master Mix (Promega, USA).
Clonal Analysis of Carbapenem Resistant *A. baumannii*. Genetic relatedness among CRAB isolates from the GCC was determined by rep-PCR based typing using the DiversiLab® system (bioMérieux, Oakleigh, Australia). DNA fragment patterns were analyzed using the Kullback-Leibler statistical method to determine clonal relationships and to create the dendrogram with a 95% cut-off. Isolates were considered related and defined as rep-PCR clusters if ≥95% similar (21, 22).

Representative isolates, determined by DiversiLab rep-PCR clusters, from the six countries were also analyzed by multilocus sequence typing (MLST). Genotyping by MLST was performed as previously described (23), using the seven housekeeping genes *gltA*, *gyrB*, *gdhB*, *recA*, *cpn60*, *gpi*, and *rpoD*. Analysis of the allele sequences and ST were performed through the *A. baumannii* MLST website (http://pubmlst.org/abaumannii).

Clinical data collection. Clinical data for each patient who was identified as infected or colonized with CRAB included in this study were collected by the participating institutions. A concise one-page questionnaire was used to collect demographic data, the clinical source of the isolates, microbiology results, antibiotic exposure, travel within the last 6 months and medical history. Hospital-acquired infections are defined by a positive microbiology culture from an infection in patients who had been hospitalized for 48 hours or longer. Patients transferred from another hospital had their hospital stay duration calculated from the date of the first hospital admission (24). Hospital-acquired colonization was defined by a positive microbiology culture of surveillance sampling and not associated with clinical manifestation of an infection from patients who had been hospitalized for 48 hours or longer. Healthcare-associated infections were classified as infections occurring in patients within 48 hours after admission who had been hospitalized during the previous 90 days, who had been recipients of hemodialysis, recipients of intravenous medication, or received home wound care in the 30
days prior the infection, or who were residents of nursing homes or long-term care facilities. Otherwise, cases were considered to be community acquired (24).

**Human Ethics.** The University of Queensland granted human ethics clearance to conduct this project, number 2011000474. Permission from King Abdulaziz Medical City, Saudi Arabia to conduct the region-wide collaborative study on multidrug resistant Gram-negative bacilli was granted Ref. #: IRBC/193/12.

**Results**

**Bacterial Isolates and Carbapenem Susceptibility.** A total of 117 non-repetitive isolates non-susceptible to imipenem and/or meropenem were further assessed. The numbers of CRAB in each participating hospital were as following: Saudi Arabia-Riyadh, 49; Saudi Arabia-Khobar, 31; Kuwait, 8; United Arab of Emirates, 8; Oman, 5; Qatar, 8; Bahrain, 8 (Table 1). Carbapenem co-resistance for the 117 CRAB isolates was found to sulfamethoxazole/trimethoprim (93%), gentamicin (95%), amikacin (83%), ciprofloxacin (98%), tetracycline (68%), ticarcillin-clavulanic acid (100%), piperacillin-tazobactam (100%) and ampicillin-sulbactam (74%).

**Carbapenemase-encoding genes.** All 117 isolates were positive for blaOXA-51-type. The clinically relevant carbapenem encoding gene blaOXA-23-type was found in 107 (91%) isolates. As a breakdown, 47 (96%) of CRAB from Saudi Arabia-Riyadh, 28 (90%) from Saudi Arabia-Khobar; 3 (38%) from Bahrain, and all of CRAB from Oman (n=5), Kuwait (n=8), Qatar (n=8), and UAE (n=8) carried blaOXA-23-type. Five isolates from Bahrain were found to be carrying blaOXA-40-type genes. None of the isolates had a positive PCR result for blaOXA-58-type, blaNDM-type, blakPC-type, blaIMP-type, or blavIM-type. Five (4%) of the CRAB isolates
did not give positive PCR results for any of the tested carbapenemase-encoding genes except for \textit{bla}\textsubscript{OXA-51-type}. None of these five isolates carried the class 1 integron, but three isolates (2.8%) (Khobar - Saudi Arabia) carried the IS\textit{Aba1} element upstream of \textit{bla}\textsubscript{OXA-51-type}, which is known to mediate the carbapenem resistance phenotype (4). Two isolates (1.7%) remained negative for all the tested carbapenemase genes.

**Genotyping and clonality.** A total of 16 DiversiLab rep-PCR clusters (clusters A to P) and 11 singletons were identified among the 117 study isolates (Table 3; dendogram can be found in the supplementary figure). The main cluster (B) included 53 of the total 117 isolates (45%) and represented isolates from all six locations or five countries. The rep-PCR analysis showed that eleven isolates had unique banding patterns. These singletons were unrelated to the remaining isolates, representing various locations, except for singleton 1 which was only slightly less than 95% similar to cluster A isolates.

Well defined clusters by location are seen in clusters A, C, F, H, M, N, and P (Table 3), whereas the remaining rep-PCR clones included isolates from two or more locations. Isolates harboring \textit{bla}\textsubscript{OXA-23-type} genes were scattered throughout the rep-PCR patterns, except for clusters K, L, and M in which all of the isolates carried both \textit{bla}\textsubscript{OXA-51-type} and \textit{bla}\textsubscript{OXA-23-type} genes.

Seven different sequence types; ST195, ST208, ST229, ST436, ST450, ST452 and ST499, as well as three novel STs, were assigned to the 15 representative isolates. ST195 isolates clustered with ST208 within the same cluster and it should be noted that there is only a single allele difference between these two sequence types which represents a true single locus variant. ST195, ST208, and ST436 fall under the widely disseminated clonal complex CC92 (also known as international clone number 2), while ST229 is under CC110 (also known as...
international clone number 3). We found good correlation between sequence type and rep-PCR cluster.

**Clinical data.** Clinical data are summarized in Table 4. The demographic and clinical data were successfully retrieved for 100 (85%) patients; Saudi Arabia-Riyadh, 49; Saudi Arabia-Khobar, 30; United Arab of Emirates, 8; Oman, 5; Bahrain, 8. We found that 25 of the patients were in the age group of ≥70 years old, and the second group (n= 23) was between 18-30 years old (Table 4). Most of the identified patients were male (n= 68) and local citizens (n= 79). CRAB were mainly isolated from swab specimens (n= 39), sputum (n= 22), and blood (n= 18) (Table 4). It is worth noting that 24% of the isolates represented healthcare-associated infection, while 53% associated with Hospital-acquired (nosocomial) infection, 7% were colonizing hospital patients. 8% of the isolates were classified as community acquired, and we could not categorize the last 8% of isolates due to lack of data. Antibiotics were administered to 87 patients before the isolation of CRAB. Overseas medical treatment information could not be collected for 50% of the patients. Four patients had recently travelled to Bangladesh, India, Singapore, or Thailand for medical proposes. An isolate from a UAE patient with recent travel history for medical purposes to Bangladesh clustered with another isolate from a UAE patient with no recent travel history (cluster F) (Table 3; dendogram can be found in the supplementary figure). Interestingly, a UAE isolate obtained from patient with recent travel history to Singapore clustered with a group of isolates from Saudi Arabia, Oman, and Kuwait (cluster B) (Table 3). However, isolates from patients with recent travel history to India and Thailand do not show similarity to any another isolate tested (Singleton 2 and Singleton 6, respectively) (Table 3). The remaining 46 patients did not receive overseas medical treatment.
Discussion

We have described the molecular genetics of CRAB isolates from patients in selected GCC hospitals. We found that OXA-23-type was the major carbapenemase mechanism responsible for the resistance phenotype. This finding is similar to data previously reported from the Gulf region (3, 25, 26) and neighboring Egypt (27). OXA-23 type contributes to carbapenem resistance in *A. baumannii* in many other parts of the world (2), and has been associated with outbreaks in Spain (28), Italy (29), and United States (30). It is important to note that outbreaks have occurred as a result of international transfer of patients (31). This represents a risk factor to hospitals in non-endemic countries receiving patients from countries with high prevalence of CRAB.

Epidemiological tools are important to develop effective strategies for monitoring CRAB. We utilized rep-PCR typing using the DiversiLab system and MLST typing, as both methods demonstrated validity to be used for comparing geographically diverse groups of clinical isolates (32). In this study we found a correlation between the carbapenemase gene profile, and rep-PCR typing together with MLST results. We also found that several large clusters of indistinguishable isolates that produced dominant OXA-23-type enzymes are not only circulating within hospitals of the GCC but also across borders. This includes the internationally disseminated ST208 and ST195, which belongs to clonal complex 92 (33-36). This finding suggests that certain strains of CRAB have been prevalent in some Gulf region hospitals for an extended period of time. It also highlights the need for optimizing infection control practices to avoid cross transmission and potential outbreaks. Lastly, this finding highlights the unanswered question regarding the source of *A. baumannii*, and how certain strains found their way into the hospital environment.

We have detected OXA-40-type producing CRAB in five isolates only in a single hospital in
Bahrain. Three of the isolates were indistinguishable, but two were quite diverse (Table 3). OXA-40 producers have been previously identified in Europe and United States (2). However, to our knowledge, this is the second report of OXA-40 in the Kingdom of Bahrain and the third from the GCC region (3). Three isolates from Saudi Arabia had ISAbal element upstream of blaOXA-51-type. This carbapenem resistance mechanism has been previously described in Saudi Arabia (37, 38). These findings of sporadic resistance mechanisms might indicate slow change in the molecular epidemiology of CRAB in the Gulf region.

No isolate was found to produce OXA-58, NDM, VIM, IMP or KPC. This is in agreement with previous work reported on CRAB in the Gulf region (3). However, genes of the NDM-type carried by CRAB have been reported from the Indian subcontinent (39, 40), Asia (41), Lebanon (42), and Europe (5). A related outbreak was reported from France in an ICU with five cases where the index patient was transferred from Algeria (43). It is believed that NDM-1 occurred in Acinetobacter spp. before becoming prevalent among Enterobacteriaceae (39). Other metallo-β-lactamases such as VIM and IMP are less common in A. baumannii (2), although recent reports from India found VIM in 45% of tested CRAB (44). KPC producing A. baumannii were not known (2) until the report from Puerto Rico (45), and subsequently found in 4.3% of tested isolates from Puerto Rico (46). We did not search for blaGES, although a recent report documented this β-lactamase in the gulf region (26).

In this study we found that the vast majority of tested CRAB isolates (84%) have been associated with healthcare exposure. CRAB has been previously described in 23% of patients with ventilator-associated pneumonia in Riyadh (1, 47). An epidemiologic study from Riyadh looked at the factors related to healthcare-associated infections caused by multidrug resistant A. baumannii among a pediatric population. The study found that ICU and hospital admission post burns increased the risk of acquiring related infections (48). A recent study identified
patients at risk for bloodstream infection due to *A. baumannii*-*A. calcoaceticus* complex, and
mainly found that critically ill and inter-hospital transferred patients, and who were heavily
exposed to healthcare settings and invasive devices are at the highest risk (49).

In summary, we have evaluated CRAB in hospitals from across the Gulf Cooperation
Council. Although this is not a formal surveillance study, it is the first “snapshot” study to
determine the molecular epidemiology of CRAB in the region. Investigating the epidemic
situation within or across hospitals provides data to support infection control policy and
practices. Our findings of multiple large clusters of OXA-23-type producing *A. baumannii* in
the same hospital and across countries have important implications for control of spread of
CRAB both in the Middle East and in hospitals receiving patients transferred from the region.
Additionally, optimizing antibiotic stewardship in hospitals, community pharmacies and
within the agricultural setting should be a priority for health agencies in the Gulf region.

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the Ministry of National Guard Health Affairs. We also thank Wan Keat Yam and
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Transparency declarations

David Paterson has received honoraria for advisory board participation from AstraZeneca, Bayer, Cubist, Pfizer and Merck, not relating to this work.

References


Table 1. Summary of CRAB clinical isolates in the GCC states.

<table>
<thead>
<tr>
<th>Location</th>
<th>Name of the Hospital</th>
<th>Category</th>
<th>Bed size</th>
<th>Semi-automated systems used for species identification and antibiotic sensitivity</th>
<th>No. of carbapenem resistant A. baumannii</th>
<th>No. (%) of carbapenem resistance mechanisms(^a)</th>
<th>IS(^{Aba1}) upstream of (\text{blaOXA-51-type})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riyadh, Saudi Arabia</td>
<td>King Abdulaziz Medical City</td>
<td>Tertiary and academic</td>
<td>1,000</td>
<td>Vitek II, bioMérieux</td>
<td>49 (100)</td>
<td>47 (96)</td>
<td>0</td>
</tr>
<tr>
<td>Khobar, Saudi Arabia</td>
<td>King Fahad University Hospital</td>
<td>Tertiary and academic</td>
<td>450</td>
<td>Vitek II, bioMérieux</td>
<td>31 (100)</td>
<td>28 (90)</td>
<td>0</td>
</tr>
<tr>
<td>Abu Dhabi, United Arab Emirates</td>
<td>Sheikh Zayed Military hospital</td>
<td>Tertiary</td>
<td>365</td>
<td>Vitek II, bioMérieux</td>
<td>8 (100)</td>
<td>8 (100)</td>
<td>0</td>
</tr>
<tr>
<td>Kuwait, Kuwait</td>
<td>Al-Ameen Hospital</td>
<td>Tertiary</td>
<td>398</td>
<td>Vitek II, bioMérieux</td>
<td>8 (100)</td>
<td>8 (100)</td>
<td>0</td>
</tr>
<tr>
<td>Muscat, Oman</td>
<td>The Royal Hospital</td>
<td>Teaching Teritary</td>
<td>750</td>
<td>Phoenix, Becton Dickinson</td>
<td>5 (100)</td>
<td>5 (100)</td>
<td>0</td>
</tr>
<tr>
<td>Doha, Qatar</td>
<td>Hamad Medical Cooperation</td>
<td>Tertiary</td>
<td>&gt;1,300</td>
<td>Phoenix, Becton Dickinson</td>
<td>8 (100)</td>
<td>8 (100)</td>
<td>0</td>
</tr>
<tr>
<td>Manama, Bahrain</td>
<td>Samllantya Medical Complex</td>
<td>Tertiary and teaching</td>
<td>1,000</td>
<td>Phoenix, Becton Dickinson</td>
<td>8 (100)</td>
<td>3 (38)</td>
<td>5 (63)</td>
</tr>
<tr>
<td><strong>Total No. (%)</strong></td>
<td></td>
<td></td>
<td>117</td>
<td>117 (100)</td>
<td>107 (91)</td>
<td>54 (46)</td>
<td>3</td>
</tr>
</tbody>
</table>

\(^a\) All isolates were negative for \(\text{blaOXA-58-type, blaOXA-18-type, blaKPC-type, blaIMP-type, and blaVIM-type}\) PCR.

\(^b\) Screening for \(\text{IS}^{Aba1}\) element upstream of \(\text{blaOXA-51-type}\) was only performed on the five isolates with negative carbapenemase genes (except than \(\text{blaOXA-51}\) type).

\(^c\) NT, not tested because they were positive for either \(\text{blaOXA-23}\) or \(\text{blaOXA-40}\) types.
**Table 2.** Sequence of primers used to screen for the carbapenemase-encoding genes, ISAba1 upstream of blaOXA-51-type, and class 1 integron.

<table>
<thead>
<tr>
<th>Primer name</th>
<th>Target</th>
<th>Sequence (5’ → 3’)</th>
<th>Size (bp)</th>
<th>Annealing temperature (°C)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXA-51-F</td>
<td><em>bla</em>OXA-51</td>
<td>TAATGCTTTGATCGGCCTTG</td>
<td>353</td>
<td>60</td>
<td>14</td>
</tr>
<tr>
<td>OXA-51-R</td>
<td></td>
<td>TGGATTGCACCTTCACTTGG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OXA-23-F</td>
<td><em>bla</em>OXA-23</td>
<td>GATGTTGTCATAGTTATGTCG</td>
<td>1,065</td>
<td>52</td>
<td>15</td>
</tr>
<tr>
<td>OXA-23-R</td>
<td></td>
<td>TCACAACAACAAAAAGCAGCTG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OXA-40-F</td>
<td><em>bla</em>OXA-40</td>
<td>GTTTAGGTTGCCCCCTTTAAA</td>
<td>246</td>
<td>50</td>
<td>14</td>
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<tr>
<td>OXA-40-R</td>
<td></td>
<td>AGTTGAGGGAAAGGAGATT</td>
<td></td>
<td></td>
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<tr>
<td>OXA-58-F</td>
<td><em>bla</em>OXA-58</td>
<td>AAGTATGGGGCTGCTGCTG</td>
<td>599</td>
<td>56</td>
<td>14</td>
</tr>
<tr>
<td>OXA-58-R</td>
<td></td>
<td>CCCCCTGCGCTCACATAC</td>
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<td></td>
<td></td>
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<tr>
<td>NDM-F</td>
<td><em>bla</em>NDM</td>
<td>GCAGGTTGATCTCCTCCGTTG</td>
<td>203</td>
<td>55</td>
<td>16</td>
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<tr>
<td>NDM-R</td>
<td></td>
<td>ACGTTGGCGATCTGG</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>IMP-F</td>
<td><em>bla</em>IMP</td>
<td>CTACCGCAAGCAGCTTCTTG</td>
<td>591</td>
<td>58</td>
<td>17</td>
</tr>
<tr>
<td>IMP-R</td>
<td></td>
<td>GAAACAAACAGTTTTGCGCTACC</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>KPC-F</td>
<td><em>bla</em>KPC</td>
<td>ATCTGACACAGCAGATGACG</td>
<td>452</td>
<td>55</td>
<td>16</td>
</tr>
<tr>
<td>KPC-R</td>
<td></td>
<td>GACGGGCAACACAATAGGTG</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>VIM-F</td>
<td><em>bla</em>VIM</td>
<td>GATGGTGTTGTTGCACATG</td>
<td>390</td>
<td>55</td>
<td>18</td>
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<tr>
<td>VIM-R</td>
<td></td>
<td>GAAATTCGACGACACAG</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ISAba1-F</td>
<td>Upstream</td>
<td>CACGAATGGCAAGTTG</td>
<td>&gt;1,107</td>
<td>58</td>
<td>19</td>
</tr>
<tr>
<td>OXA-51-R</td>
<td></td>
<td>TGGATTGCACCTTCACTTGG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HS317</td>
<td><em>intI1</em></td>
<td>GAACCTTGACGAAAGC</td>
<td>variable</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>HS320</td>
<td></td>
<td>AGTAAAGGCGCCTGCTG</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>
Table 3. Clustering results based on rep-PCR patterns of 117 carbapenem resistant *A. baumannii* isolates from the GCC states.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Total number of isolates (n=)</th>
<th>Country, Number of isolates (n=)</th>
<th>Carbenapenemase genes, Number of isolates (n=)</th>
<th>Sequence Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>Saudi Arabia-Riyadh, 8</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type 21</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh, 22</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type 1</td>
<td>ST195; clustered with ST195 and ST208*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Khobar, 19</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type 18</td>
<td>ST208; clustered with novel ST and ST195</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kuwait, 6</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ST208; clustered with novel ST and ST195</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bahrain, 2</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-40&lt;/sub&gt;-like</td>
<td>ST195; clustered with ST195</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oman, 3</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>Clusters with ST499</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>Bahrain, 3</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>Saudi Arabia-Riyadh, 2</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type 1</td>
<td>ND</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>Saudi Arabia-Riyadh, 2</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type 1</td>
<td>ND</td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>Kuwait, 1</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>G</td>
<td>5</td>
<td>UAE, 2</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>H</td>
<td>3</td>
<td>Bahrain, 3</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>Clusters with ST450</td>
</tr>
<tr>
<td>I</td>
<td>4</td>
<td>Saudi Arabia-Riyadh, 4</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>J</td>
<td>3</td>
<td>Saudi Arabia-Riyadh, 3</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>K</td>
<td>8</td>
<td>Qatar, 6</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>L</td>
<td>2</td>
<td>Kuwait, 1</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>M</td>
<td>3</td>
<td>Saudi Arabia-Khobar, 3</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>N</td>
<td>3</td>
<td>Saudi Arabia-Khobar, 3</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>O</td>
<td>2</td>
<td>Oman</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td>P</td>
<td>2</td>
<td>Saudi Arabia-Riyadh, 2</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISAb1 upstream of <em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh</td>
<td><em>bla</em>&lt;sub&gt;OXA-51&lt;/sub&gt;-type and <em>bla</em>&lt;sub&gt;OXA-23&lt;/sub&gt;-type</td>
<td>ND</td>
</tr>
</tbody>
</table>

Full dendrogram illustration can be found in the supplementary materials; ND, not determined; *There is only a single allele difference between sequence types ST195 and ST208.*
Table 4. Demographic and clinical characteristics of $n=100$ patients with carbapenem resistant *A. baumannii*.

<table>
<thead>
<tr>
<th>Age-years</th>
<th>Total number</th>
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<tbody>
<tr>
<td>0-7</td>
<td>4</td>
</tr>
<tr>
<td>7-18</td>
<td>5</td>
</tr>
<tr>
<td>18-30</td>
<td>23</td>
</tr>
<tr>
<td>30-50</td>
<td>19</td>
</tr>
<tr>
<td>50-60</td>
<td>11</td>
</tr>
<tr>
<td>60-70</td>
<td>13</td>
</tr>
<tr>
<td>70-more</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>68</td>
</tr>
<tr>
<td>Female</td>
<td>32</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Residency status</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>79</td>
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<tr>
<td>Resident</td>
<td>20</td>
</tr>
<tr>
<td>No data</td>
<td>1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Total number</th>
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</thead>
<tbody>
<tr>
<td>Blood</td>
<td>18</td>
</tr>
<tr>
<td>Sputum</td>
<td>22</td>
</tr>
<tr>
<td>Swab</td>
<td>39</td>
</tr>
<tr>
<td>Urine</td>
<td>6</td>
</tr>
<tr>
<td>Other$^b$</td>
<td>15</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial medical condition</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns</td>
<td>6</td>
</tr>
<tr>
<td>Community-acquired pneumonia</td>
<td>5</td>
</tr>
<tr>
<td>Hospital-acquired pneumonia</td>
<td>8</td>
</tr>
<tr>
<td>Motor vehicle accident</td>
<td>17</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>30</td>
</tr>
<tr>
<td>No data</td>
<td>31</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Infection category</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare-associated infection</td>
<td>24</td>
</tr>
<tr>
<td>Hospital-acquired infection</td>
<td>53</td>
</tr>
<tr>
<td>Colonization</td>
<td>7</td>
</tr>
<tr>
<td>Community-acquired infection</td>
<td>8</td>
</tr>
<tr>
<td>No data</td>
<td>8</td>
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<table>
<thead>
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<th>Antibiotic exposure before isolation</th>
<th>Total number</th>
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</thead>
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<tr>
<td>Yes</td>
<td>87</td>
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<tr>
<td>1-2 days</td>
<td>34</td>
</tr>
<tr>
<td>3-4 days</td>
<td>31</td>
</tr>
<tr>
<td>5-6 days</td>
<td>9</td>
</tr>
<tr>
<td>7-more day</td>
<td>3</td>
</tr>
<tr>
<td>but no data</td>
<td>10</td>
</tr>
<tr>
<td>No</td>
<td>12</td>
</tr>
<tr>
<td>No data</td>
<td>1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Pervious medical history</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-patient clinic or ER</td>
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</tr>
<tr>
<td>$\leq 30$ days</td>
<td>14</td>
</tr>
<tr>
<td>1-6 months</td>
<td>24</td>
</tr>
<tr>
<td>6-12 months</td>
<td>18</td>
</tr>
<tr>
<td>$\geq 12$ months</td>
<td>21</td>
</tr>
<tr>
<td>Haemodialysis</td>
<td></td>
</tr>
<tr>
<td>$\leq 30$ days</td>
<td>14</td>
</tr>
<tr>
<td>1-6 months</td>
<td>9</td>
</tr>
<tr>
<td>6-12 months</td>
<td>4</td>
</tr>
<tr>
<td>$\geq 12$ months</td>
<td>5</td>
</tr>
<tr>
<td>Surgical procedure</td>
<td>≤ 30 days</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Hospital admission</td>
<td>≤ 30 days</td>
</tr>
<tr>
<td>Yes</td>
<td>46</td>
</tr>
<tr>
<td>No</td>
<td>45</td>
</tr>
<tr>
<td>Never</td>
<td>1</td>
</tr>
<tr>
<td>No data</td>
<td>50</td>
</tr>
</tbody>
</table>

*Local is referring to citizens of the designated countries; Other includes respiratory specimens and body fluids.*
Table 1. Summary of CRAB clinical isolates in the GCC states.

<table>
<thead>
<tr>
<th>Location</th>
<th>Name of the Hospital</th>
<th>Category</th>
<th>Bed size</th>
<th>Semi-automated systems used for species identification and antibiotic sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riyadh, Saudi Arabia</td>
<td>King Abdulaziz Medical City</td>
<td>Tertiary and academic</td>
<td>1,000</td>
<td>Vitek II, bioMérieux</td>
</tr>
<tr>
<td>Khobar, Saudi Arabia</td>
<td>King Fahad University Hospital</td>
<td>Tertiary and academic</td>
<td>450</td>
<td>Vitek II, bioMérieux</td>
</tr>
<tr>
<td>Abu Dhabi, United Arab Emirates</td>
<td>Sheikh Zayed Military hospital</td>
<td>Tertiary</td>
<td>365</td>
<td>Vitek II, bioMérieux</td>
</tr>
<tr>
<td>Kuwait, Kuwait</td>
<td>Al-Ameri Hospital</td>
<td>Tertiary</td>
<td>398</td>
<td>Vitek II, bioMérieux</td>
</tr>
<tr>
<td>Muscat, Oman</td>
<td>The Royal Hospital</td>
<td>Teaching</td>
<td>750</td>
<td>Phoenix, Becton Dickinson</td>
</tr>
<tr>
<td>Doha, Qatar</td>
<td>Hamad Medical Cooperation</td>
<td>Tertiary</td>
<td>&gt;1,300</td>
<td>Phoenix, Becton Dickinson</td>
</tr>
<tr>
<td>Manama, Bahrain</td>
<td>Samlaniya Medical Complex</td>
<td>Tertiary and teaching</td>
<td>1,000</td>
<td>Phoenix, Becton Dickinson</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRAB clinical isolates in the GCC states</th>
<th>No. of carbapenem resistant A. baumannii</th>
<th>No. (%) of carbapenem resistance mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riyadh, Saudi Arabia</td>
<td>49</td>
<td>47 (96)</td>
</tr>
<tr>
<td>Khobar, Saudi Arabia</td>
<td>31</td>
<td>28 (90)</td>
</tr>
<tr>
<td>Abu Dhabi, United Arab Emirates</td>
<td>8</td>
<td>8 (100)</td>
</tr>
<tr>
<td>Kuwait, Kuwait</td>
<td>8</td>
<td>8 (100)</td>
</tr>
<tr>
<td>Muscat, Oman</td>
<td>5</td>
<td>5 (100)</td>
</tr>
<tr>
<td>Doha, Qatar</td>
<td>8</td>
<td>8 (100)</td>
</tr>
<tr>
<td>Manama, Bahrain</td>
<td>8</td>
<td>3 (38)</td>
</tr>
</tbody>
</table>

*Screening for ISAb1 element upstream of blaOXA-51 type was only performed on the five isolates with negative carbapenemase genes (except than blaOXA-51 type).

**All isolates were negative for blaOXA-58 type, blaNDM type, blaKPC type, blaIMP type, and blaVIM type.**

**NT, not tested because they were positive for either blaOXA-23 or blaOXA-40 types.**
Table 2. Sequence of primers used to screen for the carbapenemase-encoding genes, IS\textit{Aba1} upstream of \textit{blaOXA-51}-type, and class 1 integron.

<table>
<thead>
<tr>
<th>Primer name</th>
<th>Target</th>
<th>Sequence (5' → 3')</th>
<th>Size (bp)</th>
<th>Annealing temperature (°C)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXA-51-F</td>
<td>\textit{blaOXA-51}</td>
<td>TAATGCTTTGATCGGCCCTG TGGATGTCAGGCTACCTTGG</td>
<td>353</td>
<td>60</td>
<td>14</td>
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<tr>
<td>OXA-51-R</td>
<td>\textit{blaOXA-51}</td>
<td>1,065 GATGTCATAGTTATTGCAGGCTACCTTGG</td>
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<td></td>
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</tr>
<tr>
<td>OXA-23-F</td>
<td>\textit{blaOXA-23}</td>
<td>TGGATTGCACTTCACTTGG</td>
<td>246</td>
<td>50</td>
<td>14</td>
</tr>
<tr>
<td>OXA-23-R</td>
<td>\textit{blaOXA-23}</td>
<td>599 GATGTCATAGTTATTGCAGGCTACCTTGG</td>
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</tr>
<tr>
<td>OXA-40-F</td>
<td>\textit{blaOXA-40}</td>
<td>203 GAGCTGAGGATGCTTGTTGAGTGCAGGCTACCTTGG</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>OXA-40-R</td>
<td>\textit{blaOXA-40}</td>
<td>591 AGGCTGAGGATGCTTGTTGAGTGCAGGCTACCTTGG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDM-F</td>
<td>\textit{blaNDM}</td>
<td>452 GCTACCGACGAGAGTCAGGCTTTGGAGTGCAGGCTACCTTGG</td>
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</tr>
<tr>
<td>NDM-R</td>
<td>\textit{blaNDM}</td>
<td>390 GATGTTGAGGATGCTTGTTGAGTGCAGGCTACCTTGG</td>
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<td></td>
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<tr>
<td>IMP-F</td>
<td>\textit{blaIMP}</td>
<td>1,107 CACGAGACGAGAGTCAGGCTTTGGAGTGCAGGCTACCTTGG</td>
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<tr>
<td>IMP-R</td>
<td>\textit{blaIMP}</td>
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<tr>
<td>KPC-F</td>
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<td></td>
<td></td>
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<tr>
<td>KPC-R</td>
<td>\textit{blaKPC}</td>
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<td></td>
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<tr>
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<td>\textit{blaVIM}</td>
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<td></td>
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<tr>
<td>\textit{Aba1}-F</td>
<td>\textit{Upstream}</td>
<td>502 CACGAGACGAGAGTCAGGCTTTGGAGTGCAGGCTACCTTGG</td>
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<tr>
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<td>\textit{Upstream}</td>
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<td>HS317</td>
<td>\textit{intI1}</td>
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Table 3. Clustering results based on rep-PCR patterns of 117 carbapenem resistant *A. baumannii* isolates from the GCC states.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Total number of isolates (n=)</th>
<th>Country, Number of isolates (n=)</th>
<th>Carbenemase genes, Number of isolates (n=)</th>
<th>Sequence Type</th>
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<tbody>
<tr>
<td>A</td>
<td>8</td>
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<td>blaOXA-51-type, and blaOXA-23-type</td>
<td>ND</td>
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<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Riyadh, 22</td>
<td>blaOXA-51-type, and blaOXA-23-type, 21</td>
<td>ST195; clustered with ST208</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saudi Arabia-Khobar, 19</td>
<td>blaOXA-51-type, and blaOXA-23-type, 18</td>
<td>Novel ST; clustered with ST195 and ST208</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kuwait, 6</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST208; clustered with novel ST and ST195</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bahrain, 2</td>
<td>blaOXA-51-type and blaOXA-40-like</td>
<td>ST208; clustered with ST208</td>
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<tr>
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<td>Oman, 3</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST195; clustered with ST195</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>UAE, 1</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST452; clustered with ST452</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>Saudi Arabia-Riyadh, 2</td>
<td>blaOXA-51-type and blaOXA-23-type, 1</td>
<td>ND</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>Saudi Arabia-Riyadh, 2</td>
<td>blaOXA-51-type and blaOXA-23-type, 1</td>
<td>ND</td>
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<tr>
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<td></td>
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<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST499; clustered with ST499</td>
</tr>
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<td>F</td>
<td>2</td>
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<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST450</td>
</tr>
<tr>
<td>G</td>
<td>5</td>
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<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST450; clustered with ST450</td>
</tr>
<tr>
<td>H</td>
<td>3</td>
<td>Bahrain, 3</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>Novel ST; cluster with novel ST</td>
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<tr>
<td>I</td>
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<td>ND</td>
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<td>J</td>
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<td>Saudi Arabia-Riyadh, 3</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST299; clustered with ST299</td>
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<td>K</td>
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<td>Qatar, 6</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST299; clustered with ST299</td>
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<tr>
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<td>ST299; clustered with ST299</td>
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<tr>
<td>M</td>
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<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
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<tr>
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<td>3</td>
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<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ST436; clustered with ST436</td>
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<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
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<tr>
<td>P</td>
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<td>Saudi Arabia-Khobar, 2</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
</tr>
<tr>
<td>Singleton 1</td>
<td>Saudi Arabia-Riyadh</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>Singleton 2</td>
<td>UAE</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
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</tr>
<tr>
<td>Singleton 3</td>
<td>Saudi Arabia-Riyadh</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>Singleton 4</td>
<td>UAE</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
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<td>Singleton 5</td>
<td>Saudi Arabia-Riyadh</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
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<tr>
<td>Singleton 6</td>
<td>UAE</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
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</tr>
<tr>
<td>Singleton 7</td>
<td>Saudi Arabia-Khobar</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
<td>ND</td>
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</tr>
<tr>
<td>Singleton 8</td>
<td>Oman</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
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<td>Singleton 9</td>
<td>Saudi Arabia-Riyadh</td>
<td>blaOXA-51-type and blaOXA-23-type</td>
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<tr>
<td>Singleton 10</td>
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<td>blaOXA-51-type and blaOXA-23-type</td>
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<tr>
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<td>Saudi Arabia-Riyadh</td>
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Full dendrogram illustration can be found in the supplementary materials; ND, not determined; *There is only a single allele difference between sequence types ST195 and ST208.*
Table 4. Demographic and clinical characteristics of n=100 patients with carbapenem resistant *A. baumannii*.

<table>
<thead>
<tr>
<th>Age-years</th>
<th>Total number</th>
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<tr>
<td>0-7</td>
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<tr>
<td>7-18</td>
<td>5</td>
</tr>
<tr>
<td>18-30</td>
<td>23</td>
</tr>
<tr>
<td>30-50</td>
<td>19</td>
</tr>
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<td>50-60</td>
<td>11</td>
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<tr>
<td>60-70</td>
<td>13</td>
</tr>
<tr>
<td>70-more</td>
<td>25</td>
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<table>
<thead>
<tr>
<th>Gender</th>
<th>Total number</th>
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<tr>
<td>Male</td>
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<tr>
<td>Female</td>
<td>32</td>
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<table>
<thead>
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<th>Residency statuses</th>
<th>Total number</th>
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</thead>
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<tr>
<td>Locala</td>
<td>79</td>
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<tr>
<td>Resident</td>
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<table>
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<tr>
<th>Source</th>
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<tr>
<td>Blood</td>
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<tr>
<td>Sputum</td>
<td>22</td>
</tr>
<tr>
<td>Swab</td>
<td>39</td>
</tr>
<tr>
<td>Urine</td>
<td>6</td>
</tr>
<tr>
<td>Otherb</td>
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</table>

<table>
<thead>
<tr>
<th>Initial medical condition</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns</td>
<td>6</td>
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<tr>
<td>Community acquired pneumonia</td>
<td>5</td>
</tr>
<tr>
<td>Hospital acquired pneumonia</td>
<td>8</td>
</tr>
<tr>
<td>Motor vehicle accident</td>
<td>17</td>
</tr>
<tr>
<td>Hemodialysis</td>
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</tr>
<tr>
<td>Other</td>
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<td>No data</td>
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<table>
<thead>
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<th>Infection category</th>
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</thead>
<tbody>
<tr>
<td>Healthcare-associated infection</td>
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<tr>
<td>Hospital-acquired infection</td>
<td>53</td>
</tr>
<tr>
<td>colonization</td>
<td>7</td>
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<tr>
<td>Community-acquired infection</td>
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<table>
<thead>
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<th>Antibiotic exposure before isolation</th>
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<tr>
<td>1-2 days</td>
<td>34</td>
</tr>
<tr>
<td>3-4 days</td>
<td>31</td>
</tr>
<tr>
<td>5-6 days</td>
<td>9</td>
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<tr>
<td>7-more day</td>
<td>3</td>
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<tr>
<td>but no data</td>
<td>10</td>
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<tr>
<td>No</td>
<td>12</td>
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<table>
<thead>
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<th>Pervious medical history</th>
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<td>≤ 30 days</td>
<td>14</td>
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<tr>
<td>1-6 months</td>
<td>24</td>
</tr>
<tr>
<td>6-12 months</td>
<td>18</td>
</tr>
<tr>
<td>≥ 12 months</td>
<td>21</td>
</tr>
<tr>
<td>Haemodialysis</td>
<td></td>
</tr>
<tr>
<td>≤ 30 days</td>
<td>14</td>
</tr>
<tr>
<td>1-6 months</td>
<td>9</td>
</tr>
<tr>
<td>6-12 months</td>
<td>4</td>
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<tr>
<td>Time Frame</td>
<td>Cases</td>
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<td>------------------</td>
<td>-------</td>
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<td>≥ 12 months</td>
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<td>Surgical procedure</td>
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<td>≤ 30 days</td>
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<tr>
<td>1-6 months</td>
<td>18</td>
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<tr>
<td>6-12 months</td>
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<tr>
<td>≥ 12 months</td>
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<tr>
<td>Hospital admission</td>
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<tr>
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<td>6-12 months</td>
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<tr>
<td>≥ 12 months</td>
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<td>Recent overseas medical treatment</td>
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<td>India</td>
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<td>Singapore</td>
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<td>Thailand</td>
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“Local is referring to citizens of the designated countries; Other includes respiratory specimens and body fluids.”