Background and Objectives. Bacterial meningitis is a common medical condition in Qatar. The aim of this study was to describe the clinical characteristics of bacterial meningitis, the frequency of each pathogen, and its sensitivity to antibiotics and risk factors for death. Patients and Methods. This retrospective study was conducted at Hamad General Hospital between January 1, 2009, and December 31, 2013. Results. We identified 117 episodes of acute bacterial meningitis in 110 patients. Their mean age was 26.4 ± 22.3 years (range: 2–74) and 81 (69.2%) of them were male patients. Fifty-nine episodes (50.4%) were community-acquired infection and fever was the most frequent symptom (94%), whereas neurosurgery is the most common underlying condition. Coagulase-negative staphylococci were the most common causative agent, of which 95% were oxacillin-resistant, while 63.3% of Acinetobacter spp. showed resistance to meropenem. The in-hospital mortality was 14 (12%). Only the presence of underlying diseases, hypotension, and inappropriate treatment were found to be independent predictors of mortality. Conclusion. Acute bacterial meningitis predominantly affected adults and coagulase-negative staphylococci species were the common causative agent in Qatar with majority of infections occurring nosocomially. More than 90% of all implicated coagulase-negative staphylococci strains were oxacillin-resistant.

1. Introduction

Despite medical advances, acute bacterial meningitis (ABM) constitutes a global public health problem, especially in developing countries with poor health facilities due to high rates of malnutrition, poor living conditions, and lack of access to appropriate preventive and curative services that may predispose people to the disease and reduce their chances of receiving optimal treatment [1, 2]. In developed countries, the burden of the disease has reduced and its epidemiology has changed as a result of the widespread use of vaccines against the most common meningeal pathogens [3].

Accurate information on important etiologic agents and populations at risk is needed to determine public health measures and ensure appropriate management of ABM [3]. In Qatar, although ABM is a common medical condition that physicians face, there are few reports describing this disease [4–6]. We conducted the present study, the purposes of which were to (1) describe the demographic and clinical characteristics of ABM, (2) determine the relative frequency of each pathogen and its susceptibility to various antimicrobial agents, and (3) determine the outcome and the significant predictors of the outcome among patients with ABM in Qatar.
2. Materials and Methods

2.1. Design and Setting. This retrospective descriptive study, which involved all in-patients with ABM, was conducted at Hamad General Hospital between January 1, 2009, and December 31, 2013. This hospital is a 603-bed tertiary care center that covers all specialties except for hematology-oncology, cardiology, and obstetrics and it has been Joint Commission International (JCI) accredited since 2006 and is the first hospital system in the region to achieve institutional accreditation from the Accreditation Council for Graduate Medical Education-International (ACGME-I). Currently, there are three adult ICUs in Hamad General Hospital, namely, Medical ICU (MICU) with 22 beds, Surgical ICU (SICU) with 12 beds, and Trauma ICU (TICU) with 15 beds.

2.2. Definitions. ABM was diagnosed on the basis of at least one of the following compatible clinical pictures with no other apparent cause: fever (38°C), headache, meningeal signs, cranial nerve signs, and impaired mental status, plus temperature

2.3. Isolation, Identification, and Antimicrobial Susceptibility Test of Microorganisms. Identification of isolates was based on colony morphology, Gram stain, oxidase, catalase, VITEK 2 Compact (bioMérieux, Durham, USA), and Phoenix (Becton Dickinson, NJ, USA). The antimicrobial minimal inhibitory concentrations (MICs) for the isolates were determined by using Phoenix (Becton Dickinson, NJ, USA) for GNB and staphylococci and enterococci (among Gram-positive cocci). For fastidious bacteria, susceptibility was determined with a gradient strip method (E-test strips, bioMérieux, Marcy-l’Étoile, France). The breakpoint interpretation was determined according to the recommendations of the Clinical Laboratory Standards Institute (CLSI) [13].

2.4. Source of Data and Data Collection. Cases were identified via hospital’s discharge records, infection control records, and cerebrospinal fluid records maintained by the microbiology unit. These records were reviewed carefully by two investigators, in order not to miss any case. Records of all patients with bacterial meningitis were reviewed retrospectively to retrieve data on patients’ demography, sign-symptoms, underlying medical conditions, investigations, names of microorganisms and their drug susceptibility, name and duration of therapy offered, appropriateness of therapy, and outcome.

2.5. Statistical Analysis. Quantitative variables were expressed as mean ± SD. Univariate logistic regression was performed to determine the probable predictors of in-hospital mortality. All potential risk factors at ≤0.1 level in the univariate analysis were entered in the multiple logistic regression to identify the independent predictors of mortality at \( P < 0.05 \). The data were analyzed with SPSS software (v17; IBM Corp., Armonk, NY, USA).

2.6. Ethical Approval. Ethical approval (#13254/13) and a waiver of informed consent were obtained from the medical research ethical committee at Hamad Medical Corporation, Qatar.

3. Results

3.1. Demographic and Clinical Data. During the study period, we identified 117 episodes of ABM in 110 patients. There were 43, 22, 21, 12, and 18 episodes in 2009, 2010, 2011, 2012, and 2013, respectively. The study sample comprised 81 (69.2%) male and 29 (30.8%) female patients. Their mean age was 26.4 ± 22.3 years (range: 2–74), and 28 (23.9%) patients were Qatari. The peak frequency of ABM episodes was noted among adults (15–64 years old) (92.3%) (see Table 1). From a clinical point of view, fever was the most frequent symptom (110, 94%), followed by mental alteration (55, 47%), headache (43, 36.8%), and vomiting (35, 29.9%). Moreover, meningismus was detected in 31 (26.5%) patients (see Table 1).

3.2. Underlying Conditions. The most frequent underlying conditions were neurosurgery (54, 46.2%), hypertension (26, 22.2%), and diabetes mellitus (9, 7.7%) (see Table 1).
Table 1: Demographic and clinical data of the 117 patients involved in this study.

| Variable                        | Number (%), mean ± SD (range) |
|---------------------------------|--------------------------------|
| Gender                          | M 81 (69.2) F 29 (30.8)        |
| Age (mean ± SD), years          | 26.4 ± 22.3 (2–74)             |
| Age group (years)               | <1 26 (22.2) 1–5 11 (9.4)      |
|                                 | 6–14 6 (5.1) 15–24 12 (10.3)   |
|                                 | 25–34 13 (11.1) 35–44 17 (14.5)|
|                                 | 45–54 23 (19.7) 55–64 6 (5.1)  |
|                                 | ≥65 3 (2.6)                    |
| Nationality                     | Qatari 28 (23.9) Non-Qatari 82 (76.1) |
| Underlying conditions           | Diabetes mellitus 9 (7.7)      |
|                                 | Hypertension 26 (22.2)         |
|                                 | Head injury 6 (5.1)            |
|                                 | Neurosurgery 54 (46.2)         |
|                                 | Alcoholic 4 (3.4)              |
|                                 | Prematurity 7 (6.0)            |
|                                 | Liver cirrhosis 1 (0.9)        |
|                                 | Otitis media 5 (4.3)           |
|                                 | Malignancy 8 (6.8)             |
|                                 | Immunosuppression 2 (1.7)      |
| Clinical presentation           | Fever 110 (94)                 |
|                                 | Mental alteration 55 (47)      |
|                                 | Headache 43 (36.8)             |
|                                 | Vomiting 35 (29.9)             |
|                                 | Meningism 31 (26.5)            |
|                                 | Seizures 23 (19.7)             |
|                                 | Bulging fontanel 16 (13.7)     |
|                                 | Hypotension (BP < 90/60 mmHg) 12 (10.2) |
|                                 | Focal signs 11 (9.4)           |
|                                 | Photophobia 7 (6.0)            |
|                                 | Behavioral changes 3 (2.6)     |
|                                 | Petechial rash 3 (2.6)         |
| Complications                   | Hydrocephalus 19 (16.2)        |
|                                 | Ischemic stroke 5 (4.3)        |
|                                 | Brain abscess 4 (3.4)          |
|                                 | Subdural empyema 1 (0.9)       |
|                                 | Adrenal insufficiency 1 (0.9)  |
|                                 | Vasculitis 1 (0.9)             |

Table 2: Clinical data of the 117 patients involved in this study.

| Variable                   | Number (%), mean ± SD (range) |
|----------------------------|--------------------------------|
| Acquisition of infection   | Community-acquired 59 (50.4) |
|                           | Nosocomial 58 (49.6)          |
| CSF                        | Cells/μL 3880.4 ± 8654.6 (20–66000) |
|                           | Neutrophils% 74.1 ± 261.1 (1–99) |
|                           | Lymphocytes% 22.9 ± 24.8 (1–98) |
|                           | Protein (g/dL) 222.8 ± 205.9 (38–936) |
|                           | Glucose (mmol/L) 2.1 ± 1.6 (0.1–6) |
|                           | Positive Gram stain 93 (79.5)  |
|                           | Positive culture 112 (95.7)    |
|                           | Positive latex agglutination 23 (19.7) |
| Type of microorganism      | Gram-positive 62 (53)         |
|                           | Gram-negative 55 (47)         |
|                           | Positive blood culture 37 (31.6) |
| Antimicrobial therapy      | Appropriate 97 (82.9)         |
|                           | Inappropriate 20 (17.1)       |
| Outcome                   | Died 14 (12.0)                |
|                           | Alive 103 (88.0)              |

3.3. Cerebrospinal Fluid (CSF) Findings. The CSF findings of the 117 ABM episodes are listed in Table 2.

3.4. Setting of Infection and Types and Distributions of the Microorganisms. Fifty-nine episodes (50.4%) were community-acquired and the other 58 (49.6%) were nosocomially acquired ABM (see Table 3). The causative pathogens of the 117 enrolled ABM episodes are listed in Tables 3 and 4. Gram-positive pathogens accounted for 62 (53%) episodes and Gram-negative pathogens accounted for the other 55 (47%). In general, the most common causative agent of ABM in our cohort was coagulase-negative staphylococci; however, among the 59 community-acquired meningitis cases, the most common etiological agent was Streptococcus pneumoniae, whereas coagulase-negative staphylococci species were the leading cause of nosocomially acquired ABM. Among the implicated Gram-positive pathogens, coagulase-negative staphylococci species were the most common causative agent, whereas among Gram-negative pathogens, Klebsiella pneumoniae was the most common (12, 10.2%) followed by Neisseria meningitidis (11, 9.4%).

3.5. Trends of Antimicrobial Susceptibility. Details of antimicrobial susceptibility are shown in Tables 5 and 6. Among the Gram-positive cases, 3 (18.6%) episodes of Streptococcus pneumoniae were resistant to ceftriaxone, while out of all coagulase-negative staphylococci isolates, 19 (95%) were methicillin-resistant. Among the Gram-negative cases, 100% of Chryseobacterium species were resistant to meropenem and colistin, while 63.3% of Acinetobacter species showed resistance to meropenem but none for colistin. All Pseudomonas spp. were sensitive to piperacillin-tazobactam and meropenem. Among Klebsiella isolates, 2 (16.6%) were extended spectrum beta-lactamase (ESBL) producers, but all
Table 3: Distribution of different isolates in relation to setting of acquisition of meningitis.

| Microorganism                  | Setting of acquisition | Community-acquired | Total |
|--------------------------------|------------------------|--------------------|-------|
|                                | Nosocomial             | %                  |       |
| Gram-positive                  |                        |                    |       |
| Abiotrophia species           | 1 (100)                |                    | 1     |
| Enterococcus faecalis         | 5 (71.4)               | 2 (28.6)           | 7     |
| Enterococcus gallinarum       | 1 (100)                | 0                  | 1     |
| Gemella haemolysans           | 1 (100)                | 0                  | 1     |
| Leuconostoc species           | 1 (100)                | 0                  | 1     |
| Listeria monocytogenes        | 0                      | 3 (100)            | 3     |
| Staphylococcus aureus         | 0                      | 1 (100)            | 1     |
| Staphylococcus capitis        | 2 (100)                | 0                  | 2     |
| Staphylococcus epidermidis    | 14 (87.5)              | 2 (12.5)           | 16    |
| Staphylococcus haemolyticus   | 2 (100)                | 0                  | 2     |
| Streptococcus agalactiae      | 0                      | 3 (100)            | 3     |
| Streptococcus bovis II        | 0                      | 1 (100)            | 1     |
| Streptococcus intermedius     | 0                      | 1 (100)            | 1     |
| Streptococcus milleri         | 0                      | 1 (100)            | 1     |
| Streptococcus mitis           | 0                      | 1 (100)            | 1     |
| Streptococcus pneumoniae      | 0                      | 19 (100)           | 19    |
| Streptococcus salivarius      | 0                      | 1 (100)            | 1     |
| Gram-negative                 |                        |                    |       |
| Acinetobacter baumannii       | 8 (100)                | 0                  | 8     |
| Acinetobacter lwoffii         | 2 (66.7)               | 1 (33.3)           | 3     |
| Brucella spp.                 | 0                      | 1 (100)            | 1     |
| Chryseobacterium (Flavobacterium) meningosepticum | 0 | 1 (100) | 1 |
| Chryseobacterium indolgenes   | 0                      | 1 (100)            | 1     |
| Enterobacter aerogenes        | 1 (100)                | 0                  | 1     |
| Enterobacter cloacae          | 3 (100)                | 0                  | 3     |
| Escherichia coli              | 3 (75)                 | 1 (25)             | 4     |
| Haemophilus influenzae        | 1 (50)                 | 1 (50)             | 2     |
| Klebsiella pneumoniae ssp. pneumoniae | 7 (58.3) | 5 (41.7) | 12  |
| Neisseria meningitides        | 0                      | 11 (100)           | 11    |
| Pseudomonas aeruginosa        | 5 (100)                | 0                  | 5     |
| Pseudomonas putida            | 1 (100)                | 0                  | 1     |
| Salmonella group B            | 0                      | 1 (100)            | 1     |
| Serratia marcescens           | 0                      | 1 (100)            | 1     |
| Total                         | 58                     | 59                 | 117   |

3.6. Treatment and Outcome. Antimicrobial treatment was initiated for all patients. Ceftriaxone plus vancomycin combination was the most widely used antimicrobial treatment followed by meropenem. Empiric therapy was inappropriate in 20 (17.1%) episodes. The crude in-hospital mortality in our study was 14 (12%).

3.7. Univariate and Multivariate Logistic Regression Analysis of Factors Associated with Death. By the univariate analysis, the following variables were found to be probable predictors of in-hospital mortality: presence of underlying diseases, nosocomial infection, multidrug-resistant episodes, hypotension, mental alteration, and inappropriate treatments.
Table 4: Distribution of microorganisms in relation to the age group.

| Microorganism                          | <1 | 1–5 | 6–14 | 15–24 | 25–34 | 35–44 | 45–54 | 55–64 | ≥65 | Total |
|----------------------------------------|----|-----|------|-------|-------|-------|-------|-------|-----|-------|
| Abiotrophia species                    | 0  | 0   | 0    | 0     | 0     | 1     | 0     | 0     | 0   | 1 (0.8) |
| Acinetobacter baumannii                | 0  | 0   | 0    | 0     | 0     | 2     | 3     | 2     | 1   | 8 (6.8) |
| Acinetobacter lwoffii                  | 0  | 1   | 1    | 0     | 0     | 0     | 0     | 0     | 0   | 3 (2.6) |
| Brucella spp.                          | 0  | 0   | 0    | 0     | 0     | 0     | 1     | 0     | 0   | 1 (0.8) |
| Chryseobacterium (Flavobacterium)      | 1  | 0   | 0    | 0     | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| meningosepticum                       |    |     |      |       |       |       |       |       |     |       |
| Chryseobacterium indologenes           | 1  | 0   | 0    | 0     | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Enterobacter aerogenes                 | 1  | 0   | 0    | 0     | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Enterobacter cloacae                   | 0  | 0   | 0    | 0     | 0     | 1     | 2     | 0     | 0   | 3 (2.6) |
| Enterococcus faecalis                  | 2  | 1   | 0    | 0     | 0     | 1     | 2     | 1     | 0   | 7 (5.9) |
| Enterococcus gallinarum                | 0  | 0   | 0    | 0     | 0     | 0     | 1     | 0     | 0   | 1 (0.8) |
| Escherichia coli                       | 2  | 1   | 0    | 0    | 0     | 1     | 0     | 0     | 0   | 4 (3.4) |
| Gemella haemolysans                    | 0  | 0   | 0    | 1    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Haemophilus influenzae                 | 0  | 1   | 0    | 1    | 0     | 0     | 0     | 0     | 0   | 2 (1.6) |
| Klebsiella pneumoniae ssp. pneumoniae  | 2  | 0   | 0    | 2    | 1     | 1     | 4     | 2     | 0   | 12 (10.3) |
| Leuconostoc species                    | 0  | 0   | 0    | 0    | 0     | 0     | 1     | 0     | 0   | 1 (0.8) |
| Listeria monocytogenes                 | 3  | 0   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 3 (2.6) |
| Neisseria meningitidis                 | 0  | 1   | 0    | 3    | 3     | 1     | 2     | 0     | 1   | 11 (9.4) |
| Pseudomonas aeruginosa (PSA)           | 0  | 0   | 1    | 0    | 2     | 1     | 1     | 0     | 0   | 5 (4.2) |
| Pseudomonas putida                     | 0  | 0   | 0    | 0    | 0     | 0     | 1     | 0     | 0   | 1 (0.8) |
| Salmonella group B                     | 1  | 0   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Serratia marcescens                    | 1  | 0   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Staphylococcus aureus                  | 0  | 0   | 1    | 0    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Staphylococcus capitis                 | 0  | 0   | 0    | 0    | 0     | 1     | 1     | 0     | 0   | 2 (1.6) |
| Staphylococcus epidermidis             | 6  | 2   | 0    | 2    | 1     | 3     | 1     | 1     | 0   | 16 (13.6) |
| Staphylococcus haemolyticus            | 0  | 0   | 0    | 0    | 0     | 1     | 1     | 0     | 0   | 2 (1.6) |
| Streptococcus agalactiae               | 2  | 0   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 3 (2.6) |
| Streptococcus bovis II                 | 1  | 0   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Streptococcus intermedius              | 0  | 0   | 0    | 0    | 0     | 1     | 0     | 0     | 0   | 1 (0.8) |
| Streptococcus milleri                  | 0  | 0   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Streptococcus mitis                    | 0  | 1   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |
| Streptococcus pneumoniae               | 3  | 2   | 3    | 2    | 3     | 2     | 4     | 0     | 0   | 19 (16.2) |
| Streptococcus salivarius               | 0  | 1   | 0    | 0    | 0     | 0     | 0     | 0     | 0   | 1 (0.8) |

Total 26 (22.2) 11 (9.4) 6 (5.1) 12 (10.3) 13 (11.1) 17 (14.5) 23 (19.7) 6 (5.1) 3 (2.6) 117 (100)

(see Table 7). Only the presence of underlying diseases, hypotension, and inappropriate treatment were found to be independent predictors of mortality by multivariate logistic regression analysis (see Table 8).

4. Discussion

Acute bacterial meningitis is a serious disease which necessitates early diagnosis and aggressive therapy to improve prognosis. Regional information regarding demographic data of patients, associated underlying conditions, etiology, and antimicrobial susceptibility is essential for correct and timely management of this disorder. Our study was the first to attempt to determine the clinical picture and the spectrum of pathogens of bacterial meningitis in patients of all ages in Qatar.

This retrospective series revealed some observations that deserve attention: firstly, in contrast with the previous study [6], the trend was seen to decrease from 2009 to 2013. Among the total 117 episodes, 43 (36.7%) were reported in the year 2009, which decreased to 18 (15.4%) in 2013. Furthermore, the disease in our series predominantly affected adults rather than infants and young children. This picture is similar to what was found in west countries and it may be attributed
Table 5: Antimicrobial resistance rate of Gram-positive CSF isolates.

| Microorganisms          | TNP | pen | amp | oxc | eryt | clind | amclv | cotr | cfr | van | line | teic |
|-------------------------|-----|-----|-----|-----|------|-------|-------|------|-----|-----|------|------|
| Abiotrophia spp.        | 1   | 0   | 0   | NT  | 0    | 0     | 0     | 0    | NT  | 0   | NT   | NT   |
| Enterococcus faecalis   | 7   | NT  | 0   | NT  | NT   | NT    | NT    | NT   | NT  | NT  | NT   | 1(100)|
| Enterococcus gallinarum | 1   | NT  | 0   | NT  | NT   | NT    | NT    | NT   | NT  | 1(100) | 0   | 0   |
| Gemella haemolysans     | 1   | 0   | 0   | NT  | NT   | NT    | NT    | NT   | 0   | 0   | NT   | NT   |
| Leuconostoc species     | 1   | 0   | 0   | NT  | NT   | 0     | 0     | NT   | 1(100) | 1(100) | 0   | 0   |
| Listeria monocytogenes  | 3   | 0   | NT  | NT  | NT   | NT    | 0     | NT   | NT  | NT   | NT   | NT   |
| Staphylococcus aureus   | 1   | 1(100) | 0   | NT  | NT   | NT    | NT    | 0    | 0   | 0   | NT   | NT   |

TNP: total number of patients; pen: penicillin; amp: ampicillin; oxc: oxacillin; eryt: erythromycin; clind: clindamycin; amclv: amoxicillin/clavulanic acid; cotr: ceftriaxone; van: vancomycin; line: linezolid; teic: teicoplanin; NT: not tested.

Table 6: Antimicrobial resistance rate of Gram-negative cerebrospinal fluid isolates.

| Microorganisms                     | TNP | cfr | gen | fep | taz | cip | amclv | ctz | amk | mem | pen | rif | col | tig |
|------------------------------------|-----|-----|-----|-----|-----|-----|-------|-----|-----|-----|-----|-----|-----|-----|
| Acinetobacter spp.                 | 11  | 8(72.7) | 8(72.7) | 8(72.7) | 8(72.7) | 7(63.6) | NT    | 7(63.6) | 7(63.6) | NT   | 0   | 0   | 0   | 0   |
| Brucella species                   | 1   | NT  | NT  | NT  | NT  | NT  | NT    | NT   | NT   | NT   | NT   | NT   | NT   | NT   |
| Chryseobacterium spp.              | 2   | 1(50) | 0   | 0   | 1(50) | 0   | NT    | 2(100) | 2(100) | 2(100) | 2(100) | NT   | NT   | NT   |
| Enterobacter species               | 4   | 3(75) | 0   | 1(25) | 3(75) | 0   | 4(100) | 3(75) | 0   | 0   | NT   | NT   | NT   | NT   |
| Escherichia coli                   | 4   | 1(25) | 1(25) | 1(25) | 0   | 1(25) | 1(25) | 1(25) | 0   | 0   | 0   | NT   | NT   | NT   |
| Haemophilus influenzae             | 2   | 0   | NT  | 0   | 0   | NT   | NT    | NT   | NT   | NT   | NT   | NT   | NT   | NT   |
| Klebsiella pneumoniae spp. pneumonia | 12  | 3(25) | 0   | 3(25) | 2(16.6) | 2(16.6) | 7(58.3) | 4(33.3) | 0   | 0   | NT   | NT   | 0   | 0   |
| Neisseria meningitidis             | 8   | 0   | NT  | 0   | 0   | 2(25) | NT    | NT   | 0   | 0   | 2(25) | NT   | NT   | NT   |
| Pseudomonas aeruginosa             | 5   | NT  | 0   | 0   | 0   | 0   | NT    | 0   | 0   | 0   | NT   | 0   | 0   | NT   |
| Pseudomonas putida                 | 1   | NT  | 0   | 0   | 0   | 0   | NT    | 0   | 0   | 0   | NT   | 0   | 0   | NT   |
| Salmonella group B                 | 1   | 0   | 1(100) | 0   | 0   | 0   | 0     | 0     | 0   | 0   | NT   | NT   | NT   | NT   |
| Serratia marcescens                | 1   | 0   | 0   | 0   | 0   | 0   | 1(100) | 0     | 0   | 0   | NT   | NT   | NT   | NT   |

TNP: total number of patients; cfr: ceftriaxone; gen: gentamicin; fep: cefepime; taz: piperacillin/tazobactam; cip: ciprofloxacin; amclv: amoxicillin/clavulanic acid; ctz: ceftazidime; amk: amikacin; mem: meropenem; pen: penicillin; rif: rifampicin; col: colistin; tig: tigecycline; NT: not tested.

Table 7: Results of univariate analysis of in-hospital mortality predictors.

| Variable                    | Unadjusted odds ratio (95% CI) | P value |
|-----------------------------|--------------------------------|---------|
| Presence of underlying diseases | 2.4 (1.4–3.9)                | 0.001   |
| Nosocomial infection        | 3.2 (1.5–6.5)                | 0.1     |
| Multidrug-resistant episodes | 4.7 (3.8–5.7)                | 0.08    |
| Mental alteration           | 4.9 (1.0–24.0)               | 0.06    |
| Hypotension                 | 2.3 (0.7–7.3)                | 0.003   |
| Inappropriate treatments    | 1.9 (1.2–3.07)               | 0.01    |

to vaccine-related decline in *H. influenzae* and pneumococcal diseases [3, 9, 14, 15]. These data show that adults are the main target population which requires interventions to prevent and control diseases in Qatar.

Secondly, sex distribution of the disease showed male predominance in agreement with the previous report [6] and other reports from different countries [9, 10, 16–19]. The
reason for this is obscure, and further studies are needed to identify the cause.

Thirdly, compared with the previous studies [4, 6], changes of common causative pathogens of ABM had been noted in our series. Coagulase-negative staphylococci species were the most common causative agents followed by Streptococcus pneumoniae. This can be explained by the expansion of neurosurgical services in our hospital with a consequent increase in the number of patients with postneurosurgical state. Similarly, reports from Taiwan [15–18] showed that there has been an increasing incidence of staphylococcal infection in ABM patients. However, in agreement with many reports worldwide [2, 7, 20–23], Streptococcus pneumoniae remain the common causative agent for community-acquired infection in our study.

Fourthly, drug resistance pattern showed that 95% of the implicated coagulase-negative staphylococci species were oxacillin-resistant and 63.3% of the implicated Acinetobacter species were meropenem-resistant. Both infections were predominantly nosocomial, which raised doubt regarding the infection control program in our hospital. Moreover, these findings result in therapeutic challenge in the choice of empiric antibiotics in the initial management of ABM. These findings are consistent with reports coming from Taiwan recently [9, 18, 19]. Fortunately, so far, we have not encountered vancomycin-resistant coagulase-negative staphylococci strains or colistin-resistant Acinetobacter strains.

Finally, in an attempt to identify independent predictors of mortality in patients with ABM, many studies had been conducted. The concluded prognostic factors among these studies were diverse [9, 10, 18, 19, 22, 23]. Our study revealed many probable prognostic factors; however, only the presence of underlying diseases, hypotension, and inappropriate treatment were found to be independent predictors of mortality by multivariate logistic regression analysis.

This hospital-based study has the following limitations. First, the study was retrospective rather than prospective, and this design did not allow us to obtain additional details such as severity of the disease and long-term follow-up to evaluate the long-term sequelae of meningitis in our patients. Second, it was performed at a single hospital; the results may not be applicable to other hospitals. Third, we included patients who had a positive CSF culture or positive CSF bacterial antigen test.

Despite these limitations, we believe that our study remains the largest to date to provide comprehensive information on the epidemiology of ABM in Qatar.

In conclusion, our study revealed that there is a change in the predominantly affected age group and common causative agents of ABM. Coagulase-negative staphylococci species are the common causative agent in Qatar with majority of infections occurring nosocomially. More than 90% of all implicated coagulase-negative staphylococci strains were oxacillin-resistant. Thus, improving our infection control programs in addition to enhancing antimicrobial stewardship is essential to overcome this problem.

Conflicts of Interest
The authors declare that they have no conflicts of interest.

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