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# Prevalence of Multiple Drug-Resistant Bacteria Among Healthcare Acquired Infections in the WHO Eastern Mediterranean Region: A Systematic review

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## Abstract

**Background:** Hospital-acquired infections (HAIs) caused by multidrug-resistant (MDR) bacteria represent a growing global public health threat, particularly in low- and middle-income regions such as the WHO Eastern Mediterranean Region (EMR). Despite increasing antimicrobial resistance, comprehensive regional evidence on MDR-HAIs, including prevalence, pathogen distribution, and associated risk factors, remains limited. This systematic review aimed to examine the prevalence of MDR bacteria among HAIs in hospitalized patients across the EMR between 2014 and 2024. **Methods:** A systematic review was conducted following Cochrane guidelines. EMBASE, PubMed, and Google Scholar were searched using Medical Subject Headings (MeSH) and relevant keywords. Eligible studies included primary quantitative studies reporting MDR hospital-acquired infections in EMR countries. A total of 550 records were identified, and after screening, critical appraisal, and eligibility assessment, nine studies were included for narrative synthesis. Risk of bias was assessed using CASP and Joanna Briggs Institute appraisal tools. **Results:** The prevalence of MDR-HAIs across EMR countries ranged from 4.9% to 52.6%, with most studies reporting rates exceeding 25%. Egypt reported the highest prevalence (52.6%), followed by Libya (35.2%) and Lebanon (30.2%), while Iraq reported the lowest prevalence (4.9%). Older age and male gender were commonly associated with increased MDR-HAI risk. The most frequently identified pathogens were MDR *Pseudomonas aeruginosa,* extended-spectrum beta-lactamase (ESBL) *Klebsiella pneumoniae* and *Escherichia coli*, multidrug-resistant *Acinetobacter baumannii*, and methicillin-resistant *Staphylococcus aureus* (MRSA). Additional risk factors included comorbidities, prolonged hospitalization, prior antibiotic exposure, invasive devices, and admission to high-risk wards. **Conclusion:** MDR hospital-acquired infections remain highly prevalent across the EMR, affecting countries regardless of economic status. Strengthening surveillance systems, improving infection prevention and control strategies, and implementing coordinated antimicrobial stewardship programs are urgently needed to reduce MDR burden and improve patient outcomes in the region.

**Keywords:** Multidrug-resistant bacteria; Hospital-acquired infections; Antimicrobial resistance; Eastern Mediterranean Region; Systematic review

## Introduction

Hospital-acquired infections (HAIs), also called, Nosocomial infections, are infections acquired by patients while receiving healthcare in a hospital or any other healthcare facility (Haque et al., 2020). Every year, about 136 million HAIs are reported globally and it has been estimated that 1 in 10 hospitalised patients will be infected on average (Balasubramanian et al., 2023). These infections remain increasingly widespread in low and middle- income countries (LMIC) including East Mediterranean region (EMR) where the risk of acquiring HAIs is approximately 10–15 per 100 hospitalized patients compared to 7 per 100 hospitalized patients in high-income countries. Despite this variation, some high-income countries are also struggling to alleviate the burden of these infections where in Europe alone, nine million HAIs occur every year mainly in acute and long-term care facilities costing 25 million extra hospital days annually (WHO, 2017). HAIs affect approximately 3.2% of patients hospitalized in the United States and 6.5% in the European Union/European Economic Area (Sikora & Zahra,2024)

The major threat posed by the high burden of HAIs is their association with Antimicrobial resistance (AMR) as it was estimated that 63·5% of antibiotic resistance infections globally were associated with health care acquired infections, which is compromising the effectiveness of essential life-saving antibiotics, even for common types of infections of the blood stream, urinary tract, and gastrointestinal tract. These findings have become more concerning recently due to the reported widespread of multi-drug resistance (MDR) to antibiotics. MDRB-Infections occur when antibiotics designed to treat them are not susceptible anymore, and it is generally accepted that bacteria are categorised as MDR when showing resistance to three or more antibiotics (Parsons et al., 2019). The evolution of this problem lead to the definition of healthcare-associated multidrug-resistant (HA-MDR) bacterial infections that represent a growing public health crisis globally, and the Eastern Mediterranean Region (EMRO) is no exception. According to recent literature, MDR bacteria account for approximately 20% of all HAIs globally (Sikora & Zahra, 2024; Szabó et al., 2022). However, most recently it was indicated by the Global antibiotic resistance surveillance report 2025 (GLASS) conducted by WHO, that between 18% - 40% of laboratory confirmed bacterial infections worldwide were caused by bacteria resistant to antibiotics reflecting an annual average rise of 5% to 15% (WHO, 2025). This was not limited to first choice treatments but also, in worse cases, to the last- resort antibiotics available such as Carbapenem resistance which is reported in 54% of HAI Acinetobacter and Klebsiella cases (WHO, 2025).

HA-MDR has left devastating consequences on global mortality rate, given that globally, more than 5 million deaths were attributed to MDR in hospitalized patients with infections in addition to a significant burden on health systems and increased cost of hospitalisation. The approximate mortality rate from HAI worldwide is 10% which is considered unacceptable; however, this risk could increase up to threefold if caused by a MDRO. Consequently, the WHO (2023a) identifies antimicrobial resistance (AMR) as a top global public health threat. Both gram-positive and gram-negative MDR species are commonly reported in HAIs, but Gram-negative bacteria are being predominantly affected recently. The existence of these MDR bacteria varies between countries, depending on different factors and challenges that encompass their healthcare systems and other national factors. Low- and middle-income countries (LMICs) are mostly affected as indicated by the literature. South-East Asia and Eastern Mediterranean regions (EMR) are predominantly influenced by antibiotic resistance as 1 in 3 infections reported there has been resistant to different antibiotics, but less frequent in the European Region and Western Pacific Region 1 in 10, indicating a wide regional variation (WHO, 2025). However, the most common MDRB reported globally are methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant Enterococcus (VRE) which make 80% percent of Enterococci species, MDR Pseudomonas aeruginosa, Klebsiella spp, *Escherichia coli,* Acinetobacter spp, extended-spectrum beta-lactamase (ESBL) production, and carbapenem-resistant Enterobacteriaceae (Parsons et al., 2019).

The East Mediterranean Region is comprised of an eclectic mix of low-, middle-, and high-income countries ranging from post-conflict societies and communities with extreme deprivation, such as in occupied Palestinian territories, Yemen, and Syria where healthcare systems are aborted and IPC resources are severely compromised, to countries with extremely well-resourced healthcare systems such as the Gulf Cooperation Council (GCC) countries. (Kumar et al., 2025; Borgio et al., 2021). Consequently, despite general socio-cultural similarities across the EMR, investigating aspects related to HAIs is complex and multifaceted, albeit highly necessary in the region (Health Finance and Governance, 2018; Katoue et al., 2022). A critical analysis reveals that many interlinked factors that exist in this region, with varying degrees contributed to high prevalence rates of HAI caused by MDRB (WHO, 2024).The presence of economic sanctions imposed on some countries, disorganised and fragmented health infrastructure, variations in clinical standards, and ineffective surveillance systems have been hindering the implementation of high standard and effective IPC measures and AMR stewardship programmes, coupled with inadequate regulation of irrational antibiotic prescription in hospital settings. Despite initiatives from the WHO and other global and regional bodies to strengthen AMR surveillance, implementation has been progressing slowly, if at all (Katoue et al., 2022; WHO, 2023a).

This systematic review will focus on HAIs associated with MDR in EMR as an issue of concern, since there are clear discrepancies in the number and quality of studies conducted within the region. Only one literature review was found on this topic which specifically highlighted the burden of HA-MDR threat in the EMR (Nimer, 2022), but no systemic review on this topic could be found. Consequently, this systematic review addresses the critical need for such investigation and highlights the ongoing need for more insights into the developing scope and scale of MDR-HAI to guide future research and practice. This systematic review will inform a mapping tool for the development of enhanced evidence-based practice (EBP) since it will assist in evaluating the effectiveness of AMR programs already in place. In this vein, this study seeks to contribute to the literature and provide crucial implications on IPC practices. In addition to intrinsically helping to improve the quality of care received by patients mainly those vulnerable to HAIs, this study seeks to encourage key stakeholders to increase their integration and cooperation with international AMR programmes and invest in the available resources to implement better AMR strategies. Moreover, activate their participation with the global surveillance antibiotic resistance GLASS systems (WHO, 2022a). Overall, it aims to ultimately help to improve patient outcomes and decrease the financial burden of hospitalisation for patients and health systems (Khan et al., 2017).

## Methods

This research is a systematic review approach conducted to answer the given research question, "What is the prevalence of MDRB-Infection among hospitalised patients with HAIs in the EMR between 2014 and 2024?" The research question was identified using the "condition, context, and population" (Co Co Pop) format (Kabir et al., 2023), as described below, whereby the search condition was for prevalence of multiple drug resistance among HAIs in the EMR, and the population comprised hospitalised patients with HAIs. The research included quantitative methods of primary studies of the available literature (Saks & Allsop, 2019).

According to the "Cochrane Handbook for Systematic Reviews Guidelines 2024" (Higgins et al., 2024), a preliminary search was performed to ensure that the addressed topic is reliable and valid with enough studies available, and to avoid duplication with other published studies. English language articles were then searched systematically for the previous ten years (2014-2024) from two main scientific databases, EMBASE (Elsevier) and PubMed, which are appropriate to the research question topic in nature. In addition, Google Scholar was used to expand the search results and explore more studies that are not available from the two main databases that were searched, due to the nature of the region covered, which may require manual searching to get more relevant literature papers appropriate to this review (Kabir et al, 2024). Each database was searched in a customised way that is convenient to the database structure and as instructed.

**Data extraction**

As a basic step, MeSH terms where derived using PubMed database and MeSH headings to describe the key aspects of the research question. The main search terms identified for condition ("Co") pertained to "multiple drug resistance", "multiple drug" or "multi-drug" "resistance", or "multidrug resistance" or "extensively drug resistant". Additionally, to specify type of infection and population ("Pop"), hospital infection was searched and described as "hospital-acquired infection" or "nosocomial infection".

After a trial scoping search and reviewing the results, terms were refined to add "cross-infection", in addition to commonly used abbreviations which describe hospital infection and multiple drug resistance (i.e., "HAI", "MDR", "HA-MDR", and "NI" ,the latter of which is less commonly used to refer to "nosocomial infections"). To get richer results, fully synonymous terms and abbreviations (e.g., "East Mediterranean Region", ""Eastern Mediterranean Region", and "EMR" for the "CoCo Pop" "Context") were included in the search process. However, no outcome terms were added to connote outcomes "resultant from", "caused by", or "secondary to", which restricted number of search results.

After search terms were specified, search strategy was formulated in a defined way based on the research question components that should be answered and depending on the database searched. Boolean markers were used predominantly in PubMed as advised by their guidelines, and less frequently in EMBASE, as instructed (the EMBASE search allows a maximum of eight Boolean markers). The Boolean marker OR was used mainly to combine the terms that have same or similar meanings, such as "Multiple drug resistance" OR "resistance multiple drug" OR "multi-drug resistance" OR "multidrug resistance" OR "extensively drug resistant" OR "multi-drug-resistant".

The AND marker was then integrated to link "Multiple drug resistance" with "HAI" terms, which narrowed the search topic to hospitalised patients that have HAIs only as indicated in the research question's "Pop" (hospitalised patients with HAI). Another marker, NOT, was used in some instances to exclude community acquired infections, as determined in exclusion criteria, since they are not germane to the main topic. Furthermore, truncations were used mainly in brackets, colon, comma to get more advanced results since it works as a highlight for the main terms, such as HAI "prevalence incidence" AND "East Mediterranean Countries" (EMR).

This strategy was modified when using Google Scholar as it does not support use of Boolean markers. Instead, advanced search keys were used to conduct the basic search. One example, with all the words "multiple resistance bacteria"; with at least one of the words "multiple drug resistance", "HAI", "nosocomial infection", "cross infection", "East Mediterranean countries", "prevalence", and "incidence". Detailed search strategy examples are represented in Supplementary Table 1.

**Data selection**

Overall, 550 studies were selected from the main databases and the updated PRISMA chart 2020 (MJ, 2021) was used to demonstrate the selection process Figure 1. As a basic step, duplicates were checked and removed using Mendeley reference manager before the assessment process was conducted. The total number of duplicates detected was 50 studies, and the number of selected studies was reduced to 500 studies. Then, these studies were assessed primarily for relevant study design and study title manually. This systematic review included only primary studies which are published in English, which were freely accessible in full-text versions, since it was not feasible to obtain articles from the main authors in instances where articles were not freely accessible due to time constraints.

The main study designs selected were cross-sectional studies, retrospective and prospective (cohort or observational) studies, in addition to pooled analysis of national surveys. Systematic reviews or literature reviews were excluded. Another element that was checked primarily is study title. Only studies that demonstrated the main topic as defined in the research question, particularly HAIs and MDR in one of the countries that are listed within the WHO's EMR, were included for abstract checking. As a result, 453 studies were excluded and 47 studies were included. During this step, hand or manual searching of reference lists was also performed in some of the included studies as an essential step to increase reliability of this review and decrease level of bias (Tawfik et al., 2019). As a result, four studies were obtained from hand searching and added to the total number of included studies so the number of included studies for abstract checking became 51 studies. Abstracts of the 51 retrieved articles were checked for further assessment. The exclusion of non-relevant articles was based on a defined inclusion and exclusion criteria represented in Supplementary Table 2, which resulted in exclusion of 16 irrelevant studies and inclusion of 35 studies for the next step. In total, 16 studies were excluded from the 35 studies and only 19 quantitative studies were included for further assessment.

The extracted items were synthesised in a descriptive manner using tables and graphs. Meta-analysis was not possible to be conducted due to several reasons, mainly because the methodologies of included studies and study designs were diverse, and not all studies provided standard deviation values or alternative values such as mean and median, which are essential to perform meta-analysis according to Cochrane handbook for synthesising and presenting findings (Higgins et al., 2024).

**Critical appraisal**

All 19 studies that were critically appraised are presented in different checklists in Supplementary tables 3 - 5. As a result, nine studies were selected and included for data extraction process and narrative synthesis, as presented in the following tables. For cross-sectional studies, CASP critical appraisal checklists for cross-sectional studies was used, for retrospective or prospective cohort studies, Critical appraisal for cohort studies using CASP Checklist for cohort study was utilised (Critical Appraisal Skills Programme, 2024), and for observational studies reporting prevalence data, Joanna Briggs Institute (JBI) critical appraisal checklists for prevalence studies was used (Munn et al., 2020).

**Risk of bias**

The included studies were judged after answering questions to various items provided by different critical appraisal tools that were utilised for each study design and were represented in Supplementary Tables 3 - 6. The risk of bias was subjected to critical appraisal assessment, which was performed before data extraction. Overall, three studies were evaluated as "good" quality studies, four were deemed "intermediate", and one was considered as "poor quality". These results are represented in Table 1. External validity items were centred on the recruited sample or targeted population and its representativeness of general studied population. However, internal validity was evaluated through questions about validity of data collection and measurements tools, and reliability of parameters measured. Generally, good quality studies are those detected to have a low risk of selection bias, which were mainly studies that were performed in more than one hospital. For instance, Matta et al. (2018) performed their research across five hospitals, while Thomsen et al. (2023) analysed twelve years of national-level AMR surveillance data. Notwithstanding scrupulous methods used in many studies, some risk

Review Article



of bias was expected even with good quality studies, since it was commonly reported that there was difficulty in retrieving data using surveillance data or patients' records.

Table 1: Study design and quality

| Author, Year | Study Design | Quality |
|---|---|---|
| **Abdel Hadi et al. (2024)** | Retrospective observational | Good |
| **Abdulrahman et al. (2024)** | Case series study | Intermediate |
| **Balkhy et al. (2020)** | Pooled analysis of prospective observational data | Intermediate |
| **Hassan et al. (2018)** | Prospective observational study | poor |
| **Matta et al. (2018)** | Retrospective cohort study | Good |
| **Mousavi et al. (2024)** | Cross-sectional study | Intermediate |
| **Al-fituri & Almenfi(2024)** | Cross-sectional study | Intermediate |
| **Thomsen et al. (2023)** | Retrospective study (12 years)/national AMR data | Good |
| **Ketata et al. (2021)** | Point-prevalence survey | Intermediate |

Cross-sectional studies often do not study causalities or confounding factors between outcome and exposure, and the reviewed studies of this type were performed mostly in one hospital or ward. For instance, in a study conducted by Ketata et al. (2021) there was an increased chance of bias related to external validity because the data obtained was sourced from a point-prevalence surveillance system in a hospital that have underreporting issues. Moreover, a prospective observational data study by Balkhy et al. (2020) was performed over a ten-year period, which was a strength of this study, but changes in HAI definitions during the study period were reported, which made the interpretation of results more complicated and affected the elements of internal validity.

Finally, one poor quality study with high risk of bias was detected (Hassan et al., 2018), due to several reasons related to internal and external validity. The sample recruited was small number of patients from one ward and had no follow-up for patients, thus it would be likely to underestimate the prevalence of HA-MDR infections.

**Ethical approval**

Before proceeding with this systematic review, an ethical form application was submitted and approved by the University of Essex board committee. No ethical concerns were associated with this secondary research (systematic review), utilising publicly available data from published studies. Notwithstanding, many recent studies indicated that methodological orientation, different types of biases, and quality of evidence retrieved in systematic reviews could be appraised as potential sources of ethical considerations (Suri, 2020). For this reason, all included studies were checked for their demonstration of ethical requirements.

## Results

Overall, nine quantitative studies were included in this systematic review, as described in the previous chapter, and were analyzed for data extraction. The studies were undertaken in different countries that are defined and listed by WHO as being within the EMR (WHO, 2024). These studies were conducted and published between 2017 and 2024, covering an eight-year interval. The distribution of these studies is represented in Supplementary Table 4.1. Eight of the studies were undertaken in hospitals; two each were undertaken in private hospitals (including one trauma hospital), tertiary hospitals, public hospitals, and university hospitals. One study was conducted using the national AMR from participating hospitals in the UAE. Among the countries included, three studies were conducted in high income countries, three in upper-middle countries, and three in lower-middle income countries, as presented in Table 2.

Table 2: Studied contexts and income levels

| Author, Year | Country | Income level |
|---|---|---|
| **Abdel Hadi et al. (2024)** | Qatar | High income |
| **Abdulrahman et al. (2024)** | Mosul, Iraq | Upper-middle income |
| **Balkhy et al. (2020)** | Saudi Arabia | High income |
| **Hassan et al. (2018)** | Egypt | Lower-middle income |
| **Matta et al. (2018)** | Lebanon | Lower-middle income |
| **Mousavi et al. (2024)** | Urmia, Iran | Upper-middle income |
| **Al-fituri & Almenfi(2024)** | Benghazi, Libya | Upper-middle income |
| **Thomsen et al. (2023)** | United Arab Emirates | High income |
| **Ketata et al. (2021)** | Tunisia | Lower-middle income |

**Study characteristics**

The included quantitative studies used various research designs. While all studies are categorized as quantitative, some substantive descriptive data was included in some instances, to identify and discuss the risk factors associated with the high prevalence of HA-MDR, such as in the studies by Ketata et al. (2021) and Matta et al. (2018). Study designs for each individual study are presented in Supplementary Table 8.

The targeted population assessed by these studies was hospitalized patients which was a common characteristic between all studies. Adults and pediatric hospitalized patients (n = 6) were included in most of the studies, with no age restrictions, while a single study included critical care unit patients (Hassan et al., 2018), one study was conducted among adult trauma patients (Al-fituri & Almenfi, 2024), and one assessed the records of adult patients only (Matta et al., 2018). On the other hand, seven studies provided data on the prevalence of bacterial HA-MDR indicating various types of MDRB, one study assessed the prevalence of blood stream infection (BSI) gram-negative MDRB (Matta et al., 2018), and one study examine the incidence of HA-MRSA bacteria (Thomsen et al., 2023).

**HA-MDR infection prevalence**

The data represented in Table 4.3 reveals key findings about the prevalence of HA-MDR infections across different EMR countries. There was a major variation in the frequency of HA-MDRB-Infections prevalence related to HAI among countries, as illustrated by the bar graph in Figure 4.1. The percentage of HA-MDR infections reported exceeded 25% in six of the included countries, including Egypt which reported the highest prevalence rate with 52.60%. The second highest values were recorded in Libya and Lebanon with similar percentages of 35.20% and 30% respectively. In addition, comparable HA- MDR values were reported from two studies conducted in UAE (28.14%) and Tunisia (28.3%). A study from Saudi Arabia undertaken in 2020 indicated a prevalence rate of 25%, which is still considered relatively high rate in comparison to other values. Conversely, lower HA-MDR prevalence was reported by studies conducted in Qatar and Iran with similar values of 13% and 13.2% respectively. The lowest prevalence rate was indicated in Iraq (4.9%).

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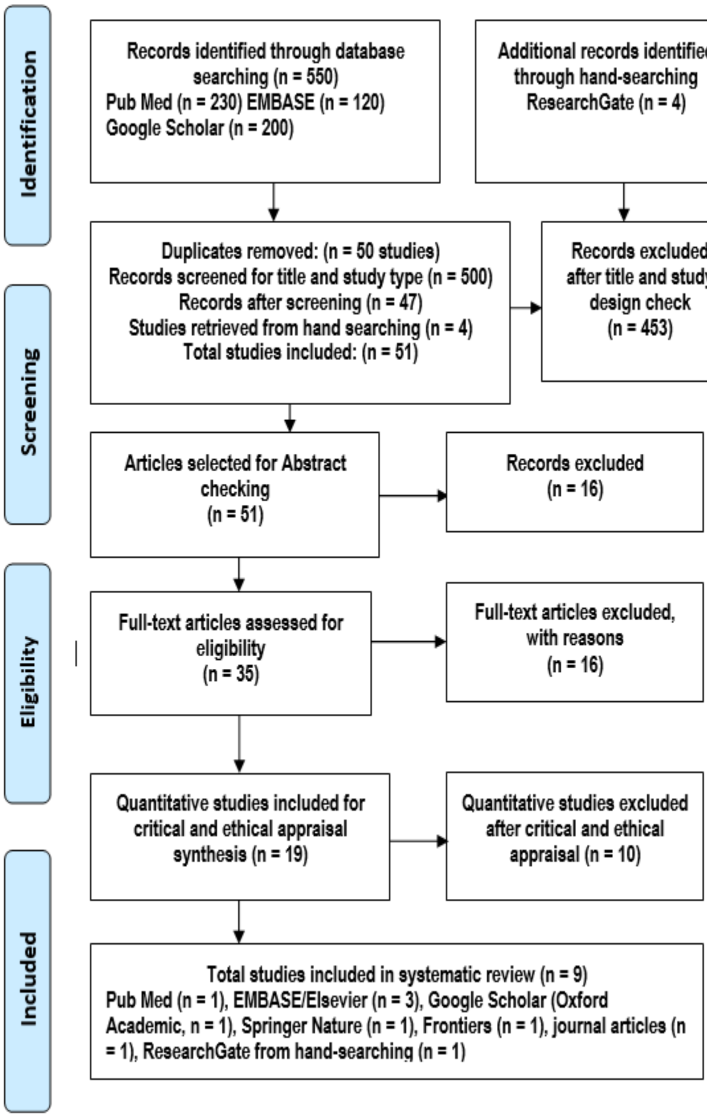
Figure 1. PRISMA flow diagram




**Demographic variations**

According to demographic data represented in the data extraction table (Table 4.7), median ages varied between studies. Some studies focused on younger populations, such as the study undertaken in Iraq among trauma patients, with a median age of 29.5 years. This study reported the lowest HA-MDR prevalence rate of 4.90%. On the other hand, some studies which focused on older population reported higher rates of HA-MDR infections, such as the study conducted in Egypt with median age of 57.9 years and a prevalence rate of 52.60%.

The variation of HA-MDR based on gender was estimated in only five studies out of nine, as shown in Table 4.4. In general, as indicated by five studies, a higher prevalence was often observed in males as reported in Qatar (61.6%), Libya (61%), Lebanon (52.2%), Tunisia (53.5%), and Iraq (75%). Table 4.4 shows the prevalence of different types of infection analyzed in the reviewed studies.

**MDR Pathogens**

It can be seen from the data in Table 4.5 that the studies investigated different types of HA-MDRB including ESBL bacterial strains. MDR *Pseudomonas aeruginosa* and MRSA were frequently reported by these studies, while VRE and MDR Stenotrophomonas were reported in only one study. There was a clear variation between the most prevalent MDRB among these countries. As shown in Table 4.5, MDR *Pseudomonas aeruginosa* was reported by seven studies out of nine, including one in Egypt, which reported a remarkable prevalence rate of 100%; this was the highest in comparison to all HA-MDRB reported. The prevalence of MDR *Acinetobacter* *baumannii* (68.3%) in Saudi Arabia was the highest among all studies that reported this bacterium. In Qatar, ESBL E. coli was the dominant resistant bacteria, reported with 62.7%. Iran and Tunisia reported comparable lower prevalence rates of ESBL E. coli of 27.51% and 27.3% respectively. In Iraq, ESBL K. pneumoniae was highly prevalent, at a rate of 41.7%, while Lebanon reported only 1.7%. MRSA was reported in six countries, but it was higher in the UAE and Saudi Arabia (with 28.14% and 27%, respectively), followed by Libya with 16%. Notably, a high rate of MDR Stenotrophomonas (70%) was investigated and reported only in Saudi Arabia, in addition to VRE with a rate of 20.3%.

**Risk factors**

Six of the studies reported on the risk factors associated with higher risk of acquiring HAI caused by MDRB (Table 4.6). Most of these (n = 5) found that patients that have existing comorbidities were at increased risk of developing HA-MDR. Studies from Qatar, Iraq and Tunisia showed a correlation between diabetes, hypertension, neurologic disorders, coronary heart disease, end stage kidney disease and HA-MDR. In addition, it was demonstrated by Balkhy et al. (2020) in Saudi Arabia there was an increased rate of gram-positive resistant bacteria in dialysis patients. Moreover, study from Lebanon showed that there was a significant relation between older age and immune-suppressed patients and HA-MDR infections, which was consistent with the study from Tunisia (Ketata et al., 2021).

Ketata et al. (2021) and Abdel Hadi et al. (2024) reported several extrinsic risk factors of HA-MDR, including previous healthcare contact, antimicrobial exposure within 90 days, prolonged hospital stay, and admission to high-risk wards in Tunisia and Qatar (respectively). Furthermore, Ketata et al. (2021) and Hassan et al. (2018) reported that intravenous line duration, indwelling catheters and invasive medical devices were linked to increased risk of infection by studies in Egypt and Tunisia.

## Discussion

Based on this review, the prevalence rate of HA-MDRB-Infections in the EMR was reported to be remarkably high in most studies, but there were some major variations between some countries. The lowest rates were detected in Iraq (4.9%) (Abdulrahman et al., 2024), Qatar (13%) (Abdel Hadi et al., 2024), and Iran (13.2%) (Mousavi et al., 2024), and the highest of 52.60% was in Egypt (Hassan et al., 2018), while the other five countries ranged between 25-35.2% (Al-fituri & Almenfi, 2024; Balkhy et al., 2020; Ketata et al., 2021; Matta et al., 2018; Thomsen et al., 2023). Surprisingly, the burden of HA-MDR infections in some high-income countries including UAE and Saudi Arabia were comparable to the rates detected in low-income countries (Balkhy et al., 2020; Thomsen et al., 2023). These results are a serious concern since they exceed the median prevalence rate of HA-MDR of 17.2% detected globally between 2018-2023. This variation could be exemplified by the concept of inverse correlation between surveillance level and AMR burden established recently which indicated that countries who have minimal surveillance, have higher prevalence rates of AMR and selection bias (WHO, 2025; Morel et al., 2021).

**Causes of elevated rates of HA-MDR in EMR**

The alarming rates of HAI caused by MDRB that were explored in most areas (Al-fituri&Almenfi,2024; Hassanetal.,2018; Ketataetal.,2021; Matta et al., 2018) might be attributed to the presence of persistent low economic status and sanctions and underfunded healthcare facilities coupled with continuous political conflicts and escalations. Consequently, EMR countries has suffered from weak or aborted healthcare systems that have limited capacities and inadequate resources to prevent and encounter this issue. The exacerbation of HA-MDR phenomenon might also be imputed to the lack of adequate laboratory resources to detect resistant bacteria and inform appropriate antibiotic options which are sensitive to certain types of bacteria. Furthermore, ongoing conflicts in many areas have led to broken sanitation infrastructure, overcrowded and limited healthcare isolation facilities, and limited access to clean water, which accelerate the spread of multiple resistant bacteria in healthcare settings and poses a significant threat on healthcare systems even on the national level (Raoofi et al., 2023; Al Bakri et al., 2025). One typical example was the emergence of MDR Acinetobacter species into some hospitals in Lebanon during the Syrian conflict owing to the displacement of Syrian civilians who were infected by these strains.

In addition, these results are consistent with WHO latest report on IPC which indicated that 42.9% of EMR countries have either no IPC program in place, or no supporting guidelines implemented (WHO, 2022a), and noticeably, only 47.1% of EMR countries have implemented the five core components of AMR surveillance systems which is the lowest amongst all other regions including African (51.9%) and South-East Asia (50%)

(WHO, 2025) . Therefore, these results affirm the presence of major inadequacy in IPC strategies, AMR programs, and regulatory frameworks in this region mainly in low-income countries and areas of conflicts coupled with lack of IPC mentors and adequate training and education among healthcare managers, and minimal political commitment (Al Bakri et al., 2025).

The similarly high rates of HA-MDR detected between high-, middle-, and LMICs signifies that this problem exists in most countries in the EMR, regardless of their economic status (Al-fituri & Almenfi, 2024; Balkhy et al., 2020; Thomsen et al., 2023). A recent systematic review on the global burden of HAI indicated that the burden of HAIs in LMICs is significantly higher than high-income countries (Raoofi et al., 2023); However, the results of this review reveal that this fact does not apply to the prevalence of HA-MDR infections in the analyzed studies, thus income level is not a definitive indicator that represents the burden of these infections and other factors should be considered.

Various lower-middle income countries in the region had prevalence above 25% (including Lebanon, Libya, and Tunisia) (Al-fituri & Almenfi, 2024; Ketata et al., 2021; Matta et al., 2018) , which some studies speculated was due to intrinsic resource limitations, but relatively well-resourced health systems such as in the UAE and Saudi Arabia, had similar infection rates. It is more likely that the systematic lack of integrated infection prevention and control (IPC) practices and protocols across regional health systems underlies the egregiously high prevalence of HA-MDR. This reinforces the fact that even in the presence of IPC strategies, functionality and sustainable implementation along with behavioral commitment among healthcare workers, remains the critical component of achieving an effective AMR approach (WHO, 2023).

**Demographic factors**

In terms of demographic variation, a link between older age and increased chance of acquiring HA-MDR infections was noticed in this region, since studies which reported high prevalence rates of HA-MDR focused mostly on older population (Hassan et al., 2018; Mousavi et al., 2024). This relation was similarly demonstrated in another systematic review on MDRB-Infections done in the Arabian Peninsula (Borgio et al., 2021), which supports its potential generalisation.

In terms of gender, several studies indicated a causal relationship between male gender and increased risk of having HA-MDR infections, as the prevalence rate of HA-MDR among males exceeds 50% in several studies (Abdel Hadi et al., 2024; Al-fituri&Almenfi,2024; Ketata et al., 2021; Mattaetal.,2018). This affirms worldwide findings indicating that males are generally more prone than females to acquire HAIs, as indicated by several recent studies in literature (Huetal.,2021; Khammarniaetal.,2021; Zhang et al, 2021).

**Infection types**

Analysis of the most prevalent MDRB among HAI in the EMR reveals that the most common MDR infectious pathogens reported were MDR *Pseudomonas aeruginosa*, ESBL Klebsiella pneumonia and ESBL E. coli, MDR Acinetobacterboumani, and MRSA. Conversely, VRE and MDR Stenotrophomonas metophilia were only reported in one study only.

Remarkably, all detected MDRB manifested a high infectivity activity among HAI in this review, and this could justify the high prevalence rates of HA-MDR detected. However, MDR gram-negative bacteria showed significant high rates that make them the prominent cause of these infections in the EMR (AbdelHadietal.,2024; Abdulrahmanetal.,2024; Al-fituri & Almenfi,2024; Balkhyetal.,2020; Hassanetal.,2018; Ketataetal.,2021; Mattaetal.,2018; Mousavietal.,2024; Thomsen et al.,2023). Unexpectedly, gram-negative MDR P. aeruginosa exhibited alarming resistant activity of 100% in Egypt (Hassan et al., 2018); while this extreme was not detected elsewhere, a similarly high rate was also detected in a survey, which highlighted the severe magnitude of the AMR problem across the country, which was attributed to its aborted healthcare system and IPC program (El-Kholy et al., 2021). This case is a typical example that reflects the real scenario existing in different parts within the region including high income countries such as high rates of Acitenobacter boumani of 68.3% in Saudi Arabia and 62.7% of ESBL E. coli in Qatar (Balkhy et al., 2020; Thomsen et al., 2023). This could exemplify the emerging status of AMR associated with HAI in the EMR (Borgio et al., 2021). However, these findings are compatible with the reported global resistance rates of gram-negative bacteria which become predominant resistant bacteria mainly E. coli and K. pneumoniae which has been detected highly resistant to fluoroquinolones and third-generation cephalosporins to the extent that it exceeds a rate of 70% for both pathogens in the African region. Similarly, in Italy, MDR Acitenobacter boumani has been detected with 80% resistance to Imipenem and this is considered a significant finding that illustrates the severity of this problem globally (WHO, 2025).

Review Article



On the other hand, gram-positive MRSA was reported in six countries out of nine (Al-fituri & Almenfi, 2024; Balkhy et al.,2020; Hassan et al.,2018; Matta et al.,2018; Mousavietal.,2024; Thomsen et al.,2023), which makes it one of the pathogens of concern in this region. This finding was anticipated, as MRSA was detected as one of the most impactful MDR pathogens in other regions which impose a common threat globally. MRSA has been reported to have a median resistance rate of 27.1% globally which is consistent with the rates explored in this review. However, it is crucial to be treated using strict treatment guidelines since its resistance to conventional antibiotics has exceeded 70% as indicated by a recent international systematic review (Parsonsetal., 2019; Raoofietal., 2023; WHO, 2025).

Reporting

As described above, this review highlighted a clear similarity in MDR activity and high prevalence rates of HA-MDR between some middle-income and high-income countries (Al-fituri & Almenfi, 2024; Balkhyetal., 2020; Mousavi et al., 2024; Thomsen et al.,2023) in comparison to low-income countries (Hassan et al., 2018; Matta et al., 2018), despite the existence of IPC and AMR policies suggesting that such policies are not actually applied fully in clinical practice. According to global reports on IPC, 70% of health systems have a universal IPC program in place (WHO, 2022b); however, the results of this review show that having an IPC and AMR stewardship program established does not mean it is active and actionable, or that it is embedded within a broader, effective strategic plan.

Notably, the high prevalence rate of MDR Stenotrophomonas maltophilia detected in Saudi Arabia reveals the presence of a new MDRB which was not commonly reported in the EMR among all available studies, which fits with this being a newly emerging pathogen of concern as indicated by literature (Said et al., 2023). Thus, this MDRB should be accounted with other commonly reported MDR pathogens in the region. Accordingly, the fact that VRE that evidently makes up to 80%of Enterococci species (Parsons et al., 2019), in addition to MDR Stenotrophomonas maltophilia only being reported in Saudi Arabia, does not totally exclude their existence in other countries in the region. However, this signifies the presence of a major discrepancy in the local surveillance and monitoring systems in the EMR, which consequently leads to underreporting of these types of MDRB. This major issue was previously declared in WHO report, as only 59.1% of EMR countries have an HAI surveillance system in place, with poor evidence of functionality (WHO, 2022a), as reflected by the findings of the current review.

The underreporting of MDRB is a fundamental problem, since it makes the existence and scope of the problem ambiguous, whereby it is ignored by HCPs and healthcare managers, which could lead to undesirable outcomes on patient and healthcare institutions. In the case of MDR VRE, this bacterium is considered one of the most dangerous that can be acquired during hospitalization (Parsonsetal., 2019); consequently, the absence of knowledge around the existence and nature of such infections imposes a challenging endeavor for EMR healthcare managers. A suspended surveillance system and lack of governmental initiatives was identified in literature as one of the major problems that hinder the success of actionable IPC and AMR approaches in the EMR (Borgio et al., 2021; El-Kholyetal., 2021; Nimer, 2022).

**Risk factors**

The risk factors of developing HA-MDR infections that were explored in this review established a link between the presence of co-morbidities particularly diabetes and hypertension in addition to diseases that cause alteration to the immune system and increased risk of acquiring HAI caused by MDRB (Abdulrahman et al., 2024; Balkhy et al., 2020; Ketata et al., 2021; Matta et al., 2018; Thomsen et al., 2023). Additionally, prolonged hospitalization, particularly in critical wards, corresponds with increased rates of MDR among HAI (Hassan et al., 2018). These correlations were demonstrated by the European Centre for Disease Prevention and Control (ECDC), which reported that patients who are critically ill and in acute care departments are mostly affected by HA-MDR infections due to the complexity of care in these units (Szabó et al., 2022).

Older age was also observed as one of the prominent factors that increase the risk of acquiring MDR infections (Matta et al., 2018), which confirmed the suggested correlation made in this review between older age and increased rate of HA-MDR infections. Moreover, previous exposure to antibiotics during hospitalization was observed as a major contributing factor to develop HA-MDR (Thomsen et al., 2023). This highlights a critical problem that exists in the EMR, which is the unjustified prescription and administration of antibiotics coupled with the absence of well-defined AMR policies (Nimer, 2022).

This problem has evidently existed for a substantial period. A large study in 2010 revealed that 40.7% of HA-MDR infections were already being treated with antibiotics (Amazian et al., 2010). Furthermore, since bacteria exhibit most HAI cases, the excessive and inevitable use of antibiotics in treatment has contributed directly to the development of resistant organisms, exacerbating the prevalence and severity of associated infections (Sikora & Zahra, 2024; Szabó et al., 2022). This is predisposed by the unregulated access to antibiotics and over the counter availability with cheap prices which encourage self-medication especially in people who are influenced by low economic status. In addition, there is no evidence that healthcare professionals in this region has been strictly following the AWaRe classification framework which inform antibiotic prescribing guidance (WHO, 2023).These risk factors are vital elements to consider when evaluating the burden of HA-MDR in the region, since they revealed some of the obstacles that lead to the expansion of antibiotic resistance threat in the region.

**Evaluating research findings against research question**

Overall, the findings of this systematic review provided a deeper investigation of the prevalence rate of HA-MDRB-Infections in the EMR and addressed the main types of MDRB responsible for these infections in hospitalized patients as indicated by all available studies on this topic in the region. In addition, the review demonstrated the main risk factors that increase the possibility of acquiring these infections. By answering these questions, this approach was relevant and successful to meet the main objectives which answer the main research question on the prevalence of MDRB-Infection among hospitalized patients with HAIs in the EMR between 2014 and 2024.

**Limitations**

This systematic review has several limitations. First, the number of eligible studies from the Eastern Mediterranean Region was limited, and several countries lacked recent or available data, particularly those affected by conflict or resource constraints. Second, the included studies varied in design, sample size, and reporting methods, which limited direct comparison and prevented meta-analysis. Third, some studies were conducted in single hospitals, which may reduce generalizability to national or regional populations. Finally, potential publication bias may exist, as only English-language and freely accessible full-text studies were included.

**Conclusions**

This systematic review highlights the substantial burden of multidrug-resistant hospital-acquired infections across the Eastern Mediterranean Region. Gram-negative bacteria, particularly *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Acinetobacter baumannii*, were the predominant pathogens, while MRSA remained an important gram-positive contributor. The findings indicate considerable gaps in infection prevention and control practices, antimicrobial stewardship implementation, and surveillance systems across the region.

Several clinical and healthcare-related risk factors were identified, including comorbidities, prolonged hospitalization, prior antibiotic exposure, and invasive medical procedures. These findings emphasize the urgent need for strengthened surveillance, improved infection prevention strategies, and coordinated antimicrobial stewardship programs across EMR healthcare systems. Addressing these challenges is essential to reduce the burden of multidrug-resistant infections and improve patient outcomes in the region.

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**Conflict of Interest**

The authors declare no potential conflict of interest concerning this article's research, authorship, and publication.

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