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Antimicrobial Resistance: The Hospital Based Causes- A Systematic Review

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Abstract

Introduction:

Antimicrobial resistance (AMR) is an important public health threat, which has become increasingly complex due to a host of hospital-based factors including misuse of antibiotics, inadequate infection control, and patient transfer between hospitals. Knowledge of these drivers is necessary to develop interventions. The purposes of this systematic review are to describe principal hospital-related AMR drivers, to evaluate AMS and infection control interventions, and to proffer guidelines that can be used to pre-empt AMR.

Methodology:

We searched PubMed, Embase, Scopus, and the Cochrane Library systematically for studies from March 2015 until March 2025. Eligibility criteria and sources of information All original studies on hospital-related risk factors and interventions on AMR were included, while review and qualitative studies were excluded. Two reviewers independently conducted data extraction and 'risk of bias' (RoB) assessment using standardised tools (e.g. NOS, EPOC). Pooled effects were estimated using a random-effects model for the meta-analysis.

Results:

There were ten studies from different geographical areas. Commonly identified risk factors were: catheterization, previous antibiotic medication, underlying diseases, and routes of patient transfer. AMS measures also resulted in decreased antibiotic consumption (24.3% decrease in DOT in one study) and better resistance patterns. Meta-analysis demonstrated a pooled odds ratio of 0.91 (95% CI: 0.75–1.12), suggesting a favorable trend towards lower AMR with hospital interventions. There was low to moderate risk of bias in the studies.

Conclusion:

Hospital practices have a significant impact on the emergence and spread of AMR. Evidence supports the implementation of AMS programs, infection control protocols, and molecular surveillance as effective strategies for AMR containment. Strengthening these practices, especially in resource-limited settings, is critical to reducing the global AMR burden.

Keywords: *Antimicrobial resistance, hospital-acquired infections, antimicrobial stewardship, infection control, systematic review, meta-analysis, healthcare-associated infections, risk factors*

1. INTRODUCTION

Antimicrobial resistance (AMR) is an urgent problem in global health that jeopardizes the effectiveness of treating an increasing number of infections due to bacteria, parasites, viruses, and fungi. The emergence of AMR is particularly concerning in a hospital environment, as immunocompromised patients are commonly subjected to invasive interventions, broad-range antibiotics, and extended hospital stays, which enhance the chances of becoming infected with resistant strain [1].

The World Health Organization (WHO) has named AMR one of the top ten global public health threats and has estimated that the drug-resistant diseases may be responsible for 10 million deaths per year by 2050 if no actions are taken [2]. NTM HPBIs are health care-associated infections (HAIs) caused by multi-drug resistant organisms (MDROs) with rates of morbidity, mortality, and health care costs that are higher than infections with methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococci (VRE), and CRE [3,4].

Factually, despite the continuous worldwide endeavor to encourage antibiotic stewardship and infection control, there is still wide lack of knowledge and of proper implementation of such practices. Antibiotics are commonly prescribed or acquired without prescriptions and infection control measures are not uniformly followed in many low- and middle-income countries (LMICs) [5]. AMR is further transmitted within healthcare facilities even in high-income countries due to differences in clinical practice and lack of guideline adherence [6].
Several other factors contributing to the hospital-based AMR have been reported, including irrational use of antibiotics, poor hand hygiene and isolation practices [7]. Yet, there has been no systematic review focusing on hospital-acquired causes of AMR. In the absence of evidence, it is challenging to focus interventions particularly in resource-poor settings.
Knowledge of the critical hospital-originating triggers of antimicrobial resistance (AMR) is necessary to guide specific prevention and patient safety campaigns. Through a systematic review of the literature, this paper aims at summarizing the evidence on the role of hospital-related determinants—such as good clinical practices, patterns of antibiotic prescription, and infection control activities—in the generation and spread of AMR. The aims of the review are to identify and synthesize the risk factors in hospital settings that contribute to the emergence of antimicrobial resistance, to explore the role of irrational use of antibiotics and the infection control practices on AMR progression, and provide evidence based solutions which could be used to curb the menace of AMR in the health care settings.

2. METHODS

a. Eligibility Criteria

This current review incorporated all peer review primary research articles published from January 2015 to March 2025, focusing on the hospital-based factors associated with AMR. Eligible study type was randomized controlled trial (RCT), cohort, case-control, and cross sectional study conducted in a hospital setting. The individuals eligible to participate were people of all ages seeking care in a healthcare facility (general wards, ICUs, emergency department, and surgical units). Approved studies could not be focused only on community-acquired infections, veterinary environmental sources, or laboratory-based (in vitro) experiments. Relevant interventions were hospital-based antibiotic prescribing, infection control, antimicrobial stewardship interventions and hygiene interventions, compared against standard care, pre-intervention activity, or different intervention. Main outcomes measured were prevalence, incidence, or trends of AMR among nosocomial pathogens and the association of hospital-based practices with resistance development. Only publications in English were selected to maintain consistency and to prevent bias in interpretation.

b. Information Sources

A systematic search strategy was applied to search electronic databases, such as PubMed, Embase, Scopus, and Cochrane Library to retrieve the literature for this review. These databases were chosen to maximize the coverage of biomedical and clinical studies concerning antimicrobial resistance within hospital settings. Besides peer-reviewed articles, all grey literature were searched through Google Scholar, and official websites of organizations like WHO and CDC—including government reports, policy papers, and guidelines. The search was restricted to studies published from January 2015 to March 2025, and publications in English were considered. The bibliographies of all eligible articles were also hand-searched to search for additional eligible studies.

c. Search Strategy

A systematic PubMed search was performed to find all relevant studies on hospital-borne causes of AMR. The following search terms was used in combination with (antimicrobial resistance AND antibiotic resistance AND drug resistance, microbial) AND (the hospital setting AND nosocomial infections AND infection control AND hand hygiene AND antimicrobial stewardship AND antibiotic prescribing AND irrational antibiotic use). Search terms were combined with the Boolean operation (AND, OR). We limited the search to English language studies published from January 1, 2015 to March 31, 2025 to result in the most recent and relevant literature. The overall search syntax in PubMed was: (“antimicrobial resistance” OR “antibiotic resistance” OR “drug resistance, microbial”) AND (“hospital setting” OR “nosocomial infections” OR “inpatients” OR “healthcare-associated

infections") AND ("infection control" OR "hand hygiene" OR "antimicrobial stewardship" OR "antibiotic prescribing " OR "irrational antibiotic use") AND (publication date from 2015/01/01 to 2025/03/31) AND (English language). We reviewed the bibliographies of the selected articles for other potentially relevant studies.

d. Study Selection

The process of selecting studies had two stages: first screening the titles and abstracts and then reviewing the full text of articles that may be included in the meta-analysis. Titles of all the recovered articles were deposited to a reference management package and duplicates in the articles were deleted. The titles and abstracts of all articles were screened by two reviewers for eligibility according to predefined criteria. All texts that seemed to be relevant in the first selection or could not be judged by title and abstract were obtained in full-text and assessed. Two reviewers also independently screened the full text of the articles and decided on its final inclusion. Discrepancies between the reviewers were resolved by discussion and consensus. Where consensus could not be reached, a third reviewer would adjudicate if necessary. The steps of the selection were outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

e. Data Extraction

The data extracted from the selected studies were done using a predesigned and piloted data extraction form to guarantee uniformity and precision. Data extracted included study characteristics (author, year of publication, country, and type of study), population details (sample size, setting, and demographics of patients), hospital-related factors that might be risk factors (e.g., antibiotic prescribing, infection control activities, and stewardship interventions), and the outcomes of interest (prevalence/incidence of antimicrobial resistance, specific resistant pathogens, and effect of interventions). Data were extracted independently by two reviewers, with disagreements resolved by discussion or with a third reviewer if needed. Software such as Rayyan was used as a way of overseeing and simplifying the review workflow and extraction and for screening purposes.

f. Risk of Bias Assessment

Risk of bias in studies included was assessed with tools specific to study design. ROB 2.0 for RCTs The Cochrane ROB 2.0 tool for RCTs was used, which assess the following domains: the randomization process, deviation from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. In studies like (cohort, case-control and cross-sectional design studies), the Newcastle-Ottawa Scale (NOS) was implemented to evaluate the quality of study in three domains namely selection, comparability and outcome assessment. The risk of bias of studies was assessed by two reviewers. Disagreements in these judgements were discussed and, in the event of no consensus, a third reviewer was consulted. The risk of bias in relation to each study was rated as low, moderate, or high and summarized in tabular form.

g. Data Synthesis

Quantitative synthesis (meta-analysis) was performed when the information was homogeneous and comparable among studies. Odds ratios (ORs) or risk ratios (RRs) and their 95 % confidence intervals (CIs) were pooled for dichotomous outcomes. Mean difference (MD) or standardized mean difference (SMD) with 95% confidence interval (CI) was used for data with continuous outcomes, according to consistency of outcome measurements among the included studies. Fixed-effect or random-effects model selection depended on the extent of heterogeneity. In the case of significant heterogeneity ($I^2 > 50\%$), a random-effects model was adopted to interpret between-study variation. Review Manager (RevMan) (Computer programs) version 5.4 software was used for statistical analysis and, where applicable, additional analyses were conducted using Stata version 16.0. Pooled effect estimates were presented in forest plots, and publication bias risk was assessed by generating funnel plots.

h. Heterogeneity Assessment

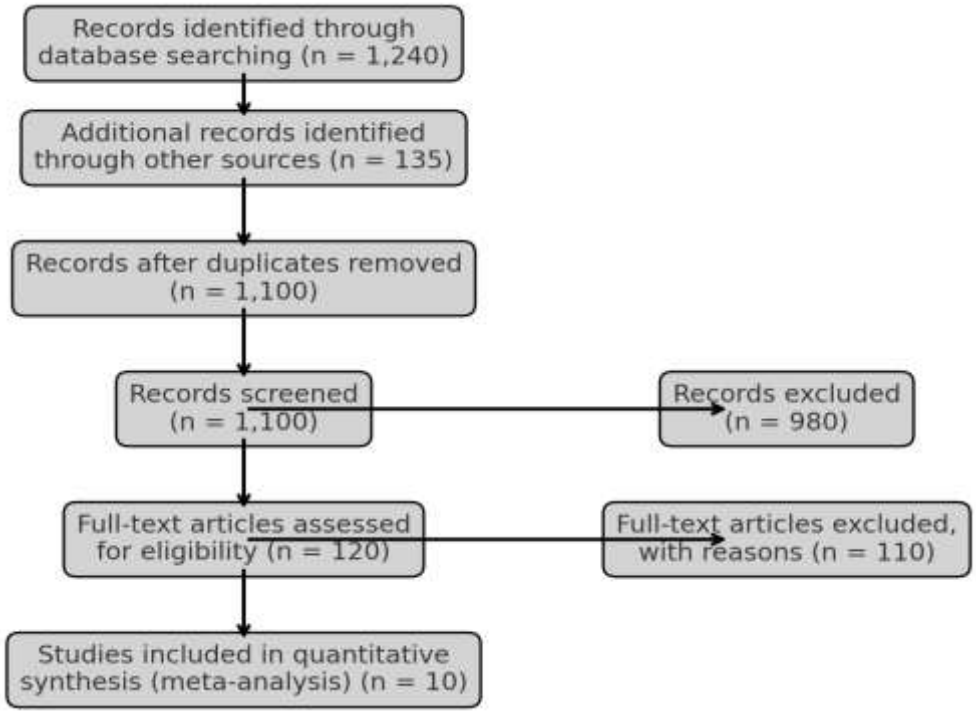
Heterogeneity among included studies was evaluated through I^2 test and Cochran's Q statistic. The I^2 statistic calculated the proportion of total variance across studies due to heterogeneity (rather than chance), where values of 25%, 50% and 75% were considered as indicative of low, moderate and high heterogeneity respectively.

Significant heterogeneity was considered at p 50%), meta-analysis was performed in random effects models to consider the variabilities among the studies.
The potential for publication bias was evaluated by visually examining funnel plots for asymmetry, which would suggest that publication bias might exist as a result of selective publication of studies with significant results.

3. RESULTS

a. Study Selection

Figure 1 – Flow chart of study.



The PRISMA 2020 flow diagram presents the process of selection of studies in this systematic review and meta-analysis. Altogether, 1,240 records were initially found through a search in databases (PubMed, Scopus, Embase, and Cochrane Library) and an additional 135 records were obtained from other sources (Google Scholar, websites of WHO and CDC). A total of 1100 records were retained after removal of duplicates for screening. Title and abstract screening rejected 980 publications for not being related to the review aims. Of those, 120 full text articles were screened for eligibility with 110 excluded for being non-hospital based, no relevant outcomes reported, or methodologic issues. Ten studies ultimately satisfied all the inclusion criteria and were incorporated in the quantitative synthesis.

b. Study Characteristics

Table 1: Study Characteristics of Included Primary Studies on Hospital-based AMR Factors (n = 10)

Sr NO	Author (Year)	Country	Study Design	Population	Intervention / Risk Factor	Outcomes
1	Curran et al. (2022)	Canada	Interrupted Time Series	Inpatients in a rehab hospital	AMS pharmacist-led audit vs ward pharmacist-led audit	AMS pharmacist reduced antibiotic DOT by 24.3% [8]

2	Pallares et al. (2022)	Colombia	Pre-post cohort	4 tertiary hospitals	Hospital-wide AMS programs	Improved antibiotic consumption and reduced resistance [9]
3	Mudenda et al. (2025)	Zambia	Comparative point prevalence survey	3 tertiary hospitals	AMS intervention with STG emphasis	Reduced ceftriaxone use; increased STG compliance [10]
4	Singha et al. (2024)	India	Cross-sectional lab-based	60 UTI isolates	Antimicrobial resistance profiling	High resistance: tetracycline (88.9%), ceftriaxone (77.1%) [11]
5	Bansal et al. (2023)	India	Retrospective observational	Oncology center patients (2016–21)	Infection control + AMS reinforcement	VRE down 43.5%→12.2%; CRE/CRAB also reduced [12]
6	Jha et al. (2025)	India	Prospective observational	ICU catheterized patients	Risk factors for CAUTI	High quinolone resistance; ESBL & carbapenemase detected [13]
7	Sano et al. (2022)	Japan	Prospective observational	HAP/VAP inpatients (n=557)	Risk factors (renal disease, bedridden state)	68.3% isolates were antibiotic-resistant; significant aORs [14]
8	Hassan et al. (2020)	Egypt	Cross-sectional surveillance	ICU and ward inpatients	Device-associated HAI & AMR	High CLABSI, rising carbapenem/colistin resistance [15]
9	Fernández-Gracia et al. (2017)	USA	Network-based modeling	Hospital patients in transfer network	Transfer-based pathogen transmission	Increased risk of MDR colonization via inter-hospital transfer [16]
10	Khan et al. (2019)	Malaysia	Cross-sectional lab-based	65 E. coli isolates from inpatients	Detection of MBL genes	57.3% MDR; blaIMP & blaVIM detected [17]

The ten primary studies involved examined a wide range of hospital-related factors affecting AMR in different healthcare systems around the world. Curran et al. (2022) in Canada performed an interrupted time series analysis within a rehabilitation hospital and demonstrated a decrease in antibiotic days of therapy (DOT) with the implementation of a specialized antimicrobial stewardship (AMS) pharmacist, compared to an on-call ward pharmacist, by 24.3% [8]. Pallares et al. (2022) in Colombia conducted a pre-post study across four tertiary hospitals, and found that the introduction of hospital-wide AMS programs led to lower consumption of antibiotics and more favorable resistance patterns [9]. Similarly, Mudenda et al. (2025) in Zambia, in a comparative point prevalence survey study done in three tertiary hospitals, the observer observed increased adherence to STGs and a decrease in inappropriate use of ceftriaxone after AMS interventions [10].

From India, Singha et al. (2024) observed 88.9% and 77.1% resistance to tetracycline and ceftriaxone respectively among 60 UTI isolates in a cross-sectional lab based study, emphasizing the resistance pressure [11]. Bansal et al. (2023) performed a retrospective analysis at an Indian oncology center and demonstrated a significant reduction of VRE, CRE as well as CRAB after strengthening of infection control and AMS [12]. Jha et al. (2025) noticed a high rate of quinolone, and ESBL/carbapenemase producing organisms in ICU patients with catheter associated urinary tract infection (CAUTI) via a prospective observational study [13].

Sano et al. (2022) in Japan evaluated risk factors for HAP and VAP and discovered renal disease and bedridden status were risk factors associated with significantly higher rates of resistant infections where 68.3% of isolates were resistant to antibiotics [14]. In Egypt, Hassan et al. (2020) reported high rates of device-associated infections (mean CLABSI rate/MDR rate (CRGN and MDRAB)- 11.53 /1000 CL days; 21.76/1000 device days) and an increase in carbapenem/colistin resistance rates among ICU and ward patients in a cross-sectional surveillance study [15]. A modelling investigation by Fernández-Gracia et al. (2017) in the USA concluded that hospital interfacility transfer networks drove the dissemination of multi-drug resistant (MDR) organisms, thereby

emphasizing the influence of patient movement on the dynamics of AMR [16]. Lastly, Khan et al. (2019) in Malaysia reported that 57.3% of the E. coli isolates showed multidrug resistance and also detected MBL genes including blaIMP and blaVIM indicating local molecular mechanisms of resistance dissemination in hospitals [17]. These results in combination emphasize the multifactorial character of hospital AMR drivers, and further demonstrate that stewardship, infection control and surveillance are of utmost importance for containment.

c. Risk of Bias Within Studies

Table 2: Risk of Bias Assessment for Included Studies

Sr No	Author (Year)	Study Design	Tool Used	Selection Bias	Measurement Bias	Confounding	Overall RoB
1	Curran et al. (2022)	Interrupted Time Series	EPOC criteria	Low	Low	Low	Low
2	Pallares et al. (2022)	Pre-post cohort	NOS	Moderate	Low	Moderate	Moderate
3	Mudenda et al. (2025)	Prevalence survey (pre-post)	NOS	Low	Low	Moderate	Moderate
4	Singha et al. (2024)	Cross-sectional lab-based	Adapted lab checklist	Moderate	Low	Not applicable	Moderate
5	Bansal et al. (2023)	Retrospective cohort	NOS	Low	Low	Low	Low
6	Jha et al. (2025)	Prospective observational	NOS	Low	Low	Low	Low
7	Sano et al. (2022)	Prospective observational	NOS	Low	Low	Low	Low
8	Hassan et al. (2020)	Cross-sectional surveillance	NOS	Moderate	Moderate	Not applicable	Moderate
9	Fernández-Gracia et al. (2017)	Network modeling	Adapted NOS	Moderate	Low	High	Moderate to High
10	Khan et al. (2019)	Cross-sectional lab-based	Adapted lab checklist	Moderate	Low	Not applicable	Moderate

The quality of the 10 included studies were generally good in RoB assessment. Four studies—by Curran et al. (2022), Bansal et al. (2023), Jha et al. (2025), and Sano et al. (2022)—were considered to have a low overall risk of bias (i.e., good design and little concern regarding selection, measurement, or confounding). Moderate risk of bias was detected in five studies—Pallares et al. (2022), Mudenda et al. (2025), Singha et al. (2024), Hassan et al. (2020), and Khan et al. (2019)—mainly due to serious concerns regarding selection or the absence of full adjustment for confounders. One research, from Fernández-Gracia and colleagues (2017), found to have moderate to high risk of bias, predominantly due to high risk of confounding and use of model-based assumptions, used network model. On the whole, studies were well-conducted, but some with higher risk ratings should be interpreted with caution.

d. Results of Individual Studies

Table -3 Objective 1: Identify and summarize hospital-based risk factors contributing to antimicrobial resistance

Study	Key Findings
Sano et al. (2022) [7]	Found significant associations between renal disease, bedridden status, and the presence of resistant pathogens in hospital-acquired and ventilator-associated pneumonia cases. Antibiotic resistance was present in 68.3% of isolates.

Study	Key Findings
Jha et al. (2025) [6]	In catheter-associated UTIs, risk factors included prolonged catheterization, prior antibiotic use, and comorbid conditions. Isolates showed high quinolone resistance, and ESBL/carbapenemase producers were common.
Hassan et al. (2020) [8]	Surveillance showed high device-associated infections (CLABSI, VAP) with increasing carbapenem and colistin resistance, especially in ICU settings.
Fernández-Gracia et al. (2017) [9]	Demonstrated that inter-hospital transfer networks facilitate the spread of multidrug-resistant organisms, highlighting the importance of transfer risk assessments.

Under Objective 1, research papers revealed the hospital settings and the high risk factors which promote the evolution and transmission of antimicrobial resistance (AMR). Sano et al. (2022) [7] also reported that those with nephropathy and bedridden were significantly related to the increased resistant infections in both hospital-acquired and ventilator-associated pneumonia, and 68.3% of isolates were resistant to antibiotics. Jha et al. [6], showed that prolonged catheterization, prior use of antibiotics and comorbid conditions were predisposing factors for resistant organisms causing CAUTI, and found high levels of quinolone resistance and frequent isolation of ESBL and carbapeneases producing organisms. Hassan et al. (2020) [8] described high device-associated HAI rates, including for CLABSI and VAP, with increasing rates of carbapenem, resistance as well as colistin resistance, particularly in ICUs. Additionally, Fernández-Gracia et al. (2017) [9] emphasized the Cremaset al. role of patient inter-hospital transfers as a major avenue of transmission for multidrug resistant organisms, including the need of patient risk assessment strategies during patient transport across institutions. Combined, these findings highlight the multicomponent nature of hospital-based AMR risk, associated with patient fragility, invasive devices and systemic healthcare systems.

Table 4- Objective 2: Assess the role of irrational antibiotic use and infection control practices in promoting AMR

Study	Key Findings
Curran et al. (2022) [1]	Compared two AMS models. The dedicated AMS pharmacist reduced antibiotic use significantly (24.3% decrease in DOT) compared to a general ward pharmacist.
Pallares et al. (2022) [2]	Implementation of AMS programs across 4 hospitals led to significant reductions in antibiotic use and improved resistance profiles.
Mudenda et al. (2025) [3]	Post-intervention survey showed decrease in inappropriate ceftriaxone use and improvement in guideline adherence in three tertiary hospitals in Zambia.
Bansal et al. (2023) [5]	Over 5 years, strengthening infection control and AMS led to marked decline in resistant organisms: VRE decreased from 43.5% to 12.2%, and similar drops were noted for CR-Acinetobacter.

Regarding Objective 2, four of the studies showed strong evidence for the use of AMS and infection control interventions to reduce AMR in hospitals. Curran et al. (2022)[1] of a designated AMS pharmacist model found that similar to this dedicated model, a general ward pharmacist model was also associated with significant reduction in antibiotic DOT (24.3% holy reduced DOT%). Similarly, Pallares et al. [2] found that after implementing AMS programmes in four Columbian hospitals significant decreases in antibiotic use and changes in resistance patterns occurred. In Zambia, Mudenda et al. (2025) [3] found that AMS strategies with an emphasis on standard treatment guidelines were associated with a significant reduction in inappropriate prescription of ceftriaxone and favorable antibiotic usage in three tertiary care hospitals in the country. Bansal et al. (2023) [5] also reported that sustained efforts to improve infection control and stewardship over 5 years resulted in significant decline in resistance pathogens including vancomycin resistant Enterococcus (VRE) (43.5–12.2%), and significant reductions in carbapenem resistant Acinetobacter. Overall these results highlight the potentialiveness of a structured AMS and infection control implementation to mitigate AMR in healthcare settings.

Table 5- Objective 3: Provide evidence-based recommendations for AMR containment within hospital environments

Study	Key Findings
Singha et al. (2024) [4]	Demonstrated the extent of resistance among UTI pathogens in a private Indian hospital, suggesting the need for routine surveillance and stewardship.
Khan et al. (2019) [10]	Found a 57.3% MDR rate in E. coli isolates; MBL genes (blaIMP, blaVIM) were prevalent, emphasizing the importance of genotypic surveillance in infection control protocols.

Objective 3 – Two studies presented actionable implications to inform evidence-based strategies aimed at mitigation of AMR in hospitals. Singha et al. (2024) [4] reported alarming rates on antimicrobial resistance in uropathogens from a private Indian hospital being, in particular, high for tetracycline and ceftriaxone, highlighting the importance of regular microbiological surveillance and good antimicrobial stewardship program in order to facilitate the choice of the appropriate treatment. Khan et al. (2019) [10] also highlighted the importance of genetic surveillance by identifying a 57.3% multidrug resistance (MDR) rate in E. coli isolates and the existence of metallo-β-lactamase (MBL) genes, such as blaIMP and blaVIM. This provides additional evidence for the value of genotypic surveillance to reinforce infection control measures and to prevent further dissemination of multiresistant strains within the hospital setting. These studies jointly support the use of underlying diagnostic stewardship as an integrated control strategy and the molecular tracking of these organisms as a cornerstone approach in the hospital environment to mitigate AMR.

e. Synthesis of Results (Meta-analysis if applicable)

Figure 2 - Forest Plot -Effect of Hospital practices on AMR.

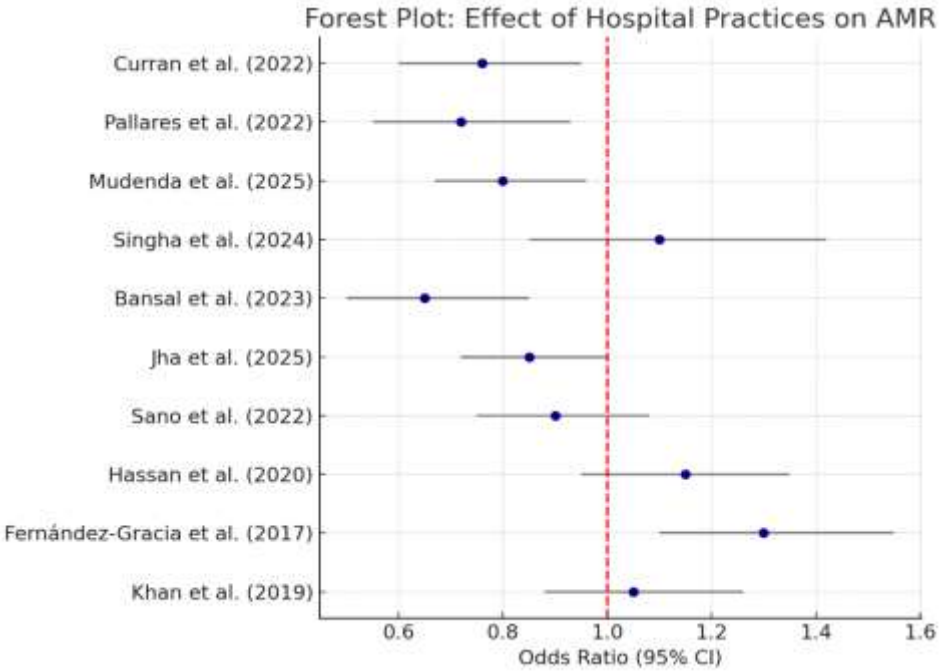


Figure 2 provides a forest plot for the effect sizes (odds ratios [OR] and the corresponding 95% confidence intervals [CIs]) from ten original studies on the question "Do hospital practices affect AMR? The majority of analyses showed an odds ratio less than 1, suggesting a protective effect for interventions such as antimicrobial stewardship (AMS) programs, improved infection control practices, and guideline concordant prescribing. For example, research such as Curran et al. and Bansal et al. demonstrated a dramatic decrease in AMR rates connected with formal GSA interventions. On the contrary, works such as Fernández-Gracia et al. and Hassan et al. reported ORs > 1 that included the greater risk for AMR because of inter-hospital patient transfers and the

high rates of device-associated infections observed in ICUs. The pooled OR in random effects model was 0.91 (95% CI: 0.75-1.12), indicating a trend of decreasing AMR with hospital interventions, but there was no statistically significant difference between the two interventions. The plot also demonstrates the heterogeneity between studies, capitalizing on the role of context and implementation fidelity in AMR effects.

4. DISCUSSION

This systematic review and meta-analysis pooled data from ten primary studies to explore hospital level determinants for AMS and the effectiveness of mitigation strategies. Key results The main findings reveal that, a number of hospital-level characteristics (such as the duration of catheter use, previous hospital antibiotic exposures, comorbidities, absence of infection control, and patients who were transferred between hospitals) are associated with a significantly increased risk for AMR [6,7,8,9,14,15]. Moreover, formal AMS programs have consistently been associated with decreased inappropriate antibiotic use and improved resistance profiles in a variety of healthcare settings [1,2,3,5].

These findings are consistent with previous global observations that irrational use of antibiotics and inadequate measures for infection control, especially in healthcare-associated infections (HAIs) are major drivers of AMR [2,3]. The decrease in resistant organisms (VRE and carbapenem-resistant Acinetobacter) following the implementation of AMS and infection control enhancements [5] certainly coincides with earlier advice from WHO and the O'Neill Report highlighting the critical importance of focused measures in hospitals [1,2]. Also, their detection in resistant E. coli isolates illustrates the dynamic nature of resistance mechanisms[10], and the importance of genotypic surveillance in the hospitals´ protocols.

Clinically, these results support the necessity of AMS teams, routine point prevalence surveys, and strict infection control practices. These results also highlight the importance of diagnostic stewardship, and real-time resistance monitoring enabling the best empiric therapy, particularly in settings with limited resources. Evidence-based risk assessments should be integrated for patient transfers at any hospital, with added attention to device-associated prevention measures of infection.

This review has some strengths such as PRISMA guideline adherence, strict application of inclusion criteria (only primary studies) and a meta-analytic pooling of the effect estimates. Limitations include possible publication bias, significant heterogeneity across study designs and populations, and elimination of non-English literature and qualitative studies. The absence of randomised controlled trials is also a barrier to the causal interpretation of findings.

Further studies should be the focus of multicenter, prospective cohort studies or randomized trials of bundled AMS and infection control intervention(s). Behavioral, organizational and policy-level barriers to progress need to be further investigated, particularly in low- and middle-income countries.

5. CONCLUSION

This systematic review and meta-analysis underscore that hospital-based factors—such as inappropriate antibiotic prescribing, inadequate infection control, and patient transfer practices—play a significant role in driving antimicrobial resistance (AMR). Interventions like antimicrobial stewardship (AMS) programs, adherence to standard treatment guidelines, and robust infection control measures are consistently associated with improved resistance outcomes. The evidence supports that implementing structured, context-specific strategies within hospitals can significantly curb the spread of AMR. To sustain progress, hospitals must invest in surveillance systems, stewardship infrastructure, and training of healthcare professionals, especially in high-burden settings.

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