

Prevalence and Molecular Epidemiology of NDM-Producing Enterobacterales in Gulf Cooperation Council Countries: A Literature Review

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BACKGROUND

WHO Critical Priority Pathogen: Carbapenem-resistant Enterobacterales (CRE) are classified as the highest-priority pathogens requiring urgent intervention worldwide.

New Delhi metallo- β -lactamase (NDM) was first identified in 2008 in *Klebsiella pneumoniae* from a Swedish patient treated in New Delhi, India. It rapidly disseminated globally, with multiple NDM variants (NDM-1 to NDM-30+) now identified. NDM belongs to Ambler Class B metallo- β -lactamases and confers resistance to all **β -lactam antibiotics** except aztreonam. It is **not inhibited** by conventional β -lactamase inhibitors (clavulanate, tazobactam, sulbactam).

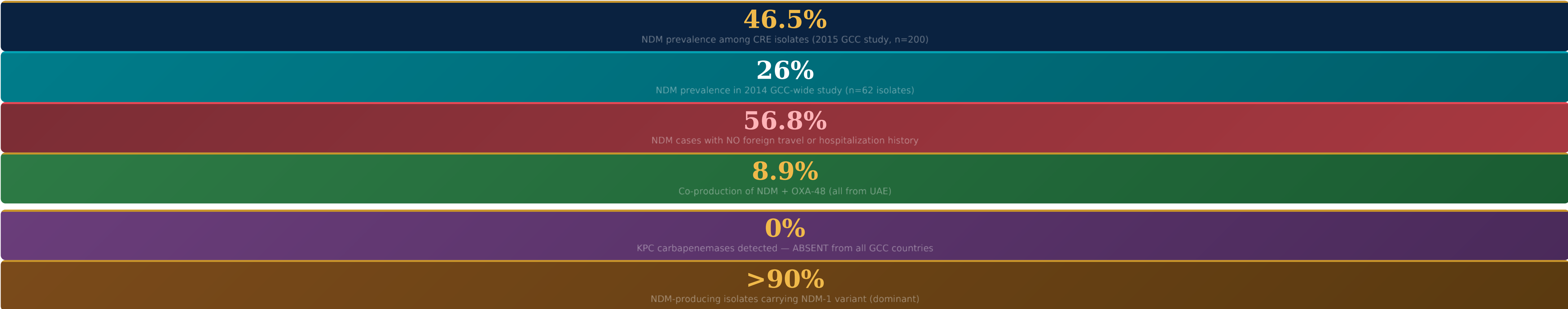
GCC Region: The Gulf Cooperation Council countries (Saudi Arabia, UAE, Kuwait, Qatar, Bahrain & Oman) represent a unique epidemiological nexus due to high population mobility, large expatriate workforces, and intensive healthcare utilization.

Despite the Middle East being recognized as an NDM epicenter, comprehensive regional data synthesis across GCC countries had not been previously performed.

METHODS

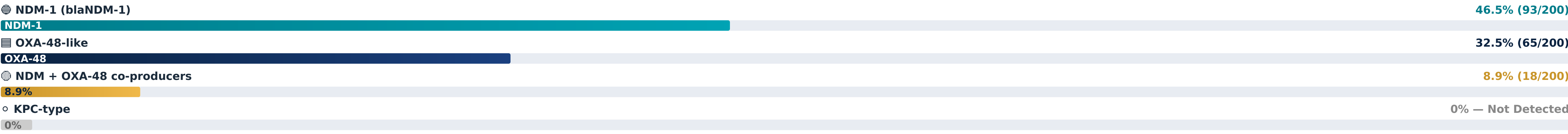
- Database Search**
PubMed, Scopus & Web of Science searched systematically (2010-2024)
- Search Terms**
"NDM" OR "carbapenem resistance" AND "Saudi Arabia" OR "UAE" OR "Kuwait" OR "Qatar" OR "Bahrain" OR "Oman" OR "GCC"
- Inclusion Criteria**
GCC-based studies; Enterobacterales only; molecular confirmation of NDM; peer-reviewed; English language
- Exclusion Criteria**
Non-Enterobacterales; single case reports; conference abstracts without full-text; no molecular confirmation
- Data Extraction**
Prevalence, species, NDM variants, sequence types, plasmid types, co-resistance, transmission data
- Synthesis**
Narrative synthesis due to methodological heterogeneity; no meta-analysis performed

KEY STATISTICS



CARBAPENEMASE DISTRIBUTION

Carbapenem-Resistant Enterobacterales (n=200, Four GCC Countries, 2015)



Distinct Regional Pattern: Complete absence of KPC carbapenemases distinguishes GCC from North America & Europe where KPC-producing ST258 *K. pneumoniae* predominates.

MOLECULAR EPIDEMIOLOGY

Country	Dominant Clone	Plasmid Type	Key Feature
Saudi Arabia	ST152	IncHI1b	NDM + OXA-48 co-producers
UAE	ST14	IncHI1b (>170kb)	Highest dual carbapenemase rate
Oman	ST147	IncHI1b (>170kb)	Similar plasmid to UAE strains
Kuwait	Diverse	IncX3	NDM-7 rare variant detected
Qatar	Diverse	Various	No clonal relationship to others
Bahrain	Diverse	Various	Limited published data

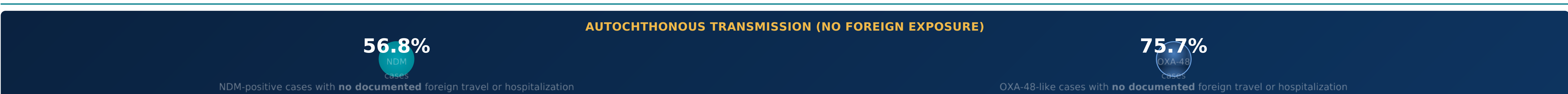
Dominant Species: *Klebsiella pneumoniae* accounts for ~70–80% of all NDM-producing isolates across the GCC region

NDM-7 variant (IncX3 plasmids) identified in Kuwait, Oman & UAE — highly mobile plasmids with efficient conjugation

IncHI1b plasmids carrying blaNDM are >170kb and shared between UAE (ST14) and Oman (ST147)

Both clonal spread AND horizontal gene transfer operating simultaneously in the GCC

TRANSMISSION DYNAMICS



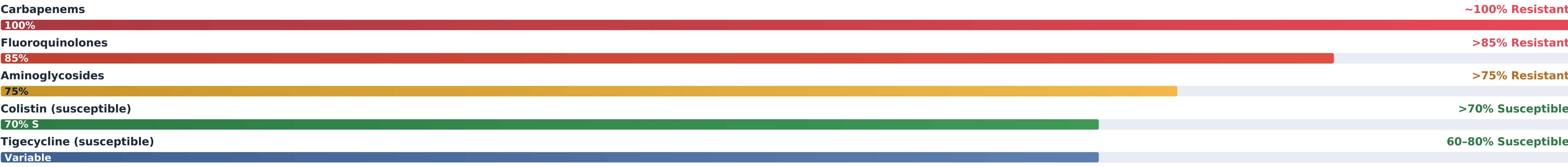
- Established endemicity:** NDM is no longer merely an imported pathogen — it is endemic in GCC healthcare facilities
- Hospital-associated:** ~84% of NDM CRE cases are healthcare-associated; 16% community-onset
- Risk factors:** ICU admission, prolonged hospitalization, invasive devices, and prior antibiotic exposure
- Environmental reservoirs:** Hospital water systems (sinks, drains) implicated in some outbreak clusters
- Foreign exposure:** 78.6% of patients with prior foreign healthcare carried NDM, demonstrating importation pathway still active

COUNTRY-SPECIFIC NDM FINDINGS ACROSS GCC

Saudi Arabia Dominant Clone: ST152 Largest GCC country; highest number of reported cases; NDM + OXA-48 co-production in same centers; major healthcare hub for Hajj/Umrah pilgrims
United Arab Emirates Dominant Clone: ST14 Highest rate of dual carbapenemase producers (NDM + OXA-48); >85% expatriate population; major international travel hub; IncHI1b plasmids >170kb
Oman Dominant Clone: ST147 ST147 carrying IncHI1b plasmids similar to UAE strains; NDM-7 rare variant detected; limited published surveillance; plasmid sharing with UAE suggests regional spread
Kuwait Clonally Diverse NDM-7 on IncX3 plasmids confirmed; IncX3 plasmids known for high conjugation frequency; limited longitudinal surveillance data published
Qatar Clonally Diverse NDM-positive isolates show no clonal relationship to other GCC strains; suggests independent introduction or horizontal plasmid transfer; limited published data
Bahrain Limited Data NDM presence confirmed in multi-country studies; most underrepresented in published literature; national surveillance system needed; small geographic area, high healthcare utilization

ANTIMICROBIAL SUSCEPTIBILITY

Resistance Rates in NDM-Producing Isolates:



Treatment Challenge: Ceftazidime-avibactam is NOT active against MBLs including NDM. Aztreonam-avibactam shows promise but was unavailable in GCC during the study period.

DISCUSSION

- NDM as dominant carbapenemase:** At 26–46.5%, NDM is the most prevalent carbapenemase in the GCC, reflecting strong epidemiological links to the Indian subcontinent
- Endemicity established:** With over half of NDM cases arising without foreign exposure, GCC healthcare facilities can no longer rely solely on screening international travelers
- Dual mechanism spread:** Both clonal dissemination (country-specific STs) and horizontal plasmid transfer (shared IncHI1b plasmids between UAE and Oman) operating concurrently
- High-risk clones:** ST152, ST14, and ST147 are globally recognized pandemic lineages with enhanced fitness for nosocomial survival and transmission
- Regional divergence:** Absence of KPC and predominance of NDM/OXA-48 distinguishes GCC from Western resistance patterns, reflecting distinct importation pressures
- Temporal increase:** Middle East-Africa surveillance (ATLAS 2018-2022) showed CRE doubling from 5.7% to 10.4%, suggesting GCC burden is increasing

PUBLIC HEALTH RECOMMENDATIONS

- Enhanced screening:** Active surveillance for CRE carriage in ICU, transplant, oncology and post-surgical wards
- Contact precautions:** Strict implementation for all confirmed or suspected CRE-positive patients
- Environmental controls:** Systematic sampling of hospital water systems; UV disinfection and hydrogen peroxide vapor in outbreak settings
- Antimicrobial stewardship:** Carbapenem-sparing strategies and formulary restrictions with stewardship review
- Regional surveillance:** Harmonized GCC-wide surveillance platform with standardized methods and real-time data sharing
- Whole-genome sequencing:** Expand WGS-based transmission reconstruction to identify and interrupt nosocomial spread
- Antibiotic policy:** Regulation of over-the-counter antibiotic availability across GCC member states

CONCLUSIONS



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