Original Research

Carbapenem-Resistant Enterobacteriaceae (Cre) Screening By Risk Factor Based Active Surveillance: An Infection Control Measure For Intensive Care Unit In Central India.

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Abstract:
Carbapenem-resistant Enterobacteriaceae (CRE) poses a growing threat in healthcare-associated infections, with limited therapeutic options. Klebsiella pneumoniae is the predominant causative agent globally. CRE, residing in the human intestine, serves as a risk factor for subsequent infections, presenting a healthcare challenge due to high morbidity and mortality rates. This study aimed to determine the prevalence of asymptomatic CRE carriers in an Intensive Care Unit (ICU) setting.The cross-sectional study spanned three years, involving rectal swab collection from ICU-admitted patients. Isolates underwent manual identification, carbapenem resistance screening, and susceptibility testing. Risk factors for CRE colonization were assessed using a composite questionnaire. The study revealed a prevalence of 3 to 7% CRE colonization, higher in ICU patients (13-51%). Active surveillance and compliance with infection control measures are essential in preventing CRE transmission, particularly in the ICU.

The analysis of 584 rectal swabs highlighted gender-specific risk factor distributions. Males showed higher CRE colonization rates, particularly with high-end antibiotic exposure and Foley's catheterization. Escherichia coli dominated CRE isolates (70.27%), followed by Klebsiella pneumoniae (18.92%) and Enterobacter cloacae (10.81%).Discussion focused on the challenges posed by MDR bacteria, emphasizing the importance of hand hygiene and resource limitations in underdeveloped countries for CRE surveillance. Despite no consensus on the best detection method, rectal swabs emerged as a sensitive tool for active surveillance. Critically ill CRE-colonized patients face higher infection risks, emphasizing the need for tailored interventions.The study faced limitations, including single-time rectal screening and unexplored resistance mechanisms. The absence of clonality assessments restricted determining if CRE bacteremia resulted solely from colonization. Turnaround time, isolation duration uncertainties, and dedicated beds in the ICU also posed challenges.In conclusion, the study advocates for early CRE detection through rectal swab screening. However, challenges persist in effectively controlling colonization and infection rates. Active surveillance's impact relies on robust preventive measures and cohesive team communication. Future research should address limitations and delve into molecular characteristics for better treatment and infection control.

Key Words: Carbapenem-resistant Enterobacteriaceae (CRE), Intensive Care Unit (ICU), Health care facilities (HCF)& Multidrug-resistant (MDR).

Introduction:

Carbapenem-resistant Enterobacteriaceae (CRE) are increasingly morecommon causes of healthcare-associated infections for which a very few therapeutic options exist[1]. The most common causative agent of CRE infections worldwide is *Klebsiella pneumoniae*followed by *Escherichia coli*, *Klebsiella oxytoca*, and *Enterobacter cloacae*[2,3].One of the potential endogenous reservoirs of CRE is the human intestine, where Enterobacteriaceae, including K. pneumoniae, can reside as colonizers. Colonization with CRE is a known risk factor for subsequent CRE infections[1]. Infections by CRE are considered a health care challenge because CRE isolates are usually extensively drug resistant and associated with high morbidity and mortality[5,6]. Colonization is considered to be a prerequisite for infection[7], which suggests that prevention of CRE colonization is important in preventing the morbidity and mortality associated with these infections[8]. The prevalence of CRE

colonization in hospitalized patients ranges from 3 to 7%, but can be higher in patients admitted to intensive care units (ICUs). In one of the Indian study it was found that the prevalence of CRE in ICU ranges between 13% and 51%. A proactive approach by active surveillance and a strong compliance with infection control measures would be needed to prevent the spread of CRE transmission particularly in an ICU setup[9].

Aim:

The aim of the study was to determine the prevalence of asymptomatic carriers of CRE among patients admitted in our ICU from the community and other health care facilities (HCF).

Objectives:

1. To isolate and identify members of Enterobacteriaceae in the rectal swab of patient admitted from community and other health care facilities (HCF) in ICU using standard manual method.
2. To screen for carbapenem resistance by growing the isolates on MacConkey agar with 1µg/ml meropenem.
3. To determine susceptibility of the suspected meropenem resistant isolates to meropenem and imipenem by Kirby Bauer disc diffusion method using CLSI guidelines.
4. To determine risk factors associated with CRE colonization.

Material and methods:

This prospective Cross-sectional study was carried outat the Department of Microbiology in collaboration with the Department of Anesthesiology, Chirayu Medical College & Hospital, and Bhopalfor a duration of three years (from December 2019 to December 2022) to plan out a road map for infection control measures in our hospital.All patients with age of 18 Years and above who were admitted in ICU at the given time period were included in the study after taking proper informed consent. Patients of less than 18yrs of age, Patients transferred from other units within the hospital to ICU, as these patients will not be screened for CRE at the time of admission& Patient not given consent were excluded from the study. Two rectal swabs (for improved yield) were collected in chorus from the patients by inserting the swab 1 cm into the rectum while rotating the swabs. A nylon flocked swab system was used for sample collection and this was immediately transferred to the laboratory, for processing. Swabs were vortexed for 10 s in peptone water, and 100 µl was plated on MacConkey agar with Meropenem at 1 µg/ml as well as on MacConkey agar plate without Meropenem for determination of viable colony counts. Plates were incubated overnight at 37°C in an incubator and then interpreted. Lactose fermenting colonies were identified as pink, mucoid or non-mucoid colonies on MacConkey agar plate and non-lactose fermenting colonies as colorless colonies. Suspected CRE colonies from MacConkey agar with Meropenem at 1 µg/ml were suspended in saline to the density of a 0.5 McFarland standard and antimicrobial susceptibility for Imipenem, Meropenem& Ertapenem was determined in Muller-Hilton agar plate by Kirby Bauer method. Susceptibility was determined using 2019 breakpoint criteria of the Clinical and Laboratory Standards Institute. Isolates non-susceptible to either Imipenem, Meropenem&Ertapenem were defined as CRE positive. Patients were categorized into two groups based on rectal colonization as CRE-colonized or non-colonized. Intergroup analysis for categorical data was done using Chi-square test. Statistical analysis was done using IBM Statistical analysis was done using SPSS software (SPSS ver. 21, IBM, Chicago, USA). Patients were also screened based on a predetermined/ composite questionnaire which included duration of stay in the other hospital, exposure to high end antibiotics (carbapenem, colistin, tigecycline, polymyxin B, vancomycin, teicoplanin), devices inserted, surgery done in the past 90 days and past history of colonization and infection with CRE (Annexure-1).The study was approved by the Institutional ethical committee.

Results:

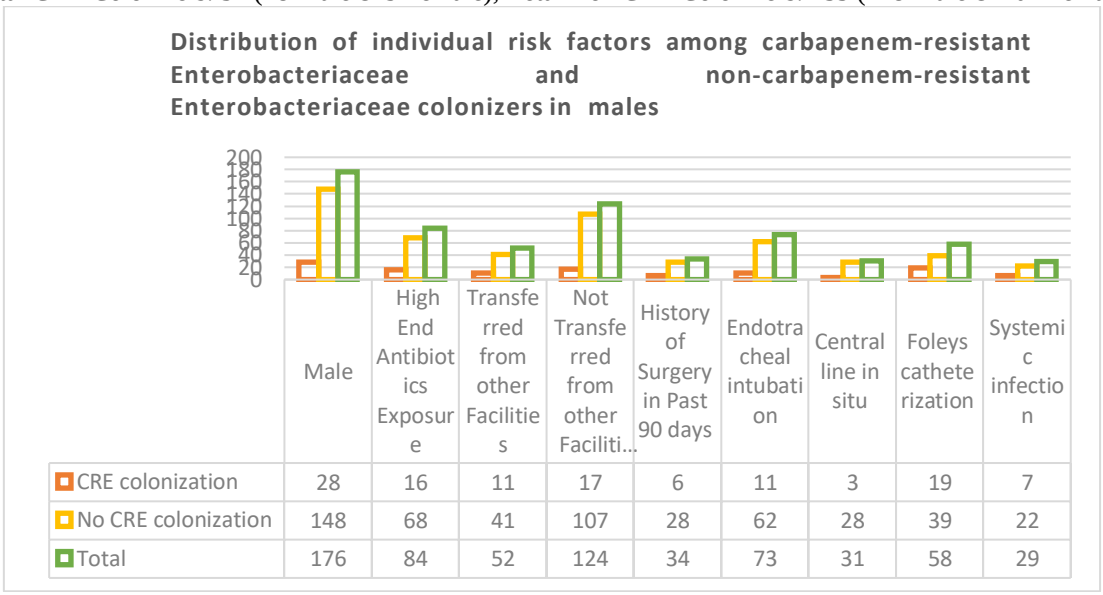
A total of 584 Rectal Swabs were collected from 292 patients. The results were hypothesized based on single positive rectal swab from each patient. Distribution of different risk factors gender wise across the two groups is summarized in Table 1.

Table 1: Distribution of individual risk factors among carbapenem‑resistant Enterobacteriaceae and non‑carbapenem‑resistant Enterobacteriaceae colonizers

Risk factors	CRE colonization	No CRE colonization	Total
Male	28	148	176
High End Antibiotics Exposure	16	68	84
Transferred from other Facilities	11	41	52
Not Transferred from other Facilities	17	107	124
History of Surgery in Past 90 days	6	28	34
Endotracheal intubation	11	62	73

Central line in situ	3	28	31
Foleys catheterization	19	39	58
Systemic infection	7	22	29
Risk factors	**CRE colonization**	**No CRE colonization**	**Total**
Female	9	107	116
High End Antibiotics Exposure	2	45	47
Transferred from other Facilities	4	69	73
Not Transferred from other Facilities	5	98	103
History of Surgery in Past 90 days	1	4	5
Endotracheal intubation	6	47	53
Central line in situ	3	36	39
Foleys catheterization	7	58	65
Systemic infection	3	27	30

Total CRE Colonizers: 37 (28 Male & 9 Female); Total Non CRE Colonizers: 255 (148 Male & 107 Female)



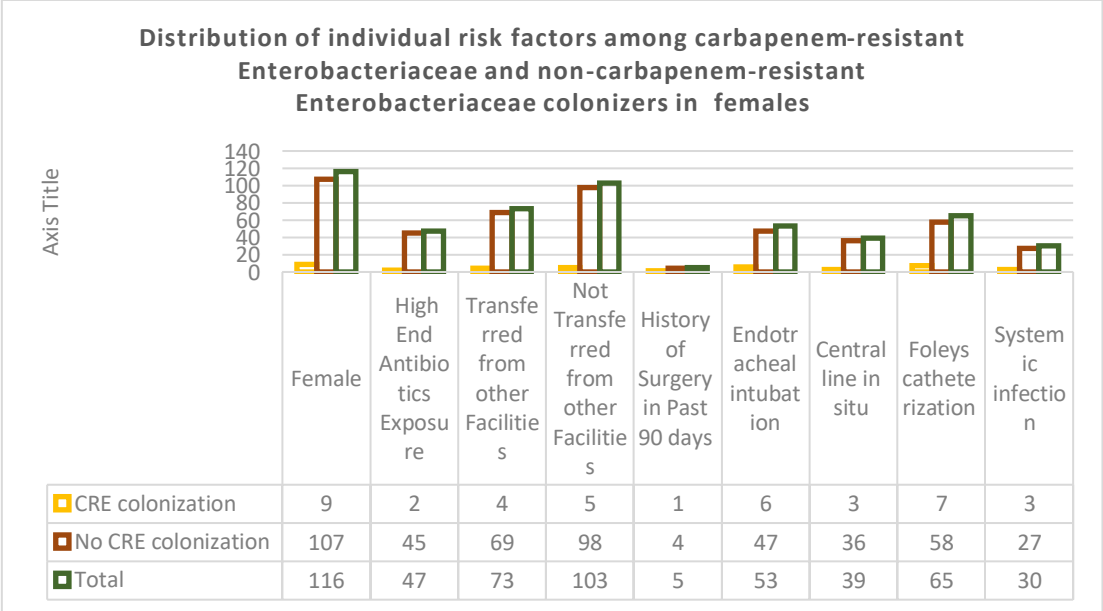


Table 1 presents the distribution of individual risk factors among individuals colonized with carbapenem-resistant Enterobacteriaceae (CRE) and those without CRE colonization. The data is categorized based on gender and various risk factors. Here's a concise interpretation of the table:

For Males:

- Of the 176 individuals, 28 with CRE colonization and 148 without CRE colonization were observed.
- High-end antibiotics exposure was noted in 16 individuals with CRE colonization and 68 without CRE colonization.
- 11 individuals transferred from other facilities had CRE colonization, while 41 did not.
- History of surgery in the past 90 days was observed in 6 individuals with CRE colonization and 28 without CRE colonization.
- Endotracheal intubation was present in 11 individuals with CRE colonization and 62 without CRE colonization.
- 3 individuals with CRE colonization had a central line in situ, compared to 28 without CRE colonization.
- Foleys catheterization was noted in 19 individuals with CRE colonization and 39 without CRE colonization.
- Systemic infection was observed in 7 individuals with CRE colonization and 22 without CRE colonization.

For Females:

- Among the 116 individuals, 9 had CRE colonization, and 107 did not.
- High-end antibiotics exposure was seen in 2 individuals with CRE colonization and 45 without CRE colonization.
- 4 individuals transferred from other facilities had CRE colonization, while 69 did not.
- History of surgery in the past 90 days was observed in 1 individual with CRE colonization and 4 without CRE colonization.
- Endotracheal intubation was present in 6 individuals with CRE colonization and 47 without CRE colonization.
- 3 individuals with CRE colonization had a central line in situ, compared to 36 without CRE colonization.
- Foleys catheterization was noted in 7 individuals with CRE colonization and 58 without CRE colonization.
- Systemic infection was observed in 3 individuals with CRE colonization and 27 without CRE colonization.
- In summary, the table provides a detailed breakdown of the distribution of specific risk factors among individuals with and without CRE colonization, stratified by gender.

Table 2: Distribution of isolates among Carbapenem Resistant Enterobacteriaceae colonization

Name of Organism Isolated	Numbers	% Distribution
Escherichia coli	26	70.27%
Klebsiella pneumoniae	7	18.92%
Enterobacter cloacae	4	10.81%

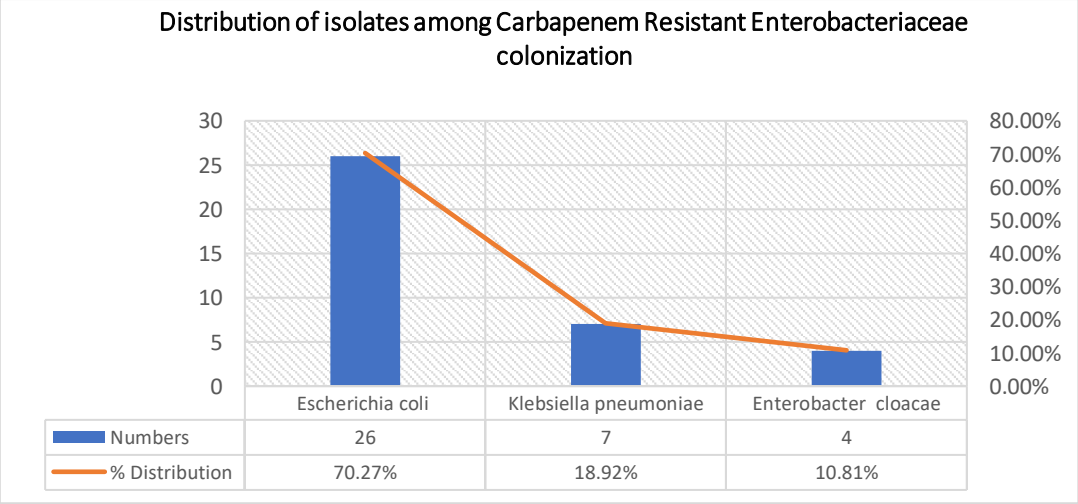


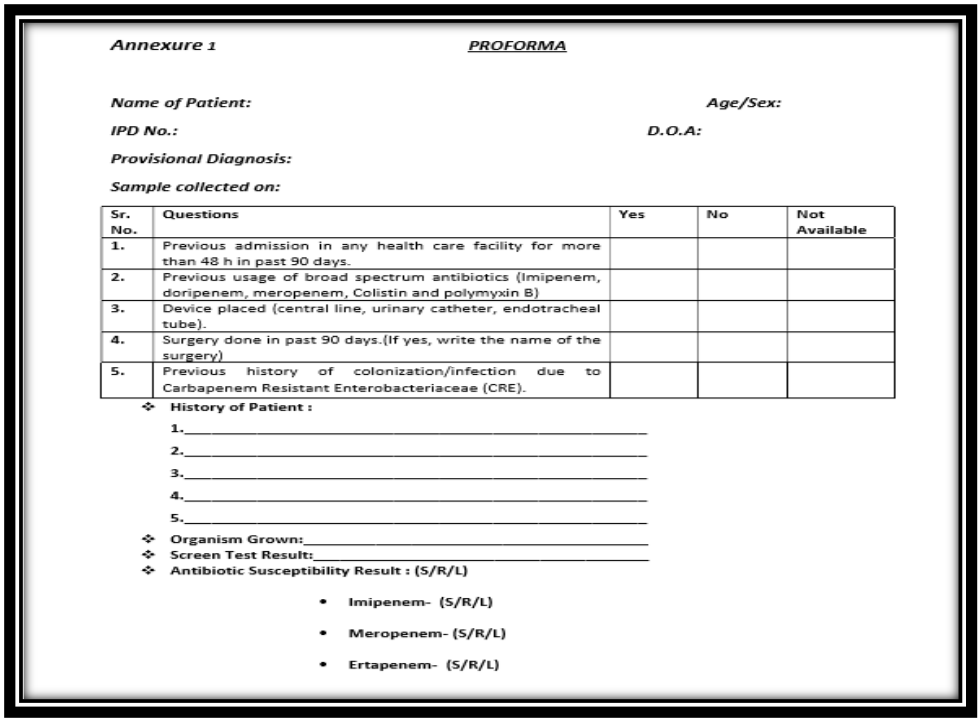
Table 2 presents the distribution of isolates among individuals with Carbapenem-Resistant Enterobacteriaceae (CRE) colonization, indicating the number and percentage distribution of each identified organism. Here's a descriptive interpretation of the results:

Escherichia coli:
- There were 26 isolates of Escherichia coli among individuals with CRE colonization.
- Escherichia coli constitutes the majority of the isolates, representing 70.27% of the total distribution.

Klebsiella pneumoniae:
- There were 7 isolates of Klebsiella pneumoniae among individuals with CRE colonization.
- Klebsiella pneumoniae accounts for 18.92% of the total distribution.

Enterobacter cloacae:
- There were 4 isolates of Enterobacter cloacae among individuals with CRE colonization.
- Enterobacter cloacae makes up 10.81% of the total distribution.

In summary, Escherichia coli is the most prevalent organism among CRE isolates, comprising the majority of cases at 70.27%. Klebsiella pneumoniae and Enterobacter cloacae are also identified but to a lesser extent, constituting 18.92% and 10.81% of the isolates, respectively. These findings provide valuable insights into the specific organisms contributing to CRE colonization in the studied population.



Annexure 1 ***PROFORMA***

Name of Patient: ***Age/Sex:***

IPD No.: ***D.O.A:***

Provisional Diagnosis:

Sample collected on:

Sr. No.	Questions	Yes	No	Not Available
1.	Previous admission in any health care facility for more than 48 h in past 90 days.			
2.	Previous usage of broad spectrum antibiotics (Imipenem, doripenem, meropenem, Colistin and polymyxin B)			
3.	Device placed (central line, urinary catheter, endotracheal tube).			
4.	Surgery done in past 90 days.(If yes, write the name of the surgery)			
5.	Previous history of colonization/infection due to Carbapenem Resistant Enterobacteriaceae (CRE).			

- **History of Patient :**
  1. _____
  2. _____
  3. _____
  4. _____
  5. _____
- **Organism Grown:** _____
- **Screen Test Result:** _____
- **Antibiotic Susceptibility Result : (S/R/L)**
  - **Imipenem- (S/R/L)**
  - **Meropenem- (S/R/L)**
  - **Ertapenem- (S/R/L)**

Discussion:

Individuals colonized by multidrug-resistant (MDR) bacteria serve as crucial reservoirs, facilitating the horizontal transmission of these microorganisms within hospital environments. In healthcare settings lacking proper adherence to safety standards for hand hygiene, there is an increased risk of propagating resistant strains, posing a threat to human health with elevated chances of infection-related morbidity and mortality. Moreover, in underdeveloped countries, limited resources for surveillance screening of carbapenem-resistant Enterobacteriaceae (CRE) present an additional concern. These resource constraints delay the implementation of measures for the detection of resistant bacteria, hampering infection control and prevention efforts. Despite ongoing research, there remains no consensus in the literature regarding the optimal method for detecting CRE colonization. Nevertheless, rectal swabs have demonstrated sensitivity and good correlation in the screening process for active surveillance, establishing them as the primary method for such surveillance. Critically ill patients colonized with CRE face an increased susceptibility to developing invasive infections with broad resistance to available antibiotics. The severity of the disease varies based on factors such as the pathogen's virulence, the host's defense mechanisms, and exposure to medical procedures. This comprehensive overview highlights the interconnected challenges associated with MDR bacteria, emphasizing the importance of adherence to safety standards, the impact of limited resources on surveillance in underdeveloped regions, and the ongoing quest for effective methods, with rectal swabs emerging as a key tool in active surveillance for CRE colonization. The severity of infections in critically ill patients underscores the urgent need for robust infection control strategies and tailored medical interventions. Adler et al. demonstrated in their study that agar dilution using 1 µg/ml of

Carbapenem exhibited a sensitivity of 84.9%, specificity of 94.3%, and an overall accuracy of 92.1% for detection[13]. Therefore, we employed this methodology to identify CRE isolates. The data presented in Table 1 offers a comprehensive insight into the distribution of individual risk factos among individuals colonized with carbapenem-resistant Enterobacteriaceae (CRE) and those without CRE colonization. Stratified by gender, the table delineates noteworthy patterns and associations, shedding light on potential determinants of CRE colonization.In our study CRE colonization was detected in 12.7% patients during active surveillance by rectal swab. The CRE colonization rate in our study was very less as compared to study done by McConville et al. who detected colonization rate of 28%[1] but almost similar to study done by Banachet al.[4]For males, the observed prevalence of CRE colonization among 176 individuals reveals that 28 individuals were colonized while 148 were not. Notably, exposure to high-end antibiotics was discerned in 16 individuals with CRE colonization, contrasting with 68 individuals without CRE colonization. Transfer from other facilities also exhibited an association, with 11 individuals colonized with CRE compared to 41 without colonization. Additionally, a history of surgery in the past 90 days, endotracheal intubation, central line in situ, Foley's catheterization, and systemic infection demonstrated varying frequencies between individuals with and without CRE colonization. Similarly, for females, among 116 individuals, 9 had CRE colonization while 107 did not. High-end antibiotics exposure, transfer from other facilities, history of recent surgery, endotracheal intubation, central line in situ, Foley's catheterization, and systemic infection exhibited distinct patterns between females with and without CRE colonization. Patients who were exposed to high end antibiotic had significant association with CRE colonization which was similar to the study done Swaminathan et al.[12]In summary, Table 1 serves as a detailed breakdown of the distribution of specific risk factors, providing a gender-stratified perspective on CRE colonization. This analysis is crucial for understanding the nuanced interplay between individual characteristics and the likelihood of CRE colonization, offering valuable insights for future research and targeted intervention strategies. The predominant cause of CRE infections globally is attributed to K. pneumoniae, as documented by Tzouvelekis LS et al.[2]. Our study findings, as depicted in Table 2, align with this observation. These intestinal colonizers have the capacity to persist over an extended duration, serving as a reservoir for both endogenous infections and as a potential source for cross-transmission to other patients. The distribution of isolates, as outlined in Table 2, underscores the significance of Escherichia coli, Klebsiella pneumoniae, and Enterobacter cloacae in the context of Carbapenem-Resistant Enterobacteriaceae (CRE) colonization. In the context of a research article focusing on CRE screening through rectal swab as a tool for risk factor-based active surveillance, the following discussion points can be considered:

- Prevalence of Escherichia coli: The dominance of Escherichia coli in CRE isolates, comprising 70.27% of the cases, highlights its substantial presence in individuals undergoing screening. This finding emphasizes the importance of targeting Escherichia coli specifically in CRE surveillance efforts.
- Role of Klebsiella pneumoniae: Klebsiella pneumoniae, though representing a smaller proportion at 18.92%, remains a noteworthy contributor to CRE colonization. Understanding its prevalence is crucial for tailoring surveillance strategies, especially given the clinical significance of Klebsiella pneumoniae in healthcare-associated infections.
- Significance of Enterobacter cloacae: Enterobacter cloacae, while constituting a smaller fraction at 10.81%, should not be overlooked. Its presence underscores the diverse nature of CRE isolates and reinforces the need for comprehensive screening methods that encompass various Enterobacteriaceae species.

Implications for Risk Factor-Based Active Surveillance: The identified distribution of CRE isolates informs the design and implementation of risk factor-based active surveillance, particularly when employing rectal swabs. Tailoring surveillance efforts based on the prevalence of specific organisms, such as Escherichia coli, can enhance the sensitivity and specificity of CRE detection.

Clinical Relevance: The prevalence of Escherichia coli, Klebsiella pneumoniae, and Enterobacter cloacae in CRE colonization has direct clinical implications. Understanding the distribution of these organisms aids in developing targeted interventions for infection prevention and control, including the judicious use of antibiotics and the implementation of measures to limit cross-transmission.

Tailoring Intervention Strategies: Tailoring intervention strategies based on the specific organisms identified in CRE colonization is imperative. Escherichia coli, being the major contributor, may necessitate targeted infection control measures. Simultaneously, understanding the presence of other organisms informs a more nuanced approach to CRE prevention and containment, considering the unique characteristics and resistance patterns of each species.

Limitations and Future Directions: Acknowledging the limitations of the study, such as potential biases in sampling or regional variations, is essential. Additionally, further research could explore the molecular characteristics and resistance profiles of these isolates to better inform treatment strategies and

infection control measures. Our study is subject to certain limitations that warrant acknowledgment. Firstly, the screening for Carbapenem-Resistant Enterobacteriaceae (CRE) via rectal swabs was conducted exclusively at the time of admission and was not repeated subsequently. This temporal limitation may impact our ability to capture the evolving dynamics of CRE colonization over time. Additionally, the study did not delve into the specific mechanisms underpinning resistance in CRE, and clonality assessments were not conducted to ascertain whether bacteremia attributed to CRE was solely a consequence of colonization. Nevertheless, the use of phenotypic methods was implemented for the reliable detection of CRE. The follow-up duration was confined to the current admission in the Intensive Care Unit (ICU), precluding an evaluation of CRE acquisition or loss of colonization during subsequent visits. This limitation becomes particularly relevant if the same patient was readmitted to the ICU from other units within the hospital. Several practical challenges were encountered, such as the turnaround time of surveillance reports, which may have implications for timely intervention. Additionally, uncertainties exist concerning the optimal duration of isolation for individuals colonized by CRE. The availability of dedicated beds for isolation in the ICU also posed a challenge, potentially impacting patient management and infection control measures. Surveillance culture reports were not disclosed to the treating physicians during the culture process, thus lacking an immediate impact on clinical decision-making, such as the initiation of isolation precautions or adjustments in antibiotic management. While guidelines recommend initiating contact isolation simultaneously with sample processing, we deemed this measure not cost-effective at the time. Nonetheless, it's noteworthy that there were no reported outbreaks during the study period. In conclusion, while our study provides valuable insights into CRE colonization in the ICU, these limitations underscore the importance of future research endeavors to address gaps in understanding the dynamics of CRE, unravel resistance mechanisms, and navigate the practical challenges associated with surveillance and isolation protocols. In corollary, the distribution of CRE isolates among individuals undergoing rectal swab screening reveals the prevalence of specific organisms. This information is crucial for refining risk factor-based active surveillance strategies and implementing targeted interventions to mitigate CRE colonization in healthcare settings. The study findings contribute valuable insights to the broader conversation on effective CRE screening and surveillance approaches. The advantages of active surveillance lie in its capacity to shield susceptible patients from the potentially severe consequences of Carbapenem-Resistant Enterobacteriaceae (CRE) infection.

Conclusion:

In conclusion, the early detection of Carbapenem-Resistant Enterobacteriaceae (CRE) colonization through screening tests has proven to be a crucial tool in the effort to control the spread of CRE. Nevertheless, despite years of observation, there has been limited success in effectively controlling both colonization and infection rates. The prevalence of CRE colonization and colonization-related infections has remained high, accompanied by elevated mortality rates. Therefore, it is evident that while an active CRE surveillance protocol is indispensable, its impact relies heavily on the successful implementation of preventive measures and the establishment of effective communication and feedback mechanisms among team members.

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Methodology: Dr. Rajdeep Paul, Dr. Saurabh G Agarwal & Dr. Kuldeep Singh

Writing- Original Draft: Dr. Rajdeep Paul

Writing- review & editing: Dr. Saurabh G Agarwal

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References:

1. McConville T. H., Sullivan S. B., Gomez-Simmonds A., Whittier S., Uhlemann A. C. (2017). Carbapenem-resistant Enterobacteriaceae colonization (CRE) and subsequent risk of infection and 90-day mortality in critically ill patients, an observational study. PLoS ONE 12:e0186195. 10.1371/journal.pone.0186195.
2. Tzouvelekis LS, Markogiannakis A, Psichogiou M, Tassios PT, Daikos GL. Carbapenemases in Klebsiella pneumoniae and other Enterobacteriaceae: an evolving crisis of global dimensions. ClinMicrobiol Rev. 2012;25(4):682–707. Epub 2012/10/05. doi: 10.1128/CMR.05035-11.
3. Gomez-Simmonds A, Hu Y, Sullivan SB, Wang Z, Whittier S, UhlemannAC. Evidence from a New York City hospital of rising incidence of genetically diverse carbapenemresistant Enterobacter cloacaeand dominance of ST171, 2007–14. J AntimicrobChemother. 2016. doi: 10.1093/jac/dkw132 ; PubMed Central PMCID: PMCPMC4954924.
4. Banach DB, Francois J, Blash S, Patel G, Jenkins SG, LaBombardi V, et al. Active surveillance for carbapenem-resistant Enterobacteriaceae using stool specimens submitted for testing for Clostridium difficile.Infect Control Hosp Epidemiol 2014;35:82-4.
5. Schwaber MJ, Klarfeld-Lidji S, Navon-Venezia S, Schwartz D, Leavitt A, Carmeli Y. Predictors of carbapenem-resistant Klebsiella pneumoniae acquisition among hospitalized adults and effect of

acquisition on mortality. Antimicrob Agents Chemother. 2008;52:1028– 33.
6. Borer A, Saidel-Odes L, Riesenberg K, Eskira S, Peled N, Nativ R, et al. Attributable mortality rate for carbapenem-resistant Klebsiella pneumoniae bacteremia. Infect ControlHospEpidemiol. 2009;30:972–6.
7. Bonten MJ, Weinstein RA. The role of colonization in the pathogenesis of nosocomial infections. Infect Control HospEpidemiol. 1996;17:193–200.
8. Guidelines for the Prevention and Control of Carbapenem-Resistant Enterobacteriaceae, Acinetobacter baumannii and Pseudomonas aeruginosa in Health Care Facilities. Geneva: World Health Organization; 2017. 1, Background. Available from: https://www.ncbi.nlm.nih.gov/books/NBK493062/
9. Ramanathan YV, Venkatasubramanian R, Nambi P S, Ramabathiran M, Venkataraman R, Thirunarayan M A, Samundeeswari P, Ramakrishnan N. Carbapenem-resistant enterobacteriaceae screening: A core infection control measure for critical care unit in India? Indian J Med Microbiol 2018;36:572-6.
10. CLSI. Performance standards for antimicrobial susceptibility testing. Clinical and Laboratory Standards Institute. Twenty-ninth informational supplement, Clinical and Laboratory Standards Institute, Wayne, PA, 2019, M100–S292019.
11. A. Lerner, J. Romano, I. Chmelnitsky, S. Navon-Venezia, R. Edgar, Y. CarmeliAntimicrobial Agents and Chemotherapy Feb 2013, 57 (3) 1474-1479; DOI: 10.1128/AAC.01275-12
12. Swaminathan M, Sharma S, PolianskyBlash S, Patel G, Banach DB, Phillips M, et al. Prevalence and risk factors for acquisition of carbapenem-resistant enterobacteriaceae in the setting of endemicity. Infect Control Hosp Epidemiol 2013;34:809-17.
13. Adler A, Navon-Venezia S, Moran-Gilad J, Marcos E, Schwartz D, Carmeli Y, et al. Laboratory and clinical evaluation of screening agarplates for detection of carbapenem-resistant enterobacteriaceae from surveillance rectal swabs. J Clin Microbiol2011;49:2239-42.