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PREVALENCE OF ESBL-PRODUCING ESCHERICHIA COLI AMONG FOOD HANDLERS AND HOUSEHOLD CONTACTS IN URBAN SETTINGS

Original Article

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Short Title: ESBL-Producing E. coli Carriage in Urban Communities

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Abstract

Background: Extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* has emerged as a major public health concern, extending beyond hospital environments into community settings. Food handlers and household contacts represent potential reservoirs for resistant organisms, yet data on their colonization in urban areas remain limited.

Objective: To estimate the prevalence of ESBL-producing *E. coli* carriage among food handlers and their household contacts in an urban setting, and to examine its associations with recent antibiotic use, hygiene practices, and recent gastrointestinal illness.

Methods: A cross-sectional study was conducted in Lahore over four months. A total of 320 participants (160 food handlers and 160 household contacts) were enrolled. Stool specimens were collected and processed using standard microbiological techniques, and ESBL production was confirmed following CLSI guidelines. A structured questionnaire assessed sociodemographic information, antibiotic use in the past three months, hygiene practices, and recent gastrointestinal illness. Data were analyzed using SPSS version 26, with logistic regression performed to estimate adjusted odds ratios (AORs).

Results: Overall prevalence of ESBL-producing *E. coli* was 32.5%, with food handlers showing a slightly higher prevalence (35.6%) compared to household contacts (29.4%). Recent antibiotic use was strongly associated with carriage (AOR 3.21, 95% CI: 1.86–5.52), as were poor hygiene practices (AOR 2.48, 95% CI: 1.39–4.43) and gastrointestinal illness within the past month (AOR 1.87, 95% CI: 1.04–3.37). Carriage was inversely associated with higher educational level but not with sex or age.

Conclusion: ESBL-producing *E. coli* carriage was common among both food handlers and household contacts, with prevalence exceeding 30%. Antibiotic misuse, poor hygiene, and gastrointestinal illness emerged as key modifiable risk factors. Community-level interventions focusing on antibiotic stewardship and hygiene education are essential to reduce the burden and transmission of resistance.

Keywords: Antibiotic Stewardship, Community-Acquired Infections, Escherichia coli, Extended-Spectrum Beta-Lactamases, Food Handlers, Gastrointestinal Diseases, Hygiene, Microbial Drug Resistance.

Introduction

Escherichia coli (E. coli) is a commensal organism that resides in the human gastrointestinal tract but is also a leading cause of enteric and extraintestinal infections worldwide (1). Over the past few decades, the global medical community has witnessed a concerning rise in antibiotic-resistant strains of E. coli, particularly those producing extended-spectrum beta-lactamases (ESBLs) (2). ESBL enzymes confer resistance to third-generation cephalosporins and related beta-lactam antibiotics, agents that have traditionally been relied upon for the treatment of severe infections (3). The emergence and dissemination of ESBL-producing E. coli pose a significant public health challenge, especially in low- and middle-income countries where surveillance systems are limited, antibiotic use is often unregulated, and opportunities for bacterial transmission in community settings are high (4). Food handlers represent a crucial group in the epidemiology of antimicrobial resistance due to their potential role in transmitting resistant organisms through direct contact with food and surfaces (5). In many urban areas, large populations rely on ready-to-eat meals prepared by food vendors, and lapses in hygiene or handwashing practices can facilitate bacterial spread. Similarly, household contacts play a critical role in sustaining the cycle of colonization and transmission (6). Within households, close interactions, shared environments, and common food sources can contribute to the unnoticed circulation of ESBL-producing E. coli (7). Despite the growing recognition of these risks, much of the available literature focuses on hospital-based surveillance or patient populations, leaving a substantial knowledge gap regarding community-level carriage among asymptomatic individuals who serve as potential reservoirs. A growing body of evidence suggests that the prevalence of ESBL-producing organisms in the community may be underappreciated (8). Studies from South and Southeast Asia, for instance, have documented alarmingly high colonization rates among healthy individuals, with prevalence estimates often surpassing 30%. Similar findings have been reported in Africa and Latin America, underscoring that antimicrobial resistance is no longer confined to clinical settings but has firmly established itself in the broader community (9). The situation is particularly pressing in densely populated urban environments, where population mobility, overcrowding, and inadequate sanitation can facilitate rapid dissemination. These realities necessitate a closer examination of community-level carriers, particularly those whose roles or living arrangements heighten the risk of bacterial transmission.

Antibiotic consumption is a well-documented driver of resistance, with recent or inappropriate use increasing the likelihood of harboring resistant strains. In many urban settings, antibiotics are easily accessible without prescription, and self-medication practices are widespread. This overuse and misuse accelerate the selection pressure for resistant organisms, particularly ESBL producers (10). Hygiene practices, another important determinant, can either mitigate or exacerbate this risk. Poor adherence to hand hygiene, unsafe food handling, and inadequate sanitation create opportunities for resistant bacteria to spread among food handlers, their customers, and household contacts. Additionally, recent episodes of gastrointestinal illness may disrupt the gut microbiota, providing a more favorable environment for colonization by resistant organisms. Each of these factors highlights the interconnected nature of antibiotic use, hygiene behavior, and microbial carriage. Despite the magnitude of the problem, relatively little attention has been given to understanding the burden of ESBL-producing E. coli in healthy food handlers and their households in urban settings. Most available studies have prioritized clinical isolates, while asymptomatic carriers remain understudied (11). This represents a missed opportunity to understand the silent community reservoirs that contribute to the persistence and transmission of antimicrobial resistance. Without identifying these reservoirs, interventions to curb resistance risk being incomplete or misdirected. Furthermore, urban food environments represent dynamic systems where bacteria may spread not only between handlers and consumers but also into households, perpetuating a cycle of colonization that sustains resistance within the population.

The rationale for the present study is therefore rooted in this urgent public health need. By investigating the prevalence of ESBL-producing E. coli carriage among food handlers and their household contacts, valuable insights can be gained into the extent of community colonization and the factors that drive it. This research specifically explores the association between carriage and recent antibiotic use, hygiene practices, and episodes of gastrointestinal illness, as these represent modifiable risk factors that may be targeted by public health interventions. Understanding these associations is critical in designing preventive strategies that extend beyond clinical management to encompass community-level interventions, including antibiotic stewardship, food safety education, and household hygiene promotion. In summary, the rise of ESBL-producing E. coli underscores a global health crisis that transcends hospital boundaries and extends into the everyday lives of communities. Food handlers and their households are pivotal in this transmission chain but remain insufficiently studied in urban environments (12). This study seeks to address this gap by estimating

the prevalence of ESBL-producing E. coli among these populations and by examining how recent antibiotic use, hygiene behaviors, and gastrointestinal illness contribute to colonization. The objective is to generate evidence that not only quantifies the b urden but also informs context-specific strategies for breaking the cycle of resistance at its community source.

Methods

The study was conducted as a community-based cross-sectional survey in Lahore, Pakistan, over a period of four months. The research was designed to estimate the prevalence of ESBL-producing *Escherichia coli* carriage among food handlers and their household contacts, and to explore its associations with recent antibiotic use, hygiene practices, and recent gastrointestina l illness. A cross-sectional design was considered most appropriate as it allowed the assessment of both the prevalence of colonization and the relationship with selected exposures within a defined period of time in a large urban setting. Participants were recruited from food outlets, including street vendors, small restaurants, and household-based food sellers, as well as from the households of consenting food handlers. Eligibility criteria included individuals aged 18 years or older who were actively involved in food preparation or handling at the time of recruitment, and at least one consenting household member residing in the same home. Household members were eligible if they were over 10 years of age to ensure comprehension during the consent and interview process. Individuals currently admitted to hospital, those receiving long-term antibiotic prophylaxis, and those unwilling to provide a stool sample were excluded from the study. Sample size was calculated using the standard formula for prevalence studies, based on an expected community carriage prevalence of 25% for ESBL-producing *E. coli*, with a 95% confidence interval and a 5% margin of error. Applying these assumptions, the minimum required sample size was estimated at 288 participants. To account for potential non-response and incomplete data, the target was increased by 10%, resulting in a final planned recruitment of 320 participants. The sample was equally distributed between food handlers and their household contacts to allow meaningful subgroup comparisons. Data collection involved both biological sampling and structured interviews. Each participant was asked to provi de a fresh stool specimen collected in sterile containers under the supervision of trained field staff. Samples were transported in cold boxes to the microbiology laboratory within four hours of collection. Stool specimens were cultured on MacConkey agar supplemented with cefotaxime to screen for potential ESBL-producing organisms. Colonies suggestive of *E. coli* were identified using standard biochemical methods, and confirmation was performed with API 20E identification kits. ESBL production was confirmed using the double-disk synergy test with cefotaxime, ceftazidime, and clavulanic acid, following Clinical and Laboratory Standards Institute (CLSI) guidelines. All laboratory work was conducted under strict biosafety protocols to minimize contami nation or exposure risk.

Alongside specimen collection, participants completed a structured questionnaire administered by trained interviewers in the local language. The questionnaire captured sociodemographic information, recent antibiotic use within the past three months, self-reported hygiene practices including frequency of handwashing before food preparation and after toilet use, and any episode of gastrointestinal illness in the preceding month characterized by diarrhea, vomiting, or abdominal pain. The questionnaire was pretested on 20 individuals prior to the main study to ensure clarity and cultural appropriateness, and necessary revisions were incorporated. Outcome measurement focused on two domains. The primary outcome was stool carriage of ESBL-producing *E. coli*, expressed as prevalence among both food handlers and household contacts. Secondary outcomes included associations between carriage and three predefined exposures: recent antibiotic use, self-reported hygiene practices, and history of gastrointestinal illness. Antibiotic use was verified through recall and cross-checked where possible with prescriptions or packaging. Hygiene practices were categorized into high, moderate, or poor adherence based on frequency of handwashing in key situations. Gastrointestinal illness was recorded as a binary variable based on self-report. Data were entered into a secure electronic database and double-checked for accuracy. Statistical analyses were performed using SPSS version 26. Descriptive statistics were first calculated to summarize baseline characteristics of the participants, including means and standard deviations for continuous variables, and proportions for categorical variables. The prevalence of ESBL-producing *E. coli* was reported with 95% confidence intervals. To explore associations between carriage and the main exposures, chi-square tests were used for categorical variables, and independent t-tests were used for continuous variables. Since data followed a normal distribution, logistic regression was performed to estimate

adjusted odds ratios for the likelihood of ESBL carriage, controlling for potential confounders such as age, gender, and educational level. A p-value of less than 0.05 was considered statistically significant.

Ethical approval for the study was obtained from the Institutional Review Board of the University of Health Sciences, Lahore. Written informed consent was obtained from all adult participants, and for individuals aged 10–17 years, assent was obtained along with consent from parents or guardians. Confidentiality was maintained by assigning unique study identifiers and storing all data in password-protected files. Participants found to be colonized with ESBL-producing organisms were counseled about hygiene practices and advised to seek medical care if symptoms of infection developed. By integrating microbiological evidence with community-level behavioral data, the methods of this study were designed to yield robust insights into the prevalence of ESBL-producing *E. coli* and the modifiable risk factors contributing to its spread in urban households and food environments. The methodological rigor, including structured sampling, standardized laboratory confirmation, and appropriate statistical analysis, ensures that the study findings can be reliably interpreted and compared with future research.

Results

The study enrolled a total of 320 participants, including 160 food handlers and 160 household contacts, all of whom provided complete data and stool specimens for analysis. The mean age of participants was 34.7 ± 11.6 years, with a range from 12 to 65 years. Slightly more than half of the sample were male (52.5%), and the majority had received at least primary education. Household size averaged 6.2 ± 2.4 members, reflecting the dense living conditions in urban Lahore. Baseline sociodemographic characteristics are presented in Table 1. Stool culture results revealed that 104 participants (32.5%) were colonized with *Escherichia coli* producing extended-spectrum beta-lactamases (ESBL). Prevalence among food handlers was 35.6% (57/160), compared to 29.4% (47/160) among household contacts. The difference was not statistically significant ($p = 0.18$). The majority of isolates demonstrated resistance to cefotaxime and ceftazidime, while sensitivity to carbapenems was preserved in all confirmed isolates.

Analysis of risk factors demonstrated that recent antibiotic use within the preceding three months was reported by 91 participants (28.4%). Of these, 54.9% carried ESBL-producing *E. coli*, compared to 23.0% among those without recent antibiotic exposure. This difference was highly significant ($p < 0.001$), and the unadjusted odds ratio indicated more than a threefold higher likelihood of carriage among recent antibiotic users. Hygiene practices varied, with 41.3% of participants reporting high adherence, 36.6% moderate adherence, and 22.1% poor adherence. ESBL carriage was most prevalent among those with poor hygiene practices (48.6%), followed by moderate (30.5%), and least among those with high adherence (21.4%) ($p < 0.001$). Gastrointestinal illness within the past month was reported by 67 individuals (20.9%), and the prevalence of ESBL carriage in this group was 46.3% compared to 28.1% among those without illness ($p = 0.01$). Multivariable logistic regression demonstrated that recent antibiotic use, poor hygiene adherence, and gastrointestinal illness remained independently associated with ESBL carriage after adjusting for age, gender, and education. Recent antibiotic use had an adjusted odds ratio (AOR) of 3.21 (95% CI: 1.86–5.52), poor hygiene practices an AOR of 2.48 (95% CI: 1.39–4.43), and gastrointestinal illness an AOR of 1.87 (95% CI: 1.04–3.37).

The overall prevalence of ESBL-producing *E. coli* was comparable across males (33.9%) and females (31.0%) ($p = 0.61$). Age did not significantly influence carriage, though slightly higher prevalence was observed in the younger age group (18–30 years, 36.1%) compared to older adults (>50 years, 27.3%). Educational level showed a protective gradient, with the lowest prevalence among those with tertiary education (20.8%) compared to those without formal education (41.7%). The findings clearly demonstrated that carriage of ESBL-producing *E. coli* was common among both food handlers and their household contacts in Lahore, with prevalence exceeding 30%. Antibiotic use, hygiene behavior, and gastrointestinal illness were consistently and strongly associated with carriage, highlighting these as important exposures of interest. Tables 2 to 4 and Figures 1 and 2 summarize the key outcome data.

Table 1: Demographic and baseline characteristics of participants (n=320)

Variable	*Food Handlers (n=160)*	*Household Contacts (n=160)*	*Total (n=320)*
Mean age (years ± SD)	35.2 ± 10.8	34.1 ± 12.4	34.7 ± 11.6
Male sex (%)	88 (55.0)	80 (50.0)	168 (52.5)
Primary education or more (%)	126 (78.8)	118 (73.8)	244 (76.3)
Mean household size	6.1 ± 2.3	6.4 ± 2.5	6.2 ± 2.4

Table 2: Prevalence of ESBL-producing *E. coli*

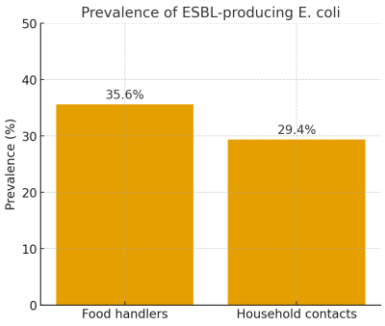
Group	*Carriers n (%)*	*Non-carriers n (%)*	*p-value*
Food handlers (n=160)	57 (35.6)	103 (64.4)	0.18
Household contacts (n=160)	47 (29.4)	113 (70.6)	
Total (n=320)	104 (32.5)	216 (67.5)	

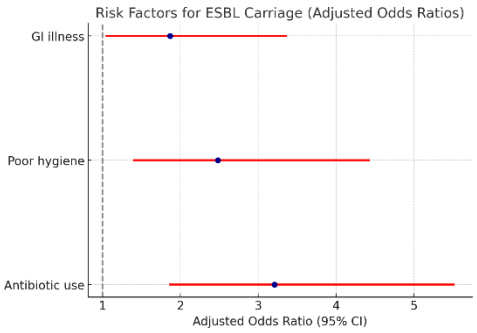
Table 3: ESBL carriage by recent antibiotic use and hygiene practices

Variable	*Carriers n (%)*	*Non-carriers n (%)*	*p-value*
Antibiotic use (n=91)	50 (54.9)	41 (45.1)	<0.001
No antibiotic use (n=229)	54 (23.6)	175 (76.4)	
High hygiene adherence (n=132)	28 (21.2)	104 (78.8)	<0.001
Moderate hygiene (n=117)	36 (30.8)	81 (69.2)	
Poor hygiene (n=71)	34 (47.9)	37 (52.1)	

Table 4: ESBL carriage by gastrointestinal illness (n=320)

V ariable	*Carriers n (%)*	*Non-carriers n (%)*	*p-value*
Gastrointestinal illness (n=67)	31 (46.3)	36 (53.7)	0.01
No illness (n=253)	71 (28.1)	182 (71.9)	





Discussion

The present study demonstrated that colonization with ESBL-producing *Escherichia coli* was common among both food handlers and their household contacts in an urban setting, with overall prevalence exceeding 30%. This finding highlights that antimicrobial resistance has extended well beyond hospital walls and is firmly entrenched in community environments (13). The observation that recent antibiotic use, poor hygiene practices, and recent gastrointestinal illness were independently associated with carriage emphasizes the multifactorial drivers of resistance spread in the population (14). The prevalence reported here aligns with estimates from South and Southeast Asia, where community carriage rates have been documented between 20% and 40% (15). Comparable studies from India and Bangladesh reported prevalence exceeding 30%, particularly among healthy individuals in urban areas. In Africa, prevalence estimates have ranged more widely, though similarly elevated figures have been noted in Nigeria and Ethiopia (16). The current results therefore confirm the global recognition that ESBL-producing organisms are no longer confined to healthcare-associated infections but circulate widely among asymptomatic carriers in the community (17). That the prevalence among food handlers was slightly higher than among household contacts suggests occupational exposure and food-handling practices may contribute to increased risk, though both groups demonstrated substantial carriage rates (18). The association with recent antibiotic use was both strong and statistically significant, consistent with well-established evidence that antibiotic exposure promotes selection and persistence of resistant organisms in the gut. The threefold increased odds of carriage among recent antibiotic users observed in this study mirrors findings from international cohorts, where inappropriate or repeated antibiotic consumption has consistently emerged as a critical determinant of resistance (19). This highlights the urgent need for robust community-level antibiotic stewardship interventions, particularly in settings where antibiotics remain easily accessible without prescription (20). Hygiene behavior was also a significant predictor of carriage, with poor adherence nearly doubling the likelihood of colonization compared with high adherence. This finding supports the widely acknowledged role of hygiene in preventing both foodborne transmission and interpersonal spread of resistant organisms. Previous research in community food environments has emphasized that lapses in hand hygiene among food handlers create opportunities for resistant bacteria to contaminate prepared food, thereby reaching wider populations (21). The current study strengthens this argument by demonstrating a direct link between self-reported hygiene practices and carriage status.

The observation that gastrointestinal illness was associated with increased prevalence of ESBL carriage provides an additional layer of understanding. Disturbances in the intestinal microbiota during diarrheal episodes may create conditions conducive to colonization by resistant organisms (22). Although causality cannot be established in a cross-sectional design, the association underlines the importance of considering gastrointestinal health when examining resistance dynamics in the community. The implications of these findings are substantial. Food handlers occupy a central position in urban food systems, and colonization with resistant organisms poses potential risks for wider dissemination through prepared meals and kitchen environments. The presence of colonization among household contacts further illustrates that resistance is sustained within family units, creating silent reservoirs that may complicate infection control. The study highlights the necessity of integrated interventions that address not only clinical management but also food safety education, community awareness of hygiene, and rational antibiotic use. A key strength of this research lies in its combined approach, integrating microbiological confirmation with behavioral and epidemiological data. This

dual perspective allows for a more comprehensive understanding of how resistant organisms circulate within the community and the factors that sustain them. The inclusion of both food handlers and household contacts provides comparative insights into occupational and domestic risk factors, an area rarely addressed in previous studies. Laboratory confirmation using standardized methods further strengthens the validity of the microbiological findings.

Nonetheless, certain limitations must be acknowledged. The cross-sectional design precludes causal inference, and associations between exposures and carriage must be interpreted cautiously. Self-reported data on antibiotic use and hygiene practices may have been subject to recall or social desirability bias, potentially underestimating the strength of associations. The study was limited to one urban center, and while Lahore provides a representative urban environment, results may not be generalizable to rural or peri-urban settings. Additionally, molecular characterization of the ESBL genes was not performed, which would have provided deeper insights into the specific resistance mechanisms circulating in the community. Despite these limitations, the study adds to the growing body of evidence that antimicrobial resistance in *E. coli* is an entrenched problem in community settings. By identifying modifiable factors such as antibiotic use and hygiene, it provides actionable evidence for policymakers and public health practitioners. Future research should build on these findings by incorporating longitudinal designs to explore causal pathways, expanding geographic coverage to capture rural and semi-urban contexts, and integrating molecular epidemiology to better track transmission dynamics. Intervention studies focusing on hygiene promotion among food handlers and stewardship programs at the community level would also be valuable in testing practical strategies to curb the spread of resistance.

Conclusion

This study demonstrated a high prevalence of ESBL-producing *E. coli* among food handlers and their household contacts in Lahore, with significant associations identified for antibiotic use, hygiene behavior, and gastrointestinal illness. The findings underline the importance of antibiotic stewardship and hygiene interventions in the community to interrupt the cycle of resistance. Addressing these modifiable risk factors is essential for limiting the spread of resistant organisms in both food environments and households.

AUTHOR CONTRIBUTIONS

Author	Contribution
Shabeer Haider****	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Murtaza Khodadadi	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published

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