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Original Research Article

Point-Prevalence, Antibiotic Resistance Profiles and Associated Risk Factors of Uropathogenic Bacteria in Kibra, an Informal Settlement of Nairobi City County, Kenya

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Abstract: ***Background*:** Urinary tract infections (UTIs) are common bacterial infections, and rising antimicrobial resistance threatens effective treatment in resource-limited settings. ***Objective*:** This study determined the prevalence, antimicrobial resistance profiles, and risk factors associated with uropathogenic bacteria among residents of Kibra informal settlement, Nairobi. ***Methods*:** A cross-sectional mixed-methods study was conducted in Kibra informal settlement and the microbiology laboratory of a tertiary county hospital between November 2025 and February 2026. A total of 607 urine specimens were collected from symptomatic residents and processed using standard microbiological techniques. Antimicrobial susceptibility testing was performed according to Clinical and Laboratory Standards Institute (CLSI) 2023 guidelines. Additionally, 100 household respondents completed structured questionnaires on antibiotic-use practices, while 50 participants took part in focus group discussions exploring health-seeking behaviour, antibiotic acquisition and use, disposal practices, and barriers to appropriate antibiotic use. Quantitative data were analysed descriptively and inferentially, while qualitative data underwent thematic analysis. ***Results*:** Of 607 specimens, 150 (24.7%; 95% confidence interval 21.4–28.3) grew a bacterial uropathogen. *Escherichia coli* predominated (57.3%). Resistance was highest to ampicillin (92.0%), ceftriaxone (81.8%) and trimethoprim-sulfamethoxazole (74.7%), and lowest to nitrofurantoin (8.4%), amikacin (1.5%) and meropenem (0.0%). Multidrug resistance was 84.7% (127/150); 83.3% (90/108) of isolates from species in which screening is interpretable showed a phenotype consistent with extended-spectrum β-lactamase production. Among 100 respondents, 84.0% took an antibiotic for their last episode, 49.0% bought it without prescription and 42.0% completed the course. No socio-demographic factor was significantly associated with inappropriate antibiotic use (88.0%). Focus groups identified informal drug outlets and cost as drivers. ***Conclusion*:** One in four specimens from symptomatic Kibra residents grew a bacterial uropathogen, with high multidrug resistance. Ampicillin, trimethoprim-sulfamethoxazole and third-generation cephalosporins are unsuitable for empirical treatment; nitrofurantoin remained active. Enforcement of prescription-only dispensing, community stewardship education, point-of-care testing and local antibiogram surveillance are needed.

Keywords: Urinary Tract Infection, Point Prevalence, Antimicrobial Resistance, Uropathogens, Informal Settlement, Kenya.

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INTRODUCTION

Urinary tract infections (UTIs) are among the most common bacterial infections worldwide, affecting an estimated 150 million people each year [1]. Uropathogenic *Escherichia coli* is the leading cause, followed by *Klebsiella*, *Proteus*, *Enterobacter* and *Staphylococcus* species [1]. In low- and middle-income countries urine culture is seldom available at the point of care, so UTIs are treated empirically and treatment success depends on local patterns of antimicrobial resistance (AMR). AMR was associated with an estimated 4.95 million deaths worldwide in 2019 [2].

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In Kenya, studies in health facilities show high resistance to commonly used UTI drugs. Among 1027 uropathogens from patients with UTI symptoms, 64% were resistant to trimethoprim and 66% were multidrug resistant (MDR) [3]. A wider East African analysis also found MDR bacteria to predominate among symptomatic patients [4], although the proportion of MDR UTIs at Kenyan sites (33%) was lower than in Tanzania and Uganda [5].

Community antibiotic practices may add to this problem. Self-medication and dispensing of antibiotics without prescription are widespread in developing countries [6, 7]. In informal settlements in Kisumu, 43% of households reported antibiotic use [8].

Kibra (also spelt Kibera) is one of the largest informal settlements in Africa, with high population density, poor sanitation and limited access to formal healthcare [9]. In Kibra, 80% of presumptive *E. coli* from stool were resistant to three or more antibiotic classes, yet antibiotic use explained little of this carriage, which was associated instead with environmental factors (9). Whether urinary isolates from symptomatic residents show a similar picture is unclear, and we are not aware of studies that combine culture-confirmed uropathogen data, resistance profiles and community antibiotic-use data from Kibra.

We therefore determined the point prevalence, antibiotic resistance profiles and risk factors of uropathogenic bacteria among residents of Kibra, and explored community antibiotic-use practices that may contribute to resistance.

MATERIALS AND METHODS

Study Design and Setting

This was a cross-sectional mixed-methods study with three components drawn from the same community but from separate samples: laboratory analysis of urine specimens from symptomatic Kibra residents, a structured household survey and focus group discussions (FGDs). The survey and FGDs were done in November and December 2025, and laboratory analysis between December 2025 and February 2026. Laboratory work was done at the microbiology laboratory of a tertiary county hospital, the main public referral facility serving Kibra.

Study Population and Sampling

Laboratory Component

We included urine specimens from symptomatic residents of Kibra (residence confirmed from the laboratory request form) that were submitted to the laboratory during the study period; 607 specimens were included. Patients on antibiotic therapy expected to interfere with culture and those too ill to provide a sample were excluded. Specimens were coded (KB-001 to KB-150 for bacterial isolates) and analysed anonymously.

Survey Component

Eligible respondents were residents aged 15 years or older who had lived in Kibra for at least six months and who reported symptoms of UTI or recent antibiotic use for UTI. Sampling was multi-stage: Kibra was purposively selected; households were chosen by systematic random sampling across the villages of Gatwekera, Laini Saba, Makina, Silanga and Kianda, using a frame developed with community health promoters and local administrative units; and one eligible person per household was invited to take part.

Qualitative Component

Five FGDs of ten participants each were purposively composed of women, men, young adults, community health volunteers and caregivers, and older residents and drug-shop attendants.

The minimum sample size from Cochran's formula, assuming an expected proportion of 50%, 95% confidence and 5% margin of error, was 607 (Population adjustment for design considerations and anticipated non-response was considered). Because of resource and time constraints, the survey (n=100) and the set of bacterial isolates (n=150) were smaller subsets derived from the specimens using available eligible participants and isolates that met the study inclusion criteria.

Data Collection

Trained research assistants fluent in English and Kiswahili administered a structured questionnaire face to face, recorded on tablets with Open Data Kit. It covered socio-demographic characteristics, health-seeking behaviour, antibiotic use, knowledge, attitudes and practices, and household water and sanitation. The questionnaire was pre-tested in Kariobangi, a community with socioeconomic, demographic, and healthcare access characteristics comparable to those of the study population. This ensured the suitability of the study tools for the target population. FGDs followed a guide on health-seeking behaviour, antibiotic acquisition and use, knowledge, disposal practices and barriers to appropriate use, were audio-recorded and were transcribed and anonymized.

Urine Culture and Identification

Mid-stream urine (10–20 mL) was collected in sterile screw-capped containers after instruction on hand washing and cleaning the genital area, and transported in cold boxes within 4–6 hours. A calibrated loop delivering 1 µL of uncentrifuged urine was streaked onto cystine lactose electrolyte-deficient (CLED) agar, with MacConkey and 5% sheep blood agar as supplementary

media, and incubated aerobically at 35–37 °C for 18–24 hours (48 hours before reporting no growth). Colonies were counted and multiplied by 1000 to give colony-forming units (CFU) per mL. A count of 10^5 CFU/mL or more of a single organism was taken as significant bacteriuria (10). Isolates were identified by Gram stain, conventional biochemical tests (11) and the VITEK 2 system (Gram-negative and Gram-positive cards; identifications of acceptable or better quality were accepted, the rest were confirmed with conventional tests). Yeasts, confirmed by Gram stain and the germ-tube test, were excluded from the bacterial analysis, as were specimens without a confirmed organism identification.

Antimicrobial Susceptibility Testing

Susceptibility was determined by Kirby-Bauer disk diffusion on Mueller-Hinton agar (12) and by VITEK 2 AST-N and AST-P cards, and interpreted with Clinical and Laboratory Standards Institute (CLSI) 2023 breakpoints (13). *E. coli* American Type Culture Collection (ATCC) 25922, *Pseudomonas aeruginosa* ATCC 27853 and *Staphylococcus aureus* ATCC 25923 were run with each batch. The antibiotic panel differed between isolates, so results are given as the number resistant over the number tested for each antibiotic, and untested isolates were not counted as susceptible. "Resistant" refers only to isolates classified resistant; intermediate results were reported separately and not counted as resistant. MDR was resistance to agents in three or more antibiotic classes (14). Among *E. coli*, *Klebsiella pneumoniae*, *K. oxytoca* and *Proteus mirabilis*, isolates resistant to all third-generation cephalosporins tested (cefotaxime, ceftazidime and ceftriaxone) but susceptible to meropenem were classed as presumptive extended-spectrum β-lactamase (ESBL) producers; cefoxitin resistance was used as a marker of possible AmpC production.

Outcome Definitions and Data Analysis

Point prevalence was the proportion of specimens from symptomatic Kibra residents that grew a bacterial uropathogen at significant count. Inappropriate antibiotic use was a composite outcome: not completing a course, obtaining an antibiotic from a pharmacy or drug seller without prescription, or having bought antibiotics without prescription two or more times. Analysis used Python (pandas, SciPy and statsmodels). Prevalence is presented with 95% confidence intervals (CIs, Wilson method). Survey data were summarised as frequencies, percentages and means; associations were tested with the chi-square test and the independent-samples t-test. Binary logistic regression with age, low education (none or primary), low household income (below 10 000 Kenya shillings (KES)) and sex as predictors was used for inappropriate antibiotic use. FGD transcripts were analysed thematically.

Ethical considerations

The study followed the Declaration of Helsinki. Approval was granted by the Kenyatta University Ethics Review Committee (PKU/3323/140329) and the National Commission for Science, Technology and Innovation (NACOSTI; license P/26/4190549) before any research activity. Written permission from the Director/Superintendent of the hospital where the laboratory work was done was obtained. All participants gave written informed consent; participants aged 15–17 years gave assent with written parental or guardian consent. Specimens and data carried study codes instead of personal identifiers.

RESULTS

Specimens and Point Prevalence

Of the 607 specimens, 150 (24.7%; 95% CI 21.4–28.3) grew a bacterial uropathogens, giving the point prevalence. A further 26 (4.3%) were culture-positive but excluded (nine *Candida* species, 14 unidentified-organism reports and three without confirmed identification), and 431 (71.0%) showed no significant growth or mixed growth or contamination (Table 1). The 150 patients had a mean age of 38.0 years (range 1–106); 98 (65.3%) were female, eight were younger than 15 years and 14 were 65 years or older.

Table 1: Culture outcomes of 607 urine specimens from symptomatic Kibra residents

Outcome	n	%	95% CI
Bacterial uropathogen (included in analysis)	150	24.7	21.4–28.3
Culture-positive but excluded	26	4.3	2.9–6.2
Candida species	9	1.5	0.8–2.8
Organism unidentified	14	2.3	1.4–3.8
Identification not confirmed	3	0.5	0.2–1.4
No significant growth, or mixed growth or contamination	431	71.0	67.3–74.5
Total	**607**	**100.0**	–

CI, confidence interval (Wilson). The first row is the point prevalence of culture-confirmed bacterial urinary tract infection. Specimens with no significant growth and those with mixed growth or contamination are reported together.

Distribution of Uropathogens

E. coli was the commonest isolate (86/150; 57.3%), followed by *K. pneumoniae* (15; 10.0%), *P. aeruginosa* (8; 5.3%) and *S. aureus* (7; 4.7%). Seventeen species were recovered in all (Table 2).

Table 2: Uropathogenic bacteria isolated and multidrug resistance by organism (n=150)

Organism	n	%	Multidrug resistant, n (%)
Escherichia coli	86	57.3	81 (94.2)
Klebsiella pneumoniae	15	10.0	13 (86.7)
Pseudomonas aeruginosa	8	5.3	4 (50.0)
Staphylococcus aureus	7	4.7	1 (14.3)
Enterococcus faecalis	5	3.3	3 (60.0)
Citrobacter freundii	5	3.3	5 (100.0)
Klebsiella oxytoca	5	3.3	4 (80.0)
Klebsiella aerogenes	5	3.3	5 (100.0)
Enterococcus faecium	3	2.0	3 (100.0)
Proteus mirabilis	2	1.3	2 (100.0)
Proteus vulgaris	2	1.3	2 (100.0)
Enterobacter cloacae complex	2	1.3	2 (100.0)
Other (five species, one isolate each) *	5	3.3	2 (40.0)
Total	**150**	**100.0**	**127 (84.7)**

Multidrug resistant, resistant to agents in three or more antibiotic classes. **Acinetobacter lwoffii*, *Acinetobacter haemolyticus*, *Staphylococcus saprophyticus*, *Proteus hauseri* and *Morganella morganii*.

Antibiotic Resistance

Among all isolates, resistance was highest to ampicillin (92.0%, 115/125), ceftriaxone (81.8%, 108/132), cefuroxime (80.3%), cefotaxime (79.3%), cefepime (79.1%), ceftazidime (76.7%), trimethoprim-sulfamethoxazole (74.7%, 74/99) and aztreonam (74.0%); ciprofloxacin resistance was 52.2% (70/134). Resistance was low to nitrofurantoin (8.4%, 8/95), amikacin (1.5%) and meropenem (0.0%) (Table 3). Six of the eight nitrofurantoin-resistant isolates were *Proteus* or *Morganella* species, which are intrinsically resistant; among the remaining 89 isolates tested, resistance was 2.2% (2/89). Gentamicin (11.0%), piperacillin-tazobactam (12.4%), cefoxitin (14.7%) and amoxicillin-clavulanic acid (17.6%) also retained activity.

E. coli was resistant to ampicillin in 96.5%, ceftriaxone in 93.0%, trimethoprim-sulfamethoxazole in 85.2% and ciprofloxacin in 58.1%, and was fully susceptible to nitrofurantoin and meropenem. *K. pneumoniae* showed a similar but less severe pattern (Table 4).

Table 3: Resistance of uropathogenic isolates to the antibiotics tested (n=150)

Antibiotic	Isolates tested	Resistant, n	Resistant, %
Ampicillin	125	115	92.0
Amoxicillin-clavulanic acid	85	15	17.6
Piperacillin-tazobactam	121	15	12.4
Cefuroxime	127	102	80.3
Cefoxitin	95	14	14.7
Cefotaxime	140	111	79.3
Ceftriaxone	132	108	81.8
Ceftazidime	133	102	76.7
Cefepime	134	106	79.1
Aztreonam	127	94	74.0
Meropenem	134	0	0.0
Gentamicin	145	16	11.0
Amikacin	134	2	1.5
Ciprofloxacin	134	70	52.2
Trimethoprim-sulfamethoxazole	99	74	74.7
Nitrofurantoin	95	8	8.4

Percentages use the number of isolates tested as denominator; untested isolates are not counted as susceptible. Pooled values include species with intrinsic resistance. Intermediate results were not counted as resistant.

Table 4: Resistance of *Escherichia coli* and *Klebsiella pneumoniae* to key antibiotics

Antibiotic	*E. coli* (n=86): resistant/tested (%)	*K. pneumoniae* (n=15): resistant/tested (%)
Ampicillin	82/85 (96.5)	13/15 (86.7)
Ceftriaxone	80/86 (93.0)	10/15 (66.7)
Trimethoprim-sulfamethoxazole	52/61 (85.2)	4/9 (44.4)
Ciprofloxacin	50/86 (58.1)	7/15 (46.7)
Gentamicin	9/86 (10.5)	0/14 (0.0)
Nitrofurantoin	0/61 (0.0)	0/9 (0.0)
Meropenem	0/86 (0.0)	0/15 (0.0)

The number tested varied by antibiotic because the panel was not uniform across isolates.

Multidrug Resistance and Presumptive ESBL Production

Overall, 127 of 150 isolates (84.7%; 95% CI 78.0–89.6) were MDR, a figure that includes resistance phenotypes intrinsic to some species. MDR was near-universal among Enterobacterales (*E. coli* 94.2%; *K. aerogenes*, *Citrobacter freundii*, *Proteus* species and *Enterobacter cloacae* complex 100.0%) and lowest in *S. aureus* (14.3%) (Table 2). Among the 108 isolates of the four species in which the ESBL screen is interpretable, 90 (83.3%) met the presumptive definition, including 77 of 86 *E. coli* (89.5%) and 10 of 15 *K. pneumoniae* (66.7%) (Table 5). Cefoxitin resistance was infrequent (14.7%), which is more consistent with ESBL production than with AmpC hyperproduction; the phenotype remains presumptive.

Table 5: Presumptive extended-spectrum β-lactamase (ESBL) phenotype by species

Species	Isolates	ESBL phenotype, n	%
Escherichia coli	86	77	89.5
Klebsiella pneumoniae	15	10	66.7
Klebsiella oxytoca	5	3	60.0
Proteus mirabilis	2	0	0.0
Total (species in which the screen is interpretable)	**108**	**90**	**83.3**

Resistant to cefotaxime, ceftazidime and ceftriaxone and susceptible to meropenem. The phenotype is presumptive; no confirmatory testing or gene detection was done.

Community Antibiotic Use

The 100 survey respondents had a mean age of 30.9 years (standard deviation 9.8; range 15–62) and 62.0% were female; 53.0% reported a household income below KES 10 000 and 45.0% had no education beyond primary level (Table 6). Three-quarters (75.0%) reported UTI-like symptoms in the previous 12 months. Of these, 53.0% first sought care at a pharmacy or drug shop, and a diagnostic urine test had been done in only 31.0%. Most respondents (84.0%) took an antibiotic for their most recent episode: 49.0% bought it from a pharmacy or drug seller without prescription, 27.0% had a prescription, 17.0% received it from friends or family and 7.0% used leftover tablets. Only 42.0% reported completing the course; 69.0% of those who stopped early cited symptom improvement and 19.0% cited lack of money. Antibiotics had been bought without prescription more than once by 64.0%, and 75.0% kept leftover antibiotics at least occasionally.

Knowledge was mixed: 59.0% knew that antibiotics act on bacterial infections, 39.0% wrongly believed they act on viral infections, and 40.0% thought it safe to stop once symptoms improved. Leftover antibiotics were mostly thrown in household rubbish (53.0%) or flushed down the toilet (18.0%); 33.0% had shared antibiotics. Only 39.0% of households had piped water and 74.0% used pit latrines (Table 7).

Table 6: Characteristics and antibiotic-use practices of survey respondents (n=100)

Characteristic	Category	n (%)
Sex	Female	62 (62.0)
	Male	38 (38.0)
Education	None / primary	9 (9.0) / 36 (36.0)
	Secondary / tertiary	37 (37.0) / 18 (18.0)
Monthly household income (KES)	<10 000	53 (53.0)
	10 000–25 000	24 (24.0)
	25 000–50 000 / >50 000	14 (14.0) / 5 (5.0)
UTI-like symptoms in past 12 months	Yes	75 (75.0)

Characteristic	Category	n (%)
First source of care	Pharmacy or drug shop	53 (53.0)
	Public clinic	22 (22.0)
	Private clinic	13 (13.0)
	Self-care at home / traditional healer	10 (10.0) / 2 (2.0)
Diagnostic urine test before treatment	Yes / no / do not know	31 (31.0) / 60 (60.0) / 9 (9.0)
Took antibiotic for most recent episode	Yes	84 (84.0)
Source of antibiotic	Bought without prescription	49 (49.0)
	Clinician's prescription	27 (27.0)
	Friend or family	17 (17.0)
	Leftover from previous illness	7 (7.0)
Completed full course	Yes / no / do not remember	42 (42.0) / 44 (44.0) / 14 (14.0)
Ever bought antibiotics without prescription	Never / once	18 (18.0) / 18 (18.0)
	2–5 times / more than 5 times	39 (39.0) / 25 (25.0)
Keeps leftover antibiotics	Never / occasionally	25 (25.0) / 35 (35.0)
	Often / always	29 (29.0) / 11 (11.0)

UTI, urinary tract infection; KES, Kenya shillings. Percentages are of the 100 respondents as recorded.

Table 7: Knowledge, disposal practices and household environment of survey respondents (n=100)

Item	Category	n (%)
Antibiotics are effective against bacterial infections	Yes / no / do not know	59 / 14 / 27
Antibiotics are effective against viral infections (incorrect belief)	Yes / no / do not know	39 / 43 / 18
Safe to stop antibiotics once symptoms improve	Yes / no / do not know	40 / 39 / 21
Perceived seriousness of antimicrobial resistance	Not / somewhat / very	21 / 43 / 36
Disposal of leftover antibiotics	Rubbish	53 (53.0)
	Keep for future use	23 (23.0)
	Flush down toilet	18 (18.0)
	Return to pharmacy	6 (6.0)
Shares antibiotics with family or friends	Yes	33 (33.0)
Main household water source	Vendor or kiosk	44 (44.0)
	Piped	39 (39.0)
	Borehole / river	16 (16.0) / 1 (1.0)
Sanitation	Pit latrine	74 (74.0)
	Flush toilet	24 (24.0)
	None or open defecation	2 (2.0)

Counts of 100 respondents; percentages equal the counts.

Factors Associated with Inappropriate Antibiotic Use

Inappropriate use, by the composite definition, was reported by 88.0% of respondents. No predictor was significant (Table 8): low education showed a borderline association (odds ratio 3.00, P=0.181), as did age (1.06 per year, P=0.091), and the model as a whole was not significant (likelihood-ratio chi-square 2.89, P=0.217). Education and course completion (P=0.090), income and unprescribed purchase (P=0.484) and age and course completion (P=0.665) were also unrelated.

Table 8: Bivariate tests and logistic regression for inappropriate antibiotic use among survey respondents (n=100)

Association or predictor	Test statistic or odds ratio	95% CI	P
Bivariate tests			
Education × course completion	$\chi^2 = 10.95$ (df 6)	–	0.090
Household income × unprescribed purchase frequency	$\chi^2 = 11.53$ (df 9)	–	0.484
Age, completed versus not completed course	$t = -0.44$ (df 98)	–	0.665
Logistic regression (outcome in 88.0%)			
Low household income (below KES 10 000)	0.78	0.22–2.75	0.695
Low education (none or primary)	3.00	0.60–15.05	0.181
Age (per year)	1.06	0.99–1.14	0.091
Male sex	0.95	0.25–3.66	0.943

CI, confidence interval; df, degrees of freedom. Model: likelihood-ratio chi-square 2.89, P=0.217, pseudo-R^2 0.079. Confidence intervals were derived from the reported coefficients and P values.

Focus Group Discussions

Five themes emerged from the five FGDs (50 participants). First, participants relied on local chemists and unlicensed kiosks because formal facilities were seen as distant, slow and costly: "The clinic wants you to pay for a test first before they even give you medicine" (man, 41 years). Second, cost drove non-adherence; courses were split into small purchases or stopped when symptoms eased. Third, awareness of resistance was uneven, higher among community health volunteers who had attended earlier sensitisation. Fourth, sharing and stockpiling of tablets was normal. Fifth, participants linked shared latrines, irregular water supply and overcrowding to recurrent symptoms. Participants proposed licensing and training of drug-shop attendants, subsidised point-of-care urine testing, community-led awareness campaigns and better shared sanitation.

DISCUSSION

In this mixed-methods study in Kibra, 24.7% of urine specimens from symptomatic residents grew a bacterial uropathogen, *E. coli* accounted for 57.3% of isolates, and resistance to ampicillin, third-generation cephalosporins and trimethoprim-sulfamethoxazole exceeded 70%. Most isolates (84.7%) were MDR, and a presumptive ESBL phenotype was present in 83.3% of isolates from species in which it can be interpreted. Nitrofurantoin, amikacin and meropenem kept their activity. In the community, antibiotics were mostly obtained without prescription, courses were often incomplete, and inappropriate use was not concentrated in any socio-demographic group.

The prevalence we found is lower than culture positivity among patients with UTI-like symptoms attending facilities in East Africa (35.0%, 2653 of 7583) [4], in Kenya (54%, 1027 of 1898) [3], and among outpatients in Morogoro, Tanzania (41%) (15). The figures are not like-for-like. We used a single-organism threshold of 10^5 CFU/mL, whereas the East African study counted 10^4 CFU/mL of one or two uropathogens [4], our denominator comprised all specimens from symptomatic residents, including those that showed no growth or were contaminated; and our specimens were processed at one referral hospital. Our estimate describes culture-confirmed infection among symptomatic people whose urine was cultured, not the prevalence of UTI in the settlement.

E. coli was the leading pathogen, as expected [1], and *Klebsiella* species together accounted for 16.7% of isolates. *Staphylococcus* species were frequent in the East African facility series (26.3% to 37.6%) [3, 4], but made up only 5.3% of our isolates, which may reflect differences in specimen quality or laboratory practice between settings.

Resistance in Kibra was higher than in Kenyan facility data for the drugs that matter most in empirical therapy. Resistance of all isolates to trimethoprim-sulfamethoxazole was 74.7% (*E. coli* 85.2%), against 64% for trimethoprim and 57% for sulfamethoxazole in Kenyan facilities [3], ciprofloxacin resistance was 52.2% against 27%, and ceftriaxone resistance 81.8% against 11% (3). Our MDR proportion (84.7%) exceeds the 66% in Kenyan facilities (3), 50.9% across East Africa [4], 33% at Kenyan sites in the Holistic Approach to Unravel Antibacterial Resistance in East Africa (HATUA) study [5], and 51% in Morogoro [15]. Nitrofurantoin resistance (8.4%, or 2.2% after excluding intrinsically resistant species) was close to the 9% reported in Kenyan facilities [3]. The very high MDR proportion in urinary *E. coli* (94.2%) is consistent with the 80% of stool *E. coli* resistant to three or more classes in Kibra [9], which is compatible with a large community reservoir. Our isolates, however, came from a tertiary referral laboratory, and patients reaching it are likely to include those whose empirical treatment has failed, so resistance may be higher than among community cases.

The community survey describes the conditions in which such resistance may arise: most people first sought care at drug shops, few had a urine test, about half bought antibiotics without prescription, fewer than half completed courses, and three-quarters kept leftovers. Household antibiotic use was reported by 43% of households in Kisumu's informal settlements [8], the proportion in our survey (84.0%) refers to the most recent symptomatic episode and is not comparable. The lack of significant socio-demographic predictors, in a sample where 88.0% met the outcome definition, probably reflects low power and a near-constant outcome in a uniformly poor population. This agrees with work from Kibra, where antibiotic use explained little of the carriage of resistant bacteria, which was driven by unsanitary living conditions [9], and with the HATUA finding that context is a stronger driver of MDR UTI than individual antibiotic use [5]. Our survey respondents and laboratory patients were different people, so we could not link behaviour to resistance.

These findings have practical implications. Ampicillin, trimethoprim-sulfamethoxazole, third-generation cephalosporins and, at about 50% resistance, ciprofloxacin cannot be relied on for empirical treatment of UTI in Kibra. Local guidelines for uncomplicated lower UTI should be reviewed to prioritise nitrofurantoin, on which resistance was low. Pharmacy and county authorities should enforce prescription-only dispensing in informal drug outlets and offer licensed training to drug-shop attendants, who said in the FGDs that they would welcome it. Community health promoters could lead education on completing courses, not sharing or stockpiling antibiotics and safe disposal,

and subsidised point-of-care urine testing at community dispensaries would reduce purely empirical treatment. Investment in shared sanitation and water supply should be treated as an AMR measure as well as a sanitation measure [9], and a routine local antibiogram at facilities serving informal settlements would allow guidelines to be updated over time.

The study has strengths: culture-confirmed outcomes read against CLSI breakpoints with reference strains, quality checks on identification and data entry, and triangulation of laboratory, survey and qualitative data. It also has limitations. First, the isolates come from specimens of symptomatic residents processed at a tertiary hospital laboratory, so the prevalence is not a community prevalence and probably over-represents patients who had failed empirical treatment. Second, the three components were separate samples, so no causal inference can be drawn. Third, the survey (n=100) and isolate set (n=150) fell below the calculated minimum of 384, limiting precision and power; 25 respondents also reported no symptoms in the previous 12 months. Fourth, antibiotic use was self-reported over 12 months and subject to recall and social-desirability bias. Fifth, the antibiotic panel and method were not uniform, so results are reported per number tested; ESBL status was inferred phenotypically; and the MDR figure includes some intrinsic resistance. Sixth, the isolate set included children and adults over 90 years, and we could not verify that each isolate came from a different patient. Seventh, environmental exposures were measured by a few household items and were not analysed against resistance. Finally, the cross-sectional design gives one point in time and cannot describe trends.

Future studies should link individual antibiotic use to resistance in the same participants, confirm ESBL and other resistance genes by molecular methods, include asymptomatic residents to estimate community prevalence, and observe antibiotic dispensing directly in Kibra's drug outlets.

In conclusion, one in four specimens from symptomatic Kibra residents grew a bacterial uropathogen, and these isolates were highly multidrug resistant, while community antibiotic use was marked by drug-shop purchase without prescription and incomplete courses. Nitrofurantoin, amikacin and meropenem retained activity, and empirical treatment guidelines, dispensing practice and sanitation all need attention.

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