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Drug resistant enterobacteria in drinking water supplies of Kano State, Nigeria

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ABSTRACT: Drinking water sources are epidemiologically suspected as one of the major transmission agents for pathogenic and perhaps drug resistant *Enterobacteria*. Accordingly, in the period October, 1995 – September, 1996, water samples as were available from tap, borehole, well, dams and rivers in randomly selected 19 Local Government areas of Kano State were screened for these bacteria. 1201 isolates comprising *Citrobacter sp.* (16.91%); *Enterobacter aerogenes* (14.99%); *Klebsiella sp.* (10.24%); *Proteus sp.* (9.58%); *Shigella sp.* (9.49%); *Escherichia coli* (8.24%); *Salmonellae* (7.99%) and *Vibrio sp.* (4.08%) as well as *Pseudomonas Pyocyanea* (18.48%) were detected. The total coliform counts, except for borehole water, were statistically above the WHO standard limit for potability ($P \leq 0.05$). In-vitro sensitivity test to Ampicillin, Amoxicillin, Carbenicillin, Cloxacilin, Erythromycin, Nitrofurantoin, Floxacin, Gentamacin, Penicillin, Streptomycin, tetracycline and Metronidazole showed varied frequencies of multiple resistance incidences. The study indicates presence of drug resistant Enterobacteria in drinking waters of Kano State. Result corroborates the findings of an earlier preliminary study on incidence of Enterobacterial infections in the state (1985 – 1995). Efficient treatment and storage, periodic bacteriological monitoring of drinking water, restriction in the use of antimicrobials are recommended for control of the menace.

Key Words: Municipal water supply; Drinking water; Water pollution; Enterobacteria; Drug resistance.

Introduction

Drinking water is regarded as one of the major vehicles for disseminating infectious, commensal and perhaps antibiotic-resistant members of the family *Enterobacteriaceae* (3, 12, 14, 15, 16). One epidemiological study by the same authors in Kano State (1985-1995) showed a high incidence rate of typhoid, paratyphoid fevers, diarrhea, dysentery, cholera, meningitis, pneumonia and gastro-enteritis. Increase morbidity and mortality cases due to them generated high suspicion upon public sources of water and irrigated vegetable items.

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Precisely, in the late 1995 to 1996 alone, up to 231, 981 morbidity and 2836 mortality cases were witnessed despite the intervention of WHO, UNDP, UNICEF, red Cross and host of other organizations and/or personalities. Even then, the disaster was still endemic in Kano and in fact its neighbourhood, that a large segment of the population of developing countries are exposed to bacterially contaminated waters mainly from open wells, rivers, ponds and even taps. The contamination is not only by man but by animals (birds, rodents etc) (2).

Many workers remarked that phenotypic high frequencies of antimicrobial resistance could exist among coliform and faecal coliform populations in contaminated drinking water supplies. This may be a real threat to public health (5). It is needed therefore, to monitor and document aspect of these infectious agents in our environment. Thus, it is one of the requirements of the WHO to undertake periodically bacteriological analysis of drinking water (17). Therefore, for chemotherapeutic and thus epidemiological importance, the pattern (frequency) of drug resistance among pathogenic and commensal Enterobacteria in drinking water supplies in Kano State, Nigeria was studied.

Materials and Methods

Three hundred and seventy-six drinking water samples from tap, well, borehole, river/stream, dam and/or pond in 19 Local Government area of Kano State (11° 13'N; 7°34'1-9.50'E), were screened for members of *Enterobacteriaceae* by adopting the standard protocols for bacteriological examination of drinking water (2, 4, 6, 17). The isolates were tested *in-vitro* for sensitivity to sixteen antimicrobials namely: Ampicillin, Amoxicillin, Carbenicillin, Cloxacillin, Chloramphenicol, Co-trimoxazole, Cefruxime, cephaloxin, Erythromycin, Nitrofurantoin, Floxacillin, gentamicin, penicillin, Streptomycin, Tetracycline and Metronidazole using Disk Diffusion technique (7,8).

Results

One thousand, two hundred and one isolates comprising *Citrobacter* (16.91%) *Enterobacter aerogenes* (14.99%); *Klebsiella* (10.24%); *Proteus sp.* (9.58%); *Shigella sp.* (9.49%); *Escherichia coli* (8.24%); *salmonellae* (7.99%) and *Vibrio sp.* (4.08%) as well as *Pseudomonas Pyocyanea* (18.48%) were isolated (Table 1). Both membrane filter and MPN counts except for borehole watersamples were statistically above standard limits for portability ($P < 0.05-0.001$).

Result showed high multiple resistance incidence to Ampicillin, Cephaloxine, Cotrimoxazole, Cloxacillin, Penicillin, Nitrofurantoin and Streptomycin (Table 2). Lower resistance frequencies (0-33%) were however observed with Amoxicillin, Chloramphenicol, Carbenicillin, Erythromycin, Floxacillin, gentamicin, Metronidazole and Tetracycline. Much of it perhaps was by transference among bacteria in environmental waters rather than by exposure to drug itself. Poor environmental sanitation and the problem of self-medication could be part of the hydra-headed factors facilitating the spread of these organisms.

Discussion

Widespread occurrence of members of the family Enterobacteriaceae in the drinking water systems studied could be said to be evidently responsible, at least in part, to the outbreak of gastro-enteritis, typhoid, cholera, neonatal meningitis, shigellosis, respiratory. A preliminary epidemiological study by the authors of this work in 1995, generally supports this observation. The economic, political as well as the social and moral implications of the disaster have been noted internationally because of the high incidence of enterobacterial epidemics in Kano State.

Table 1: Frequency of occurrence of *Enterobacterial genera* isolated from the various sample types studied.

Sample Type	Total Samples	Isolates								
		Cit.	Ent.	Esc.	Kleb	Prot.	Sal	Shig.	Vibr.	Pseu.
SW	146	71	76	46	47	48	40	45	23	85
		48%	52%	31.5%	32.2%	32.8%	27.3%	30.8%	15.8%	58.2%
WW	95	59	41	20	33	36	19	31	9	61
		12%	69.4%	21%	34.7%	37.8%	20%	32.6%	9.5%	64.2%
TW	52	24	12	11	13	6	12	13	3	29
		46.1%	50%	21.1%	25%	11.5%	23%	25%	5.8%	57%
BW	46	4	1	0	6	0	2	2	0	15
		8.1%	2.1%	0%	13%	0%	4.3%	4.3%	0%	32.6%
RW	21	16	10	10	7	16	12	12	7	21
		76.1%	47.6%	47.6%	33.3%	76.1%	57.1%	57.1%	33.3%	100%
DW	16	12	11	12	7	9	11	11	7	11
		80%	73.3%	80%	46.6%	60%	73.3%	73.3%	46.6%	73.3%
Total	376	203	180	99	123	115	96	114	49	222
% Predominance level		16.91	14.99	8.24	10.24	9.58	7.94	9.49	4.08	18.48

KEY:

SW – Stored water; **WW** – Well water; **TW** – Tap water; **BW** – Borehole water; **RW** – Riverand/or Stream water; **DW** – Dam water.
 Cit. – *Citrobacter sp.*, Ent. – *Enterobacter aerogenes*; Esc. – *Escherichia coli*; Kleb. - *Klebsiella sp.*; Pseu. – *Pseudomonas pyocyanea*.

Table 2: Level of antibiotic resistance (%) among Enterobacterial Isolates

Antibiotic	AMP	CAB	CNP	COT	CXM	CPH	ERY	FUR	FXN	GEN	PEN	STR	TCN	MET	CMX	CLX
Isolate																
<i>Citrobacter</i>	87	19	7	40	80	90	21	63	11	12	93	40	47	25	20	25
<i>Ent. Aero.</i>	53	14	27	53	73	100	57	22	11	33	80	13	47	0	67	100
<i>E. coli</i>	47	20	7	60	93	100	33	30	30	27	87	60	40	0	0	100
<i>Kleb. Pneu.</i>	50	23	14	50	100	90	21	44	11	29	71	31	39	23	60	(-)
<i>Proteus sp.</i>	33	8	7	47	100	75	17	75	22	7	73	33	67	38	0	0
<i>Salmonella</i>	60	0	0	40	90	80	33	44	11	20	67	53	13	08	33	50
<i>Shigella sp.</i>	87	37	27	13	89	89	33	46	25	39	71	40	13	25	0	50
<i>V. cholerae</i>	62	22	8	23	100	63	50	33	100	23	18	54	0	29	0	50
<i>P. pyocyanea</i>	70	67	40	50	100	100	44	100	20	40	40	83	100	33	(-)	(-)

Key: (-) = Not tested; AMP – Ampicillin; AMOX – Amoxicillin; CLX – Cloxacillin; CAB – Carbenicillin; CNP – Chloramphenicol; CMX – Cephroxime; CPH – Cephaloxine; ERY – Erythromycin; FUR – Nitrofurantoin; FXN – Floxacin; GEN – Gentamicin; MET – Metronidazole; STR – Streptomycin; TCN – Tetracycline.

Additionally, it was generally observed that within the period 10th February – June, 1996, the high gravity of the epidemics was responsible for the refusal, by Saudi Arabia, of visas to the Nigeria's intending pilgrims. This has been very obnoxious to Nigeria politically and economically. Additional adverse grudges marked onto Nigeria were when, in 1995, it was deterred of hosting the Junior World Soccer Competition for the same reason. Of medical importance also is *Pseudomonas pyocyanea* (*Pseudomonas aeruginosa*) which is not a member of coliform group; but was seen to occur with the highest frequency of 19% to 58% of the total samples against all other detected enterobacterial organisms. This coincides with the results of so many observers who states that the organism is hardy, pathogenic and is found nearly always in all environments suitable for Enterobacteriaceae (4,9).

The epidemiological importance of the capacity to transfer multiple antibiotic resistance between bacterial species can hardly be over-emphasized. It was variously shown that spread of these resistant strains (1,8), requires antibiotic exposure to select them from the sensitive majority and hygienic conditions that encourages the transfer to fresh susceptible subjects. Another explanation relating to this finding is probably between different factors that make the epidemiology of antibiotic resistance so complex and any but the most general prediction so uncertain. Meanwhile, as Marie and Fernando (10) put it, much of it is by transference rather than by exposure to the drug itself. This, bearing in mind that organism disseminated by wild animals and even rural human dwellers that were not necessarily exposed to drugs, could still introduce enterobacterial organisms into waters. These could become resistant to antibiotics only when such factors are transferred to them in the water or else where as they come across the resistance members. They further elucidated that *in-vitro* experimental models confirm that some antibiotic resistances are selected only at certain selective concentrations of antibiotics. Accordingly, Microbiologists are faced with daily evidence of the huge adaptive, and evolutionary possibilities of bacteria based on the combination of immense population numbers and overwhelming genetic diversity. As they concluded, the variability is mechanism of resistance of antibiotics in pathogenic and commensal bacterial, and the resulting adaptation of microbes to chemotherapeutic agents constitutes a major threat to the development of modern medicine. The understanding of the mechanism underlying such variability is one of the more important applications of Evolutionary Biology in public health.

Thus, pharmacologists and microbiologists are faced with daily challenges of resistance to drug in pathogenic and commensal bacteria. Applying such would judiciously help in solving the epidemiological problem in Kano State.

It is recommended that, public should be enlightened more on personal hygiene, environmental sanitation, restriction on the use of antibiotics and encouraging on the water sanitation associations in villages. The result of the present study suggests the need for ensuring a safe water supply to the public by the able individual organizations and the government. Combined-drug therapy should be adopted when in any given instance they are found to be reliable. However, caution has to be continuously observed by our clinicians in antibiotic choice of treatment. Moreover, antibiotic use policies should strictly be advocated in Nigeria generally.

Conclusion

Result indicates presence of potentially pathogenic drug resistant strains of Enterobacteria in drinking water sources of Kano State in 1995 and 1996. Epidemiologically, it corroborates the findings of an earlier preliminary study on the incidence of Enterobacteria infection in Kano State between 1985 and 1995. Efficient methods for treatment and storage, periodic bacteriological monitoring of drinking water sources; restriction in the use of antibiotics, as well as encouraging the use of appropriate vaccines are recommended for control of the menace.

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