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Review article

Enterobacteria in drinking water: a public health hazard

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Abstract

Drinking water is being incriminated as one of the major vehicles for disseminating infectious and antibiotic-resistant members of the family – *Enterobacteriaceae.* This was variously reported by results of epidemiological study in many parts of developing countries. Typhoid, paratyphoid fevers, diarrhea, dysentery, cholera, meningitis and gasteroenteristis particularly between 1985 and 1995 were prevalent. Few similars were seen in2001, 2003 and even 2009. Increasing morbidity and mortality cases due to these diseases generated high suspicions upon public water systems and irrigated vegetable items as vehicles for transmission of the organisms. This is an addition to the problem of antimicrobial resistance being increasingly displayed by the bacterial groups. However the contribution of β-lactamase inhibiting antimicobials as well as developing of new drugs from plant sources may help to alleviate the menace.

Keyword: Enterobacteriaceae, Hazards, Drinking water, Developing Countries

Introduction

The family *Enterobacteriaceae* comprised the coliform and faecal coliform bacteria[1]. These bacteria are intestinal; as normal microflora of man and other animals, but with a greatest potential of inhabiting any other part of the body as saprophytes obligates or opportunistic pathogens[2]. Many also multiply in vegetation sewage and surface waters around man's environment. The organisms are also allochtonous to water and vegetation under natural conditions[3]. Their occurrence is considered a parameter for evaluating the quality of drinking water as reported by the World Health Organization[4, 5]. It was established that these pollution – indicator bacteria consist of disease-causing genera of importance to public health[6]. Report have variously shown that potable water supplies have become a problem due to their role in transmitting bacteria to consumers[7, 8.] Phenotypes exhibiting high frequencies of antimicrobial resistance could exist among coliform and faecal coliform populatiosn in contaminated drinking water supplies[9]. This poses a real not only as source of disease but also as a source for the spread of resistant factors (R – Factors) to other pathogens. This follows the reports[10] indicated that drug resistance among the *Enterobacteriaceae* exist due to a careless widespread use of antibiotics by the populations of especially the developing countries where water and food hygiene is low. The typical genera of this large heterogenous family include *Citrobacter spp, Edwardsiella spp, Enterobacter aerogenes, Erwinia spp, Escherichia coli, Klebsiellae, Proteus spp, Salmonella, Serratia, spp, Shigellae, Vibrio spp* and *Yersinia enterocolkitica*, *Shigella, Salmonella* and *Vibrio Cholera* as well *Vibrio parahaemolyticus* are obligate pathogens; *Proteus* and *Klebsiellae* which inhabit mainly the urinogenital and respiratory tracts are opportunistic pathogens. *Escherichia coli* and *Enterobacter aerogenes* are normal microbiota, becoming pathogenic under very exceptional circumstances[1,4,10,11]. It is therefore the objective of the present work to review the current findings concerning the role of drinking water in the dissemination of enterobacteriaceae and to identify some of the steps being taken to address the situation especially in the developing countries.

Enterobacteria and Drinking Water; An Epidemiological Perspective

A large segment of the population of developing countries are drinking untreated or partially-treated, unprotected surface waters from open wells, rivers and ponds, that are often heavily contaminated by faeces and excretal matter, laden with opportunistic pathogens. The introduction of *Enterobacteri-aceae* is not only by man but also animals such as donkeys, sheep, cattle, rats, birds and wind (Bichi *et al.*, 2002). Water related diseases are prevalent in these nations. It has been estimated that up to 2000 million people are without safe water supplies or adequate sanitation[12,13]. The World Health Organization reported that some 30,000 people die everyday from water-related diseases and enterobacterial types carry most of the blame. Some other studies that confined study, in the present scientist were reported by several workers[7,14,1]. A study of this nature should be encouraged some preliminary studies[15] indicated that there had been repeated epidemics of enterobacterial infections, especially between the period 1985 and 1996. The high incidence of diarrhea with or without blood,

dysentery, typhoid and paratyphoid fevers, urinary tract infections, food poisoning, cholera, pneumonia and even meningitis have been endemic and, so becomes matter of concern. The WHO, the UNDP, the Red Cross, the UNICEF and a host of other well-meaning organizations and/or personalities, the world-over, have seriously become worried hence disturbed when, in 1996 alone, up to 231, 981 morbidity and 2836 mortality cases were witnessed. Perhaps, the main vehicle for their transmission among others could be water supply sources which were seemingly in a deplorable condition. As reiterated by the Scientific Working Group of the Health Organization[5], the major epidemiological factors contributory to this menace include poor personal and environmental hygiene, inavailability of safe drinking water, careless attitude towards maintenance and protection of water supply systems, poor medical and other health facilitates and, above all, hunger and poverty. Monitoring these organisms in drinking water is therefore very essential.

The Microbiology of Enterobacteria

These organisms are Gram-negative, non – spore-forming bacilli of size 1 – 3 x 0.4-0.7 micrometer. Members of the group are capable of profuse growth aerobically and anaerobically on simple laboratory media such as peptone water without the addition of blood or serum. They circular, convex, smooth colonies of up to 2mm in diameter after overnight incubation on MacConkey agar. They are oxidase-negative and produce acid and/or gas fermentatively from glucose or lactose. They reduce nitrates to nitrites. The medically – important ones are the *Arizona spp, Citrobacter spp, Enterobacter aerogenes, Escherichia coli, Klebsiella spp, Proteus spp, Salmonella, Shigella spp* and *Vibrio spp*. Pseudomonas species and Vibrio species are however outside the family *Enterobacteriaceae* have been inoluded in this paper because of their close association with the main organisms being discussed[1,2,16,17].

Escherichia Coli

E. coli according to Edwards[18] is motile, Gram-negative, non-spore-forming bacillus. Typically, it produces positive tests for indole and methyl red but negative for lysine, citrate and vorges proskaeur. It is positive for decarboxylase and manitol fermentations. It produces gas from glucose as well as lactose. It has typical colonial morphology with an irrisdescent "sheen" on differential media such as Eosine Methylene Blue agar. Colonies on MacConkey's medium are smooth, glossy, translucent and rose pink. It is impaired or totally inhibited on desoxycholate citrate agar (DCA). *E. coli* is distinguished from other coliforms by its ability to form gas from lactose at 44^0C.

Klebsiella, Enterobacter* and *Serratia Species

Klebsiella species exhibit mucoid growth, large polysaccharide capsules and lack motility and usually give positive tests for lysine decarboxylase and citrate. Most *Enterobacter* species give positive tests for motility, citrate and ornithine decarboxylase and produce gas from glucose. *Enterobacter aerogenes* has small capsules. *Serratia* on the other-hand produces DNase, lipase and gelatinase. *Klebsiella, Enterobacter* and *Serratia* usually give positive voges-proskaeur reactions[19].

Proteus Species

The following four species are recognized: [20] *Proteus vulgaris, P. mirabilis, P. morgani* and *P. retagri.* Members of this group deaminate phenylalanine, they are motile, grow on potassium cyanide medium (KCN) and ferment xylose. Cultures produce fishy smell. Proteus species move very actively by means of peritrichous flagella, resulting in "swarming" on solid media unless it is inhibited by chemicals, such as phenylalanine alcohol or cystine-lactose-electrolyte-deficient medium.

Proteus species are highly motile ,and this makes them "swarm" actively in growth media. They are urease-positive while *Providencia* species are usually negative and ferment lactose very slowly or not at all. *Proteus mirabilis* is more susceptible to antimicrobial drugs, including penicillins, than members of the group.

Citrobacter

Members of this genus are citrate-positive capable of growth in potassium cyanide medium and differ from *Salmonella* in that they do not decarboxylate lysine. They ferment lactose very slowly if at all.[20]

Salmonellae

These do ferment glucose and mannose without producing gas but do not ferment, lactose or sucrose. Most of them produce hydrogen sulphide gas in Triple Sugar Iron agar. They are often pathogenic for humans or animals when ingested. *Arizona* is included in the group[1].

Shigellae

These are non-motile and usually do not ferment lactose but do ferment other carbohydrates producing acid but not gas. They do not produce hydrogen sulphide gas. The four *Shigella* species (*Shigella flexineri, S. dysentricus, S. boydii* and *S. sonnei*) are closely related to *E. coli*. Many share common antigens with one another and with other enteric bacter[1].

Vibrios

Some bacteriologist maintained that *Vibrios* are members of the family *Enterobacteriaceae*[12,17]. Medically-important ones include *V. cholerae* serogroup 01 which causes pandemic clolera *V. cholerae* serogroup 01 which causes cholera-like diarrhoes, mild diarrhoes, rarely extraintestinal infection. *V. parahaemolyticus* causes gastroenteritis, possibly extra-intestinal infection. Others, such as *V. mimicus*, *V. vulnificus, V. hollisae, V. fluvialis, V. damsela, V. alginolyticus, V. metaschnikovil* infect ear, wound and ulcers in other parts of the body. They are among the most common bacteria in surface waters worldwide[10]. Unpon first isolation, *V. chlorerae* is a comma-shaped, curved rod, 2-4 micrometer long which becomes straight rod, like other Gram-negative enteric bacteria, on prolonged cultivation[12,17]. *Vibrio clolerae* is selectively isolated using Thioglycolate Citrate Bile Salt (TCBS) agar at 37^0C when enriched first in alkaline peptone water. Characteristic colonies are convex, smooth round colonies that are opaque (greenish-yellow typically) and granular in transmitted light[2].

Other Enterobacteriaceae

These include Yersinia, Edwardsiella and Erwinia. They are occasionally found in human infection. Hafnia, Cedelea and Kluyvera are all genera of the family[12,14,15].

Antigenic Structure

Enterobacteriaceae have a complex antigenic structure. They are Classified by more than 150 different heat-stable somatic O (Lipopolysaccharide) antigens, more than 100 heat-stable K (Capsular) antigens and more than 50 H (Flagella) antigens. In Salmonella typhi, the capsular antigens are called vi antigens[12.18]. O antigens are the most external parts of the cell wall consisting of repeating units of polysaccharides with unique sugars. Antibodies to O antigens are predominantly 1gM. Each genus has specific O group but a single organism may posses several O antigens. Most Shigella share one or more O antigens with *E. coli* and may cross – react with some Providencia, *Klebsiella* and *Salmonella* species. Occasionally, O antigens may be associated with specific human disease, e.g., specific O types of *E. coli* are found in diarrhea and urinary tract infection[12.] example 0157:H7 emanating as an emerging pathogen[27]. K antigens are external to O antigens on some but not all *Enterobacteriaceae.* Some are polysaccharides including the K antigens to *E. coli,* others are proteins. K antigens may interfere with agglutination by O antisera, and they may be associated with virulence, e.g., *E. coli* strains producing KI antigens are prominent in neonatal meningitis and K antigens of *E. coli* cause attachment of the bacteria to epithelial cells prior to gastro-intestinal or urinary tract invasion. *Klebsiella* forms large capsules containing polysaccharides (K antigens) covering the somatic O or H antigens and can be identified by capsular swelling tests with specific antisera. Human infections of the respiratory tract are caused particularly by capsular types 1 and 2; those of the urinary tract by 8, 9, 10 and 24. H antigens are located on the flegalla and are heat – labile and can be removed by alcohol. Contain flagella protein (Flagellins) which agglutinate IgG[12].

Enterobacterial Pathogensis

The harmful effects caused by enterobacterial pathogens to man and animals result after successful invasion and final establishment in the host system resulting in an immunological interactions manifested by a specific disease type presentation. This is mostly a consequence of strict and opportunistic pathogen action[22].

Gastroenterists

This is define accordingly as the inflammation of the mucous membrane of the gastro-intestinal tract due to the dietic error and/or bacterial infection. Other incriminated aetiologic agents are the protozoa such as *Entamoeba histolytica, Giardia lamblia,* enteric viruses and helminthes. It may also be due to toxins and allergic reaction[12,16,21]. Gastroenteritis is one of the disastrous communicable infections occurring all over the world more especially in development countries where the standard of hygiene and economy is very low[23]. It was maintained that poor environment sanitation including low control of flies facilitated the introduction of enterobaterial into foods and water. A warm humid climate with lack of adequate storage facilities (Refrigeration and smoking) act as well. "Well-oral" is the route of transmission mainly. Both adults and children suffer from the disease but infants are one susceptible due to probably immature immunological responses and malnutrition especially in non-breast fed infants fed infants. This was reiterated to be due to their slow rate of mucosal epithelial regeneration hence low production of local immunologlobin A. As a consequence, gastroenteritis is probably responsible for the killing of more children throughout the world than any probably responsible single disease. Further, under nutrition makes infants more susceptible to viral and bacterial intestinal pathogens and render their effects more ravaging. Intake of toxins such as methylchlorides, arsenic etc., leads also to uncountable cases of gastroenteritis[24, 25, 26]. It was confirmed that many of the cases are due to emerging[27]. *E. coli* enteropathogenlic *E. coli* (EPEC), 0157:H7 enterotoxigenic *E. coli* (ETEC), enteroinvasive *E. coli* (EIEC), *Shigella dysentricus, Salmonella paratyphi, Klebsiella, Proteus, Citrobacter,Vibrio* and a vast numbedr of other *Enbterobacteriaceae. Clastridium perfdringes, Staphylococcus faecalis* and *Streptococcus faecalis* are also very critical with respect to gastroenteritis.

Yersiniosis

This is a disease caused by *Yersinia enterocolitica.* It is characterized by enterocolitis and acute septiceamia with diarrhoe, common in Europe and the United States of America. It present up to 1-3% type gastroenteritis but with no comparable data in the developing countries, study in Victoria Australia, reported that the pathogenic organism exists frequently in environmental waters. Generally, the clinical manifestations include hypersecretion of toxins leading to travelers' diarrhea, profuse diarrhoe, vomiting, muscular cramps, loss of electrolytes (Na^+, K^+, Ci^- etc) leading to suppression of urine with consequent loss of body fluids and thus, dehydration and collapse in many case[10,28]. Morbidity and mortality is high due to the case of case of the spread of the pathogen though contaminated food and water as a result of ignorance on the dangers associated with poor environmental and personal hygiene[29].

Shigellosis

The infection types, shigellosis, is also known as bacillary dysentery[30]. It is an acute infection of the colon occurring throughout the world and spreads by contaminated food and water. Most severe amongst its types is the dysentery due to *Shigella dysenteriae* followed by *S. flexineri, S. boydii* and that of *S. sonnei* is the least. Te incubation period is one week after which vomiting, high fever, profuse diarrhoes with blood in stool abruptly set in. dehydration and sometimes collapse and death within a few hours result. But *S. sonnei* presents milder symptoms with slight fever, diarrhea, vomiting,colic abdominal pain but without any serious constitutional symptoms. However, recovery is attained within a week. This diseases calls for treatment with tetracycline, ampicillin, sulphonamides and streptomycin[14,15,31] *Shigella* infection accounts, in 1973, for up to 39, 3121 cases with up to 29 deaths in Nigeria as reported by the World Health Organization[5].

***Salmonella* Food – Poisoning**

Salmonella typhimurium is the implicated specie[32]. Sheep, rodents, birds in addition to human carriers are sources. Careful handling of meat and other food items, keeping them in rodent-proof containers and maintaining proper storage conditions and ensuring health of food handlers would assist in preventing the disaster[33]. Antitoxins as injectables are employed for treatment[34].

***Typhoid and Paratyphoid* Fevers**

These are due to *Salmonella typhi* and *S. paratyphi* A, B(*S. schottmuelleri*) and C *(S. Hirschfield*). The former is much more severe and has claimed more lives than the latter[35]. Typhoid and paratyphoid B occur worldwide while paratyphi A is common in the East and C is rare. The disease are prevalent in countries with low standard of sanitation one local study reported up to n5% incidence in children[14]. The clinical picture is marked after an incubation period of about two weeks with onset of headache (10 day for typhoid), myalgia, tiredness, cough and fever with about 0.5^0C rise per day to reach up to 40^0C in the first week with accompanying febrile illness. Characteristic rashes consisting of a few crop spots appear, particularly on the abdomen or chest for a few days, which can easily be over-looked[12]. Constipation may be pronounced initially, culminating in diarrhoes by the second week with severe attack to take patient into "COMAVIGIL". It characterized by drowsiness, confusion, muttering to one-self, plucking at beddings, delusion, irritability and other psychotic reaction as well as anemia. In the third and fourth weeks, however, improvement sets in gradually. Diagnosis is achieved using blood culture by employing selective media such as Desoxychlolate citrate agar (DCA) or serologically by Widal test[22]. Chloramphenicol parenterally and/or orally, tetracycline and metronidazole and the drugs of choice after carrying out sensitivity test[31].

Cholera

Vibrio cholerae cause epidemic and pandemic cholera in Africa, Asia and Middle East, remarkable within 1800-1900 and 1960's and up to date in many parts of the world[5.15]. *Vibrio parahaemolyticus* cause gastroenteritis infection while *V. mimicus, V. alginalyticus* and *V. vulnificus* cause ear, would, soft tissue and other extra-intestinal infections but are uncommon. Up to $10^8 - 10^{10}$ organisms have to be ingested before pathogenicity is presented. In many instances, only 1-5% of exposed susceptible persons develop the disease, as compared to only $10^2 - 10^5$ CFU for *salmonellosis* or shigellosis. The diseases is spread by in individuals with early mild illness and/or by water, food, flies and person to person contact Carrier State Seldom exceeds 3-4 weeks and true chronic carriers are rare. There is mortality rate without treatment between 25% and 50%. Infection with *Vibrio* is much more fatal therefore than that of any other member of the Enterobateriaceae with results of acidosis, dehydration diarrheoa, shock and death. Numerous reports have indicated many species of *Vibrio* isolated from Rivers, tanks ponds, wells and other household waters in communities attacked by its epidemics. *Vibrio* survives in water for up to 3 weeks.[36] Control rests only on education and improvement of sanitation of food and water. Patients should be isolated, excreta disinfected. Chemoprophylaxis with antimicrobials such as tetracycline reduces stool output and shortens *Vibrio* excretion. Oral re-hydration Therapy (ORT) is the best[5]. Tetracycline-resistant *Vibrio* has emerged and it is posing a serious problem. Travelers from endemic areas should present immunization certificates valid only for 6 months(popularly called yellow card).

Other related diseases

These include Travelers' diarrheoa that is characterized by vomiting, dirrhoea and fever due to hypersecretion of toxins caused by pathogenic strains of *E. coli* with incubation period of 2-72hours (WHO, 1987); The ETEC, EPEC account count for up to 90% of the Urinary Tract Infections (UTI); in newborn with low 1gM, sepsis secondary to UTI is also common[28]; It is also known that *E. coli* is responsible for up to 40% cases of meningitis in neonates due to K antigens[37]. The emergence of *E. coli* 0157:H7 is now very frightening[27]. Up to 3% of pneumonias are due to *Klebsiella pneumoniae* which is common with respiratory tract of up to 5% normal individuals. It causes hemorrhagic necrotizing lesion in lungs. It also causes UTI and can cause hospital-acquire infection. *Enterobacter aerogenes* is incriminated in UTI and sepsis, and probably only free-living in the intestine. *Serratia marcesan* is common opportunistic pathogens in hospitalized patients. Usually pneumonia, bacteraemia and endocarditis result. It is often multiply resistant to ampicillin and penicillin and but sensitive to cephalosporins[2]. *Proteus* spp, are free-living saprophytes in soil, vegetation, water and sewage. They are also found in the intestine of many healthy persons. They produce infections in human only when they leave the intestinal tract, they are found in UTI, bacteraemia, pneumonia and local lesions in debilitated patients or those receiving intravenous infusion[2]. *Proteus* spp are also alleged in food poisoning *P. mirabilis* cause urinary tract infections and occasionally other infections. *P. vulgaris* and *Morganella morgani* are important nasocomial pathogens. Their urease enzymes hydrolyse urea liberating ammonia, thus, urine becomes alkaline and this promotes stone formation making acidification somewhat impossible[38]. Its invasion of the urinary tract is due to rapid swarming motility of the organism[22]. Strains of *Proteus* vary greatly in antibiotic for other members of the group are aminoglycosides (streptomycin and Gentamicin) and cephalosphorins (Cephatoxine).

Providential rettgeri, P. alkalifaciens and *P. sturtii* are members of the intestinal flora. All cause urinary tract infections and are often resistant to antimicrobial therapy[12]. Epidemiological investigations, declared that the role of food and water in the transmission of *Citrobacter* spp should not be underestimated. The genus comprises *Citrobacter frendii, C. diversus* and *C. amalonaticus.* They are causative sagents of infections of the urinary tract, wounds (sepsis) and the respiratory tract. There were isolation from cases of septicaemia and meningitis and occasionally from hospital infections outbreaks[39]. *Pseudomonas pyocyanea* (*P. aeruginosa*) on the other hand, is a strict aerobic, (only anaerobic in the presence of nitrates), Gram-negative, non-spore-forming and non-capsulated bacilli. It is motile with polar flagella which are mono or multitrichous, oxidase and catalase-positive. Breakdown of carbohydrate is typically oxidative. They are primarily saprophyticand ubiquitous and are found in soil, water, plant and elsewhere in man's environment. It is a classic opportunistic pathogen with innate resistance and high

adaptability to many antibiotics and disinfectants. It is thus very difficult to eradicate from man's environment. It is particularly dangerous when it infects debilitated patients especially those who have suffered multiple injuries or individuals receiving radiation therapy. In such conditions, infection frequently extends from local site to become septicaemic.Its attack on HIV/AIDS patients is therefore not in doubt. Acute otitis media and externa, infection of the urinary tract, eye and pulmonary system. Severally burnt patients are also risk. This "hardy" and notorious organism was stated to be a single threat to life in infancy, 1,2,40. Characteristically, the organism tolerates a wide temperature range (5-42^{0}C) with an optimum of 37^{0}C. It requires a pH of between 7.4 and 7.6. Growth occurs on all ordinary media. On nutrient agar, colonies are 2-4mm in diameter, convex, with entire edge and effuse growth is not uncommon. It presents sweet musty odour and produces green pigment (pyocynin) with diffuses into the medium. Fluorescencein (yellow); pyorubin (red) and pyomelanin (brown) are also produced. Of its high resistance, Bacteriologist use selective media- Cetrimide or Dettol agarplates for the isolation of *P. pyocyanea* from the environment. In one study, Maimuna and Arzai showed that the organism was able to grow in 1:2, 1:1 And 100% dilution of dettol unlike all other organisms tested (*E. coli, Shigella, Proteus* and *Staphylococcus*)[41].

Immunity to *Enterobacteriaceae*

Specific antibodies develop in systemic infection but are uncertain whether it lasts. Antibodies against the core glycolipid of *Enterobacteriaceae* are associated with the protection against the haemodynamic sequelae of bacteraemia due to Gram – negative rods and also reduce the feverish response and augment intravascular clearance of certain organism[16,17,40].

Diagnosis of Enterobacteria

Specimens helpful for diagnosing enterobacterial infections include faeces, urine, pus, blood, sputum, spinal fluid and materials from localize site of the disease process. For epidemiological purposes, drinking waters and foods are also good materials for investigation. These are cultured on blood agar for rapid preliminary identification. Triple sugar Iron agar (TSI), Desoxycholate Citrate agar (DCA), Wilson and Blairs Brilliant Green Bismuth Sulphate (BBS) agar Xylose Lysine Desoxycholate Bile Salt agar (TCBS) are selective for *Salmonella, Shigella, Proteus, Citrobacter* and *Vibrio cholera* respectively[10,18,5]. Biochemical tests such as Indole, Methyl, Voges-Proskaeur and Citrate (IMViC test) as well as specific serological test are coupled for detailed identification[19]

Control and Preventive Measures

In November, 1980, the General Assembly of the United Nations, formally declared 1981-1990 period as the International Drinking Water Supply and Sanitation Decade with its target to making available, to all, by the year 1990, a supply of safe drinking water and adequate sanitary facilities. The scheme aimed at prevention and control of water and sanitation-related disease and the promotion and the promotion of health and socio-economic growth. To secure such benefits, however, resources must be available. Communities and health authorities must work together to bring about improvement. Since then, the United Nation Development Programme (UNDP) has taken an active role in assisting governments of member states by providing technical support teams and coordinating available external support[8,14,15,33].This has led to a profound development as borehole tube wells and sand filters have been planted in some localities[42]. In addition to that, the rampant sales of unhygienically prepared water and food packaged in polythene bags, has been halted by some countries. They produced many publications in national dailies and, in conjunction with. Radio and Television Authorities, public was made aware of this disaster. In the same line, individuals and communities were becoming increasingly involved in planning and constructing sanitation and water systems as they have started becoming aware of the hazards involved in lack of adequate and potable water supply [8,33].

The Problem of Antibiotic Resistance in Enterobacteria

The ability of *Enterobacteriaceae* to produce disease is well established. As well, information on antibiotic susceptibility especially for aquatic and seemingly wild isolates are being reported. However, the pattern of sensitivity to amoxicillin, carbenicillin, chloramphenicol, co-trimoxazole, erythromycin, floxacin, gentamicin, streptomycin, ciproxim, cephalexin and tetracycline were found to be in the region of 40% to 90%. But *Pseudomonas* species showed a high resistance to co-trimoxazole and streptomycin. With ampicillin, the situation was discouraging. For example, it was seen to be resisted by almost all the organism at greater frequency with the exception of *Proteus* spp. In general, multiple drug resistance was evidenced. Nevertheless, carbenicillin, co-trimoxazole, floxacin, chloramphenicol, gentamicin and metronidazole could still reliably employ as their efficacy and potency on *Enterobacteriaceae* was shown to be high. About 67% of *Proteus spp* were observed to show high sensitivity to ampicillin compared to all other genera in a study in Kano Nigeria[14]. This may be explained by the fact that ampicillin has been utilized much more extensively by the population by way of self-medication and that could have paved the way for the resistance development by most enterobacteria studied. With co-trimoxazole, the sensitivity was also lower than for the other much more active antimicrobials mention earlier. The high popularity of the drug among the population in the common name "Septrin" might have accounted for that. Another study reported that amoxacillin, clavulante, ciprofloxacin, cefodaxime and clindamycin appeared less active[43]. This shows a positive correlation with the result of another work in Nigeria where only 23%, 37%, 8%, 25%, 28% and of *Klebsiella spp*, *Proteus spp, Salmonella spp, Shigella spp, Vibrio spp* and *Pseudomonas spp*, respectively showed sensitivity to the drugs[14,15]. It was also observed that 25% *Citrobacter* and non-of *E. aerogenes* and *E. coli* showed resistance activity to this agent. It could thus be recommended that while trying to treat enterobaterial infections chemotherapeutically, multiple drug therapy should be employed, so that chemotherapeutics such as chloramphenicol, co-trimoxazole, gentamicin, tetracycline and doxycycline can be combined appropriately to achieve greater efficacy and potency[39]. Amoxicillin, which at present becomes a drug of choice for the treatment of typhoid and paratyphoid fevers, was observed to be tolerated by up to 33% *Salmonella spp* tested up to 60% of *Klebsiellae* and *E. Aerogenes* showed low sensitivity to this agent. Nevertheless, *Citrobacter spp, E. coli, Proteus spp, Shigella spp* and *Vibrio spp* were very much susceptible,

with cloxacillin, only *Proteus spp* and *Citrobacter* showed appreciable sensitivity. But others were very much resistant, and whose frequency range from 50% in *Salmonella, Shigella, Vibrio spp* to 100% amongst *E. aerogenes* and *E. coli*. This showed that antibiotic resistance which is especially notorious with *Enterobacteriaceae* has become a serious menace to clinicians and laboratory agents[22,44]. Worldwide resistance of *Shigella spp* to sulphonamides, tetracyclines streptomycin, chloramphenicol and ampicillin is well known[45]. This was also thought to be responsible for *Salmonella* typhoid-acquired resistance to chloramphenicol, which resulted in many deaths in Mexico and elsewhere in 1976. Mahlu[42] maintained that *Vibrio cholerae* became resistant to tetracycline in 1976 just after six (6) month's usage in Tanzania. There were numerous reports similar to this on *V. cholerae* isolated from rivers, ponds, tanks and household reserves that are resistance to antibiotics. Resistance of *Yersinia enterocolitica* to antibiotics was also reported[47]. Multiple antibiotic resistances has also been reported in Bangladesh with up to 5-30% incidence rates[44]. Enterobacterial isolates resistant to penicillin, trimethoprim, sulphamethoxaziole, tetracycline and chloramphenicol have been reported elsewhere. Transferable drug resistance was detected in 69% *E. coli*, 60% *Klebsiella*, 67% *Proteus* and *Citrobacter* strains. The increased incidence of drug resistance has created difficulty in treating urinary and gastro-intestinal tract infections strikingly[43,45,46.]. In drinking water of Baghdad City 66% of enterobacterial isolates were resistant to one or more of the twelve (12) antibiotics tested among which ampicillin, carbenicillin, cefatoxime and colistin resistance was more frequent[7]. It could be stated therefore, that the existence of antibiotics resistance and among the family *Enterobacteriaceae* severally limits the possibilities of antibacterial therapy worldwide. Drug resistance is favored by the extensive use of antibacterial drug in our communities. The overuse and misuse of these drugs have led to the death of sensitive strains leaving resistance ones to survive multiply and infect new hosts[43,44,46,47]. The situation, in developing countries, was serious for the following reasons[14,15,46,47.] Antimicrobials /antibiotics are obtainable outside of recognized treatment centres, and taken without medical authorization or supervision. This lead to an inappropriate use and then being taken at wrong dosages and for an insufficient length of time. Laboratory facilities and trained personnel are often not available of facilitate isolation of pathogens and perform sensitivity test. Guidelines regarding the selection of drugs and information about drugs resistance are not perfectly communicable in many of those presenting antimicrobials especially in rural areas. Control procedures in hospital are often inadequate resulting in the spread of infectious diseases and resistant strains. it has to be borne in mind however, that enterobacterial organisms that were not resistant before, could still be introduced into environmental waters by wild animal's and even human rural dwellers that were not necessary exposed to drugs[9,11]. But the resistant factors are retransferred to them as they come across the resistant ones in such water[43]. This is epidemiologically very important to note. The ways through which such problems could be limited have been reviewed and reported by some workers[47,48]. It is believed that there are potent plant extracts that could be used to supplement or augment the present day chemotherapeutics.

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