CO-INFECTION OF SCHISTOSOMA HAEMATOBIUM AND ESCHERICHIA COLI IN PUPILS ATTENDING SOME SELECTED SCHOOLS IN ZARIA, NIGERIA

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BY

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MARCH, 2016.

DECLARATION

I declare that the work in this dissertation entitled "Co-infection of *Schistosoma haematobium* and *Escherichia coli* in Pupils Attending Some Selected Schools in Zaria, Nigeria" was carried out by me in the Department of Microbiology, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria under the supervision of Prof. J.B. Ameh and Prof. H.I. Inabo. The information derived from the literature has been duly acknowledged in the text and references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

BALOGUN, Adinoyi David _____ _____

Signature Date

CERTIFICATION

This dissertation entitled "Co-infection of *Schistosoma haematobium* and *Escherichia coli* in Pupils Attending Some Selected Schools in Zaria, Nigeria" by Adinoyi David BALOGUN (Msc/Sci/30755/2012–2013) meets the regulations governing the award of Master of Science degree in Microbiology of Ahmadu Bello University, Zaria and is approved for its contributions to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to God Almighty the Immortal, Invisible and the only wise God. To my parents who believed in me against all odds, offered their love, prayers, support and shoulders for me to lean on when the going got tough.

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ABSTRACT

This study was designed to investigate co-infection of *Schistosoma haematobium* and *Escherichia coli* in pupils attending some selected primary schools in Zaria, Nigeria. A total of 520 urine samples were collected from the pupils and were analyzed for ova of *Schistosoma haematobium* and also the urines were also cultured for *Escherichia coli.* The ova of *Schsitosomiasis* was determined using the standard centrifugation method. *E,coli* was isolated using Cystiene Lactose Electrolyte Deficient (CLED) Agar and was subcultured on Eosin Methylene Blue(EMB) Agar. IMVIC biochemical test were carried out on the isolates. Further biochemical test was carried out to confirm the isolates were *Escherichia coli.* Antibiotic susceptibility test was carried out on the *E,coli* isolate using disk diffusion method. The prevalence of *Schistosoma haematobium* was 20.4%, *Escherichia coli* was 4.6% and the co-infection was 4.6%. The prevalence rates of *Schistosoma haematobium* infection in LEA Z, LEA J, LEA G, and LEA P were 14.6%, 26.9%, 18.5% and 21.5% respectively. The prevalence of *E. coli* and co-infection in LEA Z, LEA J, LEA G and LEA P were 2.3%. 5.4%, 4.6% and 6.2%. The highest prevalence of *Schistosoma haematobium* was found among the age group of 10-14years There was a significant association (χ^2=8.936, df=3, *P*=0.030*) between age and *Schistosoma haematobium* infection. The prevalence of *E.coli* was found to be higher among the age group of 15-19 years and the prevalence was higher in the female (4.7%) than male (4.6%). There was no significant association between *E. coli* infection and age. The prevalence of *Schistosoma haematobium* in male pupils (23.5%) was found to be higher than the female pupils (15.0%). There was significant association between *Schistosoma haematobium* and Gender. The prevalence of *Escherichia coli* in females pupils was higher when compared to the male pupils. There was no significant association between *E. coli* and gender. Higher prevalence of

Schistosoma haematobium was found among pupils who use streams /lakes as source of drinking water. There was significant association between *S. haematobium* and source of drinking water.The antibacterial susceptibility profile of the isolates was determined using 10 different antibiotics. All the isolates were susceptible to Gentamicin. Some of the isolates were resistant to Ciprofloxacillin, Amoxycillin, Chloramphenicol, Tetracycline, Sulphamethoxazole Trimethropin, Nalixidic acid, Ampicillin, Doxycycline and Nitrofurantoin.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Urinary tract infections (UTI) represent one of the most common infections encountered in medical practice today and occurring from the neonate to the geriatric age group (Kunin, 1994). Despite the widespread availability of antibiotics, UTI remains the most common bacterial infection in the human population (Tambekar *et al.,* 2006). About one hundred and fifty million individuals had been reported to be affected by UTIs annually worldwide (Gupta *et al.,* 2001). Urinary tract infections occur as a result of the microbial colonization of urine and the invasion of any structure of the urinary tract by microbial organisms such as bacteria, viruses, and/or parasites (Stamm, 1999; Stamm, 2008).

Urinary tract infections associated with *Schistosoma haematobium* affects the entire genitourinary tract (Ifeanyi *et al.,* 2009). Bacterial infections are often recurrent and important in the prepatent period of urinary schistosomiasis which may be instrumental in precipitating renal failure (Ifeanyi *et al,* 2009). In urinary schistosomiasis, secondary bacterial infections are common and in men can involve the seminal vesicles, spermatic cord, and to a lesser extent, the prostate. In women, infection can involve the cervix and fallopian tubes and can cause infertility (Ifeanyi *et al.,* 2009).

Urinary tract infection (UTI) is the commonest microbial infectious disease in community practice with a high rate of morbidity and financial cost. Urinary tract infections are described as bacteriuria with urinary symptoms. Urinary tract infection can affect lower and sometimes both lower and upper urinary tracts. The term cystitis had been used to define the lower UTI infection

and is characterized by symptoms such as dysuria, frequency, urgency, and suprapubic tenderness. The presence of the lower UTI symptoms does not exclude the upper UTI which is often present in most UTI cases (Sobel and Kaye, 2010). The treatment of UTI can be classified into uncomplicated and complicated on the basis of their choice of treatment (Sabra and Abdel-Fattah, 2012). Urinary Tract Infection is more common in females than in males as female urethra structurally found less effective for preventing the bacterial entry (Warren *et al.,* 1999). It may be due to the proximity of the genital tract and urethra and adherence of urothelial mucosa to the mucopolysaccharide lining (Schaeffer *et al.,* 2001: Akortha and Ibadin, 2008). The other main factors which make females more prone to UTI are pregnancy and sexual activity (Arul *et al.,* 2012). In pregnancy, the physiological increase in plasma volume and decrease in urine concentration develop glycosuria in up to 70% women which ultimately leads to bacterial growth in urine (Lucas and Cunningham 1993). Sexual activity in females also increases the risk of urethra contamination as the bacteria could be pushed into the urethra during sexual intercourse as well as bacteria being massaged up the urethra into the bladder during child birth (Ebie *et al.,* 2001: Kolawole *et al.,*2009).

The resulting disease conditions from UTI include cystitis and pyelonephritis which is known to be non-age discriminatory as it affects both older persons and infants. Moreover, pyuria as evidenced by the inflammation of the genitourinary tract is common in subjects with asymptomatic bacteriuria (Nicolle *et al.,* 2005). Asymptomatic UTI in particular has been associated with an increased risk of developing pyelonephritis, maternal and infant morbidity, pre-term labour and low birth weight (Oyagade *et al.,* 2004). Urinary tract infections of both bacterial and parasitic origins had been associated with high incidence of squamous cell carcinoma of the bladder and the cervix (Schwartz, 1984); *Escherichia coli* and *Schistosom*a spp.

are the most widely reported UTI-caused by bacteria and parasite respectively (Ariyo *et al.*,2004).

Microbial invasion being the basis of urinary tract infection could be seen in various clinical manifestations resulting in various disease conditions in both male and female of all ages. Young adults particularly female are, however, the most at risk of bacteriuria. For example, in the United States, UTIs result in approximately 8 million physician visits and more than 100,000 hospital admissions per year of sexually active women treated annually for UTIs. Up to 95% of the UTI cases in the U.S are treated with antibiotics such as cotrimoxazole without bacteriological investigation since these infections are so routinely encountered in medical practice (Gupta *et al.,* 2001). Urinary tract includes the organs that collect and store urine and release it from the body which include: kidneys, ureters, bladder and urethra. UTIs are among the most common bacterial and some parasitic infections in humans, both in the rural community and hospital settings and had been reported in all age groups in both sexes (Hooton and Stamm, 1996).

1.2 Statement of the Research Problem

Urinary tract infections in childhood are common and may be difficult to diagnose in young children because of non-specific symptoms. Symptoms such as fever, vomiting, screaming, anorexia and irritability may indicate a urinary tract infection, but they are also common in other childhood diseases. Urinary tract infections in children are significant source of morbidity, particularly when associated with abnormalities. The bacterium *Escherichia coli* which is part of the normal flora of the body is responsible for most of the reported urinary tract infection especially in primary school children and or appropriate school age children. *Escherichia coli* is

normally harmless in the small intestine where it normally resides and becomes a problem when it gains spread to the urinary tract (Shaw *et al.,* 1998).

Drug resistance is a large and growing problem with urinary tract infection. The prevalent pathogens of UTIs have been found to be resistant to chemotherapeutic agents (Okonko *et al.,* 2009), though the antimicrobial susceptibilities of these pathogens are highly predictable. Development of resistance to these antimicrobial agents in UTI cases will therefore affect the future treatment and management of the infections with drugs. Adequate treatment and control of these conditions need good knowledge of the organisms, their epidemiological characteristics and their antibacterial susceptibility testing is therefore mandatory (Singh *et al.,* 2009).

1.3 Justification of the Research

Children are particularly vulnerable to schistosomiasis because of their habit of playing in water, where they may contract the infection. As such, they are the ideal target group to investigate the prevalence of schistosomiasis, and the data collected from this age group can be used to assess not only whether schistosomiasis threatens the health of schoolchildren, but can also be used as a reference for evaluating the need for community intervention (Nokes *et al.,* 1992; Engels et *al.,* 2002: Stothard *et al*., 2009). There is therefore an urgent need for a renewed commitment to control schistosomiasis and concurrent bacteriuria among children in the country. Parasitic worm infection and bacteria are common in tropical and subtropical countries and many people suffer from multiple parasite infections concurrently. It is important to gain knowledge on co-endemicity patterns because such information can help to design and prioritize interventions and control strategies focusing on areas at highest risk of co-infection. With the pressing need for systematic approaches to health systems, it is necessary to first identify the scope of health

problems within communities especially infections caused by parasitic worms and some bacteria. Currently, even the best data systems develop only univariate summary tabulations of what in many instances is pervasive co-morbidity. Integrated approaches to disease control require an in-depth understanding of spatially explicit risk profiles for simultaneous infection with multiple species of parasites. However, cost effective distribution of these drugs, and other control measures, require priority knowledge of high-risk areas, where co infection is most prevalent.

1.4 Aim

The aim of this research study was to determine the coinfection of *Schistosoma haematobium* with *E.coli* in pupils attending some selected schools in Zaria, Nigeria.

1.5 Objectives

The objectives are to:

1. To determine the association between risk and socio-demographic factors with *Schistosoma haematobium, Escherichia coli* infections and coinfection rate
2. Determine the prevalence of *Schistosoma haematobium* and *Escherichia coli* among pupils attending some selected primary schools in Zaria.
3. Determine the coinfection of *Schistosoma haematobium* and *E. coli* among pupils attending some selected primary schools in Zaria.
4. To determine the antibiogram of *Escherichia coli* isolated from the urinary tract of primary school children.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Urinary Tract Infections

Urinary tract infection (UTI) is the presence of microorganisms, predominantly bacteria, in the urinary tract, which is usually sterile (Zorc *et al.,* 2005). These uropathogens generally infect cells in the urinary tract by initial attachment and subsequent ascension from the urethra, to the bladder, kidney and through the systemic circulation, causing bacteraemia, as a result of the renal cells being compromised (Kaper *et al.,* 2004).

Uropathogenic organisms are more likely to colonize anatomically and functionally normal urinary tracts; however individuals with obstructed and abnormal urinary tract structures have a higher risk of UTI (Zorc *et al.,* 2005). Infections of the lower urinary tract, is a cause of morbidity, with increasing incidence of urinary tract infections predisposing the host to more severe renal cell damage (Crain and Gerschel, 1990). The more severe renal damage frequently leads to renal scarring and hypertension with high mortality rate (Jacobson *et al.,* 1989). Some studies confirm individuals with compromised immune systems like diabetics, as more susceptible to urinary tract infections (Deresinski, 1995; Geerlings *et al.,* 2000).

2.2 Clinical Manifestations of Urinary tract infection

There are varying clinical manifestations, including asymptomatic bacteriuria, cystitis and acute pyelonephritis (Foxman, 2001).

2.2.1 Asymptomatic bacteriuria

This clinical manifestation of urinary tract infection is commonly associated with females; from the pubertal to adult stages. Asymptomatic bacteriuria has been found to have 4 to 6% prevalence in healthy young adults with an increase to 20% in ambulatory elderly adults (Hooton *et al.*, 2000). It is a condition characterized by a positive urine culture test without the female individual experiencing common infections and symptoms, such as fevers and especially, abdominal or flank pains. Asymptomatic bacteriuria has also been found in some studies to be facilitated by diabetes mellitus in female subjects, as a result of glucosuria (Patterson and Andrriole, 1987; Lucas and Cunningham, 1993). Contraction of asymptomatic bacteriuria in diabetic females is further compounded by other risk factors, such as sexual intercourse, the duration of diabetes and its complications and insulin use. Pregnant women are mainly predisposed to asymptomatic bacteriuria, as they experience a decrease in immuno-competence, coupled with risk factors, such as sexual intercourse, which permits both commensal and non-commensal bacteria to colonize and multiply in the urogenital canals (Scott *et al.*, 1990). Although this condition is benign, some researchers suggest that it might progress to symptomatic if not diagnosed, and in pregnant women it might lead to pyelonephritis, premature births and higher foetal mortalities (Nicolle, 1994; Connolly and Thorp, 1999; Delzelle and Leferre, 2000).

2.2.2 Cystitis

This is the most prevalent UTI found in women, although not absent in men (Hanno, 2007). Cystitis is localized in the bladder and can lead to the more complicated acute pyelonephritis due to the continual ascension of causative microorganisms through the ureter into the kidney with the aid of adherence structures (Ottem *et al.*, 2007). Symptoms, such as suprapubic pain,

abdominal or flank pains, urine incontinence and malodorous urine have been associated with cystitis (Zorc *et al.,* 2005). Individuals with cystitis could also experience dysuria, urgency and change in frequency of urination (Rabin *et al.,* 2000). However, fever has not been linked with this condition and is known not to cause any renal injury.

2.2.3 Acute pyelonephritis

Pyelonephritis is a progressed result of urinary tract infection due to the ascension of bacteria that have colonized the urethra and the bladder (Bass *et al.,* 2003). This is an upper urinary tract infection, involving the ureter, collecting system and finally, the renal parenchyma (Bergeron, 1995). The ability of uropathogens to cause upper tract infections has been attributed to bacteria adhesion, virulence factors and motility coupled with the host's anatomic, humoral and genetic factors (Kaper *et al.,* 2004). Acute pyelonephritis is commonly associated with symptoms such as flank and abdominal pains, fevers and chills (Griffiths *et al.,* 2011). However, children may express non-specific symptoms, such as poor feeding, irritability and jaundice in newborns.

2.3 *Escherichia coli*

Escherichia coli is a Gram negative lactose fermenting bacillus found mainly in the gastrointestinal tract of humans and other mammals. This microorganism can colonize the peri-urethral region of infants a few hours after birth (Linshaw, 1996). *E. coli* is mainly a commensal, co-habiting with its animal host (Scott *et al.,* 1990). Several strains of this organism exist without causing disease, except when found in individuals with immuno-compromised conditions such as diabetes mellitus or when the gastrointestinal tract has been breached as in peritonitis (Epoke *et al.,* 2000). The bacteria successfully persist in the mucosal layer of the mammalian colon and form the most abundant facultative anaerobes in the human microflora

(Kaper *et al.,* 2004).There are two proposed models for the mechanisms that enable *E. coli* successfully occupy the colon as its niche. The first model suggests the more efficient utilization of gluconate in the colon than other resident microbes and thus dominating the niche (Sweeney *et al.*, 1996). A more recent model is based on the ability of several clones of the bacterium acquiring specific virulence factors, giving them the ability to adapt to various biological environments and cause several diseases (Marrs *et al.,* 2005). However, only a few of the pathogenic *E.coli* with some combinations of these virulence factors turn to be successful in causing disease in healthy individuals (Kaper *et al.,* 2004). *E. coli* is a diverse species of bacteria grouped into two subsets; enteric/diarrhoea causing and the extra-intestinal disease causing type, including urinary tract infection. These subsets can further be divided into groups, based on the use of specific combinations of virulence factors, the molecular mechanisms employed in infections and also occasional peculiar symptoms associated with the diseases caused. Such groups are termed pathotypes (Marrs *et al.,* 2005).

2.4 Classification/Taxonomy of *Escherichia coli.*

Escherichia coli are Gram negative anaerobic or facultative anaerobic bacterium. It is a non-spore forming short rod. However, Eosin methylene blue agar is the selective media for the organism. The bacteria is cultivated at the optimum temperature of 37°C (O'Brien *et al.,* 1983), however other strains of *E. coli* can multiply at a temperature of 49°C. *Escherichia coli* is a facultative gram negative bacilli that ferments lactose to produce acid and gas. Since 1977, it has been recognized that some diarrhoegenic strains of *E. coli* produce toxins that have an irreversible cytopathic effect on cultured Vero cells (Konowalchuk *et al.,* 1977). Such verocytotoxigenic *E.coli* (VTEC) have been shown to belong to over 100 different serotypes (Johnson *et al.,* 1983). They are also describe as Shiga toxin-producing *E. coli* (STEC) due to the

similarity demonstrated between verocytotoxins (VT) and Shiga toxins (Stx) of *Shigella dysenteriae* (O'brien *et al.,* 1983). In the past two decades, VTEC O157:H7 has increased in importance world-wide as a public health problem. Each strain has a typical gram-negative cell wall containing lipopolysaccharide. *Escherichia coli* encompasses an enormous population of bacteria that exibit a very high degree of both genetic and phenotypic diversity. Genome sequencing of a large number of isolates of *E. coli* and related bacteria shows that a taxonomic reclassification would be desirable.

However, this has not been done, largely due to its importance and *E. coli* remains one of the most diverse bacteria species: only 20% of the genome is common to all strains. The genera *Escherichia* and *Salmonella* diverge around 102 million years ago, which coincides with the divergence of their hosts: the formal being found in mammals and the latter in birds and repties (Battistuzzi *et al.,* 2004). This was followed by a split of the escherichian ancestor into five species (*E. albertii*, *E. coli*, E. *fergusonii*, *E. hernannii*, *E. vulneris*). The last *E. coli* ancestor splits between 20 and 30 million years ago (Lecointre *et al.,* 1998). The genus belongs in a group of bacteria informally known as "coliforms", and is a member of the Enterobacteriaceae family ("the enterics") of the Gammaproteobacteria (Brener *et al.,* 2005).

2.5 Habitat

Escherichia coli are normal inhabitants of the human gastrointestinal tract and are among the bacteria species most frequently isolated from stool cultures. *E. coli* and other facultative anaerobes constitute about 0.1% of gut flora (Eckburg *et al.,* 2005). Cells are able to survive outside the body for a limited amount of time, which makes them ideal indicator organisms to test environmental samples for fecal contamination (Feng *et al*., 2002; Thompson, 2007). There

is, however, a growing body of research that has examined the survival of *E. coli* in the the host (Ishii and Sadowsky, 2008).

2.6 Cell Structure and Physiology

Escherichia coli cells are typically rod-shaped, and are about 2.0 micrometers (μm) long and 0.25-1.0 μm in diameter, with a cell volume of 0.6-0.7 μm³ (Kubitschek, 1990). Optimal growth of *E. coli* occurs at 37°C (98.6°F) but some laboratory strains can multiply at temperatures of up to 49°C (120°F) (Fotadar *et al*., 2005). Growth can be driven by aerobic or anaerobic respiration, using a large variety of redox pairs, including the oxidation of pyruvic acid, formic acid, hydrogen and amino acids, and the reduction of substrates such as oxygen, nitrate, fumarate, dimethyl sulfoxide and trimethylamine N-oxide (Ingledew and Poole, 1984).

2.7 Pathogenesis of *Escherichia coli*

Over 700 antigenic types (serotypes) of *E. coli* are recognized based on O, H, and K antigens (Touchon *et al.,* 2009). At one time serotyping was important in distinguishing the smaller number of strains that actually cause disease. Its carriage in the intestinal tract of healthy animals particularly cattle represents a source of direct and indirect infection to humans. All pathogenic strains of *E.coli* contains genomic regions (island) loaded with a suite virulence genes that encode key traits and for adherence, colonization, invasion and secretion of toxic compounds and transport functions as wellas sidophore production (Touchon *et al.,* 2009).

2.8 Enteric/diarrhoeic *Escherichia coli*

Six different pathotypes of *E.coli*, known to cause diarrhoea have been identified. These are the enteropathogenic(EPEC), enterohaemorrhagic (EHEC), enterotoxigenic (ETEC),

enteroaggregative (EAEC), enteroinvasive (EIEC) and diffused adherence (DAEC) *E.coli* (Kaper *et al.,* 2004; Marrs *et al.,* 2005).

2.8.1 Enteropathogenic *E. coli*

This pathotype of enteric *E. coli* has been tagged as the most important cause of potential fatal infant diarrhoea (Nataro and Kaper, 1998). This pathotype causes diarrhoea by attaching and effacing; having intimate adherence to the intestinal epithelial cells and inducing drastic change in the cytoskeleton of these cells. The condition is further enhanced by the accumulation of the polymerized protein, actin, beneath the attached bacterium, leading to the formation of a pedestal-like structure. A 35-kb pathogenicity island, called the locus of enterocyte effacement (LEE) is responsible for this pathogenic trait (McDaniel *et al.,* 1995).

Homologues of the LEE have also been detected in other pathogens in humans, including the EHEC. The LEE also encodes the protein, intimin, which serves as a ligand for epithelial cell attachment and further stimulates T-helper cell response (Jerse *et al.,* 1990; Higgins *et al.,* 1999). However, the mechanism for causing diarrhoea is not well understood and has been attributed to active ion secretion, increased intestinal permeability, intestinal inflammation or loss of absorptive surface (Nataro and Kaper, 1998).

2.8.2 Enterohaemorrhagic *E. coli*

Bloody diarrhoea which requires an extremely low *E. coli* infectious dose has been associated with enterohaemorrhagic *E. coli* (Kaper *et al.,* 2004).The key virulence factor used by EHEC is the Shiga toxin also known as the verocytotoxin (VT). It consists of five identical B subunits and a single A subunit. The B subunits bind the holotoxin to the glycolipid receptors on target

cells, while the A subunit cleaves ribosomal RNA, inhibiting protein synthesis (Melton-Celsa and O'Brien, 1998). Shiga toxin is produced in the colon,where it mediates local damage, which results in bloody diarrhoea, haemorrhagic colitis and intestinal perforation. This factor travels by blood transport to the kidney where it damages renal endothelial cells and leads to inflammation (Andreoli *et al.*, 2002).

2.8.3 Enterotoxigenic *E. coli*

ETEC causes watery diarrhoea, through colonizing of the mucosa of the small intestine and activating synthesis of enterotoxins, leading to intestinal secretions (Nataro and Kaper, 1998). These enterotoxins are either heat-labile (LT) or heat-stable (ST), with the heat-labile related to the cholera enterotoxin of *Vibrio cholerae* (Spangler, 1992). The LT enterotoxin transfers ADP-ribosyl moiety from NAD to the α subunit of the regulatory G protein for adenylate cyclase. This permanent activation leads to increased levels of cAMP, which uncontrollably activates kinases responsible for chloride channeling in epithelial cells. The net effect of this action is an increased chloride secretion, which leads to diarrhoea (Sears and Kaper, 1996).

2.8.4 Enteroaggregative *E. coli*

This enteric *E. coli* is differentiated from the other pathotypes by its characteristic adherence to each other and the cells of the intestinal walls. These pathogens form piles of microbial layers to the intestinal walls, in a manner known as auto aggregation (Nataro and Kaper, 1998). Experiments have shown that this phenomenon is made possible by fimbrial structures for adhesins (Nataro *et al.*, 1992; Nataro *et al.*, 1994; Czeczulin *et al.*, 1997). Thus, the main mechanism of EAEC infection is due to their ability to associate with each other and colonize the intestinal mucosa, secreting enterotoxins and cytotoxins (Nataro *et al.*, 1998).

2.8.5 Enteroinvasive *Escherichia coli*

The *Shigella* spp have been found to be biochemically and pathogenically related to this pathotype of *E. coli* (Pupo *et al.,* 2000).The afore-mentioned microorganisms share essential virulence factors. Enteroinvasive *Escherichia coli* infects in the early stage by penetration through the epithelial cells of the intestines, followed by endocytic vacuolation. Once in the cytoplasm, the pathogen multiplies, followed by directional movement of the progenies, which is facilitated by concentration of cellular actin into a 'tail', extending from one pole of the bacteria to the other (Sansonetti, 2002). This enables EIEC to invade adjacent cells and cause inflammatory colitis and mainly small bowel syndrome.

2.8.6 Diffused adherent *E. coli*

Diffused adherent *E. coli* (DAEC) have a characteristic diffuse pattern of adherence to target cells and have been associated with several cases of diarrhoea, especially among infants (Nataro and Kaper, 1998). The mechanism involves a cytopathic effect that is characterized by the host cells developing long cellular extensions, which wrap around the bacteria. Further studies have found the presence of adhesion virulence factors as essential for this pathotype of *E.coli* to induce this characteristic sequence, in order to cause diarrhoea (Bernet-Camard *et al.,* 1996).

2.9 Uropathogenic *E. coli*

Non-pathogenic and pathogenic *E. coli* which migrate from the colon of the human host can colonize the urinary tract system and persist (Sweeney *et al.,* 1996). These microorganisms may possibly evolve through mutations or transformation into DNA sequences carrying virulence factors or introducing pathogenicity islands with associated virulence factors (Kaper *et al.,*

2004). These changes or additions in the genetic make-up of *E. coli* enable its adaptation and ability to persist in its new urine-abundant environment.

2.9.1 Virulence factors

Virulence is the ability of an organism to cause disease in a host and this depends on specific characteristics, due to inherent or acquired genes which enable the pathogen to infect its host (Johnson, 1983). Uropathogenic *E. coli* interacts with its host, through three major pathways facilitated by three major groups of genes, called virulence factors. These virulence factors are gene products, such as structural tissues, exotoxins or membrane-bound toxins and iron acquisition structures. No single virulence factor has been identified in isolation but various combinations of these virulence factors have been found in isolated cultures of uropathogenic *E. coli* as the cause of pathogenicity (Brooks *et al.,* 1981; Lomberg *et al.,* 1984; Johnson *et al.,* 1983). Studies have further shown that this is predominant in UTI than faecal isolates of *E. coli* (Brooks *et al.,* 1981; Hacker *et al.,* 1983).This observation therefore, suggests synergistic action of virulence factors as the mechanism of uropathogenic *E. coli* invading host defense system to cause disease (Johnson, 1983). However, variation in the expression of these virulence factors in isolated uropathogenic *E. coli* have been identified in several studies, attributed possibly to geographical differences and strain types.

2.9.1.1 Adherence

This is the primary interaction route the *E. coli* adopts in order to infect its host (Baddour *et al.,* 1990). Attachment to uro-epithelial cells enables the pathogen to persist and form reservoirs for subsequent infections. The mechanism is partially inhibited by the shedding of host uro-epithelial cells in the high current flow of urine (Hooton and Stamm, 1996). Fimbriae, a

morphologically and functionally distinct structure from flagella, have been found to be responsible for adherence of the uropathogen to the host cells and other surfaces like pollen, latex beads and spores (de Man *et al.,* 1987). Studies have found the attachment and agglutination of erythrocytes by *E. coli* isolates to be a function of the presence of fimbrae. However, this process of agglutination of erythrocytes is influenced by the exposure of the *E. coli* to antibiotics, like Ampicillin, Trimethoprim and Tetracycline (Hales and Amyes, 1985). Fimbrae is made up of repeating protein subunits and their ability to adhere to cells have been assessed and characterized, based on their resistance to the sugar, mannose in attaching to substrates (van Die *et al.,* 1988).Adherence also depends on the host epithelial cells, as patients with recurrent urinary tract infections tend to promote fimbrae adherence, as compared to same cells from control patients (Bruce *et al.,* 1983). Other factors such as the antibacterial properties of UTI-free patients, stages of menstrual cycle and hormonal treatments also influence the degree of adherence by the uropathogen to host uro-epithelial cells (Reid, 2001).

2.9.1.2 Mannose resistant adhesions

This is a trait of most strains of uropathogenic E. coli, which enables them cause agglutination of erythrocytes by way of attachment and cross linking, even in the presence of mannose and has a strong correlation with haemolysin-production (Evans *et al.,* 1980). Diversity in this trait is characterized, based on receptor specificity. Adhesins that recognize the P blood group antigen receptors are termed P fimbriae, while others that identify antigens in the absence of P fimbriae called X adhesins (Johnson, 1983).

2.9.1.3 P fimbriae

Evidence show that this type of adhesin is specific for the Gal (α 1-4) Galβ moiety present as carbohydrate components in glycosphingolipids and glycoproteins in mammalian cells, avian eggs and on some bacteria, collectively called P blood group antigen (Marcus *et al.,* 1981). Strains exhibiting this kind of adherence either attach to surfaces naturally bearing the Gal (α1 - 4) Galβ moiety or by possibly secreting substances that contain this moiety to serve as a receptor to facilitate adherence (Kroncke *et al.,* 1990). These P fimbriated strains further show slight variance as some adhere more specifically to the Gal (α 1-4) Galβ moiety than to its ceramide derivative, the globotetraosylceramide (Kroncke *etal*.,1990). Receptors for the P fimbriae are of different densities and distribution in the cells they are found. They are mainly present on the erythrocytes of humans, pigs, pigeons, goats and dogs but not on these cells from horses, cow and guinea pigs (Parry and Rooke, 1985). Uro-epithelial cells of humans also express the Gal (α 1-4) Galβ receptor but with similar densities expressed in both males and females (Lomberg *et al.,* 1986). P fimbriae is made up of four subunits, together with some accessory proteins; one major subunit, Pap A, and three minor subunits, Pap E, Pap F and Pap G (Lindberg *et al.*,1987; Lund *et al.*,1987). The Pap A forms the bulk of this protein structure and is essential for fimbriae formation but not a determinant for Gal-Gal adherence as studies show the adherence complex can form on the *E. coli* cell surface without fimbriae formation (Lindberg *et al.,* 1984). The minor subunits are minutely localized at the tip of the fimbrial structure with a more elaborate Pap C found on the outer membrane, forming the assembly platform for fimbrial growth (Lindberg *et al.,* 1987). These fimbriae components are arranged on a multicistronic gene cluster called pap (Baga *et al.,* 1984). A recent work showed the gene pap C, having a 94 and 45% distribution in *E.coli* isolates from patients of non-immuno-compromised and immuno-

compromised conditions and also more prevalent in isolates from pyelonephritis and prostatitis than in cystitis (Ruiz *et al.,* 2002; Rijavec *et al.,* 2008). Again, a study conducted in Brazil recorded a distribution of 21.1% of pap C in *E.coli* isolates from UTI patients (Santo *et al.,* 2006). Expression of the P fimbriae is subject to both genetic and environmental factors. Fimbrial expression is favoured by a temperature of 37^{o} C but inhibited between 18-22^{o}C (Abraham *et al.,* 1986; Gander and Thomas, 1987). In addition, concentrations of trimethoprim also inhibit the expression of fimbriae. Findings of the absence of P fimbriae in isolates of pyelonephritis adult patients have led to investigators speculating it is as a result of an underlying anatomic abnormality in the host renal tissues (Dowling *et al.,* 1987).

2.9.1.4 X adhesins

Non-fimbrial adhesins that are able to cause mannose resistant hemagglutination in the absence of fimbriae are collectively called X adhesins. They are mainly of the Dr family, S fimbriae and others (Johnson, 1983). Adhesins of the Dr family are so called due to their hybridizing with DNA probes that bind to certain parts of the Dr blood group antigen and these include the O75X and the afimbrial adhesin I(AFA-I) and afimbrial III (AFA-III) (Labigne-Roussel and Falkow, 1988; Nowicki *et al.,* 1990). Structurally, Dr adhesins appear as a fine mesh, a coil-like or filamentous coating structure on the cell membrane (Arthur *et al.,* 1989). Receptors for this type of adhesin are located on the decay accelerating factor on cells making up the Bowman's capsule, basement membrane and uro-epithelial cells, which prevent erythrocyte lysis by complement (Nowicki *et al.,* 1989). However, different strains bearing the Dr adhesins bind to different portions of the Dr antigen receptor with adhesion inhibited by the antibiotic Chloramphenicol. Genetically, the Dr adhesin is made up of five closely packed genes arranged in a cluster, which may be single or have several copies (Labigne-Roussel *et al.,* 1985).

Moreover, the amino acid sequence of this gene cluster differs from one strain to the other (Labigne-Roussel and Falkow, 1988).

2.9.1.5 S. Fimbriae

S fimbriae Adhesins that cause mannose resistant haemagglutination by specifically attaching to the terminal sialyl-galactoside residues on human erythrocytes are termed S fimbriae (Parkkinen *et al.,* 1989). The gene cluster for this fimbriae comprises a structural subunit which bears similarities to the Pap A of the P fimbriae, an adhesin and accessory proteins. Expression of S fimbriae is also regulated genetically (Riegman *et al.,* 1990). Genetically, the Dr adhesin is made up of five closely packed genes arranged in a cluster, which may be single or have several copies (Labigne-Roussel *et al.,* 1985). Moreover, the amino acid sequence of this gene cluster differs from one strain to the other (Labigne-Roussel and Falkow, 1988)

2.9.1.6 Other X adhesins

Some less common X adherence strains have been identified, based on specific binding to other erythrocyte group antigens. The M adhesin binds to the terminal amino acid sequence of the M blood group and the G fimbriae also binds to the N-acetylglucosamine moiety of the erythrocyte (Vaisanen-Rhen *et al.,* 1983)

2.9.2 Mannose-sensitive adhesins

This type of adhesin is unable to affect haemagglutination in the presence of mannose and one of such has been identified in *E. coli* strains.

2.9.2.1 Type 1 fimbriae

Adherence by type 1 fimbriae is competitively inhibited by mannose and some of its conjugates like α-methylmannoside but not by other monosaccharide molecules (Johnson, 1983). This has left researchers to speculate that the receptors for type 1 fimbriae have a mannose component (Neeser *et al.,* 1986). It has also been found that nitrophenol and its derivatives inhibit adherence of type 1 fimbriae to epithelial tissues but no haemagglutination of erythrocytes (Falkowski *et al.,* 1986). Receptors for this adhesin are distributed through the buccal, intestinal and vaginal cells of humans and other mammals (Falkowski *et al.,* 1986; Wold *et al.,* 1988). However, most investigators have identified type 1 fimbriae to be a lesser contributory factor to E. coli being uropathogenic (Duncan, 1988; Parkkinen *et al*., 1989). The gene cluster for type 1 fimbriae encodes a structural subunit, an adhesin and accessory proteins, similar to that of P fimbriae and X adhesins and regulatory proteins (Abraham *et al.,* 1987; Abraham *et al.,* 1988). In addition, isolated strains exhibit only a single copy of the gene cluster which has the expression of the str uctural subunit independent of the adhesin subunit. Moreover, most isolated strains identified to possess these genes are either fully fimbriated with type 1 fimbriae or non-fimbriated at all (Hultgren *et al.,* 1986; Gander and Thomas, 1987). Growth of the fimbriae is promoted by limiting oxygen concentrations and prior exposure to low concentrations of cephalosporins with chloramphenicol inhibiting its expression. Some *E. coli* cells in a population also have the tendency to genetically switch from non-fimbriated to fimbriated and vice versa (Nowicki *et al.,* 1984; Korhonen *et al.,* 1986).

2.9.2.2 Iron complexing structures/ siderophores

Microorganisms like *E. coli* require iron for most metabolic processes, such as oxygen transportation, the electron transport system and DNA synthesis. The iron required is obtained

from host cells (Neilands *et al.,* 1985; Bagg and Neilands, 1987b). A deficit of this mineral is detrimental to a pathogen as it would not be able to reproduce efficiently to persist in the host. This lack of iron may be due to the insolubility of iron and some defence mechanisms employed by the host to starve the pathogen of iron (Gross *et al.,* 1984).

Almost all biological forms of iron are complexed with iron proteins within cells, requiring its separation in order to be shuttled into the bacteria cell (de Lorenzo and Martinez, 1988) Additionally, host organisms respond to bacteria infection by decreasing the absorption of iron in the intestines to reduce iron concentration available for survival of the pathogenic cells (Schaible and Kaufmann, 2004). These pathogens however, have adopted mechanisms to efficiently scavenge for iron from hosts with the aid of iron acquisition structures, called siderophores. Two main siderophores are employed by *E. coli*, namely aerobactin or hydroxamate siderophore; made up of two lysine amino acid units and a citrate molecule and the catecholate, enterobactin (Neilands *et al.,* 1985).

2.9.2.3 Aerobactin/Hydroxamate siderophore

Hydroxamate siderophore has been found to be the most efficient iron complexing protein structure, employed by E. *coli* to keep up a high iron concentration of $10^5$to 10^6 per cell (Bagg and Neilands, 1987b; de Lorenzo and Martinez, 1988). Although a small molecule of about 616 molecular weight, its structure enables the effective chelating of iron to be shuttled into the bacterial cell, due to its high affinity constant of $10^{23}$for iron (Neilands *et al.,* 1985; de Lorenzo and Martinez, 1988). After synthesis of this structure, *E. coli* secretes it to the surface of the cell, where it extracts Fe^{3+} in its environment, made possible by haemagglutination or cytolysis of host cells, caused by fimbriae attachment or cytotoxicity of secreted toxins respectively. The

$Fe^{3+}$is taken up into the pathogen through an outer membrane protein receptor (Carbonetti and Williams, 1984). Strains of *E. coli* with the aerobactin system presents an advantage over similar ones as they are uninhibited by other proteins found in serum and dilute urine and thus are able to cleave iron from its iron-protein transferrin and make it readily available (Williams and Carbonetti, 1986; Bagg and Neilands, 1987b). Again, the aerobactin siderophore protein is recycled for iron complexing and shuttling, instead of it being hydrolyzed and resynthesized (Braun *et al.,* 1984). Aerobactin is genetically made up of five genes; four encoding the enzymes for synthesis of aerobactin and the fifth for the outer membrane protein (Bindereif and Neilands, 1983; Carbonetti and Williams, 1984). The four genes are termed iuc, found in a long sequence, designated bacteria gene (DBAC), whose gene products catalyze the hydroxylation of lysine, acetylation of hydroxyl group to hydroxamic acid and condensation of two hydroxamic acids with citrate (de Lorenzo and Neilands, 1986). Synthesis is however, inhibited by very high concentrations of intracellular iron, whereby iron complexes with a ferric regulatory protein, fur, and binds to the promoter region of aerobactin operon, blocking transcription (Bagg and Neilands, 1987a)

2.9.2.4 Enterobactin siderophore

This is the primary iron complexing protein, utilized by *E. coli*. The catecholate component of enterobactin contributes to its high affinity constant of 10^{52} for iron (Williams and Carbonetti, 1986). Enterobactin also possesses a higher ability to remove iron from the iron-binding protein, transferrin, in buffered solutions (Bagg and Neilands, 1987b). However, this property is reversed in serum or urine where there are proteins which bind and reduce or possibly abolish the activity of the siderophore. In contrast to aerobactin, the enterobactin siderophore is hydrolyzed after extraction of iron to be resynthesized to repeat the formation of iron complexes (Braun *et al.,*

1984; de Lorenzo and Martinez, 1988). In addition, the enterobactin system leaves free iron in the cytosol of the bacteria, instead of delivering it to bacteria iron centres in the cytoplasm (Williams and Carbonetti, 1986). Similar to the aerobactin system, enterobactin requires genes for siderophore synthesis and outer membrane transport protein but involves a higher number of these genes. The system requires at least sixteen genes; seven for synthesis of the siderophore structure, eight forthe outer membrane transport structure and the last for a protein responsible for cleaving iron from the siderophore in the cytoplasm (Crowley *et al.,* 1991).

2.9.3 Toxin genes

In order for microorganisms to obtain essential nutrients from host cells, certain cytolytic proteins are synthesized to effect the rupturing of host cells. These protein molecules are either secreted or membrane bound. Examples of such molecules are haemolysin, cytotoxic necrotizing factor 1 and usp protein.

2.9.3.1 Haemolysin

Haemolytic *E. coli* synthesizes cytolytic proteins that rupture erythrocytes in mammals and some aquatic species. These toxins are mainly proteins of about 110 kDa, with some phospholipid components and are either secreted α haemolysin or membrane-bound β-haemolysin (Beutin*et al.,* 1988; Wagner *et al.,* 1988). Activity of this toxin requires calcium ions (Ca^{2+}) as a cofactor at about ≥10 mM, although activity in the absence of this ion has been reported (Bhakdi *et al.,* 1986). Haemolysin acts by inserting into lipid-containing cation-selective channels in host erythrocytes, making it more permeable to molecules, such as Ca^{2+}, $K^{+}$and sucrose. This leads to lysis or the erythrocytes being bleached of haemoglobin (Jorgensen*et al.,* 1986; Bhakdi *et al.,* 1988). In addition to erythrocyte lysis, haemolysins are also known to be cytotoxic to host

defence cells. Exposure to haemolysin causes polymorphonuclear lymphocytes to lose their morphology, due to degranulation and loss of leukotrienes, and a resultant impaired natural defence mechanisms, such as loss of response to chemical signals and phagocytosis (Gadeberg and Larsen, 1988; Bhakdi *et al.,* 1989). Haemolysin also stimulates the generation of reactive oxygen species from renal tubular cells and histamine release from mast cells and basophils, causing the compromise of renal tissues (Keane *et al.,* 1987; Gross-Weege *et al.,* 1988).

A four-gene operon, termed hly,has been identified to be involved in the production of haemolysin (Johnson, 1983). The hly A and hlyC are genes for synthesizing the toxin protein structure and activation of the intracellular protein, respectively (Felmlee *et al.,* 1985).

Secretion of activated toxins from the cell membrane is made possible by the activity of hly B and the process further aided by the protein product of hly D (Wagner *et al.,* 1988). The haemolytic action of *E.coli* is regulated physicochemically by temperature and iron concentration. Haemolytic activity is inhibited by high temperatures with a corresponding decrease in haemolysin production, when iron concentration increases (Bohach and Snyder, 1985; Mackman *et al.,* 1986).

2.9.3.2 Cytotoxic necrotizing factor-1(CNF-1)

This toxin was identified as a cell product of *E. coli* strains, mainly isolated from diarrhoea experiencing infants (Caprioli *et al.,* 1983). Studies have shown CNF-1 can induce cell death and cause changes in cell morphology as it caused necrosis of rabbit skin and induced multi-nucleation of tissue cultured cells (Blanco *et al.,*1992; Capo *et al.,*1998). Most pathogenic isolates of *E. coli* produce CNF-1 of varying percentages, based on source of bacteria strains; 40% of strains isolated in urinary tract infections and 5-30% of strains involved in diarrhoea

Blanco *et al.,* 1992; Landraud *et al.,* 2000). CNF-1 acts on host epithelial cells and leukocytes, like monocytes or macrophages, via the activation of guanosine 5′-triphosphates (GTP) binding proteins, Rho A, Rac and Cdc (Chant and Stowers, 1995; Fiorentini *et al.,*1997; Capo *et al.,* 1998; Fiorentini *et al.,* 1998). The action of these GTP proteins, with specific effects on actin, is dependent on the regulation of the actin-myosin cytoskeleton. Rho A is specifically modified by CNF-1 by deamination of glutamine 63 (Gln 63) of the protein into glutamic acid (Flatau *et al.,* 1997). Moreover, the GTP proteins serve as substrates for the deaminase activity of the CNF-1 and this has subsequently been linked to the accumulation of stress fibres in epithelial cells (Fiorentini *et al.,* 1997; Lerm *et al.,* 1999).

This action leads to modification of microvilli structure and also inhibits trans-epithelial migration of polymorphonuclear leukocytes. Work on monocyte-macrophages reveal CNF-1 increases filamentous actin content, which results in a decrease in phagocytotic activity (Capo *et al.,* 1998).

2.9.3.3 usp Protein

The gene encoding this protein toxin was first isolated from uropathogenic *E. coli* responsible for causing inflammation of the prostate gland in a patient (Kurazono *et al.,* 2000). Similar to the CNF-1, studies suggest usp is common amongst uropathogenic strains than faecal strains (Yamamoto *et al.,* 2001). The usp gene is located on the chromosome and not on plasmids of pathogenic *E. coli* (Nakano *et al.,* 2001) . The gene was found to be located on a 4.2kb pathogenicity island, followed downstream by putative sequences without functions in a mouse model (Nakano *et al.,* 2001; Yamamoto *et al.,* 2001). However, analysis of the sequence upstream revealed a recurrent sequence, identical to that responsible for the production of

haemolysin-coregulated protein (Hcp protein) in *Vibrio cholera* which has an unknown function (Williams *et al.,* 1996).

Homology studies have drawn a relation between the usp protein and the S-type pyocin of some *Pseudomonas aeruginosa* strains. These pyocins are ribosomally synthesized antimicrobial molecules which microbes direct against closely related competing strains in their environment (Riley, 1998). The S pyocin is also chromosomally encoded and synthesized as a protein complex, comprising a 'killing protein' with a nuclease activity and an immunity protein against the nuclease action on the producer cell (Kurazono *et al.,* 2000; Nakano *et al.,* 2001). It is therefore, suggested that the uropathogenic *E. coli* increases virulence by synthesizing and secreting its bacteriocin, usp protein, to eliminate competing microbes but persists to continually infect the host, with the help of an immunity protein against the bacteriocin. A screening of E. coli isolates from UTI patients identified usp gene prevalence of 44% (Starcic-Erjavec *et al.,* 2008). Other studies in different geographical regions, like Japan in Asia, have recorded the distribution of usp in uropathogenic *E. coli* to be as high as 7993%, giving an indication of geographical locations contributing to differences in strains (Yamamoto *et al.,* 2001; Kanamaru *et al.,* 2003). A similar work done in the United States on only women, recorded a 68.5% distribution of usp gene in the isolates (Bauer *et al.,* 2002)

2.10 Taxonomy of *Shistosoma haematobium*

Schistosomes are parasitic blood-dwelling fluke worms belonging to the genus *Schistosoma;* family, Schistosomatidae; order, Digenea; class, Trematoda; phylum, Plathyhelminths; and kingdom, Animalia. The genus *Schistosoma* contains six species that are of major pathological importance to man, *Schistosoma haematobium* (*S. haematobium*), *S. mansoni*, *S. japonicum*, *S.*

mekongi, *S. intercalatum*, and *S. guineensis* (Webster *et al.*, 2006). The species differ in their final location in the human host, the species of the intermediate (snail) host they use in their life cycle, the pathology they induce, and the number, size and shape of the eggs they produce. This *Monograph* is restricted to *S. haematobium.*

2.11 Structure

Unlike all other pathologically important trematodes, schistosomes are not hermaphroditic, but have separate sexes. The adult worms are 1–2 cm long with a cylindrical body that features two terminal suckers, a complex tegument, a blind digestive tract, and reproductive organs. The male's body forms a groove or gynaecophoric channel, in which it holds the longer and thinner female. As permanently embraced couples, the schistosomes live within the perivesical (*S. haematobium*) or mesenteric (other species) venous plexus. Schistosomes feed on blood particles through anaerobic glycolysis (Rumnajek, 1987).

2.12 Life Cycle and Biology of the Worm

The life cycle of *S. haematobium* is illustrated in Fig. 2.1. The female *S. haematobium* worm produces hundreds of eggs per day throughout her life. The eggs (144x58μm, with a characteristic terminal spine) penetrate through the bladder wall where they are excreted with urine. Each ovum contains a ciliated larva (miracidium), which secretes proteolytic enzymes that help the eggs migrate into the lumen of the bladder. About half of the eggs produced do not reach the vesical lumen, and are carried away with the bloodstream, and/or trapped in the tissues. These retained eggs provoke a granulomatous inflammatory response, which is the main cause of pathology in the human host. The excreted eggs hatch if they come into contact with water, and release the miracidium. These remain viable for up to 48 hours and are able to locate a suitable

freshwater snail host (i.e. *Bulinus* spp. for *S. haematobium*) using external stimuli such as light and snail-derived chemicals. In the snail, asexual multiplication takes place, and several generations of multiplying larvae (sporocysts) develop. Eventually, these sporocysts produce large numbers of infective larvae with a typical bifurcated tail (cercariae). These leave the snail at a rate of thousands per day after a period of weeks. Shedding of these cercariae can continue for months. The cercariae survive for up to 72 hours and use water turbulence and skin-derived chemicals to locate the human host. They attach to and penetrate the human skin within 3–5 minutes. They lose their tail, and the young parasites (schistosomulae) migrate with the bloodstream via the lungs to the liver, where they mature into adult worms in the portal vein and mate. The paired worms migrate against the bloodstream to the perivesicular veins, where in a total of 4–7 weeks after infection they start producing eggs throughout their adult life. The lifespan of an adult worm averages 3–5 years, but can be as long as 30 years (Wilkins, 1987). An infected person probably harbours an average of hundreds (range, 10s–1000s) of worms (Gryseels and De Vlas, 1996).

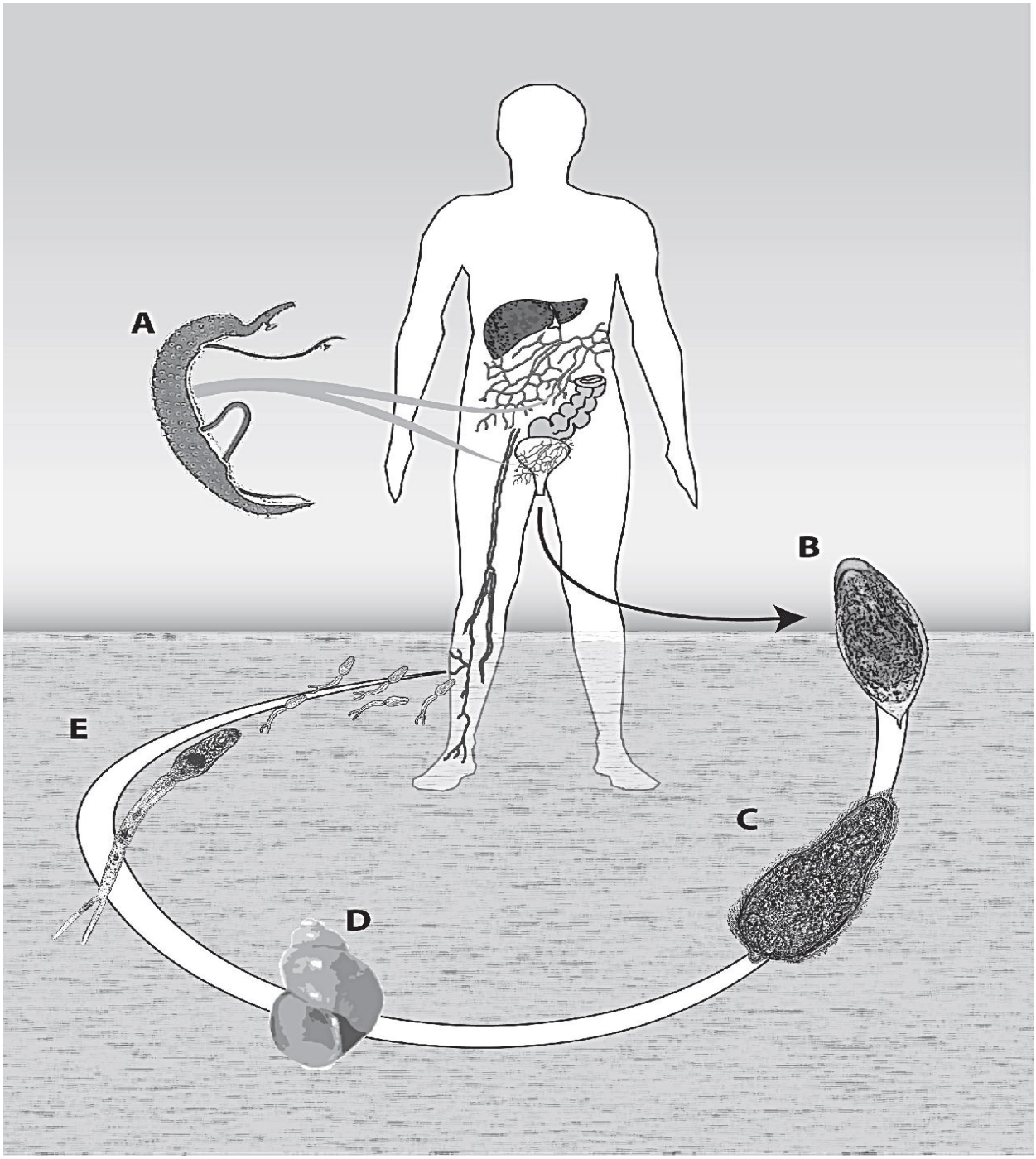

Figure 2.1: Life cycle of *Schistosoma haematobium*

A: paired adult worms; **B**: egg; **C**: miracidium; **D**: intermediate snail host; **E**: cercariae

Source: Bruno Gryseels, Institute for Tropical Medicine, Antwerp, Belgium (1996).

2.13 Transmission, and Risk Factors for Infection

All *Schistosoma* infections follow direct contact with freshwater-harbouring cercariae (see life cycle). Three major factors are responsible for maintaining the transmission of the infection they include: 1) contamination of fresh water with excreta containing schistosome eggs, 2) the presence of the snail intermediate hosts, and 3) human contact with water-infested with cercariae (Jordan and Webbe, 1993).

Contact with contaminated freshwater is the major risk factor of infection (Jordan and Webbe, 1993). The main risk groups are school-age children, specific occupational groups (fishermen, irrigation workers, farmers), and women and other groups using infested water for domestic purposes (WHO Expert Committee, 2002). Many other host-related and environmental risk factors have also been identified and they may affect the risk of acquiring schistosome infection, and/or influence the distribution, prevalence, intensity of infection, morbidity and mortality of schistosomiasis. Among these are genetic factors (Quinnell, 2003), behaviour, household clustering climate, immune response of the host, and concomitant infections (e.g. hepatitis) (IARC, 1994).

2.14 Persistence, Latency, and Natural History of Infection

2.14.1 Persistence

Schistosome worms do not multiply in the host. The infection status is the result of an accumulation of consecutive infections, where individuals with the most intense infections usually have a higher risk of developing morbidity (Gryseels *et al.*, 2006). In the absence of re-infection, the infection subsides when the schistosome worm dies, which is usually after 3–5 years. However, in endemic areas with continuous exposure, re-infection is the rule rather than

the exception. In highly endemic areas, children start to accumulate worms as soon as they are old enough to have contact with water and may, because of the chronic nature of the infection and continued susceptibility to re-infection, remain infected throughout their lives. The possibility that adults might develop immunity to schistosome infections was initially suggested based on the shape of the age–intensity curve in endemic communities, which characteristically shows a rise in intensity during the first two decades of life, followed by a decline in adults to very low levels (Butterworth, 1998). Indeed, numerous studies have provided epidemiological and clinical evidence that people living in endemic areas acquire some form of protective immunity after years of exposure. However, agerelated innate resistance mechanisms may also play an important part in the epidemiology of schistosomiasis (Butterworth, 1993;Gryseels*et al.*, 2006).

2.14.2 Latency and Natural History

Not much is known about the latency between the onset of infection and the appearance of cancer, or about the steps that might lead to cancer. Infection with *S. haematobium* is not synonymous with clinical disease, and many infections are asymptomatic. Of those infected, a small proportion develops serious chronic disease, after varying durations of exposure and infection (Homeida *et al.*, 1988; Vennervald and Dunne, 2004). Mostafa *et al.*, (1999) noted that the incidence of bilharzial bladder cancer in various African countries peaks between the ages of 40–49 years, while infection with *S. haematobium* begins in childhood (as early as 6 months of age), and peaks usually in the second decade of life (between the ages of 5–15 years). This would imply a latency period of 20–30 years.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

This study was carried out in some selected schools from four local government areas in Zaria. The Schools were LEA K, LEA J, LEA Z, and LEA G.

3.2 Sample Size Estimation

The sample was calculated using this formula as described by Ifeanyi *et al.,* (2009).

n=

n= the number of sample

z= standard normal distribution at 95% confidence limit = 1.96

p= prevalence of the previous study= 50%

l= allowable error which is taken as 5%

q= (1-p) = 1-0.50=0.50

N= = 384.16

A total number of 520 samples were collected for this study.

3.3 Ethical Approval

Ethical approval was collected from Kaduna state ministry of health and Kaduna state Universal Basic Education Board (SUBEB**).**

3.4 Administration of Questionnaire

Structured questionnaire (Appendix 1) was administered to the pupils who consented. It was completed by the researcher on the bais of the answer given by each respondent.

3.5 Sample Collection

Midstream urine was collected into a 10ml calibrated sterile specimen bottle from each of the the pupil. The specimen bottles were labeled appropriately and transported to the laboratory, and kept at 4^{o}C for further analyses.

3.6 Laboratoty Examination of Urine Sample

3.6.1 Examination for the Ova of *Schistosoma haematobium*

Urine examination for *S. haematobium* eggs was done using the standard centrifugation method as described by Cheesbrough (2006). Thus the urine from each specimen bottle was shaken thoroughly to mix. After mixing which a sterile disposable 10 ml syringe was used to draw the sample into centrifuge tube. It was centrifuged using a centrifuged at 3000 rpm for 15 minutes and at the end of centrifugation the tube were removed. The supernatant was decanted while the sediment was re-mixed by tapping the bottom of the tube. One drop from each of the tube was placed on a slide after which it was covered with a cover slip and examined microscopically using ×10 and ×40 objectives for the confirmation of the ova of *S. haematobium,* which was

identified by their possession of terminal spine. This same process was carried out on the remaining sediments.

3.6.2 Preparation of Media for the Growth of *Escherichia coli*

3.6.2.1 Preparation of Cysteine Lactose Deficient Agar (CLED)

About 36g of CLED was measured using automated weiging balance into 1000ml of distilled water, which was thoroughly mixed. The mixture was heated to dissolve completely completely and allowed to cool and was autoclave at 121^{o}C for 15 minutes. The autoclave was allowed to cool and the liquid media was removed. About 15ml of the liquid media was poured into a sterile petrish dish.

3.6.2.2 Preparation of Eosin Methylene Blue Agar (EMB)

About 36g of EMB was measured using automated weiging balance into 1000ml of distilled water, which was thoroughly mixed . The mixture was heated and allowed to cool and was autoclave at 121^{o}C for 15 minutes. The autoclave was allowed to cool and the liquid media was removed. About 15ml of the liquid media was poured into a sterile petrish dish.

3.6.2.3 Preparation of Nutrient Agar (NA)

About 28g of nutrient agar was measured using automated weiging balance into 1000ml of distilled water, which was thoroughly mixed . The mixture was heated to dissolve completely. The mixture was dispense into bottles and was autoclaved at 121^{o}C for 15 minutes. The autoclave was allowed to cool and the bottles were removed and slanted.

3.6.2.3 Preparation of Mueller Hilton Agar (MHA)

About 36g of MHA was measured using automated weiging balance into 1000ml of distilled water, which was thoroughly mixed . The mixture was heated and allowed to cool and was autoclave at 121^{o}C for 15 minutes. The autoclave was allowed to cool and the liquid media was removed. About 15ml of the liquid media was poured into a sterile petrish dish.. The prepared media were then stored at 4°C for use in the cultivation of *E. coli*.

3.7 Cultivation of *Escherichia coli*

Bacterial isolates were identified according to the standard microbiological procedures as describe by Cheeseborough (2006) which include examination of specimens to detect, isolate, and identify pathogens or their products using, Microscopy, Culture techniques, Biochemical methods.

3.7.1 Isolation of *E. coli.*

The turbid urine sample was streaked immediately on Cysteine lactose electrolyte deficient (CLED) agar. While the one that was not turbid was transferred into a sterile centrifuging tube and was centrifuged at 15 minutes to get sediment and the sediment obtained was used to streak on the media using a wireloop. The CLED agar medium plate was incubated at 37^{o} C for 24 hours to observe the growth of *E. coli.* The plate was then brought out of the incubator and examined grossly for size, morphology and colony. Yellow colonies observed were suspected to be *E.coli.*

The suspected colonies were then subcultured on Eosin methylene blue (EMB) agar using a flamed wireloop and was incubated at 37^{o}C for 24hours. Green metallic sheen colonies suspected to be *E. coli* were observed on EMB agar plate. Nutrients agar slants were prepared to preserve pure colonies for further use.

3.7.2 Gram staining

The smears of all the presumptive *Escherichia coli* isolates were made by selecting an isolated colony on a nutrient Agar plate and emulsifying it in a drop of physiological saline on a clean grease-free glass slide. The smear was allowed to air dry and heat-fixed by passing it over the blue flame of a Bunsen burner. The fixed smear was Gram stained by flooding it with Crystal violet (primary stain) for 60 seconds after which it was washed off with clean water. It was again stained with Lugols iodine for 60 seconds after which it was washed off using clean water. The smear was then decolourised rapidly by the application of acetone which was immediately washed off with clean water. The smear was finally stained with safranin for 60 seconds after which it was washed off with clean water and air dried on a draining rack.

The Gram stained smears were examined under the microscope using × 40 objectives and ×100 (oil immersion) objectives. The Gram stained smears that showed Gram negative short rods were regarded as positive for *Escherichia coli*.(Cheesbrough, 2006).

3.7.3 Biochemical characterization of *E. coli*

3.7.3.1 Indole test

The culture of the organism was enriched in peptone water then Kovac's reagent was added and indole was extracted by shaking the culture with equal volume of xylene, ethyl ether or petroleum ether, 1ml of Kovac's reagent was then added and a red rose ring was observed between the layer of ether and peptone water thus confirming the organism to be *E.coli*

3.7.3.2 Methyl Red test

The MR-VP medium was inoculated from a young culture suspected to be *E.coli* and was incubated at 35^{o}C for two days. Five drops of indicator were added to the culture and a red color indicates a positive (acid) reaction for *E.coli*.

3.7.3.3. Voges-Proskauer (VP) test

Approximately 2ml of the medium containing the organism was inoculated and incubated at 37^{o}C for 48 hours, 1ml of 10% potassium hydroxide (KOH) was added and left for one hour. Pink colour indicates a positive result and if there is no colour change means a negative result confirming *Escherichia coli*.

3.8 Confirmation of *E. coli* using Microgen™ GnA-ID Kit.

The isolates were further subjected to biochemical tests using *E. coli* (Microgen™ GnA- ID System) Microgen™ Kits. The data obtained by the Microgen GnA-ID microwell strip was designed to generate a 4 digit octal code which was used to intercept the result by the Microgen Identification System Software.

A colony was emulsified from an 18-24 hour culture in 3ml sterile 0.85% saline for the GN A microwell test strips. The adhesive tape sealing the microwell test strips were carefully peeled. Three to four drops of the bacterial suspension were added to each well of the mineral oil. The top of the microwell test strips were read after 18-24 hours incubation. The adhesive tape was removed and all positive reactions were recorded with the aid of the colourful chart. Two drops of Kovac's reagent were added to well 8 and read after 60 seconds. One drop of each of VP I and VP II reagent were added to well 10 and read after 15-30 minutes. One drop of TDA reagent was added to well 12 and read after 60 seconds. The adhesive tape was removed and all reactions read and recorded according to manufacturer's instructions. *E.coli* was identified using the Microgren kit software which involves the imputation of the octal code generated.

3.9 Antibiotic Susceptibility Testing

The antibiotic susceptibility testing of the isolates were carried out using the disc diffusion technique (Kirby-Bauer disk diffusion method (Bauer *et al*., 2002) according to the methods recommended by the Clinical Laboratory and Standards Institute (CLSI, 2015) to determine the susceptibility or resistance profiles of the isolates. About 3-5 discrete colonies of the isolates were inoculated into 5ml of normal saline and incubated overnight at 37°C. The overnight culture was then standardized with 0.5ml MacFarland standard suspensions. Sterile cotton swab was used to inoculate the bacterial suspension to freshly prepared pre-dried Mueller-Hinton agar plates prepared according to manufacturer's instructions. The antibiotic sensitivity discs were aseptically and spaciously placed on the inoculated Mueller-Hinton agar plates. The antibiotic discs used were Amoxicilin (10µg), Cefotaxime (30µg), Ciprofloxacin (5µg), Chloramphenicol (30µg), Tetracycline (30µg), Trimethoprim (25µg), Gentamicin (10µ) (Oxiod Ltd, UK). The reference standard strains used as control in this study include *Escherichia coli* ATCC 25922.it

was obtained from the National Institute for Pharmaceutical Research and Development, Idu, Abuja, Nigeria.

3.9.1 Measurement of diameter of the inhibition zone

After incubation, the test plates were examined for confluent growth and zone of inhibition. The diameter of each zone of inhibition was measured in millimeter (mm) using a ruler on the underside of the plate. The interpretation of the measurement as sensitivity, intermediate and resistant was made according to Clinical Laboratory Standards Institute manual (CLSI, 2015).

3.9.2 Multi-drug resistance index

The multiple-antibiotic resistance (MAR) index was determined for each isolate by dividing the number of antibiotics to which the isolate is resistant by the total number of antibiotics tested (Ehinmudu, 2003)

$$\text{MDR index} = \frac{\text{Number of antibiotics the isolate is resistant to}}{\text{Total number of antibiotics tested.}}$$

3.10 Statistical Analysis

The data obtained in this study were analyzed through Statistical Package for Social Science (SPSS version 21) software. The data were presented as mean, standard error of mean (SEM), frequencies and percentage seroprevalence rate. The differences between discrete variables were valuated using the Chi-square (χ^2) test, Odds Ratio (OR) and the correspondng 95% confidence interval (CI) to measure the strength of association.

CHAPTER FOUR

4.1 RESULTS

4.1 Age Factor and Gender related Prevalence of *Schistosoma haematobium*

Age as a factor in determining the risk of *Schistosoma haematobium* infection was examined. Subjects enrolled in this study were classified into four different age groups based on 5 pupils in each groups. The result of analysis revealed a significant association between age and the prevalence of *Schistosoma haematobium* infection (χ^2=8.936, df=3, *P*=0.030*). A higher prevalence of 24.9% was recorded among subjects within the age group of 10-14 years, while those in age group 0-4 years had the least prevalence of 0.0% (Table 4.1).

Gender-related prevalence of urinary schistosomiasis showed a significant association (χ^2=5.340, *P*=0.020*, df=1, OR=2.130, CI=1.231-3.210). A higher prevalence of 23.5% (77/327) was observed among the male subjects as compared to 15.0% (92/95) recorded among their female counterpart (Table 4.1).

4.2 Test of Association of Risk Factor in relation to *Schitosoma haematobium*

The test of association between prevalence of *Schistosoma haematobium* and source of water showed a significant association (χ^2=13.72, df=3, *p*=0.008*). A Higher prevalence of 30.3% was recorded among pupils that use stream/lakes as source of drinking water. The least prevalence of 17.1% was recorded among pupils who use borehole as drinking water source (Table 4.2).

The analysis of data with respect to toilet type in relation to prevalence of *Schistosoma haematobium* revealed no significant association (χ^2=4.103 df=3, *p* =0.251). Highest prevalence of 24.6% was recorded among pupils who use nearby bush/ open field for defecation and the least prevalence of 14.3% was recorded among pupils that use water system (Table 4.2).

Circumcision as a risk factor in relation to *Schistosoma haematobium* infection revealed a significant association (χ^2=6.456 df=1, p =0.034*). Highest prevalence of 83.3% was observed among pupils that are not circumcised compared to 29.4% of pupils that are circumcised. Swimming in relation to the prevalence of *Schistosoma haematobium* revealed significant association (χ^2=10.415 df=1, p=0.030*). Highest prevalence of 22.1% was observed among pupils that swim in contaminated streams when compared to 28.4% of pupils that do not swim. Highest prevalence was observed among pupils that wash in infected streams while those that do not wash in streams had a prevalence of 19.3%. The difference observed among two groups revealed no significant association (χ^2=0.339 df=1, P=0.560) (Table 4.2).

Evaluation of farming in marshy area as a possible risk factor for *Schistosoma haematobium* infection showed no significant association (χ^2=1.253 df=1, p=0.263). A higher prevalence of 30.0% was recorded among pupils that do not farm in marshy area when compared to the prevalence of 17.6% those that farm in marshy areas (Table 4.2).

Table 4.1: Distribution of *Schistosoma haematobium* in relation to Age and Gender

Age (Years)	No Examined	No Positive (%)	Odds Ratio	χ^2	p-value
0-4	5	0(0)			
5-9	208	31(14.9)			
10-14	289	72(24.9)		8.936	0.030*
15-19	18	3(16.7)			
Gender					
Male	327	77(23.5)	2.130(1.231-3.120)	5.340	0.020*
Female	193	29(15.0)			

Key: No= Number, χ^2=Chi-Square,

Table 4.2: Distribution of *Schistosoma haematobium* in relation to Risk Factors

Risk factors	No Examined	No Positive (%)	χ^2	Odds Ratio (95% CI)	p-value
Source of water					
Tap	82	17(20.7)			
Borehole	128	22(17.1)	13.723		0.008*
Well	198	34(17.2)			
Stream/lake	112	34(30.3)			
Toilet Type					
Water system	91	13(14.3)			
Open field	175	43(24.6)			
Pit latrine	234	40(17.1)	4.103		0.251
Beside the Stream	20	4(20.0)			
Circumcision					
Yes	309	91(29.4)	6.456	0.926(0.657-1.304)	0.074
No	18	15(83.3)			
Swimming in Streams					
Yes	281	62(22.1)	10.415	1.153(0.817-1.672)	0.003*
No	239	44(18.4)			
Washing in Streams					
Yes	301	64(21.3)	237(78.7)	1.109(0.783-1.570)	0.560
No	219	42(19.2)	177(80.8)		
Farming in Marshy Areas					
Yes	250	44(17.6)	206(82.7)	0.834(0.591-1.179)	0.263
No	270	62(30.0)	208(70.0)		

Key: No= Number, χ^2=Chi-Square,

4.3 Test of Association of Symptoms inrelation to *Schitosoma haematobium*

Painful urination as a symptoms in relation to *Schistosoma haematobium* showed no statistically significant association (χ^2=2.596, df=1, p=0.273). Higher prevalence of 81.8% was found in pupils with painful urination when compared with the prevalence of 76.9% in pupils who do not have painful urination (Table 4.3).

Abdominal pains as symptoms in relation to *Schistosoma haematobium* showed no statistically significant association (χ^2=2.596, df=1, p=0.273). Higher prevalence of 23% was recorded among pupils with abdominal pains when compared with the prevalence of 17.8% observed among pupils that do not have abdominal pains (Table 4.3). There was no significant association between urge to urinate and the prevalence of *Schistosoma haematobium* (χ^2=0.223, df=1, p=0.895). Higher prevalence of 20.6% was observed among pupils that do not feel the urge to urinate when compared with the prevalence of 20.3% of those who feel the urge to urinate (Table 4.3).

Nausea as symptoms in relation to *Schistosoma haematobium* infection revealed no significant association (χ^2=0.711, df=1, p=0.399). Higher prevalence of 21.6% was recorded among pupils that have nausea when compared with the prevalence of 18.5 % observed among pupils that do not have nausea. There is no significant association between loss of Appetite and the prevalence of *Schistosoma haematobium* (χ^2=0.626, df=1, p=0.871). Higher prevalence of 20.6% was observed among pupils with loss of appetite when compared with the prevalence of 20.0% observed in pupils without those loss of appetite (Table 4.3).

Table 4.3: Distribution of *Schistosoma haematobium* in relation to Symptoms

Symptoms	No Examined	No Positive (%)	χ^2	Odds Ratio (95% CI)	p-value
Painful Urination					
Yes	229	53(23.1)	1.920	0.787(0.561-1.105)	0.166
No	291	53(18.2)			
Abdominal pains					
Yes	256	59(23.0)	2.596		0.273
No	264	47(17.8)			
Frequency					
Yes	311	63(20.3)	0.223		0.895
No	209	43(20.6)			
Nausea					
Yes	200	37(18.5)	0.711		0.399
No	320	69(21.6)			
Loss of Appetite					
Yes	335	69(20.6)	0.026		0.871
No	185	37(20.0)			

Key: No= Number, χ^2=Chi-Square,

4.4 Biochemical Characterization of *Escherichia coli*

The biochemical characteristics and gram stain reaction of organism isolated is presented in table *Escherichia coli* is Gram negative rod, Indole positive, VP negative, methyl red positive and citrate utilization negative.

4.5 Age Factor and Gender related Prevalence of *Escherichia coli*

Age as a possible risk factor in relation to *E. coli* infection was also examined in this study and classified into four groups. The result showed no significant difference between age group and the prevalence of *Escherichia coli* infections (χ^2=2.015, df=3, p=0.569). All the subjects within age group of 15-19 years had the highest prevalence of 15-19% while those in age group 0-4 years had the least prevalence of 0.0% *Escherichia coli*. The analysis of data based on gender revealed a significant association with the prevalence of *Escherichia coli* (χ^2=0.002, p=0.968, df=1). The highest prevalence of 4.7% (9/193) was observed among the female subjects as compared to 4.6% (15/327) recorded among their male counterpart (Table 4.5).

4.6 Test of Association of Risk Factors in relation to *Escherichia coli* Infection.

The test of association between prevalence of *Escherichia coli* and source of water showed no significant association (χ^2=0.231, df=3, P=0.745). Highest prevalence of 11.6% was recorded among pupils who use stream/lakes as source of water. The least prevalence of 0.0% was recorded among pupils that use tap water (Table 4.6).

The analysis of data with respect to toilet type in relation to prevalence of *Escherichia coli* revealed no significant association (χ^2=0.231 df=3, P=0.999). Highest prevalence of 5.0% was recorded among pupils that defecate beside the streams and the least prevalence of 4.4% was recorded among pupils that use water system (Table 4.6).

Circumcision as a risk factor in relation to *Escherichia coli* infection revealed no significant association (χ^2=0.548 df=1, *P*=0.303). Highest prevalence of 88.9% was observed among pupils who are not circumcised compared to 2.6% of pupils that are circumcised. Swimming in relation to the prevalence of *Escherichia coli* revealed no significant association (χ^2=0.165 df=1, *P*=0.648). Highest prevalence of 5.0% was observed among pupils that swim in streams when compared to4.2 % of pupils who do not swim. Highest prevalence of 5.3% was observed among pupils who wash in streams when compared to the prevalence of 3.7% of pupils that wash in streams. There was no significant association observed (χ^2=0.796 df=1, *P*=0.372) (Table 4.6).

Farming in marshy areas as a factor in relation to *Escherichia coli* infection show no significant association (χ^2=0.222 df=1, *P*=0.638). Highest prevalence of 5.2% was recorded among pupils whodo not farm in marshy area when compared to the prevalence of 4.0% among those that who farm in marshy areas (Table 4.6).

Table 4.5 Distribution of *Escherichia coli* in relation to Age and Gender

Factor	No Examined	No Positive (%)	χ^2	Odds Ratio (95% CI)	p-value
Age (Years)					
0-4	5	0(0.0)			
5-9	208	9(4.3)	2.105	1.982(1.543-3.128)	0.569
10-14	289	13(4.5)			
15-19	18	2(11.1)			
Gender					
Male	327	15(4.6)	0.002	1.765(1.567-2.101)	0.968
Female	193	9(4.7)			

Key: No= Number, χ^2=Chi-Square,

Table 4.6 Distribution of *Escherichia coli* in Relation to Some Risk Factors

Risk factors	No Examined	No Positive (%)	χ^2	Odds Ratio (95 CI)	p-value
Source of water					
Tap	82	0(0.0)			
Borehole	128	2(1.6)	0.231		0.745
Well	198	9(4.5)			
Stream/lake	112	13(11.6)			
Toilet type					
Water system	91	4(4.4)	0.021		0.999
Open field	175	8(4.6)			
Pit latrine	234	11(4.7)			
Beside thes treams	20	1(5.0)			
Circumcision					
Yes	309	8(5.2)	0.548	1.366(0.595-3.133)	0.303
No	18	16(88.9)			
Swimming in Streams					
Yes	281	14(5.0)	0.165	1.005 (0.459-2.202)	0.684
No	239	10(4.3)			
Washing in Streams					
Yes	301	16(5.3)	0.796	1.455(0.634-3.339)	0.372
No	219	8(3.7)			
Farming Marshy Areas					
Yes	250	10(4.0)	0.222	0.705(0.314-1.583)	0.638
No	270	14(5.2)			

Key: No= Number, χ^2=Chi-Square

4.7 Test of Association of Symptoms in relation to *Escherichia coli* Infection.

Painful urination as a symptoms in relation to *E.coli* infection showed no statistically significant association (χ^2=2.596, df=1, p=0.273). Higher prevalence of 95.5 was found in pupils with painful urination when compared with the prevalence of 95.2% in pupils that did not present painful urination (Table 4.7).

Abdominal pains as symptoms in relation to *Escherichia coli* revealed no significant association (χ^2=0.705, df=1, P=0.303). Highest prevalence of 5.4% was recorded among pupils with abdominal pains when compared with the prevalence of 3.8% observed among pupils with no abdominal pains. There is no significant association between urge to urinate and the prevalence of *Escherichia coli* (χ^2=0.403, df=1, P=0.817). Highest prevalence of 5.3% was observed among pupils that do not feel urge to urinate when compared with the prevalence of 4.2% of those that feel the urge to urinate (Table 4.7).

Nausea as symptoms in relation to *Escherichia coli* revealed no significant association (χ^2=0.109, df=1, P=0.871). Highest prevalence of 5.0% was recorded among pupils with nausea when compared with the co-infection rate of 4.4% observed among pupils without nausea. There is no significant association between urge to urinate and the prevalence of co-infection rate (χ^2=0.407, df=1, P=0.523). Highest prevalence of 5.4% was observed among pupils that do not have good appetite when compared with the co-infection rate of 4.2% of those that have good appetite (Table 4.7).

4.7 Distribution of *Escherichia coli* in Relation to Some Clinical Symptoms

Symptoms	No Examined	No Positive (%)	χ^2	Odds Ratio	p-value
Painful Urination					
Yes	229	15(4.5)	0.436	1.312(0.585-2.943)	0.509
No	291	9(4.8)			
Abdominal pains					
Yes	256	14(5.4)	0.705	0.984(0.342-1.106)	0.303
No	264	10(3.8)			
Frequency					
Yes	311	13(4.2)	0.403	1.456(1.345-3.167)	0.817
No	209	11(5.3)			
Nausea					
Yes	200	10(5.0)	0.109	1.017(1.432-2.010)	0.741
No	320	14(4.4)			
Loss of Apetite					
Yes	335	14(4.2)	0.407	1.289(1.002-1.987)	0.523
No	185	10(5.4)			
Total					

Key: No= Number, χ^2=Chi-Square,

4.8 Age Factor and Gender related to Coinfection of *Schistosoma haematobium* with *Escherichia coli*

Age in relation to co-infection was also examined in this study and classified into four groups. The result shows no significant difference between age group and the co-infection (χ^2=2.015, df=3, p=0.569) (Table 4.8). All the subjects within age group of 15-19 years had the highest co-infection of 15-19% while those in age group 0-4 years had the least co-infection rate of 0.0%. The analysis of data based on gender revealed a significant association with the co-infection (χ^2=0.002, p=0.968, df=1) (Table 4.8). The highest co-infection 4.7(9/193) was observed among the female subjects as compared to 4.6 (15/327) recorded among their male counterpart (Table 4.8).

4.9 Test of Association of Risk Factors in relation to Coinfectioin of *Schistosoma haematobium* with *Escherichia coli*

The test of association between co-infection and source of water showed no significant association (χ^2=0.231, df=3, P=0.745). Highest co-infection rate of 11.6% was observed among pupils that use stream/lakes as source of water. The least co-infection of 0.0% was recorded among pupils that use tap water (Table 4.9).

The analysis of data with respect to toilet type in relation to co-infection of *Escherichia coli* with *Schistosoma haematobium* revealed no significant association (χ^2=0.231 df=3, P=0.999). Highest co-infection of 5.0% was recorded among pupils that defecate beside the streams and the least prevalence of 4.4% was recorded among pupils that use water system (Table 4.9).

Circumcision as a risk factor in relation to co-infection raterevealed no significant association (χ^2=0.548 df=1, P=0.303). Highest co-infection of 88.9% was observed among pupils that are

not circumcised compared to 2.6% of pupils that are circumcised. Swimming in relation to co-infection rate revealed significant no association (χ^2=0.165 df=1, *P*=0.648). Co-infection of 5.0% was observed among pupils that swim in streams when compared to the co-infection rate of 4.2 % of pupils that do not swim. Highest co-infection of 5.3% was observed among pupils that wash in streams when compared 5 to the co-infection of 3.7% of pupils that do not wash in streams. There was no significant association observed (χ^2=0.796 df=1, *P*=0.372) (Table 4.9).

Farming in marshy areas as a factor in relation to co-infection show no significant association (χ^2=0.222 df=1, *P*=0.638). Highest co-infection rateof 5.2% was recorded among pupils that do not farm in marshy area when compared to the co-infection of 4.0% those that farm in marshy areas (Table 4.9).

Table 4.8 Distribution of Co-infection in relation to Age and Gender

Factor	No Examined	No Positive (%)	χ^2	Odds Ratio (95% CI)	*p*-value
Age (Years)					
0-4	5	0(0.0)			
5-9	208	9(4.3)	2.105	1.982(1.543-3.128)	0.569
10-14	289	13(4.5)			
15-19	18	2(11.1)			
Gender					
Male	327	15(4.6)	0.002	1.765(1.567-2.101)	0.968
Female	193	9(4.7)			

Key: No= Number, χ^2=Chi-Square,

Table 4.9Distribution of Co-infection in Relation to Some Risk Factors

Risk factors	No Examined	No Positive (%)	χ^2	Odds Ratio(95% CI)	p-value
Source of water					
Tap	82	0(0.0)			
Borehole	128	2(1.6)	0.231		0.745
Well	198	9(4.5)			
Stream/lake	112	13(11.6)			
Toilet type					
Water system	91	4(4.4)	0.021		0.999
Open field	175	8(4.6)			
Pit latrine	234	11(4.7)			
Streams	20	1(5.0)			
Circumcision					
Yes	309	8(5.2)	0.548	1.366(0.595-3.133)	0.303
No	18	16(88.9)			
Swimming in Streams					
Yes	281	14(5.0)	0.165	1.005 (0.459-2.202)	0.684
No	239	10(4.3)			
Washing in Streams					
Yes	301	16(5.3)	0.796	1.455(0.634-3.339)	0.372
No	219	8(3.7)			
Marshy Areas Farming					
Yes	250	10(4.0)	0.222	0.705(0.314-1.583)	0.638
No	270	14(5.2)			
Total					

Key: No= Number, χ^2=Chi-Square,

4.10 Test of Association of Symptoms Inrelation to Coinfectioin of *Schistosoma haematobium* with *Escherichia coli*

There was no significant association between painful urination andco-infection (χ^2=0.436, df=1, *P*=0.509). Higher co-infectionof 4.8% was recorded among those pupils that do not have painful urination when compared to the co-infection of 4.5% of pupils with painful urination. Abdominal pains as symptoms in relation to co-infection revealed no significant association (χ^2=0.705, df=1, *P*=0.703). Highest co-infection of 5.4% was recorded among pupils with abdominal pains when compared with the co-infection of 3.8% observed among pupils with no abdominal pains. There is no significant association between urge to urinate and the prevalence of co-infection rate (χ^2=0.403, df=1, *P*=0.817). Highest co-infection of 5.3% was observed among pupils that do not feel the urge to urinate when compared with co-infection of 4.2% of those that feel the urge to urinate.

Nausea as symptoms in relation to co-infection revealed no significant association (χ^2=0.109, df=1, *P*=0.871). Highest co-infection rate of 5.0% was recorded among pupils with nausea when compared with the co-infection of 4.4% observed among pupils without nausea. There is no significant association between urge to urinate and co-infection (χ^2=0.407, df=1, *P*=0.523). Highest co-infection of 5.4% was observed among pupils that do not have good appetite when compared with the co-infection rate of 4.2% of those that had good appetite

Table 4.10; Distribution of Co-infection in Relation to Some Clinical Symptoms

Symptoms	No Examined	No Positive (%)	χ^2	Odds Ratio (95% CI)	p-value
Painful Urination					
Yes	229	15(4.5)	0.436	1.312(0.585-2.943)	0.509
No	291	9(4.8)			
Abdominal pains					
Yes	256	14(5.4)	0.705	0.984(0.342-1.106)	0.703
No	264	10(3.8)			
Frequency					
Yes	311	13(4.2)	0.403	1.456(1.345-3.167)	0.817
No	209	11(5.3)			
Nausea					
Yes	200	10(5.0)	0.109	1.017(1.432-2.010)	0.741
No	320	14(4.4)			
Loss of Appetite					
Yes	335	14(4.2)	0.407	1.289(1.002-1.987)	0.523
No	185	10(5.4)			
Total					

Key: No= Number, χ^2=Chi-Square,

Table4.11 Biochemical Characterisation and Identification of *E.coli* Using Microgen Identification Kit.

	Lys	Orn	H_2S	Glu	Mann	Xyl	ONPG	Indole	Urease	VP	Citrate	TDA	%	OC	ORG
Z7	+	+	-	+	+	+	+	+	-	-	+	-	84.29	6762	*E.coli*
Z34	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
Z14	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
S1	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
S12	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
S21	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
S50	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
S51	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
S7	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
S46	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
G21	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
G97	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
G23	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
G18	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*

G8	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
G111	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
P5	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
P59	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
P36	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
P43	+	+	-	+	+	+	+	+	-	-	+	-	84.29	6762	*E.coli*
P78	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
P18	+	-	-	+	+	+	+	+	-	-	-	-	85.00	4760	*E.coli*
P90	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
P122	+	+	-	+	+	+	+	+	-	-	-	-	97.11	6760	*E.coli*
Z10	+	-	-	+	+	+	+	-	+	+	+	-	67.00	4756	*K. pneumonia*
S11	+	-	-	+	+	+	+	+	-	-	+	-	69.55	4762	*K. oxytoca*
P5	+	-	-	+	+	+	+	-	+	-	+	-	65.20	4752	*K. pneumonia*
P10	+	-	-	+	+	+	+	+	-	-	+	-	69.55	4762	*K. oxytoca*

Key; Lys=Lysine, Orn=Ornithine, Glu=Glucose, Man=Mannitol, Xyl=Xylose, V*P*=Voges proskauer, OC= Octal Code, ORG=Organism

4.11 Prevalence of Schistosoma haematobium, *Escherichia coli* and Coinfection

A total of 520 urine samples were collected from schools in Pambegua, Giwa, Zaria and Sabon-gari and examined for the presence of ova of *Schistosoma haematobium* and *Escherichia coli*. The prevalence rate of *Schistosoma haematobium* among the study population in this study was found to be 20.4%, while that of *Escherichia coli* was 4.6% and co-infection was 4.6% (Figure 4.1).

4.12 Prevalence of Schistosoma haematobium, *Escherichia coli* and Coinfection Inrelation to Sampling Locations.

The analysis of data with respect to sampling locations showed no significant association with prevalence of *Schistosoma haematobium* infection (χ^2=6.493, df=3, p=0.09). Among the four sampling locations selected in this study, Zaria local government area had the highest prevalence of 26.9% (35/130) for *S.haematobium* infection when compared to other locations (Table 4.12). The analysis of data based location revealed that no significant association with prevalence of *Escherichia coli* (χ^2=2.446, df=3, p=4.85). Highest prevalence of 6.2% (8/130) was observed in Kubau local government when compared with other locations used in this study. Least prevalence of 2.3% (3/130) was recorded in Zaria local government. The analysis of data based location revealed that no significant association with prevalence of co-infection (χ^2=2.446, df=3, p=4.85). Highest co-infection of 6.2% (8/130) was observed in Kubau local government when compared with other locations used in this study. Co-infection of 2.3% (3/130) was recorded in Zaria local government.

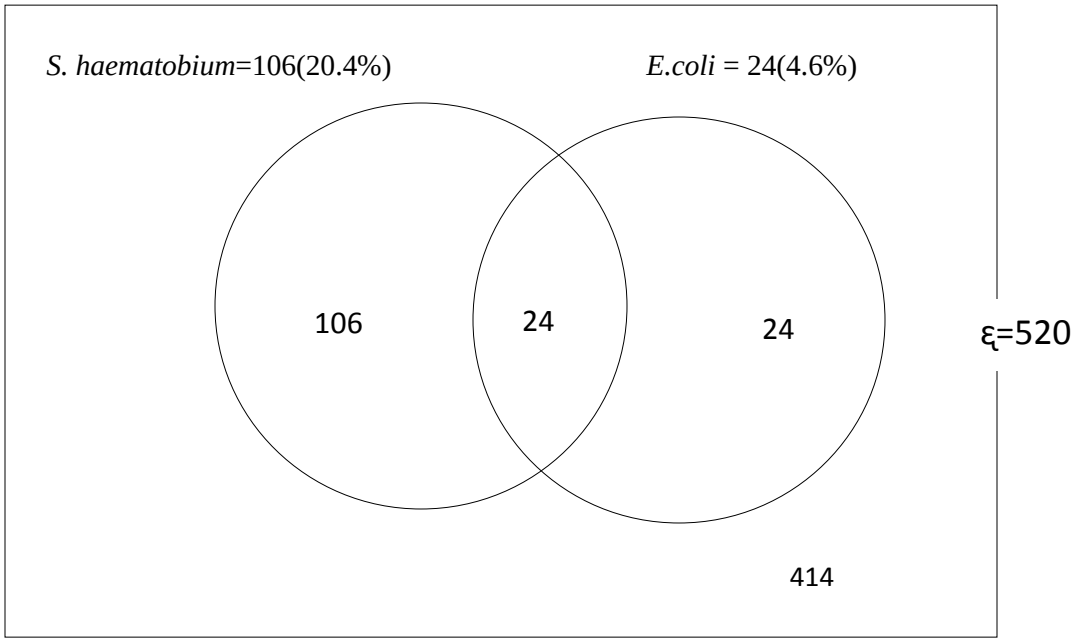

Figure4.1: Prevalence of *S. haematobium, Escherichia coli* and Co-infection.

Table 4.12; Distribution of *Schistosoma haematobium, Escherichia coli* and Co-infection in relation to Location

Location	*S haematobium*				*E. coli*			Co-infection		
	No Examined	No Positive (%)	χ^2	*p*-value	No Positive (%)	χ^2	*p*-value	No Positive (%)	χ^2	*p*-value
LEA Z	130	19(14.6)			3(2.3)			3(2.3)		
LEA J	130	35(26.9)			7(5.4)			7(5.4)		
LEA G	130	24(18.5)	6.493	0.09	6(4.6)	2.446	4.85	6(4.6)	2.446	4.85
LEA P	130	28(21.5)			8(6.2)			8(6.2)		
Total	**520**	**106**			**24**			**24**		

Key: No= Number, χ^2=Chi-Square

4.13 Antibiotic Suscebiltty of *Escherichia coli* Isolated From Urine of Primary School pupils

Table 4.13 showed the antimiucrobial susceptibility patterns of *E. coli* isolates from urine samples. Gentmicin had higher susceptibility of 100% when compared with to Ciprofloxacillin, Amoxycillin, Chloramphenicol, Tetracycline, Sulphamethoxazole-trimethoprim, Nalixidic acid, Ampicillin, Doxycycline and Nitrofurantoin with the susceptibility of 50%, 20.8%, 50%, 37.5%, 30.8%, 87.5%, 8.3%, 45.8% and 7%. However amplicillin had higher resistant of 91.7% when compared to Ciprofloxacillin, Amoxycillin Gentamicin, Chloramphenicol, Tetracycline, Sulphamethoxazole-trimethoprim, Nalixidic acid, Doxycycline and Nitrofurantoin with the resistance 50%, 79.2%, 37.2%, 62.5%, 79.2%, 12.5% and 25%.

4.14 Multiple Antibiotic Resistance Phenotype of *Escherichia coli* Isolated from Urine Sample of Primary School Pupils.

Table 4.14 showed the predominant MAR phenotype of *Escherichia coli* isolated from urine of primary school children multiple antibiotics resisitance indices. The predominant multiple antibiotic resistance phenotype ranges 2-6 antibiotics.

4.15 Multiple Antibiotic Resistance Indices of *Escherichia coli* Isolated from Urine Sample of Primary School Pupils.

Fig 4.2 showed about 33% of the isolates had MAR index of 0.8, 29% of the isolates had MAR index of 0.7, 25% of the isolates had MAR Index 0.6 while 8% and 4% had MAR OF 0.2 and 0.1 respectively.

Table 4.13; Antimicrobial susceptibility patterns of *E. coli* Isolates from urine samples.

Antibiotics	Symbol	Disc content (µg)	Resistant (%)	Intermediate (%)	Susceptible (%)
Ciprofloxacin(10)	CIP	10	12(50.0)	0(0.0)	12(50.0)
Amoxyicillin	AML	10	19(79.2)	0(0.0)	5(20.8)
Gentamicin	GN	30	0(0.0)	0(0.0)	24(100.0)
Chloramphenicol	C	30	9(37.2)	3(12.5)	12(50.0)
Tetracycline	TE	30	15(62.5)	0(0.0)	9(37.5)
Sulphamethoxazole-trimethoprim	SXT	25	19(79.2)	0(0.0)	5(20.8)
Nalidixic acid	NA	30	3(12.5)	0(0.0)	21(87.5)
Ampicillin	AMP	10	22(91.7)	3(12.5)	2(8.3)
Doxycycline	DOX	30	7(29.2)	6(25.0)	11(45.8)
Nitofurantoin	F	30	5(20.8)	1(4.2)	18(7)

Table 4.14; Predominant Multiple Antibiotic Resistance Phenotype for *Escherichia coli* Isolated from Urinary Tract.

Number of antibiotic combination	Number of isolates (%) with pattern	Resistance phenotype
2	1(4)	AMP, AMOX
3	5(21)	SXT,AMP, AMOX,
	2(8)	SXT, AMOX,DOX
	1(4)	AMP, TE, DOX
4	1(4)	CIP,F,SXT,C
	1(4)	CIP,AMP,NA,AMOX
	1(4)	CIP, F, TE, AMOX
	3(13)	SXT,AMP,TE,AMOX
5	2(8)	CIP,F,SXT,TE,C
	1(4)	SXT,AMP,NA,TE,AMOX
	1(4)	CIP,SXT,AMP,TE,AMOX
	1(4)	SXT,AMP,TE,AMOX,DOX
	1(4)	CIP,SXT,AMP,AMOX,DOX
	1(4)	CIP,SXT,AMP,TE,AMOX
6	2(8.3)	CIP,NA,TE,AMOX,DOX,C

KEY: F=Nitrofurantoin, C=Chloramphenicol, CI*P*=Ciprofloxacin, TE=Tetracycline, SXT=Trimethoprim-sulfamethoxazole, DOX=doxycycline NA=Nalixidic acid, AMOX=Amoxicillin

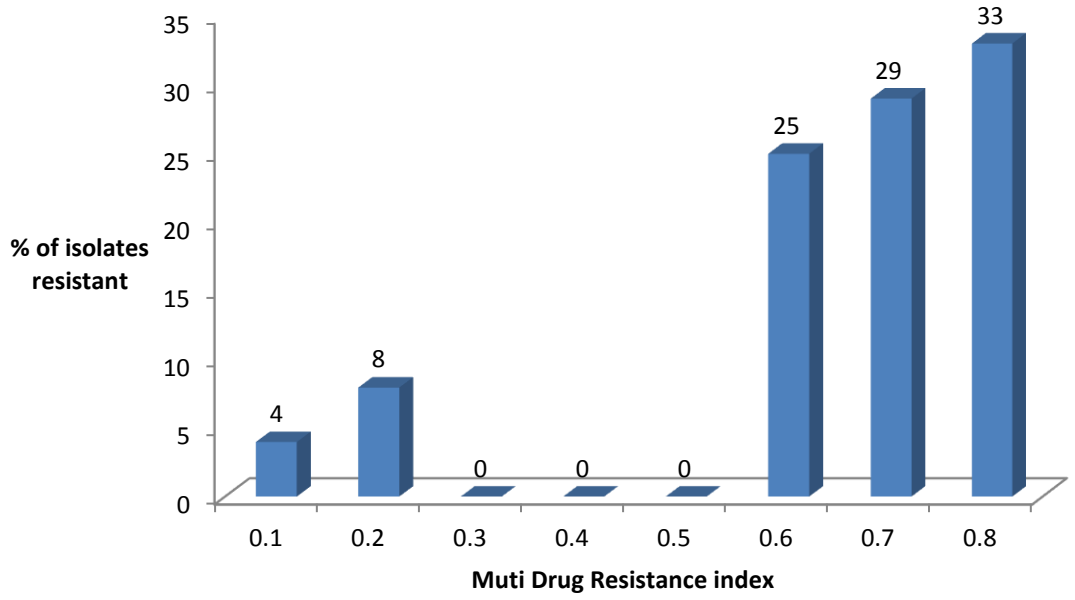

Figure 4.2: Multiple Antibiotics Resistance Indices and the Percentage of IsolatesInvolved.

***NOTE; MARI ≥0.2 Depicts the source as high risk source.**

CHAPTER FIVE

5.0 DISCUSSION

Urinary schistosomiasis is a chronic insidious and debilitating trematode infection which reduces productivity and affects the development of the young. Urinary tract infection defines a condition in which the urinary tract is invaded by pathogens. However, several studies have implicated bacteriuria co-infection with urinary schistosomiasis

In this study, the high prevalence of urinary schistosomiasis among pupils age group 10-14 years could be explained due to the fact that children within this age group are more adventurous and engage in indiscriminate water contact-activities. These children sometimes urinate or even defecate into the water bodies thereby voiding the eggs of shistosomes for its propagation. This result is similar to the findings of Ekejindu *et al.* (2002), Adeyaba and Ojeaga, (2002), and Morenike *et al.* (2011). However this result contrasts the report of Ukpai and Ezeike, (2002) from Anambara State respectively, from which pupils within the age group 5-10years were most infected.

Findings from this study on age distribution of the urinary schistosomiasis also disagreed with the study of Ugbomiko *et al.* (2010) in south western Nigeria where the peak of infection was observed among children within 13-15 years of age. The variation between prevalence of urinary schistosomiasis within the age group from Zaria may be attributed to the natural environment, water contact, and available water influencing snail breeding in different ecological areas.

Generally, male pupils more were infected with *Schistosoma haematobium* than the female pupils. This is because the male pupils actively participate in swimming activities during and after school hours. This practice exposes the male pupils to high risk of infection since the level of exposure to cercariae of schistosomes in such water bodies may be frequent. Although, the female pupils may engage in water fetching and washing beside the streams/water bodies, their exposure is not as those of the boys who may also assist in fetching water (Ishaleku *et al.,* 2012).

Pupils who use streams for bathing were more infected with *Schistosoma haematobium* than pupils that don't swim. Also, from this study pupils who defecated in bushes/open field were more infected than those that use latrines. This agrees with report of Ishaleku *et al.* (2012). This means the usage of modern toilet facilities helps in reducing the chances of pupils sneaking to bath rivers/streams in the name of going for defecation. However, shortage of portable water supply remains a major problem. Although the Government had approved various projects to counter this challenge, yet the problem persists. This has aggravated the problem of schistosomiasis as more people resort to water collection from unsafe sources such as streams and water bodies. Lack of portable water and proper toilet system in the study area might have expose people to the risk of infection.

In this study, pupils with painful urination were more infected with urinary schistosomiasis, similarly pupils with abdominal pains were more infected. This may be due to the fact that urinary schistosomiasis causes genital lesions, vaginal bleeding. Pain during sexual intercourse and nodules in the vulva in female and in male can induce pathology of the seminal vesicles, prostate and other organs which may also have other long-term irreversible consequences, including infertility (WHO, 2015).

The result in this study revealed high prevalence of *E. coli* in female pupils. This may be due to the fact that females are more prone to bacterial invasion and colonization of their vaginal and urethral openings; the structure and location of these opening are ineffective in preventing bacterial entry. Also unhygienic method of wiping the anus from back to front aids the transfer of faecal borne pathogens into the vulva and the vagina (Warren *et al.,* 1999; Arul *et al.,* 2012; Isa *et al.,* 2013; Allamin *et al.,* 2015; Bishop and Shehu, 2016). The result is in accordance with studies of Aiyegoro *et al.,* 2007; Alo *et al.,* 2012; Allamin *et al,* 2015) who conducted researches on the prevalence of *Escherichia coli* among school children,

The prevalence of *E. coli* was higher in pupils that swim in streams than those does that do not swim in stream. This could also be as a result of faecal contamination that favours the growth of the organism. The high prevlance of *E. coli* in the uncircumcised pupils could be due to the presence of the foreskin which can harbour bacteria that can subsequently invade the urinary tract.In this study some pupils infected with *E. coli* did not present symptoms such as painful urination, abdominal pain and frequency. This indicates asymptomatic infection that may not be easily detected.

The 20.4% prevalence of *Schistosoma haematobium* in this study, is similar to the prevalence of 19.8%, 24.3% and 20%, reported in Cross river, Borno and Yobe States respectively (Opara *et al.,* 2007; Biu *et al.* 2009*;* Biu *et al.,* 2012). However, this prevalence is lower than reported 30.5%, 41.6%, 58.1%, 71.8%, 79.4%, 55%, 34.1% and 48.3% reported in Nassarawa, Kano, Abeokuta, Ogun, Ebonyi, Yobe, Enugu and Ebonyi state respectively (Vander werf *et al.,* 2003; Faruk *et al.,* 2009; Uneke *et al.,* 2009; Ekpo *et al.,* 2010; Isahleku *et al.,* 2012; Ossai *et al.,* 2014; Dagona, 2014). However, Ugochukwu *et al.* (2013) reported a lower prevalence of 15.7% in Anambra State when compared to the prevalence recorded in this study. The differences in the

overall prevalence rates may be influenced by peculiar ecological characteristics and level of contact of individuals with water bodies and the degree of exposure to infective cercariae of *Schistosoma haematobium* (Dangona, 2014).

The co-infection of *Schistosoma haematobium* and *E. coli* in this study disagreed with result of of ifeanyi *et al.,* 2009 who reported prevalence of 31.3%. However, there is scarcity of information regarding the co-infection of *Schistosoma haematobium* with *Escherichia coli*. Most other works however have been conducted on *Schistosoma haematobium* and *Plasmodium* spp (Amoani *et al.,* 2015; Deribrew *et al.,* 2013), *Schistosoma haematobium* and viruses (Secor, 2006) and *Schistosoma masoni* and *Salmonella* species (Modebe *et al.,* 2014).

The prevalence 4.6% for *E. coli*in this study is contrary to prevalence reported in some studies by Ejaz *et al.* (2006), Aiyegoro *et al.* (2007), Abubakar (2009); Okonko *et al.* (2009), Jombo *et al.* (2010), Alo *et al.* (2012), Elo-illo *et al.* (2013) and Ogefere and Oluka (2013), who reported prevalence of 37%, 24.5%, 42.1%, 36.4%, 16%, 15.6% and 30.77% respectively. The low prevalence of *E. coli* recordedin this study is not far fetch; previous studies and enlightenment programme have been conducted in the study area. Variation in this study could be due to ecological and environmental factors as well as socio-economic factors (Okonko *et al.,* 2009).

The antibiotic susceptibility pattern of *E. coli* isolated in this study showed that Gentamicin(30µg) is an effective antibiotics. This result is similar to Bigwan and Elijah (2013), Ayoade *et al.,* (2013) and Allamin *et al.,* (2015). Also Nalixidic acid (30µg) and Nitrofurantoin (30µg) were considerably effective agreeing with the study of Nwas, (2014) and Sunil *et al.,* (2014). However this result disagrees with the study of Mohammmed *et al.* (2007) who reported

40% resistance to Gentamicin (30µg). Gentamicin(30µg) which is intravenously administered (Ehinmidu *et al.,* 2003; Bishop and Shehu, 2016) hence helps to prevent indiscriminate use.

The resistance of *E. coli* to Tetracycline (30µg) and Doxycycline (30µg) observed in this study is similar to the study of Akingbade *et al*. (2013). The resistance of Ampicillin(10µg) had reported by other researchers in different parts of Nigeria and other parts of world (Gupta *et al.,* 2007; Amin *et al.,* 2009; Manjunath *et al.,* 2011, Ayoade *et al.,* 2013; Ogefere and Oluka, 2013; Guatan and Pokhrel, 2012). The high resistance of *E. coli* to these antibiotics observed in this study may reflect the fact that they are the most common antibiotics taken without proper prescription. The result obtained is similar to those obtained from Jos, Lafia, Abuja, Enugu, Porthaccourt, Lagos and Ibadan. (Ako-nai *et al* 2005 ; Nwanze *et al.,* 2007; Kolawole *et al.,* 2009; Okesola and Oni, 2009).

The multiple antibiotic index (MAR) is a tool that reveals the spread of bacteria resistance in a given population (Ehinmidu, 2003). A MAR index $\geq$0.2 implies that the *E. coli* isolates were obtained from an environment where several antibiotics were abused. The MAR index obtained in this in this study is a possible indication that a large proportion of the isolates have been exposed to several antibiotics.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Schistosoma haematobium and *Escherichia coli* infections among primary school pupils is a major health concerns. In this study the coinfection of *Schistosoma haematobium* with *E.coli* was 4.6%. The prevalence of *Schistosoma haematobium* and*E. coli* were found to be 20.4% and 4.6% respectively. This study shows that age, gender, source of water and swimming in streams are factor responsible for urinary schistosomiasis.

The prevalence of *Schistosoma haematobium* was significantly high in the boys than in the girls. However, prevalence of *Escherichia coli* was higher in girls than the boys. The coinfection of *Schistosoma haematobium* with *E.coli* was higher in Kubau but the occurence of *Schistosoma haematobium* was higher among pupils from Sabon-gari area.

All the *Escherichia coli* isolates were susceptible to the Gentamicin and some of the isolates were resistant to Ampicillin, Amoxicillin, Trimethoprim-sulfamethoxazole, Nalixidic acid, Nitrofurantoin, Tetracycline, Doxycycline and Chloramphenicol.

6.2 Recommendations

1. The result obtained in this study clearly established the need for control strategies such as disease surveillance and chemotherapy in the study area by the Ministry of Health.
2. There is need for provision of safe water supply for households as well as safe recreational water sources for children by the government.

3. It will be of great value to embark on extensive public health enlightenment programmes on information about the disease transmission and the need of investigation before treatment.
4. There is need to enact and enforce laws to guard against any form of indiscriminate treatment of patients without proper diagnosis or abuse of drug by any individual.
5. For mortality, morbidity and transmission due *Schistosoma haematobium* to be effectively control, there is need for guidance and monitoring by agencies such as WHO responsible for the control of tropical diseases.
6. For most endemic countries, the control of urinary schistosomiasis has been a challenging task. Despite considerable progress in pharmacological, epidemiological and clinical research coupled with concerted efforts, urinary schistosomiasis remains the major health concern in Nigeria. Rather than pay lip service to the control and eradication of the disease, government must show consistency politically and socially in implementing the concerted strategy.

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APPENDICES

Appendix I: Questionnaire

DEPARTMENT OF MICROBIOLOGY
FACULTY OF SCIENCE
AHAMDU BELLO UNIVERSITY, ZARIA

Coinfection of *Schistosoma Haematobium* and *Escherichia coli* among Children in Some Selected Secondary, Zaria Kaduna State

BIODATA

1. **Sex: Male [ ] Female [ ]**
2. **Age**

Risk factors

3. **Source of drinking water**
   (a) Tap [ ] (b) borehole [ ] (c) well [ ] (d) stream/lake [ ] (e)others [ ]

4. Type of toilet
(a) water cistern [ ] (b) open field [ ] (c) pit latrine [ ] (d) streams [ ] (e)other [ ]
5. Are you circumcised (a) Yes [ ] (b) No [ ]
6. Do you swim in streams (a) Yes [ ] (b) No [ ]
7. Do you wash in streams or use water from stream for laundry activities (a) Yes [ ] (b) No [ ]
8. Do you farm in Marshy areas (a) Yes [ ] (b) No [ ]
9. When you go streams/lake to swim do you often see snails around the water bodies (a) Yes [ ] (b) No [ ]

Symptoms

10. Do you feel pains when urinating? (a) Yes [ ] (b) No [ ]
11. Do you often feel abdominal pains? (a) Yes [ ] (b) No [ ]
12. Do you urinate frequently? (a) Yes [ ] (b) No [ ].
13. Do youn feel like vomiting (a) Yes [ ] (b) No [ ]
14.Do have loss of apetite? (a) Yes [ ] (b) No [ ]

Appendix II: Ethical Consent

MINISTRY OF HEALTH, KADUNA STATE

All Communication to be addressed to:
THE HON. COMMISSIONER
Quoting Reference and Date
Telephone: 234-248048
Website: ttp://www/moh.kd.gov.ng
Email: info@moh.kd.gov.ng

Independence Way.
P.M.B 2014
Kaduna
Kaduna State, Nigeria.

Our Ref: MOH/ADM/744/VOL.1/204 1th February, 2015

To:_____

Ministry of Health Research,
Ethical Clearance.

RE: Coinfection of Schistosoma Haematobium and Escherichia coli Among Children in Some Secondary Schools in Zaria, Kaduna State.

Name of Invesugator: - Balogun Adinoyi David

Date of Receipt of Application: - 18th November, 2014

Date of Ethical Approval: - 24th November, 2014

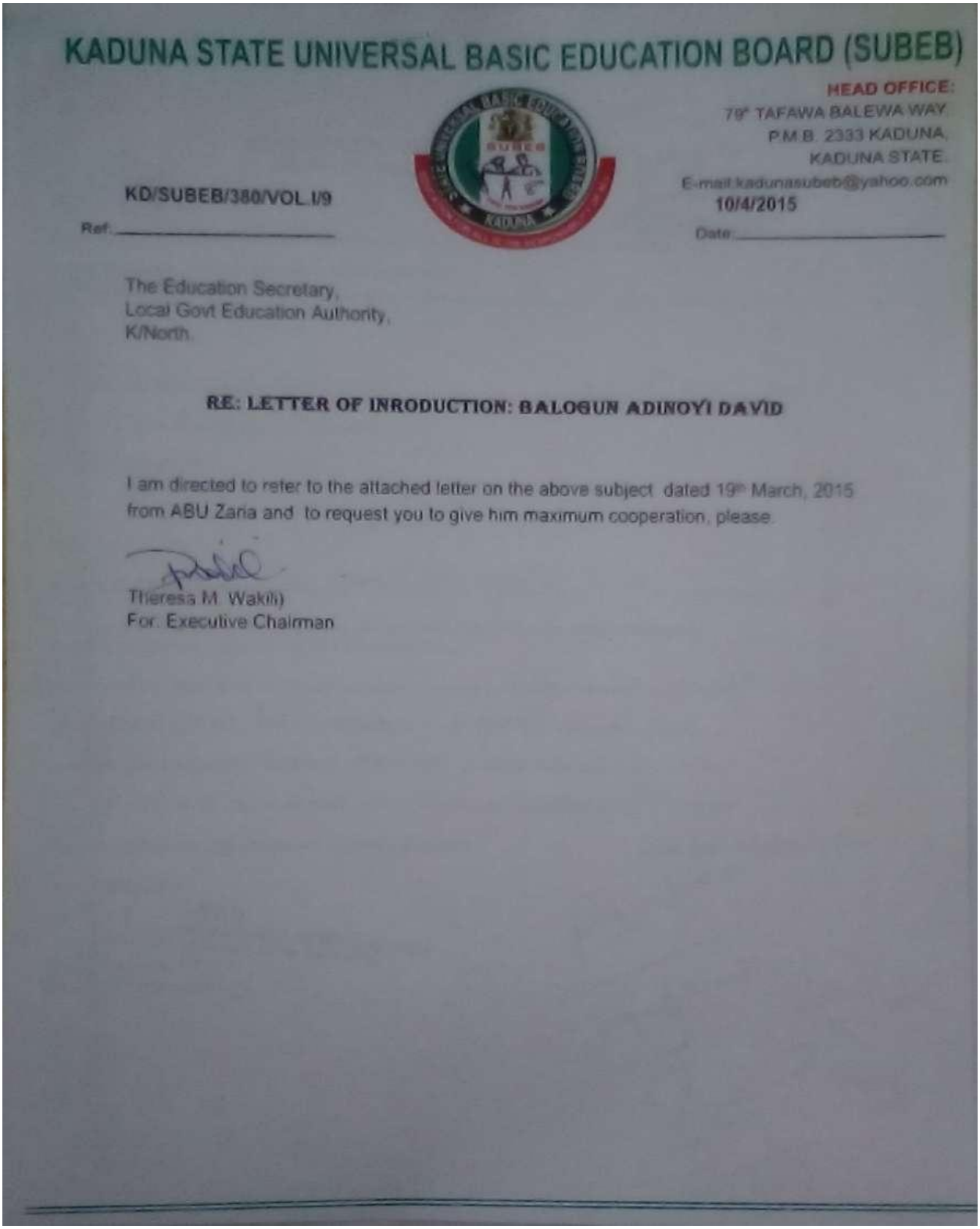
Research Period: - March to June, 2015

You are kindly to give researcher maximum cooperation during the period of Research please

However it is mandatory to submit findir gs to the ministry please.

F.A. Kurah (Mrs)
Secretary to Research Committee

Appendix III: Letter of Introduction



KADUNA STATE UNIVERSAL BASIC EDUCATION BOARD (SUBEB)

HEAD OFFICE:
79th TAFAWA BALEWA WAY.
P.M.B. 2333 KADUNA,
KADUNA STATE.
E-mail:kadunasubeb@yahoo.com

KD/SUBEB/380/VOL.I/9
Ref: _____

10/4/2015
Date: _____

The Education Secretary,
Local Govt Education Authority,
K/North.

RE: LETTER OF INRODUCTION: BALOGUN ADINOYI DAVID

I am directed to refer to the attached letter on the above subject dated 19th March, 2015 from ABU Zaria and to request you to give him maximum cooperation, please.

Thieresa M. Wakili
For. Executive Chairman

Appendix IV

LEA J= LEA Primary Sch Ool Jama'a Zango Samaru. Sabon-Gari Local Government.

LEA GW= LEA Primary School Gwariwoje Zaria Local Government

LEA G= LEA Primary School Giwa Giwa Local Government

LEA P= LEA Primary School Pambegua Kubau Local Government