World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

PREVALENCE OF ENTERIC PATHOGENS ON THE FINGER NAILS OF PRIMARY SCHOOL PUPILS IN CALABAR, CROSS RIVER STATE

Ukpong S.E. [1,*], Stanley J.C. [2], Daokoru-Olukole C. [3], Ukanwa C.C [1], Pondei J. O. [4] and Stanley H.O. [1,5]

[1] Department of Microbiology, Faculty of Science, Madonna University, Elele, Rivers State.
[2] Department of Obstetrics and Child, Niger Delta University Teaching Hospital, Bayelsa State, Nigeria.
[3] Department of Microbiology, Bayelsa Medical University, Bayelsa State, Nigeria.
[4] Department of Microbiology, Faculty of Science, University Abuja, Federal Capital Territory, Nigeria.
[5] Department of Microbiology, Faculty of Science, University of Port Harcourt, Rivers State. Nigeria.
* Corresponding Author

ORCID Details
Susana Ekere Ukpong: https://orcid.org/0009-0001-5769-3819
Joshua Chinazaekpere Stanley: https://orcid.org/0009-0007-5972-2832

World Journal of Advanced Research and Reviews, 2026, 32(02), 804–811

Publication history: Received on 02 October 2026; revised on 08 November 2026; accepted on 10 November 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.32.2.2650

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ABSTRACT

Fingernails can harbour microorganisms obtained from the environment, faecal material, polluted surfaces and other sources. Among school pupils, poor fingernail hygiene such as lack of proper washing of hands and fingernails trimming may facilitate the transmission of pathogenic organisms through the faecal-oral route. This study investigated bacteria associated with fingernails of primary school pupils, with particular attention on enteric organisms of public-health importance. Fingernails samples were collected from eighty (80) pupils attending four primary schools in Calabar metropolis, Cross River State, Nigeria. Samples were collected using sterile cotton wool swabs moistened with physiological saline and examined using standard microbiological culture and biochemical identification procedures. The overall bacterial positivity was 81.3% (65/80), with the highest prevalence among pupils aged 5-7 years (89.66%), while the lowest prevalence was observed among children aged 11-13 years (73.33%). The organisms isolated include Escherichia coli (44.6%), followed by *Staphylococcus aureus* (16.92%), *Klebsiella spp.* (13.9%), *Coagulase-negative Staphylococcus* (10.77), *Shigella spp.* (7.69) *Salmonella spp. (4.62) and Proteus spp.* (1.53). Gender analyses indicated that Escherichia coli was the most frequently isolated organism among both males (40.00%) and females (48.57%). *Staphylococcus aureus* occurred in 16.67% of males and 20.00% of females, while *Klebsiella spp.* were more frequently among males (20.00%) than females (8.57%). However, the association between gender and bacterial isolates distribution was not statistically significant p>0.005. The virulence factors analysis revealed differences in the production of lipase, haemolytic activity, DNase, gelatinase and coagulase. *Staphylococcus aureus* demonstrated lipase, DNase, gelatinase and coagulase activities, with alpha haemolysis. *Salmonella specie and* Escherichia coli exhibited lipase production and gamma -haemolysis, while *Shigella spp.* demonstrated alpha-haemolysis, DNase, and gelatinase activities. *Proteus spp.* demonstrated lipase and gelatinase activities, together with beta haemolysis, whereas *Klebsiella pneumoniae* showed DNase activity. These results indicated that some isolated from the pupil's fingernails possessed extracellular enzymes activities and haemolytic features associated with their potential to cause infection. The overall investigations highlight the occurrence of bacterial contamination on the finger nails of school pupils and emphasize

the necessity of proper handwashing, regular fingernail hygiene, and improved sanitation in schools to minimize the potential transfer of bacterial pathogens.

Keywords: Enteric Pathogens, Fingernail Washings, Primary School Pupils, Gender, Virulence-Associated Characteristics, Calabar.

1 INTRODUCTION

Enteric pathogens are microorganisms capable of causing diseases of the gastrointestinal tract Janda, et al., (2021), proposed that enteric pathogens belong to the family Enterobacteriaceae, the family contained of a single genus Enterobacter which encompassed a variety of organisms that ferment glucose with the production of gas. Included in the genus Enterobacter were species of several genera currently recognized in the Enterobacteriaceae ;*Erwinia spp. Escherichia coli, Klebsiella spp. Proteus spp. Salmonella spp., Serratia spp., Shigella spp.* Riedel, et al., (2026) described the characteristics of Enterobacteriaceae; they are gram negative, oxidase negative, non-spore forming, non-acid fast straight rod shaped bacteria 0.3-6.0um, motility by peritrichous flagella, except for Tamela are non -motile, they are non-halophilic facultative anaerobes. Mostly they grow well between 22 and 35°C on peptone, meat extract and MacConkey media.

Transmission of these organisms commonly occurs through the oral-faceal route, particularly when contaminated hands come into contact with food, water, the mouth or other surfaces. The hands are an important pathway through which enteric microorganisms can move from contaminated faecal material, soil and environmental surfaces to susceptible individuals. A systematic review and meta-analysis described hands as an important route of enteric pathogen transmission because polluted hands can facilitate both direct hand-to-mouth exposure and indirect transmission through food, water and soil. Consequently, proper handwashing and fingernail hygiene are crucial measures for lowering the transmission of pathogenic microorganisms (World Health Organization [WHO], 2024).

Cantrell et al., (2023), discovered, the significance of hand transfer of pathogenic bacteria, which was attributed to the fact that physicians carried the agent of childbed fever (Group A beta hemolytic Streptococcus) on their hands. However, hand washing and disinfection to prevent spread of infection was not practiced until the later part of the 19th century due to the effort of Pasteur Lister. This knowledge has led to studies and procedures in health care settings (example surgery patient contact) That minimizes contamination and prevents the transfer of life-threatening pathogenic microorganisms from one individual to another.

Fingernails may be particularly important in microbial transmission because microorganisms and organic materials can become trapped in between the nails and around the nail margins. Children regularly engage in activities involving soil, playground surfaces and shared objects, and they may also have frequent hand-to-mouth contact. Consequently, lack of proper cleaning of the fingernails can facilitate the accumulation and subsequent transfer of microorganisms. Eberemu et al (2017). Primary schools constitute an important setting for studying hand and fingernail hygiene because children spend considerable periods together in relatively confined environments. Close contact, shared materials, common toilet facilities and eating together can provide opportunities for the transfer microorganisms. Evidence from school-based studies indicates that hand hygiene is an important component of infection prevention in educational settings. The importance of this issue is particularly relevant in Nigeria. A recent baseline investigation involving primary schools in Nigeria found that observed handwashing was very low at important times, including before eating and after toilet use.

Consequently, more than half of children's hands sampled contained more than 100 CFU of *Escherichia coli* per 100mL of hand rinse sample. In a Nigerian study specifically examining fingernail associated bacteria among 200 primary school pupils, bacteria were recovered from 198 samples. E. coli occurred at 30%, while Proteus spp., Klebsiella spp. and Salmonella spp. occurred at 10.5%, 8% and 3.5%, respectively. These findings indicate the potential importance of fingernail contamination as a component of school hygiene and enteric disease prevention. Hand hygiene interventions are therefore an important public-health measure. A systematic review and meta-analysis of intervention in under-developed countries, found that promotion of handwashing with soap was associated with a reduction in diarrheal disease risk among children. The world health Organization also recommends accessible handwashing facilities with soap and water in schools and emphasizes hand hygiene at important times, including after toilet use and before eating. Udujih et al (2024). The study aimed at determining the prevalence of bacterial pathogens associated with the fingernails of primary school pupils, with particular emphasis with the fingernails of primary school pupils and with organisms of enteric significance.

2 MATERIALS AND METHODS

2.1 Study Area

The study took place in Calabar, Cross River State, Nigeria. Calabar is the administrative capital of Cross River State, located in the South-South geopolitical zone of Nigeria. The city comprises Calabar municipality and Calabar South Local Government Areas and lies within the coastal lowlands of southeastern Nigeria. It is situated approximately between latitudes 4^0 55′ and 5^0 15′ and longitudes 8^0 15′ and 8^0 35′E. The city is drained by the Calabar and great Kwa Rivers, which flow toward the Atlantic Ocean.

2.2 Study Design

A cross-sectional descriptive study was carried out, to investigate the enteric bacterial species that contaminate the fingernails of primary school children in Calabar Metropolis, Cross River State.

2.3 Study population

The study population comprised of 80 primary school pupils attending selected primary schools in Calabar, Cross River State. The selected schools include; SCH 1: Obufa-Esuk Primary School, SCH 2: Command Primary School, SCH 3: Academy Primary School and lastly SCH 4: Seventh Day Adventist Nursery -Primary School. Children from the above selected schools were picked to participate in the study and provide samples for the analysis.

2.4 Sample Collection

Peptone water was accurately prepared and emptied into sterile bottles, sterile swab sticks were dipped into the peptone H_20 and were used to wash the finger nails of the school pupils, each swab stick was used for the washing of the subungual areas to get the organisms present under and around the entire fingernails of the pupils. The samples were immediately transported to the laboratory for bacteriological studies. A total of 80 samples were collected from 80 pupils and the collection was made randomly from four primary schools in Calabar namely: Mayne Avenue primary school, Obufa Esuk primary School, Seventh-Day Adventist Nursery/Primary School and Command Primary School.

2.5 Microbiological Analysis of fingernails washings of the Primary School Pupils

The culture medium that was used for the microbiological analysis is MacConkey agar, The MacConkey agar (MA) was poured into the prepared plates, allowed to solidify after which the swab sticks were used to streak on the surface aseptically and incubated for 24 hours, after which plates were evaluated for growth. (Spencer and Ragout de Spencer, 2001). All plates were prepared in duplicate. Colonies were isolated, identified and recorded after incubation period. The different colonies on each plate were stored on nutrient agar slants.

2.6 Characterization and Identification of isolated bacteria and fungi

The bacteria isolates obtained were identified based on a combination of colonial morphology, motility tests and gram staining; these tests were conducted to determine the cultural characteristics of the isolates. The biochemical tests conducted was described by Wang, (2024) and include; catalase test, oxidase test, glucose test, glucose fermentation tests and hydrolysis of arginine. Special attention was given to enteric microorganisms.

2.7 Detection of Virulence-associated genes

The detection of virulence-associated genes was carried out according to method described by Wilkie et al., (2024). Pure cultures of Escherichia coli, *Salmonella spp., Shigella spp., Staphylococcus aureus, Coagulase-negative Staphylococcus, Proteus spp.,* and *Klebsiella spp.* were screened for selected virulence -associated genes using polymerase chain reaction (PCR). Genomic DNA was extracted from the isolates using commercial DNA extraction kit according to the manufacturer's directives. The extracted DNA was subjected to polymerase chain reaction (PCR) amplification using species-specific primers targeting selected relevant virulence determinants were used polymerase chain reaction amplification. The amplified products were separated by agarose gel electrophoresis and visualized using a gel documentation system. Accurate positive and negative controls were made available. Isolates producing bands of the expected sizes were considered positive for the corresponding virulence-associated genes, and the virulence profiles were determined based on the genes detected.

2.8 Ethical Approval

Ethical approval was obtained from the Health Research ethics committee of the University of Calabar Teaching Hospital (UCTH), Calabar, Cross River State, Nigeria, before commencement of the study. Permission was obtained from the head teachers of the relevant schools, while written informed consent was obtained from the parents and guardians of the

participating pupils. Participation was voluntary, confidentiality was maintained using coded identifiers, and samples were collected using standard aseptic procedures with minimal inconvenience.

3 RESULTS AND DISCUSSION

Table 1: Presents the results of virulence factors producing potential of bacterial isolates, the result indicated that *Staphylococcus aureus, Shigella* species, *Proteus* species demonstrated α hemolytic activity while showed *Klebsiella pneumonia, Coagulase positive staphylococcus and Salmonella species showed no hemolytic, on the other hand, Escherichia coli showed* β-hemolytic activity. *Staphylococcus aureus*, *Shigella and Proteus* species, exhibited gelatinase activity, were capable of producing lipase at the same time, and are DNase positive whereas *Klebsiella pneumonia, Coagulase positive staphylococcus, Escherichia coli did not exhibit gelatinase activity.*

Table 1: Virulence Attributes of the Isolated Bacterial Species

Isolate	Lipase	Haemolysis	DNase	Gelatinase	Coagulase
Klebsiella pneumonia	-	-	+	-	-
Staphylococcus aureus	+	Alpha	+	+	+
Salmonella spp.	+	Gamma	+	-	-
Shigella specie	-	Alpha	+	+	-
Escherichia coli	+	Gamma	-	-	-
Coagulase negative staphylococcus	-	Gamma	-	+	-
Proteus spp.	+	Beta	-	+	-

Table 2: Bacterial isolates recovered from the Fingernails of primary school pupils in Calabar.

Bacterial isolates	Number isolated	prevalence (%)
Escherichia coli	29	44.6
Salmonella specie	3	4.62
Shigella specie	5	67.7
Staphylococcus specie	11	16.9
Coagulase negative staphylococcus	7	10.8
Proteus specie	1	1.53
Klebsiella pneumonia	9	13.9
TOTAL	65	100

Table 3: Distribution of pathogenic bacteria isolated from the fingernail washings of Primary School pupils in Calabar according to age group

Age Group	Number Tested	(%) with pathogenic Bacteria
2 – 4	13	84.62
5 – 7	29	89.66
8 – 10	23	73.91
11 – 13	15	73.33
TOTAL	80	___

Table 2 presents the results of the bacterial isolates isolated from the fingernails of primary school pupils in Calabar. A total of eighty (80) fingernail-washing samples were evaluated for the presence of enteric and other bacterial organisms. The bacterial isolates recovered include; Escherichia coli which was the most frequently isolated organism with the percentage occurrence of (44.6%), followed by *Staphylococcus aureus* with the percentage occurrence of (16.92%), *Klebsiella spp.* (13.9%), *Coagulase-negative Staphylococcus* (10.77), *Shigella spp.* (7.69) *Salmonella spp. (4.62) and Proteus spp.* (1.53).

Table 3: presents the results of the distribution of pathogenic bacterial according to school pupil's age. The prevalence of disease-causing bacteria isolated from the fingernail washings of the primary school pupils differed across the different age groups. The highest prevalence was recorded among pupils aged 5-7 years (89.66%), seconded by those aged 2-4 years (84.62%). Pupils aged 8-10 years had a prevalence of (73.91%), while the lowest prevalence was observed among children aged 11-13 years (73.33%). Generally, the findings indicate a relatively high occurrence of pathogenic bacteria across all age groups, with the highest prevalence occurring among children aged 5-7 years

Table 4: Distribution of Pathogenic Bacteria isolated from the fingernail washings of Primary School Children in Calabar according to gender

Bacteria isolates		**No. of pathogens found in both gender Males**	**Females**
Escherichia coli	29	12	17
Salmonella species	3	1	2
Shigella species	5	2	1
Staphylococcus aureus	11	5	7
Coagulase negative staph	7	3	4
Proteus species	1	1	1
Klebsiella species	9	6	3
TOTAL	65	30 (46.15%)	35 (53.85%)

Table 4: presents the results of the distribution of pathogenic bacterial isolated from the fingernail washings of the primary school pupils according school pupils' gender. Out of the male pupils examined, Escherichia coli was the most frequently isolated organism (12; 40.00%), seconded by Klebsiella spp. (6; 20.00%) and Staphylococcus aureus spp. (5; 16.67%). Among the thirty-five female pupils examined, Escherichia coli was the most frequently isolated organism (17;48.57%), seconded by Staphylococcus aureus spp. (7; 20.00%) and Coagulase-negative Staphylococcus (4; 11.43%). Klebsiella spp. were more frequently isolated among males (20.00%) than females (8.57), whereas, Escherichia coli, Salmonella spp., Staphylococcus aureus, Coagulase-negative Staphylococcus indicated higher frequencies among the female pupils. Shigella spp. and Proteus spp. occurred at relatively low frequencies in both gender groups.

Table 5: Distribution of bacterial pathogens in relation to the schools attended by the pupils in Calabar.

School Attended	**Number of pupils examined**	**No. of pathogenic isolates**	**Percentage (%) Distribution**
Obufa Esuk primary school	20 pupils	19	29.23
Command primary school	20 pupils	16	24.62
Academy primary school	20 pupils	18	27.69
Seventh day Adventist		12	18.46
Nursery/ primary school	20 pupils		
TOTAL	80 pupils	65(81.3%)	100

Table 5: presents the results of the distribution of pathogenic bacterial recovered from the fingernail washings of the primary school pupils in relation to schools attended by children in Calabar. A total of 80 pupils were examined, with

20 pupils sampled from each school, yielding 65 disease-causing isolates. SCH 1 recorded the highest proportion of isolates, accounting for 29.23% (19 isolates), seconded by SCH 3 with 27.69% (18 isolates), and SCH 2 with 24.62% (16 isolates) whereas SCH 4 recovered the lowest proportion, with 18.46% (12 isolates). Thus, the distribution of pathogenic bacteria isolates varied among the four schools, with SCH 1: contributing the highest proportion and SCH 4: contributing the least proportion of the isolates recovered.

4 DISCUSSION

The virulence-associated characteristics of bacterial isolates recovered from the fingernail washings primary school pupils exhibited various characteristics, including lipase production, hemolysis, DNase production, gelatinase production, and coagulase activity. These characteristics may contribute to the survival of the bacteria, colonization, and pathogenic potential. The disparity in virulence-factors expression among the isolates suggest phenotypic heterogeneity, reflecting differences in their biological properties and potential pathogenic capabilities. These findings are broadly aligned with those of Akinkunmi et al., (2013), who reported variations in virulence-factor expression among Staphylococci isolated from the faecal samples of children in Ile-Ife, Nigeria. Similarly, Wilkie et al., (2024) identified virulence-associated genes in bacterial pathogens recovered from daycare environments in Nigeria. Umana et al., (2017) also reported virulence activities, lipase production, hemolysis, DNase production, gelatinase production, and coagulase activity. Among bacterial isolates from fish sold in Akwa Ibom State, Nigeria. The disparity between these studies may be attributed to differences in bacterial species, sample sources, strains and laboratory methods of evaluation, therefore this study is a comparison of virulence-associated characteristics displayed by bacterial microorganisms isolated from fish. The detection of these virulence-associated characteristics of bacterial isolates recovered from the fingernail washings primary school pupils highlights the potential role of contaminated fingernails in transmitting microorganisms. Frequent washing with soap, proper fingernail hygiene, and health education are therefore recommended to reduce the danger of microbial transfer among primary school children.

The present research showed a high occurrence disease-causing bacterial organisms associated with the finger-nails washings of primary school pupils in Calabar, Rivers State. Out of the eighty (80) pupils examined, 65 (81.25%) yielded pathogenic bacterial isolates. The microorganisms isolated include; *Staphylococcus aureus, Shigella* species, *Proteus* species, *Klebsiella pneumonia, Coagulase positive staphylococcus, Salmonella species and Escherichia coli.* The relatively high occurrence of bacteria among the pupils indicates that finger-nails may serve as crucial sites for the carriage and possible transmission of microorganisms through hang-to-mouth contact with contaminated environmental surfaces especially where hand hygiene practices are inadequate (Bloomfield et al., 2007; Freeman et al., 2014). The overall occurrence observed in this study aligns with the findings of Eberemu and Magu (2017), who reported bacterial recovery from 198 (99%) of two-hundred (200) primary school children examined in Dutsin-Ma, Katsina State, Nigeria. Their study reported Staphylococcus spp. (37%), E. coli (30%), Proteus spp. (10.5%), Klebsiella spp. (8%), Pseudomonas spp. (5%), Salmonella spp. (3.5%). The 81.25% positively recorded in the present study is lower than the 99% reported by Eberemu and Magu. Such disparity may be attributed to difference in geographical location, environmental sanitation, personal hygiene practices, availability of handwashing facilities, age, constituent of the study populations, method of sampling, and microbiological techniques.

The age-range analysis indicated that the highest prevalence occurred among the pupils of age 5-7 years (89.66%), followed by those aged 2-4 years (84.62%), while pupils aged 8-10 and 11-13 years recorded prevalence of 73.91% and 73.33%, respectively. Although the prevalence appeared higher among the younger age groups, the disparity was not statistically significant $p > 0.05$. This shows that, within the population studied, age was not significantly associated with occurrence of bacterial contamination of the finger-washings. Furthermore, the relatively high occurrence among younger pupils may have to do with developing personal hygiene habits, frequent contact with contaminated surfaces, outdoor activities, and hand-to-mouth behaviour. interestingly, Eberemu et al., (2017) also reported the highest bacterial occurrence among pupils aged 5-7 years, the similarity may indicate that the younger pupils could have more exposure to the sources of finger nail contamination. *Escherichia coli* was the most frequently recovered organism in the present study, occurring in 12 (40.00%) males and 17 (48.57%) females. The predominance of E. coli is similar to the findings of Maani-Abuzahra et al., (2025), who reported the presence of 100CFU/100mL of Escherichia coli in primary school pupils. The very high occurrence observed in this study could be attributed to disparity in environmental exposure and poor hygiene practices between the study populations, important deficiencies in the school hand washing facilities and practices. The presence of E. coli on the finger-nail is crucial because the organism is associated with the intestinal tract and may serve as an indicator of faecal contamination, therefore, its isolation from the pupils finger-nails shows lack of proper hand hygiene which could be as a result of toilet use or contact with contaminated materials.

Staphylococcus spp. were also relatively common in this study, it was isolated from 5 males (16.67%) and 7 (20.00%) females. These values were lesser than the 37% reported by Eberemu et al., (2017). A similar predominance of Staphylococci has been reported in other studies investigating microorganism associated with fingernails Adeoti et al. (2021). In a study of fingernail microbiota among students of Oke-Ogun Polytechnic, Nigeria. Reported Staphylococcus

aureus at 22.2% while E. coli accounted for 16.6%, Salmonella spp. at 13.9%, demonstrating the ability of fingernails to harbour pathogenic and normal skin associated bacteria, such genus is commonly associated with human skin and may transferred to the finger-nail through frequent contact. Coagulase negative staphylococcus was isolated from 3 males (10.00%) and 4 females (11.43%). In most cases, Coagulase negative staphylococci are frequently regarded as normal flora, some species can act as opportunistic pathogens, particularly in susceptible individuals. One 1 Salmonella specie was isolated from the male gender pupils (3.33%) while 2 (5.71) was isolated from the female gender of the pupils, these results collaborated with the findings of Eberemu et al., (2017), who isolated 3.5% Salmonella from the finger-nail of pupils, although , the Salmonella isolated from the finger-nail of pupils was low, the presence of the isolate on the finger nail washing of school pupils is of epidemiological importance because the organism is an enteric organism and can be transmitted through oral route. Similarly, Shigella was isolated from 2 males (6.67%) and 1 female (2.86%), the isolation of these enteric organisms indicates that the fingernails were contaminated and can provide opportunity for indirect transfer of the organism through food, utensils, classroom materials, and other frequently touched surfaces. From the results above *Klebsiella spp.* occurs more frequently among males, with 6 isolates (20.00%), compared to 3 isolates (8.57%) among females. The occurrence was more than 8% as reported by Eberemu et al., (2017). Proteus spp. was less frequently recovered, occurring in one male and one female pupil. The occurrence of Proteus spp. was therefore lower than 10.5% reported by Eberemu and Magu, (2017). The disparity that is seen between the previous and present studies may result from geographical, environmental, behavioral, and methodological variation.

The results from the gender analysis, indicated the difference in the distribution of individual organisms, for instance, Escherichia coli and Staphylococcus species were more frequently isolated among the female pupils, while Klebsiella were mostly isolated from males, although, statistical analysis showed no significant association $P > 0.05$ between gender and the distribution of bacterial gender and the distribution of bacterial isolates. Therefore, the results obtained reflect the disparity in individual hygiene behavior, exposure to the environment, playing activities, and other factors that can be measured. The results of the distribution of isolates across the four schools indicated variation. School 1: reported the highest number of isolates (29.2), followed by school 3: (27.7%), school 2 (24.6%), and school 4 (18.5%). However, there was no significant difference $P > 0.05$ in the distribution of the isolates among the four schools where samples were collected, although school1 contributed the largest proportion of isolates while school 4 contributed the least, this is because an equal number of pupils were examined (20) in each school, the difference in isolate distribution may be attributed to variations in individual hygiene practices, environmental exposure, sanitation facilities, water availability, or other school-specific factors rather than difference in sample size.

The high occurrence of Escherichia coli, Staphylococcus and the detection of other enteric organisms such as Salmonella spp. and Shigella spp. are of public health significance, and similar studies examining children with nail-biting habits have demonstrated increased carriage of Enterobacteriaceae. Baydas et al. (2007), reported significantly higher carriage of *E. coli* and other member of Enterobacteriaceae among nail-biters than children without the habit. Other study among school children found Enterobacteriaceae in 65% of children with chronic nail-biting habit compared with 8.6% among non-nail-biters (Jain et al., 2013), These findings support the possibility that these isolates can be transmitted through the faecal-oral route, and polluted fingernails may enhance their movement from contaminated surfaces to food or the mouth. The investigations therefore buttress the necessity of proper hand and nail hygiene among school pupils. Frequent hand washing with soap and, cleaning beneath the finger-nails, trimming the finger-nails, washing hand after toilet use and before eating, and discouraging hand-to-mouth contact are crucial measures for minimizing the potential transmission of pathogenic bacteria. Evidence from systematic review indicates that effective hand washing hygiene can reduce the risk of infectious diseases community settings (Aiello et al.,2008; Ejemot et al., 2008). Such measures can reduce bacterial carriage on hands and fingernails and consequently minimize the potential transmission of enteric and other pathogenic organisms among school children.

5 CONCLUSION

The present study indicated a high occurrence of pathogenic bacteria in fingernail washings among primary school pupils in Calabar. Even though major differences were noticed according to age, gender, and school, the statistical analyses indicated that none of the variables was significantly associated with the observed bacterial distribution at 5% level of significance ($p<0.05$), The investigation highlight the potential role of fingernails in harboring pathogenic bacterial and underscore the necessity for sustained and strengthened hygiene education among primary school pupil, adequate water and sanitation facilities, effective trimming of fingernails and regular hand washing practices with soap and running water, cleaning underneath the fingernails and avoiding unnecessary hand-to-mouth contact. Primary schools should also make provision for adequate access to water, soap, functional toilet facilities and appropriate environmental sanitation. Periodic health and hygiene education involving teachers, pupils, parents and caregivers are therefore measures for reducing the potential transmission of enteric microorganisms in the school environments.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The authors highly appreciate the management of University of Calabar, and the department of microbiology in particular for making their laboratories available for this work. We are immensely grateful.

Disclosure of conflict of interest

The authors have not declared any conflict of interests.

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