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Original Article

Bacterial pathogens associated with eyeglasses and risks of infection: A cross-sectional study in South-West Nigeria

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Abstract

Ocular infections have been associated with bacterial contamination of eyeglasses. This study assessed bacterial contaminants associated with the eyeglasses of the staff and students of Babcock University, Ilishan-Remo, Ogun State, Nigeria. A total of 100 participants comprising 33 males and 67 females (aged 16-76 years) were recruited for the study after obtained the written informed consents. A structured questionnaire was used to collect the demographic and clinical information. A total of 100 eyeglasses were examined for bacterial contamination using standard bacteriological methods. A one–way analysis of variance (ANOVA) and Tukey–Kramer multiple comparisons test were used to determine the differences between the bacterial loads among the eyeglasses of study participants. We found that the percentage of eyeglass lenses with unacceptable levels of contamination (>10^5CFU/mL) and acceptable levels of contamination were 19% and 46%, respectively. The percentages of eyeglass handles with unacceptable and accepted level of contamination were 49% and 7%, respectively. Most of the isolated bacteria were sensitive to the tested antibiotics. Risk factors associated with bacterial contamination of eyeglasses were exposure to dusty environment, irregular cleaning, and poor compliance with eyeglass care guidelines. Our study further underscores the claim that eyes glasses may serve as potential vehicles for bacteria capable of causing ocular infections.

Keywords: Antibiotic susceptibility, bacterial pathogen, contamination, eye glasses, risk factor

Introduction

Ocular infections are common (Graham et al., 2007; Schaftenaar et al., 2014) and have been associated with microbial contamination of contact lenses and eyeglasses (Butt et al., 2012; Willcox, 2007). Many frequently used devices, such as eyeglasses and contact lenses, are rarely sterilized or kept clean, which increases the likelihood of bacterial contamination and colonization (Francis et al., 2016; Wu et al., 2015). Significant number of people wear eyeglasses for functional or purely cosmetic reasons (Kaschke et al., 2013; Nwaugo et al., 2008). The human eyes have a special anatomy that make them vulnerable to infectious agents, including bacteria, as well as direct environmental exposure. The eyelids, conjunctiva, and cornea are the main parts of the eyes that are most frequently infected. Several ocular diseases, including conjunctivitis, keratitis, scleritis, choroiditis, iridocyclitis, retinal vasculitis, retinitis, and posterior uveitis, have been linked to contamination of handles and lenses of eyeglasses. This is quite worrisome, because these bacteria are transferred to the eyewear through contact with infected hands and other methods (Willcox, 2007).

Numerous microorganisms have been linked to eye infections caused by microbial contamination and colonization of eyeglasses. A study reported the presence of

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bacterial contaminants such as *Staphylococcus sp.*, *Streptococcus sp*, *Pseudomonas s., Aeromonas sp*, *Citrobacter sp, Haemophilus influenza*, *Chlamydia trachomatis* and *Neisseria gonorrhoeae* on surgeon's eyeglasses (Butt et al., 2012). Another study reported the presence of fungal contaminants such as *Microsporium sp, Penicillium s., Aspergillus sp, Trichophyton sp* and *Candida sp* on the eyeglasses of patients attending ophthalmology clinic at Abia State University, Uturu, Nigeria (Nwaugo et al., 2008). A study reported three main species as potentially implicated agents: *Enterococcus sp, Staphylococcus sp,* and *Aspergillus sp* (Lange, 2014). Osaro-Matthew et al. (2015), reported the presence of *Klebsiella sp* (1.89%), coagulase-negative *Staphylococcus* (9.43%), *Bacillus sp* (13.21%), *Pseudomonas aeruginosa* (13.21%), *Streptococcus sp* (16.98%), *Staphylococcus aureus* (28.30%) and *Escherichia coli* (51.89%) on the medicated eye glasses worn by students and staff of a public tertiary institution in South-East, Nigeria.

To the best of our knowledge, there is no information available on the quantity, frequency, and distribution of bacterial contamination in Babcock University personnel and students' eyeglasses in Ilishan-Remo, Ogun State, Nigeria. Such a study is necessary due to the dearth of data in this area. The aim of this study was therefore to assess the load, frequency and distribution of bacterial contaminants present on the eye glasses used by staff and students of Babcock University, Ilishan-Remo, Ogun State, Nigeria. The study also intended to evaluate the antibiotic sensitivity pattern of the recovered bacterial isolates in addition to assess the risk variables linked to bacterial contamination of the eyeglasses.

Methods

Study design, population and sample size

This cross-sectional descriptive study was conducted between April and June 2018 at Babcock University, a premier Seventh-day Adventist institution of higher learning situated in the South-Western area of Nigeria, in Ilishan-Remo, Ikenne Local Government Area, Ogun State, Nigeria. The targeted of the samples were Babcock University students and faculties (aged 16 and older) who wear glasses, whether functional or cosmetic, regardless of their tribal, religious, and cultural affiliations. The population proportion formula described by Charan and Biswas (2013) was used to estimate the sample size (n) required for the study. The minimal sample size needed was calculated using a 95% confidence interval, a prevalence rate of 93.4% from a prior study (Osaro-Matthew et al., 2015) and a margin of error set at 0.05. A final sample size of 100 was obtained by adding 5% of the original sample size in order to reduce mistakes caused by the possibility of non-compliance.

Sampling and data collection

Simple random sampling was used to choose the study subjects among the University's nine schools. Through the distribution of structured questionnaires to the participants, demographic and medical information of the participants was collected. The participants demographic information included occupation, gender, marital status, age, and tribe were asked in the first section of the questionnaire. Data on different types of eyeglasses, how to care for and maintain them, history of past eye infections, risk factors, personal hygiene, and health care seeking behaviour were then assessed and collected.

Specimen collection, transportation and laboratory analysis

Each participant's eyeglass lenses and handles were swabbed with two different sterile cotton-tipped applicators that had been soaked with sterile peptone water (Panreac-AppliChem, Spain) using proper aseptic methods. Each swab stick was severed at the hank region, and the head holding the cotton was aseptically put into a sterile bottle containing 10 mL of peptone broth. The bottle was then promptly corked properly using aseptic techniques (including wearing of sterile hand gloves). The samples were then brought to the laboratory in a tightly sealed case and processed within eighteen hours of being collected from the personnel and students.

Determination of bacterial count

The contents of the bottles were allowed to stay for 30 min before being vortexed for sixty seconds. Ten-fold serial dilutions was thereafter prepared using sterile distilled water and 0.02 mL of appropriate dilution was spread onto sterile nutrient agar, blood agar and MacConkey's agar, contained in petri-dishes with 0.05 mg/mL of ketoconazole added to inhibit fungal growth. The surface viable count as described by (Miles et al., 1938) was used for the determination of bacterial load in the eye glass swabs. The number of colony forming units (CFU) per mL from the original eye glass swab broth sample was calculated using the given equation: CFU/mL equal with mean number of colonies multiply by number of drops/mL and multiply by dilution factor. The petri dishes were then incubated aerobically at 37^{o}C for 24 h. Colonies from the plates thereafter were purified and stored on nutrient agar slants for characterization and identification.

Isolation of pure cultures

Purity plate was conducted for mixed cultures using the streak plate technique as described by Ochei and Kolhatkar (2000). Aseptic streaking of the inoculum with the aid a wire loop resulted in continuous dilution of the inoculum to give well separated distinct colonies.

Identification of bacterial isolates

After incubation, plates containing cultured samples were examined and colonies of bacteria were identified using Gram-staining. Gram negative bacteria were identified further by biochemical tests such as motility, oxidase, sugar fermentation, urea hydrolysis, indole, citrate, hydrogen sulfide, methyl red and Voges-Proskauer tests, while, Gram positive cocci were characterized by performing catalase and coagulase test as described previously (Cheesbrough, 2006b). The results of these tests were entered into IDENTAX bacterial identifier (Sun Microsystems's Java Technology) for the taxonomical identification of bacteria isolates on the basis of their phenotypic characteristics. Pure cultures of the identified organisms were stored on nutrient agar slant for subsequent antibiotic sensitivity testing.

Determination of the antibiotic sensitivity pattern of bacterial isolates

The antibiotic sensitivity pattern of the bacterial isolates was determined using the disc diffusion technique as described previously (Bauer, 1966); (Cheesbrough, 2006a). Using the interpretative chart, the zone of inhibition of each antibiotic was interpreted as 'resistant', 'intermediate' or 'susceptible'.

Data analysis

A one-way analysis of variance (ANOVA) and Tukey–Kramer multiple comparisons test were performed using Statistical Package for Social Sciences version 18 (SPSS-18.0) software to determine the differences between the bacterial loads among the eyeglasses of study participants. A p-value <0.05 was considered significant.

Results

Characteristics of respondents

The demographic characteristics of the participants are presented in Table 1. A total of 100 participants comprising 33 males and 67 females were included in the study. Majority of the participants belong to the age group 16–25 years (36%), while the least belong to 76 years and above (2%). Based on the marital status, 76% were single while 24% were married. With regard to their occupation, 24% were staff and 76% were students. Majority of the participants were Christians (76%) and 42% were Yoruba (42%) (Table 1).

Table 1. Demographic characteristics of the study participants

Characteristics	Category	Number (n)	Percentage (%)
Sex	Male	33	33
	Female	67	67
Age group (years)	16-25	36	36
	26-35	20	20
	36-45	16	16
	46-55	11	11
	56-65	10	10
	66-75	5	5
	76 and above	2	2
Marital status	Single	76	76
	Married	24	24
Occupation	Staff	24	24
	Student	76	76
Religion	Christianity	76	76.0
	Islam	24	24.0
	Traditional	0	0
Tribe	Yoruba	42	42
	Ibo	25	25
	Hausa	3	3
	Others	30	30

Table 2. Frequency of bacterial contamination of eye glasses according to the demographic characteristics of the study participants.

Characteristics	Category	Number examined n (%)	Number of lenses contaminated n (%)	Number of handles contaminated n (%)	p-value
Sex	Male	33 (33)	33 (33)	33 (33)	0.711
	Female	67 (67)	67 (67)	67 (67)	
Age group (years)	16-25	36 (36)	36 (36)	36 (36)	0.223
	26-35	20 (20)	20 (20)	20 (20)	
	36-45	16 (16)	16 (16)	16 (16)	
	46-55	11 (11)	11 (11)	11 (11)	
	56-65	10 (10)	10 (10)	10 (10)	
	66-75	5 (5)	5 (5)	5 (5)	
	76 and above	2 (2)	2 (2)	2 (2)	
Marital status	Single	76 (76)	76 (76)	76 (76)	0.880
	Married	24 (24)	24 (24)	24 (24)	
Occupation	Staff	24 (24)	24 (24)	24 (24)	0.880
	Student	76 (76)	76 (76)	76 (76)	
Religion	Christianity	76 (76)	76 (76)	76 (76)	0.280
	Islam	24 (24)	24 (24)	24 (24)	
	Traditional	0 (0)	0 (0)	0 (0)	
Tribe	Yoruba	42 (42)	42 (42)	42 (42)	0.430
	Ibo	25 (25)	25 (25)	25 (25)	
	Hausa	3 (3)	3 (3)	3 (3)	
	Others	30 (30)	30 (30)	30 (30)	

Table 3. Bacterial load of lenses of eye glasses according to the demographic characteristics

Demographic characteristics	Category	Bacterial load*			p-value
		Acceptable n (%)	Inconclusive n (%)	Unacceptable n (%)	
Sex	Male	15 (45.5)	11 (33.3)	7 (21.2)	0.919
	Female	31 (46.3)	24 (35.8)	12 (17.9)	
Age group (years)	16-25	19 (52.8)	12 (33.3)	5 (13.9)	0.631
	26-35	7 (35)	8 (40.0)	5 (25.0)	
	36-45	9 (56.2)	3 (18.8)	4 (25.0)	
	46-55	4 (36.4)	4 (36.4)	3 (27.3)	
	56-65	4 (40.0)	5 (50.0)	1 (10.0)	
	66-75	3 (60.0)	1 (20.0)	1 (20.0)	
	76 and above	0 (0.0)	2 (100.0)	0 (0.0)	
Marital status	Single	38 (50)	25 (32.9)	13 (17.1)	0.350
	Married	8 (33.3)	10 (41.7)	6 (25.0)	
Occupation	Staff	8 (33.3)	10 (41.7)	6 (25.0)	0.350
	Student	38 (50.0)	25 (32.9)	13 (17.1)	
Religion	Christianity	36 (47.4)	29 (38.2)	11 (14.5)	0.108
	Islam	10 (41.7)	6 (25.0)	8 (33.3)	
	Traditional	0 (0.0)	0 (0.0)	0 (0.0)	
Tribe	Yoruba	16 (38.1)	14 (33.3)	12 (28.6)	0.624
	Ibo	10 (40.0)	8 (32.0)	7 (28.0)	
	Hausa	3 (100)	0 (0.0)	0 (0.0)	
	Others	17 (56.7)	13 (43.3)	0 (0.0)	

*Bacterial load <10^4CFU per mL as acceptable level of contamination, 10^4-10^5CFU per mL as inconclusive and >10^5 CFU per mL as unacceptable level of contamination.

Bacterial contamination based on demographic characteristics

The frequencies of bacterial contamination of the eye glasses according to the demographic characteristics of the participants are presented in Table 2. All the lenses and handles of eye glasses examined were contaminated regardless of the demographic characteristics of the study participants.

Furthermore, the bacterial load on the of lenses of eye glasses of the participants according to their demographic characteristics is presented on Table 3. There were 46% of the lenses examined had bacterial load <10^4CFU/mL (acceptable level of contamination), 35% falls between 10^4-10^5 CFU/mL (inconclusive), while 19% had bacterial load above 105 CFU/mL (unacceptable level of contamination). The percentage of eyeglass lenses with unacceptable level of contamination was higher than those with acceptable level of contamination. Meanwhile, there was no significant difference (p>0.05) in the level of contamination between and within the categories of participants.

Table 4 shows the bacterial load on the handles of eye glasses according to participant demographic characteristics. A total of 7% of them had acceptable level of contamination, 44% had inconclusive while 49% had unacceptable level of contamination.

The percentage of eyeglass handles with acceptable level of contamination was lower than those with unacceptable level of contamination. Meanwhile, there was no significant difference (P>0.05) in the level of contamination between and within the categories of participants.

Table 4. Bacterial load on the handles of eye glasses of the participants according to their demographic characteristics.

Demographic characteristics	Category	Bacterial load* Acceptable n (%)	Inconclusive n (%)	Unacceptable n (%)	p-value
Sex	Male	3 (9.1)	11 (33.3)	19 (57.6)	0.313
	Female	4 (6.0)	33 (49.3)	30 (44.8)	
Age group (years)	16-25	1 (2.8)	18 (50.0)	17 (47.2)	0.359
	26-35	2 (10.0)	6 (30.0)	12 (60.0)	
	36-45y	2 (12.5)	8 (50.0)	6 (37.5)	
	46-55	0 (0)	3 (27.3)	8 (72.7)	
	56-65	2 (20.0)	5 (50.0)	3 (30.0)	
	66-75	0 (0)	2 (40.0)	3 (60.0)	
	76 and above	0 (0)	2 (100.0)	0 (0)	
Marital status	Single	5 (6.6)	35 (46.1)	36 (47.4)	0.757
	Married	2 (8.3)	9 (37.5)	13 (54.2)	
Occupation	Staff	2 (8.3)	9 (9)	13 (54.2)	0.757
	Student	5 (6.6)	35 (46.1)	36 (47.4)	
Religion	Christianity	5 (6.6)	37 (48.7)	34 (44.7)	0.242
	Islam	2 (8,3)	7 (29.2)	15 (62.5)	
	Traditional	0 (0)	0 (0)	0 (0)	
Tribe	Yoruba	3 (7.1)	13 (31.0)	26 (61.9)	0.153
	Ibo	3 (12.0)	10 (40.0)	12 (48.0)	
	Hausa	0 (0)	2 (66.7)	1 (33.3)	
	Others	1 (3,3)	19 (63.3)	10 (33.3)	

*Bacterial load <104CFU per mL as acceptable level of contamination, 104-105 CFU/mL as inconclusive and >105 CFU per mL as unacceptable level of contamination.

Table 5. Bacterial load on the eye glasses of the study participants according to the type and surface

Type of eye glasses	Surface examined	Bacterial load* Acceptable n (%)	Inconclusive n (%)	Unacceptable n (%)	Total n (%)	p-value
Recommended	Lens	32 (42.7)	27 (36.0)	16 (21.3)	75 (37.5)	0.434
	Handles	6 (85.7)	29 (65.9)	40 (81.6)	75 (37.5)	
	Total	38 (25.4)	56 (37.3)	56 (37.3)	150 (75)	
Non-recommended	Lens	14 (56.0)	8 (32.0)	3 (12.0)	25 (12.5)	0.172
	Handles	1(14.3)	15(34.1)	9 (18.4)	25 (12.5)	
	Total	15 (30.0)	23 (46.0)	12 (24.0)	50 (25.0)	

* Bacterial load <10^4CFU per mL as acceptable level of contamination, 104-105CFU per mL as inconclusive and >10^5 CFU per mL as unacceptable level of contamination.

Table 5 shows the bacterial load on the eye glasses of the study participants according to the type of glasses and surface examined. In all, 150 medicated eyeglasses and 50 non-medicated eyeglasses were examined. There was no significant difference (p>0.05) between the proportion of medicated eyeglasses with acceptable level of contamination (25.4%) and those with unacceptable level (37.3%). Still, there was no significant difference (p>0.05) between the proportion of non-medicated eyeglasses with acceptable.

Table 6: Gram characterization and frequency of bacterial contaminants on lenses and handles of the eye glasses of the study participants

Gram reaction	Bacterial Isolates	Hand les N (%)	Lens N (%)	Total N (%)	p-value
Positive	Coagulase-positive *S. aureus*	23 (23.0)*	31 (31.0)*	54 (54.0)	> 0.05
	Coagulase-negative *S. species*	30 (30.0)	22 (22.0)	52 (52.0)	> 0.05
Negative	*Bacillus* species	11 (11.0)	14 (14.0)	24 (24.0)	> 0.05
	Escherichia coli	15 (15.0)	11 (11.0)	26 (26.0)	> 0.05
	Klebsiella pneumoniae	16 (15.0)	12 (12.0)	28 (28.0)	> 0.05
	Proteus mirabilis	6 (6.0)	10 (10.0)	16 (16.0)	> 0.05

There was no significant difference in the frequency of bacterial contaminants found on eyeglass handles compares to the lenses (p>0.05). However, the percentage of *S. aureus* found on the both the handles and lenses was significantly higher (p<0.05) than *P. mirabilis* which was the least isolated.

Table 6 shows the Gram characterization and frequency of bacterial contaminants on the lenses and handles of eye glasses of the study participants. On the handles, the most frequent organism was the coagulase-negative *Staphylococcus* sp (30%), while the least was the *Proteus mirabilis* (6%). On the other hand, coagulase-positive *Staphylococcus aureus* (31%) was the most frequent organism found on the lenses, while *Proteus mirabilis* (10%) was the least frequent. There was no significant difference in the frequency of bacterial contaminants found on eyeglass handles compares to the lenses (p>0.05). However, the percentage of *S. aureus* found on the both the handles and lenses was significantly higher (p<0.05) than *P. mirabilis* which was the least isolated.

Table 7 shows the risk factors associated with bacterial contamination. All participants agreed to exposure of their glasses to dusty environment. Although all of them indicated that they have a glass case for keeping their glasses, only 43% of them keep their glasses in the case all the time, while 57% of them do so very often. 87% of the participants indicated that they cleaned their glass case all the time. 68% clean their eyeglasses often, while 32% do so more often. 18% of participants agreed to cleaning only the lenses, while 82% agreed to cleaning both the handles and lenses of their glasses. Furthermore, 91% of participants used running water as the solution in cleaning their glasses, while 9% use liquid lens cleaner. All participants (100%) agreed to use the lens cleaner material to clean their glasses. When asked about history of any signs and symptoms, 3% indicated red eye, 34% indicated itchy eye, 3% indicated painful eye, 16% indicated ocular discharge, 12% indicated eye strain, while 32% had no history of any signs and symptoms. All participants agreed to washing their hands always after using the toilet. With regard to frequency of eye check-up, 91% indicated that they go less often, while 9% of the participants go often. When asked to grade their compliance with eye glass care and maintenance, 34% indicated a very good level of compliance, while 66% indicated excellent level of compliance.

Table 7: Risk factors associated with bacterial contamination of eye glasses.

Characteristics	Responses	No. of Participants (%)	No. with contaminated eye glasses (%)
Do you expose your eye glasses to dusty environment?	Yes	100 (100.0)	100 (100.0)
	No	0 (0)	0 (0)
How often do you keep your eye glasses in its case when not in use?	Less often	0 (0)	100 (100)
	Often	0 (0)	
	Very often	57 (57.0)	
	All the time	43 (43.0)	
How often do you clean the case for your eyeglasses?	Less often	0 (0)	100 (100)
	Often	0 (0)	
	Very often	13 (13.0)	
	All the time	87 (87.0)	
How often do you clean or wipe your eyeglasses	Less often	0 (0)	100 (100)
	Often	68 (68.0)	
	More often	32 (32.0)	
Which part of the eye glasses do you clean?	Lenses only	18 (18.0)	100 (100)
	Handles only	0 (0)	
	Both	82 (82.0)	
Which solution do you use for cleaning your eye glasses?	Mouth breath	0 (0)	100 (100)
	Saliva	0 (0)	
	Running water	91 (91.0)	
	Liquid soap	0 (0)	
	Liquid lens cleaner	9 (9)	
What material do you use for wiping your eye glasses?	Handkerchief	0 (0)	100 (100)
	Tissue paper	0 (0)	
	Paper towel	0 (0)	
	Napkins	0 (0)	
	Part of my clothes	0 (0)	
	Lens cleaner material	100 (100)	
Do you have history of any of the following signs/symptoms?	Red eye	3 (3.0)	100 (100)
	Swollen eye	0 (0)	
	Itchy eye	34 (34.0)	
	Painful eye	3 (3.0)	
	Foreign body sensation	0 (0)	
	Ocular discharge	16 (16.0)	
	Eye strain	12 (12.0)	
	None	32 (32.0)	
Hand hygiene after toileting	Wash always	100 (100)	100 (100)
	Wash often	0 (0)	
	Wash less often	0 (0)	
	Never	0 (0)	
How often do you go for eye check-up?	Less often	91 (91.0)	100 (100)
	Often	9 (9.0)	
	Very often	0 (0)	
Grade your compliance with eyeglass care and maintenance	Very poor	0 (0)	100 (100)
	Poor	0 (0)	
	Good	0 (0)	
	Very good	34 (34.0)	
	Excellent	66 (66.0)	

Figure 1 and 2 shows the antibiotic sensitivity pattern of Gram positive and Gram negative bacterial isolates recovered from the eyeglasses of the study participants. S. aureus was most sensitive (96.8%) to ciprofloxacin and gentamycin, but least sensitive (3.2%) to streptomycin, nalidixic acid, pefloxacin and clotrimazole. Coagulase negative *Staphylococcus sp* were most sensitive (95.5%) to chloramphenicol and erythromycin, but least sensitive (0%) to streptomycin and clotrimazole. Bacillus species were most sensitive (85.7%) to ciprofloxacin, chloramphenicol, tetracycline, gentamycin and amoxycillin, but least sensitive (7.1%) to streptomycin, nalidixic acid, pefloxacin and clotrimazole. Gram negative bacterial isolates on the other hand also show the same pattern, with most of them sensitive to ciprofloxacin, chloramphenicol and tetracycline (80-100%) and least sensitive to erythromycin (18.2-40%).

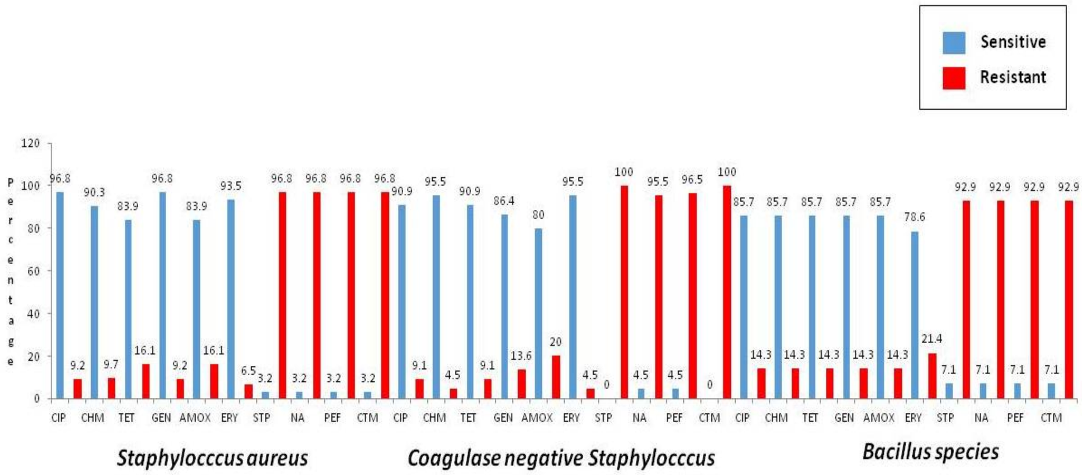

Figure 1: Histogram showing the antibiotic sensitivity pattern of Gram positive bacterial isolates recovered from the eye glasses of the study participants. AMOX: amoxycillin, CHM: chloramphenicol, CIP: ciprofloxacin, CTM: clotrimazole, ERY: erythromycin, GEN: gentamycin, NA: nalidixic acid, PEF: pefloxacin, STP: streptomycin, TET: tetracycline

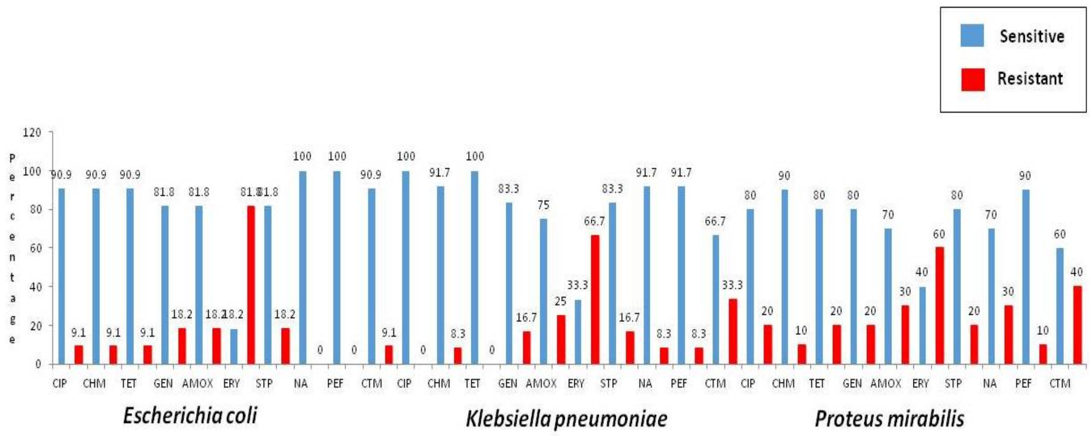

Figure 2: Histogram showing antibiotic sensitivity pattern of Gram negative bacterial isolates recovered from the eye glasses of the study participants. AMOX: amoxycillin, CHM: chloramphenicol, CIP: ciprofloxacin, CTM: clotrimazole, ERY: erythromycin, GEN: gentamycin, NA: nalidixic acid, PEF: pefloxacin, STP: streptomycin, TET: tetracycline

Discussion

Eyeglasses may act as possible carriers for bacteria that might infect the eyes. As stated by Willcox (2007), bacterial contamination of eyeglasses, particularly the lenses and handles, has been linked to ocular infection. This institutional based study was designed to determine the bacteriological quality of eye glasses of staff and students of Babcock University, Ogun State. The study specifically seeks to determine the extent of bacterial contamination, the distribution of bacterial contaminants, identify associated risk factors, as well as determine the antibiotic sensitivity pattern of bacterial pathogens recovered from the eye glasses of the study participants.

The result of this study show that all the eyeglasses (100%) examined had bacterial contaminants, unlike the works of Butt et al. (2012) and Osaro-Matthew et al. (2015), who reported bacterial contaminants in 95.0% and 93.4% of the eyeglasses examined, respectively. The types of bacterial contaminants present on the eyeglasses examined in this study (*Escherichia coli, Staphylococcus aureus, Proteus mirabilis, Bacillus species, Klebsiella pneumoniae* and coagulase-negative *Staphylococcus*) differ somewhat from those of Butt et al. (2012), who reported *S. epidemidis* and S. *haemolyticus* in addition to *S. aureus*.

Bacterial genera observed in this present work is however similar to those of Osaro-Matthew et al. (2015), who reported *Streptococcus* and *Pseudomonas* species in addition to *E. coli, Bacillus* species, *Klebsiella* species, *S. aureus*, and coagulase-negative *Staphylococcus* species observed in this study. With regard to the frequency of bacterial contaminants, Gram positive organisms with the highest and lowest occurrences in this study were *Staphylococcus aureus* (54%) and coagulase-negative *Staphylococcus* (52%), respectively who agrees with the work of Osaro-Matthew et al. (2015), who reported the same, 28.3% and 9.4%, respectively. On the other hand, Gram negative organisms with the highest and lowest occurrences were *Klebsiella* species (28.0%) and *Proteus mirabilis* (16%), respectively. This differs from the work of Osaro-Matthew et al. (2015), who reported Escherichia coli (51.9%) and Klebsiella species (1.89%).

In this study, staff eyeglass handles (54.2%) and lenses (25.0%) have more unacceptable level of bacterial contamination when compared those of the students, 47.4% and 17.1%, respectively. This is consistent with the work of Osaro-Matthew et al. (2015), who reported a higher occurrence on staff eyeglass handles (47.17%) and lenses (43.40%), against the 30.19% and 32.08%, respectively, observed on students' eyeglass handles and lenses. This could be attributed to the fact that most staff were parents, and may be too busy to take care of their eye glasses unlike the Students that are more privileged to only care for themselves and their studies. This is in line with the research done by Nwaugo et al. (2008) who also shared similar views.

Furthermore, male eyeglass handles (57.6%0 and lenses (21.2%) have more unacceptable level of bacterial contamination when compared those of the females, 44.8% and 17.9%, respectively. This is also in harmony with the report of Osaro-Matthew et al. (2015), who observed 52.83% and 50.94%, respectively among male eyeglass handles and lenses, respectively, as well as 26.42% and 22.64% among female eyeglass handles and lenses, respectively. According to Nwaugo et al. (2008), who worked on fungal contamination of eye lenses, explained that male eye lenses are more contaminated than the females because they engage in more outdoor works/ activities than the females.

Comparison of bacterial contamination of eyeglass surfaces shows that the handles are more contaminated than the lenses. This also agrees with the observation of Osaro-Matthew et al. (2015). This can be as a result of the fact that the hands are often employed to adjust the glass handles at intervals unlike the lenses, and pathogenic organisms harboured in the hands are easily transferred from the hands to the handle through touching. Also it was observed that most people clean only the lenses of their eye glasses and they leave the handles unclean forgetting the fact that it can harbor a large amount of microorganisms.

With regard to age, the highest unacceptable level of bacterial contamination was observed among participants who were between 46-55 years (27.3%). These are staff members of the University, who may not have enough time for eyeglass care and maintenance due to their tight schedules. The observation in this study however disagrees with that of Nwaugo et al. (2008), who observed a higher occurrence of fungal contamination among eyeglasses of Patients attending optometry clinic at Abia State University, Uturu, Nigeria, age 21-30 years (30.97%). Furthermore, from this study, it was also observed that the percentage of the recommended glass lenses (21.3%) and handles (81.6%) with unacceptable level of bacterial contamination were more than those of the non-medicated eye glass lenses (12.0%) and handles (18.4%). This observation is a worrisome and therefore calls for more personal hygiene and eyeglass care by users of recommended eyeglasses.

With regard to risk factors associated with bacterial contamination of eyeglasses, majority of the participants (91%) clean their glasses with running water, while the remaining 9% use lens cleaner. The implication of this is that their eyeglasses are not properly disinfected as water in itself, does not possess antibacterial properties. Even though most people are of the opinion that using lens cleaner materials was the best option, the outcome of this study cast doubt on that belief. This finding concurs with that of Osaro-Matthew et al. (2015), therefore washing of the lens cleaner materials properly and frequently is necessary to maintain the hygiene of eyeglasses. In this study, coagulase-positive *Staphylococcus* (a normal flora of the nasopharynx) had the highest frequency of occurrence, and this shows that the participants might have made use of handkerchief meant for cleaning the nasal area to clean their eyeglasses at one point or the other, thereby transmitting *S. aureus* to the glasses (handle/lens). In addition, since some people are known to intentionally or unintentionally blow their nostrils with bare hands without washing afterwards, coagulase-positive *Staphylococcus* can be easily spread from one person to another by hand shaking.

On the other hand, coagulase-negative *Staphylococcus* species, especially *S. epidermidis* has long been thought to be non-pathogenic and is typically seen on the skin of many healthy individuals, their role as pathogens and their dramatically rising incidence rate have just recently come to light (Cheesbrough, 2006d). This can be a result of broader population hygiene issues. Most Nigerian populace do not always wash their hands well with soap and water after using the restroom, or even after eating or performing housework and due to the fact that human hands still contain a lot of pathogenic organisms even after thorough hand washing. When they are not adequately cleaned or sanitized, they serve as an ideal vehicle for the spread of bacteria to other locations and surfaces, particularly on eyeglasses for those who wear them.

Bacillus species were also present on the surfaces of the eyeglasses and these are spore formers, explaining why they are found everywhere. Due to the spore formation which enables them to survive in all environments, they have the ability to colonize surfaces (Willcox, 2007). *Proteus mirabilis* are normally found in the gastrointestinal tract and has been implicated in contaminated surfaces due to poor toilet and hand hygiene. As an opportunistic microorganism, it is most times frequently resistant to antibiotics (Kayser et al., 2005).

About 5% of healthy people typically have *Klebsiella pneumoniae* in their respiratory tracts and faces. In immunosuppressed patients, infection with this organism can result in bacteraemia with a localized lesion. In addition, it is second only to *E. coli* in terms of urinary tract pathogens and it is among the top 10 bacterial pathogens that cause hospital-acquired illnesses (Cheesbrough, 2006d; Cowan et al., 1960).

E. coli is a Gram-negative motile bacteria that naturally inhabits the digestive tract, but it has also been isolated from blood, pus, urine, cerebrospinal fluid, and other bodily fluids. It is known that specific *E. coli* strains can induce diarrheal illnesses. The organism is one of the main agents that can cause meningitis and bacteraemia in newborns, as well as the most harmful organism implicated in urinary tract and wound infections in people (Cheesbrough, 2006c).

For the antibiotic sensitivity pattern of the bacterial isolates recovered from the eyeglasses of the study participants. *S. aureus* was most sensitive (96.8%) to ciprofloxacin and gentamycin, coagulase-negative *Staphylococcus* species were most sensitive (95.5%) to chloramphenicol and erythromycin, bacillus species were most sensitive (85.7%) to ciprofloxacin, chloramphenicol, tetracycline, gentamycin and amoxycillin. *Klebsiella Pneumoniae, E. coli*, and *Proteus mirabilis* were most sensitive to ciprofloxacin, chloramphenicol and tetracycline (80-100%). This pattern was different from the sensitivity pattern reported by Osaro-Matthew et al. (2015), in which *E. coli* was most sensitive to ceftriaxone (96.4%), *Staphylococcus aureus* was most sensitive to gentamycin (100%), Coagulase-negative *Staphylococcus* species was most sensitive to ofloxacin and peflacine (100%), while *Klebsiella* species was most sensitive to ofloxacin, peflacine, ceftriaxone, gentamycin, ceporex (100%). This shows that the antibiotic sensitivity pattern of bacterial pathogens is constantly evolving, hence the need for continuous antibiotic sensitivity pattern monitoring and surveillance to combat the menace of emergence and re-emergence of antibiotic resistance as recommended by past studies (Cobo, 2022; Girma and Aemiro, 2022; Junior et al., 2022).

Conclusion

The outcome of this present study shows that more of the eyeglass lenses and handles of the staff examined had unacceptable level of bacterial contamination than those of the Students. Risk factors associated with bacterial contamination of eyeglasses as observed in this study include: exposure of glasses to dusty environment, irregular cleaning of eyeglasses, not using recommended liquid lens cleaner, poor compliance with eyeglass care and maintenance. Consequent upon these, the following measures are hereby recommended: personal hygiene, especially hand cleaning after each visit to the toilet, regular cleaning of eyeglasses with recommended disinfectants of reputable quality, high compliance with standard eyeglass care and maintenance practice, and regular visit to the eye clinic for routine check-up.

Authors' contributions

Conceptualization: SSE and OME; Data Curation: SSE, OME and GEI; Formal Analysis: MOD and GOM; Funding Acquisition: SSE and OME; Investigation: SSE and OME; Methodology: SSE, OME and RYA; Project Administration: SSE; Resources: SSE and OME; Software: SOM, SOA and NIO; Supervision: SSE and GEI; Validation: SOM, JMO and NIO; Writing – Original Draft Preparation: SSE and OME; Writing – Review & Editing: SSE, GEI, MOD and RYA.

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Conflict of interest

Researcher has declared that no competing interests exist.

Ethical approval

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