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ORIGINAL

Potential microbial hazards of the external auditory canal in users of over-ear, in-ear, and on-ear earsets

Posibles riesgos microbianos del conducto auditivo externo en usuarios de auriculares de botón, de botón y de tapón

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ABSTRACT

Introduction: in recent years, there has been an increase in the use of earsets among people, especially the young.
Objective: this study evaluates the relationship between bacterial and fungal ear growth among different earsets (over, in, and on-ear) users and the possibility for earsets to act as a vector for prevalent diseases.
Method: ear samples (168) were collected from 84 male healthy students and subjected to isolation of bacteria and fungi. Also, evaluation of the participants' awareness, practices, habits, and symptoms were evaluated.
Results: bacterial isolates from 54 (64,3 %) participants were identified as 11(13,1 %) isolates of *Staph. epidermidis*, 10(11,9 %) *P. aeruginosa*, 25 (29,8 %) *Staph. aureus*, and 8(9,5 %) *Strep. pneumoniae*. The participants 35(41,7 %) use wireless earsets, 17(20,2 %) use wired earsets, 24(28,6 %) use both wired and wireless earsets while only 8(9,5 %) non-used. according to earset shapes and types, 33(39,3 %) use more than one type, 25(29,8 %) use over-ear, and 14(16,7 %) use on-ear. Participants share earsets with other persons, 34(40,5 %) participants do not share earsets, 26(31,0 %) share sometimes, and 24(28,6 %) frequently share earsets.
Conclusions: the presence of bacteria isolated from the external ear auditory canal correlated positively with using cotton buds, using sharp tools to clean the earwax, sharing earsets with other persons, type (wired or wireless), and shape (over-ear, in-ear, on-ear) of earsets significantly. Using cotton buds and sharp tools to clean the earwax significantly correlated positively with ear symptoms that are usually felt or suffered.

Keywords: Microbial Assessment; Ear Infection; Earset; Earbud; Earphone; Headphone; Over-Ear; In-Ear; On-Ear.

RESUMEN

Introducción: en los últimos años ha aumentado el uso de auriculares en la población, especialmente entre los jóvenes.
Objetivo: este estudio evalúa la relación entre la proliferación de bacterias y hongos en los oídos de diferentes

usuarios de auriculares (sobre, dentro y en la oreja) y la posibilidad de que los auriculares actúen como vectores de enfermedades prevalentes.
Método: se recogieron muestras de oído (168) de 84 estudiantes varones sanos y se sometieron a aislamiento de bacterias y hongos. También se evaluaron la concienciación, las prácticas, los hábitos y los síntomas de los participantes.
Resultados: se identificaron los aislamientos bacterianos de 54 (64,3 %) participantes: 11(13,1 %) aislamientos de Staph. epidermidis, 10(11,9 %) P. aeruginosa, 25 (29,8 %) Staph. aureus y 8(9,5 %) Strep. pneumoniae. Los participantes 35(41,7 %) utilizaban auriculares inalámbricos, 17(20,2 %) utilizaban auriculares con cable, 24(28,6 %) utilizaban tanto auriculares con cable como inalámbricos, mientras que sólo 8(9,5 %) no los utilizaban. Según la forma y el tipo de auriculares, 33(39,3 %) utilizaban más de un tipo, 25(29,8 %) utilizaban auriculares de botón y 14(16,7 %) utilizaban auriculares de botón. Los participantes comparten los auriculares con otras personas: 34(40,5 %) no los comparten, 26(31,0 %) los comparten a veces y 24(28,6 %) los comparten con frecuencia.
Conclusiones: la presencia de bacterias aisladas del conducto auditivo externo se correlacionó positivamente con el uso de bastoncillos de algodón, el uso de herramientas afiladas para limpiar el cerumen, el uso compartido de auriculares con otras personas, el tipo (con cable o inalámbricos) y la forma (sobreauriculares, intraauriculares, sobreauriculares) de los auriculares de forma significativa. El uso de bastoncillos de algodón y de herramientas afiladas para limpiar el cerumen se correlacionó positivamente de forma significativa con los síntomas del oído que se suelen sentir o padecer.

Palabras clave: Evaluación Microbiana; Infección de Oído; Auriculares; Auriculares de Botón; Auriculares de Casco; Auriculares sobre la Oreja; Auriculares Intraauriculares; Auriculares sobre la Oreja.

INTRODUCTION

The skin serves as an epithelial barrier to the environment and is home to a variety of microorganisms. The specific microhabitats that characterize the nutritional and environmental circumstances of this ecosystem. [1] The skin of the ear canal is joined to the eardrum, bone, and cartilage directly. So, the ear structures and components can get infected with microorganisms.[2,3]

Anywhere in the world, ear infections have various causes and incidence rates. A common ear infection is brought on by bacteria, viruses, and fungi.[4] The majority of bacteria are normal flora that colonize the host without spreading infection. The natural bacterial ecology of the ear is made up of several bacterial colonies, many of which are often found in the external auditory canal.

Staphylococci (such as *S. auricularis*, *S. capitis*, *S. epidermidis*, and occasionally *S. aureus*), Coryneforms (such as *Turicella otitidis*), *Pseudomonas aeruginosa*, alpha-hemolytic *Streptococcus*, and some of *Micrococcus* spp. are among the mostly non-path.[5]

A fungal infection is another infection affecting otitis externa (OE). Several symptoms could indicate an exterior canal fungus infection (e.g., fine, dark coating with *Aspergillus*; white, sebaceous-like material with *Candida*).[6] After infection, the clinically visible disease may or may not be present, and clinically relevant disease is only present in a tiny percentage of infections.

Inflammation of the middle ear; can be suppurative, acute or chronic, or non-suppurative, with effusion. Many people suffer from acute otitis media (AOM), chronic otitis media (COM), and otitis media (OM) with effusion. Cellulitis of the ear canal epidermis and subdermal tissue, along with acute inflammation and fluctuating edema, are symptoms of acute OE.[3]

AOM is characterized by the presence of fluid and a sudden start of signs and symptoms of middle ear inflammation. Whereas COM is described as ear effusion remaining in the middle ear for a prolonged period, OM with effusion is the presence of ear effusion (EE) in the absence of acute infection.[2] Many ways can be used to spread microbial illnesses. A sufficient number of organisms must endure in the environment and get to a vulnerable host for the disease to spread.

Many bacteria have evolved to live in water, soil, food, and other environments, and microbes can be transmitted from environment or person to person.[7] The disease condition is exacerbated by heat, moisture retention, epithelium desquamation, and maceration. There have been some reports on airplane headsets, headphones, and stethoscope earpieces that suggest a link between using headphones or stethoscopes and developing OE.[8]

On the other hand, increasing numbers of people are using digital devices as access to them has increased especially earphone use has increased globally, particularly among college and high school students who share earbuds frequently.[9]

A growing global concern has been the use of electronic devices and gadgets, particularly mobile phones, by young people. The problem has only been made worse by the global COVID-19 lockdown. Students now spend more time on their electronic devices thanks to getting used to virtual classes. It is well known that excessive use of gadgets has detrimental health effects. Long-term use of a device is linked to a number of negative effects, including headache, nausea, ophthalmological issues, and psychological consequences.[10]

Numerous studies of the human environment have shown that items including earbuds, door handles, faucets, phones, money, fabrics, and plastics have been colonized and contaminated.[11] Moreover, using devices including earbuds, earphones, and headphones readily serves as a vector for possible germs that could cause OE.[8]

Since using earsets can increase the canal's warmth and humidity, increase the risk of skin abrasion, and serve as a vehicle for the entry of bacteria into the canal's skin, they have been proposed as potential risk factors for external auditory canal infection.[12]

Therefore, the goal of this study is to evaluate the relationship between bacterial and fungal ear growth among different earsets (earbuds, earphones, and headphones) users as well as the possibility for earsets to act as a vector for prevalent diseases. Also, evaluation of awareness, practices, habits, and symptoms of the participants.

METHOD

Collection and processing of samples

This cross-sectional study included 84 males (*n*=84) healthy participants College of Applied Medical Sciences, Saudi Arabia. The samples were collected during April and May 2023 and processed at the Medical Laboratory Department's microbiological lab. A total of 168 ear samples (two sterile cotton swabs per participant, one for bacterial and one for fungal isolation) were collected from one ear of 84 male healthy student participants (aged 18-25 years) and subjected to inoculation and culturing to isolate bacteria and fungi, also data collected by the questionnaire (a form of Google to ensure confidentiality and accuracy) of participants were analyzed. Because of different names and definitions of earsets among people, different shapes of earsets including over-ear, in-ear, and on-ear in addition to wired and wireless types were in the Google questionnaire form to facilitate the choices of participants and to overcome the confusion (figure 1).

Figure 1. Different shapes of used earsets. a; Over-ear, b; In-ear, c; On-ear

Participants who had used any medication (antibacterial and antifungal antibiotics as well as corticosteroids and other ear medications) known to predispose to microbial ear infection in the previous three months were excluded from this investigation.

Before sample collection, the outer part of the ear was wiped with a disposable alcohol (70 % isopropyl) pad, after approximately 30 seconds, two samples were taken by rolling carefully sterile cotton swab sticks three times in a half circle clockwise direction.

All samples from the external auditory canal were taken by the same person and processed directly by inoculating them into 5 % sheep blood agar (BA), and Nutrient agar (NA, Scharlau, Barcelona, Spain) media were used for the isolation of bacteria and then incubated at 37°C for 24 h, while Sabouraud's dextrose agar (SDA, Scharlau, Barcelona, Spain) for the isolation of fungi and then incubated at 27° C for 2-14 days. All bacterial isolates were subjected to macroscopically, and microscopically examination as well as biochemical tests including gram staining and assayed for catalase test, coagulase production, mannitol fermentation, oxidase test, lactose fermentation, blood hemolysis, and other microbiological diagnostic tests. In addition to Novobiocin, Bacitracin, and Optochin (MASTDISCS CO) susceptibility test and then Petri

dishes were incubated at 35±2 °C for 24 h, and the diameters of the inhibition zone (IZ) were measured. Colonial morphology, culture characteristics, and microscopic examination were used for the identification of isolated mold.

Ethical approval

The study was conducted at the Medical Laboratory Department, Faculty of Applied Medical Sciences, PSAU, Al-Kharj, Saudi Arabia. The studies meet the ethical guidelines of Prince Sattam bin Abdulaziz University, Deanship of Scientific Research, and ethical approval has been agreed under Reference No. SCBR-043-2023. The procedure was standard care, with no experimental treatment methods or drugs. All processes were carried out in conformity with relevant guidelines and regulations. Informed consent was obtained from all subjects verbally. Participants' confidentiality was demonstrated throughout the trial by replacing their names with serial numbers.

Statistical design

SPSS software (Statistical Package for the Social Sciences, version 23, SPSS Inc. Chicago, IL, USA) was used to organize, tabulate, and statistically analyze the acquired data. The chi-square test was used to compare two groups using number and percent (frequency), whereas the Kruskal-Wallis (K-W) test was used to compare more than three groups. For statistically significant interpretation of significance test results, significance was set at $p<0,05$. Spearman's correlation test was used to examine the relationship between variables, including different types according to the shapes of earsets and ear symptoms that usually feel or suffer from it, average feeling or suffering from ear symptoms, average feeling or suffering from ear symptoms, and presence of bacteria.

RESULT

In recent years, there has been an increase in the use of earsets among students. The use of earsets may increase the risk of developing external ear infections in addition to other negative effects.

A total of 168 ear samples were collected from 84 male healthy student participants and subjected to inoculation and culturing to isolate bacteria and fungi, also data collected from participants were analyzed (table 1).

Table 1. General characteristics of participants and consequences (outcomes) among participants

Variable	Sample (*n*=84) *n* (%)
Age in Years	
18-21	50 (59,5)
22-25	34 (40,0)
Suffering from chronic diseases	
No	59 (70,2)
Diabetes	13 (15,5)
Blood pressure	8 (09,5)
other chronic diseases	4 (04,8)
Taking medications	
No	71 (84,5)
Yes	13 (15,5)
Consequences (outcomes) among participants	
Ear symptoms that usually feel or suffer from it	
No ear symptoms or feeling	20 (23,8)
Blocked ear and ear pain	29 (34,5)
Ear discharge (secretion)	25 (29,8)
Itching	10 (11,9)
Average feeling or suffering from ear symptoms	
No ear symptoms or feeling	18 (21,4)
Rarely	32 (38,1)
Sometimes	13 (15,5)
Frequently	21 (25,0)

Depending on the awareness of participants about using earsets (earbuds, earphones, and headphones)

may increase the chances of microbial infection in the ear; out of 84 participants, 53(63,1 %) suggested that the use of earsets might increase the chances of infection with microbes, while 31(36,9 %) participants did not support this idea. Also, this study showed that the presence of bacteria or no presence of it as well as the type of isolated bacteria was not affected (not significant *p*-value > 0,05) by the participant's awareness.

A study of potential consequences (outcomes) among 84 participants and the average feeling or suffering from ear symptoms of these participants were expressed in table 1.

The bacterial isolates from 54 (64,3) participants, out of them 44 (52,4 %) gram-positive cocci bacteria, 10 (11,9 %) gram-negative bacilli while 30 (35,7 %) participants had no bacterial growth. In addition, 11 (13,1 %) isolates were identified as *S. epidermidis*, while 10 (11,9 %) had *P. aeruginosa*, 25 (29,8 %) *S. aureus*, 8 (9,5 %) *S. pneumoniae* bacteria were identified. On the other hand, only one (1,2 %) mold (*Aspergillus* sp.) was isolated from participants (table 2).

The practices, habits, and symptoms of the participants in this study were measured, in addition to the bacterial assessment isolated from the external auditory canal to evaluate the effect of the earset use among participants (table 2).

The average use of cotton buds to clean the earwax was evaluated (table 2). A comparison of the presence or type of isolated bacteria between participants using and not using cotton buds to clean the earwax was evaluated among participants and they showed significant findings ($p<0,05$). This indicates that this habit/practice does affect the presence and type of bacteria in the external auditory canal.

In this study, participants were using sharp tools or other non-medical tools to clean earwax, such as keys. The presence and type of isolated bacteria and the effect of using sharp tools or any other non-medical tools to clean earwax were evaluated among participants, and they showed significant findings ($p<0,05$). This indicates that this habit/practice does affect the presence and type of bacteria in the external auditory canal.

Using wired or wireless (Bluetooth) earsets, earbuds have become more popular among all age groups. Moreover, the presence and types of isolated bacteria when using wired or wireless (Bluetooth) earsets were evaluated among participants and they showed significant findings ($p<0,05$). This indicates that this habit/practice affects the presence and type of bacteria in the external auditory canal.

Regarding types according to shapes of earsets, 33(39,3 %) use more than one type, 25(29,8 %) use headphones (over the ear), 14(16,7 %) use earphones (on the ear), while 8(9,5 %) do not use earsets. On the other hand, the presence and types of isolated bacteria in earsets showed significant findings ($p<0,05$). This indicates that this habit/practice does affect the presence of bacteria in the external auditory canal.

In addition, the average daily use of earsets among the participants was evaluated in addition to presence and types of isolated bacteria, and the average use of earsets daily, showed non-significant findings ($p>0,05$), This indicates that this habit/practice does not affect either the presence or type of bacteria in the external auditory canal.

The duration (how long) of use of earsets by years among the participants, was evaluated in table 2. As for the relation between the presence and types of isolated bacteria and the duration (how long) of using earsets by years, they were evaluated among participants and showed non-significant findings ($p>0,05$). This indicates that this habit/practice does not affect either the presence or type of bacteria in the external auditory canal.

According to participants sharing earsets with other persons, the relation between the presence of bacteria and the sharing of earsets with other persons was evaluated among participants, and they showed significant findings ($p=0,048$), This indicates that this habit/practice affected the presence of bacteria in the external auditory canal.

Based on the participants using earsets during sports, the relation between the presence and type of isolated bacteria and using earsets during sports was evaluated among participants, and they showed non-significant findings ($p>0,05$). This indicates that this habit/practice does not affect the presence and type of bacteria in the external auditory canal.

Nevertheless, on average (number of times/week) swimming or using the swimming pool, the link between the presence and type of isolated bacteria and the average (number of times/week) swimming or using the swimming pool, showed non-significant findings ($p>0,05$). This indicates that this habit/practice does not relate to either the presence or type of isolated bacteria in the external auditory canal.

In the case of suffering ear pain during and after using earsets. The link between the presence of isolated bacteria and suffering from ear pain during and after using the earsets was evaluated among participants, and they significantly showed findings ($p<0,05$), This indicates that this symptom is related to the presence of bacteria in the external auditory canal.

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Table 2. The practices, habits, and symptoms of the participants and the presence of isolated bacteria

Variable	Total *n* (%)	No-bacterial growth *n* (%)	Presence of bacteria *n* (%)	H (*P*)	Gram +ve			Gram -ve	H (*P*)
					Staphylococcus epidermidis *n* (%)	*Staphylococcus aureus* *n* (%)	*Streptococcus pneumoniae* *n* (%)	*Pseudomonas aeruginosa* *n* (%)	
n (%)	84 (100)	30 (35,7)	54 (64,3)		11 (13,1)	25 (29,8)	8 (9,5)	10 (11,9)	
Effect of using cotton buds to clean the earwax									
Not use	16(19,0)	08(09,5)	08(09,5)	09,191 (0,021*)	02(02,4)	04(04,8)	00(00,0)	02(2,4)	14,082 (0,593)
Rarely (one time /month)	28(33,3)	10(11,9)	18(21,4)		03(03,6)	08(09,5)	03(03,6)	04(04,8)	
One time /week	16(19,0)	05(06,0)	11(13,1)		04(04,8)	06(07,1)	01(01,2)	00(00,0)	
Two times /week	12(14,3)	03(03,6)	09(10,7)		01(01,2)	02(02,4)	03(03,6)	03(03,6)	
Used frequently	12(14,3)	04(04,8)	08(09,5)		01(01,2)	05(06,0)	01(01,2)	01(01,2)	
Effect of Using sharp tools or any other non-medical tools to clean earwax									
Not use	59(70,2)	26(31,0)	33(39,3)	07,120 (0,028*)	09(10,7)	13(15,5)	06(07,1)	05(06,0)	16,795 (0,032*)
Rarely	23(27,4)	03(03,6)	20(23,8)		01(01,2)	12(14,3)	02(04,8)	05(06,0)	
Used frequently	02(02,4)	01(01,2)	01(01,2)		01(01,2)	00(00,0)	00(00,0)	00(00,0)	
Effect of using wired or wireless (Bluetooth) earsets									
Not use	08(09,5)	03(03,6)	05(06,0)	12,58 (0,006*)	00(00,0)	05(06,0)	00(00,0)	00(00,0)	27,731 (0,006*)
Wired earset	17(20,2)	10(11,9)	07(08,3)		04(04,8)	01(01,2)	01(01,2)	01(01,2)	
Wireless (Bluetooth) earsets	35(41,7)	15(17,9)	20(23,8)		01(01,2)	12(14,3)	03(03,6)	04(04,8)	
Wired and wireless earsets	24(28,6)	02(02,4)	22(26,2)		06(07,1)	07(08,3)	04(04,8)	05(06,0)	
Different types (according to shapes) of earsets									
Not use	08(09,5)	03(03,6)	05(06,0)	10,138 (0,009*)	00(00,0)	05(06,0)	00(00,0)	00(00,0)	22,725 (0,121)
Headphone (over-ear)	25(29,8)	11(13,1)	14(16,7)		05(06,0)	04(04,8)	03(03,6)	02(02,4)	
Earphone (on-ear)	14(16,7)	05(06,0)	09(10,7)		00(00,0)	04(04,8)	00(00,0)	05(06,0)	
In-ear (earbud)	04(04,8)	02(02,4)	02(02,4)		01(01,2)	01(01,2)	00(00,0)	00(00,0)	
Use more than one kind	33(39,3)	9(10,7)	24(28,6)		05(06,0)	11(13,1)	05(06,0)	03(03,6)	
The average daily of using earsets									
Not use	08(09,5)	03(03,6)	05(06,0)	01,859 (0,602)	00(00,0)	05(06,0)	00(00,0)	00(00,0)	11,893 (0,454)
Less than 1 hour daily	14(16,7)	07(08,3)	07(08,3)		01(01,2)	04(04,8)	00(00,0)	02(02,4)	
From 1 to 2 hours daily	31(36,9)	11(13,1)	20(23,8)		04(04,8)	08(09,5)	05(06,0)	03(06,6)	
More than 3 hours daily	31(36,9)	09(10,7)	22(26,2)		06(07,1)	08(09,5)	03(03,6)	05(06,0)	
Duration of using of ear set by years									
Not use	08(09,5)	03(03,6)	05(06,0)	01,872 (0,759)	00(00,0)	05(06,0)	00(00,0)	00(00,0)	16,010 (0,452)
Less than one year	04(04,8)	01(01,2)	03(03,6)		00(00,0)	02(02,4)	01(01,2)	00(00,0)	
From 1 to 2 years	22(26,2)	07(08,3)	15(17,9)		04(04,8)	06(07,1)	02(02,4)	03(03,6)	
From 3 to 4 years	29(34,5)	13(15,5)	16(19,0)		02(02,4)	09(10,7)	02(02,4)	03(03,6)	
5 years or more	21(25,0)	06(07,1)	15(17,9)		05(06,0)	03(03,6)	03(03,6)	04(04,8)	

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Sharing of earsets with other persons									
NO	34(40,5)	13(15,5)	21(25,0)	06,469 (0,048*)	05(06,0)	10(11,9)	03(03,6)	03(03,6)	4,672 (0,792)
Sometimes	26(31,0)	09(10,7)	17(20,2)		04(04,8)	05(06,0)	03(03,6)	05(06,0)	
Frequently	24(28,6)	08(9,5)	16(19,0)		02(02,4)	10(11,9)	02(02,4)	02(02,4)	
Using earsets during sports									
NO	24(28,6)	5(6,0)	19(22,6)	05,543 (0,136)	04(04,8)	12(14,3)	01(01,2)	02(02,4)	19,829 (0,070)
Rarely	20(23,8)	9(10,7)	11(13,1)		02(02,4)	05(06,0)	04(04,8)	00(00,0)	
Sometimes	17(20,2)	9(10,7)	08(09,5)		01(01,2)	03(03,6)	00(00,0)	04(04,8)	
Frequently	23(27,4)	07(08,3)	16(19,0)		04(04,8)	05(06,0)	03(03,6)	04(04,8)	
The average (number of times/week) swimming or using the swimming pool									
NO	28(33,3)	08(09,5)	20(23,8)	6,348 (0,096)	04(04,8)	09(10,7)	05(06,0)	02(02,4)	16,163 (0,184)
1 to 2 times weekly	33(39,3)	09(10,7)	24(28,6)		07(08,3)	09(10,7)	02(02,4)	06(07,1)	
3 to 4 times weekly	17(20,2)	09(10,7)	08(09,5)		00(00,0)	06(07,1)	00(00,0)	2(2,4)	
5 times weekly or more	06(07,1)	04(04,8)	02(02,4)		00(00,0)	01(01,2)	01(01,2)	00(00,0)	
Suffering from ear pain during and after using the earsets									
NO	37(44,0)	08(09,5)	29(34,5)	08,027 (0,045*)	07(08,3)	13(15,5)	02(01,2)	07(08,3)	136,01 (0,191)
Rarely	15(17,9)	05(06,0)	10(11,9)		01(01,2)	05(06,0)	03(03,6)	01(01,2)	
Sometimes	29(34,5)	16(19,0)	13(15,5)		03(03,6)	05(06,0)	03(03,6)	02(02,4)	
Frequently	03(03,6)	01(01,2)	02(02,4)		00(00,0)	02(02,4)	00(00,0)	00(00,0)	

Note: *Significant (P<0,05). (x^2) chi-square tests. (H) Kruskal-Wallis tests.

Table 3. Correlation matrix between selected variables among participants using earsets (n=84).

Variable	Awareness of participants about using earsets may increase the chances of microbial infection in the ear	Effect of using cotton buds to clean the earwax	Effect of using sharp tools or any other non-medical tools to clean earwax	Effect of using wired or wireless (Bluetooth) earsets	Different types according to shapes of earsets (over-ear, in-ear, on-ear)	Sharing of earsets with other persons	Using ear sets during sports	The average (number of times/week) swimming or using the swimming pool
Ear symptoms that usually feel or suffer from it	R =0,187 P =0,185	R =0,268 P =0,021*	R =0,292 P =0,013*	R =0,210 P =0,135	R =0,159 P =0,127	R =0,340 P =0,004*	R =0,237 P =0,091	R =0,193 P =0,171
Average feeling or suffering from ear symptoms	R =-0,02- P =0,886	R =0,355 P =0,010*	R =0,369 P =0,025*	R =0,101- P =0,480	R =0,051 P =0,637	R =0,243 P =0,082	R =-0,033- P =0,818	R =-0,016- P =0,910
Presence of bacteria	R =0,149- P =0,291	R =0,293 P =0,013*	R =0,266 P =0,049*	R =0,379 P =0,006*	R =0,392 P =0,016*	R =0,283 P =0,017*	R =-0,092- P =0,516	R =-0,145- P =0,304

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The correlation matrix between selected variables among participants using earsets illustrated in table 3, showed that: The effect of using cotton buds to clean the earwax significantly correlated positively (p<0,05) with ear symptoms that are usually felt or suffered from it, average feeling or suffering from ear symptoms, and the presence of bacteria isolated from the external ear auditory canal. So, using cotton buds may increase the suffering and occurrence of symptoms in the ear, average feeling or suffering from ear symptoms, and the presence of bacteria isolated from the external ear auditory canal.

Also, the effect of using sharp tools or any other non-medical tools to clean earwax correlated positively (p<0,05) with ear symptoms that are usually felt or suffered from it, the suffering and occurrence of symptoms in the ear, average feeling or suffering from ear symptoms, and the presence of bacteria isolated from the external ear auditory. So, using sharp tools or any other non-medical tools to clean earwax increases the suffering and occurrence of symptoms in the ear, Average feeling or suffering from ear symptoms, and the presence of bacteria isolated from the external ear auditory canal.

Moreover, sharing earsets with other persons significantly correlated positively (p<0,05) with ear symptoms that are usually felt or suffered from it, and the presence of bacteria isolated from the external ear auditory canal. So, sharing earsets with other people may increase the suffering and occurrence of symptoms in the ear, and the presence of bacteria isolated from the external ear auditory canal.

Also, the effect of using wired or wireless (Bluetooth) earsets significantly correlated positively (p<0,05) linked to the presence of bacteria isolated from the external ear auditory canal. So, using wired or wireless (Bluetooth) earsets may increase the presence of bacteria isolated from the external ear auditory canal.

In the same context, the effect of using different types (according to shapes) of earsets (over-ear, in-ear, on-ear) significantly correlated positively (p<0,05) with the presence of bacteria isolated from the external ear auditory canal. So, using different types (according to shapes) of earsets may increase the presence of bacteria isolated from the external ear auditory canal.

DISCUSSION

In recent years, human behavior and lifestyle Improvement changed over time according to many factors. There has been an increase in the use of earsets among people, including students. The use of earsets and other behaviors may increase the risk factor of developing external ear infections in addition to other negative effects therefore studying the use of earsets and their types is important to evaluate this effect of bacterial and fungal infection. This is due to the fact that prolonged use of the device may raise the temperature and humidity of the earlobes and canals that are covered by the headphones, increasing the risk of skin abrasion. It may also act as a vector for the introduction of bacteria into the skin of ear canals. The device's local pressure exertion may also be a contributing factor.[8,9,11,13]

This study includes healthy individuals, only male participants were selected, and female participants were excluded because the hormonal effect of females may increase sebum excretion in the ear canal or due to hormonal changes in the epidermis of the external ear canal, which causes the environment in the canal to resemble other risk factors. OE appears to be more common during pregnancy. Furthermore, external auditory canal infection is most common in the third trimester of pregnancy.[14,15]

Depending on the awareness of participants about using earsets (may increase the chances of microbial infection in the ear; 63,1 % suggested that the use of earsets might increase the chances of infection with microbes, while 36,9 % of participants did not support this idea. This is near to the Alarfaj et al.[16] results which state there was an adequate awareness of the side effects of excessive usage of earbuds among teenagers and young adults but not agree with El Magrahi et al.[17] study in Libya by students using earphones (72 % unaware).

Potential consequences (outcomes) of all participants in the current study showed that 34,5 % suffered from blocked ear and ear pain, 29,8 % from ear discharge, and 11,9 % had a feeling of itching in their ears while 21,4 % had no ear symptoms or feeling of any symptoms. These findings may differ partially from those of Alarfaj et al.[16], who noticed that the most commonly reported symptoms of prolonged earbud use were 23 % otalgia, 28 % itching, and 21,8 % excessive ear wax. They discovered that ear disease, hearing loss, ear infection, ringing in the ears, and dizziness were the most often stated ear complications caused by excessive use of headphones.

The average feeling or suffering from ear symptoms of these participants in the current study exhibited that 21,4 % did not have any ear symptoms or feeling of symptoms, 38,1 % rarely did not feel any symptoms, 25,0 % frequently felt ear symptoms, and 15,5 % participants sometimes felt ear symptoms. In another study, the use of headphones (by customer service employees) is not related to an ear infection but related to increasing ear symptoms and middle ear infection average among headphone users already suffering from a chronic middle ear infection.[18]

In the current study, the most common microbial isolates among participants were isolated bacterial isolates, only one (1,2 %) fungus was isolated from participants. Of the bacterial isolates from 64,3 % of all participants, 52,4 % were gram-positive cocci bacteria, 11,9 % were gram-negative bacilli and 35,7 % of participants had no bacterial growth. Bacterial isolates identified as *Staphylococcus aureus* (29,8 %), *Staphylococcus epidermidis*

(13,1 %), *Pseudomonas aeruginosa* (11,9 %), and *Streptococcus pneumoniae* (9,5 %). A previous study showed that the bacteria *Staphylococcus aureus* and *Pseudomonas* species are common commensals found in the ear.[19,20] Also, the results of this study are close to the results of another study that confirmed that Gram-positive organisms were found in 92 % of earphones and 96 % of ear canals, with Gram-negative organisms found in 4 % of ear canals and 8 % of earphones. That could be due to students not sharing earphones and forgetting to clean their earsets, which can harbor many bacterial types.[17]

In the current study, the practices and habits of the participants showed, that 33,3 % of participants had rarely used cotton buds to clean the earwax, 19,0 % had used it one time /week, 14,3 % participants had used it two times /week, 14,3 % used frequently, while 19,0 % do not use cotton buds to clean the ear. That means approximately most (81 %) participants used cotton tips to clean earwax. Olajide et al.[21] also reported that the majority of participants (92,8 %) used cotton buds to clean their ears.

The current study indicates that using cotton buds to clean the earwax habit does affect the presence but does not affect bacterial type in the external auditory canal. In other words, the presence of bacterial isolates correlated positively with the use of the cotton bud for removing ear wax. This does agree with other studies.[21,22] The use of a cotton-tip applicator to clean the ears is thought to be the major cause of OE in different ages, this is explained by the cotton buds making cerumen more entrance inside the ear canal and the cotton-tip applicator may cause scraping of the ear canal, while in Khan et al.[23] study is not consistent with the current study. This may be attributed to the method of using earbuds, the time of study, and environment/ climate differences (dry, hot, humid) study area.

Participants were using sharp tools or other non-medical tools to clean earwax, 70,2 % of participants did not use sharp tools, 27,4 % rarely used sharp tools, and 2,4 % used them frequently. The current results indicate that using sharp tools or any other non-medical tools to clean earwax affects (significantly) the presence and type of bacteria in the external auditory canal. By using correlation matric was explained that the presence of bacterial isolates correlated positively with the use of sharp tools to clean the ear canal. The use of non-medical and sharp tools to clean the ear canal causes scraping or injury to the ear canal and introduces foreign microorganisms into the ear canal can quickly traumatize the ear canal and lead to infection as well as a sign of otomycosis or eczema.[21]

Using wired or wireless (Bluetooth) earsets in the current study, wireless known as earbuds among young participants have become more popular among all age groups. In this study, 41,7 % of participants use only wireless earsets, 20,2 % use wired earsets, and 28,6 % of participants use both wired and wireless earsets. The number of earbud or wireless earsets participants is high in the current study but decreased slightly in participants in the Alarfaj et al.[16] study was performed in the eastern province of KSA, where most participants (92,7 %) use earbuds, while only 7,3 % use headphones and the number of wireless (earbud) participants is increasing among students.[16,24] The current study indicates that using wired or wireless (Bluetooth) earsets practice affects (significantly) the presence and type of bacteria in the external auditory canal or by correlation matrix analysis, the presence of bacterial isolates correlated positively with the use of wired or wireless ear devices, this agrees with Zia et al.[25] study which confirmed ear infections and suffering from tinnitus symptoms associated with headphone use.

Regarding types according to the shapes of earsets in the current study, 39,3 % use more than one type, 29,8 % use headphones (over the ear), 16,7 % use earphones (on the ear), and 09,5 % do not use earsets. This means that the largest percentage of participants use more than one kind of earset (39,3 %). Alarfaj et al.[16] results showed the use of earbuds was found among 32,5 % of the respondents. The previous study, that the earsets type according to different shapes (over-ear, in-ear, on-ear) of earsets as a factor does affect (significantly) the presence of bacteria in the external auditory canal, by correlated matrix, the presence of bacterial isolates correlated positively with the use of different earsets shapes. This may be attributed to the nature of the materials, shape, structure, and mechanical mechanism of the earset with the ear.

In the present study, the average daily of earsets among the participants showed 36,9 % use the earsets for 1 - 2 hours daily, 16,7 % use earsets for less than one hour, 9,5 % do not use the earsets and 36,9 % use more than 3 hours daily. This indicates that the average use of earsets daily does not affect (non-significant) either the presence or type of bacteria in the external auditory canal. According to the duration (how long) of use of earsets by years among the participants in the present research, 34,5 % use earsets for 3 - 4 years, 26,2 % use earsets for 1 to 2 years, 25,0 % used it 5 years and more, 4,8 % used the ear set for less than one year, and 9,5 % did not use earsets. This indicates that the duration (how long) of using earsets by years does not affect (non-significant) either the presence or type of bacteria in the external auditory canal. In Alarfaj et al.[16] study, 46,6 % of participants had been using earbuds for 1-5 years, with many of them using them daily (32,5 %) for roughly 1-2 hours (49,8 %).

According to participants sharing the earsets with other persons in the current study, 40,5 % of participants do not share earsets, 31,0 % share the earsets sometimes, and 28,6 % of participants frequently share earsets. Sharing earsets with other persons affects (significantly) and correlates positively with the presence of bacteria

in the external auditory canal. This agrees with the results of another research that proved an increase in bacterial growth in the ear, and the prevalence increased by sharing the earpiece.[8,26]

Based on the participants who are using earsets during sports in the present research, 28,6 % are non-used, 27,4 % frequently use ear sets during sports, 23,8 % rarely use ear sets during sports, and 20,2 % were using earsets sometimes during sports. In the previous study, using earsets during sports does not affect (non-significantly) the presence and type of bacteria in the external auditory canal. While Flowers and Pillay's[27] research discovered that individuals are unaware of the proper way to clean the ear, it is critical to educate gym members on how to care for their ears and avoid future damage from using earsets.

The average (number of times/week) swimming or using the swimming pool does not affect (non-significantly) the presence and type of bacteria in the external auditory canal. This does not agree with Nussinovitch et al.[22] study causing Acute OE, this is explained by using swimmer pools frequently in the summer and may be caused by a reduction in canal acidity, leading to overgrowth of bacteria. The ear feels itchy and uncomfortable, and the canal is bloated and red. However, the results in the current study may be attributed to the dry weather and low humidity in the study area in addition to the time of the study.

From all of the above results, in the current study, the presence of bacteria in the ear auditory canal correlated positively with using cotton buds and using sharp tools to clean ear wax, sharing earsets with other persons, using different types (wired or wireless) and shapes (over-ear, in-ear, on-ear) of earsets. This agrees with the results of other research proved that owing to frequent and constant use of earphones, OE was present in a large percentage (56 %–92 %) of swabs of the ear or earphone swabs in one of the studies, which found an increase in bacterial growth in the ear, and the prevalence increased by sharing the earpiece.[8,26]

Limitations

This study had some limitations. The sample size was limited because the study was carried out and contained data from a single study location at one time, and not every behavior of participants was observed.

CONCLUSION

The lifestyle has significantly changed, with a particular emphasis on learning methods that rely on electronic devices, including earsets. More public health education is needed to educate how to disinfect ear sets to reduce earsets microbial load and how to choose suitable designs and types of earsets, especially those appropriate to the user's ear, because the type (wired and wireless) and shape (over-ear, in-ear, on-ear) of earsets correlated positively to the presence of bacteria in the ear auditory canal. Moreover, further instruction in public health is needed to prevent individuals from some bad habits, including removing wax by using sharp tools and the risk of sharing earsets with other persons. The awareness about the negative effects of excessive usage of earsets in addition to the negative effects of every type of earset and how to reduce prolonged use of the device, which can raise the temperature and then increase the humidity of the outer ear, which facilitates and increases the transport of microbes into auditory canals. Earset use may raise the likelihood of acquiring external ear infections, among other undesirable consequences; therefore, using an earset is considered one of the potential risk factors for ear infections.

Recommendation

Earsets use may raise the likelihood of acquiring external ear infections, among other undesirable consequences, therefore using an earset is considered one of the potential risk factors for ear infection. More research is needed to evaluate the different negative effects of all types of earsets. Moreover, it validates the general population's high degree of knowledge and its relevance to the long-term effects of excessive earset use among males and females.

Implications of the study for practice

This is the first time that the effect using of different types of earsets separately, whether over-ear, in-ear, and on-ear earsets or even wired or wireless, has been studied. This study benefits in understanding the risks associated with using different types of earsets and factors that minimize these risks by investigating the presence, growth, and transmission of bacteria and fungi in the external auditory canal of individuals using various types of earsets. This information can help identify specific species responsible for causing infections. Moreover, determining how these pathogens are transmitted among users through sharing or using contaminated earsets. Understanding the transmission patterns may aid in developing recommendations for proper hygiene practices to reduce infection risks.

What does this paper add to the body of knowledge?

Evaluating the likelihood of contracting an ear infection while using different types of earsets individually (including over-ear, in-ear, and on-ear earsets or even wired or wireless) and comparing these risks with other

potential sources of infections. Identifying high-risk factors can help prioritize preventive measures. Based on the findings, guidelines for users to maintain proper hygiene practices when using various types of earsets, including regular cleaning of earbuds and earpieces, avoiding sharing headsets with others, and seeking medical attention if experiencing symptoms of an ear infection. Finally, it could help in raising awareness among consumers about the potential risks associated with improper use of earsets to encourage responsible practices and promote overall ear health.

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CONFLICT OF INTEREST

Declare potential conflicts of interest; The authors declare that there is no conflict of interest.

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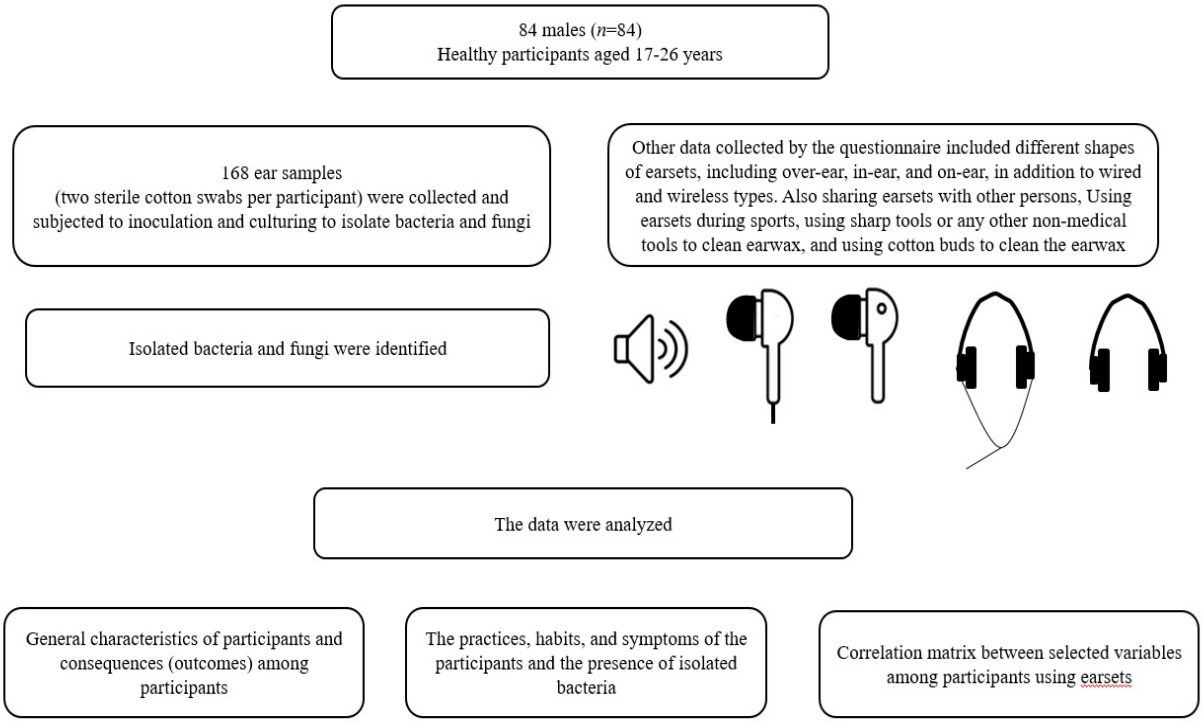
ANNEX



Annex 1. Graphical abstract

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