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RESEARCH ARTICLE

BACTERIAL CONJUNCTIVITIS AMONG MALNOURISHED CHILDREN: CAUSES, ASSOCIATED FACTORS, AND OPHTHALMIC ANTIBIOTIC RESISTANCE PATTERNS OF COMMON BACTERIAL ISOLATES

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Abstract

Background and aims: More than 15 million children worldwide are thought to have one or more congenital or acquired visual impairments. If their immune system is defective due to poor nutrition, children are more susceptible to eye infections and other eye disorders. The ongoing, intense war and disruption of social services have had a clear impact on the overall health and nutritional status of children and the entire population in Yemen. Therefore, the purpose of this study was to study bacterial conjunctivitis in malnourished children by identifying bacterial causes and associated factors and determining patterns of ocular antibiotic resistance in bacterial isolates.
Subject and methods: A cross-sectional study was carried out in the three selected places (Alkhpt hospital in Al-Kapt district, Al-Khamis hospital in Al-Khamis district, and Al-Joumhori hospital in Al-Mahwatt city), from November 2022 until June 2023. The first clinical investigations of malnutrition and conjunctivitis were done by doctors in the hospitals and recorded in the pre-designed questionnaire. Collected eye swabs were investigated for bacteriological agents and antibiotic susceptibility according to standard laboratory methods in the National Center of Public Health Laboratories Sana'a (NCPHL).
Results: The study included 351 males (46.4%) and 406 females (53.6%). 143 children (18.9%) suffer from moderate acute malnutrition (MAM) and 55 (7.3%) from severe acute malnutrition (SAM), with total global acute malnutrition equal to 198 (26.2%).There was a highly significant association of bacterial conjunctivitis with MAM (OR=3.1, p<0.0001), SAM (OR=2.9, p<0.0001), and severe stunting (OR=2.2, p<0.0001).
Conclusions: The severity of acute malnutrition was very high in the study area, reaching a critical phase and exceeding the emergency threshold. The commonest causative organisms of bacterial conjunctivitis were *S. aureus* and *Branhamella catarrahalis*. Since there isn't a single medication that can effectively treat these diverse species of bacteria, it's best to look into bacteriological culture and *in vitro* antibiotic sensitivity.
Keywords: bacterial causes, bacterial conjunctivitis, children, malnutrition, ophthalmic antibiotic resistance.

INTRODUCTION

Over 15 million children worldwide are thought to have one or more congenital or acquired visual impairments[1]. According to a Ghanaian study, congenital defects are responsible for 60% of juvenile blindness and 93% of hospital visits are related to acquired eye problems[2-3]. Children do not have fully developed vision at birth; instead, their capacity to see develops as they grow. Both functional and electrophysiological studies indicate that their visual acuity is rather low from birth[4]. Infant's rapid changes in visual development mean that by the time they are three to five years old, they are honing the skills they have already learned[5]. During this period, any vision problems that develop should be recognized and addressed as once as they may be congenital or acquired. Eye and vision problems can cause

developmental delays, and the longer a visual problem is ignored, the more the child's brain becomes accustomed to it[5].

"Conjunctivitis" is a general term that covers a variety of conditions. Conjunctivitis, also known as "pink eye", is an inflammation of the outer layer of the white part of the eye and the inner surface of the eyelid makes the eye look pink or crimson. Itching, discomfort, irritation, or searing could be present. The affected eye may be "stuck" or have more tears in the morning. Additionally, the white part of the eye may enlarge. Itching is more likely to result from an allergic reaction. Conjunctivitis can affect one or both eyes[6]. Viral infections account for around 70% of cases of infectious conjunctivitis, and bacterial infections cause about 30% of cases. The non-infectious types, which include neoplastic, immunogenic, mechanical/irritant/ toxic, and allergy, are less common than viral and bacterial infections[6,7]. An examination of the occurrence of positive cultures in these situations indicates that about 32% of patients who present to their general practitioner with purulent (mucous) secretions, prickly secretions in the eyelids, or red eyes have bacterial origins. Although bacterial conjunctivitis usually affects one eye, research by Shields and Sloane[8], and Silvester *et al.*[9], have shown that it can occasionally affect both eyes. Staphylococcal species are most frequently contracted by adults with bacterial conjunctivitis, followed by *Haemophilus influenza* and *S. pneumoniae*[10]. Children's conjunctivitis is bacterially caused in 50–75% of cases; *S. pneumoniae*, *H. influenzae*, or *Moraxella catarrhalis* are the most common bacteria that cause these illnesses. The two bacteria that cause the most severe cases of bacterial conjunctivitis in children are *Neisseria gonorrhoeae* and *Chlamydia trachomatis.* Ophthalmologists should refrain from using broad-spectrum topical antibiotics right soon because MRSA is the causative agent of up to 64% of instances of topical antibiotic-resistant staphylococcalconjunctivitis. Thereis no proof that any particular topical antibiotic agent is superior to another. An ophthalmologist must treat this with antibiotics that are effective against MRSA, such as besifloxacin ophthalmic suspension[7,11].

Antibiotic misuse is associated with a rise in bacterial resistance, which is why there has been a global movement to limit antibiotic use in recent years. In the United Kingdom, for instance, GPs have recommended less chloramphenicol for conjunctivitis; nevertheless, because it was the first antibiotic to be made available without a prescription, its use has multiplied[8,9]. The surveillance of pathogenic organisms and resistance susceptibility patterns have a major impact on antimicrobial selection. An important study conducted in the US[10]. Research on trends in bacterial resistance to antimicrobials over the past ten years has limited application in the UK, since the antibiotic chloramphenicol, which is widely used in the UK, is not used in the USA due to a rare but purported association between topically administered chloram-phenicol and aplastic anemia[10]. The ongoing, intense war and disruption of social services have had a clear impact on the overall health and nutritional status of children and the entire population in Yemen. Therefore, the purpose of this study was to study bacterial conjunctivitis in malnourished children by identifying bacterial causes and associated factors and determining patterns of ocular antibiotic resistance in bacterial isolates.

SUBJECTS AND METHODS

Study design: This cross sectional study was carried out in the three selected places (Al-Khpt hospital in Al-Kapt district, Al-Khamis hospital in Al-Khamis district and Al-Joumhori hospital in Al-Mahwatt city), from November 2022 until June 2023 (time allowed for field work for the Master's degree).

The sample size: At 99% confidence levels, the sample size was computed using the following formula: Based on the information from the previous year, the approximate number of children who attended the four designated institutions for medical examinations in a year is equal to 2000. According to the study conducted in Yemen on adults by Al-Aryani *et al.*[12], the estimated recurrence rate for bacterial conjunctivitis in children was approximately 39%, with an acceptable margin of error of 3.6%. Consequently, in order to obtain results in the Yemen study areas that are reasonably close to the actual results, we need at least 757 pediatric patients at a 99% confidence level.

Data collection: Individual data were collected in a self designed questionnaire including; nutritional stats, clinical data, demographic data, association conjunctivitis with malnutrition, and laboratory results.

Fields and laboratory works: The first clinical investigations of malnutrition and conjunctivitis were done by doctors in the hospitals and recorded in the pre-designed questionnaire. Then, bacterial eye swabs were taken for both eyes from all children in the three selected places. Collected eye swabs were investigated for bacteriological agents and antibiotic susceptibility in detail. First, conjunctiva samples were collected using sterile cotton swabs from the inferior conjunctival fornix as per local protocol. Then swabs were put in transport media, then transferred to the National Center of Public Health Laboratories Sana'a (NCPHL) for investigation and antibiotic sensitivity. Following that, samples were inoculated onto MacConkey agar, chocolate agar, and Columbia agar containing 5% blood. It was then incubated in environments that were appropriate. Following 24 and 48 hours of incubation, plates were checked for the presence of microorganisms linked to conjunctivitis. Lastly, common laboratory techniques were used to identify the isolated organisms[13]. A small amount of bacterial proliferation is considered a negative outcome.

Antibiotic sensitivity tests: In accordance with CLSI recommendations, antimicrobial susceptibility testing was performed on Muller-Hinton agar using the Kirby-Bauer disk diffusion method. Commercial antimicrobial discs (Oxoid, UK) have been used to evaluate antimicrobial susceptibility. For ocular infections, thirteen (13) antibiotics were selected with a variety of modes of action, such as those that interfere

with protein synthesis, DNA, and cell walls (Table 6). The diameter of the inhibition zones were used to calculate the antibacterial efficacy after incubation. Based on the diameter of the inhibitory zone, the bacterial strains were categorized as either resistant (R) or sensitive (S)[14].

Ethical approval: The official approval was given by the Medical Ethics Committee of Sana'a University's Faculty of Medicine and Health Sciences on May 12, 2021, with reference number 2021-15. Every research participant signed a consent form. Every piece of information, including patient identity and clinical specifics, were kept private.

Statistical analysis: The data were analyzed using a case-control study design in order to link potential risk factors, such as starvation, to conjunctivitis. Children with conjunctivitis who showed signs of bacterial infection were matched with those whose bacterial cultures were negative. The association odds ratios (OR) and their 95% confidence intervals (CI) were observed using the chi square. 2x2 tables were utilized to estimate values (OR, CI, χ^2) in order to determine the potential odds ratio and significance of bacterial conjunctivitis occurrence. A *p*-value of 0.05 or less indicated statistical significance for the outcome.

RESULTS

Patients came from three different Al-Mahweet governorate district: Al-Mahwatt city made up 40% of the patients, Al-Kapt district made up 31.8%, and Al-Khamis district made up 29.2%. In terms of mother education, 245 (32.4%) of mothers are illiterate, 348 (46%) are in primary, elementary, or preparatory school, 126 (16.6%) have a secondary diploma, and only 38 (5.02%) are in a university. With respect to father education, 161 (21.3%) of the fathers were illiterate, 273 (36.1%) had a primary, elementary, or preparatory diploma, 272 (36.6%) had a secondary diploma, and just 51 (6.7%) had a university degree.

Table 1: Socio-demographic characteristics of the sick children involved in the study (n = 757).

Socio-demographic characteristics		Number of the studied sick children (*N* = 757) N (%)
Sex	Male	351 (46.4)
	Female	406 (53.6)
District	Al-Kapt district	241 (31.8)
	Alkhamis district	221 (29.2)
	Al-Mahwatt city	295 (40)
Mother educational level	Illiterate	245 (32.4)
	Primary/elementary/preparatory	348 (46)
	Secondary/diploma	126 (16.6)
	University+	38 (5.02)
Father educational level	Illiterate	161 (21.3)
	Primary/elementary/preparatory	273 (36.1)
	Secondary/diploma	272 (36)
	University+	51 (6.7)
Father job	Unemployed	252 (33.3)
	Employed	500 (66.1)
	Student	5 (0.7)
Family monthly income	Enough	83 (11)
	Not enough	674 (89)
Residency	resident	582 (76.9)
	Internally displaced persons (IDPs)	167 (22.1)
	Muhamsheen	8 (1.05)
Drinking water supply in the house	Available and Regular	162 (21.4)
	Available but not regular	503 (66.4)
	Not available	92 (12.2)

In terms of occupation of the fathers, there were 500 (66.1) employed and 252 (33.3%) jobless. When family monthly income was taken into account, 674 (89%) of the respondents did not have enough money for their family each month, while 83 (11%) did. When it came to residency, there were 582 (76.9%) residents, 167 (22.1%) internally displaced people (IDPs), and 8 (1.05%) Muhammashins. With respect to drinking water supply in the homes of respondents, just 21.4% of the children had a regular and readily available supply, 66.4% had a supply that was readily available but irregular, and 12.2% had no supply at all (Table 1).

Hundred and forty three children (18.9%) suffer from moderate acute malnutrition (MAM), and 55 (7.3%) of total children suffer from severe acute malnutrition (SAM), with total globalacute malnutrition equal to 198 (26.2%). The Al-Khamis district had the highest rate of malnutrition, accounting for 41.6% of all children tested in the district. Considering the category of chronic malnutrition (stunting) prevalence among children attending hospitals in the three districts, the rate of moderate stunting was 23.2%, while the severe stunting rate for tested children was 17.8%. The overall stunting rate was 41.1% (Table 2).

Table 2: Prevalence of acute malnutrition and chronic malnutrition among the sick children seeking care in health facilities by district in Al-Mahweet governorate.

Category of Acute malnutrition			
	Moderate acute malnutrition (MAM)	**Severe acute malnutrition (SAM)**	**Global acute malnutrition**
Districts	N (%)	N (%)	N (%)
Al-Kapt (*n* = 241)	49 (20.3)	9 (3.7)	58 (24.1)
Al-Khamis (*n* =221)	60 (12.6)	32 (6.7)	92 (41.6)
Al-Mahwatt city (n=295)	34 (11.5)	14 (4.7)	48 (16.4)
Total (n=757)	143 (18.9)	55 (7.3)	198 (26.2)
Category of chronic malnutrition (stunting)			
Districts	**Moderate stunting N (%)**	**Severe stunting N (%)**	**Overall stunting N (%)**
Al-Kapt (*n* =241)	55 (22.8)	46 (19.1)	101 (41.9)
Al-Khamis (*n* = 221)	58 (26.4)	37 (16.7)	95 (41.7)
Al-Mahwatt city (295)	63 (21.4)	52 (17.6)	115 (39)
Total n=757	176 (23.2)	135 (17.8)	311 (41.1)

Total positive growth was 22.5%, and the total non-significant growth rate was 77.5%. The most common bacteria isolated was *S. aureus*, with 34.7% of the total isolates, followed by *Branhamella catarrahalis* at 22.4% and *S. epidermidis* at 10%, while *H. influenzae* is counted as only 7.6% of the total isolates. Other bacteria, such as *Pseudomonas aeruginosa*, *E. coli*, and *S. pneumoniae*, were counted at 2.4%, 3.5%, and 2.9%, respectively (Table 3).

The most common symptoms that occurred among children clinically diagnosed as conjunctivitis were eye itching (97.6%), red eye (85.3%), and gritty or scratchy feeling (81.1%), followed by watering eye (70.1%), and pinkness of the conjunctiva (62.9%). Less common symptoms that occurred in children were conjunctiva redness (45.4%), sticky discharge (45%), swelling of the conjunctiva (44.6%), yellowish discharge (44.2%), and vasodilatation (44.2%). A rare symptom that occurred was crusting of the infected eye (34.7%). Most of the infected patients had two eye infections (84.9%), and only 15.1% had one eye infection. Co-infections with upper respiratory tract infections occurred in 25.1% of conjunctivitis patients, common cold in 19.9%, and sore throat in 22.7% (Table 4).

There was a highly significant association of bacterial conjunctivitis with MAM, in which the rate of conjunctivitis among this group was 41.9%, with an associated odds ratio equal to 3.1, a CI equal to 2.1–4.5, an X^2 equal to 33.9, and a $p<0.0001$; and with SAM, (rate of conjunctivitis=49.1%, OR= 2.9, a CI= 1.6–5.1, X^2 =14.9, $p<0.0001$). Also, there was a highly significant association of bacterial conjunctivitis with global acute malnutrition, in which the rate of conjunctivitis among this group of patients was 43.9%, with an associated odds ratio equal to 4.1, a CI equal to 2.8–5.8, and an X^2 equal to 63 and $p<0.0001$.

Table 3: Bacterial pathogens isolated from the 757 children by collecting eye swabs.

Pathogens	**N (%)**
S. aureus	59 (34.7)
S. epidermidis	17 (10)
S. pneumoniae	5 (2.9)
S. viridians	2 (1.2)
S. pyogenes	1 (0.6)
Lancefield Group C *streptococci*	1 (0.6)
S. faecalis	2 (1.2)
Non-hemolytic *streptococci*	1(0.6)
B. catarrahalis	38 (22.4)
H. influenzae	13 (7.6)
P. aeruginosa	4 (2.4)
E. coli	6 (3.5)
Enterobacter species	2 (1.2)
Klebsiella species	2 (1.2)
S. marcescens	2 (1.2)
Proteus species	3 (1.8)
Moraxella species	6 (3.5)
C. albicans	6 (3.5)
Total non-significant growth	587 (77.5)
Total positive growth	170 (22.5)
Total tested for eye swab culture	757 (100)

Considering the category of chronic malnutrition (stunting), there was a highly significant association of bacterial conjunctivitis with severe stunting, in which the rate of conjunctivitis among this group of patients was 36.3%, with an associated odds ratio equal to 2.2, a CI equal to 1.5–3.2, and an X^2 equal to 15.2 and $p<0.0001$. Also for overall stunting, there was a highly significant association between bacterial conjunctivitis and the rate of 36.3%, with an associated odds ratio equal to 1.6, a CI equal to 1.2–2.3, X^2 equal to 9, and a *p*-value of 0.002. Considering the normal healthy children group, there was a very low rate of conjunctivitis with a protected odds ratio equal to 0.06, CI=0.04-0.16 and this result is confirmed to be significant ($X^2=77$, $p<0.0001$).

There was no significant association between bacterial conjunctivitis and sex. Considering districts, there was a highly significant association of bacterial conjunctivitis with Al-Khamis district, in which the rate of conjunctivitis among this group of patients was 31.2%, with an associated odds ratio equal to 1.8, a CI equal to 1.3–2.6, an X^2 equal to 10.7, and a *p*-value of 0.001 (Table 5).

Table 4: Clinical signs of conjunctivitis among the children seeking care in health facilities in Al-Mahweet governorate.

Signs	N (%)
Positive bacterial growth	170/251 (67.7)
Sticky discharge	113/251 (45)
Yellowish discharge	111/251 (44.2)
Gritty or scratchy feeling	201/251 (80.1)
Crusting of the infected eye	87/251 (34.7)
Red eye	214/251 (85.3)
Swelling of conjunctiva	112/251 (44.6)
Watering eye	176/251 (70.1)
Normal pupils reactive	161/251 (64.1)
Itching	245/251 (97.6)
One eye infection	38/251 (15.1)
Two eye infections	213/251 (84.9)
Pinkness of the conjunctiva	158/251 (62.9)
Vasodilatation	111/251 (44.2)
conjunctiva redness	114/251 (45.4)
Upper respiratory tract	63/251 (25.1)
Common cold	50/251 (19.9)
Sore throat	57/251 (22.7)
Clinical diagnosed conjunctivitis	251/757 (33.2)

The susceptibility patterns of the main bacteria isolated from individuals with conjunctivitis to the several antibiotics that are frequently used for ocular infections are displayed in Table 6. Antibiotic resistance in the eyes in *S. aureus* isolates ranged from 6.8% for polymyxin B to 55.9% for erythromycin. Ophthalmic antibiotic resistance in *B. catarrahalis* isolates varied from 5.3% for levofloxacin and polymyxin B to 78.9% for erythromycin. Ocular antibiotic resistance in *H. influenzae* isolates ranged from 0.0% for ciprofloxacin and polymyxin B to 46.2% for erythromycin. The rate of resistance to the ocular antibiotic in isolates of *S. epidermidis* varied from 11.8% for ofloxacin, moxifloxacin, polymyxin B, chloramphenicol, and fusidic acid to 41.2% for erythromycin and azithromycin.

DISCUSSION

In the current study, global acute malnutrition (GAM) affects 198 children (26.2%), of whom 143 (18.9%) have moderate acute malnutrition (MAM) and 55 (7.3%) have severe acute malnutrition (SAM). This high prevalence of GAM is classified as a critical phase, and it exceed the emergency threshold 15%[15]. The national rate of GAM for Yemen was 16% in the last demographic health survey (DHS) in 2013[16].

Nonetheless, the GAM rates in the governorates of Ibb and Sana'a were categorized as inadequate (between 5% and 9.99%), according to the Nutrition Cluster report (SMART) released in April 2017[17]. The overall stunting rate was 41.1% in the current study. The high rate of acute and chronic malnutrition among the children under five years in Al-Mahweet governorate is continue due to deterioration of food security in Yemen which it is expected to continue as long as the conflict is ongoing, thus acting household livelihoods and the general marketing situation. Food prices have sharply increased in local markets, which deprives the majority of this survey population who depend on the local market to get their daily food. In addition to high prices, other challenges include a reduction in family income from farming, fishing, or governmental salaries[18].

Perhaps the most delicate organ in the human body is the eye. The eye must retain a transparent and healthy surface despite being exposed to pathogens, allergies, and physical shocks from the outside world in order for the retina to be exposed to light for optimal vision. The eye must also avoid reacting to these dangers in the same way that other organs do since doing so may compromise the eye's ability to detect light.

Additionally, the surface of the eye is home to a unique microbiome that controls the growth of pathogens and offers protection without needlessly causing inflammation. Ocular barriers, including the lids, tear film, and antimicrobial substances, physically shield the eye under normal physiological conditions.

The innate and adaptive immune systems, in conjunction with the microbiome, also inhibit the proliferation of pathogenic organisms[19,20]. Infection may occur when these defenses are compromised by a systemic illness, physical trauma, wearing contact lenses, or other environmental stresses[19-21].
Nevertheless, the majority of pathogens responsible for bacterial conjunctivitis[7,22], keratitis[23], and postoperative endophthalmitis[24,25] originate from the natural flora. According to the current investigation, 32.2% of the 251/757 children (33.2%) with clinically confirmed conjunctivitis also had no detectable harmful micro-organisms. The current study's bacterial culture eye swab positivity rate was 22.5%; this is less than the 51.7% positive bacterial rate reported from babies in Sana'a, Yemen, who had ocular discharge[26].

Table 5: Association of malnutrition, sex and district with occurrences of bacterial conjunctivitis among children seeking care in health facilities in three districts in Al-Mahweet governorate.

Factors	Positive culture, n=177 N (%)	*OR*	*95% CI*	X^2	*p*
Category of Acute malnutrition					
MAM , n=143	60 (41.9)	3.1	2.1-4.5	33.9	<0.0001
SAM, n=55	27 (49.1)	2.9	1.6-5.1	14.9	<0.0001
Globel acute malnutrition n=198	87 (43.9)	4.1	2.8-5.8	63	<0.0001
Category of chronic malnutrition (stunting)					
Moderate stunting, n=176	41 (23.3)	0.9	0.65-1.4	0.02	0.8
Severe stunting, n=135	49 (36.3)	2.2	1.5-3.2	15.2	<0.0001
Overall stunting, n=311	90 (28.9)	1.6	1.2-2.3	9	0.002
Normal healthy, n=248	10 (4.03)	0.06	0.04-0.16	77	<0.0001
Sex					
Male, n= 351	91 (25.9)	1.3	0.9-1.8	2.3	0.12
Female, n= 406	86 (21.2)	0.76	0.5-1.07	2.3	0.124
Districts					
Al-Kapt district, n=241	61 (25.3)	1.2	0.8-1.6	0.7	0.39
Al-Khamis district, n=221	69 (31.2)	1.8	1.3-2.6	10.7	0.001
Al-Mahwatt city, n=295	47 (15.9)	04	0.33-0.71	14.9	<0.0001

Additionally, the current study rate (22.5%) is lower than that of Al-Eryani *et al.*[12], who found that among adult patients who previously presented to their medical practitioner in Sana'a city with red eyes, purulent (mucous) secretions, or prickly secretions in the eyelids, the positive growth rate was 39.5%. Furthermore, this outcome is even lower than that of adult patients in the USA who presented to their general practitioner with purulent (mucous) or prickly discharges in their eyelids, with a reported 32% of them having bacterial etiology[7]. However, the bacterial rate in this study was higher than the low-positive isolation rate of 15.8% of all conjunctivitis cases reported by Silvester *et al.*[9], in the UK in 2016. Variable rates of positive isolates have also been reported in other investigations[27,28]. If all isolated bacteria are included in some research instead of simply pathogenic bacteria, then this discrepancy can be explained. Furthermore, as bacterial swabs were obtained from every patient with suspected conjunctivitis, including those with viral conjunctivitis, the isolation rate may be lower than the true rate. Numerous patients arrived after beginning topical antibiotic treatment, which may have lowered the current study's positive isolation rate. Furthermore, Saudi Arabia (60%) and Iraq (69%) showed higher incidence rates among neonates[29,30]. However, greater incidence rates-81.5% and 80.5%, respectively from Iran and the United Arab Emirates were also recorded[31,32]. This significant range can be explained by variations in the geographic distribution of infections and in the quality of prenatal and obstetric care provided.

S. aureus accounted for 34.7% of all the isolates in the current investigation, followed by *B. catarrahalis* (22.4%) and *S. epidermidis* (10%), with *H. influenzae* accounting for just 7.6% of all the isolates. The prevalence of *S. aureus* in our investigation is consistent with the fact that *S. aureus* is a global contributor to a number of eye diseases, including endophthalmitis, blepharitis, cellulitis, conjunctivitis, keratitis, and dacryocystitis[7,23,33,34]. *S. aureus* is regarded as a powerful and frequently hazardous pathogen due to its capacity for multidrug antibiotic resistance and the astounding variety of toxins and enzymes in its toolbox[35,36]. The current study's findings are consistent with those published by Azari and Barney[7] and Smith and Waycaster [37] in the USA, where *S. aureus*, *S. pneumoniae*, and *H. influenzae* were the most prevalent pathogens causing bacterial conjunctivitis in adults. Consistent with reports from US and UK research, the most prevalent bacteria was*S. aureus*[9,10,38]. According to what other workers have reported, cross-infection is probably the cause of the high *S. aureus* infection rate[26].
Other bacteria included in the study included *E. coli*, *S. pneumoniae*, and *P. aeruginosa*, which had counts of 2.4%, 3.5%, and 2.9%, respectively. These rates differ from the findings of the Al-Arosi *et al.*[26], study, which indicated that *S. aureus* was the most frequent causal agent with a high proportion of 56.2%, followed by *K. pneumoniae* (28.6%), *E. coli* (12.4%), and *P. aeruginosa* (2.9%). Similarly, a number of studies from various countries throughout the world, including the United Arab Emirates, Iran (53.9%), Nigeria (57.1%), and Pakistan (65%), have shown that *S. aureus* is the

primary bacterial cause of newborn conjunctivitis[31,39]. In contrast, the main isolates from Saudi Arabia, Iraq, and India were, respectively, 26.32%, 25.36%, and 35% of *E. coli*, *K. pneumoniae*, and *E. clocae*[29,30,40]. *Neisseria gonorrhoeae* and *C. trachomatis*, which are typically causes of ophthalmia neonatorum, have not been diagnosed in these three institutions despite the fact that prophylaxis for neonatal cases of either disease was not practiced. A comparable discovery of negligible or nonexistent instances of *gonococcus* and chlamydial conjunctivitis has been documented in other sources[39,41]. The results might point to an uncommon case of *chlamydia* and *gonorrhea* in the community. In the event that an ocular infection does arise, harm from the infection and the immune response must be avoided by quick and efficient treatment. The pathogen's identification informs clinical decisions about the treatment of eye illnesses.

Table 6: Antibiotic resistance rate of major bacterial isolates that isolated from children to antibiotics commonly used to treat eye infections.

Antibiotics	*S. aureus*, n=59 N (%)	*B. catarrahalis*, n=38 N (%)	*S. epidermidis*, *n*=17 N (%)	*H. influenza*, *n*=13 N (%)
Ciprofloxacin	17 (28.8)	2 (5.3)	3 (17.6)	0 (0.0)
Ofloxacin	14 (23.7)	3 (7.9)	2 (11.8)	1 (7.7)
Levofloxacin	15 (25.4)	2 (5.3)	3 (17.6)	1 (7.7)
Moxifloxacin	14 (23.7)	3 (7.9)	2 (11.8)	1 (7.7)
Tobramycin	29 (49.2)	13 (34.2)	5 (29.4)	2 (15.4)
Gentamicin	27 (45.8)	10 (26.3)	3 (17.6)	2 (15.4)
Erythromycin	33 (55.9)	30 (78.9)	7 (41.2)	6 (46.2)
Azithromycin	31 (52.5)	26 (68.4)	7 (41.2)	5 (38.5)
Bacitracin	20 (33.9)	14 (36.8)	4 (23.5)	4 (30.8)
Polymyxin B	4 (6.8)	2 (5.3)	2 (11.8)	00 (0.0)
Neomycin	15 (25.4)	2 (5.3)	3 (17.6)	1 (7.7)
Chloramphenicol	14 (23.7)	8 (21.1)	2 (11.8)	2 (15.4)
Fusidic acid	5 (8.5)	4 (10.5)	2 (11.8)	2 (15.4)

The reasonable question to ask is, "Is this bacterium a pathogen or a commensal?" after the culture results are back. While many ocular bacteria can be either commensal or pathogenic based on the circumstances of the eyes, several types of bacteria are always thought of as pathogens. That is the point of intersection between the art and science of choosing an empirical treatment. Understanding both pathogenic and normal ocular microorganisms is essential for timely and efficient therapy[25,33]. The susceptibility patterns of the main bacteria isolated from individuals with conjunctivitis to the several antibiotics that are frequently used for ocular infections are displayed in Table 6. Ocular antibiotic resistance in *S. aureus* isolates ranged from 6.8% for polymaxin B to 55.9% for erythromycin. This makes it obvious that no single medication can effectively treat all of these different kinds of bacteria. Based on the study's findings, certain generalizations about how to treat pediatric conjunctivitis in the absence of laboratory facilities can be made because fusidic acid and neomycin can be given and are effective against the majority of bacteria identified from this age range. As an alternative, you could utilize polymyxin B and moxifloxacin.

Considering the association of malnutrition, district with occurrences of bacterial conjunctivitis. There was a highly significant association of bacterial conjunct-tivitis with MAM. The findings are in agreement with a study by Dias *et al*., in Portugal[42]. This is explained by the possibility that malnourished children who are already weakened may experience conjunctivitis more frequently, as their undeveloped lacrimal system allows germs to proliferate. When the lacrimal system is functioning properly, tears are produced, the eyelids' opening and shutting functions as a pump to help tears spread throughout the surface of the eye, and the lacrimal ducts work as a drainage system, carrying germs and epithelial debris away with the tears[43].

Considering the category of chronic malnutrition (stunting), there was a highly significant association of bacterial conjunctivitis with severe stunting, in which the rate of conjunctivitis among this group of patients was 36.3%, with an associated odds ratio equal to 2.2, a CI equal to 1.5-3.2, and an X^2 equal to 15.2 and $p<0.0001$. This correlation can be explained by the fact that undernourished children regularly exhibit deficiencies in the innate and adaptive arms of the immune system[44]. Numerous research examine the theory that immunological dysfunction causes and results from starvation, and they provide an overview of the most important recent experimental data. 245 studies documenting immunological parameters in malnourished children (age 0–5 years) were published between 1957 and 2014, according to a recent systematic literature analysis[44]. The analysis does point out that most of the trials were done on hospitalized children with severe forms of malnutrition and many co-infections, and they were done using outdated immunological techniques some decades ago. Lack of long-term investigations, especially for mild and moderate malnutrition, made it difficult to characterize immunodeficiency.

Therefore, the exact nature of immunodeficiency in undernutrition is still unknown; nonetheless, the evidence that is currently available generally agrees that malnutrition impairs both innate and adaptive immunity. Innate immune dysfunction includes decreased complement proteins, fewer circulating dendritic cells, decreased granulocyte microbicidal activity, impaired epithelial barrier function of the skin and mucus membranes, including the gut and eyes, but preserved leukocyte counts and acute phase response.

Defects in adaptive immune function include reduced levels of soluble IgA in saliva and tears, lymphoid organ atrophy, reduced delayed-type hypersensitivity responses, fewer circulating B cells, a shift from Th1-associated to Th2-associated cytokines, and lymphocyte hyporesponsiveness to phytohemagglutinin, but preserved lymphocyte and immunoglobulin levels in peripheral blood. Despite this, most malnourished children seem to respond adequately to vaccination, although the timing, quality, and longevity of vaccine-specific responses may be impaired[45,46].

When districts were taken into account, the Al-Khamis district showed a highly significant correlation with bacterial conjunctivitis. Among this patient group, the rate of conjunctivitis was 31.2%, with an associated odds ratio of 1.8, a confidence interval of 1.3–2.6, an X^2 of 10.7, and a *p*-value of 0.001. This outcome can be explained by the Al-Khamis region's higher endemicity of infectious diseases, its location in a hot and humid climate, and its relative poverty compared to the other regions. In addition, this district had greater rates of all forms of malnutrition than the other two districts.

Limitations of the study

One of the limitations of this study is that it is a single-center research study so the results cannot be extrapolated to the national level. Furthermore, the sample size of the current study was not large enough, so a larger population size could have provided more accurate results. Eye injury or malnutrition were not linked to all demographic factors of the children and their families.

CONCLUSIONS

Malnutrition among children in Al-Mahweet governorate is a serious public health problem as it is in other parts of Yemen, and the severity of acute malnutrition was very high in the study area reached critical phase, and exceed the emergency threshold. The majority of families in Yemen depend on food purchase from the market, which is itself a disaster because of economic deterioration and lack of salaries and most children families did not have enough monthly income. The commonest causative organisms in the children were *S. aureus* and *B. catarrahalis.* Since there isn't a single medication that can effectively treat these diverse species of bacteria, it is best to look into bacteriological culture and *in vitro* antibiotic sensitivity.

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AUTHOR'S CONTRIBUTIONS

Al-Eryani SA: writing, review and editing, methodology. **Al-shamahi EY:** formal analysis, data curation, conceptualization. **Al-Shamahi EH:** writing, review, and editing, methodology, data curation. **Al-Shamahy HA:** supervision, review. **Sharaf MMA:** writing, review and editing, data curation. All authors read and approved the final manuscript for publication.

DATA AVAILABILITY

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

CONFLICT OF INTEREST

There is no conflict of interest around this work.

REFERENCES

1. Jonas DE, Amick HR, Wallace IF, *et al*. Vision screening in children aged 6 months to 5 years: Evidence report and systematic review for the US Preventive Services Task Force. JAMA 2017; 318(9):845–858. *https://doi.org/10.1001/jama.2017.9900*
2. Ilechie AA, Essuman VA, Enyionam S. Prevalence of congenital eye anomalies in a paediatric clinic in Ghana. East Mediterr Health J 2014 ; 9(19) Suppl 3:S76-80. PMID: 24995765.
3. Demissie BS, Demissie ES. Patterns of eye diseases in children visiting a tertiary teaching hospital: South-western Ethiopia. Ethiop J Health Sci 2014 Jan;24(1):69-74. *https://doi.org/10.4314/ejhs.v24i1.9*
4. Bates A. Common eye problems among children. London J Prim Care (Abingdon) 2010 Jul;3(1):27-30. *https://doi.org/10.1080/17571472.2010.11493292*
5. Chando J, Ogbonna G. Prevalence of eye problems amongst under five children at Ophthalmology Department Mzuzu Central Hospital. Acta Sci Surg Res 2022;1(3):15-22.
6. Rapuano C. American Academy of Ophthalmology Cornea/External Disease Panel', Preferred Practice Pattern Guidelines. Conjunctivitis 2008.
7. Azari AA, Barney NP. Conjunctivitis: A systematic review of diagnosis and treatment. JAMA 2013 Oct 23;310(16):1721-9. *https://doi.org/10.1001/jama.2013.280318*
8. Shields T, Sloane PD. A comparison of eye problems in primary care and ophthalmology practices. Fam Med. 1991 Sep-Oct;23(7):544-6. PMID: 1936738.
9. Silvester A, Neal T, Czanner G, Briggs M, Harding S, Kaye S. Adult bacterial conjunctivitis: Resistance patterns over 12 years in patients attending a large primary eye care centre in the UK'. BMJ Open Ophthalmol 2016; 1(1): e000009. *http://dx.doi.org/10.1136/bmjophth-2016-000006*
10. Kaufman HE. Adenovirus advances: New diagnostic and therapeutic options. Curr Opin Ophthalmol 201; 22(4):290-3. *https://doi.org/10.1097/ICU.0b013e3283477cb5*
11. Yamaguchi T. Inflammatory response in dry eye. Invest Ophthalmol Visual Sci 2018;59(14): DES192-DES199. *https://doi.org/10.1167/iovs.17-23651*
12. Al-Eryani SA, Alshamahi EYA, Al-Shamahy HA, Alfalahi GHA, Al-Rafiq AA. Bacterial conjunctivitis of adults: causes and ophthalmic antibiotic resistance patterns for the common bacterial isolates. Universal J Pharm Res 2021; 6(1):25-28. *https://doi.org/10.22270/ujpr.v6i4.636*
13. Cheesbrough M. District laboratory practice in tropical countries. Cambridge: Cambridge University Press; 2010.*https://doi.org/10.1017/CBO9780511581304*
14. CLSI. Performance Standards for Antimicrobial Disc Susceptibility Tests. (11th edn.), Approved standard M02-A11– Publication of Clinical and Laboratory Standards Institute [CLSI), 2012, USA, 32
15. Bilukha, O.; Leidman, E. Concordance between the estimates of wasting measured by weight-for-height and by mid-upper arm circumference for classification of severity of

nutrition crisis: Analysis of population-representative surveys from humanitarian settings. BMC Nutr 2018, 4:24.
16. MoPHP, CSO. Yemen National Health and Demographic Survey; Ministry of Public Health and Population, and Central Statistical Organization (CSO): Sana'a, Yemen, 2013.
17. Ziolkovska A. Nutrition Cluster Bulletin: Overview of the Nutrition Situation as of 31 March 2017; UNICEF: Sana'a, Yemen, 2017.
18. FEWS. Yemen Alert; Famine Early Warning System Network: Sana'a, Yemen, January 2017.
19. Armstrong, R.A. The microbiology of the eye. Ophthal Physiol Opt 2000; 20: 429–441.
20. Ung L, Chodosh J. Foundational concepts in the biology of bacterial keratitis. Exp Eye Res 2021 Aug; 209:108647. *https://doi.org/10.1016/j.exer.2021.108647*
21. Miller D, Iovieno A. The role of microbial flora on the ocular surface. Curr Opin Allergy Clin Immunol 2009 Oct; 9(5):466-70. *https://doi.org/10.1097/ACI.0b013e3283303e1b*
22. Høvding G. Acute bacterial conjunctivitis. Acta Ophthalmol 2008 Feb; 86(1):5-17. *https://doi.org/10.1111/j.1600-0420.2007.01006.x.Epub*
23. Lichtinger A, Yeung SN, Kim P, *et al*. Shifting trends in bacterial keratitis in Toronto: An 11-year review. Ophthalmol 2012; 119(9):1785-90. *https://doi.org/10.1016/j.ophtha.2012.03.031*
24. Benz MS, Scott IU, Flynn HW Jr, Unonius N, Miller D. Endophthalmitis isolates and antibiotic sensitivities: A 6-year review of culture-proven cases. Am J Ophthalmol 2004; 137(1):38-42. *https://doi.org/10.1016/s0002-9394(03)00896-1*
25. Olson R, Donnenfeld E, Bucci FA Jr, *et al*. Methicillin resistance of *Staphylococcus* species among health care and nonhealth care workers undergoing cataract surgery. Clin Ophthalmol. 2010;4:1505-14. *https://doi.org/10.2147/OPTH.S14333*
26. Al-Arosi SAH, Al-shamahi EY, Al-Kholani AIM, *et al*. Neonatal bacterial conjunctivitis in tertiary hospitals in Sana'a city, Yemen. Universal J Pharm Res 2021; 6(6):36-42. *https://doi.org/10.22270/ujpr.v6i6.697*
27. Rietveld RP, van Weert HC, Ter Riet G, Bindels PJ. Diagnostic impact of signs and symptoms in acute infectious conjunctivitis: Systematic literature search. BMJ 2003; 327(7418):789. *https://doi.org/10.1136/bmj.327.7418.789*
28. Sheikh A, Hurwitz B, van Schayck CP, McLean S, Nurmatov U. Antibiotics versus placebo for acute bacterial conjunctivitis. Cochrane Database Syst Rev 2012; 9: CD00 1211. *https://doi.org/10.1002/14651858*.CD001211.pub3
29. Faraz A, Farhan MA. Microbial etiology of neonatal conjunctivitis in a general hospital in Saudi Arabia. Alshifa J Ophthalmol 2019; 15(1): 30-34.
30. Al-Atrushi AAS, Al-Brefkani A. Ophthalmia neonatorum in Duhok, north of Iraq: bacterial causative agents and their antibiotic sensitivity pattern. Isra Med J 2012; 4(4): 09-213.
31. Nsanze H, Dawodu A, Usmani A, Sabarinathan K, Varady E. Ophthalmia neonatorum in the United Arab Emirates. Ann Trop Paediatr 1996; 16(1):27-32. *https://doi.org/10.1080/02724936.1996.11747800*
32. Afjeiee SA, Tabatabaei SR, Fallah F, *et al*. A microbiological study of neonatal conjunctivitis in two hospitals in Tehran, Iran. Asian Pac J Trop Dis 2013; 3(6):429–33. *https://doi.org/10.1016/S2222-1808(13)60096-1*
33. Al-Dhaheri HS, Al-Tamimi MD, Khandekar RB, Khan M, Stone DU. Ocular pathogens and antibiotic sensitivity in bacterial keratitis isolates at King Khaled Eye Specialist Hospital, 2011 to 2014. Cornea 2016; 35(6):789-94. *https://doi.org/10.1097/ICO.0000000000000844*
34. Callegan M, Engelbert M, Parke D, Jett B, Gilmore M. Bacterial endophthalmitis: Epidemiology, therapeutics, and bacterium-host interactions. Clin Microbiol Rev 2002; 15:111–124.
35. Grumann D, Nübel U, Bröker BM. *Staphylococcus aureus* toxins- Their functions and genetics. Infect Genet Evol 2014; 21:583-92. *https://doi.org/10.1016/j.meegid.2013.03.013*
36. Astley R, Miller FC, Mursalin MH, Coburn PS, Callegan MC. An eye on *Staphylococcus aureus* toxins: Roles in ocular damage and inflammation. Toxins (Basel). 2019; 11(6):356. *https://doi.org/10.3390/toxins11060356*
37. Smith AF, Waycaster C. Estimate of the direct and indirect annual cost of bacterial conjunctivitis in the United States. BMC Ophthalmol 2009; 9:13. *https://doi.org/10.1186/1471-2415-9-13*
38. Udeh BL, Schneider JE, Ohsfeldt RL. Cost effectiveness of a point-of-care test for adenoviral conjunctivitis. Am J Med Sci 2008; 336(3):254–264.
39. Gul SS, Jamal M, Khan N. Ophthalmia neonatorum. J Coll Physicians Surg Pak 2010; 20:595-598.
40. Goel K, Randhawa VS, Saili A, *et al*. Incidence, etiology and risk factors associated with neonatal health care associated conjunctivitis: A prospective study from a tertiary care hospital in India. J Trop Pediatr 2016; 62(1):10-18. *https://doi.org/10.1093/tropej/fmv064*
41. Ogunfowora OB, Ajewole JO, Ajibode HA. Conjunctival bacterial infection among hospitalized neonates. Annals Health Res 2020; 6(2): 230-238. *https://doi.org/10.30442/ahr.0602-12-85*
42. Dias C, Gonçalves M, João A. Epidemiological study of hospital acquired bacterial conjunctivitis in a level III neonatal unit. The Sci World J 2013. *https://doi.org/10.1155/2013/163582*
43. Haas J, Larson E, Ross B, See B, Saiman, L. Epidemiology and diagnosis of hospital-acquired conjunctivitis among neonatal intensive care unit patients. The Ped Infect Dis J 2005; 24(7):586. *https://doi.org/10.1097/01.inf.0000168742.98617.66*
44. Rytter MJ, Kolte L, Briend A, Friis H, Christensen VB. The immune system in children with malnutrition- A systematic review. PLoS One 2014; 9(8):e105017. *https://doi.org/10.1371/journal.pone.0105017*
45. Prendergast AJ. Malnutrition and vaccination in developing countries. Philos Trans R Soc Lond B Biol Sci 2015; 370(1671):20140141. *https://doi.org/10.1098/rstb.2014.0141*
46. Savy M, Edmond K, Fine PE, Hall A, Hennig BJ, Moore SE, Mulholland K, Schaible U, Prentice AM. Landscape analysis of interactions between nutrition and vaccine responses in children. J Nutr 2009; 139(11):2154S-218S. *https://doi.org/10.3945/jn.109.105312*