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Full length article

Streptococcus pyogenes in human at Dhamar, Yemen: Prevalence and antimicrobial susceptibility profiles

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ABSTRACT

This cross-sectional study was carried out across multiple areas of Dhamar, Dhamar Governorate between 2024 and 2025 to assess the prevalence of *Streptococcus pyogenes* among individuals and to evaluate the antimicrobial susceptibility of the isolated strains. A total of 381 throat swabs were collected from participants presenting with sore throat of varying severity. Samples were transported to the Faculty of Veterinary Medicine, Thamar University, where culture and biochemical analyses were performed. Out of the 381 samples examined, 67 (17.59%) tested positive for *S. pyogenes*. The highest prevalence was observed in Robbat Al-Qalah (4.72%), while the lowest was recorded in Rakhamah (0.26%). Age-wise distribution showed the highest prevalence in the 5–15 years group (7.61%), and the lowest in individuals aged 45 years and above (2.36%). Seasonal variation revealed the peak prevalence in October (4.99%) and the lowest in March (0.79%). Statistically significant differences ($P < 0.05$) were noted in prevalence across locations and months. Antimicrobial susceptibility testing indicated that the isolates were sensitive to Penicillin G, Amoxicillin, Ampicillin, Cefotaxime, Cephalosporins, Ceftriaxone, Lincomycin, and Vancomycin. Conversely, resistance was observed against Streptomycin, Gentamicin, Levofloxacin, Tetracycline, Erythromycin, and Clindamycin. In conclusion, *Streptococcus pyogenes* is prevalent in the studied areas of Dhamar Governorate. Routine monitoring of antibiotic resistance in both human and veterinary contexts is recommended. Further epidemiological investigations are warranted to expand knowledge of streptococcal infections in other regions of the governorate.

Keywords: *Streptococcus pyogenes*, Antimicrobial Resistance, Dhamar, Yemen.

INTRODUCTION

Streptococci are Gram-positive bacteria that typically occur in chains or pairs. They form part of the normal flora of humans and animals, yet several species act as pathogens. The most significant among them is *Streptococcus pyogenes*, the primary cause of pyogenic infections (Kushwaha et al., 2014). Classified under Lancefield Group A, this beta-hemolytic species is commonly referred to as Group A beta-hemolytic Streptococci (GABHS). Group A Streptococcus (GAS) consists solely of *S. pyogenes* (Khan et al., 2002). Food, milk, and dairy products can serve as vehicles for transmitting this organism to humans and animals (Jakee et al., 2013; Rifa et al., 2025).

Although *S. pyogenes* can infect individuals of all ages, children are particularly susceptible (DeMuri & Wald, 2014). It is capable of producing a wide spectrum of diseases, ranging from mild conditions such as pharyngitis and impetigo to life-threatening illnesses including streptococcal toxic shock syndrome, necrotizing fasciitis, acute rheumatic fever, and acute glomerulonephritis (Carapetis et al., 2005; Luca-Harari et al., 2009; AlShamisi, 2016; Pickering et al., 2025). Mortality rates from severe

GAS infections remain high worldwide, affecting both developed and developing nations (Steer et al., 2007; Lepoutre et al., 2011).

The prevalence of *S. pyogenes* infections reflects the interaction of three key factors: the pathogen itself, host immunity, and environmental influences (Verma et al., 2018; Biała et al., 2025). Globally, the bacterium is responsible for approximately 616 million cases of pharyngitis and 111 million cases of pyoderma in children each year (Sanyahumbi et al., 2016). Severe GAS diseases affect around 18 million people, with 1.78 million new cases and at least 517,000 deaths annually, most occurring in low-income regions (Tesfaw et al., 2015; Barth et al., 2020; Gashaw et al., 2025).

Culture techniques and subsequent bacteriological procedures remain the gold standard for diagnosing GAS infections (Saleh, 2009; Hassanain et al., 2024). Penicillin continues to be the most widely prescribed treatment for acute streptococcal infections such as pharyngitis and tonsillitis. However, indiscriminate antibiotic use without medical supervision contributes to the emergence of resistant strains and promotes carrier states (Devi et al., 2011; Dunne et al., 2013).

Despite the substantial burden of GAS on human and animal health and its serious public health implications, limited research has been conducted on its epidemiology and antimicrobial resistance. This study therefore aims to assess the prevalence and antimicrobial susceptibility patterns of GAS among individuals in Dhamar Governorate, Yemen.

MATERIALS AND METHODS

Study area

This cross-sectional study was conducted between March 2024 and October 2025 across several areas of Dhamar, Dhamar Governorate. Geographically, Dhamar is situated at 14°33′0″N and 44°24′6″E, at an elevation of approximately 2,400 meters above sea level. The region experiences average summer temperatures of around 28.2 °C, while in winter, nighttime and early morning temperatures often fall below zero. The average relative humidity is 49%. Dhamar Governorate has a population of about 1,668,167 and covers an area of 7,587 square kilometers, representing a significant portion of the country's total land area.

Study population

The study population were from different areas of Dhamar. Eligible participants for entry into the study were those living in Dhamar, aged 5–46 years with history of sore throat and evidence fever. Patients who had used antibiotics in the 2-week period prior to this current illness were excluded. The sample size was calculated by the statistical program of Epi-info (version 6.04). The required sample size **is** 381 participants.

Collection of Samples

Throat swab samples were collected following the procedures described by El-Ghany et al. (2015), Spellerberg & Brandt (2022), and Kumsal et al. (2023). In brief, the sampling process was explained to each participant prior to collection. Under adequate lighting, participants were asked to open their mouths as widely as possible. Using a tongue depressor, the investigator gently rubbed a sterile cotton swab over the tonsillar area, avoiding contact with the tongue and lips to minimize contamination by oral microbiota.

The collected swabs were immediately placed in aseptic containers, labeled, and transported to the Microbiology Laboratory at the Faculty of Veterinary Medicine, Thamar University, Dhamar. Samples were obtained from several areas of Dhamar, Dhamar Governorate, including Dhamar city, Thi Sahar, Al-Melaah, Al-Moaheb, Dhamar Al-Gharn, Manghathah, Rakhamah, and Robbat Al-Qalah. Additional information such as participant age, location, and month of collection was also recorded. All samples were delivered to the laboratory within one to two hours of collection for processing.

Processing of samples

Culture, Isolation and Identification

In the laboratory, each swab was first rolled over a small portion of a sheep blood agar plate. The inoculum was then streaked across the remainder of the plate using a sterile loop to obtain well-isolated colonies, followed by incubation under anaerobic conditions at 37 °C for 24 hours. After incubation, small grayish-white colonies surrounded by clear zones of hemolysis were selected and subjected to Gram staining and the catalase test. Colonies that appeared in chains and tested catalase-negative were sub-cultured on 10% sheep blood agar containing a low concentration of bacitracin and incubated again at 37 °C for 24 hours.

Streptococcus pyogenes was identified based on sensitivity to bacitracin and confirmed using a Rapid Antigen Detection Test (RADT). All procedures were performed according to the methods described by Cheesbrough (2006), Ba-Saddik et al. (2014), Ashgar et al. (2017), Spellerberg & Brandt (2022), and in line with the manufacturer's instructions.

Antibacterial susceptibility

All isolates were subjected to *in vitro* antibiotic drug susceptibility test as per method described by Cheesbrough (2006) and Ranjan et al. (2010). The antimicrobials commercially available in 'market used for treatment of Streotococci infections such as Penicillin G, Amoxicillin, Gentamicin, Tetracycline, Ampicillin, Streptomycin, Cephalosporin, Erythromycin, Lincomycin,

Vancomycin, Clindamycin, Levofloxacin, Cefotaxime and Ceftriaxone were tested *in vitro* for their efficacy against various isolates identified in this study. The antimicrobial discs were placed on the surface of an agar plate previously seeded with a standard amount of the organism to be tested. The plates were incubated at 37°C for 18-24 hours subsequently; the plates were examined for the development of zone of inhibition around the discs. The diameter of the zone of inhibition was measured in mm and compared with the values listed in standard chart provided by the manufacturer, on the basis of which the isolates were categorized as resistant (R), moderately sensitive (M) or highly sensitive (S) to the antimicrobial contained in that particular disc.

Statistical of analysis

The collected raw data were organized using Microsoft Excel spreadsheets and analyzed with SPSS statistical software, version 20. Descriptive statistics were applied to calculate prevalence percentages. Chi-square tests were performed to assess associations between *Streptococcus pyogenes* prevalence and potential risk factors, including age, month of collection, and geographic area. Statistical significance was determined at a threshold of **P < 0.05.**

RESULTS

Prevalence of *Streptococcus pyogenes*

The results of isolation and identification of *Streptococcus pyogenes* and it`s prevalence in participants is presented in Table 1. As shown, out of 381 throat swab samples examined, 67(17.59%) were found positive for *S. pyogenes.*

Table 1. Overall Prevalence of *Streptococcus pyogenes* in participants at Dhamar Governorate

No. of Samples examined	No. of Positive samples	Prevalence %
381	67	17.59

The distribution of *S. pyogenes* according to source of samples /study areas are depicted in Table 2. As shown, the highest prevalence rate was recorded in Robbat AlQalah area (4.72%); whereas, the lower rate in Rakhamah (0.26 %). Statistically, significant differences (P<0.05) were observed between prevalence and study area.

The distributions of *S. pyogenes* according to age are presented in Table 3. As shown, the higher prevalence rate was recorded in age group of 5-15 years old (7.61%); whereas the lower rate in age group of 36-46 years old (2.36%). The age factor did not influence(P<0.05) on the prevalence rate distribution among the participants.

Table 2. Prevalence of *Streptococcus pyogenes* in participants according to study area (n=381)

Area	No. of Positive samples	Prevalence %	*P* Value
Dhamar city/district	4.0	1.05	**0.008**
Thi Sahar	3.0	0.79	
Al-Melaah	9.0	2.36	
Al Moaheb	12	3.15	
Dhamar Algharn	13	3.41	
Manghathah	7.0	1.84	
Rakhamah	1.0	0.26	
Robbat AlQalah	18	4.72	
Total	67	17.59	

Table 3. Distribution of *Streptococcus pyogenes* in participants according to ages (n=381)

Age group	No. of Positive samples	Prevalence %	*P* Value
5-15 Yrs	29	7.61	0.309
16-20 Yrs	18	4.72	
21-35 Yrs	11	2.89	
36-46 Yrs	9	2.36	
Total	67	17.59	

Considering the distribution of *S. pyogenes* according to Month-wise, the results are presented in Table 4. As shown, the higher prevalence rate was recorded in month of October (4.99%) whereas, the lower rate recorded in month of March (0.79 %). Statistically, significant differences (P<0.05) were observed between prevalence rates of *S. pyogenes* and months factor.

Table 4. Distribution of *Streptococcus pyogenes* in participants according to month variation(n=381)

Month	No. of Positive samples	Prevalence %	P value
Mar	3.0	0.79	0.031
Apr	6.0	1.57	
May	8.0	2.10	
Jun	10	2.62	
Jul	9.0	2.36	
Aug	7.0	1.84	
Sep	5.0	1.31	
Oct	19	4.99	
Total	67	17.59	

Susceptibility of isolates to antibacterial drugs

The susceptibility of isolates to antibacterial agents was evaluated in this study. The findings showed that *S. pyogenes* was sensitive to most of the tested antibacterial, including Penicillin G, Amoxicillin,

Ampicillin, Cefotaxime, Cephalosporins, Ceftriaxone, Lincamycin, and Vancomycin. In contrast, resistance was observed against Streptomycin, Gentamycin, Levofloxacin, Tetracycline, Erythromycin, and Clindamycin. For the remaining antibacterial agents tested, the isolates exhibited either intermediate resistance or complete resistance (see Table 5).

Table 5. Susceptibility patterns of S. *pyogenes* isolates to antimicrobial drugs (n=67)

Antibacterial	No. of isolates	Susceptibility
Penicillin G	67	S
Amoxicillin	67	S
Ampicillin	67	S
Tetracycline	67	R
Cephalosporin	67	S
Erythromyin	67	R
Gentamycin	67	R
Streptomycin	67	R
Levofloxacin	67	R
Ceftriaxone	67	S
Cefotaxime	67	S
Lincamycin	67	S
Clindamycin	67	R
Vancomycin	67	S

S= Sensitive, R= Resistant

DISCUSSION

Prevalence of *Streptococcus pyogenes*

The present study was conducted to identify and determine the prevalence of *Streptococcus pyogenes* and to assess the antibiogram of isolates collected from Dhamar, Dhamar Governorate. Examination of throat swab samples revealed an overall prevalence rate of 17.59%. These findings are consistent with those reported by Shulman et al. (2012), Olivieri et al. (2015), Biała et al. (2025), Šlosárková et al. (2019), and Khalaf et al. (2020), who documented prevalence rates of 12.4%, 14.3%, 16%, 17.9%, and 20%, respectively. However, the prevalence observed in this study was higher than that reported by Belachew (2016), Li et al. (2018), Verma et al. (2018), and Pickering et al. (2025), who recorded rates ranging between 5.5% and 7%. Variations in prevalence rates between studies may be attributed to differences in sample size, diagnostic techniques, and the availability of healthcare services. Moreover, since *S. pyogenes* commonly inhabits the upper respiratory tract and other organs of the human body, its frequent detection at relatively high rates is expected.

Geographical differences were also noted. The highest prevalence was recorded in Robbat Al-Qalah, while the lowest was observed in Rakhamah. These variations may be linked to environmental conditions and disparities in access to medical facilities. Additionally, clinical cases of sore throat were more frequently reported in Robbat Al-Qalah, likely due to poor housing, inadequate drainage systems, and insufficient personal and environmental hygiene in that area.

Age was found to play a significant role in the distribution of *S. pyogenes*. The highest prevalence was observed among individuals aged 5–15 years, whereas the lowest was recorded in those aged 45 years and above. These results align with the findings of Vijaya et al. (2013), Othman et al. (2019), Frenck et al. (2023), and Tyrrell et al. (2024), who noted that streptococcal infections tend to decline with increasing age. The higher prevalence in younger age groups may be explained by immunological factors.

Seasonal variation was also evident. The highest prevalence was recorded in October, while the lowest occurred in March. These results are consistent with those of Saleh (2009), who reported that streptococcal infections in Yemen peaked during the winter months (November and December) and the rainy season (July and August). The increased prevalence during colder months may be attributed to environmental conditions that favor the survival and multiplication of the microorganism.

Antimicrobial Susceptibility

One of the main objectives of the present study was to evaluate the sensitivity and resistance patterns of *Streptococcus pyogenes* isolates against antibacterial drugs commonly available in the Yemeni market. The results demonstrated that *S. pyogenes* isolates were sensitive to most of the tested antibiotics, including Penicillin G, Amoxicillin, Ampicillin, Cefotaxime, Cephalosporins, Ceftriaxone, Lincamycin, and Vancomycin. These findings are consistent with previous studies (Stevens, 1995; Shulman et al., 2012; Ba-Saddik et al., 2014; Krohn et al., 2018; Khalaf et al., 2020; Helal et al., 2020). In contrast, resistance was observed against Streptomycin, Gentamycin, Levofloxacin, Tetracycline, Erythromycin, and Clindamycin, which aligns with the results reported by other researchers (Olivieri et al., 2015; Michos et al., 2016; Vela et al., 2017; Khalaf et al., 2020). The resistance of *S. pyogenes* to certain antibacterial agents may be attributed to factors such as the overuse and misuse of antibiotics, impaired cellular uptake of the drugs, or the emergence of mutant strains (Adesola, 2012).

CONCLUSION

It could be concluded from findings of study that, *S.pyogenes* was found to be prevalent among the population in the study areas, and bacterial resistance to antimicrobial agents was observed. It is therefore recommended that routine testing for antibiotic resistance be conducted for drugs prescribed to both humans and

animals. Additionally, further research is needed to investigate the epidemiology of *Streptococcus* infections in other regions of study areas.

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DATA AVAILABILITY

The data are available within text of the article.

ETHICAL CONSIDERATIONS

The study received approval from the Faculty of Veterinary Medicine, Thamar University. Informed consent, either verbal or written, was obtained from all adult participants, as well as from the parents or guardians of children, prior to the collection of samples**.**

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests or conflicts of interest that could have influenced the results or the publication of this work.

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المكورات العقدية المقيحة في الانسان في ذمار، اليمن: معدل الانتشار وأنماط الحساسية للمضادات الحيوية

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الملخص

تم إجراء هذه الدراسة المستعرضة القطاع في مناطق مختلفة من محافظة ذمار خلال الفترة بين 2024-2025 لتحديد انتشار المكورات العقدية القيحية في الإنسان، والعوامل المرتبطة بها وأنماط الحساسية الدوائية للسلالات المعزولة. تم جمع ما مجموعه 381 مسحة من الحلق من المشاركين من مختلف مناطق ذمار، محافظة ذمار. تم نقل العينات إلى المختبر في كلية الطب البيطري بجامعة ذمار حيث تم إجراء الزراعة الميكروبيولوجية والاختبارات الكيميائية الحيوية. كشفت النتائج أنه من بين 381 مسحة فموية/الحلق تم فحصها، كانت 67 (17.59%) إيجابية للإصابة بالمكورات العقدية القيحية. تم تسجيل أعلى معدل انتشار في منطقة رباط القلعة (4.72%)؛ في حين كان أدنى معدل في رخمة (0.26%). تم تسجيل أعلى معدل انتشار في الفئة العمرية من 5–15 سنة (7.61%)، بينما كان أدنى معدل في الفئة العمرية > 45 سنة ومافوق (2.36 %). تم تسجيل أعلى معدل انتشار في أكتوبر (4.99%)، في حين كانت النسبة أقل في مارس (0.79%). احصائيا، لوحظت فروق ذات دلالة معنوية ($P < 0.05$) بين انتشار المكورات العقدية وعوامل الشهر ومنطقة الدراسة. كشفت اختبارات التحسس للمضادات الحيوية أن سلالات *S. pyogenes* المعزولة كانت حساسة للبنسلين G، والأموكسيسيلين، والأمبيسيلين، والسيفوتاكسيم، والسيفالوسبورين، والسيفترياكسون، واللينكوميسين، والفانكومايسين بينما كانت مقاومة لكل من الستريتومايسين، والجنتاميسين، والليفوفلوكساسين، والتيتراسايكلين، والإريثروميسين، والكليندامايسين. خلصت الدراسة الى ان المكورات العقدية القيحية *S. pyogenes* منتشرة في مناطق الدراسة. وتوصي الدراسة بإجراء اختبار دوري للمضادات الحيوية الموصوفة للبشر والحيوانات، واجراء المزيد من الدراسات حول وبائيات المكورات العقدية القيحية في مناطق أخرى من محافظة ذمار.

الكلمات المفتاحية: المكورات العقدية *S. pyogenes*، مقاومة المضادات الحيوية، ذمار، اليمن.

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