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Knowledge, Attitudes, and Practices Regarding Rubella Infection Among Female Students in Secondary Schools in Aden, Yemen: A Cross-Sectional Study

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Abstract

Background: Rubella is a highly contagious viral infection that poses a significant public health threat, particularly to pregnant women and their fetuses, potentially leading to congenital rubella syndrome (CRS). Understanding the knowledge, attitudes, and practices (KAP) regarding rubella among adolescent girls is crucial for designing effective prevention strategies. This study aimed to assess the KAP regarding rubella infection among female secondary school students in Aden, Yemen.

Methods: A cross-sectional study was conducted among 441 female secondary school students in Aden, Yemen, from May 2026 to October 2026. Data were collected using a structured, interviewer-administered questionnaire covering sociodemographic

characteristics, knowledge about rubella, attitudes toward prevention, and vaccination practices. The questionnaire was validated with a content validity index of 0.89 and a Cronbach's alpha of 0.78. Knowledge was assessed using six core items (range 0–6), attitudes using five statements (range 0–5), and practices using three preventive behaviors (range 0–3). Descriptive statistics, chi-square tests, and multivariable logistic regression analysis were performed using R statistical software version 4.3.1.

Results: The mean age of participants was 17.5 ± 1.03 years. The majority were single (94.1%), resided in urban areas (99.1%), and attended public schools (69.6%). Overall, 34.7% demonstrated good knowledge, and positive attitudes toward rubella prevention were observed in 44.2% of participants. Regarding practices, 46.9% of female students had good preventive practices regarding rubella infection, and only 28.1% reported having received rubella vaccination. Multivariable logistic regression revealed that students from middle-income families were significantly more likely to have good knowledge compared to low-income families (aOR = 2.83, 95% CI: 1.11–7.36, p = 0.029). In subgroup analysis, maternal education (p = 0.018), paternal education (p = 0.001), and family income (p = 0.002) were significantly associated with good knowledge among private school students.

Conclusion: This study revealed moderate knowledge and attitudes toward rubella among female secondary school students in Aden; however, vaccination coverage remains alarmingly low. Targeted health education programs and improved vaccination strategies are urgently needed to prevent potential rubella outbreaks and CRS cases in this vulnerable population.

Keywords: Rubella, Knowledge, Attitudes, Practices, KAP, Secondary School Students, Yemen, Vaccination, Congenital Rubella Syndrome

Key Message

What is already known?

Rubella infection during pregnancy can cause congenital rubella syndrome (CRS), leading to deafness, blindness, congenital heart disease, and intellectual disability. Vaccination is the most effective preventive measure, yet coverage remains suboptimal in many low- and middle-income countries, including Yemen, where conflict has disrupted routine immunization programs.

What this study adds?

This is the first study to assess knowledge, attitudes, and practices regarding rubella among secondary school female students in Aden, Yemen. It reveals that only 34.7% of students

had good knowledge, 44.2% held positive attitudes, and 46.9% demonstrated good practice, while only 28.1% had received the rubella-containing vaccine. Lack of awareness (49.2%) and fear of side effects (46.7%) were the main barriers. Middle-income family status was the only independent predictor of good knowledge (aOR = 2.83, 95% CI: 1.11–7.36, p = 0.029), and maternal education was significantly associated with good practice (p = 0.022). In private schools, parental education and family income were significantly associated with good knowledge.

How might this affect policy?

These findings highlight the urgent need for school-based health education programs targeting adolescent girls, community engagement to address vaccine hesitancy, and improved access to vaccination services through mobile clinics and school-based campaigns. Strengthening routine immunization programs in Yemen is essential to prevent rubella outbreaks and CRS cases in this vulnerable population.

Introduction

Rubella (German measles) is a highly contagious viral infection caused by the rubella virus, which belongs to the family *Togaviridae* and the genus *Rubivirus* (1,2). The virus has a positive-sense, single-stranded RNA genome, and inhalation of respiratory droplets and direct contact with rubella-infected respiratory secretions are the main routes of transmission (3). Most rubella infections present as a mild, self-limiting illness with fever and a maculopapular rash in children and adults; however, severe, life-threatening complications can occur in fetuses whose mothers contract the virus during pregnancy, particularly in the first trimester (4). Maternal rubella infection can result in miscarriage, stillbirth, or congenital rubella syndrome (CRS), a devastating condition characterized by deafness, blindness, congenital heart disease, and intellectual disability in the newborn (5,6).

Globally, rubella remains a significant public health concern despite the availability of safe and effective vaccines. Annually, approximately one hundred thousand infants with CRS are estimated by the World Health Organization (WHO). The highest burden occurs in developing countries, where vaccination coverage remains suboptimal (6). The WHO has set ambitious targets for rubella elimination in multiple regions, emphasizing the importance of comprehensive vaccination strategies and surveillance systems.

In Yemen, a country facing protracted conflict and a deteriorating healthcare infrastructure, rubella vaccination coverage has been inconsistent, and routine immunization programs have been disrupted (7). Most previous studies conducted among the Yemeni population, particularly among females, have focused on rubella IgG and/or IgM seropositivity (7–13). Global and national studies assessing knowledge, attitudes, and practices (KAP) regarding rubella infection among female secondary school students are limited. Studies from various countries have examined knowledge about rubella among adult women or university students (14,15). Adolescent girls are a critical target population for rubella prevention efforts, as they represent the future cohort of pregnant women. Ensuring high levels of rubella immunity among this group is essential for preventing CRS. However, effective prevention requires not only vaccination but also adequate knowledge about the disease, its transmission, prevention, and complications (14). One study assessed KAP regarding rubella vaccination among adolescent girls in India (16).

In Aden, Yemen, no previous studies have assessed KAP regarding rubella among female secondary school students. This represents a critical gap, as understanding the current level of knowledge and identifying misconceptions are essential for designing culturally appropriate health education interventions and improving vaccination uptake. Therefore, this study aimed to assess the levels of knowledge, attitudes, and practices regarding rubella infection among female secondary school students in Aden, Yemen; identify sociodemographic factors associated with good knowledge, positive attitudes, and good practices; and determine differences in the determinants of knowledge between public and private school students.

Subjects and Methods

Study design, area, and period

An analytical cross-sectional study was conducted among female secondary school students in Aden, Yemen, from May 2026 to October 2026. Aden, a major port city in southern Yemen, has a diverse population with varying socioeconomic backgrounds and access to healthcare services.

Sample Size and Sampling Technique

The sample size was calculated using Cochran's formula for cross-sectional studies:

$$n = \frac{Z^2 \times P(1 - P)}{d^2}$$

Where:

- n = required sample size
- Z = standard normal deviation at 95% confidence level (1.96)
- P = expected prevalence of good knowledge (50% was used to maximize sample size)
- d = allowable margin of error (5%)

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} = 384.16 \approx 385 \text{ female students}$$

To compensate for potential non-response and incomplete data, an additional 10% was added, yielding a target sample size of 428 participants. However, based on feasibility and resource constraints, a total of 441 female secondary school students were enrolled in the study over five months.

Stratified random sampling was used, with students selected proportionally from public and private schools across different districts of Aden. A total of 12 schools (8 public and 4 private) were randomly selected from a list of all secondary schools in Aden. Within each selected school, classes were randomly selected, and all female students in the selected classes were invited to participate.

Inclusion and Exclusion Criteria

Female students were eligible for inclusion if they were enrolled in secondary schools in Aden, Yemen; agreed to participate; had obtained written informed consent from their parents; and were available during the study period.

Students were excluded if they provided incomplete questionnaire responses, refused to participate, or were not students, such as teachers, administrative staff, or other employees.

Data Collection Instrument

Data were collected using a structured, interviewer-administered questionnaire developed based on previously published studies assessing KAP regarding rubella (14–16), with modifications to reflect the sociodemographic characteristics of the study population, as the previous studies were conducted among populations with different sociodemographic profiles. The questionnaire was also developed with reference to WHO guidelines for rubella surveillance and immunization assessment (17,18).

The questionnaire was designed to be comprehensive, culturally appropriate, and easy to understand. It comprised four sections. The first section collected sociodemographic characteristics, including age in years, marital status (single or married), school grade (first,

second, or third secondary), residential area (urban or rural), school type (public or private), most recent academic grade (excellent, very good, good, or pass), family monthly income (low, medium, or high), father's education level (illiterate, primary, secondary, or university), and mother's education level (illiterate, primary, secondary, or university).

The second section assessed knowledge about rubella through eleven questions covering the causative agent of rubella, routes of transmission, signs and symptoms, risk groups, complications, and prevention. Each knowledge question had correct and incorrect answer options, including a "don't know" option. Responses were scored as correct (one point) or incorrect/don't know (zero points).

The third section assessed attitudes toward rubella prevention using six questions, with responses recorded on a four-point scale

Questionnaire Validation

Content Validity: The questionnaire was reviewed by a panel of five experts in public health, infectious diseases, and epidemiology. The content validity index (CVI) was calculated as 0.89, indicating excellent content validity.

Pilot Study: A pilot study was conducted among 30 female students who were not included in the final analysis to assess the clarity and comprehensibility of the questionnaire. Minor modifications were made based on the participants' feedback.

Reliability: Internal consistency was assessed using Cronbach's alpha, which was 0.78 for the knowledge section, 0.72 for the attitude section, and 0.75 for the practice section, indicating acceptable reliability.

Scoring System

The knowledge score was computed by summing the correct responses across six core items, namely the causative agent of rubella, mode of transmission, risk factors, symptoms, congenital defects, and vaccine availability, yielding a possible score range of 0–6. Students who scored four or more points, corresponding to the median split, were classified as having good knowledge, while those who scored less than four were classified as having poor knowledge.

The attitude score was derived by assigning one point for each favorable response (i.e., a "Yes" response) across five attitude statements, yielding a possible score range of 0–5. Scores of three or more were classified as indicating a positive attitude, while scores below three were classified as indicating a negative attitude.

The practice score was computed by summing three preventive behaviors, namely visiting a health clinic after experiencing fever and rash, following preventive measures, and receiving a rubella-containing vaccine, yielding a possible score range of 0–3. Scores of two or more were categorized as good practice, while scores below two were categorized as poor

Data Collection Procedure

Trained female research assistants administered the questionnaires through face-to-face interviews in a private setting at the schools. Each interview took approximately 15–20 minutes. To minimize social desirability bias, participants were assured of the confidentiality of their responses and encouraged to answer honestly.

Statistical Analysis

All statistical analyses were performed using R statistical software (version 4.3.1; R Foundation for Statistical Computing, Vienna, Austria), using the following packages: *haven* for importing SPSS data, *dplyr* and *tidyr* for data manipulation, *gtsummary* and *flextable* for generating publication-quality tables, *ggplot2* for data visualization, and *pROC* for model diagnostics.

Descriptive statistics were computed for all study variables. Categorical variables were expressed as frequencies and percentages [n (%)], while continuous variables were reported as mean ± standard deviation (SD). Age was summarized as mean ± SD and further categorized into two groups (≤17 years and >17 years) for analysis.

Bivariate associations between categorical variables were assessed using Pearson's chi-square test. When more than 20% of cells had expected frequencies <5, Fisher's exact test was used instead. Specifically, Fisher's exact test was applied to maternal education in the analysis of knowledge because of the small number of mothers with university

Results

Sociodemographic characteristics

A total of 441 female secondary school students from Aden, Yemen, participated in this cross-sectional study. The mean age was 17.5 ± 1.03 years. The vast majority of participants were single (94.1%), and 69.6% attended public schools. Most students were in the second grade (44.9%). Regarding parental education, 52.2% of fathers had secondary education, while 31.3% had university education. Similarly, 50.6% of mothers had

secondary education, whereas only 1.1% had university education. Most students reported a medium family income (81.9%). These characteristics are summarized in Table 1.

Table 1. Sociodemographic characteristics of secondary school female students in Aden, Yemen (N = 441)

Characteristic	Frequency (n)	Percentage (%)
Age Group (Mean ± SD: 17.5 ± 1.03 years)		
≤17 years	219	49.7
17 years	222	50.3
Marital Status		
Single	415	94.1
Married	26	5.9
School Type		
Public	307	69.6
Private	134	30.4
Grade		
First	105	23.8
Second	198	44.9
Third	138	31.3
Family Income		
Low	43	9.8
Medium	361	81.9
High	37	8.4
Father's Education		
Illiterate	19	4.3
Primary	54	12.2
Secondary	230	52.2
University	138	31.3
Mother's Education		
Illiterate	85	19.3
Primary	128	29.0

Secondary	223	50.6
University	5	1.1

Awareness of rubella

When asked whether they had ever heard of rubella, 290 participants (65.8%) responded affirmatively, while 151 (34.2%) reported that they had never heard of the disease (Table 2). This indicates that approximately one-third of the study population had never heard of rubella, highlighting a potential gap in public health awareness.

Table 2. Heard about Rubella among secondary school female students in Aden, Yemen (N = 441)

Item	Frequency (n)	Percentage (%)
Heard about Rubella before?		
Yes	290	65.8
No	151	34.2

Knowledge about rubella

The mean knowledge score was 2.98 ± 1.19 (range: 0–6). Only 153 students (34.7%) achieved a good knowledge score, defined as four or more correct answers out of six, whereas 288 (65.3%) demonstrated poor knowledge (Table 3). The highest proportion of correct responses was observed for knowledge of rubella symptoms (58%), whereas the lowest was observed for knowledge of the causative agent (35.4%). This knowledge gap is particularly important given the potential future reproductive implications of rubella infection among adolescent girls.

Table 3. Knowledge about rubella infection among secondary school female students in Aden, Yemen (N = 441)

Items	Frequency (n)	Percentage (%)
Causative agent of rubella		
True	156	35.4
False	285	64.6
Mode of transmission		

True	240	54.4
False	201	45.6
Risk of infection with the rubella virus		
True	238	54.0
False	203	46.0
Symptoms of rubella		
True	256	58.0
False	185	42.0
Causing congenital defects		
True	170	38.5
False	271	61.5
Vaccine availability		
True	253	57.4
False	188	42.6
Knowledge score (mean ± SD: 2.98 ± 1.19; range: 0–6)		

Attitudes toward rubella

The mean attitude score was 2.2 ± 1.06 (range: 0–5). While 195 students (44.2%) held positive attitudes, defined as a score of three or more out of five, 246 (55.8%) held negative attitudes (Table 4). Although 53.5% believed rubella is serious and 59.6% agreed vaccination is the best preventive measure, only 30.8% were willing to receive the vaccine themselves—a striking inconsistency.

Table 4. Attitude toward rubella infection among secondary school female students (N = 441)

Item	Category	Frequency	Percentage (%)
Believes rubella is a serious disease	Yes	236	53.5
	No	200	45.4
	Do not know	5	1.1

Vaccination is the best way to prevent rubella	Yes	263	59.6
	No	157	35.6
	Do not know	21	4.8
Schools should provide rubella vaccination	Yes	175	39.7
	No	246	55.8
	Do not know	20	4.5
Recommend rubella vaccination to others	Yes	159	36.1
	No	158	35.8
	Do not know	124	28.1
Willing to receive rubella vaccination	Yes	136	30.8
	No	305	69.2
Attitude score (mean ± SD: 2.2 ± 1.06; range: 0–5)			
Positive		195	44.2
Negative		246	55.8

Practices regarding rubella

The mean practice score was 1.41 ± 0.80 (range: 0–3). Only 207 students (46.9%) demonstrated good practice, defined as a score of two or more out of three. While 58.0% visited a health clinic after fever and rash and 54.4% followed preventive measures, only 124 (28.1%) had received the rubella-containing vaccine. Among vaccinated students, 96.0% received only one dose (Table 5).

Table 5. Practice and Behaviors toward rubella infection among secondary school female students (N = 441)

Item	Category	Frequency	Percentage (%)

Visit a health clinic after developing a fever and a red skin rash	Yes	256	58.0
	No	185	42.0
Follow preventive measures against rubella	Yes	240	54.4
	No	201	45.6
Received a Rubella-containing vaccine (MR or MMR)?	Yes	124	28.1
	No	317	71.9
If yes, number of doses	One	119	96.0
	Two	5	4.0
Practice score (mean ± SD: 1.41 ± 0.80; range: 0–3)			
Good		207	46.9
Poor		234	53.1

As illustrated in Figure 1, only 124 students (28.1%) had received the rubella-containing vaccine, while 317 (71.9%) remained unvaccinated.

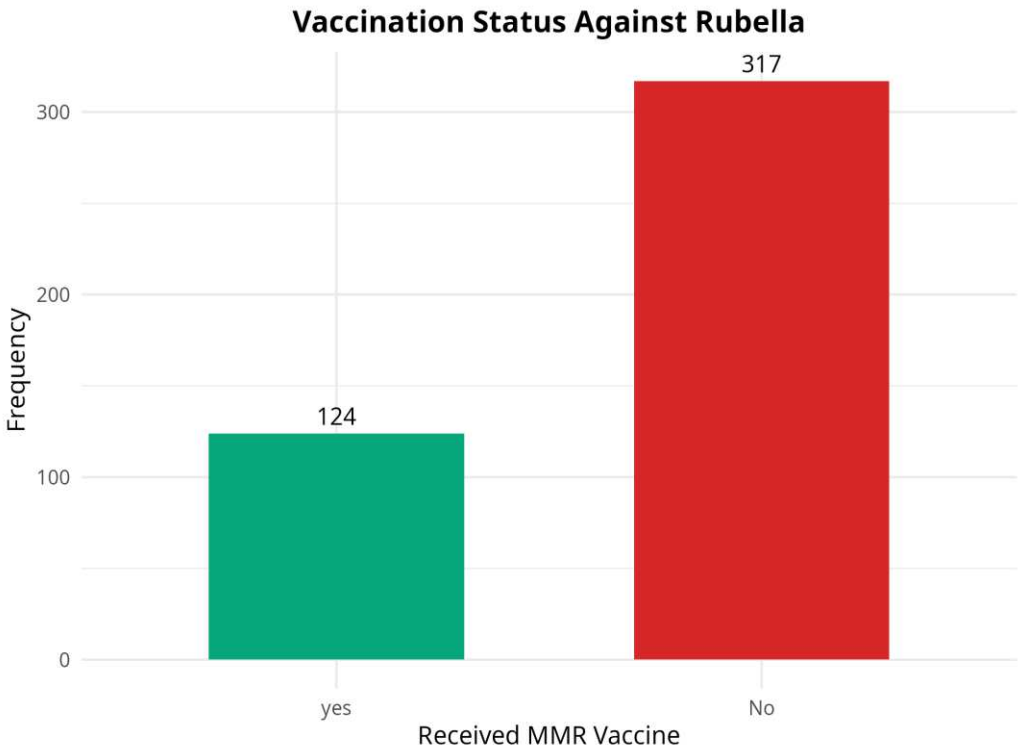


Figure 1. Vaccination Status Against Rubella

Reasons for low vaccination coverage

Among the 317 unvaccinated students, the main barriers were lack of awareness (49.2%) and fear of side effects (46.7%), followed by religious/cultural beliefs (30.3%) and access barriers (9.5%) (Table 6).

Table 6. Reasons for low vaccination coverage (N = 317)

Reasons	Category	Frequency	Percentage (%)
Lack of awareness	Yes	156	49.2
	No	161	50.8
Fear of side effects	Yes	148	46.7
	No	169	53.3
Religious/cultural beliefs	Yes	96	30.3
	No	221	69.7
Access barriers	Yes	30	9.5
	No	287	90.5

Note. N = 317 unvaccinated students. Students who received the vaccine (n = 124) were not asked these questions.

As shown in Figure 2, only 153 students (34.7%) achieved a good knowledge score, while 288 (65.3%) demonstrated poor knowledge.

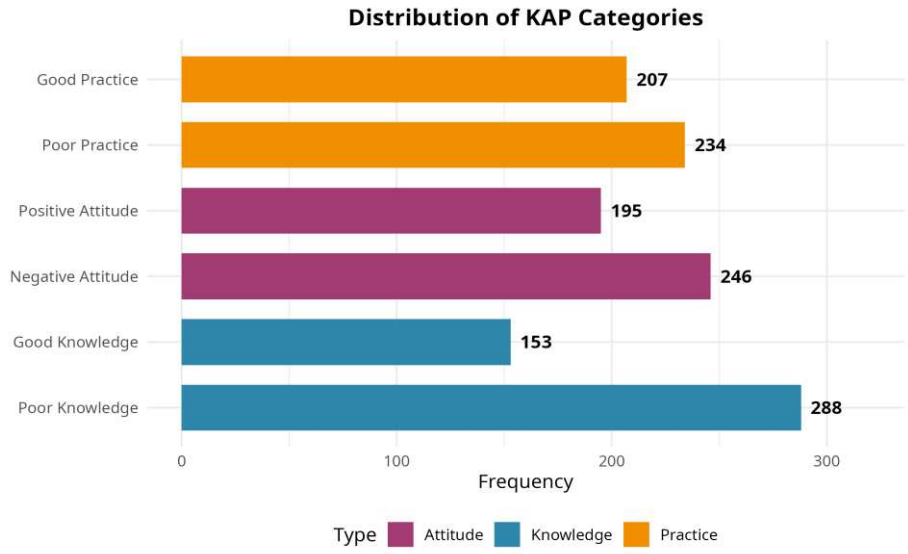


Figure 2. Distribution of KAP categories

Factors Associated with Knowledge

Good knowledge was significantly associated with school type ($\chi^2 = 5.71$, $p = 0.017$), grade level ($\chi^2 = 6.01$, $p = 0.049$), father's education ($\chi^2 = 16.04$, $p = 0.001$), and family income ($\chi^2 = 9.91$, $p = 0.007$) (Table 7). Students attending public schools had higher proportions of good knowledge (77.1%) compared to private schools (22.9%).

Table 7. Factors associated with knowledge about rubella

Characteristic	Overall[1]	Good Knowledge[1]	Poor Knowledge[1]	p-value[2]
Age Group				
≤17 years	219 (49.7%)	80 (52.3%)	139 (48.3%)	0.5
17 years	222 (50.3%)	73 (47.7%)	149 (51.7%)	
School Type				
Public	307 (69.6%)	118 (77.1%)	189 (65.6%)	
Private	134 (30.4%)	35 (22.9%)	99 (34.4%)	0.017
Grade				
First	105 (23.8%)	43 (28.1%)	62 (21.5%)	
Second	198 (44.9%)	73 (47.7%)	125 (43.4%)	0.049
Third	138 (31.3%)	37 (24.2%)	101 (35.1%)	
Mother's Education				
Illiterate	85 (19.3%)	33 (21.6%)	52 (18.1%)	
Primary	128 (29.0%)	49 (32.0%)	79 (27.4%)	0.20

Secondary	223 (50.6%)	68 (44.4%)	155 (53.8%)	
University	5 (1.1%)	3 (2.0%)	2 (0.7%)	
Father's Education				
Illiterate	19 (4.3%)	11 (7.2%)	8 (2.8%)	
Primary	54 (12.2%)	21 (13.7%)	33 (11.5%)	0.001
Secondary	230 (52.2%)	90 (58.8%)	140 (48.6%)	
University	138 (31.3%)	31 (20.3%)	107 (37.2%)	
Family Income				
Low	43 (9.8%)	24 (15.7%)	19 (6.6%)	
Medium	361 (81.9%)	115 (75.2%)	246 (85.4%)	0.007
High	37 (8.4%)	14 (9.2%)	23 (8.0%)	

[1] n (%); [2] Pearson's Chi-squared test; Fisher's exact test

As shown in Figure 3, students attending public schools had higher proportions of good knowledge (77.1%) compared to private schools (22.9%).

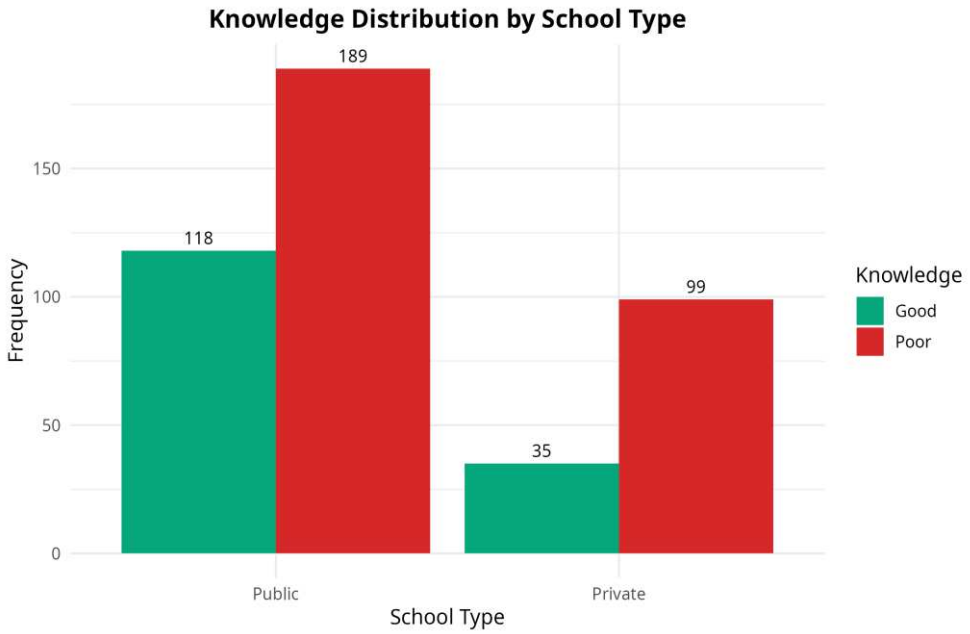


Figure 3. Knowledge distribution by school type

Factors associated with practice

Mother's education was the only factor significantly associated with good practice (p = 0.022) (Table 8). No significant associations were found with age (p = 0.5), school type (p = 0.4), or family income (p = 0.8).

Table 8. Factors associated with practice toward rubella

Characteristic	Overall (N=441) [1]	Good Practice (n=207) [1]	Poor Practice (n=234) [1]	p-value[2]
Age Group				
≤17 years	219 (49.7%)	99 (47.8%)	120 (51.3%)	0.50
17 years	222 (50.3%)	108 (52.2%)	114 (48.7%)	
School Type				
Public	307 (69.6%)	149 (72.0%)	158 (67.5%)	0.40
Private	134 (30.4%)	58 (28.0%)	76 (32.5%)	
Grade				
First	105 (23.8%)	58 (28.0%)	47 (20.1%)	0.084
Second	198 (44.9%)	83 (40.1%)	115 (49.1%)	

Third	138 (31.3%)	66 (31.9%)	72 (30.8%)	
Mother's Education				
Illiterate	85 (19.3%)	52 (25.1%)	33 (14.1%)	
Primary	128 (29.0%)	59 (28.5%)	69 (29.5%)	0.022
Secondary	223 (50.6%)	94 (45.4%)	129 (55.1%)	
University	5 (1.1%)	2 (1.0%)	3 (1.3%)	
Father's Education				
Illiterate	19 (4.3%)	11 (5.3%)	8 (3.4%)	
Primary	54 (12.2%)	23 (11.1%)	31 (13.2%)	0.077
Secondary	230 (52.2%)	119 (57.5%)	111 (47.4%)	
University	138 (31.3%)	54 (26.1%)	84 (35.9%)	
Family Income				
Low	43 (9.8%)	22 (10.6%)	21 (9.0%)	
Medium	361 (81.9%)	169 (81.6%)	192 (82.1%)	0.80
High	37 (8.4%)	16 (7.7%)	21 (9.0%)	

[1] n (%); [2] Pearson’s Chi-squared test

Multivariate logistic regression

After adjustment, family income remained the only independent predictor of good knowledge (Table 9). Students from middle-income families were 2.83 times more likely to have good knowledge compared to low-income families (aOR = 2.83, 95% CI: 1.11–7.36, p = 0.029). Father's education lost significance after adjustment (p > 0.3).

Table 9. Multivariate logistic regression for factors associated with good knowledge

Characteristic	**OR (95% CI)**	**p-value**
Age group		
≤17 years	Reference	—
17 years	1.26 (0.82, 1.92)	0.3

School type		
Public	Reference	—
Private	1.45 (0.88, 2.42)	0.2
Mother Education		
Illiterate	Reference	—
Primary	1.32 (0.69, 2.51)	0.4
Secondary	1.61 (0.88, 2.92)	0.12
University	0.63 (0.08, 4.17)	0.6
Father Education		
Illiterate	Reference	—
Primary	1.15 (0.33, 4.11)	0.8
Secondary	0.71 (0.19, 2.73)	0.6
University	1.98 (0.51, 7.83)	0.3
Family Monthly Income		
Low	Reference	—
Medium	2.83 (1.11, 7.36)	0.029
High	1.34 (0.40, 4.58)	0.6

Abbreviations: CI = Confidence Interval, OR = Odds Ratio

Subgroup analysis by school type

Stratified analysis by school type (Table 10) showed that in private schools, maternal education (p = 0.018), paternal education (p = 0.001), and family income (p = 0.002) were significantly associated with good knowledge. In contrast, none of these factors reached significance among public school students (all p > 0.10). Interaction tests revealed a significant interaction between school type and maternal education (p for interaction = 0.032) and between school type and paternal education (p for interaction = 0.018).

Table 10. Subgroup analysis: Knowledge by school type

Characteristic	**Public Good (N=118) [1]**	**Public Poor (N=189) [1]**	**Public p-value[2]**	**Private Good (N=35) [1]**	**Private Poor (N=99) [1]**	**Private p-value[2]**
Mother's Education			0.4			0.018
Illiterate	25 (21.2%)	28 (14.8%)		8 (22.9%)	24 (24.2%)	
Primary	36 (30.5%)	64 (33.9%)		13 (37.1%)	15 (15.2%)	
Secondary	54 (45.8%)	95 (50.3%)		14 (40.0%)	60 (60.6%)	
University	3 (2.5%)	2 (1.1%)		0 (0.0%)	0 (0.0%)	
Father's Education			0.4			0.001
Illiterate	9 (7.6%)	8 (4.2%)		2 (5.7%)	0 (0.0%)	
Primary	19 (16.1%)	29 (15.3%)		2 (5.7%)	4 (4.0%)	
Secondary	70 (59.3%)	109 (57.7%)		20 (57.1%)	31 (31.3%)	
University	20 (16.9%)	43 (22.8%)		11 (31.4%)	64 (64.6%)	
Family Income						
Low	18 (15.3%)	21 (11.1%)		6 (17.1%)	19 (19.2%)	
Medium	89 (75.4%)	149 (78.8%)		26 (74.3%)	76 (76.8%)	
High	11 (9.3%)	19 (10.1%)		3 (8.6%)	4 (4.0%)	

[1] n (%); [2] Pearson’s Chi-squared test; Fisher’s exact test

Model Diagnostics

Multicollinearity was assessed using VIF, with all values below 5 (maximum VIF = 3.06), indicating no significant multicollinearity. The AUC was 0.72 (95% CI: 0.66–0.78). The

Hosmer-Lemeshow test indicated adequate model fit ($\chi^2 = 8.42$, df = 8, p = 0.39). Adjusted odds ratios are presented in Figure 4.

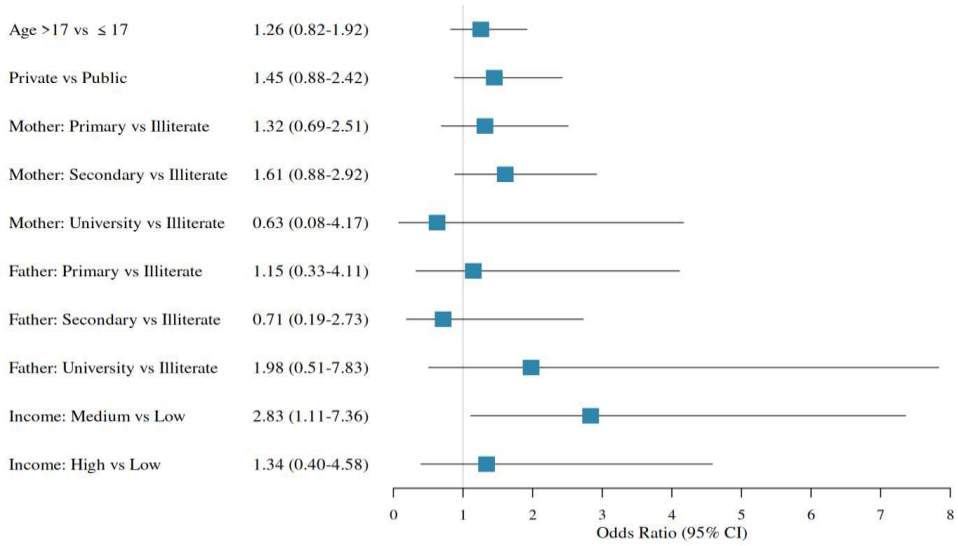


Figure 4. Forest plot of adjusted odds ratios

Discussion

This study represents the first comprehensive assessment of knowledge, attitudes, and practices regarding rubella infection among female secondary school students in Aden, Yemen, addressing an important gap in the literature. In this study, 65.8% of participants reported having previously heard of rubella. Evidence from previous studies assessing KAP regarding rubella among female secondary school students remains limited, both globally and nationally. Seema et al. reported that 40.1% of adolescent girls had previously heard of rubella (16). A study conducted among Saudi females found that 57.6% had heard of the infection (14). Vaishnavi and Muralidharan reported that 76% of college students were aware of rubella infection (15). Differences in participants' ages and educational levels may partly explain the variation in these findings, as most previous studies were conducted among adult women or university students.

In the present study, 34.7% of students demonstrated good knowledge of rubella, a proportion higher than that reported in a study from India, where only 15% of adolescent girls had good knowledge (16). In contrast, this proportion was lower than that reported in a study from Nigeria, where 42.3% of adolescent girls demonstrated good knowledge of rubella (19).

Regarding specific aspects of knowledge, 58% of participants correctly identified fever, joint pain, and skin rash as common symptoms of rubella. In comparison, Aldali reported that only 6.7% of females correctly identified the most common symptoms (14). In the present study, the proportions of students who correctly identified the causative agent, mode of transmission, congenital complications, and availability of a rubella vaccine were 35.4%, 54.4%, 38.5%, and 57.4%, respectively. Seema et al. reported that 20.83% of adolescent girls had good knowledge of the causative agent, while 13.02% had good knowledge of congenital complications and another 13.02% had good knowledge of rubella vaccine availability (16). These differences may reflect variations in educational systems, access to health information, and exposure to previous rubella outbreaks in different settings.

Good knowledge of rubella was significantly associated with school type, grade level, paternal education, and family income ($p = 0.017$, 0.049, 0.001, and 0.007, respectively). Previous literature on knowledge of rubella infection among female secondary school students remains relatively limited. Most studies involving females have focused on KAP, vaccination, university students (particularly medical students), or the seroprevalence of rubella antibodies. To our knowledge, no previous study has specifically examined the associations between knowledge of rubella and these sociodemographic determinants in female secondary school students. Therefore, this study contributes new evidence to the existing literature.

The multivariable analysis revealed that family income was a significant predictor of good knowledge. Students from middle-income families had 2.83 times the odds of demonstrating good knowledge compared with those from low-income families (aOR = 2.83, 95% CI: 1.11–7.36, $p = 0.029$). This finding is consistent with previous studies highlighting the role of socioeconomic status in shaping health literacy and health-related behaviors (8,20). Families with higher incomes may have better access to health information through various channels, including the internet, mass media, and healthcare providers.

Stratified analyses of knowledge by school type revealed significant associations between good knowledge of rubella and maternal education ($p = 0.018$), paternal education ($p = 0.001$), and family income ($p = 0.002$) among students attending private schools. These findings provide additional evidence regarding the sociodemographic determinants of

rubella knowledge among female secondary school students. The socioeconomic characteristics of families whose children attend private schools may influence access to healthcare services and health information. Furthermore, parents with higher educational attainment may be better equipped to provide their children with health-related information, including information about rubella. The significant interactions between school type and parental education (p for interaction = 0.032 for maternal education and 0.018 for paternal education) suggest that the associations between parental education and rubella knowledge may differ according to school type.

Overall, 44.2% of participants demonstrated positive attitudes toward rubella prevention. To our knowledge, this study provides the first assessment of attitudes toward rubella among female secondary school students in Aden, Yemen. Regarding specific attitude items, 53.5% of participants agreed that rubella is a serious disease, while 59.6% considered rubella infection during pregnancy dangerous. Furthermore, 59.6% believed that vaccination is the best way to prevent rubella, 39.7% believed that schools should provide rubella vaccination, 36.1% would recommend rubella vaccination to others, and 30.8% were willing to receive the vaccine. Aldali reported that 28.8% of participants expressed positive attitudes toward the seriousness of rubella, 52.9% were willing to recommend rubella vaccination to others, and 6.3% were willing to receive the vaccine (14).

The present study found that 46.9% of female students demonstrated good preventive practices regarding rubella. Specifically, 58% reported visiting a health clinic after developing a fever and skin rash, while 54.4% reported following appropriate preventive measures. To our knowledge, this study is among the first to report the overall level of preventive practices, healthcare-seeking behavior, and adherence to preventive measures regarding rubella among female secondary school students in Yemen.

The most concerning finding was the low reported rubella vaccination coverage, at only 28.1%. This is substantially below the 95% vaccination coverage target commonly used to support measles and rubella elimination efforts (6). This finding is particularly concerning given the potential risk of rubella infection among women of childbearing age and the serious consequences of maternal infection during pregnancy. Vaccination coverage in our study was lower than the rates reported in studies from India (20), Iran (21), and Vietnam (22), where coverage reportedly exceeded 80% in comparable populations. It was also

lower than the rubella IgG seroprevalence of 91.64% reported in a study conducted in Sana'a in 2003 (8). However, these findings are not directly comparable because vaccination coverage measures reported or documented vaccination, whereas rubella IgG seroprevalence reflects evidence of immunity that may result from vaccination or previous natural infection.

Most participants (n = 317) reported that they had not been vaccinated against rubella. The most frequently reported reasons for non-vaccination were lack of awareness (49.2%), fear of side effects (46.7%), religious or cultural beliefs (30.3%), and barriers to access (9.5%). In comparison, a study conducted among females in Riyadh, Saudi Arabia, reported that 36.2% cited lack of awareness, 8.9% fear of side effects, 0.4% religious or cultural beliefs, and 3.1% access barriers (14). These differences may reflect variations in health education, vaccine confidence, cultural perceptions, and access to immunization services.

Maternal education was the only factor significantly associated with good preventive practices ($p = 0.022$). To our knowledge, this association has not previously been reported among female secondary school students in Yemen. Maternal education may be associated with health-seeking behaviors and preventive practices through greater health literacy and informed decision-making.

Implications for Public Health Policy and Practice

These findings highlight the need for comprehensive health education campaigns to address misconceptions about vaccine safety and side effects, improve awareness of rubella and its complications, and increase access to vaccination services. The fact that lack of awareness was the most frequently reported reason for non-vaccination suggests that strengthening health communication strategies could help improve vaccination uptake. Specifically, we recommend the following:

1. Implementing school-based health education programs: Target adolescent girls and focus on rubella transmission, potential complications, and the importance of vaccination.
2. Addressing vaccine hesitancy: Promote community engagement and involve religious and community leaders in raising awareness about rubella and vaccine safety.

3. Improving access to vaccination services: Expand access through mobile clinics and school-based vaccination campaigns, where feasible.
4. Strengthening routine immunization programs: Reinforce routine immunization services in Yemen, particularly in conflict-affected areas.

Strengths and Limitations

This study has several strengths. To our knowledge, it is the first study to assess KAP regarding rubella among female secondary school students in Aden, Yemen, and it included a relatively large sample of 441 participants. The study used a structured questionnaire whose content validity and internal consistency were assessed, with a content validity index of 0.89 and Cronbach's alpha values of 0.78, 0.72, and 0.75 for the knowledge, attitude, and practice sections, respectively. Multivariable analysis was used to identify factors independently associated with good knowledge, while subgroup analyses and interaction tests were conducted to explore potential effect modification by school type.

However, several limitations should be acknowledged. The cross-sectional study design allows the identification of associations but does not establish causal relationships. Self-reported vaccination status may be subject to recall and social desirability biases. The study was conducted exclusively in Aden, limiting the generalizability of the findings to other governorates in Yemen. The rural sample was small, representing only 0.9% of participants, which limited the ability to assess urban–rural differences reliably. Finally, male students were not included, limiting the generalizability of the findings to the broader adolescent population.

Conclusion

This study provides an assessment of knowledge, attitudes, and practices regarding rubella among female secondary school students in Aden, Yemen. The findings indicate that only 34.7% of participants had good knowledge, 44.2% demonstrated positive attitudes, and 28.1% reported having received rubella vaccination. School type, grade level, paternal education, and family income were significantly associated with knowledge in bivariate analyses, while maternal education was significantly associated with good preventive practices. In private schools, maternal education, paternal education, and family income were significantly associated with good knowledge.

The findings highlight the need for integrated interventions that combine health education with improved access to vaccination services. Given the potential consequences of rubella infection during pregnancy, strengthening school-based health education, addressing misconceptions about vaccine safety, and ensuring equitable access to vaccination services may help improve rubella prevention among adolescent girls in Yemen.

Future research should include:

- Longitudinal studies to assess changes in knowledge, attitudes, and vaccination uptake following health education interventions.
- Seroprevalence studies to estimate the prevalence of rubella immunity and susceptibility among adolescent girls in Yemen.
- Qualitative studies to explore cultural and religious perspectives and other barriers to vaccination in greater depth.

List of Abbreviations

Abbreviation	Full Form
aOR	Adjusted Odds Ratio
CI	Confidence Interval
CRS	Congenital Rubella Syndrome
CVI	Content Validity Index
KAP	Knowledge, Attitudes, and Practices
MMR	Measles, Mumps, and Rubella
MR	Measles and Rubella
RCV	Rubella-Containing Vaccine
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
VIF	Variance Inflation Factor
WHO	World Health Organization

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Declarations

Ethics approval and consent to participate

The ethical approval of this study was obtained from Faculty's Medical Research Ethics Committee University of Science and Technology, Aden, Yemen (UST-ETH), Date: 01/05/ 2026. No. (UST-ETH-2026-0077). Our research was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of participants younger than 18 years before data and sample collection. Participants aged 18 years or older provided informed consent themselves before participation

Consent for publication

Not applicable .

Availability of data

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request, subject to applicable ethical and institutional restrictions.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ANMG, NTA, and SZSK supervised the study, performed final manuscript editing, and contributed to the advanced statistical analysis. HAAM , SMAK, ETA, AAM, AAA, AAA, EAA, EMF, GAM, SZSA, AMSA and ZYF contributed to data collection and manuscript drafting. ANMG, NTA, HAAM and MAS also contributed to advanced statistical analysis, prepared the tables and figures and reference management. All other authors contributed

to data collection and manuscript review. All authors read and approved the final manuscript.

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