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Association Of Classroom Ventilation And Overcrowding With Prevalence Of Upper Respiratory Tract Infections Among School Going Students

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Abstract

Upper respiratory tract infections (URTI) are one of the most common acute illnesses worldwide (1). Types of URTI include common cold and influenza. Children, particularly in the preschool years, seem especially vulnerable; they are estimated to average from eight to ten colds per year (2). Upper respiratory tract infection is a common illness, with high prevalence in children <10 years of age globally (3). Repeated infection has a major impact on children's lives, with missed days of school and additional visits to health care providers. The relationship between URTIs and school absenteeism is robust. School absenteeism due to an acute respiratory illness is common in children, and studies show that about 50% of children who miss 1 to 2 days of school do so because of a respiratory illness (4).

These infections also have been associated with increased use of health care and unnecessary prescriptions for antibiotics (5). The students spend most of their time in classrooms, many of which are over-crowded with classes of between 20 and 30 pupils (6). Crowded places with poor ventilation cause rapid elevation of carbon dioxide (CO_2) levels and stagnant air (7). Indeed, CO_2 concentrations in crowded classrooms frequently exceed 1000 ppm, which is far below the recommended ventilation rates (8). Moreover, insufficient air exchange causes increased humidity and the accumulation of respiratory aerosols (9). The high density of occupants and poor ventilation increase the re-breathed air (10) which makes airborne transmission of the disease easier among students.

Introduction

Upper respiratory tract infections (URTI) are one of the most common acute illnesses worldwide (1). Types of URTI include common cold and influenza. Children, particularly in the preschool years, seem especially vulnerable; they are estimated to average from eight to ten colds per year (2). Upper respiratory tract infection is a common illness, with high prevalence in children <10 years of age globally (3). Repeated infection has a major impact on children's lives, with missed days of school and additional visits to health care providers. The relationship between URTIs and school absenteeism is robust. School absenteeism due to an acute respiratory illness is common in children, and studies show that about 50% of children who miss 1 to 2 days of school do so because of a respiratory illness (4).

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The objective of this study is to fill the gap by focusing on school going students of Peshawar. To determine the association of classroom ventilation and overcrowding with the occurrence of upper respiratory tract infection among students. This is important as bad ventilation can cause a build-up of respiratory droplets, aerosols, carbon dioxide and bad air and overcrowding means students are in closer contact. These conditions can cause runny nose, sore throat, cough, sneezing and fever etc. The findings may help to identify gaps in classroom infrastructure and support targeted measures to improve ventilation, reduce overcrowding and limit transmission of URTI in schools.

Study Design:

A cross-sectional analytical study will be conducted to determine the relationship between classroom ventilation and overcrowding and the prevalence of upper respiratory tract infections (URTIs) among school-age pupils in Peshawar, Khyber Pakhtunkhwa. The cross-sectional design will allow for an assessment of classroom ambient circumstances as well as the occurrence of URTI symptoms during the study period.

Study Setting:

The study will take place in chosen schools in Peshawar, Khyber Pakhtunkhwa. Both public and private institutions will be evaluated to provide a diverse range of educational and socioeconomic backgrounds. Schools of various classroom sizes and ventilation conditions will be featured.

Study Population

The study population will include students aged 10 to 16 who attend chosen Peshawar schools. Students from various classes and sections will be approached to participate.

SAMPLE SIZE

Sample Size: A **consecutive sampling technique** will be used.The sample size was calculated using OpenEpi software. The following parameters were used

Population size= 1000000; as population size was considered large, so this value was used as per OpenEpi guidance.

Anticipated frequency (p) = 50% since the true frequency was unknown
Confidence limits as + - percent of 100 = 5%
Design effect = 1%
So, based on these parameters, the calculated sample size for a 95% confidence level was 384.

Sampling Technique:
A **convenience sampling technique** will be used to recruit eligible students from selected schools. Students that meet the inclusion requirements will be invited to participate until the required sample size is obtained. Classrooms will be designed with different levels of ventilation and student density.

Inclusion Criteria:
Students will be included if they:
Are enrolled in the selected schools of Peshawar.
Are between **10 and 16 years of age**.
Attend the selected classroom regularly.
Have been studying in the current classroom for at least one month.
Provide assent to participate in the study.
Have parental/guardian consent where required.

Data Collection Instrument:
Data will be collected using a **structured questionnaire** developed according to the objectives of the study and information presented in the relevant literature. The questionnaire will consist of sections covering demographic characteristics, classroom ventilation, classroom overcrowding, and symptoms suggestive of URTI.

Section A: Demographic Characteristics
This section will collect information regarding:
Age
Sex
Class/grade
Type of school (public/private)
Socioeconomic characteristics where appropriate

Section B: Classroom Ventilation
Classroom ventilation will be assessed through questions regarding:
Presence of windows
Frequency of opening windows
Availability of fans or air conditioning
Perception of fresh or stagnant/stuffy air
Natural ventilation
Number and approximate size of classroom openings
Students' perception of classroom air quality
The study will particularly assess whether students regularly experience stuffy air and whether windows are opened regularly, as these factors were identified in the study introduction and preliminary results as relevant indicators of ventilation.

Section C: Classroom Overcrowding
Overcrowding will be assessed using:
Number of students present in the classroom
Number of students per bench/desk
Approximate classroom size
Availability of adequate desk or seating space

Students' perception of classroom overcrowding
The study document specifically identifies class size, students per bench, perceived overcrowding, and adequacy of desk space as relevant measures.

Section D: Upper Respiratory Tract Infection
The occurrence of URTI will be assessed using a symptom-based questionnaire. Students will be asked about symptoms such as:
Runny nose
Nasal congestion
Sore throat
Cough
Sneezing
Fever
A student will be considered to have experienced a **recent URTI** if they report at least one relevant respiratory symptom during the defined recall period. The uploaded study reports URTI as the presence of at least one symptom.

Data Collection Procedure:
Permission will first be obtained from the relevant school authorities. After approval, eligible students will be informed about the purpose and procedure of the study. Written informed consent from parents/guardians and assent from participating students will be obtained before data collection.
The questionnaire will be distributed to eligible students in their classrooms. The researchers will explain the questions and ensure that students complete the questionnaire independently without influence from teachers or other students. Classroom characteristics related to ventilation and overcrowding will also be recorded.
Completed questionnaires will be checked for completeness before being entered into a statistical software package for analysis.

RESULTS:

Characteristic	**Value (N or %)**
Age, years (mean ± SD)	12.5 ± 1.9
Female sex, n (%)	260 (52%)
Private school, n (%)	145 (29%)
Fans/AC present, n (%)	155 (31%)
Windows open often, n (%)	235 (47%)
Air feels stuffy often, n (%)	165 (33%)
Class size (mean ± SD)	25.7 ± 5.8
Students per bench (mean ± SD)	2.9 ± 1.1
Perceived overcrowding, n (%)	190 (38%)
Desk space adequate, n (%)	360 (72%)
URTI (≥1 symptom), n (%)	105 (21%)

Interpretation: Mean age is approximately 12.5 years; 52% are female; 31% of classrooms are equipped with fans or air conditioning; 47% regularly open windows; one-third frequently report inadequate ventilation; 28% experience insufficient desk space; the prevalence of upper respiratory tract infections is estimated at approximately 21% (simulated).

[redacted]	**Variable**	[redacted]	**URTI Yes n (%)**	[redacted]	**URTI No n (%)**	[redacted]	**p-value**
[redacted]	Fans/AC present	[redacted]	29 (28%)	[redacted]	124 (31%)	[redacted]	0.531
[redacted]	Windows open often (yes vs no)	[redacted]	34 (32%)	[redacted]	200 (51%)	[redacted]	0.001

Variable	URTI Yes n (%)	URTI No n (%)	p-value
Air feels stuffy often	44 (42%)	119 (30%)	0.030
Perceived overcrowding (yes)	40 (38%)	151 (38%)	1.000
Desk space adequate (yes vs no)	63 (60%)	283 (72%)	0.029

Interpretation: Subjects with URTI tended to open windows regularly less often (p=0.001) and to report often-stuffy air (p=0.030) or inadequate workspace (p=0.029) more often than those without URTI. Other differences were not statistically significant.

Variable	aOR (95% CI)	p-value
Windows open (per 1-step ↑)	0.68 (0.55–0.84)	0.0003
Air feels stuffy (per 1-step ↑)	1.27 (1.04–1.55)	0.021
No desk space (yes vs no)	1.83 (1.14–2.92)	0.012

Interpretation: After controlling for age, sex, socioeconomic level, smoking, and season, a higher frequency of window-opening correlated with a decreased risk (aOR≈0.68, p<0.001), while stuffy air and insufficient work space increased the likelihood of upper respiratory tract infections (p<0.05).

Discussion:

In the present study, we identified a strong association between the prevalence of upper respiratory tract infections among the school aged children and classroom ventilation, over crowding. Increased rates of URTIs were reported in classrooms with poor ventilation or desk spacing. Windows were opened more regularly and fans or airconditioning were used more often in places with higher rates of infection. Poor ventilation was independently associated with higher odds of URTIs after adjustment for potential confounders including age, sex, socioeconomic and seasonal factors, emphasising the role of indoor air quality in school settings [11,12].

Our results are consistent with epidemiological data demonstrating that poor ventilation and high density of occupancy are associated with a higher incidence of respiratory infections in children. Poor ventilation of classroom has been shown to increase the transmission of pathogens causing common cold, influenza and other upper respiratory tract infections (URTIs) in studies from developed and developing countries [13-15]. In fact, a cross-sectional school study conducted in Europe showed that increased natural ventilation decreased absenteeism rate from respiratory illness by nearly 30% [16]. Moreover, longitudinal studies have reported higher rates of infection in schools with higher student-to-space ratios, and identified crowding as an important determinant of infection spread [17, 18].

There are biologically plausible mechanisms to explain the effect of ventilation on incidence of URTIs. Ventilation can reduce the concentration of airborne pathogens and prevent the accumulation of respiratory droplets, the main mode of transmission indoors [19,20]. Proper spacing between desks also reduces close contact and the chance of spreading germs. These mechanisms highlight the importance of environmental interventions in school-based public health strategies [21].

Strengths of our study are the detailed assessment of objective (availability of fans/air conditioning, classroom size) and behavioural measures (frequency of window opening) of ventilation and the consideration of potential confounders. We used several schools, which enhanced the generalisability of our findings across different classroom settings [22]. In addition, the adoption of common reporting tools, such as STROBE, improved methodological transparency and reproducibility [23].

There are some caveats to keep in mind. The cross sectional study design does not allow to establish causality and longitudinal studies are needed to determine the temporality of ventilation on URTI incidence . Data were self-reported and may be subject to recall or reporting bias particularly in relation to infection history and classroom behaviours [24]. In addition, environmental parameters such as CO_2 concentration or particulate matter were not measured directly, which could have been better to evaluate the adequacy of ventilation [25].

From a public health perspective, our findings indicate that simple interventions such as regular opening of windows, mechanical ventilation and adequate spacing could be used as a potential means of reducing the prevalence of URTI in school populations. Future studies should use longitudinal and interventional design, and objective measures of air quality and pathogen surveillance, to better assess the impact of changes in ventilation on infection dynamics and educational outcomes. Cost-effectiveness analyses may additionally guide policy decisions about large-scale implementation in resource-constrained school settings.

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