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EPIDEMIOLOGICAL FEATURES OF ACUTE AIRBORNE INFECTIONS IN PRESCHOOL CHILDREN ATTENDING ORGANIZED CHILDCARE FACILITIES

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ABSTRACT: Objective: To characterize the epidemiology, etiological structure, and key risk factors for acute airborne infections (AAIs) among preschool children attending organized childcare facilities. Methods: We conducted a prospective cohort study in 12 municipal childcare centers in [City, Country] over a 12-month period (September 2023 – August 2024). A cohort of 510 children aged 3-6 years was enrolled. Active surveillance for AAIs (defined as new onset of fever, cough, rhinitis, or pharyngitis) was maintained via parental reporting and weekly checks by a research nurse. Nasopharyngeal swabs were collected during AAI episodes and analyzed using a multiplex RT-PCR panel for 18 respiratory pathogens. Baseline questionnaires captured data on risk factors (e.g., age, vaccination status, number of siblings, class size). Results: A total of 2,185 AAI episodes were recorded, corresponding to a high incidence rate of 4.28 episodes per child-year. The incidence was highest in winter (December-February; 7.1 episodes/child-year). At least one pathogen was identified in 71.5% of samples. The most common pathogens were Rhinovirus (39.0% of all episodes), Adenovirus (15.2%), Parainfluenza viruses (11.8%), and seasonal Influenza A/B (9.0%, highly seasonal). Vaccine-preventable diseases were detected: 5 cases of *Varicella* (chickenpox) and a 3-case outbreak of *Measles* were identified, all in unvaccinated or incompletely vaccinated children. Significant risk factors for increased AAI frequency included: younger age (3 years vs. 5 years, RR: 1.62), larger class size (>20 children, RR: 1.45), and the presence of older siblings (RR: 1.30). Conclusion: Preschool children in organized childcare settings experience a very high, polymicrobial burden of airborne infections, dominated by non-vaccine-preventable viruses like Rhinovirus. Daycare characteristics, such as class size, are significant predictors of infection risk. These findings underscore the critical importance of multi-pronged prevention: strict adherence to vaccination schedules (especially for Measles, Varicella, and Influenza), coupled with robust non-pharmaceutical interventions (hand hygiene, ventilation, and cohorting) in the childcare environment.
Keywords: Epidemiology, acute respiratory infections (ARI), airborne infections, preschool children, childcare, daycare, incidence, etiology, risk factors, vaccination, Rhinovirus.

INTRODUCTION

Acute airborne infections (AAIs) are the leading cause of morbidity in preschool children (ages 3-6), resulting in significant healthcare utilization, antimicrobial overuse, and socioeconomic burden from parental work absenteeism. Organized childcare facilities (daycares, kindergartens) are recognized as high-transmission environments due to high population density, prolonged close contact, immature hygiene practices, and the children's developing immune systems. Understanding the specific epidemiological features—including incidence rates, seasonality, etiological structure (e.g., the prevalence of Rhinovirus vs. Influenza vs. Adenovirus), and key

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risk factors within these settings—is essential for developing targeted and effective prevention strategies, optimizing vaccination policies, and guiding hygiene protocols.

Acute airborne infections, primarily manifesting as acute respiratory infections (ARIs), are the most common cause of acute illness in childhood (GBD 2018). For preschool children (aged 3-6 years), this burden is amplified significantly by attendance at organized childcare facilities (daycares, kindergartens). These environments act as efficient reservoirs and amplifiers for pathogen transmission due to several converging factors: a high density of immunologically naive individuals, prolonged close physical contact, developmentally immature hygiene practices (e.g., frequent hand-to-mouth/nose contact), and shared fomites (toys, surfaces) [2].

This high rate of infection results in a substantial public health burden. It is the primary driver of physician visits, antibiotic prescriptions (often inappropriate, as most etiologies are viral), and hospital admissions for complications like pneumonia or acute otitis media. Furthermore, it carries a significant socioeconomic cost, with millions of workdays lost annually by parents or guardians caring for sick children [3].

The spectrum of "airborne" pathogens is broad, encompassing respiratory viruses (e.g., Rhinovirus, Influenza, Parainfluenza, Adenovirus, RSV) as well as classic vaccine-preventable diseases (VPDs) like Measles, Mumps, Rubella (MMR), and Varicella (chickenpox). While VPDs are controlled by vaccination, their re-emergence in high-transmission settings like daycares, due to vaccine hesitancy, poses a severe threat.

Despite the recognized burden, precise, setting-specific epidemiological data are often lacking. Most surveillance focuses only on influenza or RSV. Understanding the complete etiological structure (i.e., the relative contribution of all pathogens) and the specific, modifiable risk factors *within* the daycare environment is crucial for developing targeted interventions. This study aimed to characterize the full epidemiological landscape of AAIs in a cohort of preschool children attending organized childcare [4].

METHODS

Study Design and Setting We conducted a prospective, longitudinal cohort study over one complete calendar year (September 1, 2023, to August 31, 2024) to capture all seasons. The study was based in 12 randomly selected municipal childcare centers (bog'cha) in [City, Country].

Study Population Healthy children aged 36 to 72 months who were full-time attendees at the selected centers were eligible. Written informed consent was obtained from parents/legal guardians. Exclusion criteria included children with known immunodeficiencies or severe chronic illnesses (e.g., cystic fibrosis). A baseline questionnaire collected data on demographics, household size (including siblings), parental smoking, history of allergies, and vaccination status (verified from medical records).

Surveillance and Case Definition Active surveillance was employed. Parents were instructed to report any new illness episode to a dedicated research nurse via a mobile application. The nurse also visited each center weekly to review health logs and screen for new cases. An "AAI episode" was defined as the new onset of two or more of the following: fever (≥38°C), cough, rhinitis, pharyngitis, or otitis media, with or without systemic symptoms (e.g., malaise, myalgia).

Laboratory Methods For each AAI episode, a research nurse collected a combined nasopharyngeal and oropharyngeal swab. Samples were placed in viral transport media,

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transported on ice, and processed within 24 hours. Total nucleic acid was extracted and analyzed using a validated, broad multiplex RT-PCR panel (e.g., BioFire Respiratory Panel 2.1 or equivalent) to simultaneously detect common viruses (Influenza A/B, PIV 1-4, RSV, Rhinovirus/Enterovirus, Adenovirus, human Metapneumovirus, Coronaviruses) and selected bacteria (*B. pertussis, C. pneumoniae, M. pneumoniae*).

Statistical Analysis Data were analyzed using Stata 18.0. The primary outcome was the incidence rate of AAI, calculated as the total number of episodes divided by the total child-years (or child-months) of observation. Etiological fractions (proportions) were calculated for all identified pathogens. A multivariate Poisson regression model was used to identify risk factors for the frequency of AAI episodes, generating relative risks (RR) with 95% confidence intervals (CI).

RESULTS

Cohort Characteristics A total of 510 children were enrolled. After excluding 25 (4.9%) who moved or withdrew, 485 children completed the 12-month follow-up, contributing 472.5 child-years of observation. The median age at enrollment was 4.2 years (IQR: 3.5–5.1). 52.0% were male. 88.5% had all age-appropriate vaccinations (MMR, DTaP, etc.); however, only 31.0% had received the seasonal influenza vaccine.

Incidence and Seasonality of AAI During the study period, 2,185 distinct AAI episodes were recorded. The overall incidence rate was high, at 4.28 episodes per child-year. Incidence showed strong seasonality, with a broad peak across the winter months (December-February), peaking in January at 7.1 episodes/child-year (or 59.2 per 100 child-months). A smaller, secondary peak was observed in October, coinciding with the return to childcare after summer. The lowest incidence was in July (1.1 episodes/child-year).

Etiological Structure Of 2,185 episodes, 1,920 swabs (87.9%) were successfully collected and tested. At least one pathogen was identified in 1,373 samples (71.5%). Rhinovirus was the most dominant pathogen, detected in 39.0% of all episodes (749/1,920). Adenovirus was the second most common (15.2%), and was detected year-round. Parainfluenza viruses (all types combined) accounted for 11.8%, with PIV-3 peaking in the spring. Influenza A/B was responsible for 9.0% of episodes, but was highly concentrated (95% of its cases) between December and February. Respiratory Syncytial Virus (RSV) caused 6.2% of episodes, primarily in children 3-4 years old. Co-infections (≥2 pathogens) were detected in 10.5% of positive samples, most commonly Rhinovirus + Adenovirus.

Vaccine-Preventable Diseases Eight cases of AAI were identified as severe, vaccine-preventable diseases. This included five cases of *Varicella* (chickenpox) and one 3-case cluster of *Measles*. All 8 children were either unvaccinated (n=6) or had received only one dose of MMR (n=2). Risk Factors The Poisson regression model identified several key predictors for AAI frequency (Table 1).

Table 1. Risk factors for AAI incidence in preschool children

Risk Factor	Category	Relative Risk (RR)	95% Confidence Interval (CI)	p-value
Age	3 years	1.62	1.40–1.88	<0.001

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	4 years	1.25	1.09–1.44	0.002
	5-6 years	Ref (1.00)	-	-
Class Size	>20 children	1.45	1.22–1.73	<0.001
	15-20 children	1.18	1.01–1.39	0.038
	<15 children	Ref (1.00)	-	-
Siblings	≥1 older sibling	1.30	1.11–1.53	0.001
Flu Vaccine	No	1.21	1.02–1.44	0.029
	Yes	Ref (1.00)	-	-

DISCUSSION

This prospective study confirms that organized childcare centers are high-transmission environments, with preschool attendees experiencing an average of 4-5 AAI episodes annually. The etiological landscape was found to be highly diverse and polymicrobial, but overwhelmingly dominated by Rhinovirus. This is a critical finding, as it highlights that the vast majority of morbidity (and parental work loss) is caused by a "common cold" virus for which there is no vaccine and no specific treatment [5].

Our data show that while seasonal influenza is a significant contributor (9.0% of cases) and causes a sharp winter peak, its overall burden is less than that of Rhinovirus or Adenovirus. This does not diminish the importance of flu vaccination—our risk factor analysis (Table 1) showed that unvaccinated children had a 21% higher risk of AAI, and flu often leads to more severe complications.

The most alarming finding was the detection of measles and varicella, both highly contagious airborne VPDs. Their emergence, even in small numbers, within a high-transmission setting like a daycare is a critical public health failure [6]. It underscores the threat posed by vaccine hesitancy and the necessity of strict vaccine mandate enforcement at childcare entry.

The identified risk factors provide actionable targets for prevention [7]. The strong association with larger class size (RR: 1.45) suggests that public health policies aimed at reducing class density or improving staff-to-child ratios could have a direct impact on reducing infection transmission.

Limitations This study was conducted in one urban region, which may limit generalizability. Active surveillance, while robust, may still have missed very mild or asymptomatic infections. The RT-PCR panel detects pathogen nucleic acid, which may not always equate to active, viable infection, though detection in symptomatic children strongly implies causation.

CONCLUSION

Preschool children in organized childcare face a high, year-round, polymicrobial burden of acute airborne infections, with Rhinovirus being the single most common etiological agent. Public health strategies must therefore be multi-pronged. They must continue to target vaccine-preventable diseases (Influenza, MMR, Varicella) through rigorous vaccination promotion. Simultaneously, to combat the dominant, non-vaccine-preventable pathogens, non-pharmaceutical interventions such as enhancing ventilation, promoting hand hygiene, cohorting children into smaller groups, and enforcing strict stay-at-home-when-sick policies are essential.

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