

Social Segregation Cut Down the Prevalence of Acute Otitis Media in Children : Time-series Analyses From Non-pandemic and COVID-19 Period

Huiqian Yu

Fudan University Eye Ear Nose and Throat Hospital

Dantong Gu

Fudan University Eye Ear Nose and Throat Hospital

Huawei Li

Fudan University Eye Ear Nose and Throat Hospital

Qingzhong Li (✉ liqingzhong2000@163.com)

Fudan University Eye Ear Nose and Throat Hospital <https://orcid.org/0000-0002-7626-3929>

Research

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Abstract

Background: Preventing or reducing the attacks of acute otitis media (AOM) is a major worldwide healthcare problem in children. It is therefore urgent to evaluate the additional, unintended benefits of social segregation in cutting down the prevalence of AOM in children of various ages, especially during coronavirus disease 2019 (COVID-19) periods.

Methods: Children aged from 6 months to 12 years who suffer from AOM and attended the outpatient clinic of tertiary hospital in the Eye Ear Nose Throat Hospital Affiliated to Fudan University in Shanghai were investigated from January 2015 to December 2020. The change in daily outpatient attendance for AOM and time-series analyses were estimated following both non-pandemic and COVID-19 period, and age and gender were taken into account.

Results: 24543 outpatients (male:13529, female:11014) were enrolled in this clinic population. The epidemic trend of AOM in 2015-2019 was characterized by seasonal fluctuations, with a higher incidence in December and January but relatively lower outpatient records in winter and summer vacations (February, June and August). There was an estimated 63.6% (54.32%-70.36%) reduction in the daily outpatient attendance of AOM associated with the introduction of social segregation in COVID-19 period. When age was taken into account, children aged 4-6 who are in kindergarten were more vulnerable to AOM (66.2%), especially during the school period. Meanwhile, the outpatient attendance of AOM in preschoolers (before the age of three) was mainly in autumn and winter, with no significant relationship with semester change. And age structure of AOM in COVID-19 period broadly in line with that in non-pandemic period.

Conclusions: Data from non-pandemic and COVID-19 periods indicated that AOM might spread into susceptible populations by close contact, and social segregation could effectively reduce the likelihood of catching AOM. In tandem with broader consequences, certain interpersonal distance, mask effects and good hand hygiene can significantly reduce the incidence of AOM, which provides a preventive and therapeutic point of view for AOM.

Contributions To The Literature

- To our knowledge, it is the first report focusing on the additional, unintended benefits of social isolation in cutting down the prevalence of AOM in children, which underscores the role of non-pharmaceutical interventions and reductions of direct person-to-person contact and provides a preventive and therapeutic point of view for AOM.
- In the non-pandemic time-series analyses, the epidemic trend of AOM was characterized by seasonal fluctuations, with a higher incidence in December and January but relatively lower outpatient records in winter and summer vacations.
- Daily outpatient attendance of AOM declined by around two-thirds in COVID-19 period compared with the previous 5 years, but age structure of AOM in COVID-19 period broadly in line with that in non-pandemic period.
- Importantly, the incidence of AOM didn't simply increase or decrease with age, and children aged 4-6 who are in kindergarten were more vulnerable to AOM, especially during the school period.

1. Introduction

Acute otitis media (AOM) is a major worldwide healthcare problem in children, and more than 80% of children developed AOM more than once before 3 years old¹⁻⁴. WHO estimates that AOM induces a series of complications and sequelae, such as chronic suppurative otitis, which is a major cause of hearing loss in many developing countries^{5,6}.

AOM presents with acute symptoms (less than 48 hours), such as ear pain or erythema, associated with mild bulging of the tympanic membrane. Young children are at increasing risk of AOM, attributing to the immature morphological structure of the eustachian tube, naive immune function, and especially, high incidence of upper respiratory infection⁷⁻⁹. Epidemiological evidence indicates that respiratory tract infection is the most important risk factor for AOM in children. The prevalence of AOM in children with respiratory infections usually ranges from 10–50%^{3,10,11}. It was corroborated that individual and social isolation in the coronavirus disease 2019 (COVID-19) pandemic period strictly hindered acute upper respiratory infections^{12,13}. However, it is not clear that the prevalence of AOM descends by similar amounts, especially in children.

Therefore, in this study, we aimed to evaluate the prevalence of AOM in the Non-pandemic & COVID-19 Pandemic Period (2014–2020) and to explore additional, unintended benefits of social isolation, especially pandemic-related restriction on the natural history of AOM in children.

2. Materials And Methods

2.1 Participants

Daily AOM outpatient records from January 2015 to December 2020 were validated and acquired from the Eye Ear Nose Throat Hospital Affiliated to Fudan University in Shanghai. The change in daily outpatient attendance for AOM and time-series analyses were estimated following both non-pandemic and COVID-19 period.

Patients aging from 6 months to 12 years with a history of rapid onset (less than 48 hours), presence of middle ear effusion, signs of middle ear infection were included in our study. Recurrent AOM was also included in our study. Electro-otoscopic evidence of eardrum perforation, tympanosclerosis, or cholesteatoma was excluded. And chronic otitis media with effusion was also excluded in this study.

All children underwent electro-otoscopy after removing earwax, pure tone audiometry and tympanometry were examined if necessary. The main demographic data and date of hospital visits were recorded in our study. Patients were divided into three groups by age with cut-off values 3 and 7.

All procedures in studies were in accordance with the ethical standards of the World Medical Association's Declaration of Helsinki and its later amendments or comparable ethical standards. The study was approved by the Ethical Committee of the Eye and ENT Hospital of Fudan University. And informed consent was obtained from the children's parents or guardians involved in the study.

2.2 Statistical Analysis

Perform descriptive statistics on the occurrence of adverse reactions. Quantitative data will be described by mean \pm standard deviation, or median (interquartile range), qualitative data are described by frequency and frequency. Analyses of Variance (ANOVA) were used to determine the significance of differences among groups on sex and age. All analyses were performed using R. The significance level was set as $p < 0.05$.

3. Results

3.1 Characteristics of patients

The main demographic data and clinical characteristics of the outpatients are summarized in Table 1. A total of 24543 AOM cases were included in the study. A higher prevalence of males (55%, $n = 13529$) than females (45%, $n = 11014$) was observed, with no statistical differences. We recruited 3 typical groups depending on the ages and different school stages, named by preschoolers (age 3 and younger than age 3), children in kindergarten (aged from 4 to 6 years) and primary school students (aged from 7 to 12). The highest hospital visiting rates were found in the children in kindergarten (66.2%), followed by primary school students (26.2%); lower rates were found in the preschoolers (7.6%). The clear age effect was observed every year from 2014 to 2020 (Fig. 1).

Table 1
Characteristics of the study participants

		2015 (n = 3343)	2016 (n = 4063)	2017 (n = 4737)	2018 (n = 5055)	2019 (n = 5679)	2020 (n = 1666)	Overall (n = 24543)	p
Sex [N (%)]	Male	1878 (56.2)	2217 (54.6)	2611 (55.1)	2808 (55.5)	3110 (54.8)	905 (54.3)	13529 (55.1)	0.683
	Female	1465 (43.8)	1846 (45.4)	2126 (44.9)	2247 (44.5)	2569 (45.2)	761 (45.7)	11014 (44.9)	
Age [N (%)]	≤3	281 (8.4)	291 (7.2)	378 (8.0)	401 (7.9)	392 (6.9)	123 (7.4)	1866 (7.6)	< 0.001
	4–6	2145 (64.2)	2752 (67.7)	3173 (67.0)	3390 (67.1)	3699 (65.1)	1077 (64.6)	16236 (66.2)	
	≥ 7	917 (27.4)	1020 (25.1)	1186 (25.0)	1264 (25.0)	1588 (28.0)	466 (28.0)	6441 (26.2)	

3.2 Monthly epidemic trend of AOM outpatients in Non-pandemic & COVID-19 Pandemic Period (2014–2020)

Generally, the epidemic trend of AOM outpatients in 2014–2019 was basically the same with seasonal fluctuations. In terms of months, the outpatient rate of AOM was higher in November, December, and January; while AOM outpatient records were relatively lower in February, June and August (Fig. 1, Fig. 2).

Social Segregation of COVID-19 caused a dramatic decline in AOM outpatient attendance (63.6%, 95%CI, 54.32%-70.36%). The number of AOM outpatient monthly visits sustained lower in 2020, especially after January. The greatest reductions were seen in May, which reduced by 90%. Since October, the epidemic trend of AOM outpatients began to rise slowly (Fig. 1, Fig. 2).

The main events and daily epidemic trend of AOM outpatients in the COVID-19 pandemic period was showed in Fig. 3. Chinese government enforced a lockdown in Wuhan in late January, and WHO declared the outbreak of novel coronavirus a Public Health Emergency of International Concern shortly afterward. After that, the number of outpatients plummeted, significantly lower than the average level throughout the year.

3.3 Age-dependent analysis of AOM epidemiological trends in 2014–2020.

Our survey found that children aged from 4 to 6 years account for more than half of the AOM cases. The average AOM epidemic trend during 2014 to 2020 for different age groups was illustrated (Fig. 4). There was a significant difference of AOM occurrences in different seasons among different ages ($p \leq 0.01$). For children less than 3 years old, autumn and winter (September, October, November, December) were the seasons of high AOM occurrences. For children in kindergarten aged 4–6 years, they should be cautious of suffering from AOM throughout the year except February, July, and August. The seasonal or monthly AOM epidemic trends became less pronounced for primary school students (aged from 7 to 12) although it slightly fluctuated in winter.

The age distribution of AOM was not affected significantly by the epidemic situation in 2020. In the COVID-19 pandemic period, the seasonal effect of AOM was similar in preschoolers and children in kindergarten, with remarkable increases in autumn and winter. Meanwhile, the number of AOM outpatients in primary school students gradually went up since May.

4. Discussion

The prevention and treatment of AOM is one of the top priorities in our clinic. Recent studies revealed that viral infection of the respiratory tract, attendance of day-care centers and exposures to smoke have increased the likelihood of developing AOM⁴. It was reported that a lower incidence of otitis media with effusion was found in Italy, followed by restrictive anti-contagion measures^{14,15}. In relative terms, there is a higher overall incidence of AOM and it is more closely related with respiratory tract infection in children, such as COVID-19. So far, few studies focus on additional assessment of the effects of social distancing on the incidence of AOM. We thus attempt to investigate the impact of activities parallel to daily living, including the COVID-19 lockdown, on the number of admissions for ENT-related AOM at a large pediatric ENT emergency department, located in Shanghai, China, from 2015 to 2020.

First, seasonality, along with climate change in the area is recognized as an important factor in the incidence of AOM¹⁶. In agreement with previous studies, seasonal fluctuation in the prevalence of AOM was observed in 2014–2019, with a peak in winter and a nadir in the summer. This may be related to the high incidence of upper respiratory tract infections in autumn and winter¹⁷. In autumn and winter, the influenza virus leads to a significant increase in upper respiratory tract infections and therefore results in a high incidence of AOM^{16–18}.

Second, fewer outdoor social activities for children play a critical role in reducing the incidence of AOM in autumn and winter. It is worth noting that AOM prevalence dropped sharply (less than 300 children) in February every year from 2015 to 2019. Seasonally adjusted, the significant reduction of social gathering among children results in a lower prevalence of AOM in winter holidays (usually in February). The summer holidays (July and August) indicate another period of low AOM incidence, possibly due to higher temperature and relative social isolation on holiday.

In addition, social distancing, mask effects and good hand hygiene account for the decrease in the prevalence of AOM. A nationwide lockdown was imposed by the Chinese government in 2020 to prevent the spread of COVID-19. The compliance with hygienic-behavioral rules and restriction of unnecessary interpersonal contacts contributed to controlling the spread of diseases related to upper respiratory tract infection, besides COVID-19^{19–21}. Social segregation, due to the outbreak of COVID-19, also caused a dramatic decline of AOM outpatient attendance, especially from February to August, when kindergartens and primary schools closed for home-based online teaching. After September, we have resumed our normal social and teaching activities in China, and the incidence of AOM increased significantly compared with the previous few months. But generally, the AOM outpatient attendance has dropped by more than 50% compared with that in the same period of previous years. It suggests that isolation effects caused by wearing masks could avoid or slow the spread of disease to some extent, which contributed to the major reduction of AOM cases.

Furthermore, this research also allowed analysis into AOM prevalence across different age groups, and found that children aged from 4 to 6 years had the highest incidence of the disease. Importantly, the incidence of AOM didn't simply increase or decrease with age, and was involved in social and demographic factors. It was families that children spent most of their time with before 3 years old. Children aged 4–6 started school life gradually, along with more crowd gathering activities, and thus the AOM prevalence increased greatly. After age 7, children are less likely to get AOM, indicating changes in the fully-grown morphological structure of the eustachian tube and progressive maturation of the immune system^{22–24}. Seasonal variations of AOM prevalence in children at different ages were also diverse. Even during non-epidemic periods, the incidence of AOM in school-age children was closely related to the semesters, which decreased significantly in winter and summer vacation. Therefore, there was a positive effect of social isolation on the AOM prevalence for school-age children. On the other hand, the incidence of AOM in preschoolers was more correlated with season variations, but not semesters.

Despite the importance of social segregation in preventing AOM prevalence, there are still several limitations in our study. For convenience, narratives are constructed from limited data in a single audiologic center. Importantly, our study is a retrospective and hospital-based analysis so possible bias and confounding may exist when some patients postponed or refused to go to the hospital due to the initial outbreak of COVID-19.

5. Conclusion

Based on our study, we presume that the influencing factors of AOM prevalence are mainly: interpersonal distance, mask effects, seasonal variation, age factors, etc. Social segregation could effectively reduce the likelihood of catching AOM since data from the comparison between non-pandemic and COVID-19 periods indicated that AOM might spread into susceptible population by close contact. Importantly, lower AOM attack rates during social segregation underscores the role of non-pharmaceutical interventions and reductions of direct person-to-person contact, which provides a preventive and therapeutic point of view for AOM.

To our knowledge, it is the first report focusing on the effects of social isolation on AOM prevalence in children from both non-pandemic and COVID-19 period. The present study highlighted that there was a lower prevalence of AOM among the pediatric patients during both vacations of non-pandemic period and rigorous social segregation of COVID-19 period. The phenomenon of AOM periodic fluctuation in this study suggested that good classroom ventilation, hand hygiene education and isolation with upper respiratory tract infection could reduce the incidence of AOM and its cross-infection in schools. It should be emphasized, AOM epidemic trends peak in spring only in school-age children, which has a notable difference from other children and requires in-depth research on the reasons.

A rigorous prospective, population-based study are needed to identify whether keeping interpersonal distance and wearing masks could be a viable alternative in the treatment of AOM in children, especially during the epidemic of upper respiratory tract infection. And further investigation is also need to explore the role of influenza virus in the epidemic trends of AOM in the children of different age.

Abbreviations

Acute otitis media (AOM); Coronavirus disease 2019 (COVID-19)

Declarations

- Ethical Approval and Consent to participate

All procedures in studies were in accordance with the ethical standards of the World Medical Association's Declaration of Helsinki and its later amendments or comparable ethical standards. The study was approved by the Ethical Committee of the Eye and ENT Hospital of Fudan University. And informed consent was obtained from the children's parents or guardians involved in the study.

- Consent for publication

Not applicable.

- Availability of supporting data

It was not publicly available. Data are however available from the authors upon reasonable request and with permission of affiliated Eye and ENT Hospital of Fudan University.

- Competing interests

The authors have no funding, financial relationships, or conflicts of interest to disclose.

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- Authors' contributions

Qingzhong Li and Huawei Li conceived and designed the study. Qingzhong Li supervised the data analysis. Huiqian Yu and Dantong Gu contributed to the interpretation of data and provided input on the manuscript. All authors read and approved the final manuscript.

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Figures

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	407	158	215	320	297	203	109	135	202	273	397	627
2016	447	176	387	340	278	196	145	161	229	358	614	732
2017	570	199	466	488	410	254	152	170	183	317	652	876
2018	665	237	386	392	382	328	247	150	268	417	599	984
2019	918	250	465	520	463	324	198	173	262	385	639	1,082
2020	657	49	31	24	18	41	50	68	74	96	217	341

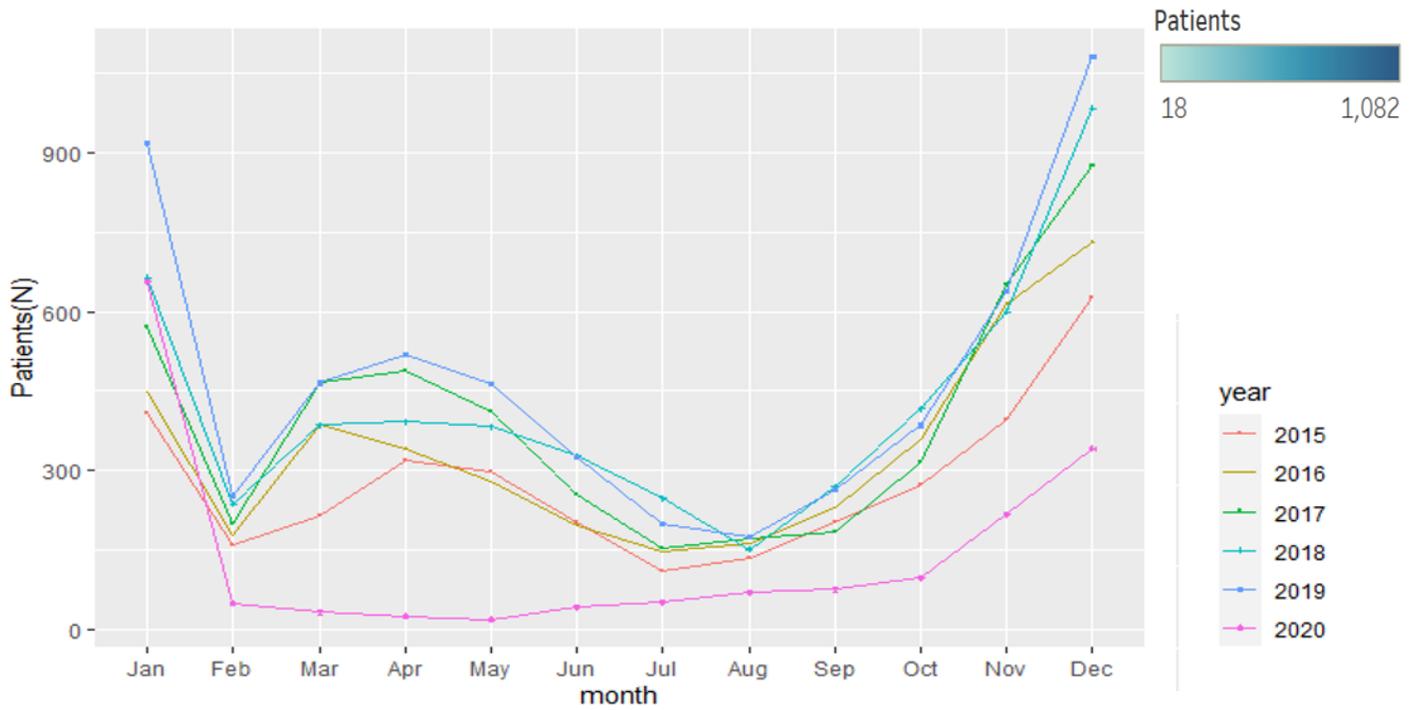


Figure 1

Number of AOM outpatients per month in 2014-2020.

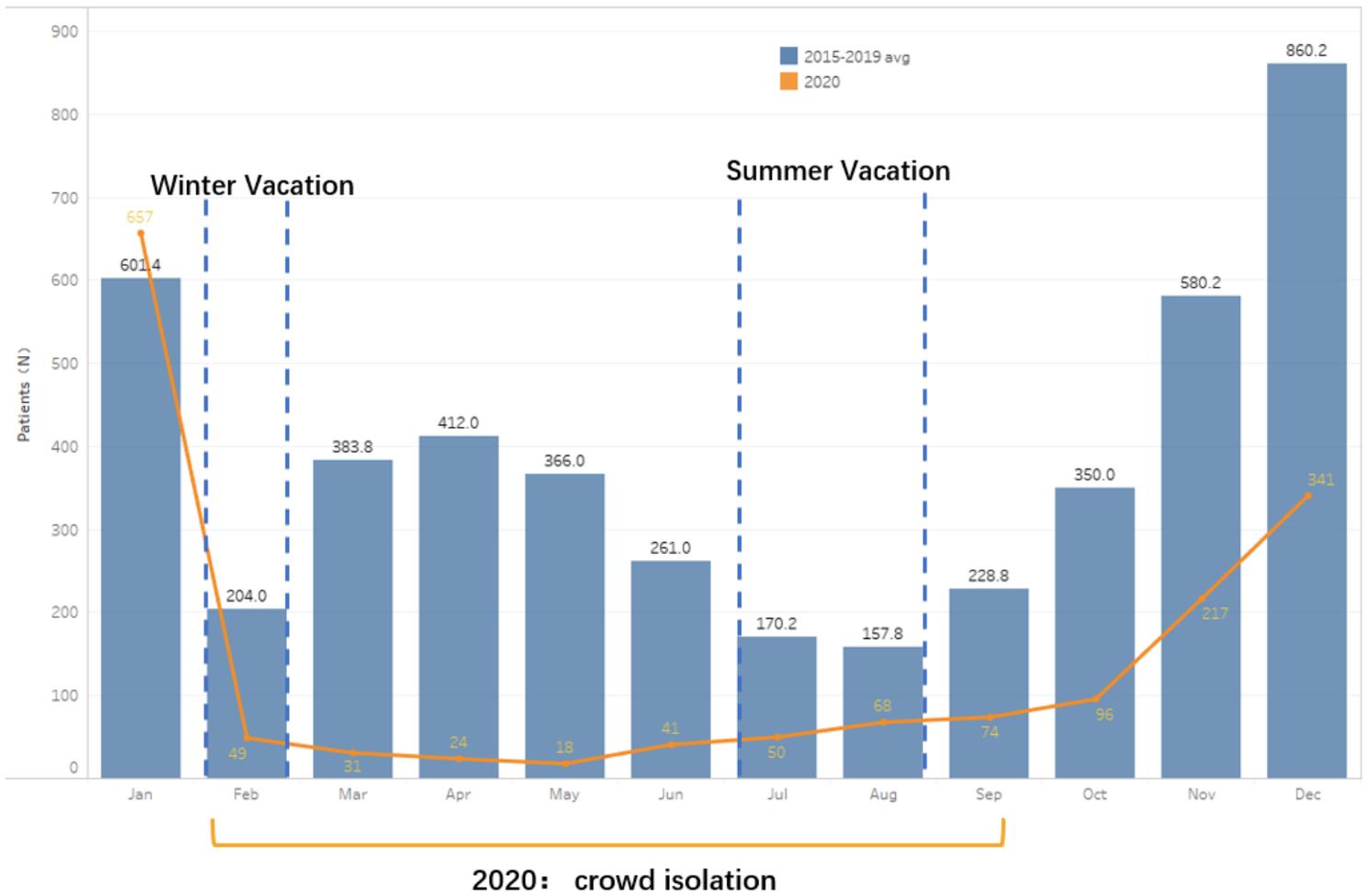


Figure 2

Number of AOM outpatients monthly in Non-pandemic & COVID-19 Pandemic Period (2014-2020).

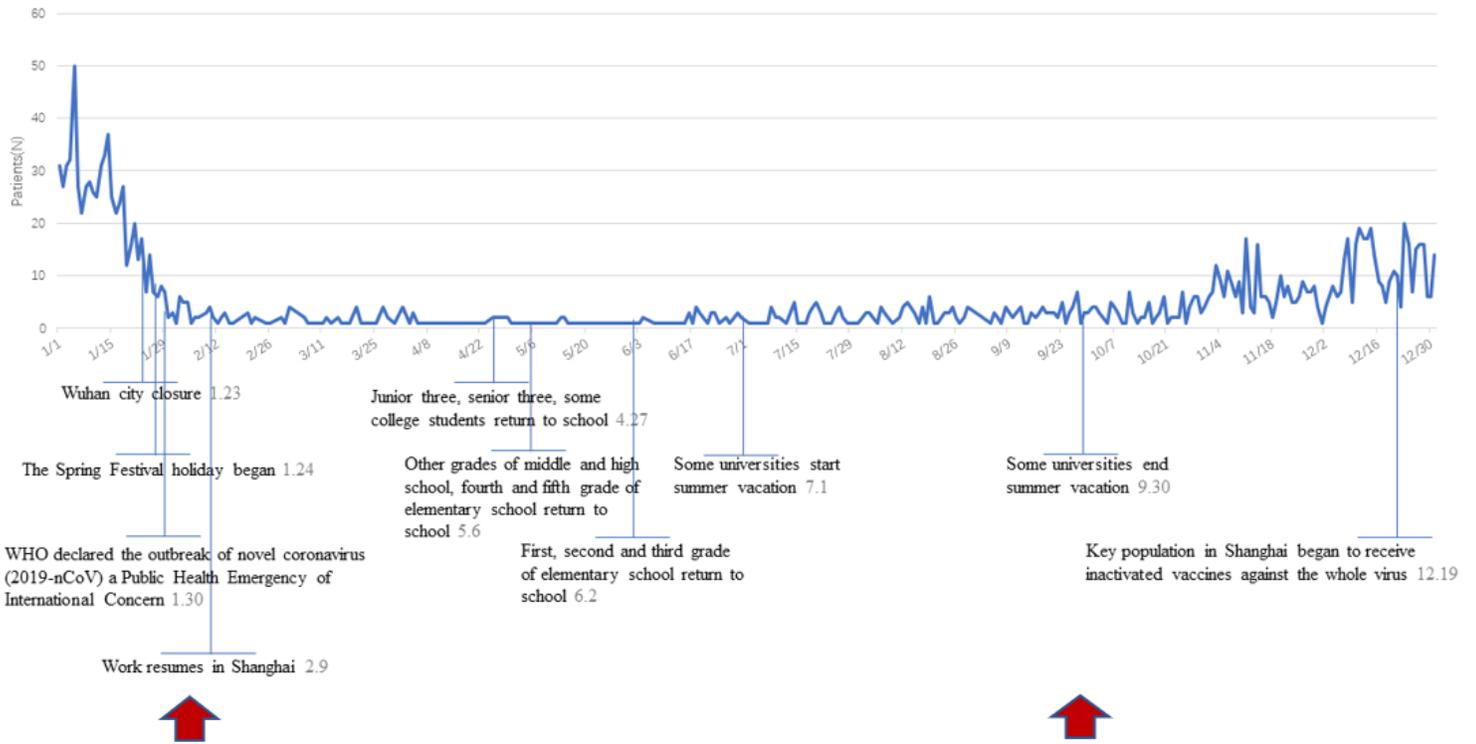


Figure 3

Daily AOM outpatients following time series chart of COVID-19 events.

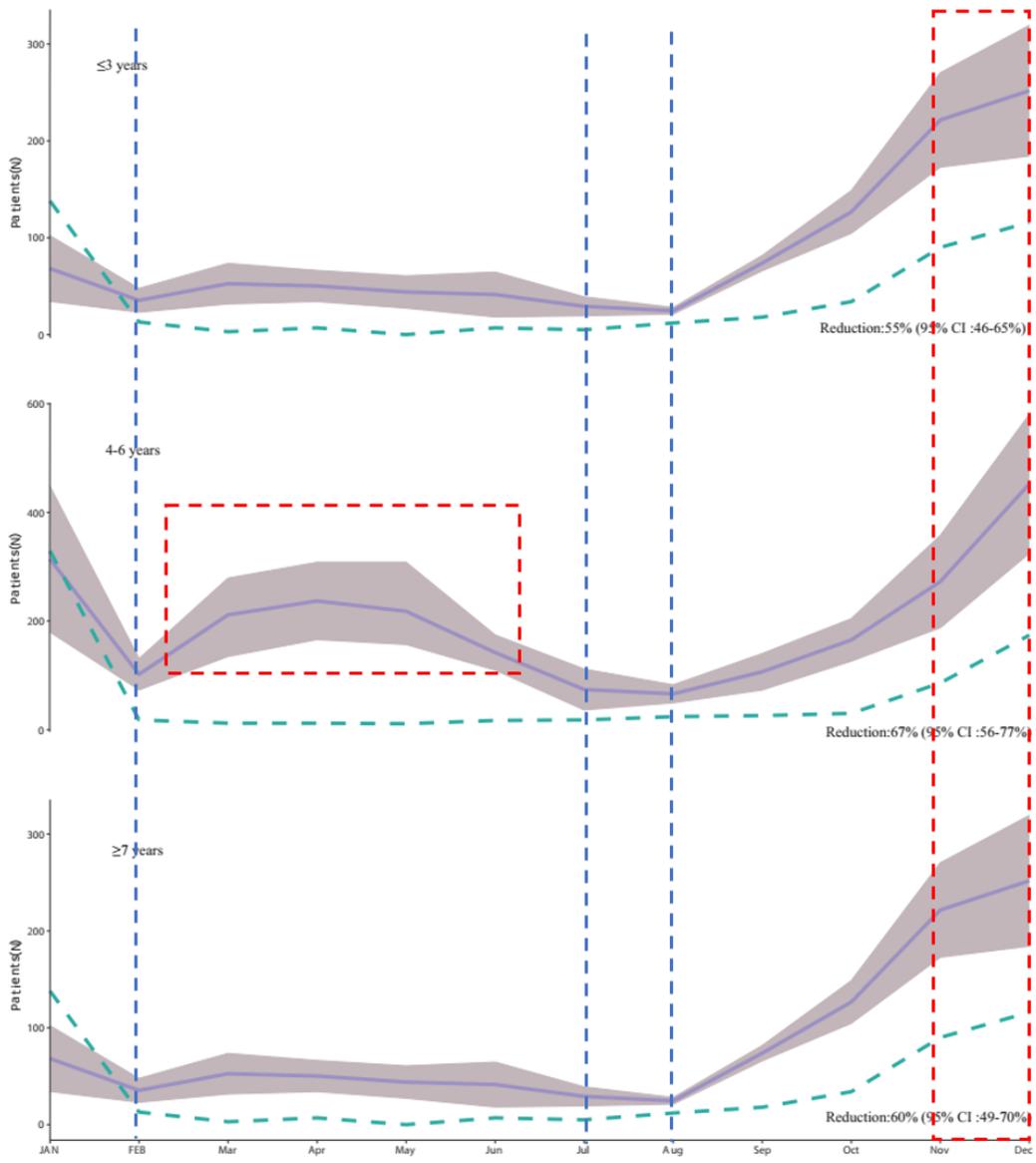


Figure 4

Age-dependent analysis of AOM epidemiological trends in 2014 – 2020. The higher outpatient rates of AOM were marked in red line; while lower AOM outpatient records were marked in blue line.