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Does social distancing impact pediatric upper airway infections? An observational controlled study and a brief literature review

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A R T I C L E I N F O

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A B S T R A C T

Purpose: SARS-CoV-2 pandemic has reduced social interaction even among children. The objective of the study was to assess the role of social distancing in the course of common pediatric upper airway recurrent diseases.
Materials and methods: Patients aged ≤14 years with at least one ENT-related clinical condition were retrospectively recruited. All patients had two outpatient evaluations in the same period (April – September): the control group had the first evaluation in 2018 and second in 2019, whereas the case group had the first evaluation in 2019 and second in 2020. Patients of each group were individually compared between their two visits and deemed improved/unchanged/worsened for each specific ENT condition. The percentage of children improved/unchanged/worsened were then collectively compared between the two groups for each condition.
Results: Patients who experienced social distancing presented a significantly higher improvement rate than controls for recurrent acute otitis media episodes (35.1 % vs. 10.8 %; Fisher's exact test $p = 0.033$) and for tympanogram type (54.5 % vs. 11.1 %, Fisher's exact test $p = 0.009$).
Conclusions: The anti-contagion social restrictions decreased the prevalence of middle ear infections and effusion in children. Further studies on larger cohorts are required to better elucidate these findings.

1. Introduction

The SARS-CoV-2 pandemic has dramatically changed the paradigm of social contacts even among children, due to a prolonged interruption of school and recreational activities. In Italy, schools were closed from March to September 2020, and a strict social isolation policy was adopted. For children this meant less possibility of interaction with each other and probably a decreased likelihood of being infected by community-acquired respiratory pathogens. Consistently, a series of observations regarding reduction in hospital accesses for *acute* upper respiratory infections during this period appeared in the recent literature [1–3]. However, the effect of school closure and reduced social interaction on *recurrent* upper respiratory infections, including pharyngo-tonsillitis, otitis media (OM), and rhinosinusitis, has not yet been extensively studied.

It has been assumed that frequent close contact with other children may lead to community-acquired acute infections of the upper respiratory tract, which are likely to support adeno-tonsillar hypertrophy [4]. Although there is no common agreement in the literature on a causative relationship between recurrent acute OM and day-care attendance, some studies depicted it as a major risk factor [5,6]. According to the Italian Society of Pediatrics instead, the indication of reducing day-care attendance in order to lower the incidence of OM is considered a weak positive recommendation [7]. However, it is still unknown if the clinical

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improvement in children may be due to seasonality in the circulation of most respiratory viruses or to the reduced school attendance, with subsequent limited exposure to potential community-acquired respiratory infections [8]. Regarding pediatric recurrent pharyngo-tonsillitis, acute OM and rhinosinusitis, a comparison is still lacking between their natural course in ordinary conditions and during a period of long-lasting limited social interactions.

The aim of this study was to assess the natural course of pediatric upper airway recurrent diseases in a cohort of patients experiencing the effects of the lockdown during the SARS-CoV-2 pandemic. Additionally, this cohort was compared to a previous historical one, which did not experience any limitation on social interactions.

2. Material and methods

2.1. Patients

This is an explorative observational, retrospective, controlled investigation that included pediatric outpatients referred for upper airway tract infections to the Pediatric ENT outpatient center of the Otolaryngology section, University Hospital of Padova. Patients were evaluated by two otolaryngologists sharing homogenous evaluation and treatment protocols during the study period.

Two different groups of patients were identified. The first group (lockdown group, $n = 37$) experienced the limitations in social interaction during the early phase of the SARS-CoV-2 pandemic, as did the whole Italian population, according to the Italian government laws for pandemic control. Such restrictions resulted in school closures from March to September 2020 and ban of gathering situations. The control group ($n = 40$) consisted of an historical cohort of patients, which had not experienced any social restrictions.

The inclusion criteria for the lockdown group were i) first outpatient clinic evaluation between April 1st and September 30th 2019, ii) re-evaluation for clinical follow-up between April 1st and September 30th 2020. For control group, the inclusion criteria were i) first outpatient clinic evaluation in the period between April 1st and September 30th 2018, ii) re-evaluation for clinical follow-up between April 1st and September 30th 2019. Moreover, both groups were required to show at least one of the following clinical features: i) tonsil and adenoid hypertrophy, history of recurrent pharyngo-tonsillitis, OM, rhinosinusitis, middle ear effusion, neck lymph node hyperplasia, history of oral breathing, snoring or sleep apnea, and ii) age ≤14 years. Exclusion criteria were i) adenoidectomy or tonsillectomy performed after the first outpatient evaluation, ii) diagnosis of allergy; iii) concomitant syndromic conditions, iv) concomitant neoplastic diseases.

Anamnestic and clinical data were retrieved from pediatric outpatient charts, including history of recurrent pharyngo-tonsillitis (defined as five or more episodes of tonsillitis in a year, episodes that are disabling and prevent normal activities, symptoms persisting for at least 1 year) [9], recurrent acute OM (defined as ≥3 episodes in a 6-month interval, or ≥4 in 12 months) [10] or recurrent rhinosinusitis (defined as acute bacterial rhinosinusitis occurring ≥4 times in a 12-month period, with a relative paucity of sinusitis symptoms at baseline between episodes) [11], history of apnea events during sleeping, history of oral breathing or snoring. Tympanogram examination was performed in the case of otological symptoms.

This study was conducted in accordance with the principles of the Helsinki Declaration. Data were examined in compliance with Italian privacy and sensitive data laws and the in-house rules of Padova University's Otolaryngology Section. The parents of all patients signed a consent form for disclosure of privacy in managing personal data for clinical and scientific purposes.

2.2. Statistical analysis

The distribution of quantitative variables is reported as mean and standard deviation (SD), or median and interquartile range (IQR). Each sign or symptom was categorized as present/absent and the change between baseline and follow-up classified as *improved*, *unchanged*, or *worsened*. Regarding tympanogram examination, variations from tympanogram type B/C into type A or from type B into type C were considered as *improved*; variations from tympanogram type A into type B/C or from type C into B were considered as *worsened*. Symptom prevalence was defined as the percentage of children with specific symptom over the total of patients and 95 % confidence interval (CI) was calculated using the Clopper-Pearson method for symptoms and with Goodman method for tympanogram [12]. The change between baseline and follow-up was compared between groups with Fisher's exact test and the difference between groups for improvement was estimated with 95 % unconditional CI. A p value <0.05 was considered statistically significant. The statistical analyses were performed with SAS 9.4 for Windows (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. Study population

Seventy-seven children (48 males [62.3 %]) with a median age at first evaluation of 55.0 months (IQR 37.0–78.0 months) were enrolled in the study, with an overall median follow-up time of 364 days (IQR 327–394 days). Thirty-seven patients met the inclusion criteria to be enrolled in the lockdown group, and 40 entered the control group. No differences for gender, age, and follow-up time were observed for patients in the two groups (Table I). Symptoms prevalence and relative confidence intervals have been reported at first evaluation and follow-up control for each group in Table II.

3.2. Effect of social distancing on upper airways infection

The comparison between the lockdown and control groups for each of the considered clinical variables has been summarized in Table III. Results are presented as improvement/worsening/unchanged percentages. Patients who experienced social distancing presented a significantly higher improvement rate than controls for recurrent acute OM episodes (35.1 % vs. 10.8 %; Fisher's exact test $p = 0.033$) and tympanogram type (54.5 % vs. 11.1 %, Fisher's exact test $p = 0.009$). No other statistically significant differences were observed between study and control groups.

4. Discussion

Several factors come into play in the development of acute upper airway infections in children: unfavorable anatomy, absence of nose blowing, day care attendance, allergy, immature immune system, low socio-economic status, gastro-esophageal reflux and tobacco smoke

Table I
Demographic characteristics and follow-up time between the first and second ENT evaluation for patients in the control and lockdown group.

	Control group (N = 40)	Lockdown group (N = 37)	*p value*
Sex			0.331[a]
Female	13 (32.5 %)	16 (43.2 %)	
Male	27 (67.5 %)	21 (56.8 %)	
Age at first contact (months)			0.516[b]
Mean (SD)	62.0 (32.3)	59.5 (36.4)	
Median (IQR)	57.0 (45.0–67.0)	46.0 (31.0–83.0)	
Follow-up time (days)			0.592[b]
Mean (SD)	356 (60)	369 (77)	
Median (IQR)	363 (331–341)	366 (327–297)	

[a] Chi-squared test.
[b] Wilcoxon rank-sum test.

Table II
Prevalence of symptoms and recurrent upper airway tract infections for cases and controls.

Characteristics	Control group (N = 40)				Lockdown group (N = 37)			
	First evaluation		Follow-up		First evaluation		Follow-up	
	No. of patients	Prevalence, % (95%CI)*	No. of patients	Prevalence, % (95%CI)*	No. of patients	Prevalence, % (95%CI)*	No. of patients	Prevalence, % (95%CI)*
Recurrent pharyngo-tonsillitis								
No	31	79.5 (63.5–90.7)	29	85.3 (68.9–95.0)	30	81.1 (64.8–92.0)	32	94.1 (80.3–99.3)
Yes	8	20.5 (9.3–36.5)	5	14.7 (5.0–31.1)	7	18.9 (8.0–35.2)	2	5.9 (0.7–19.7)
Recurrent rhinosinusitis								
No	26	65.0 (48.3–79.4)	28	77.8 (60.8–89.9)	24	72.7 (54.5–86.7)	33	94.3 (80.8–99.3)
Yes	14	35.0 (20.6–51.7)	8	22.2 (10.1–39.2)	9	27.3 (13.3–45.5)	2	5.7 (0.7–19.2)
Recurrent otitis media								
No	27	67.5 (50.9–81.4)	27	73.0 (55.9–86.2)	22	59.5 (42.1–75.2)	34	91.9 (78.1–98.3)
Yes	13	32.5 (18.6–49.1)	10	27.0 (13.8–44.1)	15	40.5 (24.8–57.9)	3	8.1 (1.7–21.9)
Snoring								
No	17	42.5 (27.0–59.1)	25	62.5 (45.8–77.3)	18	48.6 (31.9–65.6)	25	69.4 (51.9–83.7)
Yes	23	57.5 (40.9–73.0)	15	37.5 (22.7–54.2)	19	51.4 (34.4–68.1)	11	30.6 (16.3–48.1)
Oral breathing								
No	18	47.4 (31.0–64.2)	25	65.8 (48.6–80.4)	21	56.8 (39.5–72.9)	26	72.2 (54.8–85.8)
Yes	20	52.6 (35.8–69.0)	13	34.2 (19.6–51.4)	16	43.2 (27.1–60.5)	10	27.8 (14.2–45.2)
Sleep apnea								
No	31	77.5 (61.5–89.2)	36	90.0 (76.3–97.2)	27	75.0 (57.8–87.9)	32	91.4 (76.9–98.2)
Yes	9	22.5 (10.8–38.5)	4	10.0 (2.8–23.7)	9	25.0 (12.1–42.2)	3	8.6 (1.8–23.1)
Tympanogram examination								
Type A	8	30.8 (14.3–51.8)	8	30.8 (14.3–51.8)	8	30.8 (14.3–51.8)	18	78.3 (56.3–92.5)
Type B	11	42.3 (23.4–63.1)	10	38.4 (20.2–59.4)	15	57.7 (26.9–76.6)	4	17.4 (5.0–38.8)
Type C	7	26.9 (11.6–47.8)	8	30.8 (14.3–51.8)	3	11.5 (2.4–30.2)	1	4.3 (1.0–21.9)

[*] 95% CIs were calculated using Clopper-Pearson method.

Table III
Comparative analysis of variations in the clinical condition between cases (lockdown group) and controls.

	Control group (N = 40)	Lockdown group (N = 37)	*p value*[a]
Recurrent pharyngo-tonsillitis			0.709
Worsened	1 (3.0 %)	0	
Unchanged	29 (87.9 %)	29 (85.3 %)	
Improved	3 (09.1 %)	5 (14.7 %)	
Missing	7	3	
Recurrent rhinosinusitis			0.771
Worsened	1 (02.8 %)	1 (03.1 %)	
Unchanged	29 (80.5 %)	23 (71.9 %)	
Improved	6 (16.7 %)	8 (25.0 %)	
Missing	4	5	
Recurrent otitis media			0.033
Worsened	3 (08.1 %)	1 (02.7 %)	
Unchanged	30 (81.1 %)	23 (62.2 %)	
Improved	4 (10.8 %)	13 (35.1 %)	
Missing	3	0	
Snoring			1.000
Worsened	2 (05.0 %)	1 (02.8 %)	
Unchanged	28 (70.0 %)	26 (72.2 %)	
Improved	10 (25.0 %)	9 (25.0 %)	
Missing	0	1	
Oral breathing			0.861
Worsened	2 (05.6 %)	3 (08.3 %)	
Unchanged	26 (72.2 %)	24 (66.7 %)	
Improved	8 (22.2 %)	9 (25.0 %)	
Missing	4	1	
Sleep apnea			0.570
Worsened	35 (87.5 %)	29 (82.9 %)	
Unchanged	5 (12.5 %)	6 (17.1 %)	
Missing	0	2	
Tympanogram examination			0.009
Worsened	3 (16.7 %)	1 (4.5 %)	
Unchanged	13 (72.2 %)	9 (41.0 %)	
Improved	2 (11.1 %)	12 (54.5 %)	
Missing	22	15	

[a] Fisher's exact test.

exposure [13,14]. In younger children, a role for short breastfeeding time and higher number of siblings has also been reported [13]. The specific role of each of these factors in the pathogenesis of the various chronic or recurrent pediatric upper airway diseases is less clear.

SARS-CoV-2 infection containment precautions and the consequent lockdown imposed in some countries have significantly changed daily life habits. Specifically, hygiene precautions have risen, together with the awareness that infective agents can spread via droplets. On the other hand, due to the implementation of restriction measures, social interaction dramatically decreased. In Italy, day care centers and schools remained closed between March and September 2020, and all recreational activities were put on hold. These changes significantly affected the above-mentioned risk factors for upper airway infections in children, providing potential insights about their relative weight in the pathogenesis of each disease. Day care and school attendance risk factors were abolished and potential exposure to domestic environmental pollutants increased. Regarding the number of siblings in a family, some recent studies have suggested that this may represent a risk factor because of a small-scale crowding effect [15], due to the exchange of pathogens. However, it is reasonable to presume a loss of significance of this risk factor during the lockdown period, since every member of the family experienced less social interaction, thus decreasing the potential contact with pathogens [16,17].

This study revealed a significant improvement of recurrent acute OM in the lockdown cohort children in comparison with the control group (10.8 % vs 35.1 %, $p = 0.033$). Similarly, the same cohort also showed a higher improvement rate of the tympanogram (11.1 % vs 54.5 %, $p = 0.009$), which represents an objective measurement of the middle ear status, although these data were available in a limited subset of patients (Table III). These results are supported by a recent investigation conducted on a group of otitis-prone children in Italy during the lockdown period [18]. The authors found a significant reduction in the mean number of acute OM episodes in children per patient/month, between the lockdown period and the same time interval of the year before. Such findings suggest that social interaction, and therefore the exchange of infective agents seemed to be a relevant risk factor in the natural course of recurrent middle ear infection in children. Similarly, a large multicenter study reported a lower incidence of otitis media with effusion during the pandemic period, in comparison with the two previous non pandemic years [19]. In addition, recent studies demonstrated a decrease in Pediatric Emergency Department attendance during the Italian lockdown, which was particularly relevant when diagnoses as middle ear disease, and non-complicated middle ear infection were considered [20]. A similar decreasing incidence of otitis media with effusion during the lockdown period has also been observed by several authors worldwide in the last years [21–24], thus supporting the clinical influence of social distancing and a reduced school attendance especially for young children.

A brief review was conducted on the available literature comparing the upper airways inflammatory rates variation in pediatric patients during pandemic lockdown vs. no restriction periods (Table IV). The main evidence reported by the previous 12 studies were the following:

(i) reduction in the number of AOM and/or OME episodes; (ii) reduction in the number of pharyngotonsillitis cases and consequently in the need for related surgical procedures.

Of note, all the included studies had a retrospective design, most of them with a relevant heterogeneity in the age of enrolled participants.

It is generally considered that viruses, rather than bacteria, are the main pathogens that spread in a children's social community [29], while OM can be caused both by viruses and bacteria. It is possible that the recurrence in OM may be triggered by a viral infection, even when a bacterial infection is assessed. This could be due to the factor that viruses can weaken epithelial antibacterial mechanisms, causing nasopharyngeal bacteria to ascend the Eustachian tube more easily and middle ear [30]. The social contacts reduction experienced during lockdown period could also be responsible for the improvement observed in the Eustachian tube function, as a tympanogram indirectly can assess.

Table IV
Summary of results for rate variation in upper airways disorders in children before and after social restrictions due to pandemic period.

Author	Country	Study design and methodology	Age of patients	Comparative period	Variable	Variation in the pandemic period
Gelardi et al., 2020 [2]	Italy	Telephone contact with symptoms survey	3–13 years	60 days after starting of lockdown (5/3/2020); no comparison	Symptoms related to adeno-tonsillar hypertrophy	Improvement of symptoms during lockdown/social distancing period
Heward et al., 2020 [1]	United Kingdom	Cross-sectional single centre, retrospective. Telephone contact with survey	≤16 years	23/3/2020–17/5/2020 vs 27/1/2020–22/3/2020	Tonsillitis episodes	Reduction of tonsillitis episodes
Aldè et al., 2021 [21]	Italy	Retrospective. Otomicroscopy, tympanometry, pure-tone or behavioral audiometry, ABR (selected cases) threshold ABR.	6 months-12 years	Group A: 1/5/19–30/6/19 Vs 1/1/2020 – Vs 29/2/2020 1/5/2020–30/6/2020 Group B: 1/6/2018–30/8/2018 Vs 1/12/2018–28/2/2019 Vs 1/5/2019–30/6/2019	OME episodes; type B tympanogram	Reduction of OME; Reduction of type B tympanograms
Hullegie et al., 2021 [24]	Nederlands	Retrospective observational cohort study. Electronic health records, GP consultation, telephone consultations	≤12 years	1/3/2019–29/2/2020 Vs 1/3/2020–28/2/2021	AOM episodes; OME episodes; Ear discharge	Reduction of the AOM, OME and ear discharge episodes
Nguyen et al., 2021 [22]	US	Retrospective	≤18 years	1/3/2019–1/7/2019 vs. 1/3/2020–1/7/2020	Intraoperative effusion in OME during tympanostomy	Reduction of intraoperative ear effusion
Torretta et al., 2021 [18]	Italy	Telephone contact	Mean age 41.4 ± 14 months	9/3/2020–17/3/2020 Vs 1/2/2019–30/4/2019	AOM episodes; otorrhea episodes; systemic antibiotic treatments	Reduction of AOM and otorrhea episodes, and number of antibiotic treatments
Allen et al., 2022 [23]	US	Retrospective database review of ICD-10 codes	n.a.	2019 vs. 2020 vs. 2021	AOM episodes	Reduction of the OM episodes in 2020 until June 2021
Allen et al., 2022 [25]	US	Retrospective database review of ICD-10 codes	n.a.	2019 vs. 2020 vs. 2021	Tonsils related diagnosis	Reduction of Adeno-tonsillectomy procedures.
Favoretto et al., 2022 [26]	Brasil	Retrospective cohort study. ICD-10 code from electronic health records in emergency department	≤12 years	1/3/2019–28/2/2020 Vs 1/3/2020–28/2/2021	AOM episodes	Reduction of AOM
Iannella et al., 2022 [20]	Italy	Retrospective, multicentric.	>6 months (adults included)	1/03/2018–01/03/2019 Vs 1/03/2019–1/03/2020 Vs 1/03/2020–1/03/2021	OME episodes; otorrhea episodes	Reduction of OME episodes
Patel et al., 2022 [27]	Canada	Online survey delivered to pediatric otolaryngologists	n.a.	Not specified. Survey delivered 23/4/2021–19/5/2021	AOM episodes; OME episodes; acute mastoiditis; recurrent pharyngotonsillitis episodes; peritonsillar abscess	Reduction of the evaluated conditions
Zloczower et al., 2023 [28]	Israel	Cross-sectional. Electronic health records from insurance company	≤15 years	1/3/2017–29/2/2020 Vs 1/3/2020–28/2/2021 Vs 1/3/2021–28/2/2022	AOM episodes	AOM decreasing during the first COVID year but almost reached pre-pandemic levels during the second year
Present study, 2023	Italy	Retrospective, monocentric.	≤14 years	Case group: 1/4/2019–30/9–2019 Vs 1/4/2020–30/9/2020 Control group: 1/4/2018–30/9/2018 Vs 1/4/2019–30/9/2019	AOM episodes; type B tympanogram; recurrent pharyngo-tonsillitis; recurrent rhinosinusitis	Reduction of AOM episodes and number of type B tympanogram

AOM = acute otitis media; OME = otitis media with effusion; n.a. = not available.

Conversely, we found no significant reduction in the recurrence rate of pharyngo-tonsillitis in our cohort, suggesting that social interaction and recurrent contact with different pathogens, mostly viruses, play a lesser role in this setting. It has been hypothesized that a crucial role in recurrent tonsillitis and adenoid or tonsil hyperplasia can be played by biofilms [31,32]. Bacteria persist on the surface of tonsils and adenoid, protected by the production of biofilms, causing recrudescence of symptoms and disease relapse.

Finally, some limitations and strengths of the study need to be analyzed. First, the retrospective nature of the study invariably led to miss data regarding environmental risk factors for recurrent upper airway infections in children. Second, the small sample size prevented us to perform the best approach with a propensity-score match analysis. Third, the wide age-related inclusion criteria (patients being ≤14 years old) may represent a limitation in interpreting results, as the natural immunity of patients is different according to age. In the presented cohort of patients, we aimed to cover the whole pediatric population that experienced social restrictions. The analyses were conducted on age- and gender-matched groups of patients, being the median age 57 months (45.0–67.0) for controls and 46 months (31.0–83.0) for cases ($p = 0.516$), Table I. On the other hand, chronic conditions (allergy, concomitant neoplastic or syndromic diseases), that may act as confounders, were part of the exclusion criteria. Moreover, all patients were evaluated at the same Institution, by the same ENT specialists, sharing homogenous diagnosis and treatment protocols, that is definitely one of the strengths of the study, limiting treatment biases. Furthermore, our control group was recruited considering the same seasons of the year of the study group.

In order to confirm the present findings, it would be necessary to recruit a larger sample size. Unfortunately, while on one hand the SARS-CoV-2 pandemic provided the chance to perform studies on social distancing, on the other it limited the number of cases available for inclusion, because, in several clinics, pediatric ENT office evaluation for these common diseases were completely interrupted [33]. A multicentric study should be considered in order to obtain more data, but it could possibly bear differences regarding diagnostic and treatment protocols.

5. Conclusions

The present data suggest that in the pediatric age, only OM recurrence and Eustachian tube function have benefitted from a period of limited social interaction due to SARS-CoV-2 pandemic, while other upper airway infections are probably more subjected to other pathogenic mechanisms. Larger cohorts of patients are necessary to confirm these preliminary results and further elucidate the role of each risk factors in each specific pediatric upper airway disease.

CRediT authorship contribution statement

DC, SF: study conception; SP, FM, LF, SM: data collection and manuscript drafting; AF: statistical analysis; NF, DC, SF, PN, GM: manuscript drafting and final revision of the paper. All authors read and approved the final version of the manuscript.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

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