Received: 14 July 2022 | Revised: 28 September 2022 | Accepted: 1 October 2022
DOI: 10.1002/lio2.948

ORIGINAL RESEARCH

Laryngoscope
Investigative Otolaryngology

Epidemiology of pediatric acute mastoiditis in Israel: A National Registry 10-year perspective

Orit Samuel MD[1,2,3,4] | Walid Saliba MD, MPH[2,5] | Nili Stein MPH[5] | Yotam Shiner MD[1,2] | Raanan Cohen-Kerem MD[1,2,5]

[1]Department of Otolaryngology-Head and Neck Surgery, Carmel Medical Center, Haifa, Israel

[2]The Bruce Rappaport Faculty of Medicine, The Technion, Haifa, Israel

[3]Unit of Otoneurology, Lin Medical Center, Haifa, Israel

[4]University of Melbourne, Melbourne, Australia

[5]Department of Community Medicine and Epidemiology, Lady Davis Carmel Medical Center, Haifa, Israel

Correspondence
Orit Samuel, Otolaryngology-Head and Neck Surgery, Carmel Medical Center, 7 Michal street, Haifa, Israel.
Email: orit_bd@hotmail.com

Abstract

Background and Objectives: Previous small studies have proposed a higher incidence of acute mastoiditis in Israeli pediatric patients than in other Western countries. The aim of this study was to describe the incidence of acute mastoiditis and its epidemiological features over a decade, in order to identify variables that could possibly affect the incidence.

Methods: All admitted patients aged <18 years diagnosed with acute mastoiditis between 2008 and 2018 at Clalit Healthcare Services were identified and a database was generated.

Results: A total of 1189 and 1115 patients met the inclusion criteria, respectively. Acute mastoiditis diagnosis was confirmed in 95.2% of the patients. The incidence was 7.78 cases per 100,000 children-years but was significantly higher in children under 2 years of age (average of 38.31 per 100,000 children-years). No specific pattern was observed in the annualized incidence rate during the study period. Acute mastoiditis was significantly more common in children of Jewish descent than non-Jewish (10.4 vs. 3.03 per 100,000 children-years, $P < 0.001$) and of high socioeconomic status and is more common in the winter. The prevalence of household parental smoking (52%) was more than double that previously reported in the Israeli population.

Conclusions: A higher incidence of acute mastoiditis was observed in the Israeli population than in other reports. The age-dependent rate was identified along with unique epidemiological features such as seasonality, higher incidence in patients of Jewish descent, or high socioeconomic status. Related parental smoking habits lend further support against the exposure of young children to household smoking.

Level of evidence: Individual retrospective cohort study.

KEYWORDS
acute mastoiditis, acute otitis media, epidemiology, parental smoking

1 | INTRODUCTION

Acute otitis media (AOM) is the most common localized infection in children under the age of 5 years[1] while acute mastoiditis (AM) is considered the most common intra-temporal complication. Middle ear infection in AOM is presumed to spread via the aditus ad antrum to the mastoid air cells and cause periostitis, bone erosion, or the formation of subperiosteal abscess.[1]

The incidence of AM varies among countries and age groups. In the United States, it is estimated at 1.62 to 1.88 per 100,000 children-years, and has been relatively constant during the years 1997–2006.[2] In other Western countries such as Finland, Canada, and the UK, it ranges from 1.1 to 1.88 per 100,000 children per year. A higher incidence of 2.5/100,000 was found in Sweden, and a rate of 3.5–4.2 per 100,000 in the Netherlands, Norway, and Denmark. These Northern European countries are also known for their low prescription rates of antibiotics for the treatment of AOM.[3–5]

The incidence is higher in Israel. One study has shown an increase from 6.1/100,000 in 1990–2001 to 11.5/100,000 during 2002–2012.[6] In the very young pediatric population, the incidence is presumed to be even higher.[7] The underlying cause for this higher incidence is unknown.

In this study, we aimed to describe the incidence of AM among Israeli pediatric patients between 2008 and 2018 and identify the parameters that could affect the incidence. This may open the gate for further studies and consider changes in the clinical management of otic infections. It can also raise awareness of the influence of social factors such as socioeconomic status (SES), day care attendance, and parental smoking on children's health in general and AM in particular.

2 | PATIENTS AND METHODS

2.1 | Source of data

This study was based on data from the computerized database of Clalit Health Services (CHS), which provides inclusive health care for more than half of the Israeli population (~4,620,000 people). Healthcare coverage in Israel is mandatory according to the National Health Insurance Law (1995) and is provided by four groups akin to not-for-profit health maintenance organizations (HMO). All members of the different HMOs have a similar health insurance plan and access to health services, including very low medication copayment. All Israeli citizens can choose their preferred HMO group and can also move from one to another if they wish to do so, with rejection by the HMO being impossible. The electronic medical record (EMR) database of the CHS includes data from multiple sources such as records of primary care physicians, community specialty clinics, hospitalizations, laboratories, and pharmacies. A registry of chronic disease diagnoses was compiled using these data sources. Diagnoses were captured in the registry using diagnosis-specific algorithms, employing the International Classification of Diseases Ninth revision (ICD-9) code reading, computerized text recognition of diagnoses without an ICD-9 code, laboratory test results, and disease-specific drug usage. A record is kept of the data sources and dates used to establish the diagnosis, with the earliest recorded date from any source considered to be the defining date of diagnosis.

2.2 | Study design

We used the electronic medical records of Clalit Health Services (CHS) to identify all patients insured by CHS under 18 years of age with a primary discharge diagnosis of AM (ICD 9 code:383.00) between 2008 and 2018.

After reviewing the electronic medical records of all patients identified by the study investigators, we included only patients with a confirmed clinical diagnosis of AM associated with otoscopic evidence of AOM on admission or within 4 weeks before admission. AM must be characterized by at least one of the following criteria: retroauricular swelling, retroauricular erythema with or without tenderness, or displacement of the auricle. We also reviewed the supporting evidence achieved by imaging.[8] The researchers used these data to adjudicate the AM cases for this study.

For patients with more than one documented episode, events were counted separately, only if they were discrete.

The study was approved by the Institutional Review Board of the Lady Davis Carmel Medical Center and was conducted in accordance with the Declaration of Helsinki.

2.3 | Data collection

The following demographic data were collected from the CHS medical records: sex, age, ethnicity, and socioeconomic status. Socioeconomic

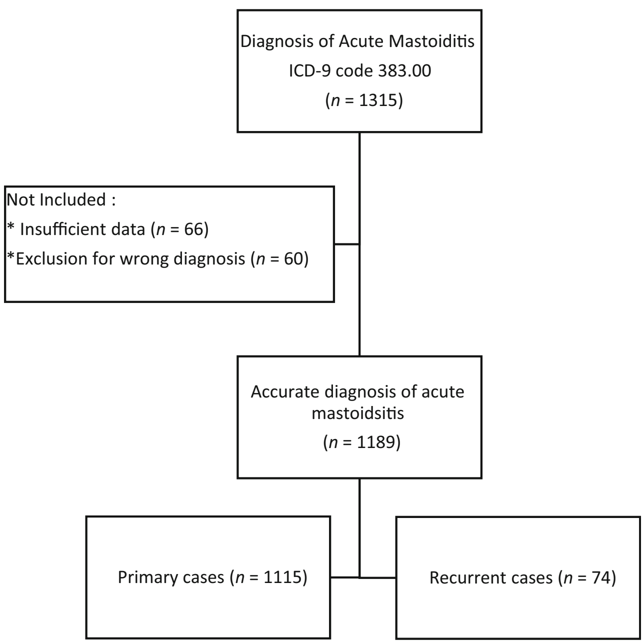

FIGURE 1 Flow chart of study participants and those that were excluded

status (SES) was based on the SES score of the clinic neighborhood, as defined by the Israeli Central Bureau of Statistics. In addition, we retrieved data on selected underlying medical conditions, including craniofacial anomalies (ICD-9 code 744756), immunodeficiency (ICD-9 code 279), and previous otolaryngologic surgery of cochlear implants (ICD-9 codes 20.96, 20.97, 20.98). Data on preceding chronic ear disease, vaccination, day care attendance, and household smoking status were collected by the investigator by reviewing medical files and reading medical reports. Parental smoking status was also retrieved from the HMO chronic illness diagnosis database, as identified from their medical records.

TABLE 1 Characteristics of the participants with validated AM diagnosis ($n = 1189$)

	N
Age (years)	
Mean (SD)	2.71 (2.82)
Median (IQR) [range]	1.56 (1.0–3.5) [0.04–17.82]
Age Group (years)	
0–2	729 (61.3%)
2–18	439 (38.7%)
Gender	
Female	591 (49.71%)
Male	598 (50.29%)
Ethnicity	
Jews	1026 (86.29%)
Non-Jews	163 (13.71%)
Socioeconomic status	
Low	382 (32.13%)
Medium	435 (36.59%)
High	361 (30.36%)
Past medical history	
Cochlear implant	41 (3.4%)
Chronic ear	28 (2.4%)
Craniofacial anom.	4 (0.3%)
Immunodeficiency	5 (0.4%)
Pneumococcal vaccine	
Vaccinated	976 (82.1%)
Not Vaccinated	49 (4.12%)
Unknown	163 (13.7%)
Pre- hospital antibiotic treatment	
Yes	393 (33.1%)
No	427 (35.9%)
Unknown	369 (31.0%)
Day care attendance	
Yes	404 (33.98%)
No	31 (2.61%)
Unknown	754 (63.41%)
Parental Smoking	
Yes	622 (52.3%)
No	567 (47.7%)

2.4 | Statistical analysis

Continuous variables are presented as means with standard deviations (SD) or medians and interquartile ranges (IQR). Categorical variables were presented as numbers and proportions. Comparison of demographic characteristics between the two age groups (≤2 and >2 years) was analyzed using the Chi square test for categorical variables and the independent t-test or Mann–Whitney test, as appropriate, for continuous variables.

Crude and specific incidence rates of mastoiditis per 100,000 individuals in each year and during the entire study period were calculated for the entire study group and for each age group separately. The comparison of the rates among the various groups and the estimation of the 95% confidence interval were computed using Open Epi software.

Statistical analyses were performed using IBM SPSS Statistics 24.0 (IBM, New York, NY, USA). For all analyses, $p < 0.05$ (for the 2-tailed tests) was considered statistically significant.

3 | RESULTS

A total of 1315 files with a primary discharge diagnosis of AM were identified from the CHS database. These files were retrospectively reviewed by the researchers for accuracy of diagnosis and data retrieval (Figure 1). The diagnosis was confirmed in 1189 AM events that occurred in 1115 patients. Data were inaccessible or insufficient for diagnosis verification for 66 patients, and for 60 AM was determined as inaccurate; thus, the positive predictive value of the

TABLE 2 Incidence of acute mastoiditis throughout the study period (2008–2018)

Year	Incidence (per 100,000)		
	Total	Age group < 2 years	Age group ≥ 2 years
2008	6.38	31.35	3.07
2009	8.36	43.13	3.59
2010	7.39	39.91	2.84
2011	8.62	43.25	3.66
2012	7.07	39.68	2.38
2013	6.37	30.24	2.90
2014	7.20	28.24	4.12
2015	9.55	46.78	4.17
2016	9.41	45.80	4.08
2017	7.83	41.45	3.08
2018	7.20	31.57	3.75
Average	7.78	38.31	3.42

diagnosis of AM in this study was 95.2%. Of the included cases, 1115 were primary cases and 74 were recurrent.

The mean (SD) age was 2.71 (2.8) years and 591 (49.71%) were females, further parameters are delineated in Table 1.

Data were incomplete for day care attendance status; this parameter was available for only 435 (36.6%) patients. Pneumococcal vaccine status was unknown in 163 (13.7%) patients, although it is known that approximately 99% of the Israeli pediatric population is vaccinated[9]

The overall crude incidence of AM during the entire study period (2008–2018) was 7.78/100,000 children (Table 2). No specific pattern was observed in the annualized incidence of AM during the study period. The lowest crude incidence was observed in 2013 (6.37/100,000), and the highest in 2015 (9.55/100,000) (Table 2).

The incidence was much higher in children under 2 years of age, as high as 38.31/100,000, compared to 3.42/100,000 for children older than 2 years.

As seen in Table 1, we noted a mentionable past medical and otolaryngological history in some of the patients, including cochlear implants (3.4%), chronic ear disease (2.4%), craniofacial anomalies (0.3%), or immunodeficiency (0.4%).

Table 3 shows the incidence of AM in the different subpopulations according to ethnicity, socioeconomic status, and sex. Jews had a significantly higher incidence of AM than non-Jews in both age groups (Table 3). Socioeconomic status is directly associated with the incidence rate. An increase in the incidence rate was observed with increasing socioeconomic class, ranging from 5.1 cases per 100,000 in the lower class to 15.2 cases per 100,000 in the higher class, with a

TABLE 3 Crude and specific incidence rates of AM per 100,000 children during the entire study period 2008–2018 presented for the entire study population and separately for children with age under 2 years and for children over 2 years

Population	Total ($n = 1189$)	Age <2 years ($n = 729$)	Age >2 years ($n = 460$)
All	7.78	38.33	3.44
Sex			
Males	7.64 (7.1–8.2)	37.9 (34.2–41.9)	3.34 (2.9–3.7)
Females	7.93 (7.4–8.5)	38.9 (35.1–43.0)	3.54 (3.2–3.9)
p-value	0.462	0.718	0.446
Ethnicity			
Jews	10.4 (8.5–12.6)	48.3 (44.1–52.8)	4.36 (3.9–4.8)
Non-Jews	3.03 (2.7–3.4)	13.8 (11.6–16.3)	1.8 (1.06–2.8)
p-value	<0.0001	<0.0001	0.0001
Socioeconomic class			
Low	5.1 (3.8–6.7)	25.6 (22.6–28.9)	2.6 (1.7–3.8)
Medium	8.3 (6.6–10.3)	41.9 (38.0–46.1)	3.5 (2.4–4.9)
High	15.2 (12.3–17.8)	73.3 (68.1–78.8)	6.2 (4.8–7.9)
p-value	a, b	a, b	a, b

Note: a: Significant difference between low SES & high SES. b: Significant difference between medium SES and high SES.

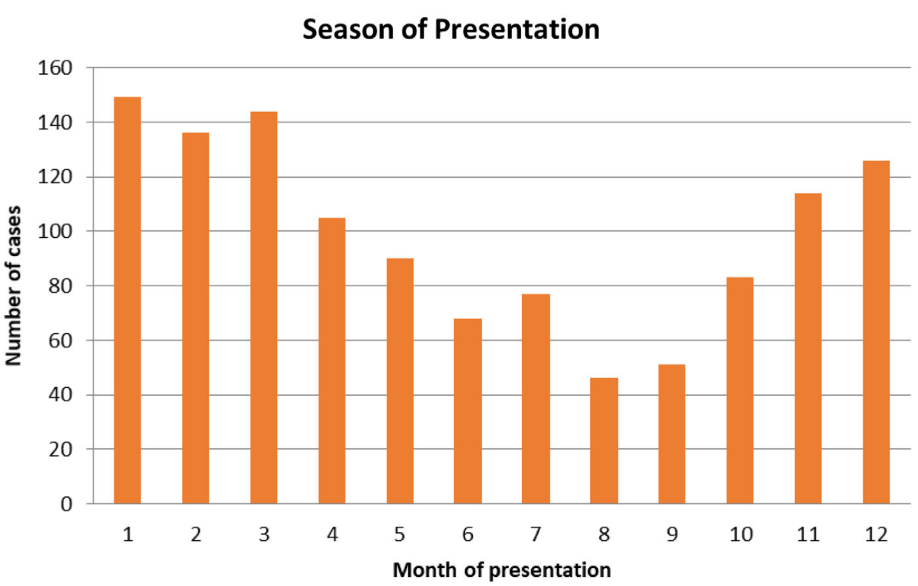

FIGURE 2 Number of cases per month of the year (labeled as month number) throughout the study period

similar pattern in both age groups (Table 3). No significant difference in AM incidence was found between males and females.

As shown in Table 1, our data on antibiotic treatment before hospitalization are limited. Any kind of antibiotic treatment was administered before admission to 33.1% of the children, and 35.9% had a specific note in their record for not getting any while for the rest of the patients (31.0%), this information was missing. We did not find any difference in pre-hospital antibiotic treatment between the Jewish and non-Jewish populations ($p = 0.21$) or between people of different socioeconomic statuses ($p = 0.91$). As this was a retrospective study, we were unable to evaluate whether the prescribed treatment was in fact taken and whether parents adhered to the medical protocol.

The distribution of incident cases of AM by month of presentation is shown in Figure 2. The highest frequency of AM was detected in winter (December–March) and it declined gradually during spring. Summer in Israel is dated from June to September, with the frequency reaching its lowest in August and increasing gradually again in fall season through winter.

4 | DISCUSSION

The incidence of AM in our study population was 7.78 to 100,000 children.

Age <2 years was found to be a strong risk factor for AM, with an incidence rate of 38.33/100,000 in this age group, which is more than 10-fold the incidence rate in children aged >2 years. In the current study, the mean age was 2.71 years (32 months), similar to that in a large French study by Gorphe et al.[3] The incidence of AM was significantly higher in patients with a high socioeconomic status, and household smoking was documented in 52.3% of children with AM.

Acute mastoiditis was found in 6.5% of patients with a past medical or otolaryngological history of cochlear implant, known chronic ear disease, craniofacial anomalies, or immunodeficiency. Their tendency toward mastoid infection might be due to anatomical or surgical iatrogenic alterations in the middle ear or tympanic membrane structure, as well as a dysfunction or a difference in the morphology of the eustachian tube, causing abnormal accumulation of secretions in the middle ear, possibly spreading to the mastoid cavity.

The reported incidence in other developed countries is lower than that in the current study and ranges from 1.2 to 4.2 per 100,000 children per year.[1,2,4,10] In the Netherlands, known for low prescription rates of antibiotics for the treatment of AOM, the incidence of AM has been reported to be 3.8/100,000 year.[5]

The underlying cause of the higher incidence of AM in the Israeli population is unknown. The young age at diagnosis in the Israeli population may be the result of earlier age at day care admittance, a known risk factor for AOM, the precursor of AM. It often starts in the first months of life, earlier than in Western societies. This might be due to possible exposure to multiple pathogens and high microbial load exposure. According to the Organization for Economic Co-operation and Development (OECD), since 2013, 100% of children aged 3 syears have been in the Israeli education system.[11] The Taub Center for Social Policy Studies in Israel reported that the enrollment rate for children aged 0–2 years in Israel is 56%, compared to 35% on average in OECD countries[12]

As in the current study, AM is mostly considered a disease of the very young.[4] The mean age of patients with AM in pediatric studies ranges from 2.5–5.1 years.[13–15] In Sweden, the increased incidence reported in the second year of life has been attributed to the initiation of day care attendance.

The high incidence in high socioeconomic status is in contrast to previous reports of AOM, most of which show an opposite result, with higher risk in the low socioeconomic class.[16] As mentioned in the Results section, we found no correlation between socioeconomic status and antibiotic treatment prior to hospitalization. Although our data on antibiotic treatment were limited, it implies that access to healthcare, specifically pharmaceutical care, is not the main factor.

The rationale for the higher rate of AM in high socioeconomic status may be that after giving birth, these parents return to work sooner. This leads to early admission to kindergartens and exposure to infection. While not including data from Israel, the OECD Family Database of 2021 states that in most OECD countries, childcare participation rates for children aged 0–2 increase with household income[17]

Another speculation is that mothers with high socioeconomic status breastfeed for a shorter period of time, while breastfeeding is known as a protective measure against AOM.[16] This notion is supported by previous studies from around the world that describe breastfeeding as one of the few positive health-related behaviors that are less frequent in high SES.[18] This tendency is present both between high- and low-income countries and in different socioeconomic groups within countries. A study of the Israeli Arab population revealed that in villages with higher socioeconomic status, the risk of early breastfeeding weaning increased with the early introduction of the formula[19] Being a risk factor for AOM, it may present a risk for AOM complications, such as AM.

The rate of household smoking exceeds previously published rates in the United States, where household smoking was estimated at 25%–43%.[20] This is also higher than the smoking rate in the general adult population in Israel, which is ∼20%.[21]

The high rate of smoking habits unequivocally presented in this study lends further support against the exposure of young children to household smoking, which was previously associated with more cases of acute and serous otitis media.[20] Our study suggests an increased risk of AM. The increased risk of parental smoking exposure may be of special relevance to the medical care of children in the developing world, where the household smoking rate is still high.

The limitations of the study include its retrospective nature, and although it is large-scale, it involves a single-country population. These findings may not translate to patients of other ethnicities, and further prospective multicenter studies worldwide are required.

5 | CONCLUSIONS AND FUTURE DIRECTIONS

A relatively high incidence rate of AM was reported in this study of AM in Israel, especially in the young population under 2 years of age.

As far as we know, there has not yet been any effort to address the problem across Israel and mitigate these potentially serious infections that could be possibly done by raising awareness or using well-defined protocols of care.

We found certain unique local characteristics such as high socio-economic status and household smoking, which may play a role as risk factors and may shed light on the pathogenesis and etiology of AM in general. The findings of this study may not be relevant only for the population of Israel, but also for our understanding of the disease and its possible prevention in other countries.

CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

ORCID

Orit Samuel https://orcid.org/0000-0001-9915-5448
Yotam Shiner https://orcid.org/0000-0002-6139-3931

REFERENCES

1. Laulajainen-Hongisto A, Saat R, Lempinen L, Markkola A, Aarnisalo AA, Jero J. Bacteriology in relation to clinical findings and treatment of acute mastoiditis in children. *Int J Pediatr Otorhinolaryngol*. 2014;78(12):2072-2078.
2. Pritchett CV, Thorne MC. Incidence of pediatric acute mastoiditis: 1997-2006. *Arch Otolaryngol Head Neck Surg*. 2012;138(5):451-455.
3. Gorphe P, de Barros A, Choussy O, Dehesdin D, Marie JP. Acute mastoiditis in children: 10 years experience in a French tertiary university referral center. *Eur Arch Oto-Rhino-Laryngol off J Eur Fed Oto-Rhino-Laryngol Soc EUFOS Affil Ger Soc Oto-Rhino-Laryngol - Head Neck Surg*. 2012;269(2):455-460.
4. Groth A, Enoksson F, Hultcrantz M, Stalfors J, Stenfeldt K, Hermansson A. Acute mastoiditis in children aged 0–16 years—a national study of 678 cases in Sweden comparing different age groups. *Int J Pediatr Otorhinolaryngol*. 2012;76(10):1494-1500.
5. Van Zuijlen DA, Schilder AG, Van Balen FA, Hoes AW. National differences in incidence of acute mastoiditis: relationship to prescribing patterns of antibiotics for acute otitis media? *Pediatr Infect Dis J*. 2001;20(2):140-144.
6. Kordeluk S, Orgad R, Kraus M, et al. Acute mastoiditis in children under 15 years of age in southern Israel following the introduction of pneumococcal conjugate vaccines: a 4-year retrospective study (2009-2012). *Int J Pediatr Otorhinolaryngol*. 2014;78(10):1599-1604.
7. Bilavsky E, Yarden-Bilavsky H, Samra Z, Amir J, Nussinovitch M. Clinical, laboratory, and microbiological differences between children with simple or complicated mastoiditis. *Int J Pediatr Otorhinolaryngol*. 2009;73(9):1270-1273.
8. Nussinovitch M, Yoeli R, Elishkevitz K, Varsano I. Acute mastoiditis in children: epidemiologic, clinical, microbiologic, and therapeutic aspects over past years. *Clin Pediatr (Phila)*. 2004;43(3):261-267.
9. WHO Vaccine-Preventable Diseases: Monitoring System. Global summary; 2020.
10. Tawfik KO, Ishman SL, Tabangin ME, Altaye M, Meinzen-Derr J, Choo DI. Pediatric acute mastoiditis in the era of pneumococcal vaccination. *Laryngoscope*. 2018;128(6):1480-1485.
11. Organisation for Economic Co-operation and Development. Education at a glance 2020: OECD indicators; 2020. Accessed September 9, 2022.
12. Vaknin D. Early childhood education and Care in Israel Compared to the OECD. Published Online July 2020.
13. Choi SS, Lander L. Pediatric acute mastoiditis in the post-pneumococcal conjugate vaccine era. *Laryngoscope*. 2011;121(5):1072-1080.
14. Grossman Z, Zehavi Y, Leibovitz E, et al. Severe acute mastoiditis admission is not related to delayed antibiotic treatment for antecedent acute otitis media. *Pediatr Infect Dis J*. 2016;35(2):162-165.
15. Marchisio P, Bianchini S, Villani A, et al. Diagnosis and management of acute mastoiditis in a cohort of Italian children. *Expert Rev Anti Infect Ther*. 2014;12(12):1541-1548.
16. Duncan B, Ey J, Holberg CJ, Wright AL, Martinez FD, Taussig LM. Exclusive breast-feeding for at least 4 months protects against otitis media. *Pediatrics*. 1993;91(5):867-872.
17. OECD. OECD Famiy database: enrolment in childcare and pre-school. OECD Publishing; 2021. https://www.oecd.org/els/family/database.htm Accessed September 9, 2022
18. Victora CG, Bahl R, Barros AJD, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet Lond Engl*. 2016;387(10017):475-490.
19. Muhsen K, Masarwa S, Guttman E, Cohen D. What are the determinants of early breastfeeding weaning and prolonged breastfeeding in Arab infants?. *Harefuah* 2011;150(4):333–337, 420, 7, 420.
20. Winickoff JP. State-of-the-art interventions for office-based parental tobacco control. *Pediatrics*. 2005;115(3):750-760.
21. Smoking in Israel: Ministry of Health Report. 2019. https://www.cancer.org.il/download/files/%D7%93%D7%95%D7%97%20%D7%A9%D7%A8%20%D7%94%D7%91%D7%A8%D7%99%D7%90%D7%95%D7%AA%20%D7%A2%D7%9C%20%D7%94%D7%A2%D7%99%D7%A9%D7%95%D7%9F%202019.pdf Accessed September 9, 2022.

How to cite this article: Samuel O, Saliba W, Stein N, Shiner Y, Cohen-Kerem R. Epidemiology of pediatric acute mastoiditis in Israel: A National Registry 10-year perspective. *Laryngoscope Investigative Otolaryngology*. 2022;7(6):2139-2144. doi:10.1002/lio2.948