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# Frequency and Predictors of Tonsil Surgery: A Systematic Review of Evidence

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## Abstract

Tonsillectomy and adenoidectomy are common procedures, performed typically on children. Evidence suggests that these procedures may be associated with health conditions, as well as with demographic, socioeconomic, and environmental factors. This review examines worldwide evidence related to the frequency and predictors of tonsil surgery for all age groups. Using PubMed, Web of Science, and Ovid Cochrane, a systematic review was conducted which retrieved 11 relevant articles. This review suggests that tonsil surgery is associated with age, geographical region of residence, and race. Further studies to evaluate factors associated with tonsil surgery will provide more information regarding the frequency of tonsil surgery, as well as the disparities in incidence of the surgery among different population groups.

**Keywords:** Frequency; Predictors; Tonsil surgery; Tonsillectomy; Adenoidectomy;

## Highlights

- A systematic review was conducted to examine the predictors of tonsil surgery
- Findings suggest that age, residence, and race are associated with tonsil surgery
- Further research is required to understand the incidence of tonsil surgery

## 1.1 Introduction

Tonsil surgery, which is typically performed on children, is one of the most common types of surgery around the world [1]. The annual frequency of such surgeries is more than 58,000 in the UK and more than 80,000 in South Korea [2,3]. Research has documented the role of tonsil removal in improving quality of life among individuals [4, 5]. Adenotonsillectomy can significantly improve sleep quality in patients with sleep apnea and also reduce the rate of complications related to sleep apnea, such as failure to thrive, craniofacial growth abnormalities, cardiovascular diseases, and enuresis [6]. Additionally, surgery can effectively eliminate airway obstruction caused by tonsillar enlargement and treatchronic or recurrent tonsillar infections [7].

Tonsil surgery involves several disadvantages including health complications and costs related to the surgery [8,9]. Common complications

include respiratory compromise and postoperative bleeding, which occur in 9.4% and 11.6% of tonsil surgeries [10,8]. Additionally, a significant amount of money is allocated each year for tonsil surgeries by individuals, governments, and insurance companies. For example, in the USA, the average cost of a tonsil surgery is approximately USD7,525 [11].

Concern exists in regards to the increase in unnecessary tonsil surgeries [12]. Considering the health risks, research sheds doubt about the actual benefits of unnecessary tonsil surgeries. Venekamp et al. (2015) conducted a systematic review of randomised controlled trials in order to assess the effectiveness and safety of tonsil surgery in children aged 2 to 16 years with sleep apnea. Based on their results, the researchers reported insufficient evidence for the benefits of tonsil surgery as a treatment for sleep apnea among children under 5 years of age. Instead, they proposed that non-surgical management may be as effective as tonsil surgery in many cases of sleep apnea [13]. Likewise, a study by Kim & Han (2015) suggested that those who have allergic rhinitis (hay fever) may worsen their long-term quality of life by receiving tonsil surgery [14]. Additionally, the study concluded that individuals with allergies should be selected for surgery with caution due to the risk of adverse outcomes [14].

The frequency of tonsil surgery may be affected by factors such as exposure to environmental tobacco smoke, sex, and age[15]. Many authors have assessed associations between tonsil surgery and demographic factors, socio-economic status, and lifestyle [3,16]. However, there are no formal systematic reviews conducted that comprehensively assess research on the predictors of tonsil surgery. This is concerning as there is a need to gather knowledge on predictors of tonsillectomy in order to inform on prevention related to unnecessary procedures. As a result, the main objectives of this study are to: 1) identify worldwide frequency of tonsil surgery by assessing all related studies and 2) examine evidence on predictors of tonsil surgery.

## 1.2 Methods

In order to retrieve all relevant studies, this systematic review sought to include all peer-reviewed publications that had examined cases of tonsil surgeries at any age, sex or nationality. Tonsil surgery was defined as adenoidectomy, tonsillectomy, or adenotonsillectomy. In order to gather the most recent data and also be consistent with other systematic reviews, the present study focused on articles published within last 10 years. Therefore, a search of PubMed, Web of Science, and Ovid Cochrane databases was conducted for English language articles from 2006 to 2016. These databases were recommended by area experts and were selected based on their focus on health science and biomedical research. This review used the following search words: frequency, prevalence, incidence, predictors, risk factors, tonsil surgery, tonsillectomy, adenoidectomy, adenotonsillectomy, as well as their synonyms, alternatives, and root words.

Exclusion criteria included studies that focused on evaluations of surgical or anesthetic techniques, surgical complications, the advantages and disadvantages of tonsil surgery, and tonsil surgeries performed for malignancies. Additionally, in order to identify predictors of tonsil surgery rather than predictors of the conditions treated by tonsil surgery (indications for tonsil surgery), studies in which participants were candidates for tonsil surgery, but did not undergo the surgery, were also excluded.

To assess the risk of bias and methodological quality of the articles, Downs and Black checklist, which examines both randomized and non-randomized studies, was selected [17]. However, since the review did not include any randomized control trials, a modified version of the checklist was used that only focused on questions related to observational studies. All studies were independently appraised by two reviewers (KK, SY) who then discussed any differences of opinion in order to determine the best fit quality score for each study. Furthermore, the remaining disagreements were evaluated by a third reviewer (CB) as a referee. In order to collect information from each study

selected, a data extraction form was developed using Microsoft Excel. The data extracted from each study included: (1) objectives; (2) design; (3) sample size; (4) participants; (5) exposures (independent variables), and (6) results. Based on this information, the results of each study were interpreted and analyzed using the checklist.

## 1.3 Results

Database searches led to a total of 3,123 citations. After adjusting for duplicates, 1,653 articles remained. Of these, 1,625 studies were excluded after screening the title and abstract. Reasons for exclusion included a focus on methods of tonsil surgery and anesthesia (810 articles); surgical complications (482 articles); the advantages and disadvantages of tonsil surgery (162 articles); tonsil surgeries performed on malignancies (10 articles), and other irrelevant subjects (161 articles). Full texts of the remaining 28 citations were examined, of which 17 studies were excluded since they focused on frequency and predictors of the indications for tonsil surgery. The remaining 11 studies were included in this systematic review. According to two independently completed appraisal checklists, all included articles were moderate to high quality and none of them were highly biased.

In relation to study designs and participants, all 11 studies were observational, consisting of one case-control study and ten cross-sectional studies (Table 1). Sample size varied from 100 to 6,300,117 participants [18,1]. Considering that tonsil surgery is more common among children than adults, eight studies limited their participants to younger age groups (under the age of 18). However, each study defined different criteria for the specific age of their participants. For example, one study included all children under the age of 15 while another considered children between the ages of 6 to 16 (Table 1).

**Table 1:** Summary of the Articles Included in the Systematic Review: Study Setting, Design, Participants, and Sample Size

| | Article | Study Setting | Study Design | Participants | Sample Size |
|---|---|---|---|---|---|
| 1 | Suvilehto et al., 2007 | Finland | Cross-sectional | Aged 2-17 (tonsillitis) | 100 |
| 2 | Vestergaard et al., 2007 | Denmark | Cross-sectional | All ages (all Danish residents) | 6,300,117 |
| 3 | Carr et al., 2007 | England | Cross-sectional | Aged <16 y. (OSA) | 117 |
| 4 | Fedeli et al., 2009 | Italy | Cross-sectional | Aged 2–9 y. | 15,096 |
| 5 | Suleman et al., 2010 | England | Cross-sectional | Aged <15 y. | Not mentioned |
| 6 | Boss et al., 2012 | USA | Cross-sectional | Aged <18 y. (outpatient surgeries) | 294 |
| 7 | Al-Hussaini et al., 2013 | UK | Cross-sectional | All ages | 699,898 |
| 8 | Choi et al., 2014 | South Korea | Cross-sectional | All ages | 403,924 |
| 9 | Straight et al., 2015 | USA | Case-control study | Aged <15 y. (recurrenttonsillitis) | 256 |
| 10 | Doganer et al., 2015 | Turkey | Cross-sectional | Aged 6-12 y. | 1,900 |
| 11 | Cote et al., 2015 | USA | Cross-sectional | Aged <24 m. (OSA or SDB) | 215 |

In relation to frequency of tonsil surgery, seven out of the 11 studies explored the frequency of tonsil surgery: 10 studies assessed the incidence of the surgery and only one study stated the prevalence of this intervention, which was 7.3% among Turkish students aged 6 to 12 [15]. According to other studies that assessed the incidence of tonsil surgery across different countries, when all age groups of the population were taken into consideration, the annual incidence of all types of tonsil surgery was between 88.9 and 159.2 per 100,000 [1-3]. From 1980 to 2011, the annual incidence of tonsil surgery was 88.9, 100.6, 105.5, 143.2, and 159.2 per 100,000, in Scotland, England, Wales, Denmark, and South Korea, respectively [1-3]. However, when measurements were limited to the lower age groups (under the age of 18), which included most of the tonsil surgeries, the annual incidence increased to 304.6-1,440 per 100,000. Specifically, Suleman et al. (2010) found that the annual

incidence of tonsillectomy is 304.6 per 100,000 among English children under the age of 15 [19], while the incidence of this procedure in the Veneto region of Italy was approximately 400% higher at 1,440 per 100,000 person-years in children aged 2 to 9 [20]. Moreover, Boss et al. (2012) identified that, out of 100,000 children under the age of 18, approximately 791 underwent outpatient tonsillectomy each year in the United States [21] (Table 2).

**Table 2:** Incidence of Tonsil Surgery (the Systematic Review Results)

| | Article | Incidence (cumulative) (per 100,000/year) | Incidence rate (density) (per 100,000 person-years) |
|---|---|---|---|
| 1 | Vestergaard et al., 2007 | | 143.2 (Denmark) |
| 2 | Fedeli et al., 2009 | | 1,440 (Italy) |
| 3 | Suleman et al., 2010 | 304.6 (England) | |
| 4 | Boss et al., 2012 | 791 * (USA) | |
| 5 | Al-Hussaini et al., 2013 | 100.6 ± 8.0 (England)<br>88.9 ± 14.9 (Scotland)<br>105.5 ± 28.1 (Wales) | |
| 6 | Choi et al., 2014 | 159.2 (Korea) | |

** Only ambulatory (outpatient) surgeries*

In relation to predictors of tonsil surgery, each of the 11 articles evaluatedat least one predictor of tonsil surgery. These predictors included demographic characteristics (including age, sex, race, and geographical location), socio-economic status, environmental factors, and co-morbidities (Table 3).

**Table 3:** Predictors of Tonsil Surgery (Results of the Systematic Review)

| Predictors \ Articles | Suvilehto, 2007 | Vestengaard, 2007 | Carr, 2007 | Fedelini, 2009 | Suleman, 2010 | Boss, 2012 | Al-Husseaini, 2013 | Choi, 2014 | Straight, 2015 | Doganer, 2015 | Cote, 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age(1) | | **4 , 16-17** | | | | **0-6, 7-12** | **0-14** | **5-9** | | | |
| Sex(2) | | **F** | | **M** | | **F** | **F** | **M** | | **F = M** | **M** |
| Race | | | | | | | | | | | **A(3)** |
| Geographical Region | | | | **A** | **A** | **A (R>U(4))** | | | | | |
| Household Income | | | | | | | | **A(5)** | | **N** | |
| Paternal Education | | | | | | | | | | **A** | |
| Maternal Education | | | | | | | | | | **N** | |
| Number of Siblings | | | | | | | | | | **N** | |
| ETS | **N** | | | | | | | | **A** | | **N** |
| Asthma | **A** | | | | | | | | | **N** | |
| Allergies | **A** | | **N** | | | | | | | **N** | |
| Serum IgE | **N** | | **N** | | | | | | | | |
| URTI | **N** | | | | | | | | | **A** | |
| High BMI | | | | | | | | | | **A** | |
| Otitis Media | **A(6)** | | | | | | | | | **A(7)** | |
| Down Syndrome | | | | | | | | | | | **A** |
| Prematurity | | | | | | | | | | | **A** |

***Empty areas =*** *Not assessed,* ***A*** *= Associated,* ***N*** *= Not-associated*

***F****=Female,* ***M****= Male*

***ETS****= Environmental Tobacco Smoke,* ***URTI****= Upper Respiratory Tract Infections*

***(1)*** *= Age group for the highest rate of tonsil surgery in years:* ***(2)*** *= The sex that had more frequent tonsil surgeries:* ***(3)*** *= African-Americans:* ***(4)*** *= Rural > Urban:* ***(5)*** *= Reversely associated:* ***(6)*** *= Otitis Media with Effusion:* ***(7)*** *= Acute Otitis Media*

### 1.3.1 Demographic Factors

In order to identify the national incidence figures in Denmark, Vestergaard et al. (2007) determined the age-specific incidence of tonsillectomy [1]. According to this study, the incidence of tonsillectomy had two peaks: at the age of 4 (for both sexes) and then at the age of 16 for females and 17 for males. Additionally, Choi et al. (2014) showed that the highest incidence of tonsil surgery occurred in Korean children aged 5 to 9 (460 per 100,000 annually) [3]. Al-Hussaini et al. (2013) revealed that the age group of 0-14 has the highest rates of tonsil surgery in the UK [2]. Furthermore, Boss et al. (2012) stated that children aged 0-6 and 7-12 were more likely to undergo tonsil surgery (1029 and 913 per 100,000 annually, respectively) [21]. However, this study did not include all age groups, limiting its participants to the under 18 group (Tables 2&3).

Seven articles assessed the relationship between sex and tonsil surgery. Results of three articles revealed that tonsil surgery was more common in females than males, while another three found that more males underwent tonsil surgery than females. The final article reported almost the same frequency of tonsillectomy for males and females (Table 3).

The only study that assessed the effects of race on the frequency of tonsil surgery was from the United States. This research revealed that the incidence of tonsil surgery was the highest among African-Americans ($p = 0.0008$, Z-test), and that Hispanics were less likely to receive tonsil surgery ($p = 0.01$, Z-test). Additionally, multivariate analysis suggested that the odds ratio of severe sleep-disordered breathing (SDB) in Caucasians was 0.08 (C.I. 0.01–0.71, $p = 0.021$) compared to African-Americans [22].

Rates of tonsil surgery were significantly different among geographical regions in England, Italy, and the United States as shown in Table 3 [21,20,19]. Suleman et al. (2010) found that there is a significant variation (7-fold) in tonsil surgery rates among children under the age of 15 in different regions of England [19]. Furthermore, Fedeli et al. (2009) illustrated similar results in Veneto, Italy [20]. Boss et al. (2012) also determined that tonsillectomy was more prevalent in the Southern United States compared to other regions of the country ($p < 0.01$). Additionally, Americans who lived in rural areas were found to have a higher risk for tonsil surgery than those who lived in urban areas (1,180 per 100,000 versus 420 per 100,000; $p < 0.05$) [21].

### 1.3.2 Socioeconomic Status

In order to assess associations between household income and tonsil surgery, Choi et al. (2014) categorized all South Korean people into two groups of high income and low income, based on their type of insurance plan. They suggested that tonsil surgery was more common among the low income group [3]. However, Doganer et al. (2015) found that household income was not associated with frequency of tonsil surgery, after dividing patients into three categories of low income (less than 1000 Turkish Lira per month), medium income (between 1000 and 2000 Turkish Lira per month), and high income (more than 2000 Turkish Lira per month) ($X^2 = 4.69$, $p = 0.096$) [15].

A study conducted by Doganer et al. (2015) on school-aged children in Turkey revealed that participants with a higher paternal educational level had a greater rate of tonsil surgery than those with low and medium levels($X^2 = 13.24$, $p= 0.001$). A high educational level was defined by the authors as 'finishing college' or above. However, the same study suggested that maternal educational level was not associated with frequency of tonsil surgery (Table 3). Through a cross-sectional study, Doganer et al. (2015) found that the number of siblings does not affect the frequency of tonsil surgery (Table 3) [15].

### 1.3.3 Environmental Factors

In order to examine associations between environmental tobacco smoke exposure and the incidence of tonsillectomy, Straight et al. (2014) conducted a case-control study on children undergoing tonsillectomy for recurrent tonsillitis (case group) and those undergoing hernia repair (control group). The authors suggested an association between environmental tobacco smoke and

the incidence of tonsillectomy in chronic tonsillitis by demonstrating that exposure to contacts who smoke was more common in the case group than the control group (OR = 2.49, p <0.001) [16]. In contrast, a cross-sectional study conducted by Cote et al. (2015) stated that environmental tobacco smoke exposure did not increase the incidence of tonsil surgery performed for sleep related breathing disorders in children aged under 2 (p = 0.001, Z-test) [22]. Additionally, Suvilehto et al. (2007) found no association between history of adenoidectomy and environmental tobacco smoke exposure in individuals with tonsillitis who were candidates for tonsillectomy (p = 0.1743, Chi-square test) [18].

### 1.3.4 Comorbidities

The current study identified two investigations which examined the association between asthma and tonsil surgery. The first study, which assessed the prevalence of asthma among candidates for tonsillectomy, found that asthma is more common among children under the age of 7 with a history of adenoidectomy than those with no history (p = 0.015, Chi-square test) [18]. However, the second study did not reveal a correlation between asthma and tonsil surgery (p = 0.772, Chi-square test) [15].

Suvilehto et al. (2007) suggested that allergies were more common among candidates for tonsillectomy who had previously undergone adenoidectomy than those who did not (p = 0.007, Chi-square test) [18]. However, using immunological tests, Carr et al. (2007) found no evidence that allergies could affect the frequency of tonsil surgery performed for sleep apnea [23]. Additionally, Doganer et al. (2015) determined that allergic diseases did not increase the frequency of tonsil surgery (p = 0.102, Chi-square test) [15]. Finally, no study suggested an association between tonsil surgery and serum IgE level, which indicates the presence of allergies [22,18].

Three studies assessed the effects of other health conditions on the frequency of tonsil surgery (Table 3). Cote et al. (2007) found that prematurity (p = 0.0001, Z-test) and Downs syndrome (0.0001, Z-test) were associated with tonsil surgery [22]. Furthermore, Suvilehto et al. (2007) concluded that ear infection (otitis media with effusion) could be a tonsil surgery comorbidity (p < 0.00013, Chi-square test) [18]. Similarly, Doganer et al.(2015) suggested that acute ear infections among children were associated with tonsil surgery (p < 0.001, Chi-square test) [15]. However, the results that were linked to an association between tonsil surgery and upper respiratory tract infections (URTI) were conflicting. While Doganer et al. (2015) found that the prevalence of URTI was associated with tonsil surgery (p = 0.001, Chi-square test) [15], Suvilehto et al. (2007) found that having a history of adenoidectomy cannot change the frequency of URTI among candidates for tonsillectomy (p = 0.0683, Chi-square test) [18]. Finally, Doganer et al. suggested that a high BMI is a predictor of tonsil surgery (OR = 2.32, p = 0.003) [15] (Table 3).

## 1.4 Discussion

Tonsil surgery improves quality of life in many patients by reducing upper airway obstructive problems and tonsillar infections [4]. However, this surgery, as any major surgery, includes some potential health and life threatening complications, such as postoperative bleeding and pulmonary problems, as well as direct and indirect costs [8,9,10]. Therefore, in order to avoid adverse consequences of the surgery, it would be advantageous to avoid unnecessary surgeries through identifying and controlling the modifiable predictors of this procedure. Although this information may not be applicable to individual cases, understanding the predictors of tonsil surgery will provide information on the causes of population-level disparities in the frequency of tonsil surgery. Several studies indicate the frequency of surgery or assess the association between potential predictors and the incidence of surgery. However, lack of sufficient evidence for an association between some of these predictors and tonsil surgery, as well as conflicting findings, has resulted in unreliable conclusions. Furthermore, no comprehensive study has simultaneously evaluated the predictors of tonsillectomy. The present study aims to fill these gaps in knowledge by finding existing evidence

regarding the frequency and predictors of tonsil surgery.

All the articles selected are observational studies; one has a case-control design, and 10 have cross-sectional designs. Almost no predictor (exposure) could be fully controlled by investigators. Considering all age groups, results suggest that the annual incidence of tonsil surgery ranges between 88.9 and 159.2 per 100,000. However, studies which focus on lower age groups (under the age of 18) identify higher but also more variable incidence numbers. The variable rates of tonsillectomy may be linked to different perspectives regarding the indications and usefulness of tonsil surgery, among different physicians with different specialities and different geographical locations [24]. Through a cross-sectional study conducted in the UK, Capper and Canter (2001) illustrate significant variations between physicians with different specialities in the definition of tonsillar diseases, the indications for tonsillectomy, and the expected benefits following tonsillectomy. This disagreement not only leads to differences in referring patients for tonsil surgery by general practitioners and pediatricians, but also affects the decision-making process of surgeons performing tonsillectomy. Therefore, it can be concluded that doctors' attitudes towards tonsillar diseases and tonsillectomy influence the rate of the surgery in their areas of practice [24].

When assessing rates of tonsil surgery in different age groups, results were dependent on age distribution with tonsil surgery being more common in the under 18 years age group compared to above 18 years. This finding is consistent with existing medical knowledge revealing that children have immunologically more active and larger tonsils compared to adults. Consequently, the present review proposes age as a predictor of tonsil surgery (Table 4).

**Table 4:** Predictors of Tonsil Surgery (Interpretation of the Results)

| Predictors | Articles Suggested the association / Assessed the association | Interpretation of the results |
|---|---|---|
| Age | **4** / 4 | Associated |
| Geographical Regions | **3** / 3 | Associated |
| Race | **1** / 1 | Associated |
| Sex | **6** / 7 | Conflicting results |
| Household Income | **1** / 2 | Conflicting results |
| ETS | **1** / 3 | Conflicting results |
| URTI | **1** / 2 | Conflicting results |
| Allergies | **1** / 3 | Conflicting results |
| Asthma | **1** / 2 | Conflicting results |
| Paternal Education | **1** / 1 | Limited evidence |
| High BMI | **1** / 1 | Limited evidence |
| Down Syndrome | **1** / 1 | Limited evidence |
| Middle Ear Infections | **2** / 2 | Limited evidence |
| Prematurity | **1** / 1 | Limited evidence |
| Maternal Education | **0** / 1 | Not associated |
| Number of Siblings | **0** / 1 | Not associated |
| IgE | **0** / 2 | Not associated |

The results of seven related studies show less agreement regarding an association with sex. Nonetheless, those studies that limit their participants to lower age groups postulate that males may have a higher risk for tonsil surgery than females. Therefore, in spite of the conflicting results, sex may be an age-specific predictor of tonsil surgery (Table 4).

Evidence suggests that a higher risk of African Americans undergo tonsil surgery. Lumeng et al. (2008) reveal that sleep disordered breathing, which is one of the main reasons for tonsil surgery [6], is more common among African Americans [25]. Additionally, a study performed on American children with sleep apnea found that African American ethnicity is associated with a 20% increase in the

number of apnea attacks [26]. An increase in the number of apnea attacks during sleep can elevate the risk of undergoing tonsil surgery [27]. The association of Hispanic ethnicity with tonsil surgery has not been confirmed by other studies [28, 29]. Goodwin et al. (2003) mention that Hispanic children are more likely to have symptoms of sleep-disordered breathing compared to White children [28]. Although assessed in only one study, it is proposed that race can be a predictor of tonsil surgery, since there is other evidence that suggests an association between race and tonsil surgery (Table 4).

According to three studies conducted in the USA, Italy, and England, the rates of tonsil surgery significantly vary among different geographical regions. Socio-economic status may be responsible for some of this variability [19]. Environmental factors, such as temperature or uncertainty about the indications for surgery are other potential causes of the heterogeneity of tonsillectomy rates among geographical regions [24, 20]. Moreover, Boss et al. (2012) suggest that the physician-to-population ratio for otolaryngologists may also account for the non-homogeneity in tonsillectomy rates among different locations in a country [21]. The authors further propose that people living in less populated areas are more likely to be candidates for tonsil surgery than residents of crowded cities. However, they do not provide reasons for the lower tonsil surgery rate in populated cities [21]. Since all the articles that examine the geographical region of residence suggest an association between geographical region and tonsil surgery, it can be concluded that certain geographical features are predictors of tonsil surgery (Table 4).

Among socio-economic factors, family (household) income is the most examined factor with inconsistent results. Choi et al. (2014) reveal that children from low-income families face a higher risk for undergoing tonsillectomy surgeries compared to high-income families [3], but results of the study conducted by Doganer et al. (2015) do not confirm any association between family economic status and tonsil surgery [15]. Additionally, two other studies illustrate conflicting results regarding the impact of family income on tonsillectomy frequencies. Cahit and Kaan (2010) suggest that students who belong to high-income families are more likely to undergo tonsil surgery [30]; whereas Ozkırış et al. (2013) state that tonsil surgery rates are higher in children from low-income families [31]. To assess the actual effects of family income on tonsil surgery rates, other factors such as health insurance coverage should be taken into account. For instance, in countries where the general population does not have appropriate health insurance coverage, it is expected that low-income families are not in a position to afford the expenses of tonsillectomy procedures. Therefore, the frequency of tonsil surgery is bound to decline in this group. However, in countries with well-established social security and public health plans, children from low-income families more frequently undergo tonsil surgery [21]. This may suggest that socioeconomic-related predictors of tonsil surgery may exists. The study by Doganer et al.(2015)found that the father's educational level correlates with the rates of tonsil surgery, and attribute this correlation to increased paternal awareness and knowledge of health issues and health care systems. In contrast, other research suggests that parental educational level negatively correlates with the rates of tonsil surgery possibly due to related relatively poor living conditions and low quality of health care, which may increase rates of tonsillar infections [31]. This review found that tonsil surgery is not associated with the mother's educational level or the number of siblings.

The damaging effect of smoking tobacco has been well-documented in the literature, as smoking is the cause of many health issues such as cancer or heart disease [32, 33]. Tobacco smoke may be harmful, not only to smokers but also to bystanders, such as children, who are exposed to smoke [34]. In a 1993 study, Hinton et al. (1993) suggest that parental smoking elevates the risk of tonsillitis and the incidence of tonsil surgeries in children by altering or opharyngeal flora, impairing mucociliary function or increasing cross infection [35]. Straight et al. (2015) also propose that second-hand smoking elevates the frequency of tonsil surgery by increasing the rates of recurrent tonsillitis

[16]. It should be noted that, after assessing the effects of environmental tobacco smoke on children who underwent tonsil surgery for sleep apnea, Cote et al. (2015) claim that the surgery is not more common among children of smokers compared to children of non-smokers [22]. Therefore, according to the current review, the evidence for the association between the rate of tonsil surgery and environmental tobacco smoke is conflicting.

Individuals who undergo tonsil surgery may have other health conditions. Cote et al. (2015) suggest that children with Down syndrome or prematurity have a higher risk for tonsil surgery [22]. In addition, Doganer et al. (2015) propose that acute middle ear infections, upper respiratory tract infections, and high BMI are more common in children who have undergone tonsil surgery [15]. Furthermore, Suvilehto et al. (2007) propose that diagnosed asthma and allergies are more common among children with previous adenoidectomy [18]. However, it is not clear if individuals who have asthma and allergies have a higher risk for adenoidectomy or if adenoidectomy increases the rates of allergies and asthma. Moreover, Doganer et al. (2015) and Carr et al. (2007) were unable to find any association between tonsil surgery and each of asthma and allergies [15,23]. Although some reviewed articles propose several co-morbidities, there is insufficient evidence to suggest that any of these health conditions are associated with tonsil surgery (Table 4).

# 1.5 Conclusion

This study suggests that tonsillectomy is a common surgical procedure. The global incidence of tonsil surgery in the general population is 88.9-159.2 per 100,000 annually. Children and young adults under the age of 18 have a higher risk for tonsillectomy than other age groups. This review suggests that the factors that affect the frequency of tonsil surgery include age, ethnicity, and geographical region of residence. However, there is limited evidence for associations between tonsil surgery and paternal educational level, prematurity, Down syndrome, otitis media, or high BMI. Furthermore, the evidence for associations between tonsil surgery and sex, household income, environmental tobacco smoke, allergies, asthma, and URTI is conflicting. Additionally, this review finds no evidence that supports associations between tonsil surgery and maternal educational level, number of siblings, or serum IgE level. Therefore, the existing evidence is insufficient to support or disprove associations between tonsil surgery and most of the predictors that are assessed in this review. Further studies to evaluate factors that can change the frequency of tonsil surgery will provide more information regarding the frequency of tonsil surgery, as well as the disparities in incidence of the surgery among different population groups. Identifying true predictors of tonsil surgery will help implement strategies that have the potential to control modifiable predictors, and thus reduce the incidence of unnecessary tonsil surgery.

## 1.6 Disclosures

The authors declare no conflict of interest. This study received no funding.

## 1.7 Ethical approval

This study obtained ethical approval from the University of Ontario Institute of Technology Research Ethics Board.

# 1.8 References

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