

A systematic review and meta-analysis of the relationship between T-lymphocytes and respiratory tract infection in children

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D – writing the article; E – critical revision of the article; F – final approval of the article

Advances in Clinical and Experimental Medicine, ISSN 1899–5276 (print), ISSN 2451–2680 (online)

Adv Clin Exp Med. 2023;32(3):275–284

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Funding sources

None declared

Conflict of interest

None declared

Received on May 11, 2022

Reviewed on July 4, 2022

Accepted on September 23, 2022

Published online on December 8, 2022

Abstract

The objective of this paper was to investigate the relationship between T-lymphocytes and respiratory tract infection in children. A meta-analysis was performed of studies related to virus-infected respiratory illnesses in children, and the change in the ratio of their T-lymphocyte subsets CD4⁺/CD8⁺. A systematic literature review was performed using MEDLINE (through PubMed), CINAHL (via Ebsco), Scopus, and Web of Science, for studies describing change in T-lymphocyte levels in children suffering from acute respiratory illnesses. Studies were included as per the Population, Intervention, Comparison, Outcomes and Study (PICOS) criteria, and relevant event data were extracted. A risk of publication bias and a risk of bias assessment were performed, and a funnel plot was designed using RevMan software. A column histogram was designed to compare the adverse effects. A total of 12 studies from the years 2000–2022 were included in the meta-analysis, containing information about 1111 patients. The current meta-analysis has a low risk of publication bias with the Egger's test p-value being 0.583 ($p > 0.05$) and the Begg's test p-value being 0.772 ($p > 0.05$). The odds ratio (OR) value was 3.66 (95% confidence interval (95% CI): 1.08–12.43), the risk ratio (RR) value was 1.91 (95% CI: 1.07–3.40) and the significance level was $p < 0.05$, which indicates that an alteration in T-lymphocyte levels occurs in respiratory infections.

T-lymphocyte levels are altered during infection, and the association between T-lymphocytes and respiratory diseases in children was investigated in this study. Based on statistically significant data ($p < 0.05$), we concluded that T-lymphocyte levels are adjusted in the event of viral respiratory sickness in children to alleviate the infection.

Key words: T-lymphocytes, respiratory tract infections, COVID-19, respiratory illnesses among children, T-lymphocyte subsets CD4⁺

Cite as

Chen X, Yang L. A systematic review and meta-analysis of the relationship between T-lymphocytes and respiratory tract infection in children.

Adv Clin Exp Med. 2023;32(3):275–284.

doi:10.17219/acem/154881

DOI

10.17219/acem/154881

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Introduction

Acute respiratory tract infections (ARTIs) are quite common in young people. Children, for example, are more susceptible to upper respiratory infections, such as the common cold, influenza and croup,^{1,2} or lower respiratory infections, such as bronchitis and pneumonia.^{3,4} The upper respiratory system includes the trachea and bronchi airways, as well as the paranasal sinuses and middle ear.^{5,6} The lower respiratory tract includes the airways from the trachea and bronchi, as well as the bronchioles and alveoli. Bacteria, fungi and viruses can cause acute respiratory infections, which can either stay limited to the respiratory tract or spread throughout the body due to infection or microbial toxins.^{7–9} When a foreign body or pathogen enters the body, the immune system recognizes the antigen and activates the immune system, causing certain cells to proliferate and differentiate to make antibodies. Antibodies work by destroying the antigen and fighting the infection. Similarly, it is thought that when children have a respiratory ailment, their T-lymphocyte level changes in comparison to their usual level, allowing the pathogen to be eliminated and the infection to be cleared. T-lymphocytes are major players in the immune system that target specific foreign particles. They will not generically attack any antigens, but they will circulate in the blood until they encounter their specific antigen and then trigger the immune response. As such, T-lymphocytes play a critical part in immunity to foreign substances, as shown in Fig. 1. It is obvious that CD8⁺ and CD4⁺ T-lymphocyte cells are necessary for facilitating the clearance of pathogens following many acute viral infections of the lung. This is the case because both types of T-lymphocytes are involved in the immune response and in providing the protection against secondary infections. Hence, the combined induction of virus-specific CD8⁺ and CD4⁺ T-lymphocyte cells and antibody production is essential for the development of optimal protective immunity.

Several review articles and case studies also reported that the change in T-lymphocyte levels in children with recurrent respiratory infections is most likely. In their review

study, Chen and John Wherry¹² observed that individuals with severe coronavirus disease 2019 (COVID-19) have altered T-lymphocyte responses that are either insufficient or overactive. Lambert and Culley¹³ discovered that the levels of T-helper cells and CD8⁺ cells alter during respiratory infections. In 2013, Tan et al.¹⁴ identified changes in circulating T-lymphocytes in children with obstructive lung disorders. According to Zimmermann and Curtis,¹⁵ COVID-19 is less severe in youngsters because of its significant potential to change T-lymphocyte levels and antibody production. In light of these findings, we conducted a systematic review and meta-analysis to look into the link between T-lymphocytes and respiratory tract infections in children, analyzing 12 case-control studies^{16–27} that compared the change in T-lymphocyte levels in children with respiratory illness to healthy controls. Although bacteria, viruses and fungi can all cause respiratory infections in children, this study focuses solely on viral respiratory disorders and their influence on T-lymphocyte numbers. All of the analyzed studies used flow cytometry to evaluate the changes in T-lymphocyte levels in terms of changing T-lymphocyte subsets: CD4⁺ and CD8⁺ levels.

He et al.¹⁶ reported an increase in T-lymphocyte count in children with acute respiratory infections, but Munteanu et al.²¹ and Gul et al.²² found a decrease in T-lymphocyte count. Similarly, Li et al.²³ and Cosgrove et al.²⁴ described an increase in T-lymphocyte levels in children with lower respiratory tract infections such as pneumonia and upper respiratory tract infections such as rhinorrhea, respectively, while Calapodopulos et al.²⁵ found a decrease in T-lymphocyte count in children with upper respiratory tract infections such as tonsillitis and sinusitis. Lu et al.²⁶ and Mahmoudi et al.²⁷ showed an increase in T-lymphocyte count in their studies on the latest pandemic, the 2019 novel coronavirus (2019-nCoV), which causes lower respiratory tract infections like pneumonia.

Considering all these contradictory reports, the present meta-analysis was conducted to evaluate whether the combined induction of virus-specific T-lymphocyte cells and enhanced antibody production occurred in children with acute respiratory illness or not. Data from the 12 selected

Respiratory illnesses in children	Types and causative virus of different respiratory tract infections	Immune response
• Children are prone to respiratory tract infections caused by viruses • These infections may affect either upper or lower respiratory tract	• Upper respiratory tract infections: • Common cold – rhino virus • Influenza – influenza virus • Lower respiratory tract infections: 1. Croup – parainfluenza virus 2. Bronchitis – adenovirus 3. Pneumonia – respiratory syncytial virus (RSV), SARS-CoV-2	• To alleviate the viral infection, immune response is activated which results in change in T-lymphocytes level • The change in T-lymphocyte is detected in terms of T-cell subsets CD4⁺ and CD8⁺ through flow cytometry

Fig. 1. Respiratory illnesses in children

SARS-CoV-2 – severe acute respiratory syndrome coronavirus 2.

studies were retrieved, statistically evaluated and analyzed in order to determine the significant link between the T-lymphocyte levels in children with acute respiratory illness.

Objectives

Through the evaluation of the combined induction of virus-specific T-lymphocyte cells and enhanced antibody production for optimal immunity, the purpose of this research is to investigate the link between T-lymphocytes and ARTIs in children. Specifically, this investigation will focus on children.

Materials and methods

In the current investigation (registration at Huzhou University, China, No. HZ #/IRB/2021/2220), we followed the normative requirements of Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA).

Search methodology

A comprehensive search was undertaken in the databases of MEDLINE (through PubMed), CINAHL (via Ebsco), Scopus, and Web of Science, concerning studies published between 2000 and 2022 and using the following keywords: “upper respiratory tract infections”, “lower respiratory tract infections”, “common cold”, “croup”, “pneumonia”, “COVID-19”, “influenza”, “viral infections”, “respiratory syncytial virus”, “rhinovirus”, “influenza virus”, “T-lymphocytes”, “T-lymphocyte subsets CD4⁺ and CD8⁺”, “immune response”, “immunity”, and “antibody production”. All included papers followed the PRISMA guidelines, and studies were chosen at random, regardless of language, publication status or study type (prospective, retrospective or clinical trial). The event data from the included studies and the demographics of patients^{16–27} were collected and used for the meta-analysis.

Separately, 2 writers (XC and LY) scanned pertinent sources for similar investigations. Full-text articles were analyzed, and abstracts were included only if they contained enough information for the meta-analysis. Obsolete references were removed, and studies that met the inclusion criteria were taken into consideration. Two researchers (XC and LY) separately obtained the event data with useful variables.

Inclusion and exclusion criteria

Studies from the years 2000–2022 that indicated the changes in T-lymphocyte levels in children during acute respiratory tract infections were included. In this analysis, only full-text articles with sufficient event data for the 2 × 2 DerSimonian and Laird method were selected, while studies with insufficient data and papers published before 2000 were excluded.

Analytical standard evaluation and heterogeneity sources

Two reviewers (XC and LY) independently assessed the methodological soundness and calculated the experimental heterogeneity. The Cochran’s Q statistic and I² index were estimated using RevMan software v. 4.1 (<https://training.cochrane.org/online-learning/core-software/rev-man>) to evaluate the heterogeneity.²⁸ The use of different case-control, prospective and retrospective studies, different number of patients, and assessment of different viral infections, either upper respiratory tract infections like the common cold, influenza, or lower respiratory tract infections like pneumonia, croup and other viruses, were all investigated as sources of heterogeneity.

Statistical analyses

The diagnostic odds ratio (OR) was determined using the DerSimonian and Laird approach for statistical analysis.²⁹ The event data were used to create a 2 × 2 table, and RevMan software was used to perform a meta-analysis. The Mantel–Haenszel (M–H) test with the random bivariate model was used to obtain the pooled diagnostic OR with 95% confidence interval (95% CI) and the risk ratio (RR) with 95% CI.³⁰ The heterogeneity of included research (Tau², χ^2 value, Q value, degrees of freedom (df) value, I² value, and p-value) was assessed using RevMan software together with their corresponding forest plots. To analyze the risk of publication bias, RevMan software was used to provide a risk of bias summary and a risk of bias graph. The publication bias of the included studies was assessed using the Begg’s test and the Egger’s test. The Deek’s funnel plot³¹ was performed by plotting the log risk ratio of each study against its standard error using MedCalc software v. 20.118 (MedCalc Software Ltd., Ostend, Belgium). The CD4⁺/CD8⁺ ratio in children with respiratory tract infections compared to healthy controls was evaluated, and a column histogram was created to compare the change in T-lymphocyte subsets.

Results

Results of literature searches

A total of 1448 studies have been retrieved from various databases. By reviewing the titles and abstracts of these investigations, we were able to eliminate 285 studies, leaving 1163 records to be assessed further. We also eliminated 642 studies due to faulty references and duplication, leaving only 521 for the final screening. Due to inclusion criteria, 395 of the 521 studies were removed, and for the remaining 126 papers, eligibility was further determined. Inadequate evidence and improper comparison criteria for creating 2 × 2 tables for the review were the main reasons for

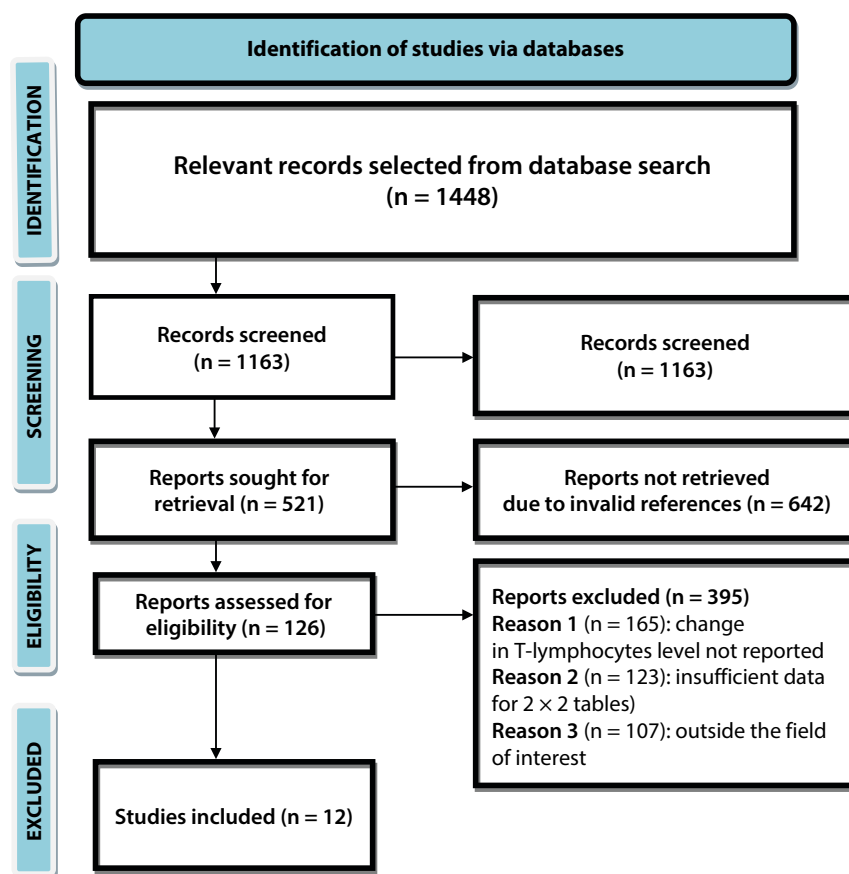


Fig. 2. Flow diagram of the study group

the omission. Finally, 12 papers from the years 2000–2022 that fit the inclusion criteria, namely a change in T-lymphocyte levels in children with recurrent respiratory infections, were incorporated into the meta-analysis, as shown in Fig. 2.

The trials included 1111 children who were recruited at random, and reported changes in CD4⁺ and CD8⁺ T-lymphocyte subsets in children with ARTIs compared to healthy controls. Each of the studied children suffered from an acute respiratory illness, such as cystic fibrosis or pneumonia. Their T-lymphocyte levels were compared with levels in healthy children of the same age group to assess changes in T-lymphocyte levels due to viral infection. Table 1 shows the demographic characteristics of the studies included in this meta-analysis. It lists the authors of each study, publication year, journal title, kind of respiratory tract infection, causative virus, number of patients and healthy controls, change in the T-lymphocyte subset ratio (CD4⁺/CD8⁺), significance level (p-value), and study conclusion. A meta-analysis was performed based on the event data from these studies, including the number of patients and healthy controls, as well as the change in their CD4⁺/CD8⁺ ratio.

Meta-analysis findings

RevMan software was used to conduct a meta-analysis. Table 2 shows the risk of bias for the included studies. The risk of bias graph in Fig. 3 and the risk of bias summary

in Fig. 4 reveal that the current meta-analysis has a low risk of bias. A funnel plot was created using RevMan software to detect publication bias or systematic heterogeneity. The current meta-analysis has a low risk of publication bias, as apparent from the symmetric inverted funnel shape plot (Fig. 5), which shows a well-conducted data collection with little chance of publication bias. It is also evident from the results of both the Egger's test and the Begg's test as the p-values of both tests are greater than 0.050 and therefore are not statistically significant. The Egger's test p-value is 0.583 ($p > 0.050$) and the Begg's test p-value is 0.772 ($p > 0.050$).

The OR of the included studies was evaluated using RevMan software to assess the link between changes in T-lymphocyte levels in children with acute upper or lower respiratory infections compared to healthy children. Figure 6 depicts the forest plot of ORs as well as data heterogeneity. The position of diamonds in the forest plot toward diseased children confirms that the likelihood of alteration in T-lymphocyte levels is higher in sick children as compared to healthy controls. As the diamond shape is not touching the line of no effect, it confirms that the difference between the 2 groups studied is statistically significant. We calculated a pooled OR of 3.66 and a 95% CI of 1.08–12.43, with heterogeneity of Tau² value of 4.51, a χ^2 value of 390.49, a df value of 11, an I² value of 97%, a Z value of 2.08, and a p-value of 0.040. An OR greater than 1 indicates that the condition or event is more likely

Table 1. Demographic summary of included studies

Study ID and year	Journal title	Respiratory illness	Causative virus	Age of patients [years]	Sample collected	Cells studied	Estimation technique	Observations				p-value	Conclusion T- lymphocyte level in respiratory illness
								Number of patients	CD4 ⁺ /CD8 ⁺ ratio	Number of healthy controls	CD4 ⁺ /CD8 ⁺ ratio		
He et al. 2005 [16]	<i>The International Journal of Infectious Diseases</i>	lower respiratory tract infections: severe acute respiratory syndrome pneumonia	SARS-associated coronavirus	<18	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	271	1.51 ±0.73	51	1.57 ±0.44	0.05	increases
Karsh et al. 2005 [17]	<i>Allergy, Asthma & Clinical Immunology</i>	lower respiratory tract infections: asthma, bronchitis	SARS-associated coronavirus	<18	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	30	2.28 ±1.3	25	4.0 ±1.3	0.005	increases
Pinto et al. 2006 [18]	<i>Pediatrics</i>	lower respiratory tract infections: bronchitis	respiratory syncytial virus	<1	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	42	2.5 ±2.01	21	3.7 ±0.65	0.001	increases
Kim et al. 2011 [19]	<i>Korean Journal of Pediatrics</i>	lower respiratory tract infections: bronchitis, pneumonia	influenza A virus (H1N1)	<18	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	16	0.86 ±0.24	13	1.61 ±0.49	0.01	increases
Connors et al. 2018 [20]	<i>Journal of Immunology</i>	lower respiratory tract infections: bronchitis	respiratory syncytial virus	<10	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	113	0.34 ±0.09	21	0.51 ±0.24	0.001	increases
Munteanu et al. 2019 [21]	<i>Experimental and Therapeutic Medicine</i>	lower respiratory tract infections: bronchitis	respiratory syncytial virus	<7	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	30	2 ±1	10	1.5 ±0.2	0.002	decreases
Gul et al. 2020 [22]	<i>Saudi Journal of Biological Sciences</i>	lower respiratory tract infections: bronchitis, pneumonia	HPIV	<12	throat or naso-pharyngeal swab	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	58	3.12 ±0.59	20	2.18 ±0.654	0.001	decreases
Li et al. 2020 [23]	<i>Journal of Infection</i>	lower respiratory tract infections: pneumonia	2019-nCoV	<6	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	40	1.57 ±0.69	16	1.73 ±0.57	0.424	increases
Cosgrove et al. 2021 [24]	<i>Pediatric Research</i>	upper respiratory tract infection: cough, congestion, rhinorrhea	rhinovirus	<18	nasal mucosa	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	54	3.58 ±2.07	9	4.98 ±2.32	0.0001	increases
Calapodopulos et al. 2021 [25]	<i>Jornal de Pediatria</i>	upper respiratory tract infection: tonsillitis, sinusitis	rhinovirus, influenza virus	<6	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	39	2.05 ±0.9	56	1.92 ±0.8	0.05	decreases
Lu et al. 2021 [26]	<i>BMC Pediatrics</i>	lower respiratory tract infections: pneumonia	2019-nCoV	<6	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	20	1.7 ±1.4	101	2.9±1.5	0.001	increases
Mahmoudi et al. 2021 [27]	<i>Frontiers in Pediatrics</i>	lower respiratory tract infections: pneumonia	2019-nCoV	<8	blood sample	T-cell subsets CD4 ⁺ and CD8 ⁺	flow cytometry	34	1.1 ±0.47	21	1.4 ±0.8	0.063	increases

SARS – severe acute respiratory syndrome; HPIV – human parainfluenza virus; 2019-nCoV – 2019 novel coronavirus.

Table 2. Risk assessment for included studies

Study ID and year of publication	He et al. 2005 [16]	Karsh et al. 2005 [17]	Pinto et al. 2006 [18]	Kim et al. 2011 [19]	Connors et al. 2018 [20]	Munteanu et al. 2019 [21]	Gul et al. 2020 [22]	Li et al. 2020 [23]	Cosgrove et al. 2021 [24]	Calapodopulos et al. 2021 [25]	Lu et al. 2021 [26]	Mahmoudi et al. 2021 [27]
Was a consecutive or random sample of patients enrolled?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Did the study avoid inappropriate exclusions?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Did all patients receive the same reference standard?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were all patients included in the analysis?	N	N	N	N	N	N	N	N	N	N	N	N
Was the sample frame appropriate to address the target population?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were study participants sampled in an appropriate way?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were the study subjects and the setting described in detail?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were valid methods used for the identification of the condition?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the condition measured in a standard, reliable way for all participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was there appropriate statistical analysis?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

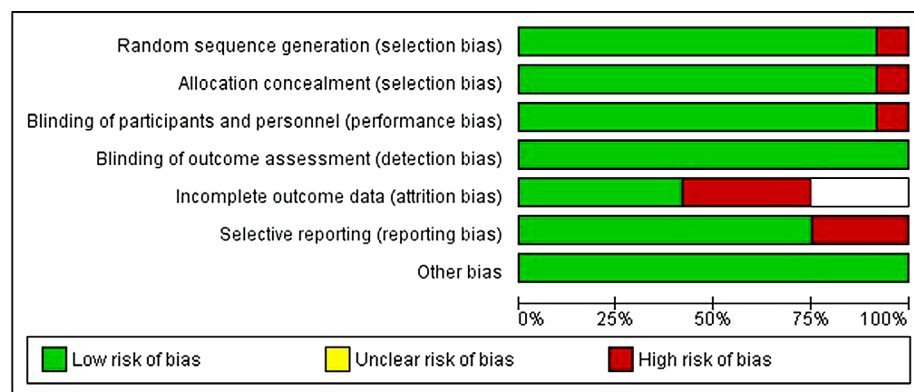


Fig. 3. Risk of bias graph

to occur. Because our calculated OR is also greater than 1, i.e., 3.66 with 95% CI ranging from 1.08 to 12.43, it confirms the increased likelihood of change in T-lymphocyte levels in children suffering from different respiratory tract infections. The high I^2 value of 97% indicates a high degree of heterogeneity of the data and a p-value of less than 0.05 indicates that the results of this meta-analysis are statistically significant. This proved that when a child has an acute respiratory tract infection (ARTI), the number of T-lymphocytes changes as an immune response to the virus.

The RR of the included studies was also calculated using RevMan software, and the resulting forest plot is displayed in Fig. 7. The location of diamonds in the OR and RR forest plots confirms that the likelihood of alteration in T-lymphocyte levels is higher in sick children as compared to healthy controls. Also, as the diamond shape is not touching the line of no effect, it confirms that the difference in the RR between the 2 study groups is statistically significant. We calculated a pooled RR of 1.91, with 95% CI ranging from 1.07 to 3.40. The RR was greater than 1, indicating that ill patients are more likely than healthy controls to exhibit changes in T-lymphocyte counts. Moreover,

the heterogeneity was high with a τ^2 value of 0.99, a χ^2 value of 283.45, a df value of 11, a Z value of 2.19, and a p-value of 0.030. These numbers point to a random sampling of data and the use of categorical research variables. A p-value of less than 0.05 indicates that the meta-analysis results are statistically significant. Hence, we can conclude that a change in T-lymphocyte levels in children with acute respiratory illness is more likely to occur.

Discussion

Pathogens cause severe illnesses and numerous complications when they invade our systems. However, the pathogen does not always triumph. Instead, our immune response is triggered, and soon after recognizing the invader, and winning immunogenicity over pathogenicity, it restores health. Children's immune systems are more active and respond faster by producing pathogen-specific antibodies via activated T-lymphocytes; in consequence, they combat the disease more effectively.

In their review article, Simon et al. state that innate and adaptive immune systems of a child are active and

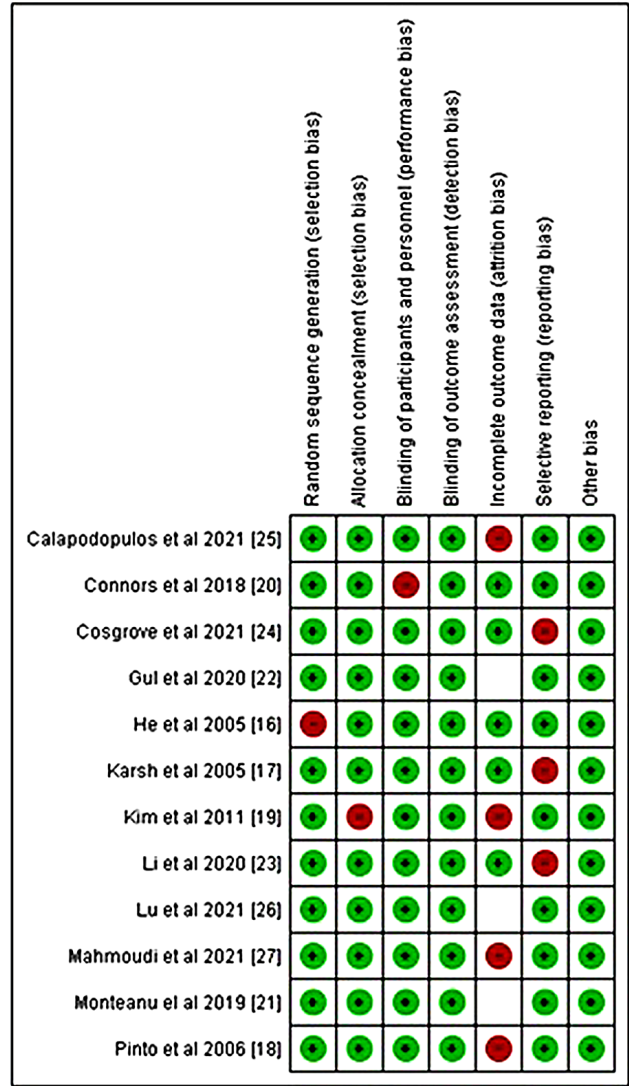


Fig. 4. Risk of bias summary

immature, but their efficacy diminishes with age.³² Similarly, Tosif et al. found that children are more sensitive to COVID-19 but, on account of their active immunity, they can mount an efficient immune response to severe

acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and prevent the infection with the virus.³³ The activity of the immune system can be measured by the number of B-cells, T-helper cells, cytotoxic T-lymphocytes, neutrophils, macrophages, and other immune response cells. The T-helper cells stimulate B-cells via their cytokines and help in the production of specific antibodies, hence the change in T-lymphocyte levels is usually measured in terms of the ratio of T-lymphocyte subsets CD4⁺ and CD8⁺ to assess the activated immune response.^{34,35} The CD4⁺/CD8⁺ ratio is the proportion of T-helper cells with CD4 on their surface to cytotoxic T-lymphocytes with CD8 on their surface.

Considering these reports, we also compared the change in the CD4⁺/CD8⁺ ratio reported in the included studies in children with recurrent respiratory illness when compared to healthy controls, measured with flow cytometry (it is presented in a column histogram in Fig. 8). The figure indicates that T-lymphocyte levels are altered and that is why we found the CD4⁺/CD8⁺ ratio either reduced or increased as compared to controls. Therefore, as a result of the altered CD4⁺/CD8⁺ ratio in the studies that were included, the OR value of 3.66 (95% CI: 1.08–12.43), the RR value of 1.91 (95% CI: 1.07–3.40), and the significance level of p 0.05, this meta-analysis came to the conclusion that T-lymphocyte levels are altered in children with acute respiratory illnesses, which is a symptomatic of infection and indicative of an activated immune response.

Limitations

The diversity of the respiratory tract infections analyzed, and the flow cytometry tests performed by different technicians may increase the likelihood of misleading concentration values, are the drawbacks of this study. Evaluating the comparative accuracy has an effect on the findings because many studies that reported equivalent T-lymphocyte values with healthy controls were not included in the analysis. Data from other relevant studies that indicate changes in T-lymphocyte levels

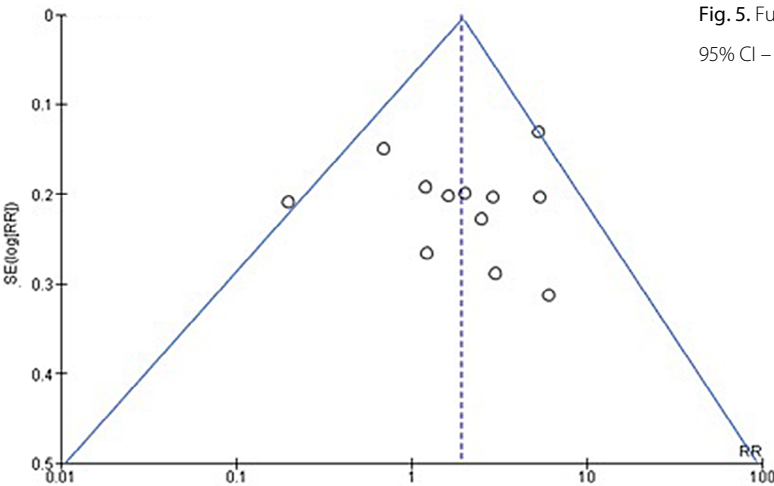


Fig. 5. Funnel plot for publication bias

95% CI – 95% confidence interval; RR – risk ratio; SE – standard error.

Publication Bias	
Egger's test	
Intercept	2.5959
95% CI	0.7216 to 4.4702
Significance level	P = 0.583
Begg's test	
Kendall's Tau	0.1429
Significance level	P = 0.772

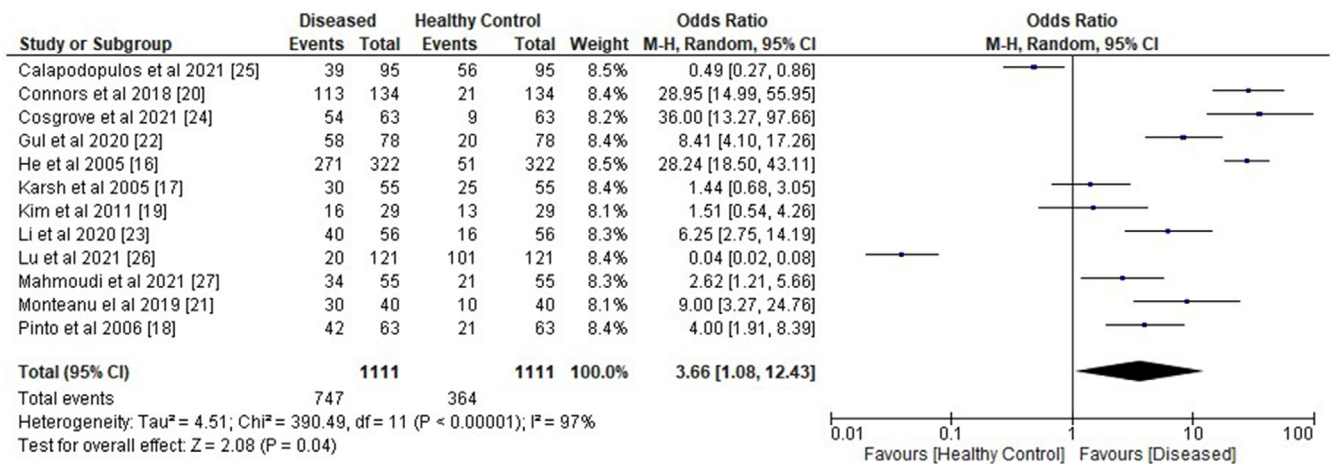


Fig. 6. Forest plot for odds ratio (OR)
95% CI – 95% confidence interval; df – degrees of freedom; M–H – Mantel–Haenszel.

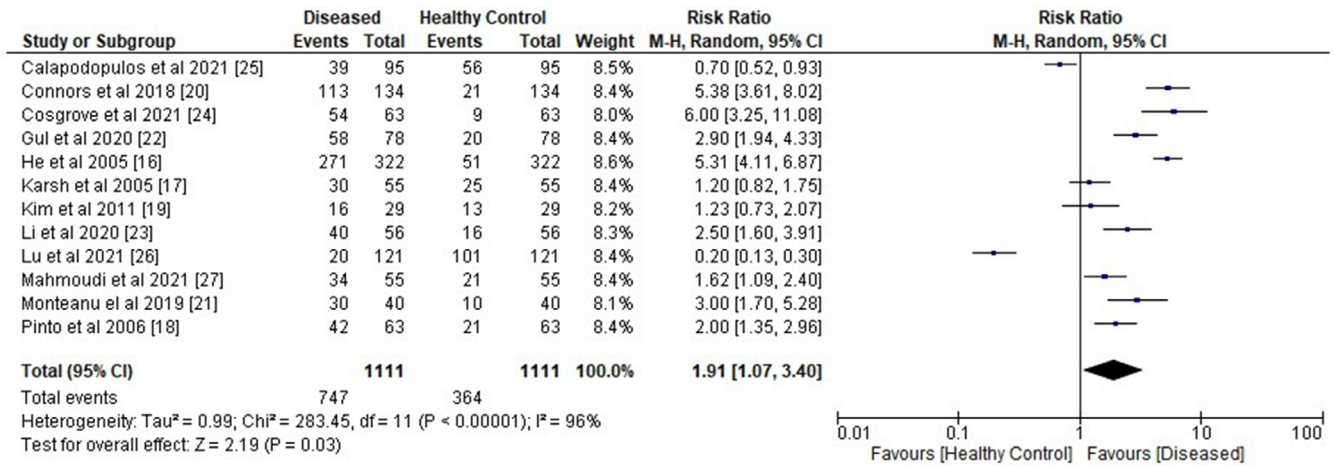


Fig. 7. Forest plot for risk ratio (RR)
95% CI – 95% confidence interval; df – degrees of freedom; M–H – Mantel–Haenszel.

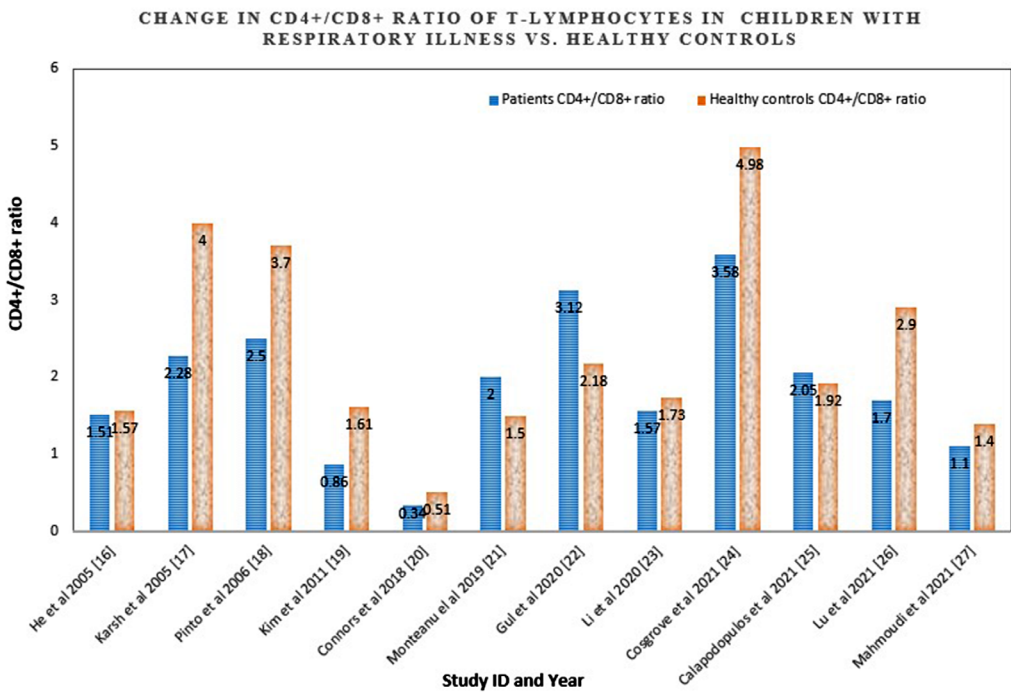


Fig. 8. Column histogram for change in T-lymphocyte subsets ratio

in children with recurrent respiratory disease can also be included to better illustrate the association. The role changed T-lymphocyte levels and acute respiratory disorders in children can be better elucidated if specific data on the patient's case history, physical examination and pathological tests are also used in the analyzes.

Conclusions

Since the T-lymphocyte levels are altered during infection, the association between T-lymphocytes and respiratory diseases in children was investigated in this systematic review and meta-analysis. Based on the statistically significant data ($p < 0.05$), we concluded that there is a strong link between T-lymphocyte levels and acute respiratory tract infections in children. The combined induction of virus-specific T-lymphocyte cells and enhanced antibody production in children with acute respiratory illness play a significant role in alleviating the infection at a faster rate by boosting their immunity.

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