



A Google Trends analysis revealed global public interest and awareness of nasal polyps

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Abstract

Introduction Nasal polyps (NPs) is a common upper airway inflammatory disorder with a huge negative burden on both the quality of life and costs to patients. However, NPs patients remain undiagnosed and untreated in a timely, which may be due to a lack of disease-related awareness. Google Trends (GT) is an online and open tool, which can provide real-world data on health informatics worldwide.

Objectives This study aimed to explore global public interest and awareness in nasal polyps (NPs) by performing a GT analysis.

Methods Data on relative search volume (RSV) for NPs globally were collected by the public website Google Trends from January 2007 to December 2021. Top-related topics, rising-related topics, and regions were extracted for further analysis. Seasonal variation analysis, the latitude difference analysis, and the rising-related topics between the developed countries and the developing countries were analyzed. A *P* value less than 0.05 was considered statistically significant.

Results The average searching strength showed an overall increasing trend, although with slight fluctuation. The public interest of NPs focuses on the symptoms and treatment for NPs and changes with time. For seasonal variation countries, the peak for the RSV occurred in winter and the bottom in summer. A region in higher latitudes may yield more RSV than that in lower latitudes. The rising-related topics in the recent 5 years reflected the significant differences in treatment and public interest of NPs between the developed and developing countries.

Conclusions Google Trends analysis revealed global public interest and awareness of the evolution of trends and related topics in nasal polyps over time. Geographic distribution and seasonal variation may be potential trigger factors for NPs, and the public's interest in treatment especially biologics is rising.

Keywords Nasal polyps · Google Trends · Analysis · Infodemiology · Rhinology

Introduction

Chronic rhinosinusitis (CRS), which a common upper airway inflammatory disorder with complex pathogenesis and different phenotypes and endotypes, CRS phenotypes are typically divided into with or without nasal polyps mainly based on the presence of polyps, and both innate and adaptive immunity systems were contributed to the heterogeneous pathogenesis of CRS [1–3]. With the higher incidence rate even affecting 5–12% of the general population worldwide, it is considered a significant public health problem that results from the huge negative burden on both the quality of life and costs to patients [4]. Chronic rhinosinusitis with nasal polyps (CRSwNP) is an important clinical phenotype which diagnosed based on the presence of nasal polyps, obvious, prevalent, and severe

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symptoms usually more than 12 weeks including anterior or posterior rhinorrhea, nasal congestion, hyposmia, and/or facial pressure or pain was presented in CRSwNP [4, 5]. In patients with CRSwNP, if the poor response or controlled to intranasal or systemic glucocorticoids intervention, surgery to remove the polyps should be considered, but higher rates of relapse and repeated intervention lead the otolaryngologists especially rhinologists face great challenges nowadays, also furthers results in the aggravating burden on quality of life and cost of patients [4, 6]. Currently, the high incidence trend of CRS was shown in recent years, actually, the higher recurrence and poor response to treatment rate of nasal polyps in patients of CRSwNP were highlighted in clinical practice, which furtherly leads to a huge quality of life and cost burden, also the patients increasingly use the Internet to search for health-related information, their health and relationship with their doctors could be affected as a result even affect clinical decision-making [7, 8].

With the rapid development and popularity of web-based sources as well as the use of the internet, while infodemiology also becomes a more popular and important part of the field of health informatics research in recent years. The infodemiology could provide us with some non-accessible otherwise information mainly through innovative and novel options and approaches for a health assessment with web-based data for analyzing, detecting, and forecasting diseases and epidemics, importantly which can predict human behavior on health topics, even aiming ultimately to inform public health and public policy. Search engines and social media have made it possible to handle user-generated data in real time in the form of infodemiology research that benefits from modern technologies, such as search engines and social media [9–12]. Among them, Google Trends is a wide-used search engine that is the most popular open tool for examining online behavior and also can provide some real-time information about trends and the changes in online interest in various keywords and topics over time, it has shown that Google search traffic data assist in predicting disease occurrence and outbreaks by analyzing human behavior toward health topics [13–16]. To date, the study of global public interest and awareness of nasal polyps was absent. Our study aimed to identify and determine the public interest and awareness that consist of annual trends, related topics, seasonal variation, geographic distribution, and the development influence of nasal polyps.

Methods

Searching tool and keyword selection

The study was performed between January and February 2022, and data were collected using the public web facility

Google Trends, available from <https://trends.google.com/trends/>. Time and country can be limited to comparison in Google Trends. For a particular search term, a scale from 0 to 100 was used to represent the relative volume of searches (RSV). A value of 100 represents the highest RSV in the defined period, and a value of 0 indicates a very low RSV. Take a further example, an RSV of 60 reflects 60% of the highest search volume monitored during the observation time. In our research, after comparing the average RSV of “nasal polyps” and “nasal polyp” as a medical condition (a topic) separately and the sum of the two keywords as the term (nasal polyps + nasal polyp), the latter one was finally selected, for it produced a higher value of the average RSV and indicated that it may include many other related searches in non-English speaking countries or people who were careless (Fig. 1).

Data query

On January 29, 2022, we queried Google Trends and downloaded the data. First, the time range was set from January 2007 to December 2021 and the category of “Health” was selected to exclude irrelevant information. Data of the “Worldwide” RSV were exported to Microsoft Excel. Top-related topics, rising-related topics, and regions were also extracted. In Google Trends, “Top-related topics” was defined as the most frequently searched topics, and “Rising-related topics” was defined as which had the highest growth in volume and was presented as a percentage of fold changes. Results marked “Breakout” had a tremendous increase of over 5000%, probably because these topics newly emerged with fewer previous searches. Non-related results were excluded manually. To examine the variation of the related topics and regions over time, we further subdivided the past 15 years into three 5 years: from January 1, 2007, to December 31, 2011, from January 1, 2012, to December 31, 2016, and from January 1, 2017, to December 31, 2021. The latitudes of the countries were obtained from the website of <https://www.latlong.net/>. For seasonal variation analysis, 3 countries whose official language was English were included. The United States was the representative from the Northern hemisphere, while Australia was the sample from the Southern hemisphere. Singapore was the representative of countries, where seasonal variation is not obvious. To compare the differences of the rising-related topics between the developed countries and the developing countries of the recent 5 years, 6 countries were included. United States, United Kingdom, and Australia were the representatives of the developed countries, while Pakistan, Brazil, and Malaysia were the representatives of the developing countries.

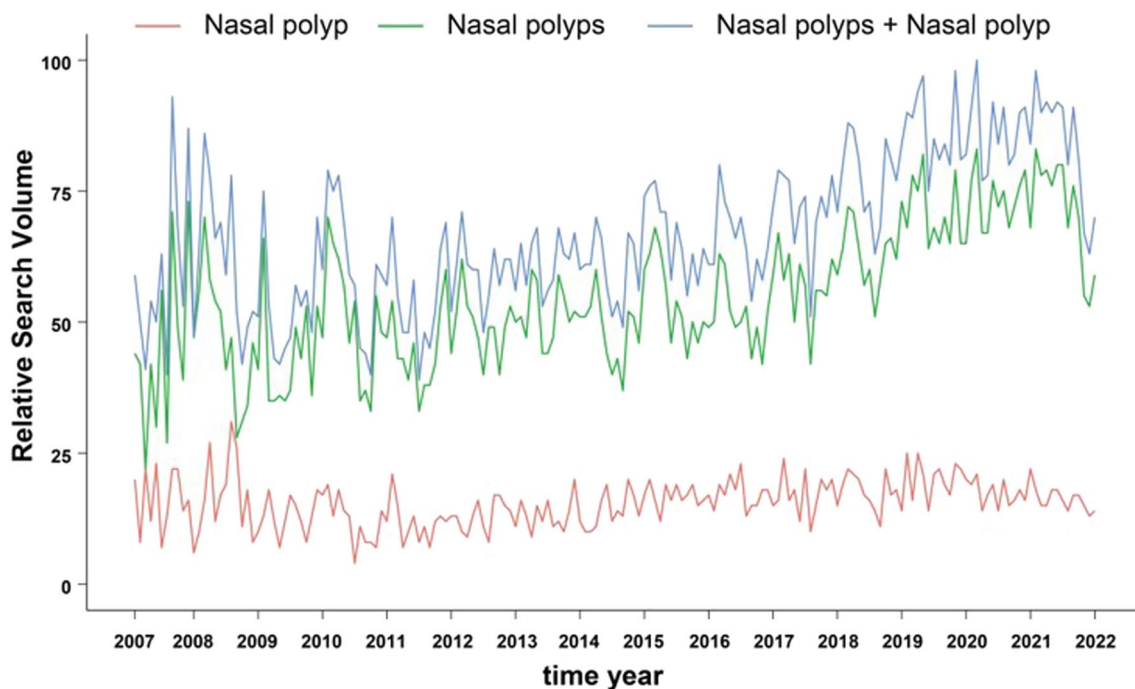


Fig. 1 Sum of the two keywords as the term (nasal polyps + nasal polyp) produced a higher value of the average RSV than “nasal polyps” and “nasal polyp” as a medical condition separately

Statistical analysis

All analysis was conducted on the R software (v 4.1.2), and the graphs were directly obtained from the plotting function of R. A cosinor model was used for seasonal analysis according to former research. A “ggplot2” package was applied to produce boxplots of seasonal variation for different countries and a smooth curve was added to the graphs. A *P* value less than 0.05 was considered statistically significant.

Ethical requirements

No animal experiments or clinical trials were involved in this study. Therefore, no permission from the ethics committee is required.

Results

Annual trends

Figure 2 shows the overall trends for RSV changing of nasal polyps over time. The maximum RSV appeared in February 2020, and the minimum value was observed in June 2011. The average searching strength showed an overall increasing trend, although with slight fluctuation. Interestingly, after the peak point, a decline in RSV was shown from years 2020 to 2021.

Related topics

The related topics in Nasal polyps from 2007 to 2021 are listed in Table 1. In top-related topics, “Polyp” was the most related ($n = 100$), followed by “Nasal polyp” ($n = 95$), “Nasal cavity” ($n = 72$), “Nose” ($n = 14$), “Sinusitis” ($n = 11$) and others. In rising-related topics, “Human nose”, “Sense of smell”, “Allergic rhinitis”, “Paranasal sinus and nasal cavity cancer”, “Fluticasone”, “Nasal irrigation”, “Paranasal sinuses”, “Functional endoscopic sinus surgery”, “Septum” and “Tea tree oil” were the “Breakout”. The rest of the top-related topics are also listed in Table 1.

The top 10-related topics of nasal polyps worldwide every 5 years from 2007 to 2021 were summarized for comparative analysis in Table 2. The results for top-related topics were consistent with the above ones. However, “Nasal spray” and “Spray” occurred in the top 10-related topics of the latter two 5 years.

We also compared the rising-related topics associated with the disease of nasal polyps every 5 years of the last 15 years, which are shown in Table 3. In the first 5 years, the most appearance includes the term “Sense of smell”, “Nasal irrigation”, “Nostril”, “Paranasal sinus and nasal cavity cancer”, “Mometasone”, “Dried nasal mucus”, “Therapeutic irrigation”, “Septum”, “Mucous retention cyst” and “Laser surgery”. In the second 5 years, the most appearance including the term “Tea tree oil”, “Beclometasone”, “Castor oil”, “Ethmoid bone”, “antrochoanal polyp”, “Nasopharyngeal

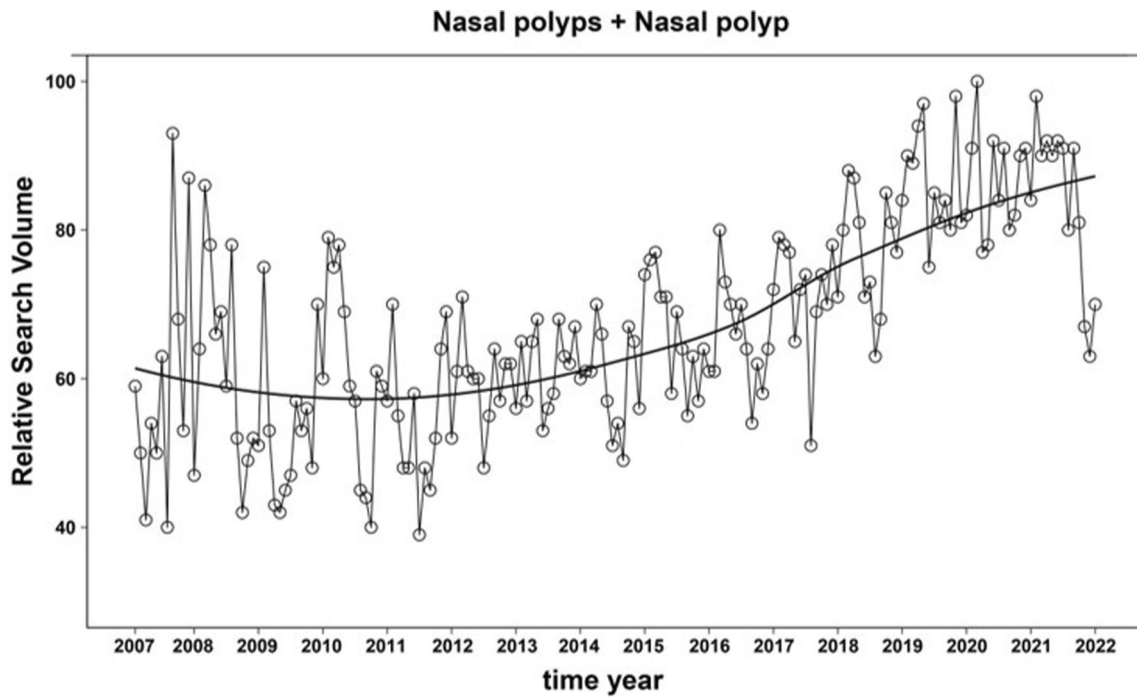


Fig. 2 Although with slight fluctuation, the average searching strength showed an overall increasing trend

Table 1 Top 10-related topics and rising-related topics in nasal polyps from years 2007 to 2021 worldwide

Top-related topics	Relative search volume	Rising-related topics	Changing fold
Polyp	100	Human nose	Breakout
Nasal polyp	95	Sense of smell	Breakout
Nasal cavity	72	Allergic rhinitis	Breakout
Nose	14	Paranasal sinus and nasal cavity cancer	Breakout
Sinusitis	11	Fluticasone	Breakout
Sinus	7	Nasal irrigation	Breakout
Spray	4	Paranasal sinuses	Breakout
Nasal congestion	3	Functional endoscopic sinus surgery	Breakout
Nasal administration	3	Septum	Breakout
Nasal spray	3	Tea tree oil	Breakout

Table 2 Top 10-related topics of nasal polyps every 5 years worldwide

2007–2011	RSV	2012–2016	RSV	2017–2021	RSV
Polyp	100	Polyp	100	Polyp	100
Nasal polyp	100	Nasal polyp	98	Nasal polyp	96
Nasal cavity	66	Nasal cavity	67	Nasal cavity	69
Nose	14	Nose	16	Nose	17
Sinusitis	13	Sinusitis	10	Sinusitis	9
Sinus	11	Sinus	8	Sinus	6
Nasal septum	4	Nasal congestion	4	Spray	4
Nasal administration	4	Human nose	3	Nasal spray	4
Nasal bone	4	Nasal spray	3	Nasal administration	4
Nasal congestion	4	Spray	3	Human nose	4

Table 3 Top 10 rising-related topics of nasal polyps every 5 years worldwide

2007–2011 rising topics	Changing fold	2012–2016 rising topics	Changing fold	2017–2021 rising topics	Changing fold
Sense of smell	Breakout	Tea tree oil	Breakout	Nasal vestibulitis	Breakout
Nasal irrigation	Breakout	Beclometasone	Breakout	Beclometasone	Breakout
Nostril	Breakout	Castor oil	Breakout	Omalizumab	Breakout
Paranasal sinus and nasal cavity cancer	Breakout	Ethmoid bone	Breakout	Dupilumab	1650%
Mometasone	Breakout	antrochoanal polyp	Breakout	Duckweeds	350%
Dried nasal mucus	Breakout	Nasopharyngeal carcinoma	Breakout	Nasal mucosa	300%
Therapeutic irrigation	Breakout	Spray	170%	Differential diagnosis	300%
Septum	Breakout	Nasal spray	120%	Dried nasal mucus	250%
Mucous retention cyst	Breakout	Nasal administration	120%	Sense of smell	110%
Laser surgery	Breakout	Nasal concha	120%	Spray	90%

carcinoma”, “Spray”, “Nasal spray”, “Nasal administration” and “Nasal concha”. In the recent 5 years, the most appearance including the term “Nasal vestibulitis”, “Beclometasone”, “Omalizumab”, “Dupilumab”, “Duckweeds”, “Nasal mucosa”, “Differential diagnosis”, “Dried nasal mucus”, “Sense of smell” and “Spray”. Table 3 shows the manifestations and treatment options of nasal polyps with time.

Seasonal variation

Figure 3 shows the seasonal variation of the disease of nasal polyps for RSV. For countries that have seasonal variation, the peak for the RSV occurred in winter (December to January for the United States, and around July for Australia) and a bottom in summer (December–January for Australia, and July for the United States) (*P* value < 0.001 for the United States, *P* value = 0.070 for Australia). For Singapore whose seasonal variation is not obvious, the curve was not fitted with the “cosinor” model (*P* value = 0.174).

Geographic distribution

The geographic distribution graph over time is shown in Table 4. From 2007 to 2011, Kenya had the highest RSV

(*n* = 100), followed by (*n* = 88), New Zealand (*n* = 66), United Kingdom (*n* = 50), and Australia (*n* = 50). From 2012 to 2016, Ireland had the highest RSV (*n* = 100), followed by United Kingdom (*n* = 92), Australia (*n* = 79), New Zealand (*n* = 73), Philippines (*n* = 72) and Nigeria (*n* = 66). From 2017 to 2021, Philippines had the highest RSV (*n* = 100), followed by United Kingdom (*n* = 98), Nepal (*n* = 98), New Zealand (*n* = 76), Ireland (*n* = 73) and Kenya (*n* = 72). Overall, a region in higher latitudes may yield more RSV than that in lower latitudes.

Development influence

In the recent 5 years, rising-related topics in developed countries are shown in Table 5. In the USA, the most appearance includes the term “Omalizumab”, “Nasal vestibulitis”, “Dupilumab”, “Nasal congestion”, et.al. In the UK, the most appearance includes the term “Nasal Corticosteroids”, “Aspirin exacerbated respiratory disease”, “Anosmia”, “Nasal vestibulitis”, “Chronic sinusitis”, “Prednisolone”, et.al. In Australia, the most appearance includes the term “Cystic fibrosis”, “Nasal administration”, “Nostril”, “Nasal spray”, et.al.

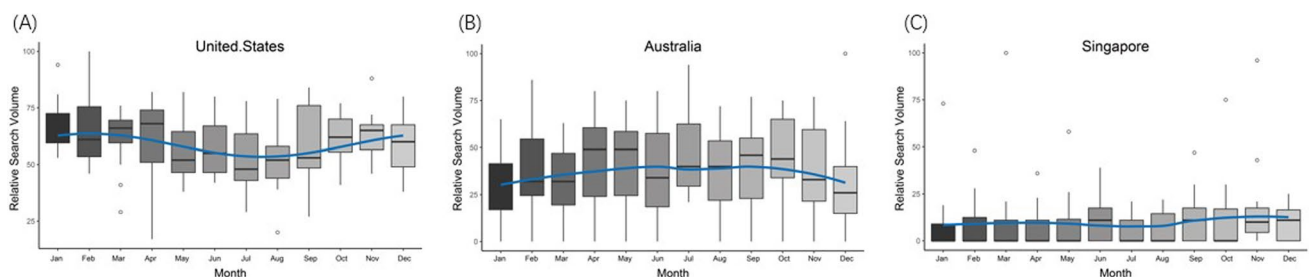


Fig. 3 Seasonal variation of the disease of nasal polyps in the United States (A *P* value < 0.001), Australia (B *P* value = 0.070) and Singapore (C *P* value = 0.174)

In the past 5 years, rising-related topics in developing countries are shown in Table 6. In Pakistan, the rising-related topics include “Homeopathy”, “Nasal congestion”, “Sense of smell”, “Asthma” and “Nasal administration”. In Brazil, the rising-related topics include “Polyp”, “Nasal polyp”, “Nasal cavity” and “Sinusitis”. In Malaysia, the rising-related topic was “Nasal congestion”.

Discussion

Health informatics research is becoming increasingly integrated with public data from the internet as a result of the development of the intelligent internet, the advantages and

competitiveness were shown in infodemiological studies for exploring human healthy behavior, including detecting the public interest and awareness of disease, understanding and monitoring the public's perception of disease management and treatment are also essential, Google Trends (GT) as an open tool which it can provide information on trends and the variations of online interest and usefulness was presented in analyzing human behavior toward health topics and in predicting disease occurrence and outbreaks, GT becoming the most popular tool for detecting online behavior [13, 14, 16]. In our study using Google search traffic data for further analysis, we revealed public interest and awareness that consist of annual trends, related topics, seasonal variation, geographic distribution, and the development influence of nasal polyps.

Table 4 Top RSV regions of nasal polyps every 5 years (geographic distribution)

2007–2011 Top Regions	RSV	Latitude	2012–2016 Top Regions	RSV	Latitude	2017–2021 Top Regions	RSV	Latitude
Kenya	100	– 0.02	Ireland	100	53.41	Philippines	100	12.88
Philippines	88	12.88	United Kingdom	92	55.38	United Kingdom	98	55.38
New Zealand	66	– 40.90	Australia	79	– 25.27	Nepal	98	28.39
United Kingdom	50	55.38	New Zealand	73	– 40.90	New Zealand	76	– 40.90
Australia	50	– 25.27	Philippines	72	12.88	Ireland	73	53.41
United States	47	34.58	Nigeria	66	9.08	Kenya	72	– 0.02
Ireland	46	53.41	Bangladesh	65	23.68	Australia	72	– 25.27
Singapore	46	1.35	Canada	64	56.13	Singapore	68	1.35
Canada	43	56.13	Singapore	60	1.35	United Arab Emirates	65	23.42
Malaysia	43	4.21	Kenya	59	– 0.02	Pakistan	64	30.38

Table 5 Rising-related topics in developed countries in the past 5 years

Topics in the USA	Changing fold	Topics in the UK	Changing fold	Topics in Australia	Changing fold
Omalizumab	Breakout	Nasal Corticosteroids	Breakout	Cystic fibrosis	Breakout
Nasal vestibulitis	Breakout	Aspirin exacerbated respiratory disease	Breakout	Nasal administration	Breakout
Dupilumab	Breakout	Anosmia	Breakout	Nostril	400%
Nasal congestion	1600%	Nasal vestibulitis	Breakout	Nasal spray	300%
Nostril	100%	Chronic sinusitis	Breakout	Nasal bone	300%
Nasal septum deviation	100%	Prednisolone	Breakout	Nasal septum deviation	250%
Human nose	90%	Sense of smell	110%	Spray	180%
Sense of smell	70%	Nasal bone	80%	Sense of smell	180%
Nose	70%	Nasal spray	60%	Nasal septum	180%
Nasal cavity	50%	Steroid	50%	Nasal congestion	180%

Table 6 Rising-related topics in developing countries in the past 5 years

Topics in Pakistan	Changing fold	Topics in Brazil	Changing fold	Topics in Malaysia	Changing fold
Homeopathy	Breakout	Polyp	100	Nasal congestion	Breakout
Nasal congestion	Breakout	Nasal polyp	86		
Sense of smell	Breakout	Nasal cavity	64		
Asthma	Breakout	Sinusitis	43		
Nasal administration	50%				

For searching annual trend that average RSV reflected, the average searching strength showed an overall increasing trend, the maximum RSV appeared in February 2020, and the minimum value was observed in June 2011, although with slight fluctuation, a decline of RSV from years of 2020 to 2021 after the peak point was showed (Figs. 1, 2), the public interest preferred COVID-19 pandemic duration should be considered as one of the main influencing factors. Overall, the searching increasing trend was presented in the past decade, which is not only closely associated with the rapid development and wide application of the internet, but may reflect the increasing public interest even or incidence rate of nasal polyps to some extent, although the complete real-world epidemiological study that can reflect incidence rate globally was absent to date. GT analysis can obtain the seasonal variation and geographic distribution information and provide a positive understanding for identifying the influence of geographic distribution and seasonal variation on health information and diseases [16–18], further analyzing both seasonal variation and geographic distribution in search of annual trend was performed in our study, we separately selected the different the northern and southern hemisphere countries who have obviously and no-obvious seasonal variation for identifying the seasonal variations, that included the United States, Australia and Singapore, and results demonstrated and supported the seasonal variation of nasal polyps for the RSV (Fig. 3), especially, the peak for the RSV occurred in winter (December–January for the United States, and around July for Australia), the peak for the RSV of seasonal variation may reflect that directly associated with the pathophysiological characteristics and mechanism of NP, actually, for nasal polyps' formation, which is a result of inflammatory outgrowths of paranasal sinus mucosa following chronic mucosal inflammation, although the pathogenesis is remained unclear, defects in the innate function of the airway epithelial barrier, including diminished expression of antimicrobial products and loss of barrier integrity, combined with colonization by fungi and bacteria likely all were probably contributed to chronic inflammation with elevated expression of many key inflammatory cytokines and chemokines, including IL-5, thymic stromal lymphopoietin (TSLP) and CCL11 in CRSwNP, these factors likely combine to drive the influx of a variety of immune cells, including eosinophils, mast cells, group 2 innate lymphoid cells and lymphocytes, which participate in the chronic inflammatory response within the nasal polyps [19, 20]. In short, the analysis of seasonal variation may reveal virus infection and allergic reactions closely associated with seasonal variation may be important external or environmental factors driving the worse of NP, although it is a multifactorial disease entity. Indeed, as consistent with previous studies, virus infection, especially the influenza virus can lead to abnormal nasal epithelium through a variety of complex interactions resulting

in aggravation of CRSwNP and further worsening the symptoms [21, 22]. Further analysis of geographical distribution shows that a region in higher latitudes may yield more RSV than that in lower latitudes, some cool-dry conditions can enhance influenza virus survival and transmissibility in temperate climates in high latitudes should be considered as one of the reasons [23]. In clinical practice, we should pay attention to or strengthen the understanding of the potential contribution of virus infection, especially influenza virus infection, to the deterioration of NP, and strengthen the policy of preventive immunization may be proposed or further emphasized in the patient with CRSwNP. In addition to viral infection, allergic reactions should also be considered an important environmental driver factor, polyps tissues usually contain high levels of T helper cell type 2 (Th2) cytokines IL-5 and IL-13 and high levels of histamine [24]. Therefore, the importance of seasonal virus infection and allergic reactions in worsening the symptoms of nasal polyps should be emphasized. The option of preseasonal biologics treatment has achieved better control of symptoms and quality of life in patients with seasonal allergic rhinitis and prevented seasonal asthma exacerbations [25, 26]. NPs, as a disease that may lead to exacerbations of symptoms due to seasonal variation, the study on whether NPs can also be treated with preseasonal to reduce the exacerbations of the symptoms, maybe an interesting focus in rhinology, allergy, and immunology fields in the future.

Tables 1 and 2 summarize the evolution trends of public interests over time. In top-related topics, “Polyp” was the most related ($n = 100$), followed by “Nasal polyp” ($n = 95$), “Nasal cavity” ($n = 72$), “Nose” ($n = 14$), “Sinusitis” ($n = 11$) and others, it also reflects that above topic associated with disease of NPs is still an important topic of public concern. Every 5 years as a timeline to further explain and evaluate the evolution trends of public interest in detail, “Nasal spray” and “Spray” occurred in the top 10-related topics of the latter two 5 years; therefore, it is obvious that care and management have become important public topics and focuses in disease of NPs. The rising topics more intuitively reflect and show the detailed transition of public interest though compared the rising-related topics associated with the disease of nasal polyps every 5 years of the last 15 years, especially in the topic of diagnosis and treatment. In addition to the differential diagnosis, the public interest has transit more obviously in the treatment options, from physical therapy options to topical glucocorticoids to biologics, such as omalizumab, dupilumab, and others, which is consistent with the current research route and hot spots of rhinology field that from the diagnosis to differential diagnosis and then to the treatment, and purposed to develop novel treatment options. Certainly, biologics have become the biggest public focus of NPs treatment, biologics targeting IgE and blockage of type 2 inflammatory cytokines such as IL-4,

IL-5, and IL-13 are rising to be a promising safe and effective treatment options in coprimary endpoint of nasal airway blockage improving and the need for rescue medical and/or surgical polypectomy reducing, such as dupilumab, omalizumab, mepolizumab, and others [27–29]. Comparing the rising-related topics between developed countries and developing countries that we selected in the past 5 years, we found the differences were presented in topics of public concern, which shows that developed countries are more interested in treatment, possibly may indirectly reflect the difference in awareness, but it does not exclude the lack of enough attention to the disease in developing countries or formerly developed countries. To sum up, the treatment of NPs is a most popular public concern topic, which is also similar to the current research hotspots in rhinology, allergy, and immunology, among them, the study on the best choice of biologics for the treatment of NPs is rising a research hotspot recently [28, 30].

A few limitations in our study should be considered and addressed, although GTs is an online and open tool and can provide real-world data on health informatics worldwide, not all countries in the world use Google as the search engine, possibly inadequate or not enough attention was attracted in some developing countries, and differences among countries also should be considered, since our analysis limits the professional terms, the terms entered using search engines may be non-professional for non-medical groups, so these factors should be considered. In summary, the results from our study provide some positive and interesting data for the optimization of clinical decision-making plans of NPs and the differences in public awareness, as well as possible research hotspots of NPs in the future globally.

Conclusion

Google Trends analysis revealed global public interest and awareness of the evolution of trends and related topics in nasal polyps over time. Geographic distribution and seasonal variation may be potential trigger factors for NPs, and the public's interest in treatment especially biologics is rising. Some positive and interesting data from Google Trends analysis further probably optimize the clinical decision-making plans of NPs and the differences in public awareness, as well as put a way for possible research hotspots of NPs in the future.

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Data Availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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