# Sustained reductions in online search interest for communicable eye and other conditions during the COVID-19 Pandemic: An Infodemiology Study

Michael S. Deiner, Gerami D. Seitzman, Stephen D. McLeod, James Chodosh, Thomas M. Lietman, Travis C. Porco

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Michael S. Deiner[1] PhD; Gerami D. Seitzman[1] MD; Stephen D. McLeod[1] MD; James Chodosh[2] MD, MSc; Thomas M. Lietman[3] MD; Travis C. Porco[3] MPH, PhD

[1]F. I. Proctor Foundation and Department of Ophthalmology University of California, San Francisco San Francisco US
[2]Department of Ophthalmology Massachusetts Eye and Ear, Harvard Medical School Boston US
[3]F. I. Proctor Foundation, Department of Ophthalmology, and Department of Epidemiology and Biostatistics, Global Health Sciences University of California, San Francisco San Francisco US

**Corresponding Author:**
Travis C. Porco MPH, PhD
F. I. Proctor Foundation, Department of Ophthalmology, and Department of Epidemiology and Biostatistics, Global Health Sciences
University of California, San Francisco
490 Illinois St, Floor 2 Box 0944
San Francisco
US

## *Abstract*

**Background:** At the start of the COVID 19 pandemic, we found reduced numbers of google searches for the term conjunctivitis. We hypothesized that physical distancing during COVID-10 reduced the spread of contagious eye disease. Here we test this hypothesis a year later, expanding to include other communicable conditions.

**Objective:** Determine if reduction in USA searches for terms related to conjunctivitis and other common communicable diseases occurred in spring-winter of the COVID-19 pandemic, and compare this outcome to terms representing non-communicable conditions, COVID-19, and to seasonality.

**Methods:** Weekly relative search frequency volume data from Google trends for 68 search terms in English for the USA, were obtained for the weeks of March 2011 through February 2021. Terms were classified a priori as 16 terms related to COVID-19, 29 terms representing communicable conditions and 23 terms representing control non-communicable conditions. To reduce bias, all analyses were conducted while masked to term names, classifications and locations. To test for the significance of changes during the pandemic, we detrended and compared post-pandemic values to that expected based on pre-pandemic trends, per season, computing 1 and 2 sided P-values. We then compared these P-values between term groups using Wilcoxon rank-sum and Fisher exact tests to assess if non-COVID terms representing communicable disease were more likely to show significant reductions in search in 2020-21 than terms not representing such disease. We also assessed any relationship between a term's seasonality and reduced search for it in 2020-21 seasons. P-values were subjected to FDR correction prior to reporting. Data were then unmasked.

**Results:** Terms representing conjunctivitis and other communicable conditions had sustained reduced search in the first 4 seasons of the 2020-2021 COVID-19 pandemic, compared to prior years. In comparison, search for non-communicable condition terms was significantly less reduced (Wilcoxon and Fisher's Exact Tests, P < 0.001; summer, autumn, winter). A significant correlation was also found between reduced search for a term in 2020-21 and seasonality of that term (Theil-Sen, P < 0.001; summer, autumn, winter). COVID-19 related conditions were significantly elevated compared to prior years, and influenza-related terms were significantly lower than prior years in winter 2020-21 (P < 0.0001).

**Conclusions:** We demonstrate the low-cost and unbiased use of online search data to study how a wide range of conditions may be affected by large-scale interventions or events such as social distancing during the COVID-19 pandemic. Our findings support emerging clinical evidence implicating social distancing and the COVID-19 pandemic in the reduction of communicable disease. They also agree with elevation of ocular conditions suggested to be linked to COVID-19 infection or behavioral changes such as mask-wearing. Clinical Trial: Not applicable

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# Title Page

## Title

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## Authors

Michael S. Deiner Ph.D.[1], Gerami D. Seitzman M.D.[1], Stephen D. McLeod M.D.[1], James Chodosh M.D. M.P.H.[2], Thomas M. Lietman M.D.[1], Travis C. Porco, Ph.D. M.P.H.[3]

## Affiliations:

1.  F. I. Proctor Foundation, University of California, San Francisco, San Francisco, California; Department of Ophthalmology, University of California, San Francisco, San Francisco, California.

2.  Department of Ophthalmology, Massachusetts Eye and Ear, Harvard Medical School, Boston, Massachusetts.

3.  F. I. Proctor Foundation, University of California, San Francisco, San Francisco, California; Department of Ophthalmology, University of California, San Francisco, San Francisco, California; Department of Epidemiology and Biostatistics, Global Health Sciences, University of California, San Francisco, San Francisco, California.

## Corresponding Author and Address for Reprints:

Travis Porco, F.I. Proctor Foundation, University of California San Francisco, 513 Parnassus, San Francisco, CA 94143. Electronic address: travis.porco@ucsf.edu

## Financial Support:

## Conflict of Interest:

No conflicting relationship exists for any author.

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**Conclusions:** We demonstrate the low-cost and unbiased use of online search data to study how a wide range of conditions may be affected by large-scale interventions or events such as social distancing during the COVID-19 pandemic. Our findings support emerging clinical evidence implicating social distancing and the COVID-19 pandemic in the reduction of communicable disease. They also agree with elevation of ocular conditions suggested to be linked to COVID-19 infection or behavioral changes such as mask-wearing.

**Trial Registration:** Not applicable

**Keywords:** Conjunctivitis, Ocular Symptoms, COVID-19, Pandemic, Communicable Disease,

Infodemiology, STD, Google Trends, Influenza, Seasonality

# Introduction

Clinical studies of the COVID-19 pandemic have suggested potential links between the COVID-19 pandemic with changes in health conditions[1–10]. This includes studies and reports on ocular symptoms and health[11–25]. Online searches and social media reflect the clinical seasonality and epidemics of conjunctivitis[26–29]. Previously, we found evidence that during the start of the COVID-19 pandemic (through April 2020), some ocular-related terms (in multiple languages on a worldwide level) showed increased search. These included "burning", "sore" and "red" eyes[30]. Subsequently, other studies of search data through June 2020 found a strong correlation between some ocular search terms and cases of COVID-19 on a country-level in Europe[31]. In our prior study, searches for English language conjunctivitis and pink eye terms in March and April 2020 were lower compared to in prior years. We hypothesized that social distancing in the USA due to the COVID-19 pandemic may have reduced the spread of conjunctivitis, a communicable disease[30].

Here, using masked analyses of searches geolocated to the USA, we further explore our hypothesis. We assessed whether a reduction in searching occurred for conjunctivitis in the USA, compared to the prior 9 years. We then assessed whether this was sustained for multiple seasons throughout the COVID-19 pandemic in 2020-2021 (2020-21). We also assessed whether search volume decreased search for other common school- and workplace-based communicable diseases. These included strep throat, chicken pox, common cold, as well as other conditions of acute exposure such as STDs, and bug bite. We compared the results for that class of terms (referred to as "communicable") to searches for control "non-communicable" conditions, including some ocular terms for which we had previously found had increased search activity at the start of the pandemic[30,31]. We also assessed whether terms with stronger seasonal variation were more likely to have decreased search during the COVID-19 pandemic. In addition, we assessed whether there was sustained change across multiple seasons, compared to the prior 9 years, for the group of terms we had classified as COVID-19 pandemic-related (related to search about distinguishing or identifying COVID-19 symptoms).
# Methods

## Google search data

Weekly relative search frequency volume (RSV) data from Google trends for search terms in English for the USA, were obtained for the weeks of 3/1/2011 through 2/28/2021 as previously described[29]. Terms were chosen based on our prior studies[30], COVID-19, and on common terms used in the USA for communicable and non-communicable conditions. Some terms served as a surrogate for ambiguously named conditions, to improve health-specificity of search data (e.g. we used "*cold medicine*" for a common cold; "*shingles treatment*" for shingles). Classifications were assigned *a priori*. Terms and classifications are shown in Tables 1-2 (Column 1). We classified 16 terms as COVID-19 pandemic-related conditions including respiratory, allergic or flu-like terms (as we assumed they may represent symptomatic search for those affected by, or initially concerned about, COVID-19). We also included 29 terms we classified as communicable (communicable conditions unrelated to the COVID-19 pandemic) and 23 terms we classified as non-

communicable (control non-communicable conditions, less likely related to the COVID-19 pandemic).

## Masking of terms, classifications and location

To reduce bias, actual search terms were masked using numeric codes before the data were analyzed. To further mask, data for the same terms for two other masked countries were also included, Names of our assigned classification groups were also encoded. In this way, those persons assessing statistical outcomes were naïve to the actual terms and to their assigned classifications, as well as to the country of search term origin.

## Statistical Analysis

**Overview**: The masked statistical analysis, described in detail below, included identifying seasonal search features for each term. It also included fitting models, for spring (Mar-May 2020), summer (Jun-Aug 2020), autumn (Sep-Nov 2020) and winter (Dec-Feb 2020-2021) in order to contrast search interest during each season of the first year of the pandemic with that season from the prior 9 years, to identify seasons for each term that differed (as well as that specifically were reduced) during the pandemic compared to the prior 9 years. We then compared those results for terms representing different classes of conditions, as well as to the seasonality of terms, as described in detail below.

**Search in 2020-21 Seasons Compared to in Prior Years**: To test for the significance of changes in the period following March 2020, the following algorithm was used. For more complete series (time series with fewer than 20% missing), we detrended the time series using the residuals from Theil-Sen regression with respect to calendar time for the pre-COVID epoch. Theil-Sen regression is a nonparametric regression procedure designed to minimize the influence of outliers, and is suitable when only a single regressor is used to model an outcome variable. Thus, when sufficient data were available, we compared post-pandemic values to what would have been expected based on pre-pandemic trends. We then compared the levels of search for spring 2020 (and the other seasons) to the pre-COVID trend line as follows. We conducted robust linear mixed effects regression comparing the residuals of observations for each season, thus comparing the level for spring 2020, summer 2020, autumn 2020, and winter 2021 to the corresponding times of previous years. We computed both 1 and 2 sided $P$-values. Significant 2-sided $P$-values represented a $P$-value for search change (increase or decrease) in 2020-21 compared to prior years. Significant 1-sided $P$-values represented a $P$-value for search reduction in 2020-21 compared to prior years. For time series containing more than 20% missing (or zero) data, we performed robust mixed regression using indicators for spring, summer, autumn, and winter of 2020 as predictors (clustering on year); one and two sided $P$-values were computed using the standard normal distribution. This analysis only compared values for each season after the pandemic began to those before. We interpreted all significant 2-sided $P$-values as indicating an increase if significance was not also seen using the 1-sided tests specific to identifying decreases. All computations were conducted using R for MacIntosh v.4.0 (R Foundation for Statistical Computing, Vienna, Austria); R packages *mblm* and *robustlmm* were used for Theil-Sen and robust linear mixed models (respectively).

**Comparing Communicable to Non-Communicable Reductions in Search in 2020-21 Seasons**: We then conducted an analysis of the previously calculated *P*-values for search reduction by term groups to ask if non-COVID terms representing communicable disease were more likely to show significant reductions in search in 2020-21 than non-communicable terms. We compared the *P*-values for search reduction between these two groups using the Wilcoxon rank-sum test. Similarly, we assessed the binary classification of significance at the 0.05 level using the Fisher exact test (where a significant *P*-value indicates a difference in the proportion of *P*-values less than 0.05 found between the 2 groups).

**Determining Seasonal Characteristics and Assessing Relationship to Reductions in 2020-21**: Standard circular statistical methods were used for seasonal analysis, computing the circular mean, a measure of central tendency for the occurrence time of searches within the yearly cycle[32]. We also report the amplitude-to-mean (AtM) ratio (the ratio of the difference between the peak and the mean to the mean itself) as an estimate of the degree of seasonality. Large AtM values correspond to large swings or oscillations, while small values correspond to minor fluctuations on a yearly cycle. Statistical significance of seasonality per term was assessed using Morlet wavelets, reporting the largest daily *P*-value for the power at the annual cycle over the course of the time series (excluding the first and last years). This provided a conservative requirement for consistency of the annual cycle for all years. Calculations were performed using R package WaveletComp. Using the *P*-values reflecting seasonality for a term, for each season, we then also assessed if there was a relationship between the *P*-value for search reduction in 2020-21 and the seasonal *P*-value for that term. This was assessed using Theil-Sen regression.

**Unmasking, Describing and Visualizing Results**: After all statistical analyses were completed, search terms, country and classifications were then un-encoded (unmasked). The weekly (x axis) and resulting mean search interest values (y axis) for terms are plotted in Figures 1 and 2. Weekly data is plotted as a log transform of the raw mean values+1 for improved scaling and visualizations. Seasons are indicated with vertical dashed line separators. The 2020 weekly mean search values are plotted as a red solid line and 2021 as red dashed line, 2017-2019 plots are gold, 2014-16 are green, and 2011-13 are blue. *P*-values at the top of each panel for any season indicate if searches in 2020-21 were significantly different overall (red, *P*-values for search change) or specifically lower (blue, *P*-values for search reduction), compared to the same quarters in 2011-2019. Missing values indicate *P*-values were *P*>.05) for search change (red) and/or for search reduction (blue). In addition, the overall seasonality is presented for each term (black text on lower left of each panel in Figures 1-2) indicating if a term is seasonal. If significantly seasonal (as defined here as *P*<.05), the amplitude to mean ratios (as an indicator of relative seasonal strength) and a circular mean week (as an indicator of the peak high season) are provided. All of the statistical values described above and included in Figures 1-2 are also presented in Tables 1-2. For *P*-values presented in all tables and figures, we subjected *P*-values to FDR correction prior to reporting. This study has UCSF IRB approval (#14-14743) and adhered to the Declaration of Helsinki.

# Results

Overall, we found that in the start of the pandemic (spring 2020), many terms of all 3 classifications appeared to have patterns of search that differed from prior years. Some changes persisted for subsequent seasons. Further description and statistical analysis is described below.

## COVID-related search during the pandemic

Of the terms we had *a priori* classified as COVID-19 pandemic-related, resulting quarterly *P*-values for search change and for search reduction as well as plotted data indicated significant search increases, compared to in prior years. Increases were observed for spring and summer 2020-21 and often in additional seasons. A common exception was that several potentially flu-related terms switched to a significant decrease in winter 2020 ($P < 0.0001$) (see Figure 1 and Table 1).
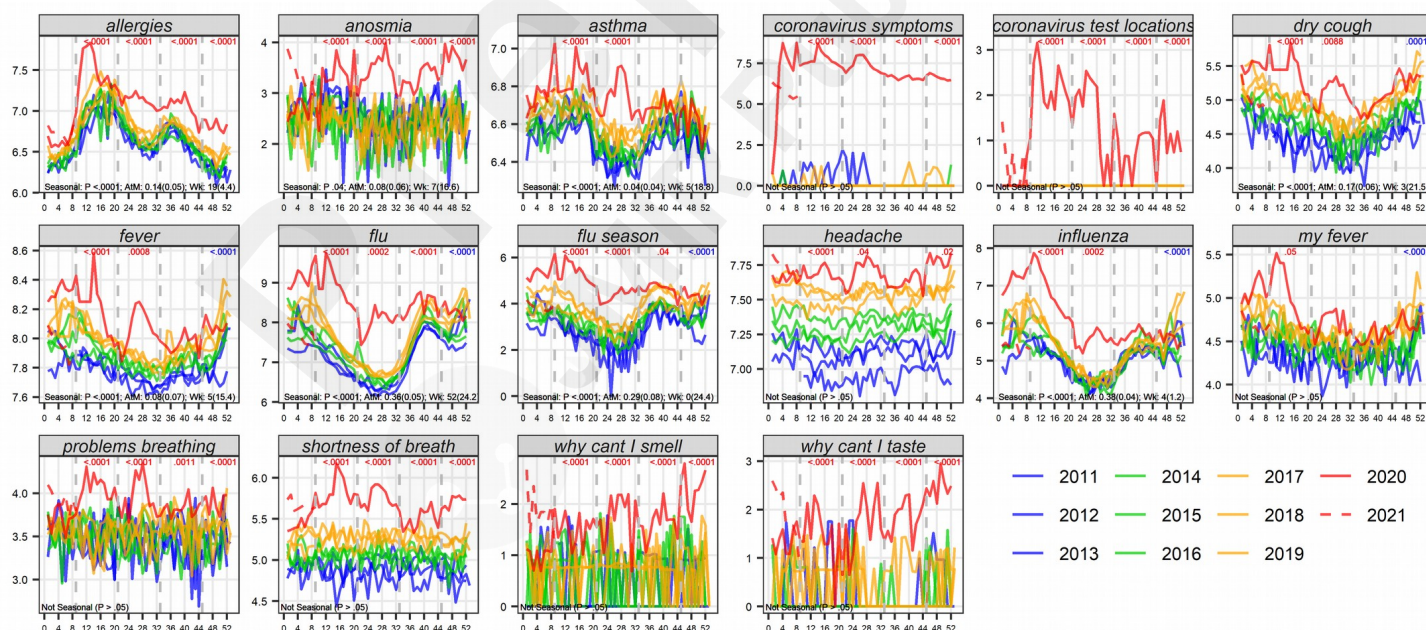


**Figure 1: Search interest for COVID-19 related terms in 2020-21 seasons compared to the same seasons in 2011-2019** Time series annual mean weekly search interest for COVID-19 related terms are shown. In each panel, representing results for one term, the x axis indicates week of the year, and y axis indicates weekly mean search interest values (log-transformed for presentation purposes) for terms. The 2020 weekly mean search values are plotted as a red solid line and 2021 as red dashed line, 2017-19 values

are gold, 2014-16 are green, and 2011-13 are blue. The 4 seasons are separated with vertical dashed lines. *P*-values at the top of each panel for each season indicate if searches in that season of 2020-21 were significantly (defined here as *P*<0.05) different overall (red, 2-sided test) than compared to the detrended average for the same quarters in 2011-2019. Significant reductions in search in 2020-21 seasons compared to prior years are indicated by blue *P*-values. *P*-values of *P*>.05 are not shown. In addition, the overall seasonal characteristics we reassessed for each term (black text on lower left of each panel) including a seasonality *P*-value. For terms with seasonality *P*-values of *P*<.05, the amplitude to mean ratios ("AtM") are also provided as an indicator of relative seasonal strength, and a circular mean week ("Wk.") is provided as an indicator of the peak high season (assuming annual seasons), with standard deviations in parentheses. Of note, this group of terms includes those we classified as potentially related, due to the public's concern about conditions with symptoms similar to those of COVID-19 (such as Flu and Allergy).

| Term | *Seasonality* | | | *Differs from Prior Yrs.* | | | | *Lower than Prior Yrs.* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Seasonal** | **AtM** | **Week** | **Spr2** | **Sum2** | **Aut2** | **Win2** | **Spr1** | **Sum1** | **Aut1** | **Win1** |
| **Covid-related terms** | | | | | | | | | | | |
| "allergies" | **<.0001** | 0.14(0.05) | 19(4.4) | **<.0001** | **<.0001** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | >.99 |
| "anosmia" | 0.04 | 0.08(0.06) | 7(16.6) | **<.0001** | **<.0001** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | >.99 |
| "asthma" | **<.0001** | 0.04(0.04) | 5(18.8) | **<.0001** | **<.0001** | 0.13 | 0.25 | >.99 | >.99 | 0.11 | 0.17 |
| "coronavirus | >.99 | | | **<.0001** | **<.0001** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | >.99 |
| "coronavirus test | >.99 | | | **<.0001** | **<.0001** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | >.99 |
| "dry cough" | **<.0001** | 0.17(0.06) | 3(21.5) | **<.0001** | **0.0088** | 0.33 | **0.0002** | >.99 | >.99 | 0.27 | **0.0001** |
| "fever" | **<.0001** | 0.08(0.07) | 5(15.4) | **<.0001** | **0.0008** | 0.86 | **<.0001** | >.99 | >.99 | 0.86 | **<.0001** |
| "flu" | **<.0001** | 0.36(0.05) | 52(24.2) | **<.0001** | **0.0002** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | **<.0001** |
| "flu season" | **<.0001** | 0.29(0.08) | 0(24.4) | **<.0001** | **<.0001** | 0.04 | **<.0001** | >.99 | >.99 | >.99 | **<.0001** |
| "headache" | 0.22 | | | **<.0001** | 0.04 | 0.43 | 0.02 | >.99 | >.99 | >.99 | >.99 |
| "influenza" | **<.0001** | 0.38(0.04) | 4(1.2) | **<.0001** | **0.0002** | 0.1 | **<.0001** | >.99 | >.99 | >.99 | **<.0001** |
| "my fever" | 0.13 | | | 0.05 | 0.13 | 0.86 | **<.0001** | >.99 | >.99 | 0.66 | **<.0001** |
| "problems breathing" | >.99 | | | **<.0001** | **<.0001** | **0.0011** | **<.0001** | >.99 | >.99 | >.99 | >.99 |
| "shortness of breath" | 0.43 | | | **<.0001** | **<.0001** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | >.99 |
| "why cant I smell" | >.99 | | | **<.0001** | **<.0001** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | >.99 |
| "why cant I taste" | 0.61 | | | **<.0001** | **<.0001** | **<.0001** | **<.0001** | >.99 | >.99 | >.99 | >.99 |

**Table 1: Search interest for COVID-19 related terms in 2020-21 seasons compared to the same seasons in 2011-2019.** This table summarizes the statistical values described and presented in Figure 1. Of note, influenza related terms were lower in winter than in prior years. "Seasonal" is a *P*-value indicating if annual search for years 2011-2019 is seasonal. For terms with seasonality *P*-values of *P*<.05, the amplitude to mean ratios ("AtM") are also provided as an indicator of relative seasonal strength, and a circular mean week ("Wk.") is provided as an indicator of the peak high season (assuming annual seasons), with standard deviations in parentheses. "Spr2-Win2" are 2-sided *P*-values indicating a change in search from prior years for that season. "Spr1-Win1"are 1-sided *P*-values indicating a decrease in search from prior years for that season. *P*-values >0.05 are gray and <=0.01 are bold.

## Infectious eye and other communicable vs. non-communicable classification groups

The two ocular terms we had classified *a priori* as communicable, "Conjunctivitis" and "Pink Eye" both had significant reductions for all 4 seasons of 2020-21 ($P < 0.0001$) compared to prior years. Overall, in 2020-21 these and other communicable condition search terms appeared to have more reductions in search than for control non-communicable terms. To test this hypothesis further, we compared the *P*-values for search changes and reductions between the communicable class of terms and the non-communicable class (excluding COVID-19 related terms) as follows below.

## Statistical comparison of communicable vs. non-communicable, non-COVID classifications

We first assessed if *P*-values for search change in the non-COVID communicable term group differed significantly from *P*-values for search change in the non-communicable group (Figure 2, red *P*-values; Table 2, Column 5-8). In spring 2020, we found no evidence for a significant difference between these groups for the values of the P values (Wilcoxon rank sum test, *P*=.99) or in the proportion of search terms with significant P values (Fisher's Exact Test, *P*=.83). In contrast, for the subsequent 3 seasons in 2020-21, the levels of searches were significantly different in 2020-21 (compared to past years) for the communicable vs. control non-communicable groups of terms. This was observed when comparing the values of the P values per group (Wilcoxon rank sum test: summer *P*=.045, autumn *P*=.02, winter *P*=.006). Similarly, the proportion of search terms with significant searched changes in 2020-21 was significantly higher for the communicable group compared for the non-communicable group (Fisher's Exact Test: summer *P*=.01, autumn *P*=.01, winter *P*=.003). These results are indicated in the column headers of Table 2 Columns 5-8.

We also assessed specifically if significant reductions in search, differed for the communicable and non-communicable classifications of non-COVID terms groups. To do so, we compared the *P*-values for search reduction (see Table 2, Columns 9-12) between groups, by season. We found little evidence for a significant difference in overall reductions in search between these groups in spring 2020 (Wilcoxon rank sum test: *P*=.04, Fisher's: *P*=.09). For each of the subsequent 3 seasons in 2020-21, the levels of search were much more significantly reduced in 2020-21 (compared to past years) for the communicable class of terms than for the non-communicable term group (Wilcoxon rank sum test: summer *P*=.0006 , autumn *P*<.0001, winter *P*<.0001; Fisher's Exact Test: summer *P*=.0006 , autumn *P*=.0004, winter *P*=.0007). These results are indicated in column headers of Table 2 Columns 9-12.
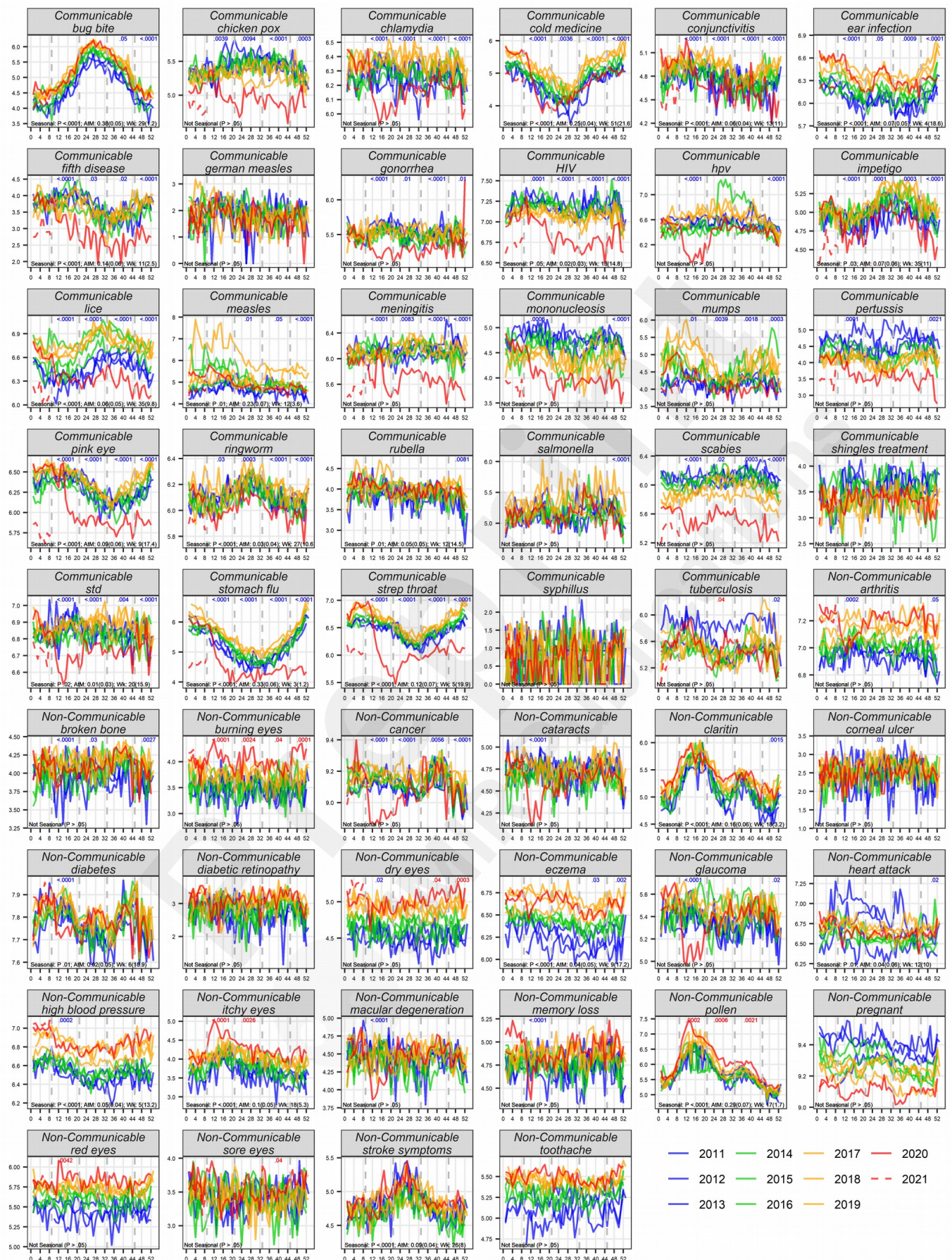
**Figure 2: Search interest for non-COVID, communicable and non-communicable terms in 2020-21 seasons compared to the same seasons in 2011-2019.** Time series annual mean weekly search interest, *P-*

values indicating changes in 2020-21 and seasonal values are as described for Figure 1. Panel labels indicate communicable (shown first) and non-communicable (shown second) classes that were compared using Wilcoxon rank sum test and Fisher's Exact Test (described in the text and Table 2).

| Term | *Seasonality* | | | *Differs from Prior Yrs.* | | | | *Lower than Prior Yrs.* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Seasonal** | **AtM** | **Week** | **Spr2** (-/-) | **Sum2** (*/*) | **Aut2** (*/*) | **Win2** (*/*) | **Spr1** (*/-) | **Sum1** (*/*) | **Aut1** (*/*) | **Win1** (*/*) |
| **Communicable and/or Acute exposure conditions(non-covid)** | | | | | | | | | | | |
| *"bug bite"* | **<.0001** | 0.38(0.05) | 29(1.2) | 0.54 | 0.43 | 0.06 | **<.0001** | 0.41 | >.99 | 0.05 | **<.0001** |
| *"chicken pox"* | 0.06 | | | **0.0047** | **0.0088** | **<.0001** | **0.0004** | **0.0039** | **0.0094** | **<.0001** | **0.0003** |
| *"chlamydia"* | 0.83 | | | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** |
| *"cold medicine"* | **<.0001** | 0.25(0.04) | 51(21.6) | **<.0001** | **0.0031** | **<.0001** | **<.0001** | **<.0001** | **0.0036** | **<.0001** | **<.0001** |
| *"conjunctivitis"* | **<.0001** | 0.06(0.04) | 13(11) | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** |
| *"ear infection"* | **<.0001** | 0.07(0.05) | 4(18.6) | **<.0001** | 0.05 | **0.0011** | **<.0001** | **<.0001** | 0.05 | **0.0009** | **<.0001** |
| *"fifth disease"* | **<.0001** | 0.14(0.06) | 11(2.5) | **<.0001** | 0.03 | 0.02 | **<.0001** | **<.0001** | 0.03 | 0.02 | **<.0001** |
| *"german measles"* | 0.38 | | | 0.71 | 0.91 | 0.81 | 0.21 | 0.97 | 0.9 | 0.63 | 0.14 |
| *"gonorrhea"* | 0.48 | | | **<.0001** | **0.01** | **<.0001** | 0.02 | **<.0001** | **0.01** | **<.0001** | **0.01** |
| *"HIV"* | 0.05 | 0.02(0.03) | 13(14.8) | **0.0001** | **<.0001** | **<.0001** | **<.0001** | **0.0001** | **<.0001** | **<.0001** | **<.0001** |
| *"hpv"* | 0.62 | | | **<.0001** | 0.15 | 0.09 | **<.0001** | **<.0001** | 0.14 | 0.07 | **<.0001** |
| *"impetigo"* | 0.03 | 0.07(0.06) | 35(11) | **<.0001** | **0.0001** | **0.0004** | **<.0001** | **<.0001** | **0.0001** | **0.0003** | **<.0001** |
| *"lice"* | **<.0001** | 0.06(0.05) | 35(9.8) | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** |
| *"measles"* | **0.01** | 0.23(0.07) | 12(3.6) | 0.1 | **0.01** | 0.06 | **0.0001** | 0.08 | **0.01** | 0.05 | **<.0001** |
| *"meningitis"* | 0.62 | | | **<.0001** | **0.0078** | **<.0001** | **<.0001** | **<.0001** | **0.0083** | **<.0001** | **<.0001** |
| *"mononucleosis"* | 0.25 | | | **0.0007** | 0.77 | 0.55 | **<.0001** | **0.0006** | 0.75 | 0.44 | **<.0001** |
| *"mumps"* | 0.62 | | | **0.01** | **0.0035** | **0.0022** | **0.0004** | **0.01** | **0.0039** | **0.0018** | **0.0003** |
| *"pertussis"* | 0.64 | | | **0.0001** | 0.84 | 0.36 | **0.0032** | **0.0001** | >.99 | 0.28 | **0.0021** |
| *"pink eye"* | **<.0001** | 0.09(0.06) | 9(17.4) | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** |
| *"ringworm"* | **<.0001** | 0.03(0.04) | 27(10.6) | 0.04 | **0.0003** | **<.0001** | **<.0001** | 0.03 | **0.0003** | **<.0001** | **<.0001** |
| *"rubella"* | **0.01** | 0.05(0.05) | 12(14.5) | 0.15 | 0.69 | 0.79 | **0.01** | 0.12 | 0.65 | 0.62 | **0.0081** |
| *"salmonella"* | 0.62 | | | 0.25 | 0.45 | 0.43 | **0.0001** | 0.2 | >.99 | 0.35 | **<.0001** |
| *"scabies"* | 0.11 | | | **<.0001** | 0.02 | **0.0003** | **<.0001** | **<.0001** | 0.02 | **0.0003** | **<.0001** |
| *"shingles treatment"* | 0.19 | | | 0.15 | 0.47 | 0.33 | 0.93 | >.99 | >.99 | >.99 | 0.62 |
| *"std"* | 0.02 | 0.01(0.03) | 20(15.9) | **<.0001** | **<.0001** | **0.005** | **<.0001** | **<.0001** | **<.0001** | **0.004** | **<.0001** |
| *"stomach flu"* | **<.0001** | 0.33(0.06) | 3(1.2) | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** |
| *"strep throat"* | **<.0001** | 0.12(0.07) | 5(19.9) | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** | **<.0001** |
| *"syphillus"* | 0.88 | | | 0.22 | 0.81 | 0.36 | 0.93 | 0.17 | 0.78 | 0.29 | 0.7 |
| *"tuberculosis"* | 0.05 | | | 0.53 | 0.04 | 0.74 | 0.02 | 0.4 | >.99 | 0.6 | 0.02 |
| **Non-communicable, control conditions(non-covid)** | | | | | | | | | | | |
| *"arthritis"* | 0.26 | | | **0.0003** | 0.33 | 0.65 | 0.07 | **0.0002** | >.99 | >.99 | 0.05 |
| *"broken bone"* | 0.23 | | | **<.0001** | 0.03 | 0.53 | **0.0042** | **<.0001** | 0.03 | 0.43 | **0.0027** |
| *"burning eyes"* | >.99 | | | **<.0001** | **0.0024** | 0.04 | **0.0001** | >.99 | >.99 | >.99 | >.99 |
| *"cancer"* | 0.26 | | | **<.0001** | **<.0001** | **0.0071** | **<.0001** | **<.0001** | **<.0001** | **0.0056** | **<.0001** |
| *"cataracts"* | 0.97 | | | **<.0001** | 0.33 | 0.5 | 0.12 | **<.0001** | 0.3 | 0.41 | 0.08 |
| *"claritin"* | **<.0001** | 0.16(0.06) | 18(3.2) | 0.5 | 0.63 | 0.59 | **0.0023** | 0.39 | >.99 | 0.46 | **0.0015** |
| *"corneal ulcer"* | 0.26 | | | 0.1 | 0.04 | 0.74 | 0.86 | 0.08 | 0.03 | 0.6 | 0.56 |
| *"diabetes"* | **0.01** | 0.02(0.05) | 6(18.9) | **<.0001** | 0.84 | 0.2 | 0.93 | **<.0001** | >.99 | 0.16 | 0.7 |
| *"diabetic*| 0.88 | | | 0.15 | 0.7 | 0.43 | 0.4 | 0.12 | >.99 | >.99 | 0.26 |
| *"dry eyes"* | 0.13 | | | 0.02 | 0.93 | 0.04 | **0.0003** | 0.02 | >.99 | >.99 | >.99 |
| *"eczema"* | **<.0001** | 0.04(0.05) | 9(17.2) | 0.3 | 0.19 | 0.04 | **0.003** | 0.24 | 0.18 | 0.03 | **0.002** |
| *"glaucoma"* | 0.41 | | | **<.0001** | 0.42 | 0.36 | 0.03 | **<.0001** | 0.38 | 0.29 | 0.02 |
| *"heart attack"* | **0.01** | 0.04(0.06) | 12(10) | 0.15 | 0.41 | 0.34 | 0.03 | 0.12 | 0.37 | 0.28 | 0.02 |
| *"high blood pressure"* | **<.0001** | 0.05(0.04) | 5(13.2) | **0.0002** | 0.91 | 0.66 | 0.29 | **0.0002** | 0.89 | >.99 | 0.2 |
| *"itchy eyes"* | **<.0001** | 0.1(0.05) | 18(5.3) | **<.0001** | **0.0026** | 0.1 | 0.22 | >.99 | >.99 | >.99 | >.99 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *"macular degeneration"* | 0.78 | | | **<.0001** | 0.42 | 0.36 | 0.08 | **<.0001** | >.99 | >.99 | 0.05 |
| *"memory loss"* | 0.92 | | | **<.0001** | 0.81 | 0.79 | 0.93 | **<.0001** | >.99 | 0.62 | 0.71 |
| *"pollen"* | **<.0001** | 0.29(0.07) | 17(1.7) | **0.0002** | **0.0006** | **0.0021** | 0.28 | >.99 | >.99 | >.99 | >.99 |
| *"pregnant"* | 0.05 | | | 0.38 | 0.43 | 0.79 | 0.8 | 0.3 | 0.38 | 0.62 | 0.53 |
| *"red eyes"* | 0.19 | | | **0.0042** | 0.72 | 0.86 | 0.59 | >.99 | >.99 | 0.66 | 0.39 |
| *"sore eyes"* | 0.83 | | | 0.51 | 0.22 | 0.04 | 0.12 | 0.39 | >.99 | >.99 | >.99 |
| *"stroke symptoms"* | **<.0001** | 0.09(0.04) | 26(8) | 0.25 | 0.91 | 0.36 | 0.06 | >.99 | >.99 | >.99 | >.99 |
| *"toothache"* | 0.62 | | | 0.06 | 0.41 | 0.13 | 0.34 | >.99 | 0.37 | 0.11 | 0.23 |

**Table 2: Search interest for non-COVID communicable vs. non-communicable term groups in 2020-21 seasons compared to those seasons in 2011-2019.** Column headers, symbols and results are as described in the legend for Table 1 with a few additional components: Sub-headers indicate the two classification groups. Differences found between the *P*-values of these groups, were assessed using Wilcoxon rank sum test and Fisher's Exact Test. Results per season are indicated in columns 5-12 headers, as "*(Wilcoxon / Fisher's)*" where "-" indicates not significantly different; "*" indicates significantly different between the term groups. These exact *P*-values are provided above in the body of the results text. *P*-values >0.05 are gray and <=0.01 are bold.

## Correlating seasonality with search reductions in 2020-21

Although we found searches for a number of terms from all 3 classifications appeared seasonal, it appeared that seasonal terms were more likely to have reduced search frequency in 2020-21 seasons (please see panels in Figure 2 including black text on lower left of all panels, and Table 2 columns 2-4). We hypothesized that seasonal conditions might be reduced by social distancing measures during the pandemic more than for those that are less seasonal. To test this hypothesis, for each season of each non-COVID term we compared the *P*-values for search reduction against the seasonality *P*-values for that term using Theil-Sen regression. For spring, we found no significant correlation between a term having reductions in search in 2020-21 and with the seasonality of a term *P*=.95). But for summer, autumn, and winter, we found a significant correlation between a term having reductions in search in 2020-21 with the seasonality of that term (Theil-Sen: summer *P*=.0004, autumn *P*=.0002, winter *P*<.0001).

# Discussion

## Principal Results

**Decreased searches for communicable and seasonal disease search terms during 2020-21**: Overall, in our masked analysis, searches for many of the 29 non-COVID communicable terms (including related to conjunctivitis) were significantly decreased during the first 4 seasons of the 2020-21 pandemic compared to in the prior 9 years. For example, 18 of the terms ("*chicken pox*", "*chlamydia*", "*cold medicine*", "*conjunctivitis*", "*ear infection*", "*fifth disease*", "*gonorrhea*", "*HIV*", "*impetigo*", "*lice*", "*meningitis*", "*mumps*", "*pink eye*", "*ringworm*", "*scabies*", "*std*", "*stomach flu*", "*strep throat*") showed reductions for all 4 seasons of the pandemic (see columns 9-12 of Table 2. For 3 consecutive seasons in 2020-21 (summer,

autumn, winter) the levels of search were much more significantly reduced in 2020-21 for the non-COVID communicable terms group than for the non-communicable terms group. These findings support our *a priori* hypothesis that social distancing from the pandemic may lead to continued reductions in conjunctivitis[30]. They also support our broader hypothesis, applying the same concept to non-COVID communicable disease in general compared to control non-communicable conditions. In a separate assessment independent of our two classifications, we also found a significant correlation between reductions in search in 2020-21 and seasonality. This is not surprising, as it appears many terms of communicable conditions were seasonal and with apparent higher seasonality overall compared to non-communicable conditions.

**Non-COVID ocular terms that also had increased search during the pandemic**: Of the terms we had initially classified as not clearly COVID-19 pandemic-related and as non-communicable, the only terms that showed significant increases in 2020-21 for one or more seasons included "*pollen*" and several ocular terms ("*burning eyes*", "*dry eyes*", "*itchy eyes*", "*red eyes*", "*sore eyes*"). Despite this, no other control ocular conditions ("*cataracts*", "*corneal ulcer*", "*diabetic retinopathy*", "*glaucoma*", "*macular degeneration*") were increased. This suggests that unlike communicable ocular conditions which had lower search during the pandemic (conjunctivitis), or non-communicable chronic ocular conditions (without sustained changed search), these other ocular conditions, may have indeed increased during the pandemic. This appears most likely for "*burning eyes*" as well as "*dry eyes*" and "*itchy eyes*". These findings lend support to some clinical studies (although not all of them draw the same conclusions) suggesting some of these elevated ocular symptoms may be linked to COVID-19 or to other impacts of the pandemic such as mask-wearing and increased screen-time[17–25,30,31].

**Non-COVID non-communicable terms that also had sustained decreased search during the pandemic**: A few non-communicable terms had sustained reductions in 2020-21. Search for "*cancer*" was reduced for all 4 seasons compared to prior years. This may be explained by decreased routine cancer screening leading to reduced patient searching for "*cancer*" based on results of screening[7]. For some terms in our communicable condition group representing conditions covered by routine annual clinical screening (such as "*std*") decreased search may therefore also reflect less screening services or test results rather than a reduced prevalence[9]. Our observed sustained reduction in search for bone fracture (*broken bone*) reflects what has also been observed clinically during the pandemic[8] and which has been attributed to less driving, sports, and other outdoor activities during the pandemic.

**Pandemic impact on search for COVID and influenza terms**: Unlike the non-COVID groups, in several seasons of 2020-21 most search terms in the group we had classified as related to COVID-19 had significant search increases. An exception was that earlier increases in search for influenza-related terms reversed in winter to become significant decreases. This could indicate that early on in the pandemic COVID-19 symptoms may have been misconstrued as related to flu or that searches to distinguish COVID-19 from flu were common. By winter 2020 though these reasons may have waned while in parallel an actual drop in flu

cases (and therefore less flu searches) occurred due to social distancing during the peak flu season. This has been suggested from clinical data as well[33].

## Limitations

As with many infodemiology studies, it is possible that multiple other causes can affect search besides occurrence rate of disease. We may expect this for some terms, for example related to those conditions reported in the news during the pandemic. But the fact that our general finding of more reduced search for communicable than non-communicable terms suggests this is not the case globally. Furthermore, a search reduction due to news stories is much less likely than an increase. Reduced search about a term related to news about that term also would not be likely to be sustained for several seasons. Many of our health terms exhibited a general overall search reduction in spring 2020 (other than those potentially related to COVID-19). Those in the non-communicable group tended to return to normal levels by summer 2020. This may indicate that seeking medical care for those other conditions was reduced due to public concern of going to clinics as well as closed clinics. Some terms had no significant changes noted during the pandemic compared to in prior years. This could reflect unchanged clinical conditions. Alternatively, the search volume for some terms may be too low overall, preventing determining statistical significance using our methods.

For a small number of terms, although searches in 2020-21 visually appeared to be lower than in prior years, they were not shown to be significant different that prior years. This could be due to our analysis accounting for secular trends already moving in that direction. For example, see the red line in the "pregnant" panel of Figure 2. Indeed, other epidemiological studies have seen a decrease during the pandemic that was also partially obscured by a prior secular trend[34,35].

## Comparison with Prior Work and Significance

This study lends support to our hypotheses and confirms theoretical public health and epidemiological assumptions about the value of social distancing to reduce the impact of conjunctivitis epidemics[30,36]. It also builds upon and complements a growing body of evidence from clinical and other epidemiologic studies that suggest social distancing during the pandemic can reduce prevalence of numerous other communicable diseases[1–6,8,9].

## Conclusions

Compared to studies based on more costly and less publicly available individual level clinical data, we demonstrate the use of online search data to study the impacts of interventions such as social distancing at very low cost and in a masked manner. This approach can be simultaneously applied to entire countries and to numerous conditions, potentially worldwide. Such approaches should be considered to complement findings from clinical studies and to reveal findings prior to availability of clinical data, such as what occurred during the COVID-19 pandemic[30].

## Acknowledgements:

## Conflict of Interest:

No conflicting relationship exists for any author.

## Abbreviations

**RSV**: weekly relative search frequency volume data from Google trends for search terms

**2020-21**: The years 2020 through 2021

**AtM**: amplitude-to-mean ratio (the ratio of the difference between the peak and the mean to the mean itself) as an estimate of the degree of seasonality

**communicable terms**: search terms that we classified *a priori* as common school-based and workplace-based communicable diseases (such as strep throat, chicken pox, common cold) and other conditions of acute exposure (such as STDs, and bug bite), and as not related to COVID-19

**non-communicable terms**: search terms that we classified *a priori* as control terms, not communicable and not related to COVID-19

**COVID-19 pandemic related terms**: search terms that we classified *a priori* as potentially related to search about distinguishing or identifying COVID-19 symptoms

**non-COVID**: search terms that we classified *a priori* as not potentially related to search about distinguishing or                              identifying                              COVID-19                              symptoms

# References

1. Lin CF, Huang YH, Cheng CY, Wu KH, Tang KS, Chiu IM. Public Health Interventions for the COVID-19 Pandemic Reduce Respiratory Tract Infection-Related Visits at Pediatric Emergency Departments in Taiwan. *Front Public Health*. 2020;8:604089.

2. Kishimoto K, Bun S, Shin JH, et al. Early impact of school closure and social distancing for COVID-19 on the number of inpatients with childhood non-COVID-19 acute infections in Japan. *Eur J Pediatr*. March 2021.

3. Hatoun J, Correa ET, Donahue SMA, Vernacchio L. Social Distancing for COVID-19 and Diagnoses of Other Infectious Diseases in Children. *Pediatrics*. 2020;146(4).

4. Pol AC van de, Boeijen JA, Venekamp RP, et al. Impact of the COVID-19 Pandemic on Antibiotic Prescribing for Common Infections in The Netherlands: A Primary Care-Based Observational Cohort Study. *Antibiotics (Basel)*. 2021;10(2).

5. Wu D, Liu Q, Wu T, Wang D, Lu J. The impact of COVID-19 control measures on the morbidity of varicella, herpes zoster, rubella and measles in Guangzhou, China. *Immun Inflamm Dis*. 2020;8(4):844-846.

6. Galassi F, Ortega-Insaurralde I, Adjemian V, Gonzalez-Audino P, Picollo MI, Toloza AC. Head lice were also affected by COVID-19: a decrease on Pediculosis infestation during lockdown in Buenos Aires. *Parasitol Res*. 2021;120(2):443-450.

7. Chen RC, Haynes K, Du S, Barron J, Katz AJ. Association of Cancer Screening Deficit in the United States With the COVID-19 Pandemic. *JAMA Oncol*. April 2021.

8. Lim MA, Mulyadi Ridia KG, Pranata R. Epidemiological pattern of orthopaedic fracture during the COVID-19 pandemic: A systematic review and meta-analysis. *J Clin Orthop Trauma*. 2021;16:16-23.

9. Johnson KA, Burghardt NO, Tang EC, et al. Measuring the Impact of the COVID-19 Pandemic on Sexually Transmitted Diseases (STD) Public Health Surveillance and Program Operations in the State of California. *Sex Transm Dis*. April 2021.

10. Rodríguez I, Hernández Y. Sexually transmitted diseases during the COVID-19 pandemic: A focus on syphilis and gonorrhoea in Cuba. *Public Health Pract (Oxf)*. 2021;2:100072.

11. Wu P, Duan F, Luo C, et al. Characteristics of Ocular Findings of Patients With Coronavirus Disease 2019 (COVID-19) in Hubei Province, China. *JAMA Ophthalmol*. March 2020.

12. Hong N, Yu W, Xia J, Shen Y, Yap M, Han W. Evaluation of ocular symptoms and tropism of SARS-CoV-2 in patients confirmed with COVID-19. *Acta Ophthalmol*. April 2020.

13. Daruich A, Martin D, Bremond-Gignac D. Ocular manifestation as first sign of Coronavirus Disease 2019 (COVID-19): Interest of telemedicine during the pandemic context. *J Fr Ophtalmol*. April 2020.

14. Daniele Verri: British Broadcasting Corporation. Coronavirus in italy: Alessandro favalli describes 'fever, headache, eyes burning'. https://www.bbc.com/sport/football/51961429. Accessed March 19, 2020.

15. Colavita F, Lapa D, Carletti F, et al. SARS-CoV-2 Isolation From Ocular Secretions of a Patient With COVID-19 in Italy With Prolonged Viral RNA Detection. *Ann Intern Med*. April 2020.

16. Zhou Y, Duan C, Zeng Y, et al. Ocular Findings and Proportion with Conjunctival SARS-COV-2 in COVID-19 Patients. *Ophthalmology*. April 2020.

17. Nasiri N, Sharifi H, Bazrafshan A, Noori A, Karamouzian M, Sharifi A. Ocular Manifestations of COVID-19: A Systematic Review and Meta-analysis. *J Ophthalmic Vis Res*. 2021;16(1):103-112.

18. Feng Y, Park J, Zhou Y, Armenti ST, Musch DC, Mian SI. Ocular Manifestations of Hospitalized COVID-19 Patients in a Tertiary Care Academic Medical Center in the United States: A Cross-Sectional Study. *Clin Ophthalmol*. 2021;15:1551-1556.

19. Agrawal D, Parchand S, Agrawal D, et al. Impact of COVID-19 pandemic and national lockdown

on ocular trauma at a tertiary eye care institute. *Indian J Ophthalmol*. 2021;69(3):709-713.

20. Al-Dairi W, Al Saeed AA, Al Sowayigh OM. Impact of Quarantine During COVID-19 Pandemic on the Quality of Life of Patients with Allergic Conjunctivitis. *Cureus*. 2020;12(12):e12240.

21. Sözener ZÇ, Öztürk BÖ, Aydın Ö, et al. Coincidence of pollen season and coronavirus disease 2019 pandemic: less time outdoors - lesser allergy symptoms in 2020. *Asia Pac Allergy*. 2021;11(2):e16.

22. Moshirfar M, West WB, Marx DP. Face Mask-Associated Ocular Irritation and Dryness. *Ophthalmol Ther*. 2020;9(3):397-400.

23. Mastropasqua L, Lanzini M, Brescia L, et al. Face Mask-Related Ocular Surface Modifications During COVID-19 Pandemic: A Clinical, In Vivo Confocal Microscopy, and Immune-Cytology Study. *Transl Vis Sci Technol*. 2021;10(3):22.

24. Koh S, Rhee MK. COVID-19 and Dry Eye. *Eye Contact Lens*. 2021;47(6):317-322.

25. Boccardo L. Self-reported symptoms of mask-associated dry eye: A survey study of 3,605 people. *Cont Lens Anterior Eye*. January 2021:101408.

26. Leffler CT, Davenport B, Chan D. Frequency and seasonal variation of ophthalmology-related internet searches. *Canadian journal of ophthalmology*. 2010;45(3):274-279. doi:10.3129/i10-022

27. Deiner MS, Lietman TM, McLeod SD, Chodosh J, Porco TC. Surveillance tools emerging from search engines and social media data for determining eye disease patterns. *JAMA Ophthalmology*. 2016;134(9):1024-1030. doi:10.1001/jamaophthalmol.2016.2267

28. Deiner MS, McLeod SD, Chodosh J, et al. Clinical Age-Specific Seasonal Conjunctivitis Patterns and Their Online Detection in Twitter, Blog, Forum, and Comment Social Media Posts. *Invest Ophthalmol Vis Sci*. 2018;59(2):910-920.

29. Deiner MS, McLeod SD, Wong J, Chodosh J, Lietman TM, Porco TC. Google searches and detection of conjunctivitis epidemics worldwide. *Ophthalmology*. April 2019.

30. Deiner MS, Seitzman GD, McLeod SD, et al. Ocular Signs of COVID-19 Suggested by Internet Search Term Patterns Worldwide. *Ophthalmology*. 2021;128(1):167-169.

31. Mirza E, Mirza GD, Belviranli S, Oltulu R, Okka M. Ocular-symptoms-related Google Search Trends during the COVID-19 Pandemic in Europe. *Int Ophthalmol*. March 2021.

32. Fisher NI. *Statistical Analysis of Circular Data*. Cambridge: Cambridge University Press; 1993.

33. Fricke LM, Glöckner S, Dreier M, Lange B. Impact of non-pharmaceutical interventions targeted at COVID-19 pandemic on influenza burden - a systematic review. *J Infect*. 2021;82(1):1-35.
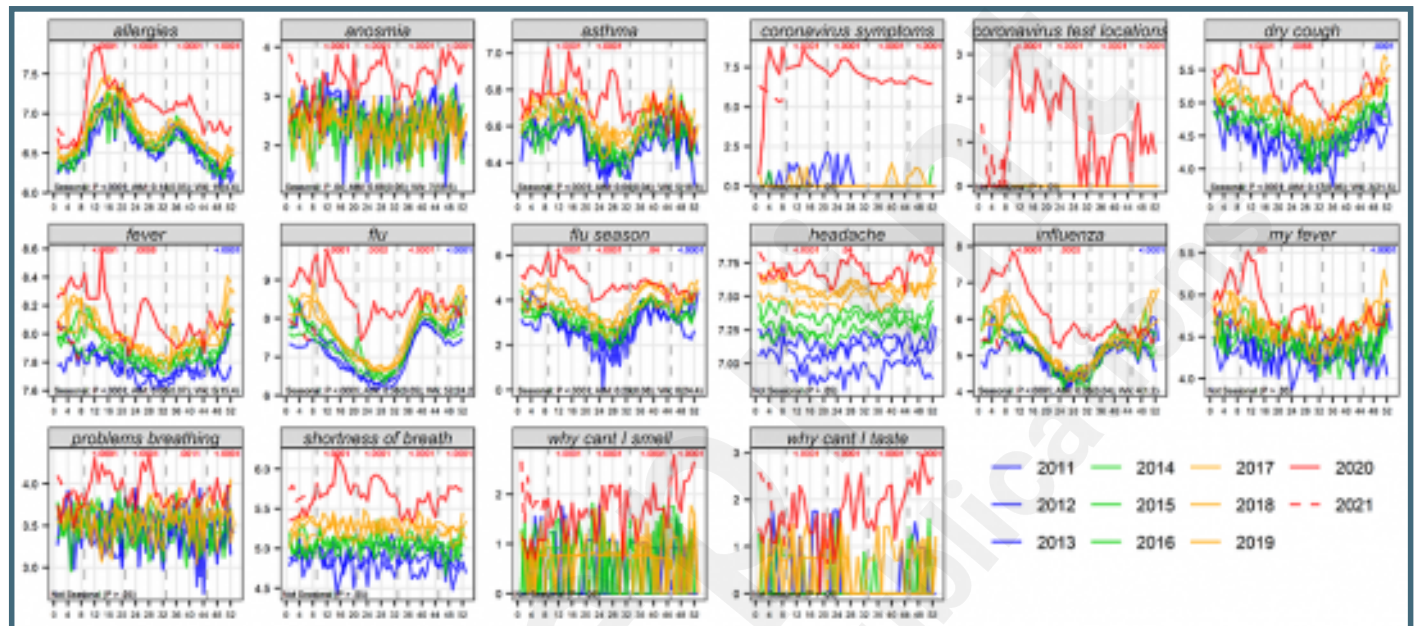
34. Ullah MA, Moin AT, Araf Y, Bhuiyan AR, Griffiths MD, Gozal D. Potential Effects of the COVID-19 Pandemic on Future Birth Rate. *Front Public Health*. 2020;8:578438.

35. Harper S. The Impact of the Covid-19 Pandemic on Global Population Ageing. *J Popul Ageing*. 2021;22(1):1-6.

36. Yen MY, Wu TS, Chiu AW, et al. Taipei's use of a multi-channel mass risk communication program to rapidly reverse an epidemic of highly communicable disease. *PLoS ONE*. 2009;4(11):e7962.

**Supplementary Files**

# Figures

Search interest for non-COVID, communicable and non-communicable terms in 2020-21 seasons compared to the same seasons in 2011-2019: Time series annual mean weekly search interest, P-values indicating changes in 2020-21 and seasonal values are as described for Figure 1. Panel labels indicate communicable (shown first) and non-communicable (shown second) classes that were compared using Wilcoxon rank sum test and Fisher's Exact Test (described in the text and Table 2).