AJIC: American Journal of Infection Control

Estimating pediatric cases of COVID-19 over time in the United States: Filling in a gaps in public use data

--Manuscript Draft--

Manuscript Number:	AJIC-D-21-01008R1
Article Type:	Original Research Article
Keywords:	SARS-CoV-2; sarbecovirus; Data science; Surveillance; pediatric
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Abstract:	Background COVID-19 continues to disturb nearly all aspects of life, leaving us striving to reach herd immunity. Currently, only weekly standardized incidence rate data per age group are publicly available, limiting assessment of herd immunity. Here, we estimate the time-series case counts of COVID-19 among age groups currently ineligible for vaccination in the USA. METHODS This was a secondary analysis of publicly available data. COVID-19 case counts by age groups were computed using incidence rate data from the CDC and population estimates from the US Census Bureau. We also created a web-based application to allow on demand analysis. RESULTS A total of 78 weeks of data were incorporated in the analysis, suggesting the highest peak in cases within the 5-11 year age group on week ending 2021-01-09 (n=61,095) followed by the 12-15 year age group (n=58,093). As of 2021-07-24, case counts in the 5-11 year age group have expanded beyond other groups rapidly. DISCUSSION This study suggests it is possible to estimate pediatric case counts of COVID-19. National agencies should report COVID-19 time series case counts for pediatric age cohorts. These data will enhance our ability to estimate the population at risk and tailor interventions accordingly.

Cover Letter

SAINT LOUIS UNIVERSITY
SCHOOL OF MEDICINE

September 2, 2021

Patricia Stone, PhD MPH RN FAAN
Editor-In-Chief
American Journal of Infection Control

Dear Dr. Stone,

We are submitting for your review, a major article titled, “Estimating pediatric cases of COVID-19 over time in the United States: Filling in the gaps of public use data”. In this manuscript, we describe a method to back calculate case counts by pediatric age groups using publicly available data. Given the arguments over emergency use authorization of pediatric COVID-19 vaccine, and the need to understand herd effects in the community with plateauing adult vaccination rates, these case counts are necessary to tailor interventions. We feel our approach is well suited for the readers of *AJIC.*

One of the more important aspects of our approach is that we created a free, open-source web application to visualize case counts, rates, and percent changes by age group in the United States as data are reported. This application is located at: https://surveillance.shinyapps.io/covid_agegroups. This application makes it easy for individuals to understand the case counts and therefore have a better view of what is needed in the pediatric setting.

All authors have read and approved the submission of the manuscript to your journal and have all contributed significantly to its completion. None of the authors have conflicts of interest in any part of the study or its results and this manuscript is not under consideration at any other journal, nor has it been presented or published in any format. There are no color images in this manuscript

Thank you for your consideration and we look forward to your review of our manuscript.

Thank you for your consideration.

Sincerely,

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Dear Dr. Stone,

We would like to thank the reviewers for their comments to improve our work. Below you will find a point-by-point response to the reviewers' comments as well as any additions or subtractions from the text of the manuscript.

Reviewer 1:

Comment 1: The reviewer requested a modification of the title

Response 1: We have modified the title for clarity. The purpose of the study is indeed to fill in a gap of public use data, being the lack of publicly available pediatric case counts.

The title now reads: Estimating pediatric cases of COVID-19 over time in the United States: Filling in a gap in public use data

Comment 2: The reviewer suggested we remove vaccination as an NPI.

Response 2: We agree with the reviewer and have modified this to read:

"…recent decreases in utilization of various interventions is concerning"

Comment 3: The author mentioned that the references do not fully cover interventions mentioned.

Response 3: We agree with the reviewer and have added references to include disinfection and hand hygiene.

Comment 4: The reviewer suggested rephrasing the sentence on lines 11 - 13

Response 4: We have modified this sentence to read:

With respect to COVID-19, we must continue to strive to meet herd immunity even if it is difficult to achieve.

Comment 5: The reviewer requested we rephrase the sentence on lines 15-19.

Response 5: We agree with the reviewer and have revised this to read:

"This number has been described to be at least 60% for Severe Acute Respiratory Syndrome Coronavirus Type 2 (SARS-CoV-2), but the actual effective herd immunity threshold is difficult to compute. This difficulty may be explained by factors such as non-random mixing of the population, ignoring completely closed or nearly isolated populations, and an inability to

determine both the longevity of immunity and overlap between immunity from natural infection and from vaccination."

Comment 6: The reviewer requested we revise sentence on lines 31 and 32.

Response 6: We have revised this to read:

"To begin understanding the status of herd immunity, we must understand immunity due to SARS-CoV-2, and know the population who is immune and at risk."

Comment 7: The reviewer requested we revise line 35.

Response 7: We have revised this to read:

"Currently, only weekly standardized incidence rate data per age group are publicly available (7), limiting community assessment of herd immunity."

Comment 8: The reviewer requested a revision of the herd immunity number on line 78 to match what was presented earlier in the manuscript.

Response 8: We have modified this to add a reference and a qualifier. This higher herd threshold is given the increased transmissibility of the delta variant and the expectation of a higher herd threshold necessity.

"To bring these groups to an 80% immunity threshold, a value more realistic than prior calculations given the increased transmissibility of the delta variant (10), there would need to be a 1900% under-reporting bias."

Comment 9: The reviewer requested we modify the sentence on line 97/99.

Response 9: We removed the following sentences to add clarity to the section.

"Interestingly, we found that different age groups suffered from variable amounts of over/under reporting. This could be due to many factors including our use of projected populations by age group, differential risk (including vaccine uptake) over time among various age groups, or differential over/under reporting in various age groups."

Comment 10: The reviewer questioned the utility of the sentence on line 100.

Response 10: We agree with the reviewer that the purpose of the manuscript was not to evaluate incidence rates, rather to back calculate case counts based on the reported incidence rates over time. However, this particular sentence only uses the incidence rate data to support the utility of having both incidence and case count data publicly available. Because of this, we

request to maintain this important section. The authors do not think any epidemiologist or practitioner would argue that having both data elements add utility for disease surveillance.

Comment 11: The author requested a citation on line 109 2nd sentence.

Response 11: We have added a citation and removed the next sentence which contained the reference to this information. Removing the next sentence added clarity and reduced duplication.

Comment 12: The reviewer questioned the purpose of the manuscript.

Response 12: The manuscripts purpose is to compute the case counts over time, which are not publicly available (e.g filling in the gaps of public use data). However, the utility of this information is presented more broadly throughout the manuscript which may have confused the reviewer. However, without putting the need for these data in context (e.g. computing herd effects, using the data to better understand population immunity, which rates do not facilitate) the authors feel there would be no purpose or utility in presenting any data. Because of this, we request to maintain our discussions of the importance of our data in the context of understanding the trajectory of the pandemic in the United States.

Comment 13: The reviewer requested we further edit the methodology of the manuscript using "an editor experienced in scientific methods"

Response 13: We have revised the manuscript to the best of our ability. The authors have well over 200 peer reviewed scientific publications using the most stringent of scientific methods throughout their careers. Because of this, we feel the comment is more of personal preference in writing style of the reviewer versus scientific merit.

Reviewer 2:

Comment 1: The reviewer suggested we add the public use data in the abstract.

Response 1: We have added the following sentence to the methods section of the abstract to clarify this:

"This was a secondary analysis of publicly available COVID-19 data from the Centers for Disease Control and Prevention (CDC)."

Comment 2: The reviewer requested clarity on which national agencies to which we referred in the discussion of the abstract.

Response 2: We have clarified this to read:
"National agencies such as the CDC…"

Comment 3: The reviewer requested information on the time frame of data use in the methods section.

Response 3: The methods section of the manuscript reads:

This was a secondary analysis of publicly available data from week ending 2020-03-07 through 2021-08-21.

These were the only data available from CDC at the time of analysis (e.g. the publicly available data to which we refer).

Comment 4: The reviewer requested a figure of the data on the web based tool.

Response 4: Figures 1 and 2 are derived from the web based tool and are included in the submission.

We would like to thank the reviewers for their comments. We look forward to hearing from you on the next steps in publication process. Thank you very much for your continued interest and consideration of our work.

Sincerely,

Timothy Wiemken, PhD MPH

Title Page (with author details) *In addition to uploading Conflict of Interest forms with your submission, please list conflict of interest

Title: Estimating pediatric cases of COVID-19 over time in the United States: Filling in a gap in public use data

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Word Count: 1470

Keywords: SARS-CoV-2, sarbecovirus, data science, surveillance, pediatric

Title: Estimating pediatric cases of COVID-19 over time in the United States: Filling in a gap in public use data

Background

COVID-19 continues to disturb nearly all aspects of life, leaving us striving to reach herd immunity. Currently, only weekly standardized incidence rate data per age group are publicly available, limiting assessment of herd immunity. Here, we estimate the time-series case counts of COVID-19 among age groups currently ineligible for vaccination in the USA.

METHODS

This was a secondary analysis of publicly available data. COVID-19 case counts by age groups were computed using incidence rate data from the CDC and population estimates from the US Census Bureau. We also created a web-based application to allow on demand analysis.

RESULTS

A total of 78 weeks of data were incorporated in the analysis, suggesting the highest peak in cases within the 5-11 year age group on week ending 2021-01-09 (n=61,095) followed by the 12-15 year age group (n=58,093). As of 2021-07-24, case counts in the 5-11 year age group have expanded beyond other groups rapidly.

DISCUSSION

This study suggests it is possible to estimate pediatric case counts of COVID-19. National agencies should report COVID-19 time series case counts for pediatric age cohorts. These data will enhance our ability to estimate the population at risk and tailor interventions accordingly.

Title: Estimating pediatric cases of COVID-19 over time in the United States: Filling in a gap in public use data

- Public use data have been valuable tools for surveillance during COVID-19
- Currently, pediatric case counts of COVID-19 over time are missing from these sources
- We estimated these cases using open data and built a tool for visualization of the data
- The tool can be found at https://surveillance.shinyapps.io/covid_agegroups
- These data support the need of emergency use authorization of vaccine for at least the 5-11 year old age group

Title: Estimating pediatric cases of COVID-19 over time in the United States: Filling in a gap in public use data

INTRODUCTION

Coronavirus disease 2019 (COVID-19) continues to disturb nearly all aspects of life worldwide. Although prevention methods such as vaccination, face coverings, hand hygiene, and surface disinfection are effective, easy-to-institute, and readily available (1-3), recent decreases in utilization of various interventions is concerning (4, 5). Despite this, a central approach to limit disease transmission, morbidity, and mortality is ensuring effective interventions are tailored to those at risk of infection and must continue to preserve public health.

With respect to COVID-19, we must continue to strive to meet herd immunity even if it is difficult to achieve (6). Herd immunity results from when a population who mix or contact one another have sufficient immunity to prevent transmission of the agent causing the disease. This number has been described to be at least 60% for Severe Acute Respiratory Syndrome Coronavirus Type 2 (SARS-CoV-2), but the actual effective herd immunity threshold is difficult to compute. This difficulty may be explained by factors such as non-random mixing of the population, ignoring completely closed or nearly isolated populations, and an inability to determine both the longevity of immunity and overlap between immunity from natural infection and from vaccination. Because of these factors, we must rely on an assumption that the currently available and highly effective vaccines for COVID-19 provide enough long-term protection from SARS-CoV-2 infection to meet a herd immunity once at least 60% of the population is vaccinated.

Currently, three vaccines are approved, or authorized for emergency use for prevention of COVID-19 in the United States for various age groups: Pfizer/BioNTech (≥12 years of age), Moderna (≥18 years of age), and Johnson & Johnson/Janssen (≥18 years of age), with Pfizer BioNTech being the only fully approved by the United States Food and Drug Administration (FDA). To reach herd immunity, approval or emergency use authorization must be provided to younger age groups quickly, since approximately 15% (≤12 years of age) to 20% (≤15 years of age) of the United States population is ineligible for vaccination from all or some of the vaccines available for adults.

To begin understanding the status of herd immunity, we must understand immunity due to SARS-CoV-2 and know the population who is immune and at risk. To determine the population at risk, we need to understand the trajectory of cases, particularly across groups ineligible for vaccine. Currently, only weekly standardized incidence rate data per age group are publicly available (7), limiting community assessment of herd immunity.

The objective of this study was to utilize publicly available data to estimate the time-series case counts of COVID-19 among age groups currently ineligible for vaccination in the United States.

METHODS

This was a secondary analysis of publicly available data from week ending 2020-03-07 through 2021-08-21. To compute case counts over time and by age group, we first obtained COVID-19 incidence rate data per 100,000 population by age group from the Centers for Disease Control and Prevention (CDC) (7). These data are published pre-standardized and therefore do not allow for computation of total caseload directly. We then obtained calendar year 2020 and 2021 single age population estimates from the United States Census Bureau (8). Using these two data elements, we were able to back compute the de-standardized rate using the following formula:

*(Age-specific COVID-19 rate per 100,000 population for 2020 or 2021 * Age-specific estimated population for the same year) / 100,000.*

This formula provided an estimate of the case count by age group using the population estimates specific for the year for which the incidence rates were published.

Next, we obtained overall (not time-series) COVID-19 case counts by age-group from the CDC (9) and computed a percent over or underestimate from our estimates to the actual reported data by age group. These percentages were used to correct the weekly case counts by adding or subtracting the specific percentage over/underestimate for each time-period and age group.

We then computed percent changes from the prior week for each count by age group using the formula:

*((current case count – prior case count) / current case count) *100*

Next, we computed herd immunity estimates for the age groups currently ineligible for COVID-19 vaccination in the United States (0-4 and 5-11 age groups), simulating different scenarios of under-reporting.

Finally, we created a web-based application to allow interested readers to visualize data.

RESULTS

A total of 78 weeks of data were incorporated in the analysis, including week ending 2020-03-07 through 2021-08-28. Total estimated case counts were close to actual case counts across the three age groups and were closer to published data after correction for over/under estimation except for the 12-15 year age group (**Table 1**). Overall reported case counts were highest among the 5-11 age group (n=1,362,512) followed by the 12-15 year age group (n=1,182,692), and finally the 0-4 year age group (n=693,100). Time series plots suggest the highest peak in cases within the 5-11 year age group on week ending 2021-01-09 (n=61,095) followed closely by the

12-15 year age group (n=58,093); though incidence rate during this time was higher in the 12-15 year age group. As of approximately 2021-07-24, case counts in the 5-11 year age group have expanded beyond 0-4 and 12-15 year age groups more rapidly than at any other time period during the pandemic (**Figure 1**).

Percent change week-on-week varied substantially with a mean percent change of 2.3% over the time series and has experience more week-to-week variability since April 2021 (**Figure 2**).

Herd immunity estimates for vaccine-ineligible age groups can be found in **Table 2.** Even with 100% under-reporting the level of immunity due to natural infection (in the best-case scenario of perfect, non-waning immunity from natural infection), only 4.2% of these children are currently immune. To bring these groups to an 80% immunity threshold, a value more realistic than prior calculations given the increased transmissibility of the delta variant (10), there would need to be a 1900% under-reporting bias.

The web-based tool for on-demand visualization can be found at: https://surveillance.shinyapps.io/covid_agegroups .This tool allows for rapid visualization of all age groups with data available for estimated case counts, corrected estimated case counts, and percent differences.

DISCUSSION

This study suggests it is possible to estimate with a reasonable degree of accuracy, the case counts of COVID-19 in younger age groups. Given national data repositories do not report pediatric COVID-19 cases by age group, the practitioner's ability to discern risks and target intervention to reduce transmission is limited. Beyond our estimates, in an impossible scenario of perfect non-waning immunity from infection, only 4.2% of the 0-11 aged population is immune.

Even if this estimate is 100% underestimated, it leaves a massive at-risk population in critical need of vaccine.

Interestingly, time-series evaluation of case counts modeled each other across the three age groups closely, suggesting proportional and equivalent transmission and infection across age groups given the population at risk. Percent change estimates were also nearly identical week-on-week for all three age groups further adding credence to similar exposure, risk, and infection profiles across age groups.

This study does not suggest that incidence rate data are not useful. In fact, arguably for most surveillance, incidence rates are far more useful as they account for the population at risk. A close evaluation of the incidence rate data by age groups currently ineligible for vaccination underscores this point (7). Throughout the pandemic, the 12-15 year old age group had higher incidence rates than did both 0-4 and 5-11 age groups, despite having lower total cases than the 5-11 cohort. However, after Pfizer BioNTech vaccine was authorized for emergency use in the 12-15 year old age group (May 10, 2021), rates of disease between ages 5-11 and 12-15 have been much closer with approximately 3.5% of the 12-15 year old age group currently fully vaccinated (11).

This study has limitations. Since COVID-19 surveillance is largely passive in the United States, it is possible that underreporting is common (12). However, recent seroprevalence studies among younger age groups suggest low infection rates (13, 14) resulting in an unknown impact of this factor on our estimates. Although we were able to correct our estimates to align with the total reported COVID-19 cases more closely, they remain variable, and our corrections may not be directly applicable to each weekly report. This could bias the visualizations and/or the total counts of those immune.

In conclusion, national agencies should consider reporting COVID-19 time series case counts for pediatric age cohorts along with the standardized rates. These data will enhance public health practitioners' abilities to estimate the population at risk and/or immune and tailor interventions accordingly.

Table 1: Week-on-week estimated case counts and corrected case counts with totals by age group, United States, weeks ending 2020-03-07 through 2021-08-28

Age Group	**Total Reported COVID-19 Case Count** (9)	**Estimated Case Count (Percent Difference from Actual)**	**Corrected Estimated Case Count (Percent Difference from Actual)**
0-4	639,100	710,307 (10.0%)	693,117 (7.8%)
5-11	1,362,512	1,319,053 (-3.3%)	1,362,450 (<0.00%)
12-15	1,182,692	1,160,171 (-1.9%)	1,269,227 (6.8%)

Table 2: Herd immunity estimates for 0-4 and 5-11 year old, COVID-19 vaccine ineligible age cohorts through week ending 2021-08-28

Age Group	Projected 2021 Population	Total Reported COVID-19 Case Count (Percent of Population Immune)	Percent Under Reporting					
			0%	10%	25%	50%	75%	100%
			Estimated Case Count (Percent of Population Immune)	Estimated Case Count (Percent of Population Immune)	Estimated Case Count (Percent of Population Immune)	Estimated Case Count (Percent of Population Immune)	Estimated Case Count (Percent of Population Immune)	Estimated Case Count (Percent of Population Immune)
0-4	20,601,023	639,100 (3.1)	671,055 (3.3)	7030,10 (3.4)	798,875 (3.9)	958,650 (4.7)	1,118,425 (5.4)	1,278,200 (6.2)
5-11	28,368,818	1,362,512 (4.8)	1,430,638 (5.0)	1,498,763 (5.3)	1,703,140 (6.0)	2043,768 (7.2)	2,384,396 (8.4)	2,725,024 (9.6)
Total	48,969,841	2,055,612 (4.2)	2,158,397 (4.4)	2,261,173 (4.6)	2,569,515 (5.3)	3,083,418 (6.3)	3,597,321 (7.4)	4,111,224 (8.4)

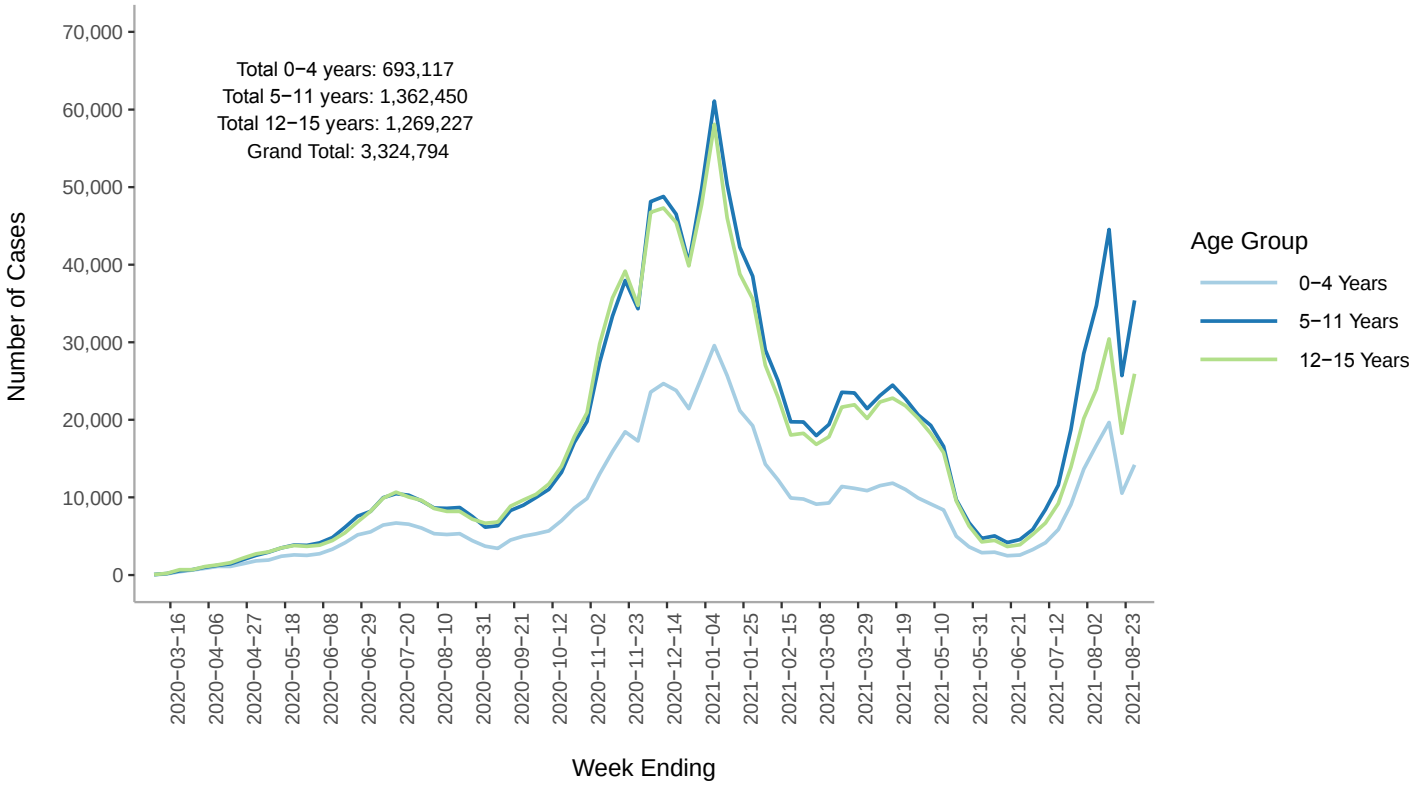

Figure 1: Time series plot of estimated COVID-19 case counts (corrected) by age group, United States, week ending 2020-03-07 through 2021-08-28

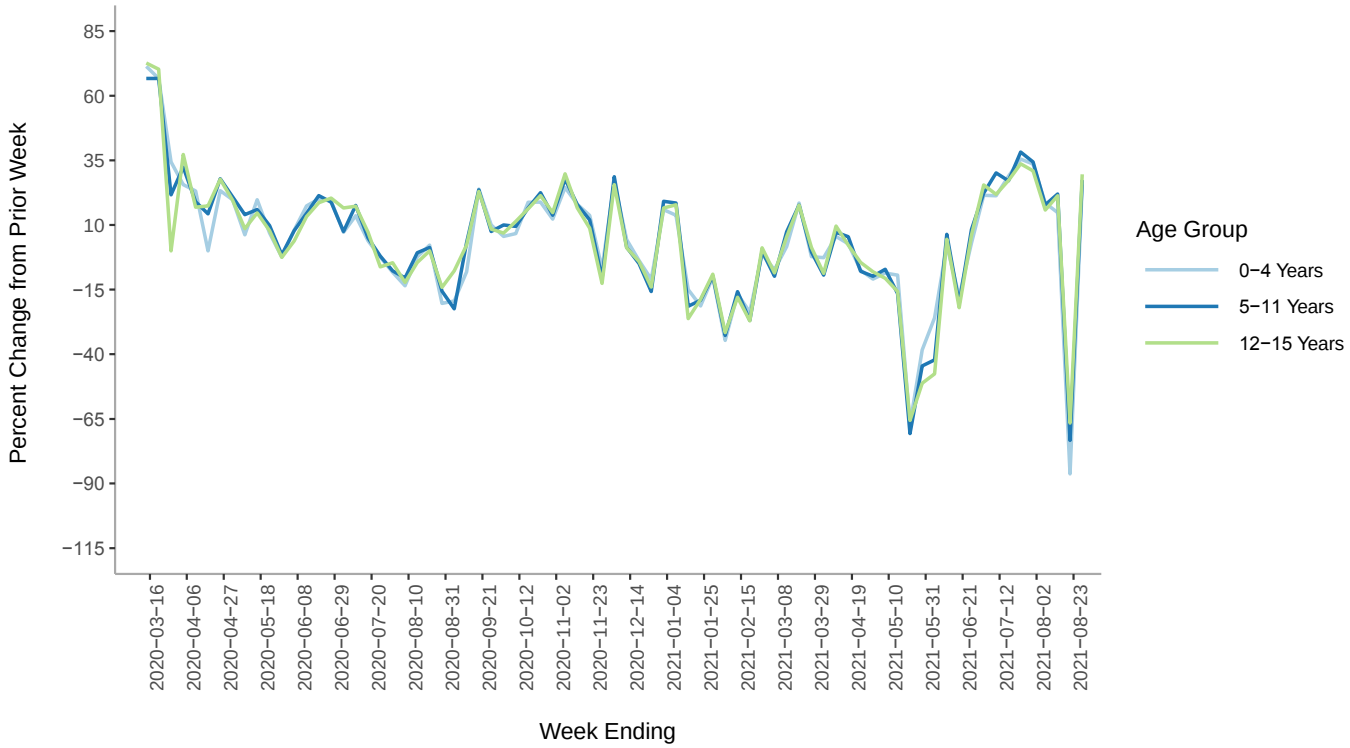

Figure 2: Time series plot of estimated percent difference week-on-week COVID-19 case counts (corrected) by age group, United States, week ending 2020-03-07 through 2021-08-28

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Figure 1

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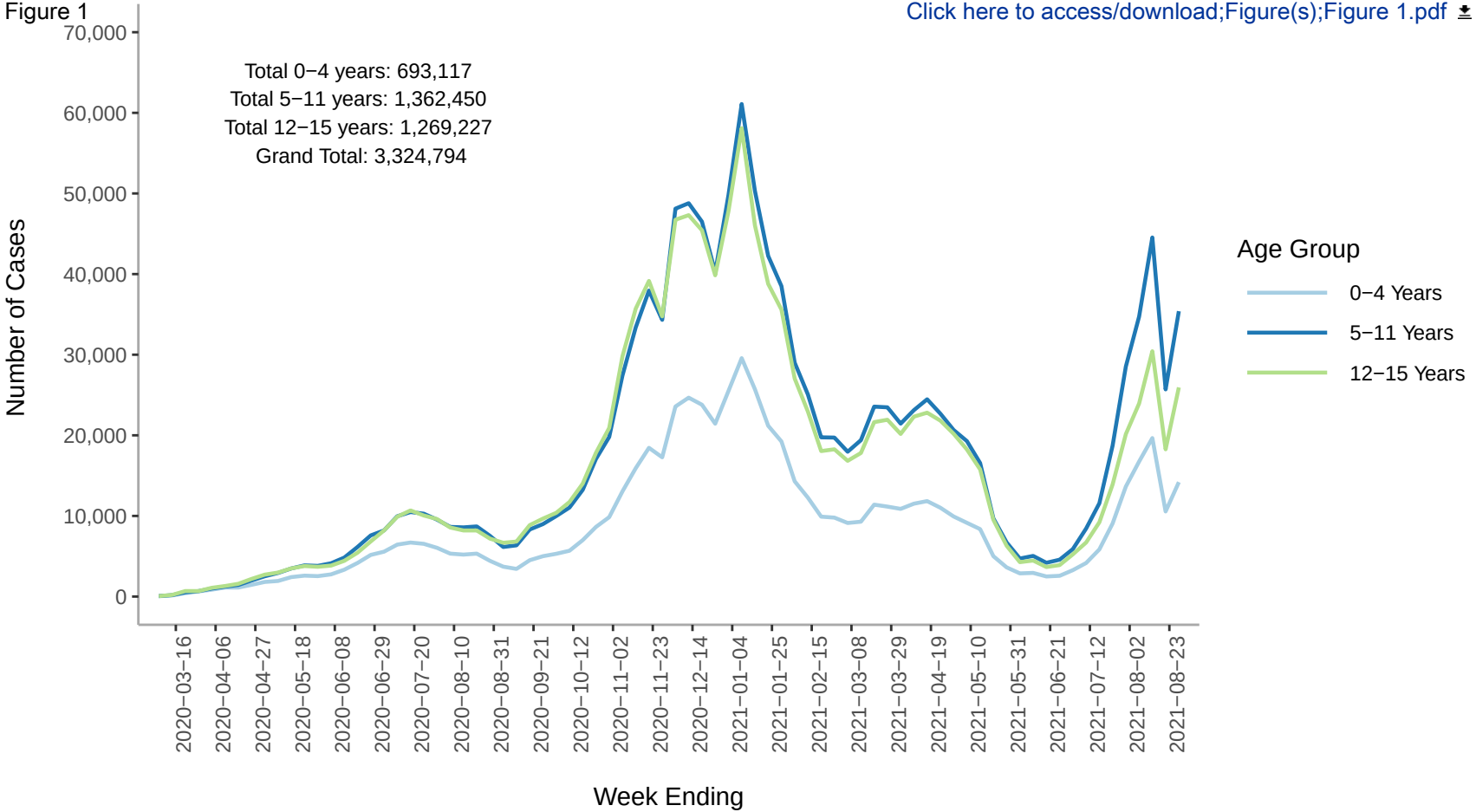

Figure 2

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