Public Health 198 (2021) 164–170

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

COVID-19 incidence, hospitalizations and mortality trends in Croatia and school closures

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ARTICLE INFO

Article history:
Received 12 April 2021
Received in revised form
23 July 2021
Accepted 23 July 2021
Available online 3 August 2021

Keywords:
COVID-19
Return to school
Joinpoint regression

ABSTRACT

Objectives: COVID-19 pandemic affected majority of students worldwide because school closures were one of the first and frequently taken measures in tackling epidemic. This study analyzed trends in COVID-19 morbidity and mortality from the beginning of pandemic in Croatia, in relation to schools opening and closing.
Study design: Retrospective data review.
Methods: Data on COVID-19 positive patients in Croatia from week 9 of 2020 to week 10 of 2021 in Croatia were analyzed using joinpoint regression. Analysis also included hospitalizations and mortality trends for age groups 26 to 65 and 66+ from week 30 of 2020.
Results: Schools opened in fall after the summer holidays in week 37. Joinpoint regression analysis revealed a statistically significant increase in cumulative incidence rates of COVID-19 in all age groups until 50th week, except in the 19–25 age group which saw an increase until 49th week. During the period of increase, there were periods of moderate increases and rapid increases in incidence that were present between 39/41 week and 43/44 week in all age groups except in those 0–6 years [from 40th till 43rd week in age groups 7–14 and 15–18, average percentage change (APC) = 87.41, $P = 0.035$, and APC = 83.47, $P = 0.013$; from 39th till 43rd in 19–25, APC = 91.90, $P = 0.002$; from 40th till 44th in 26–65, APC = 74.79, $P < 0.001$; from 41st till 44th in 66+, APC = 81.95, $P = 0.004$]. Steeper increase in hospitalizations was seen in 40th week for age groups 26 to 65 (40th to 45th week APC = 34.67, $P < 0.001$) and 66+ (40th to 45th week APC = 38.76, $P < 0.001$). Steeper increase in mortality started in 41st week for both age groups 26 to 65 and 66+ (41st to 46th week APC = 59.59, $P < 0.001$ and 41st to 45th week APC = 70.28, $P < 0.001$). Schools were closed for winter holidays in week 51. A steep decrease occurred in week 50 for cases and in week 51 for mortality and hospitalizations. There was no significant increase in hospitalizations and mortality after schools were re-opened in week 03 of 2021 (primary schools) and week 07 (secondary schools).
Conclusion: COVID-19 morbidity and mortality trends in Croatia observed in fall 2020 in Croatia perhaps cannot completely exclude potential association of school opening in all age groups. However, in winter 2021 effect was completely lacking and numbers were independent of schools' dynamics. The observed inconsistent pattern indicates that there were no association of school openings and COVID-19 morbidity and mortality trends in Croatia and that other factors were leading to increasing and decreasing numbers. This emphasizes the need to consider the introduction of other effective and less harmful measures by stakeholders, or at least to use school closures as a last resort.

Introduction

On 11 March 2020, the World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) outbreak, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

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https://doi.org/10.1016/j.puhe.2021.07.030
0033-3506/

as a pandemic.[1] In light of this pandemic researchers and policy makers have been tasked to identify public safety measures to help prevent the healthcare system from getting overwhelmed and reduce the number of deaths while keeping in mind that COVID-19 spread and implementation of different measures, such as lockdowns, will affect people's day-to-day lives and could lead to disruption in daily activities.[2,3] Over the course of this pandemic, new data have been collected and analyzed, which policy makers have to take into account and weigh the balance of risks to children's health, well-being, learning, and development posed by disease transmission versus not going to school.[4] With limited information at the beginning of the pandemic many countries chose to approach with caution and make the call to close schools rather than encounter the detrimental effects of potentially overwhelming the health care system. By mid-April 2020, 192 countries had closed schools, affecting more than 90% of the world's student population.[5] However, as knowledge of the disease progresses, clinical evidence has shown that children mainly have asymptomatic or mild disease and they are also less likely to spread the virus.[6,7] Scientific evidence and perception is still not homogeneous in regards to openings and closures of schools, and while some studies revealed that school closures do not have an impact on the incidence of coronavirus infection[8] or that outbreaks are uncommon in educational settings,[9] and clustering are rare[10] other papers strongly criticized them.[11] However, systematic reviews and meta-analysis published in this area are suggesting that children are unlikely to be the main drivers of the pandemic. Opening up schools and kindergartens seems to be unlikely to impact COVID-19 mortality rates in older people[12] or if there is an effect, the potential harms of school closures are much higher.[13] Furthermore, published meta-analysis revealed that adolescents play a less pronounced role than adults in transmission of SARS-CoV-2 at a population level[14] while a decision analytical model estimated that school closures will lead to even more years of life lost through reduced educational achievements.[15]

Croatia reported its first case on the 25 February 2020.[16] As part of the response to COVID-19 containment measures, the Croatian government declared closure of schools throughout the country, starting on 16 March 2020.[17] As the situation improved over the following month, educational institutions reopened for younger children to be able to attend in-person classes, recommendations needed to be made before this. The Croatian Institute of Public Health (CIPH) issued guidelines and recommendations for schools so that with the ease of restrictions children and staff could come back to school with minimal risk.[18] This document was revised and updated throughout the course of the epidemic with the last version being published before all children (primary and secondary) were to return to school (24 August 2020). The document is similar to WHO recommendations[19] and included general measures (hand hygiene, mask use, distancing, etc.) as well as specifically detailed measures for school settings. Specific measures were staggered arrival and departure times, limitations in mixing cohorts creating ‘bubbles’, physical distancing measures which were defined as required anywhere possible (1.5 m primary, 2 m secondary) and grades 1–4 primary were the only students omitted from mandatory masks. Schools were offered, by the Ministry of Education, three different types of models:[20] A. in-person learning; B. mixed form (primary grades 5–8 and secondary schools); C. remote learning (primary grades 5–8 and secondary schools). At that time, over 90% of schools in Croatia chose model A, which means that the majority of children attended school through in-person learning. Models B or C are applied when a student or teacher is positive for COVID-19 so the entire class stays home. In addition, model C was applied as per local decisions if the epidemiological situation requires this. This model (i.e. mostly model A with temporary use of models B or C as necessary) was in place for more than three months, and, facing the peak of the second wave at the beginning of December 2020, school closures were again introduced for secondary and some primary schools (upper grades) on December 14th, one week before official school holidays in Croatia, i.e. mid-December. The same week (December 14th) was the first week when the epidemiological situation improved substantially. The improvement continued in the following weeks and in mid-January 2021 primary schools resumed normally, while secondary schools were online until the beginning of or mid-February, depending on the situation in each county.

School closures are still one of the measures frequently suggested and considered in Croatia and other countries despite its detrimental effects to education and health. Therefore, evidence regarding the potential impact of school closure policies in Croatia could additionally add to the scientific evidence and support decisions regarding school policy. The aim of this study was to analyze trends and potential change in COVID-19 incidence, hospitalization, and mortality trends in Croatia that could be associated with school closures and re-openings during the pandemic.

Methods

For the purpose of this study data were collected, combined, and analyzed using several different data sources. Data from clinical laboratories and primary health care providers were collected using the Central Health Information System of the Republic of Croatia (CEZIH). The Croatian Institute of Public Health regularly collects data through the Croatian Health Insurance Fund (CHIF), which operates the central segment of the CEZIH system[21] and uses it for the purposes of scientific and expert analysis. Data regarding deceased COVID-19 patients were collected directly via hospital reports which communicate patients who died with or due to COVID-19. COVID-19 test results were obtained from clinical laboratories and included results of all individuals whose nasopharyngeal swab samples were tested for SARS-CoV-2 (PCR) from the 25th of February 2020 (week 09 of 2020) to 14th of March 2021 (week 10 of 2021). Age specific rates were calculated using the estimation of Croatian population at the end of 2019 according to the Croatian Bureau of Statistics.

COVID-19 incidences were analyzed from week 09 of 2020, in all age groups (0–66+ years). Hospitalization and mortality rates were analyzed from week 30 of 2020 and only in adults (26–66+ years). This was due to low hospitalization and mortality rates in younger age groups and during the first COVID-19 epidemics wave.

The joinpoint regression model defining joinpoints by performing several permutation tests and using Monte Carlo methods with Bonferroni correction was used to analyze changes in COVID-19 incidence, hospitalization, and mortality rates.[22] Analysis was carried out using Joinpoint Statistical Software for analysis of continuous linear trends with change points, i.e. joinpoints, version 4.6.0.0. Given the number of time periods, considered maximum number of joinpoint was set at 5. Logarithmic transformation was applied, with statistical significance for average percent changes (APC) set at 0.5 level.

Ethical approval for this research was granted by CIPH Ethical Committee.

For the purpose of clarity, we present a table with dates and weeks of schools' closures and openings and other major measures.

The table of schools closing and opening and other major measures the timeline and study period is available as supplementary material.

Results

During the study period (25 February 2020 to 14 March 2021—week 09 of 2020 through to end of week 10 2021), there were 251,194 new positive cases of COVID-19, 1,431,342 persons were tested, 28,004 hospitalized, and 5677 persons died. Total crude incidence rates are presented in Fig. 1. The incidences ranged from 0.00 to 6.17/1000.

Age specific incidence rates of COVID-19

Age specific incidence rates from the beginning to the end of investigated period varied from 0.00 to 0.53/1000 in 0–6 age group, 0.00 to 0.93/1000 in age group 7–14 years, 0.01 to 1.5/1000 in age group 15–18 years, 0.02 to 1.01/1000 in age group 19–25 years, 0.00 to 1.32/1000 in age group 26–65 years, and 0.00 to 0.81/1000 in 66+ years age group revealing the up to 81-fold increase in rates during the investigated period.

Joinpoint regression analysis revealed a statistically significant increase in cumulative incidence rates in all age groups until 50th week, except in the 19–25 age group which saw an increase until 49th week. However, during the period of increase, there were periods of moderate increases and rapid increases in incidence that were present between 39/41 week and 43/44 week in all age groups except in those 0–6 years. In 49th week, a decrease was observed in the 19–25 age group that was followed by a decrease of rates in all other age groups in 50th week. While a decrease was present in the majority of age groups in 2nd week of 2021, in age group 7–14 an increase was noted and followed with significant incidence increases in 15–18 and 26–65 age groups in 6th week of 2021. Significant average percent changes per week (APC) according to age groups are presented in Fig. 2.

Mortality trends of COVID-19

Because of low numbers of deceased persons before the beginning of second wave, mortality trends were analyzed from 30th week of 2020 and only for age groups 26–65 and 66+.

Mortality 66+ increased significantly from weeks 30–51. Schools were opened after the summer break in week 37. During week 42, a steep increase in mortality of 66+ began and does not slow down until week 45. In week 45 it slows down, but the increase was still notable and lasted till week 51. During week 51, a steep decrease began. The same week, week 51, schools were closed due to winter holidays. Primary schools were re-opened for face-to-face classes in week 03 and secondary schools in week 07; there was no significant increase in mortality.

Mortality 26 to 65 increased significantly from weeks 30–46. Schools were opened after the summer break during week 37. A more noticeable increase occurred in week 46. Decrease began in week 51. Schools were closed the same week because of winter holidays. There was no significant increase after schools re-opening (primary schools week 03, secondary schools week 07).

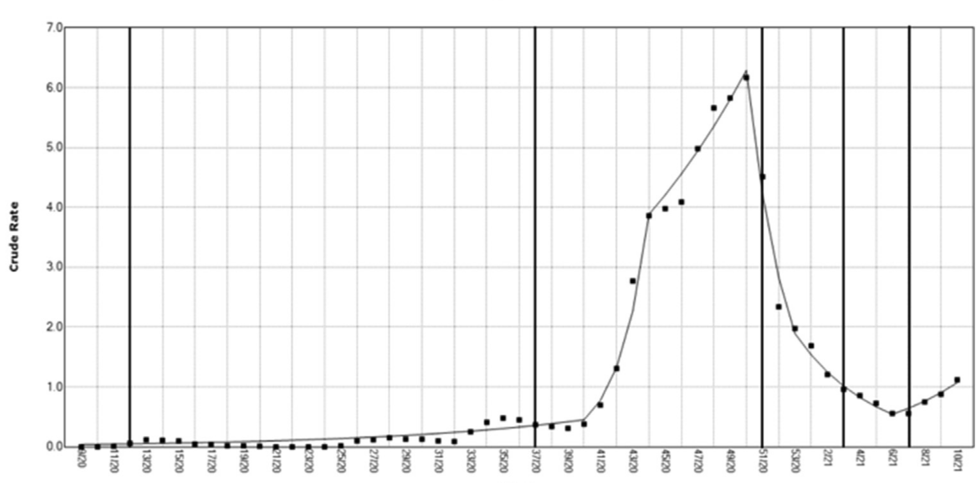
In more detail, age-specific mortality rates from the beginning to the end of the investigated period varied from 0.00 to 0.01/1000 in 26–65 age group and 0.02 to 0.09/1000 in age group 66+. In age group 26–65 years between 30th and 41st week there was a statistically insignificant APC of 5.56 ($P = 0.351$) after which a significant increase was observed until the beginning of the 51st week (41st to 46th week APC = 59.59, $P < 0.001$ and 46th to 51st week APC = 13.31, $P = 0.034$). In the age group 66+ years, there was significant increase until 51st week (30th to 41st APC = 10.24, $P = 0.007$ then 41st to 45th week APC = 70.28, $P < 0.001$ and 45th to 51st week APC = 15.05, $P < 0.001$). After 51st week significant decrease in 26–65 and 66+ years age group was present (APC = −16.52, $P < 0.001$ and APC = −16.50, $P < 0.001$ respectively). Results are presented in Fig. 3A.

Hospitalization trends of COVID-19

Hospitalization trends were analyzed from 30th week of 2020 and only for age groups 26–65 and 66+ and are shown in Fig. 3.

Hospitalizations for 66+ increased significantly from week 30. In week 37, schools were opened after the summer break. Steeper increase is noticeable from week 40 to week 45. Further but slower increase is noticeable till week 51. In week 51, a steep decrease is noticeable. Schools were closed same week due to winter holidays, week 51. There was no significant increase following primary and secondary schools reopening in weeks 3 and 7, respectively.

Hospitalizations for 26 to 65 increase significantly from week 30. In week 37, schools were opened after the summer break. In week 40, a more noticeable increase is noted. Decrease starts in



Legend: Vertical lines = marks of school closings/openings, leftmost line is school closing

Fig. 1. Weekly COVID-19 incidences during study period.

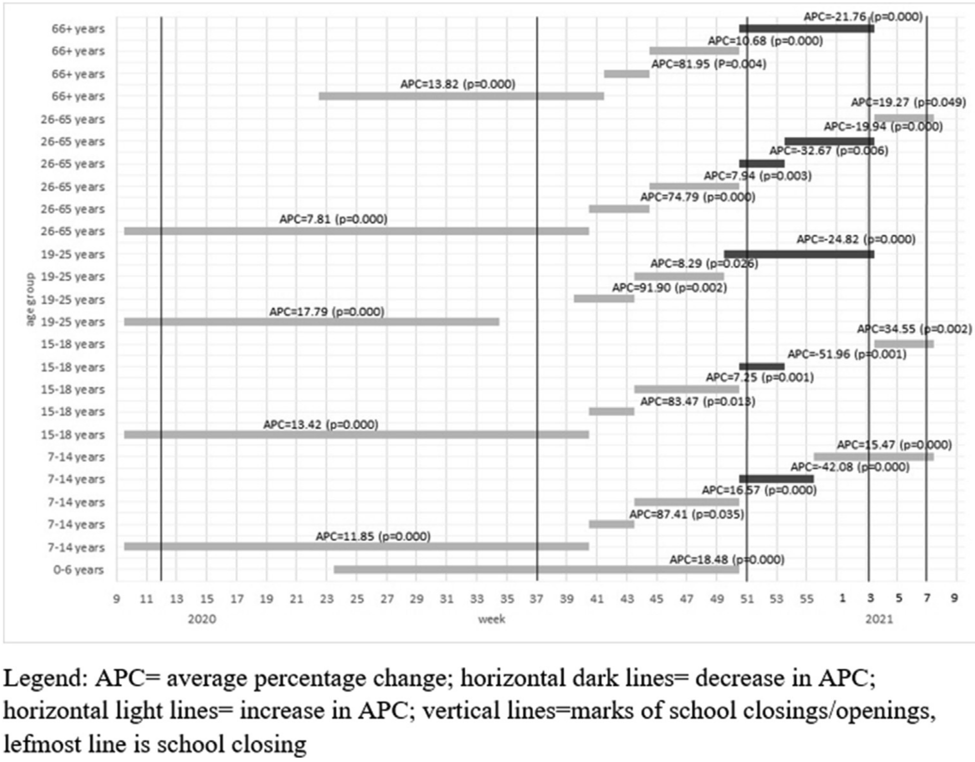


Fig. 2. Significant average percent changes of COVID-19 incidences per week (APC) according to age groups.

week 51. Schools were closed that same week, week 51. There was no significant increase after primary and secondary schools reopening on weeks 3 and 7, respectively.

In more detail, age-specific hospitalization rates from the beginning to the end of investigated period varied from 0.02 to 0.08/1000 in 26–65 age group and 0.04 to 0.24/1000 in age group 66+. In age group 26–65 years between 30th and 45th week, there was statistically significant APC increase (30th to 40th week APC = 13.06, $P < 0.001$ and 40th to 45th week APC = 34.67, $P < 0.001$). Significant decrease starts at week 50 and lasts till week 6/2021 (APC = −16.58, $P < 0.001$). In age group 66+ years between 30th and 45th week, there was statistically significant APC increase (30th − 40th week APC = 16.68, $P < 0.001$ and 40th to 45th week APC = 38.76, $P < 0.001$). Significant decrease starts at week 50 and lasts till week 8/2021 (50th − 53rd week APC = −15.30, $P < 0.001$). Results are presented in Fig. 3B.

Discussion

In Croatia, in week 37 of the year 2020 schools opened in fall for face-to-face classes following summer break. According to previously published estimations significant impact of school openings on reproduction number and epidemiological dynamics should already be seen after two weeks.[23] Trend change in 39th week was observed for age-specific 7-day cumulative incidence rates only in those 19–25 years while 7–14, 15–18, and 26–65 years had trend changes after 3 weeks and those 66+ after4 weeks. Hospitalization rates for age groups 26 to 65 and 66+ increased significantly 3 weeks after schools opening, and mortality rates increased more steeply 5 and 9 weeks after schools opening for groups 66+ and 26 to 65, respectively. Our study did not observe any significant change in the youngest age group, 0–6 years. Therefore, we can argue that the beginning of the school year did not influence this age group at all.

The decrease in cases rates began in week 50 and in mortality and hospitalization rates in week 51. The same week, week 51, schools were closed for winter holidays. This shows that the rates began to fall regardless of the schools closing because schools closing could have not caused effect within same week and for cases the decrease even began prior to schools closing. This decrease in all indicators was noted 3 weeks after the new epidemiological measures which included ban of public and private gatherings, masks mandatory outdoors if distance between two people is less than 1.5 m as well as indoors, limited number of people in shops and public transportation, closure of coffee shops, restaurants, sports activities, gyms, children's playrooms, and foreign language schools.

Re-opening in mid-January 2021 (primary schools) and mid-February 2021 (secondary schools) did not lead to a significant increase in any of the indicators.

Regarding the increase in all indicators following opening in week 37 because the effect was expected to occur earlier,[19] it is hard to speculate if the increase in rates could be associated with schools opening for the beginning of the year. It is also very hard to estimate the individual impact of school openings and closures as well as in other studies, which came to such conclusions and observed that the impact of other concurrent non-pharmaceutical interventions could not be excluded.[24] Measures embedded during the time period this study covers, besides general epidemiological measures and recommendations, included restrictions in bars and restaurants working hours and maximum capacity, mask use in all closed places, official institutions, and public transportation as well as restrictions of large gatherings and number of guests permitted at weddings and other private events. In addition, some studies imply there is seasonality in COVID-19 cases with increases being possible in fall and peaking in winter.[25] It is possible this is what happened in Croatia. Had the schools opening affected the epidemics

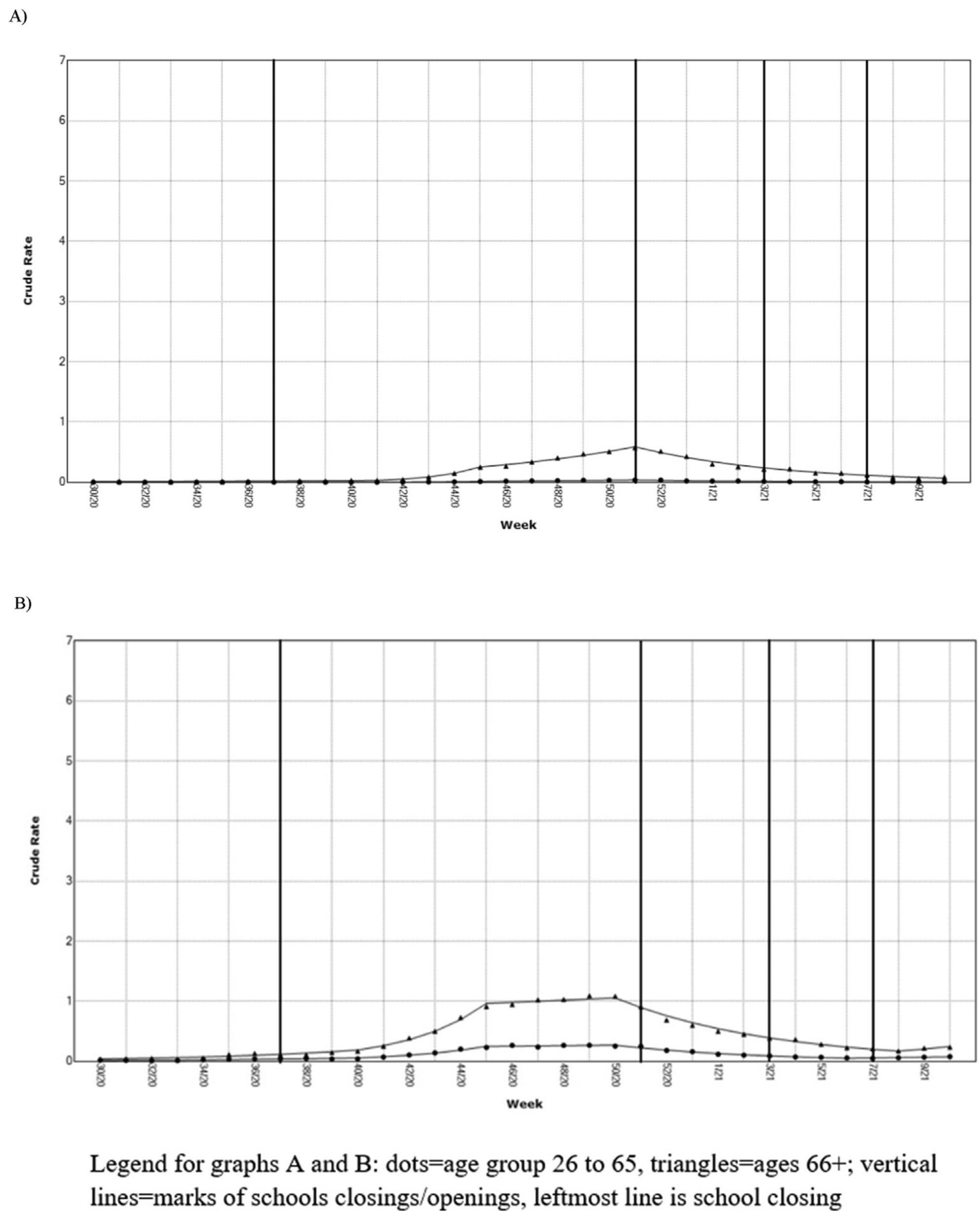


Fig. 3. Multiple joinpoint models of COVID-19 mortality (A) and hospitalization (B) rates by weeks for age groups 26 to 65 and 66+.

significantly, a rise in numbers would have happened in January and February as well. However, it has not.

Previously published systematic reviews revealed that even if there is an impact of school closures on tackling the epidemic, the impact is smaller than in case of other social distancing interventions,[13] while other meta-analysis concluded that children and adolescents play a less important role than adults in transmission of SARS-CoV-2 at a population level.[14] Furthermore, other published analysis showed that summer closures did not have significant effect on the SARS-CoV-2 transmission among children or older generations. Studies also did not find any evidence that the return to school increased infection rates among children or adults; they observed an increased rate during the last weeks of summer holidays.[26] A technical review, published by the European Centre for Disease Prevention and Control (ECDC), revealed that school settings do not play a substantial role in transmission and school closures should be used as a last resort because of the negative physical, mental health, and educational impacts on children, as well as the economic impact on society outweighing the benefits.[27]

Thus, taking into account our results, a previously published study[19] and the fact that during the 40th week seasonal changes occur, bringing colder and rainier conditions, it is hard to distinguish the impact of school openings from the other potential drivers of the sharp incidence increase in September and October 2020. However, even if that impact is not completely excluded, our study showed a completely different pattern in January and February 2021 when school began after winter holidays. After winter holidays, an increase in incidence started before or simultaneously with the return of students to primary and secondary schools in Croatia and did not show any changes in trend after two, three or four weeks. In one county, secondary schools began at even two weeks after the beginning of the incidence increase in the corresponding age group at the national level. The trends observed in January and February 2021 are in contradiction to previously published results[19] and trends observed in Croatia after the summer holidays in 2020; thus, any causality between school opening and incidence increase seems to be unlikely.

Mortality trends were analyzed only in those above 26 years because of low mortality rates in younger people and children. Our study revealed an increase in mortality rates until 51st week, one week after the decrease in incidence began. This was expected, as well as the observed decrease in mortality until the end of analyzed period, because mortality rates follow the incidence rates with a delay of up to three weeks due to the natural course of the disease.[28]

Our study investigated national data during the period of one whole year and compared incidence and mortality rates in different age groups providing better insight into incidence and mortality patterns with special reference to the beginning of school following holidays and face-to-face learning. However, there are also some limitations to our study. Official surveillance was based on laboratory confirmed cases, and therefore a clinically diagnosed case without laboratory confirmation was not included in the analysis. Furthermore, testing policy and limitation of testing capacity may have influenced confirmation to a different extent in different age groups. We were also unable to distinguish the influence of schools opening from other non-pharmaceutical interventions present during the investigated period as well as influence of concomitant seasonal changes and their influence on observed incidence trends. There are also some restrictions regarding hospitalizations and mortality data. While COVID-19 incidence data were analyzed from week 09 of year 2020 and in all age groups, hospitalization and mortality rates were analyzed from week 30 of 2020 and in adults (26–66+ years) only. This was due to low hospitalization and mortality rates in these age groups and during the first COVID-19 epidemics wave. To maintain sufficiently large numbers for analysis, we excluded population under 26 and period before week 30 of year 2020. Therefore, presented hospitalization and mortality rates should not be seen as whole-population data and data that refer to the whole period of epidemics but only second-wave adult-population data. In addition, mortality data are preliminary data, gathered from hospitals and not from official mortality certificates with official confirmation about the person died due to COVID-19 infection. Same refers to hospitalizations data. This means that there is a possibility that patients who were hospitalized or died due to another reason, but just with COVID-19 positive test as an incidental finding, are included in the current analysis.

There is no obvious pattern when it comes to increase in cases and school openings. Thus, in conclusion, schools opening and an aggravation of the epidemic in Croatia are very unlikely to have a causal relationship, and these results need to be the basis for further school policy and national health policy decision-making during the pandemic. When reconsidering school closures, stakeholders need to take into account results of published scientific literature including those that revealed that there is more than 98% probability that primary schools opening is associated with lower total years of life lost than school closure[13] due to reduced educational achievements. Schools closures are associated with interrupted and deprived learning, confusion, and stress for teachers and parents unprepared for distance learning, gaps in childcare due to absent working parents and closed schools, social isolation, and so on, and the effect is most pronounced in already marginalized and vulnerable groups of students.[29] Closures are also associated with increases in child obesity,[30] inactivity of children and mental health of both parents and children,[31] negative impacts on parents working hours and lower income, negative impact on healthcare workforce that could lead to excess in deaths,[32] and many other negative consequences.[25] There are measures that can be implemented with greater effect and less harm.[9] Therefore, school closures need to be reconsidered very carefully, each time handled carefully as an enormous health and social threat, without an impulsive reaction due to the worsening of COVID-19 numbers.

Author statements

Ethical approval

Ethical approval for this research was granted by CIPH Ethical Committee.

Funding

None declared.

Competing interests

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2021.07.030.

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