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Open schools! Weighing the effects of viruses and lockdowns on children

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**A B S T R A C T**

This review weighs the risk of infection with SARS-CoV-2 against the side effects of school closures on physical and mental health, education, and well-being of those affected by the school closures. Whereas short term effects – decreased learning and food security, and increased anxiety, violence against children, child labor and teen pregnancies – are frequently discussed, the long-term effects of school closures will be much more detrimental across the lifespan of the “Generation Corona”: Existing pandemics of inactivity and myopia, already affecting billions of people, are worsening due to less physical exercise and less time spent outdoors, poor diet, weight gain, and increased screen time during lockdowns, causing future increases of stroke, heart attack, cancer, and blindness. Socio-emotional complications of isolation, learned helplessness, economic and existential insecurity will include increased depression and suicide, decreased empathy and increased loneliness. Together with decreased educational attainment and economic productivity, the amount of ensuing increased future global morbidity and mortality justifies immediate action of school reopening.

1. Introduction

In April 2020, school closures during the ongoing corona pandemic affected 1.6 billion students in 190 countries [102]. While factories and construction sites were humming, supermarkets, pharmacies, and drugstores were open, and German tourists traveled to foreign countries near and far (sometimes returning with mutant viruses), daycare centers and schools were closed (Fig. 1) in the spring of 2020 and then again later in in Germany, almost all schools closed mid December 2020 until the end of February. Ger

As of February 16th, 2021, more than 109 million people are infected, more than 2.4 million have died, and new ever more dangerous mutants of the pathogen SARS-CoV-2 are popping up in the UK [79], US, South Africa and South America. Given that for the most part of this pandemic, Germany ranked among the 10 most infected countries and, in addition, suffers from a slow start of vaccinations, there seems to be no alternative but to keep daycare and schools closed. – Really?

First of all, the situation is serious, indeed. And lockdown measures are effective, all over the world, if implemented stringently enough. This is shown not only by the course of the pandemic in China, but also in New Zealand, Australia, and Israel. This country, which is currently the world’s most affected by SARS-CoV-2 in terms of infections per capita, has been fighting the third Corona wave with the third “hard” lockdown since January 9, 2021 (Fig. 2).

As a physician, I am used to multiplying the probabilities of benefits and risks with their effect sizes in order to weigh alternative options of therapeutic strategies rationally. For all of us, there is no alternative to death, but for each of us the roads to there are plentiful. With the exception of an early Chinese study [6], the evidence accumulated during subsequent studies from various countries indicates that the chances of children dying of corona during the current pandemic are vanishingly small [3, 25, 27, 33, 45, 50, 57, 77, 95, 99].

2. Children and COVID-19

A report published by the US Centers for Disease Control and Prevention (CDC) from October 2020 (Gould et al.), describes demographic characteristics of 114,411 Covid-19-associated deaths during May 1st to August 31st. The relative risk of dying from COVID-19 in the three youngest age groups (babies, toddlers / preschool children and school children/adolescents) is below 0,1% (Table 1).

Several recently published studies have come up with further detailed corroborative evidence. One Study from Sweden – a country where schools had not been closed during the spring of 2020 – found little evidence for the involvement of children [57]. Out of a total of 1, 951,905 Swedish children aged one to 16 years (as of Dec. 31, 2019), 65 children died – from whatever cause – in the period from November 2019 to February 2020 (i.e., before COVID-19). During the following...
four months under COVID-19 exposure – from March to June 2020 – 69 children died. During this time, a total of 15 children with COVID-19 were admitted to an intensive care unit in Sweden (corresponding to 0.77 per 100,000 children in this age range), including 4 aged 1 to 6 years (0.54 per 100,000), and 11 aged 7 to 16 years (0.90 per 100,000). Even though four of these children had a chronic concomitant disease such as cancer, none of the 15 children died.

With such low COVID-19 case rates (cf. Fig. 6) and fatality rates among children, it is not surprising that there was no increased risk of infection with SARS-CoV-2 among either preschool teachers or school teachers during the same period: As of June 30, 2020, fewer than 10 preschool teachers and 20 school teachers (out of 103,596 school teachers) had been treated in intensive care units for COVID-19, yielding no increased relative risk for educators or teachers compared with the general population.

A study from Southwest Germany published January 22nd 2021 in 2482 children of a median age of 6 (range: 1-10) and one corresponding parent (n=2482) during April and May 2020 looked for the prevalence of infection, using reverse transcriptase-polymerase chain reaction of nasopharyngeal swabs and for SARS-CoV-2 IgG antibodies in serum with enzyme-linked immunosorbent assay and immunofluorescence. They found seroprevalence to be low, with significant differences between parents (1.8%) and children (0.6%). Among the 56 families with at least 1 seropositive child or parent, seropositive parents living with seronegative children were 4.3-fold (95% CI, 1.19-15.52) more common than seropositive children living with seronegative adults, which is indicative of infections from children to parents being much less likely than from parents to children [99].

In another study published on January 26th 2021, from Bavaria (i.e., Southeast Germany), 3169 swabs were taken from children in daycare centers and elementary schools over a 12-week period in summer/fall 2020. Data showed a positive result in the PCR test in only two cases, although the number of cases in the overall population had increased sharply during the same period [33]. According to the Robert Koch Institute (RKI), nine children and adolescents were among the just over 50,000 who died of or with COVID-19 throughout Germany [26].

In an editorial with the Shakespearean title “To Spread or Not to Spread SARS-CoV-2—Is That the Question?”, Sean O’Leary [67] clearly restates in JAMA Pediatrics on January 22nd 2021 the by now well established fact, that rates of hospitalization and death are far lower in children than adults. Moreover, children account for a smaller proportion of cases than what would be expected based on the size of the childhood population [3, 99].

If children are not to blame for the spread of COVID-19 [68], why is it then that school closures are regarded by political decision makers as a sure-fire weapon against the spread of the COVID-19 pandemic? As O’Leary pointed out, the question of “Can children spread Covid-19” is often answered by “yes”, even though the chances of such a “yes” are really very small. As stated above, in ordinary medical practice, yes-no decisions appear to be binary, but the options must always be weighted. So “Yes, children can spread COVID-19” does not necessarily mean that we should close schools, if the risk is comparatively small.

A simple comparison may illustrate this point: In Germany during the year of 2019, 27,742 children (under 15 years of age) were involved in road traffic accidents, of whom 55 died. About one-third of them were on their way to or from school. This makes walking to school significantly more dangerous for German children than COVID-19. So should we leave schools closed until we achieve 100% safe traffic?

3. Lockdown and children: evidence for harm

In addition to these considerations on the comparatively small effects of the SARS-CoV-2 virus on children, we must consider the question of how much our measures of Lockdown – including school closures – are affecting the health of our children. In several quite different respects, these effects are serious and, at the same time, rarely considered. Given that school closures affected about 1.6 billion children, even small effect sizes – multiplied by this number – translate into large effects.

3.1. The inactivity pandemic

For about a decade, the decreasing amount of physical activity in the general population of developed countries has been referred to as the “global inactivity pandemic” [17, 47]. The ensuing cardiovascular diseases (heart attack, stroke) and cancers are the most common causes of death in the Western world. During lockdowns, inactivity in children
and adolescents increases even further, i.e., very common harmful effects become even more common.

Therefore, compared to the extremely low probability of children getting sick, or even dying, from COVID-19, the likelihood of developing obesity due to decreased physical activity and more screen media consumption under corona-lockdown is high, as has been reported in several studies from various countries such as Canada, Turkey, Portugal, China, and Germany [20, 61, 78, 96, 118]. According to one German study [15], during the first lockdown in spring 2020, children and adolescents (10 to 17 years of age) increased their daily screen time spent with playing computer games and using social media from about 4 to about 7 hours (see Fig. 3). In addition, they spent time watching videos and using streaming services such as Netflix – just to mention two additional highly time consuming screen activities. It is of note that on March 20th, 2020, Netflix and Youtube were asked by the European commission to decrease the rate of data transfer through their services (and thereby image quality) in order to prevent the breakdown of the internet [7]. According to BBC News, the use of video streaming services increased by 71% compared to 2019 [4].

What these numbers mean may be exemplified by quoting from an email sent to me by a Berlin school teacher upon school reopening in spring 2020: “I have now been able to see the students again for a few hours after they have spent the 7 weeks almost without exception playing in front of the computer. They were on average 5-10 kg heavier [...] and] they talked about missing their sports, but not leaving the house out of fear. Most of my students are 17-19 years old. I find it particularly alarming at this age to let students drift into digital worlds as this is the time when the foundations are laid for addictive biographies that will be difficult to correct later” ([92], p. 134, translated by the author).

The negative health effects of being overweight or even obese in childhood and adolescence are well known [82, 84, 94, 97, 101]. In addition, there is the unfortunate fact that weight is gained much more easily than lost, and therefore overweight children and adolescents very often become overweight adults. The consequences – hypertension and diabetes (type II) – and the long-term increased risk of stroke, heart attack and cancers are serious [70].

In 2012, a paper published in the Lancet medical journal put the global health consequences of inactivity at 5 million deaths annually [110]. Furthermore, it has been calculated that a 10% reduction in physical inactivity could avert 533,000 deaths per year worldwide; a reduction by 25% would avert more than 1.3 million deaths [52]. In the light of these numbers, the effect of markedly decreased physical activity in 1.6 Billion children for the extent of – by now – two lockdows, i.e.

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3 Children and adolescents spent 3h 15 min on school days and and 5h 32 min on days with no school. The weighted average of media consumption on 5 school days and 2 days with no school is 3h 54 min per day. Compared with the no school days during lockdown (right column in Fig. 2), i.e., 7h 14min, the daily increase in screen time during lockdown amounted to 3 h 20 min.

4 BBC News, August 5th, 2020.
more than three months in most countries, is open to anybody’s guess, but one thing is already clear: It will not be small.

3.2. The myopia pandemic

Myopia, or short sightedness, is usually defined as a spherical equivalent less than -0.5 diopters\(^5\) and high myopia less than -5.0 diopters (see Fig. 3). Most cases result from a developmental problem i.e., from spending too much time looking at close range during the first two decades of life [85, 109]. This is the growth window of the human eyeball, which has a built-in mechanism to grow as long as the average image on the retina is still out of focus (because the eye is still too short). So the eye grows exactly to the length, which brings the image on the retina in sharp focus [86, 87, 106]. However, if people look at close range for many hours per day, the eye grows longer, as light emanating from a point at a short distance (as in reading) will be focused further back in the eye (cf. Fig. 4). More than 140 years ago, it was discovered that schooling (implying a lot of reading) causes myopia [105]. By now, many large-scale studies show that time spent in education is associated with an increase in myopia [60,64,65,74]. In contrast, the time outdoors – looking at far range into bright light – in children and students is associated with a decrease in myopia [32, 117].

Fig. 3. Average daily use (in hours) of computer games (red) and social media (blue) by children and adolescents in September 2019 (before lockdown; lighter colors) and April 2020 (during lockdown; darker colors) on school days (left) and days with no school (weekends, holidays, lockdown; right). The corresponding column sections left and right all differ highly significantly with p <0.001 (based on data from [96], p. 83, redrawn by the author).

Forty per cent of North Americans are affected by myopia. The number of cases doubled between 1972 and 2004 and continues to grow [104]. In Europe, myopia is prevalent among 42.2 per cent of adults aged 25 to 29 years, almost twice the prevalence in adults aged 55 to 59 years [112,113], with a growing number like in the US [39]. However, outside ophthalmology circles, few people in Western countries know about the myopia pandemic [98].

This is different in Asia, where the high and still increasing prevalence of myopia is of great concern to many people. In a 15-year population-based survey of 43,858 high school students from a city in eastern China, the prevalence of myopia increased from 25.5% in 2001 to 87.7% in 2015. The prevalence of high myopia increased from 7.9% to 16.6% across the same time span [9]. Another study in 6,364 17-year olds put the percentage of myopia at 80% and of high myopia at 14% [115]. In South Korea, a population-based cross-sectional study in 23,616 male 19 year old subjects revealed a prevalence of 96.5% for myopia and 21.6% for high myopia [43]. Myopia is a risk factor for the four major causes vision impairment and even blindness at older age

\(^5\) The diopter (D) is a unit of measurement used to quantify eyesight — the more diopters eye-sight is away from zero the worse the vision.
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(1) Atrophic myopic maculopathy/retinopathy, a still untreatable slowly progressive and sight threatening condition in which visual loss develops from atrophy of the retinal pigment epithelium, and currently among commonest causes of visual impairment. Dependent on the degree of myopia, the risk is increased 18 times on average (OR 2.2 at –1 to –3D; OR 348.6 at < –9D).

(2) A similar relationship has been observed between increasing myopia and retina detachment and tearing, with an average of 7.8 times risk increase in any myopia. (OR 4.4 at –1 to –3D; OR 9.9 at –3 to –8D)

(3) Glaucoma, i.e., pathologically elevated eye-pressure, was found to be increased 2.3-fold in low myopia (down to –3D), and 3.3-fold for moderate and high myopia (below –3D).

(4) For cataracts of various types, several studies with different designs and measures report elevated ORs in the range of 1.4 to 2.1 for low myopia (<–0.5D to –2D), 3.1 for moderate myopia (–2D to –4D), 5.5 for high myopia (–4D to –6D) and 12.3 for myopia in excess of –6D (data from [22]).

Taken together, these data clearly show why myopia is widely regarded as an “underrated global challenge to vision” [34].

In Germany, only 34% of school children regularly read books (for about one hour per day on average; cf. [42]), so reading books appears to be no longer a problem for myopic eye development. However, given that smartphones not only are the most widely and most often used digital screen media [72] but also have the smallest screens (affording a very close look down to a distance of about 20 cm, compared to book reading at 50 cm), looking at smartphones for 5 hours per day or more is a concern regarding healthy eye development concern [56].

As mentioned above, in the second half of the last century, an increase in average educational attainment was observed in many developed countries. However, this factor alone cannot explain the increase in myopia as observed during this time period [111]. As there was also an increasing use of TV, videos, computers, and finally smartphones, as well as a marked decrease of outdoor physical activity and play, these factors have recently been mentioned frequently as causing myopia independent of education [29, 30, 32, 62, 63], even though not all studies looking at this association detected one (Huang et al. 2019). As more screen media use is highly correlated with decreased time spent outdoors, this may be part of the reason for the education-independent increase of myopia. Most recently however, computer use and smartphone use were specifically identified as risk factors for myopia [1, 19, 21, 107].

In the light of these data on myopia, it is little wonder that Wang and coworkers [108] have found an up to three-fold increase in the speed of growth of the length of the eye during the four month of school closure and home confinement during the COVID-19 pandemic in China. In a prospective cross-sectional study lasting for six consecutive years (2015-2020), the authors investigated the refractive changes and prevalence of myopia in 123,535 children (6 to 13 years of age; 52.1% boys) from 10 elementary schools. Comparisons were made between 2020 (after home confinement) and the previous 5 years for each age group, and a substantial myopic shift (approximately –0.3D) was found in the 2020 school-based measurements of the 6, 7, and 8 year old children. In these children, the prevalence of myopia in the 2020 measurements was higher than the highest prevalence of myopia within the years from 2015 to 2019 for children aged 6 (21.5% vs 5.7%), 7 (26.2% vs 16.2%), and 8 (37.2% vs 27.7%) years. The differences in children aged 9 to 13 years were found to be smaller and not statistically significant. “Younger children’s refractive status may be more sensitive to environmental changes than older ages, given the younger children are in a critical period for the development of myopia”, the authors conclude. Another reason why children from 9 to 13 showed little increase may be a ceiling effect: Their screen time may already have been very high, such that the lockdown could not add much more time and therefore, myopia [46] .

How should these effects be weighted? – A systematic review and meta-analysis of 145 studies (published since 1995) covering 2.1 million people, estimated the current number of people with myopia at 1.4 billion (23% of the worlds’ population) and the number of people with high myopia at 163 million (2.7%). For 2050 these numbers were predicted to be 4.8 billion people (about 50% of the world’s population) with myopia, and 938 million people (almost 10% of the world’s population) with high myopia [35]. Any further increase of almost 1 billion people with high myopia and resulting vision loss and blindness is serious matter.

Given that 1 in 3 people with high myopia becomes severely visually impaired, mostly before retirement age, it is clear that China is facing a serious public health problem. This is probably why China put a smartphone ban into effect on January 15th 2021 – i.e., just one day after the above mentioned study by Wang and coworkers on increased myopic eye development got published (Fig. 5). In a country with a population of 1.3 billion and 80% prevalence of myopia in the younger population already, and growing, the costs of myopia in terms of human suffering and economic burden seem to warrant such drastic measures.6 Much of the rest of the world is likely to follow.

3.3. Mental health problems: brain development, stress, learned helplessness, depression, anxiety, loneliness, addiction, and antisocial behavior

An increasing number of studies have reported the psychological impact of the COVID-19 crisis on the general population: Increased levels of stress, depression (including suicide risk; cf. [58]), anxiety, fatigue and decreased sleep [88,89,100]. With respect to children and adolescents, such increases can be expected to be larger, as brain development, like eye development2, happens within the first two to three decades of life, and is the more pronounced the younger the person is. Brain development depends upon experience: Learning to speak involves listening, articulating, and joint action accompanied by dialogue – it does not happen in front of screens. Even the mastery of the phonetic units of language, which happens before age one, requires learning in social contexts [48,49]. Compassion, personality, conducting dialogues and exchanging arguments, solving conflicts and much more depends upon time spent in the community of family and friends. Empathy and self-confidence come from successful emotional interactions and from projects and experiences of self-efficacy in everyday life, as long-term studies of human development have shown [81].

Instead of language development, personality formation, and social learning, lockdown primarily teaches helplessness: One learns, firstly, that one is at the mercy of the pandemic, secondly, that the measures taken against it, and thirdly that one can do nothing to change its course. In addition, one is constantly afraid of one’s own contagion, or of infecting others. Prescribed social isolation has also been shown to lead to stress, which in turn is detrimental to health – the longer it lasts, the more so [120]. Learned helplessness is the most widely applied concept of psychological causative processes for stress, anxiety and depression. As younger people learn faster than elders, they also learn helplessness faster. In addition, younger people have fewer life experiences, which help their parents and grandparents get through a ‘spell’ of social isolation, stress, and economic hardship.

Under normal circumstances, the worldwide prevalence of mental disorders in children and adolescents is 13.4% as reported by a meta-

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6 In China, school work is basically organized around the smartphone, with homework assignments made and homework itself done, using the smartphone and school software. So a general ban of smartphones from schools requires teachers and students to make substantial adjustments in their daily operational procedures.

7 This is not a coincidence: Ontogenetically, the eye is part of the brain.
Study after study found that mental health problems have increased, not so much because of the new corona virus but because of the lockdown measures taken to mitigate infections. The first came from China, where COVID-19 started and increasing levels of stress, anxiety, and depression were reported [41]. Xie and coworkers [116] found that during the pandemic in China, 23% of children from grades 2nd to 6th had depressive symptoms and 19% suffered from anxiety. In a cross-sectional study of 8079 Chinese high school students (aged 12–18 years) during the COVID-19 epidemic period the prevalence of depressive symptoms, anxiety symptoms, and a combination of depressive and anxiety symptoms was 43.7%, 37.4%, and 31.3% outbreak [119].

A representative online survey was conducted in Germany among 1,586 families with 7- to 17-year-old children and adolescents between May 26 and June 10 2020, i.e. a few weeks after the first lockdown. The authors were able to compare their results with data from the nationwide, longitudinal, representative cohort study (n = 1,556) conducted before the pandemic. The children and adolescents experienced significantly lower health-related quality of life (40.2% vs. 15.3%), more mental health problems (17.8% vs. 9.9%) and higher anxiety levels (24.1% vs. 14.9%) than before the pandemic [80].

Results from a study of 932 university students using a web-based interview indicated that students experienced considerable psychological stress during the confinement, with higher rates of emotional distress than before the pandemic [81]. Psychological distress was mainly related to several specific domains of stressors, as perceived by the participants: academic future, task overload, worsening of interpersonal conflicts, and restrictions in pleasant social contact; and far less related to the spread of the disease and its consequences for physical health [69]. Increased TV-viewing by children and adolescents increases its detrimental effects, from overweight and poor fitness in adulthood [28], to the development of attention problems [53, 66] and empathy towards parents and peers [81] to increased antisocial behavior [83]. During lockdown, TV-use has increased (see the figures on streaming services above) and therefore, these well-known side effects can be assumed to be more pronounced. The physical effects have been called “Covibesity” [44]. Unhealthy eating (more potato chips, red meat, and sugary drinks [73], decreased physical activity and more screen time all contribute to
this during lockdown. All the effects are more pronounced in already disadvantaged children such as children from low SES families and/or families with parents of low educational achievement (see below).

Part of all lockdowns is the request for people to keep a physical distance to other people in order to prevent infections. Unfortunately, this was called “social distancing” whereas people from the very beginning should have used “physical distancing” to emphasize that we can remain socially connected even while being apart. Even better, the phrase “distant socializing” was proposed by Stanford Social Neuroscientist Jamil Zaki (quoted from [16]) to make sure that by no means the promotion of loneliness is at issue. – But it was.

We experience loneliness whenever we have the experience of being abandoned or just being abandoned. It is a subjective feeling, fundamentally unpleasant and is accompanied by behavior that counteracts the condition. In contrast, social isolation refers to the objective fact of being isolated from others. Loneliness and social isolation are related but are not the same: for example, some people can feel lonely even though they are constantly among people. On the other hand, there are quite socially isolated people who live well with this and who do not mind it. According to recent estimates, loneliness has increased during lockdowns by 20-30% [37]. This certainly is a public health concern, as can be inferred from the fact that in 2018, the UK appointed a Loneliness Minister and published a national strategy for tackling loneliness[91]. So loneliness and social isolation already affected a large number of people before the pandemic.

Even though most people think of elderly people to be most affected by loneliness, it is in fact the younger people who suffer the most [8]. Social isolation and loneliness cause short term (suicide and domestic violence) as well as long term effects regarding a large number of chronic diseases [36]. The risk of these diseases increases with a considerable increase in mortality risk. Even the risk of catching COVID-19 is very likely increased in lonely people [12]. As regards the effects of loneliness and social isolation in children and adolescents, studies show that they are probably more likely to experience high rates of depression and anxiety during and after enforced lockdown and isolation, as a recent review of 83 articles concluded [54]. The true impact, however, will only come to light via future research.

To sum up: From babies to university students, physical and mental health is endangered by lockdown measures. Babies suffer from more violence and stress of their parents, toddlers miss their friends, preschoolers even more so. Children miss school (yes, they really do!), as do adolescents, who realize the importance of teachers for learning, possibly for the first time. In addition, obesity and lack of education (see below) are mutually dependent, i.e., can cause each other [11].

Unfortunately, the above quoted teacher’s concerns regarding the development of addiction are also all too justified, as the Corona pandemic has exacerbated the problem of addiction [121,122].

3.4. Educational loss, widening the SES-gap, economic hardship, and inequality

In the short term, school closures decrease learning and increase dropouts, child labor, violence against children and teen pregnancies [55]. In addition, school closures in many countries lead to food insecurity and malnutrition, since many children get their breakfast or lunch in schools [10, 103]. These consequences have been observed during the Ebola epidemic of 2014-2016 [2]. Economic downturns and unemployment due to lockdowns are associated with decreased adult mental health that may affect by the mental health of children and adolescents [24]. In the long term, the above mentioned serious effects on health and education lead to persisting socioeconomic and mortality disparities between the rich and the poor [5, 76, 103].

As children learn a lot very quickly in school, which is now down for nearly half a school year, their education suffers. A recent study of 350,000 students in Holland clearly showed, almost nothing is learned in distance education—even though, as in Holland, there has been no shortage of computers and experience with computers in the classroom for years [18]. This is exactly why the authors deliberately analyzed data from Holland. Hence, the argument that there is no experience with computers and too few devices does not apply there. The fact that there is talk in Germany of suspending compulsory school attendance, setting lower requirements, not crediting the year to the pupils and students (towards their school time, study time, or training time), or perhaps simply not valuing it at all and repeating it, provides an idea of how serious the situation really is.

Even more importantly, closed schools significantly widen the gap between stronger and weaker students. For example, a good student can be given a book if he or she misses school, and will then read it with profit. A weak student will not. The stronger a student is, the better his or her attention and ability to concentrate - also and especially when learning on the computer. In the long term, the school closure as part of the lockdown to contain the spread of the new coronavirus thus causes a social crisis through increased social inequality, which must be countered by appropriate political measures. Limiting school closures to the absolute minimum is therefore of great importance.

Ludger Wößmann, Professor of Economics of Education at Ludwig-Maximilians-Universität in Munich and Director of the Ifo Center for the Economics of Education there since 2004, has been studying the relationship between education and the economy for more than two decades. In this regard, there is very robust data on past school dropouts, short school years and newly introduced additional school years from a wide range of countries. "Nothing is as well documented in the economics of education as the relationship between education and income" (Wößmann, as cited in [23]).

These studies show that "If about a third of a school year is lost to learning, this is associated with about 3-4% lower earned income on average over the entire working life. Moreover, studies [...] show that missing school [...] permanently reduces future labor market success" ([114], p. 38). Only recently, Wößmann extrapolated the impact of school closures in Germany up to the year 2100 (which is roughly how long first graders live today) and put it at 3,300 billion euros [23]. For individual workers, the lockdown last spring (12 weeks) lost 3 percent of lifetime income. If the second lockdown is added, it is 5.5 percent of lifetime income.

However, these calculations do not yet include the effects of school closures on other groups in society (such as the elderly). It should be noted, that according to the available findings, children in particular are only rarely ill, they also pose a lower risk than adults (Fig. 6).

In addition, children are statistically more likely to be infected by adults than to infect adults. Thus, in principle, children are at lower risk than students in grades 8 to 13 (middle and high school) and adults. So from their perspective, harm is done to them without much benefit, when lockdowns are imposed.

4. Discussion: the future of “generation corona”

Children, adolescents and young adults will struggle with the consequences of the Corona pandemic on their life plans for a long time to come. Not so much the virus, but rather our actions to prevent its spread, are going to have long-term detrimental effects on an entire generation who was not only young but also insecure, lonely, less active and deprived of normal life-experiences. Opportunities to learn what young people should learn were reduced, and times were increased for what they should not learn – helplessness, eating the wrong diet, spending too much time in front of screens. In this review, the effects of school closures on young people are shown to be much more detrimental than is usually assumed, in terms of health, education, and well-being. In my view, this renders it quite likely that we will soon refer to the young people who lived through the pandemic as “Generation Corona”. The effects are global, large, and will leave a lasting imprint in minds and bodies for decades.

To be clear: The first lockdown last year was in principle hardly
infectivity tends not to persist for the entire 14 days), less than one in five.

This presents a good and very cost-effective opportunity for surveillance.

In contrast to the first lockdown, tests and mouth-nose masks are no longer in short supply. Several studies at once also showed that the virus can be detected in sewage [31] and that about one infected person for every thousand uninfected is enough to make these tests positive [51]. This has already been used to identify corona outbreaks in neighborhoods [14] or even in student dormitories [71]. Even genome analyses to identify new mutants are possible in wastewater, as Swiss scientists from the ETH in Zurich and the Institute of Bioinformatics at the University of Lausanne recently reported [40]. Because the signal for SARS-CoV-2 in wastewater could be detected at the local level 4 to 20 days before the signal of new clinical cases, and wastewater therefore shows the presence of the virus in a given area earlier than clinical cases, this presents a good and very cost-effective opportunity for surveillance.

Because swabbing has so far had to be carried out by experienced medical personnel, the so-called "gargle tests", in which the virus is detected in the gargle water, should also be mentioned at the level of school classes. If the entire class spits into the same bucket after gargling, such class-specific antigen tests would be perfectly feasible and affordable. If school sewage were also tested daily, a dense network for timely monitoring of our schools could be practically and economically feasible now, and schools could reopen.

The recent start of mass vaccination must be mentioned in this context. While it has focused on the most vulnerable (people over 80 years of age) and those who care for them, it has not been considered a high priority to vaccinate caregivers and teachers, so they can safely get back to work. Do the math: Every vaccinated teacher who is allowed to teach has a huge effect on the future health, education, and wealth of the many children he or she teaches. And we could have done better protecting the elderly in the first place: In Germany, a SARS-CoV-2 positive Santa appeared in a nursing home for the elderly, infected many and caused unnecessary deaths. Likewise, corona-deniers and conspiracy theorists pose a real problem regarding the spread of COVID-19 because of irresponsible behaviors of non-distancing and not wearing masks. Moreover, there are people who still cannot refrain from unnecessary trips and parties. Because of this, and because of a high prevalence of COVID-19 at the beginning of the year 2021, and the possibility of more lethal, mutant viruses, we do not really fight these irresponsibilities. Instead, we try to balance them with the even larger irresponsibility of using our children locked out of school as our main defense.

To conclude: We know far more now about both transmission dynamics and mitigation measures than we did in March 2020 when most schools shut down. The preponderance of evidence now shows that children 10 years and younger are both less likely to acquire SARS-CoV-2 infections and less likely to transmit them to others. Proper mitigation measures – distancing, hygiene, wearing masks, consciously [93], test individuals and groups, vaccination – can inform opening policies [38] and reduce the risks even further and bring our society back to normal. Until then, we must weigh our decisions and do as little harm as possible to the most vulnerable and at the same time, most precious resource we have in order to deal with any present or future problems: Our next generation. In my view, weighing the evidence produces a clear priority to reopen childcare facilities and (at least elementary) schools now.
