School closures and mental health, wellbeing and health behaviours among children and adolescents during the second COVID-19 wave: a systematic review of the literature

Chiusura della scuola e salute mentale, benessere e comportamenti correlati alla salute in bambini e adolescenti durante la seconda ondata di COVID-19: una revisione sistematica della letteratura

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Abstract

Objectives: to evaluate the impact of school closures, as a measure to contain the transmission of SARS-CoV-2 infection, on the psychological well-being of students of all levels starting from the 2020-2021 school year.

Design: a systematic literature review was conducted according to the PRISMA 2020 Guidelines. The literature search was conducted on 4 different databases: MedLine, Embase, PsycINFO, and L.OVE Platform. Quantitative observational studies published until 10.01.2022 were included. Studies conducted during the first pandemic wave, i.e., during the 2019-2020 school year and/or during the mandatory lockdown or confinement period, were excluded. The methodological quality of the studies was assessed with validated scales. Study selection, data extraction, and quality assessment were carried out independently by two authors.

Setting and participants: children, adolescents, and young people attending all levels of education (including universities) and, for reasons related to COVID-19, having a suspension of "in presence" school or attending classes remotely.

Main outcome measures:
a. outcomes directly related to mental health: suicides, emergency department visits, and hospitalizations for psychiatric problems; anxiety and depression, emotional difficulties, feelings of loneliness and isolation;
b. well-being outcomes: sleep quality, perceived well-being (by child/adolescent/youth or referred by parents);
c. health-related behaviours: tobacco smoking, alcohol, drug use. Outcomes related to school/academic performance, physical health, and those related to parents were not considered.

Results: after having removed duplicate articles, 2,830 records were retrieved with the bibliographic search. Twelve studies (2 uncontrolled before-after studies and 10 cross sectional surveys) were included, involving a total of 27,787 participants. Three studies involved university students, 2 involved high school students, and the remaining involved a mixed population of students attending primary and middle schools. The studies were conducted between September 2020 and April 2021. The methodological quality was rated as high in five studies and intermediate in the remaining studies. Due to the high heterogeneity of outcome measures and statistical analyses performed among the included studies, it was not possible to conduct a meta-analysis of the results of the considered publications. Nevertheless, the present review showed a clear signal of increase in mental health problems in relation to school closure or virtual instruction. In particular, results suggest evidence of association between school closure and risk of suicidal attempts or thoughts, mental health symptoms such as anxiety, depression, emotional disorders, psychological stress. Sleeping problems, drug and alcohol addiction were poorly studied.

Conclusions: despite the limitations of the included studies and possible residual confounding and contamination due to restrictive measures and social isolation implemented during the pandemic, the available evidence confirms the negative impact on students' mental health associated with school closures and distance learning. Given the availability of vaccination also for young children, a long period of school closure should be avoided also in the case of the emergence of new pandemic waves.

Keywords: school closure, COVID-19, psychological wellbeing, systematic review, youth

What is already known

■ Social distancing measures including lockdown and school closures implemented during the first wave of the COVID-19 pandemic for a relative short period of time had a negative impact on mental health and wellbeing of children and youth.

What this study adds

■ The available evidence suggests worsening impact on mental health of children, adolescents, and youth, associated with school closures and implementation of distance learning over a prolonged period of time during the second COVID-19 wave, although there is a possible residual confounding and contamination due to restrictive measure and social isolation implemented during the pandemic.

Riassunto

Obiettivi: valutare l'impatto della chiusura delle scuole di qualsiasi ordine e grado a partire dall'anno scolastico 2020-2021, quale misura per contrastare la trasmissione dell'infezione da SARS-CoV-2, sul benessere psicologico degli studenti.

Disegno: è stata condotta una revisione sistematica della letteratura secondo le Linee guida PRISMA 2020. La ricerca bibliografica è stata effettuata su 4 diversi database: MedLine, Embase, PsycINFO e L.OVE Platform. Sono stati inclusi gli studi osservazionali quantitativi pubblicati fino al 10.01.2022. Sono stati esclusi gli studi condotti durante la prima ondata pandemica, ovvero durante l'anno scolastico 2019-2020 e/o nel periodo di lockdown o confinamento obbligatorio. La qualità metodologica degli studi è stata valutata con scale validate. La selezione degli studi, l'estrazione dei dati e la valutazione della qualità è stata effettuata da due autori in modo indipendente.

Setting e partecipanti: bambini, adolescenti e giovani appartenenti alle scuole di qualsiasi ordine e grado (incluse le università) che, per motivi legati al COVID-19, hanno avuto una sospensione della frequenza scolastica in presenza o hanno seguito le lezioni da remoto.

Principali misure di esito:

a. esiti direttamente correlati alla salute mentale: suicidi, accessi in pronto soccorso e ricoveri ospedalieri per problemi psichiatrici, ansia e depressione, difficoltà emotive, sensazione di solitudine e isolamento;

b. esiti di benessere: qualità del sonno, benessere percepito (dal bambino/giovane o riferito dai genitori);

c. comportamenti correlati alla salute: uso di fumo di tabacco, alcol, droghe. Non sono stati considerati gli esiti relativi al rendimento scolastico e alla salute fisica.

Risultati: con la ricerca bibliografica, dopo rimozione dei duplicati, sono stati reperiti 2.830 record. Sono stati inclusi 12 studi (2 con disegno prima-dopo e 10 indagini trasversali), con un totale di 27.787 partecipanti. Tre studi sono stati condotti su studenti universitari, due su studenti delle scuole secondarie di secondo grado e i rimanenti includevano una popolazione studentesca eterogenea tra scuola primaria e secondaria di primo grado. Gli studi considerati sono stati condotti fra settembre 2020 e aprile 2021. La qualità metodologica è stata giudicata alta in 5 studi e media nei rimanenti. A causa dell'elevata eterogeneità delle misure di esito e delle analisi statistiche effettuate tra gli studi inclusi, non è stato possibile effettuare metanalisi dei risultati delle pubblicazioni considerate. La revisione mostra un chiaro segnale di aumento dei problemi legati alla salute mentale associati alla chiusura prolungata delle scuole e alla attivazione della didattica a distanza (DAD). I risultati forniscono evidenza di associazione tra la chiusura delle scuole e il rischio di suicidio o ideazione suicidaria, di ansia, depressione, disturbi emozionali e stress. I disturbi del sonno e l'uso di alcol e droghe sono stati valutati solo da un numero limitato di studi.

Conclusioni: nonostante i limiti degli studi inclusi, un possibile confondimento residuo e una contaminazione dovuti alle misure restrittive e di isolamento sociale messe in atto nel corso della pandemia, l'evidenza disponibile conferma l'impatto negativo sulla salute mentale degli studenti associato alla chiusura delle scuole e all'attivazione della DAD. Data la disponibilità dei vaccini anche per i bambini e i ragazzi, la chiusura prolungata delle scuole dovrebbe essere evitata anche in caso di nuove ondate pandemiche.

Parole chiave: chiusura delle scuole, benessere psicologico, COVID-19, giovani, revisione sistematica

Introduction

Social interaction among children and youth at school is a crucial factor in their cognitive and emotional development,[1] which in turn influences their social, family, and academic performance.[2] Due to the COVID-19-related social restrictions, in many countries schools and universities were closed as an additional containment measure. As a result, children and youth were moved to online distance education from home and had to cope with an unprepared and unprecedented scenario of psychological stress due to home isolation, difficulties in managing distance learning tasks as well as problems to challenges related to technological innovation and digital transformation in the educational setting.

Considering that school is an important context for the development of social relationship skills thanks to daily face-to-face interactions, and that this changed dramatically during COVID-19, recent studies suggested that children and adolescents exposed to mandatory school closure were more likely to exhibit psychological consequences related to increased feelings of loneliness and confusion, particularly in adolescents.[3] Moreover, children and youth were among the most vulnerable groups to suffer from the negative mental health consequences of the pandemic in the long-term.[4] Schools remain closed in many countries globally as part of efforts to control the COVID-19 pandemic, despite, to date, the evidence to support the effectiveness of global school closures in controlling COVID-19 is sparse.[5] School closures started in March 2020 and continued in different forms (complete closure, partial closure or as a hybrid form)[6] throughout the 2020-2021 school and academic year with an 'unusual school calendar' that was determined by outbreaks and the incidence rate in the community. Although some authors suggested a potential benefit from the distance learning mode of instruction, reporting positive academic outcomes, the study nevertheless concluded an increased psychological distress due not only to obstacles in fulfilling the online learning due to technological and instructional challenges, but also due to social and affective challenges which resulted from isolation and social distancing.[7] Furthermore, young people had to deal with the uncertainty and the lack of control over the future due to the COVID-19 pandemic. Fear of personal and family safety was the most common feeling reported by younger

students. In the family context, youth had to cope not only with their own anxiety, but also with the negative emotions and worries of their parents.[8]

Previous systematic reviews showed the negative impact on youths' mental health and physical health due to school closures during the lockdown, implemented in the first phase of the pandemic.[9-12]

To date, there is no systematic appraisal of evidence that disentangled the psychological effect of school closures and remote distance learning from the more comprehensive effects of mandatory home confinement measures during COVID-19 epidemic.

Objectives

the aim of this study is to evaluate the impact of school closures which did not include the broad range lockdown, as a measure to contain the transmission of SARS-CoV-2 infection, on the psychological well-being of students of any educational level during the 2020-2021 school/academic year.

Methods

A systematic literature review was conducted according to the PRISMA 2020 Guidelines.[13]

Information sources and search strategy

The literature search was conducted on 4 different databases: MedLine, Embase, PsycINFO, and L.OVE Platform. No restriction on date or language was imposed. Quantitative observational studies published until 10.01.2022 were included. Details of the search strategy are available in the online Supplementary Materials.

Study selection

Four couples of authors (MDS, MC, MS, ER, ADL, LL, SP, PC) independently screened each article title and abstract. Independently, the same couple of authors screened and identified potentially relevant studies which were then acquired in full text and assessed for final inclusion. Any disagreement was resolved by discussion with a third author who acted as arbitrator (RS, SM). The **studies** were **included** if they:

■ were focused on students from schools of any grade level (pre-school, primary and secondary schools, university) who, due to COVID-19-related school closure as a measure to contain the transmission of SARS-CoV-2 infection, were restrained to home with or without distance learning (for any time duration);

■ were focused on students attending distance learning with or without school closure;

■ were conducted during the 2020-2021 or the 2021-2022 school/academic years (the academic year usually ranges from September to June);

■ were not conducted during the mandatory lockdown or confinement period;

■ reported quantitative data on the impact of school closures on mental health and psychological well-being of students;

Outcomes considered were:

■ outcomes related to mental health: suicides, admissions and hospitalizations for psychiatric problems, anxiety and depression, emotional difficulties, feelings of loneliness and isolation;

■ well-being outcomes: sleep quality, perceived well-being (by child/youth or parents);

■ outcomes related to health-related behaviours: tobacco smoking, alcohol and drug use.

Outcomes related to school performance, physical health, and those related to parents were not considered.

Studies were **excluded** if they:

■ were conducted during the first pandemic wave (during the 2019-2020 school year) when mandatory lockdown or confinement were more probably in place in all countries, and/or during the mandatory lockdown or confinement period;

■ were focused on psychological effects of the pandemic period in general;

■ were descriptive studies without quantitative data on outcomes of interest.

Data extraction

Three authors (MDS, MC, and MS) independently extracted the following information using a data collection form that was validated on the first 2 studies: characteristics of the studies (year of publication, study design, country), school closure duration and distance learning option (yes/no), period of reference, source of data, setting (nursery, pre-school, primary, secondary, and university) and type of school (public/private), number of subjects enrolled, age, and gender (% of males). Information about the mental health impacts related to school closure/distance learning were also extracted. For the selection of the effect estimates, the adjusted estimates instead of the unadjusted ones were extracted. When more than one statistical model was used, the estimate was extracted from the fully adjusted model, if possible. The main study limitations were also reported to provide some insights in the methodological issues. Divergences of opinions were solved with the support of other two authors (RS and SM).

Quality assessment

The methodological quality of the studies was assessed with validated scales independently by two authors (SM and RS). The Newcastle Ottawa Scale-Cohort studies was used for prospective and retrospective cohort studies[14] and a modified version of the same scale was used for cross sectional studies.[15] Studies were judged at low risk of bias for comparability between groups

if the analyses were adjusted for the following relevant confounders: presence of other measures of social distancing, demographic and socioeconomic variables. Before-after studies without control group were assessed with the tool developed by the National Heart Lung and Blood Institute (NHLBI).[16]

Across checklists, studies were categorized as:

- high quality if they met 8-10 criteria;
- medium quality if they met 5-7 criteria;
- low quality if they met 0-4 criteria.

Data synthesis and analyses

Due to the heterogeneity of the outcome measures and of statistical analyses performed among the included studies, it was not possible to conduct a meta-analysis of the results of the considered publications. A narrative synthesis of the results was performed, grouping the studies according to the type of outcome and type of school (preschools, primary, secondary, universities). Interpretation was then weighed qualitatively, giving greater emphasis to studies having a control group for the estimation of mental health impact and less to studies without a comparison group.

Results

Study selection

Figure 1 shows the search flow according to PRISMA guidance.[13] A total of 2,830 records were retrieved after removing duplicates, of which 105 were reviewed in full text as judged to be potentially relevant. Twelve studies,[17-28] involving a total of 27,787 participants, were finally included. Two studies adopted a before-after design[17,26] and 10 a cross-sectional design;[18-25,27-28] The characteristics of the studies can be found in Table 1. Reasons for exclusion of the 93 studies assessed from full text are reported in Table S1 (see online Supplementary Materials). The main reasons for exclusion were because the studies were conducted in the first pandemic wave (during the 2019-2020 school/academic year) and because the full pandemic period, instead of the only school closure, was often considered as exposure.

Characteristics of included studies

Three studies involved university students,[21,24,25] three high school students,[19,22,23] and the remaining studies included mixed groups from both primary and secondary schools. No studies evaluated a preschooler population. The mean age of high school students who participated was of 16.5 years; the age range for studies which involved university students was between 18 and 22 years and, for those studies which included a mixed population of children and adolescents, the age range was between 3 to 17 years; this information was not reported in two studies.[24,26]

Percent of male ranged from 26.8% to 53.8%; the information was not reported in one study.[26]

All the studies were conducted between late 2020 (September-December 2020) and early 2021 (February-April 2021). Length of school closure was not reported in 5 studies;[17-19,25,27] for the other studies, the length of school closure was the following: 1.5 months in one study,[21] 2 months in one study,[26] 3 months in two studies,[20,28] 6 months in two studies,[22,23] 8 months in one study.[24] Some studies were included even though they enclosed also the first months of the pandemic, since they provided results on mental health outcomes in the specific months of the interest for this review (2020-2021 or the 2021-2022 school/academic years).[17,26]

Five studies were conducted in the US,[17-19,27-28] two in Japan,[20,26] two in Austria,[22,23] and one in each of the following countries: Slovakia,[25] China,[24] and France.[21] Out of the 10 cross-sectional studies, only 3 were of high methodological quality;[17,18,26] the remaining studies were of medium quality, especially because the sample either lacked representativeness or the sample size was not justified. Others lacked the non-respondent's description (Table 2). The two before-after studies were of high methodological quality[16,25] (Table 3).

The effect of school closure on mental health and well-being

Results about the effect of school closure on mental health are reported in Table 4.

A total of 4 studies evaluated the effect of school closures[4,17,20,26] on children and youth mental health and other 4 studies evaluated the impact of distance learning and hybrid learning.[18,19,27,28]

Other 4 studies provided only a description of mental health status of adolescents during the period of school closure or distance learning without providing any association estimate.[21-23,25]

Suicide

Three studies provided evidence of an increasing suicide or suicidal thoughts rate associated to school closure or online learning. In particular, an increasing suicide rate in populations younger than 20 years was observed in Japan in the second pandemic wave, immediately after school closures and some months after the lockdown (Incidence Rate Ratio – IRR 1.49; 95%CI 1.11-2.0 in September 2020 compared to the pre-pandemic period).[26] The study authors hypothesized that the observed increase could be explained by adolescents psychological distress after back to school following school closure.[26] In a US study, emergency department (ED) visits for suicide attempt of children and adolescents were increased (+20.4%, p-value results were not reported) in autumn 2020 (school clos-

ure period) compared to autumn 2019 (in-presence schooling mode).[17] Another US study provided evidence for a higher prevalence of seriously considering suicide in the previous 12 months in adolescents attending distance learning compared to in-presence learning during October-November 2020 (Prevalence Ratio – PR 2.45; 95%CI 1.22-4.90).[19] Moreover, this study suggested an increased prevalence of suicide-related thoughts also in students attending hybrid versus in presence instruction (PR 1.95; 95%CI 0.69-5.52).
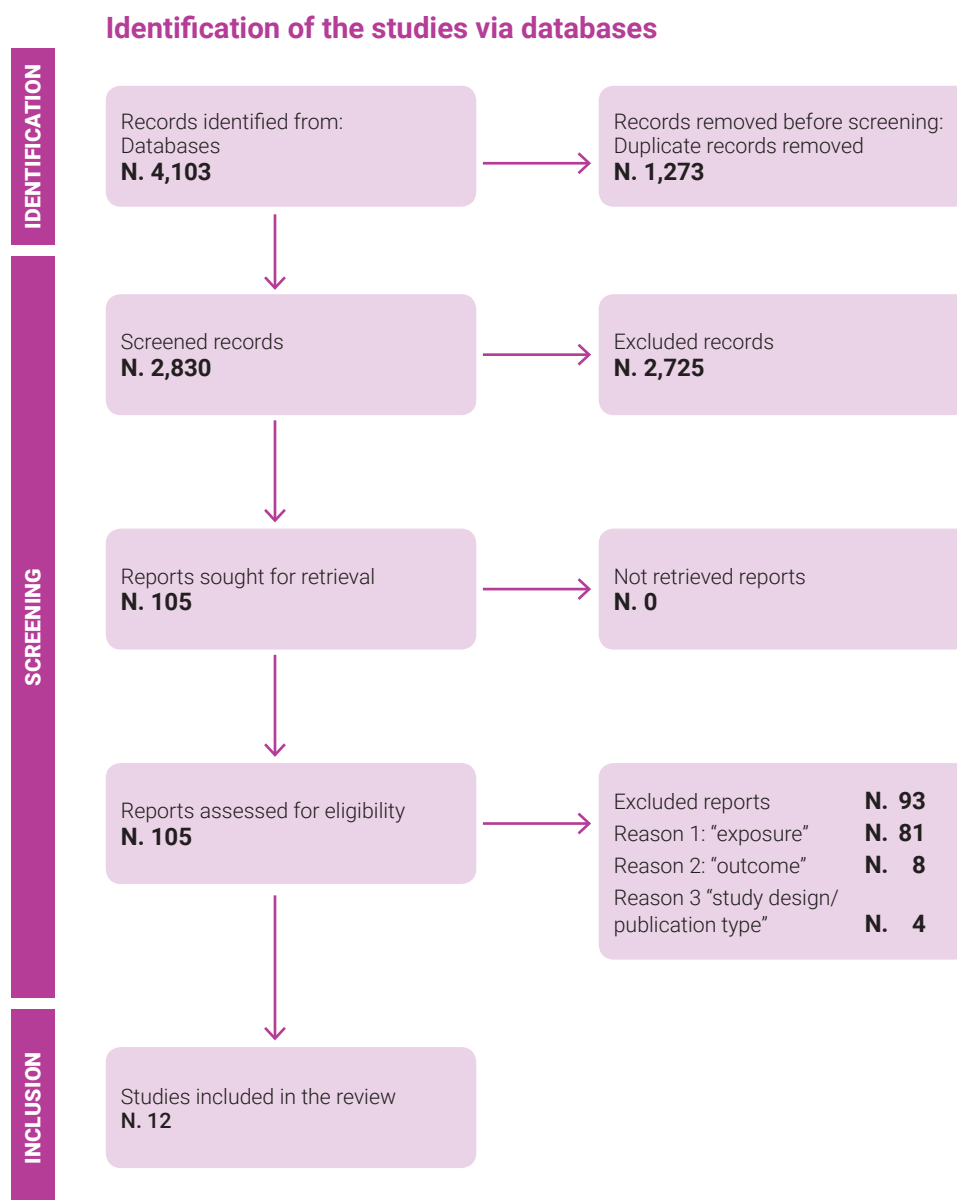
Identification of the studies via databases

Figure 1. Flowchart of the studies selection process.
Figura 1. Diagramma di flusso del processo di selezione degli studi.

Reference (first author and year)	Study design	Country	Study objective	School closure duration at the time of study	Study period	Distance learning/ school modality	Source of data	Setting[1] and type of school[2]	Number of subjects enrolled	Age in years (m, DS) Male (%)	Quality
Edgcomb 2021	Uncontrolled before-after study	USA	To compare the proportional change and adjusted risk for mental health related emergency department visits (MH-ED) prior to and during the COVID-19 pandemics, matched by 36- and 12- week intervals	SC: March 2020. DSC: NR	• March -November 2020 (during pandemic) • March November 2019 (pre-pandemic) versus Only autumn 2020 (September-November) estimates were considered	NR	Electronic health record (EHR)	NR	• Spring-autumn 2020 visits (N. 3,892); • Spring- autumn visits 2019 (N. 5,228). Total: 9,120 children visits	Age: 3-17 years Male: 49.6%	High
Hawrilenko 2021	Cross sectional survey	USA	To estimate the association between school modality (remotely, hybrid, in person) and child mental health outcomes and how it varies across sociodemographic factors	Different school modalities activated concurrently with in-person learning (Distance learning, hybrid learning) during the study period	December 2020	1,340 children (58.0%) attended school remotely, 415 (18.0%) attended school in a hybrid format, 556 (24.1%) attended school fully in person	Parent self-administered questionnaire	From preschool through high school	2,324	Mean Age: 10 years (SD 4) Male: 48%	High
Hertz 2021	Cross sectional survey	USA	To assess whether mode of school instruction influences mental health and determine if school and family connectedness attenuate these relationships	Different school modalities activated concurrently with in-person learning (Distance learning, hybrid learning) during the study period	October-November 2020	313 (55.2%) attended school remotely, 141 (24.9%) attended school in a hybrid format, 113 (19.9%) attended school fully in person.	Self-administered questionnaire	Grades 7 to 12	567	326 participants aged 13-15 and 241 participants aged 16-19 Male: 51.1%	High
Kishida 2021	Cross sectional survey	Japan	To investigate the relationship between local school closures (full or partial) due to COVID-19 and child and parent mental health	School modalities contemporary to school open (full or partial school closure)	November -December 2020	full closure: 2.02%, Partial closure: 5.95%, Full open: 92%, Online learning not provided	Parent self-administered questionnaire	Primary and secondary schools Public school: 92.2%, private schools: 6% other educational settings: 1.8%	1,984	Mean age 10.6 years (SD 2.4) Male: 53.8%	Medium
Pelissier 2021	Cross sectional survey	France	To assess the prevalence of psychological distress in medical students during the COVID-19 health crisis and to identify factors associated with psychological distress.	Distance/hybrid learning during and after school closure November-December 2020. DUC: 1.5 months	March 2021	Distance learning was provided as a hybrid format (eg. 1-3 days a week)	Self-administered questionnaire	University (public) Medical students	832	18 years: 29.8%; 19-20 years: 40.7%; ≥21 years 29.4% Male: 26.8%	Medium
Pieh&Dale 2021	Cross sectional survey	Austria	To assess stress in high-school students after a semester of home-schooling	Distance learning: first semester of school year 2020-2021 DSC: 6 months	February 2021 after school reopening	NR	Self-administered questionnaire	High school (public)	2,884	Mean age:16.5 years (SD 1.4) Male 27.9%	Medium

[1] nursery, pre-school, primary, secondary / *scuola dell'infanzia, scuola primaria, scuola secondaria* [2] public or private / *pubblica o privata*
SC: school closure / *chiusura delle scuole;* **UC:** university closure / *chiusura delle università;* **DSC:** duration of school closure / *durata della chiusura delle scuole;* **DUC:** duration of university closure / *durata della chiusura delle università;*
NR: not reported / *non riportato*

Table 1. Characteristics of the included studies.
Tabella 1. Caratteristiche degli studi inclusi.

Reference (first author and year)	Study design	Country	Study objective	School closure duration at the time of study	Study period	Distance learning/ school modality	Source of data	Setting[1] and type of school[2]	Number of subjects enrolled	Age in years (m, DS) Male (%)	Quality
Pieh&Plener 2021	Cross sectional survey	Austria	To assess mental health in high school students aged 14 to 20 years after 1 semester of attending school remotely and almost a year of social distancing in Austria	Distance learning: first semester of school year 2020-2021 DSC: 6 months	February 2021 after school reopening	NR	Self-administered questionnaire	High school (public)	3,052	Mean age: 16.5 years (SD 1.4) Male: 28.1%	Medium
Ren 2021	Cross sectional survey	China	To evaluate the psychological impact of university closure due to COVID-19 after school reopening	University reopening after a period of 8 months of university closure since January 2020 DUC: 8 months	September 2020	NR	Self-administered questionnaire	University (private)	478	Mean age: NR Male: 42.9%	Medium
Rutkowska 2021	Cross sectional survey	Slovakia	To investigate the prevalence of depressive symptoms and the level of perceived stress during e-learning and to identify the variables that have the most significant impact on mental health.	Different school modalities activated concurrently with in-person learning (Distance learning, hybrid learning) during the study period	March and April 2021	95% studied remotely, 3.4% attended school in hybrid form, 1.6% attended school fully in person	Self-administered questionnaire	University (public)	3,051	Mean age: 22.4 years (SD 4.2) Male: 41.9%	Medium
Tanaka 2021	Uncontrolled before after	Japan	To assess whether suicide mortality changed during the pandemic	SC: from March to April 2020 DSC: 2 months	February-October 2020 compared to pre-pandemic period (2016-2019). Only September-October 2020 estimates were considered	NR	Adminstrative data	NR	1,896	Children and adolescents Mean age: NR Male: NR	High
Verlenden 2021	Cross sectional survey	USA	To assess the impact of mode of instruction on stress and psychological wellbeing	Distance learning (vs hybrid and in presence learning) since the beginning of school year 2020/2021	8 November 2020	Remote instruction: 45.7% reported, in person instruction: 30.9%, combined instruction: 23.4%	Parent self-administered questionnaire	Primary school (92.9% of whom were enrolled in public school and 7.1% enrolled in private school)	1,290	aged 5-8 years: 41.5% (CI 38.3-44.9), aged 9-12 years 58.5% (CI 55.1-61.7) Male 51.7%	High
Walters 2021	Cross sectional survey	USA	To assess the effect of mode of instruction on social and psychological well-being of early adolescent schoolchildren	Distance learning during the study period since the beginning of school year 2020-2021 DSC: 3 months	November 2020	Hybrid instruction: 83.8%, In-person instruction: 8.7%, online instruction: 7.4%	Self -administered questionnaire	Middle school (grades 6 to 8).	309	Mean age: 12.4 years (SD 0.98) Male: 48.7%	Medium

[1] nursery, pre-school, primary, secondary / *scuola dell'infanzia, scuola primaria, scuola secondaria* [2] public or private / *pubblica o privata*
SC: school closure / *chiusura delle scuole*; **UC:** university closure / *chiusura delle università*; **DSC:** duration of school closure / *durata della chiusura delle scuole*; **DUC:** duration of university closure / *durata della chiusura delle università*;
NR: not reported / *non riportato*

Table 1 (continued). Characteristics of the included studies.
Tabella 1 (continua). Caratteristiche degli studi inclusi.

Reference (first author and year)	Selection				Comparability		Outcome		Total score	Overall quality
	Representativeness of the sample	Sample size	Non-respondents:	Ascertainment of the exposure			Assessment of the outcome	Statistical test		
Hawrilenko 2021	truly representative*	justified and satisfactory*	satisfactory response rate*	validated measurement**	control for important confounders*		self-report *	appropriate*	8/10	high
Hertz 2021	truly representative*	justified and satisfactory*	satisfactory response rate*	validated measurement**	control for important confounders*		self-report*	appropriate*	8/10	high
Kishida 2021	truly representative*	not justified	No description	validated measurement**	control for important confounders*		self-report *	appropriate*	6/10	medium
Pelissier 2021	somewhat representative *	not justified	unsatisfactory	validated measurement**	control for important confounders*		self-report*	appropriate*	6/10	medium
Pieh&Dale 2021	somewhat representative *	not justified	No description	validated measurement**	no control for confounding		self-report*	appropriate*	5/10	medium
Pieh&Plener 2021	somewhat representative *	not justified	No description	validated measurement**	no control for confounding		self-report*	appropriate*	5/10	medium
Ren 2021	No description of the sampling strategy	not justified	No description	validated measurement**	control for important confounders*		self-report*	appropriate*	5/10	medium
Rutkowska 2021	somewhat representative *	justified and satisfactory*	unsatisfactory	validated measurement**	control for important confounders*		self-report*	appropriate*	7/10	medium
Verlenden 2021	truly representative*	justified and satisfactory*	satisfactory response rate*	validated measurement**	control for important confounders*		self-report*	appropriate*	8/10	high
Walters 2021	Selected group	justified and satisfactory*	unsatisfactory	validated measurement**	no control for confounding		self-report*	appropriate*	5/10	medium

Representativeness of the sample: truly representative: all or random sample of the target population; somewhat representative: non random sampling; selected group: subgroup of target population selected by researchers; self-selected group: participants recruited voluntarily.
Sample size justified and satisfactory: if the study use data from a large national survey or if the study provides a sample size calculation. Not justified in the other cases
Non responders: satisfactory if respondents are at least 70% or if comparability is described.
Statistical analysis appropriate: for descriptive studies, numerator and denominator are clearly reported, and percentages given with confidence intervals; for studies that evaluate association, statistical analysis is described in the "methods" section.
Note: Stars (*) represent the score assigned to each item.

Rappresentatività del campione: rappresentativo: tutta la popolazione target o campione casuale; moderatamente rappresentativo: campione non casuale; dimensione campionaria: sottogruppo della popolazione target selezionato dai ricercatori; gruppo autoselezionato: partecipanti reclutati su base volontaria.
Dimensione campionaria giustificata e soddisfacente: *se lo studio utilizza dati da una vasta indagine o se lo studio fornisce il calcolo della grandezza del campione. Non giustificato in altri casi.*
Non rispondenti: *soddisfacente se i rispondenti sono almeno il 70% o se viene descritta la comparabilità.*
Analisi statistica appropriata: *per gli studi descrittivi, numeratore e denominatore sono chiaramente riportati e le percentuali fornite con i relativi intervalli di confidenza; per gli studi che valutano l'associazione, l'analisi statistica è descritta nella sezione "Metodi".*
Nota: *gli asterischi (*) si riferiscono al punteggio assegnato a ogni item.*

Table 2. Methodological quality of cross-sectional studies (Adapted New Castle Ottawa scale).
Tabella 2. Qualità metodologica degli studi cross-sectional (Scala New Castle Ottawa adattata).

Study ID	Objective clearly stated	Eligibility criteria defined	Participants representative of the population	All eligible participants enrolled	Sample size satisfactory	Exposure clearly described	Outcomes specified and clearly described	Blinding outcome assessor	Follow up rate	Statistical analysis appropriate	Multiple outcome measures	Group-level interventions and individual-level outcome	Total	Overall quality
Tanaka 2021	yes	yes	yes	yes	yes	yes	yes	NA	yes	yes	yes	NA	10/10	high
Edgcomb 2021	yes	yes	yes	yes	yes	yes	yes	NA	yes	yes	yes	NA	10/10	high

NA: not applicable / *non applicabile*

Table 3. Methodological quality of uncontrolled pre-post studies (NHLBI checklist).
Tabella 3. Qualità metodologica degli studi pre-post senza gruppo di controllo (NHLBI checklist).

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Tanaka 2021	Fixed effect regression to estimate the change in suicide rate (Poisson family)	Month, time trend (linear), weighted by the population, Standard errors are clustered at the city level	School closure period (wave 2 March and April 2020)	Pre-pandemic period (2016-January 2020)	Incidence Rate Ratio comparing risk in 2020 to pre-pandemic period	Mean monthly suicide rate (per million)	September: IRR 1.49 (95%CI 1.11-2.0) October: IRR 1.50 (95%CI 1.0-2.25)	none	• The effect represents a long-term effect of school closure during the national second epidemic wave.
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	school closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits in 2020 compared to 2019 (p-value calculated)	ER visits for all mental health causes (F01-F99.x, R45-R46.x, T14.91x, X71-83x)	Autumn 2020 (September-November) compared to autumn 2019: -26.5%	Reduction in both genders (p <0.01), in all age groups (3-5, 6-12, 15-17 years) (p <0.01), in all races (p <0.01) except Asian and other races	• No denominator of ER visits • p-value results not reported • No estimate for stratified analysis
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for suicidal ideation, self-harm and suicide attempts (T41.91, X71-83, R45.851)	Autumn 2020 (September-November) compared to autumn 2019: +20.4% (p-value<0.05)	NA	• No denominator of ED visits • p-value results not reported
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for developmental disorders (F80-89)	Autumn 2020 (September-November) compared to autumn 2019: -40.4% (p <0.01)	NA	• No denominator of ED visits • p-value results not reported
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for mental health disorders due to physiologic conditions (F01-09)	Autumn 2020 (September-November) compared to autumn 2019: temporal reduction (p-value<0.05)	NA	• No denominator of ED visits • Percent change and p-value results not reported
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for mental health syndromes due to physiologic factors (F50-59)	Autumn 2020 (September-November) compared to autumn 2019: No temporal change (p-value>0.05)	NA	• No denominator of ED visits • Percent change and p-value results not reported
Hertz 2021	Logistic regression comparing mental health indicators by type of learning	age, race/ethnicity, sex, poverty, school and family connected	Distance learning, hybrid learning	In-person learning	Prevalence Ratios (PR)	Seriously consider attempting suicide, past 12 months	Remote learning: PR 2.45 (95%CI 1.22-4.90) fully adjusted model Hybrid learning: PR 1.95 (95%CI 0.69-5.52) fully adjusted model	NA	

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4. Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4. Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

B. Mental health outcomes: anxiety, depression, psychological distress, sense of loneliness/isolation

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for psychotic disorders (F20-29)	Autumn 2020 (September-November) compared to autumn 2019: No temporal change (p-value >0.05)	NA	• No denominator of ER visits • Percent change and p-value results not reported
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for mood/ affective disorders (F30-39)	Autumn 2020 (September-November) compared to autumn 2019: No temporal change (p-value >0.05)	NA	• No denominator of ER visits • Percent change and p-value results not reported
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for symptoms involving emotional states, behavior (R45-46, except R45.851)	Autumn 2020 (September-November) compared to autumn 2019: No temporal change (p-value >0.05)	NA	• No denominator of ER visits • Percent change and p-value results not reported
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for personality disorders (F60-69)	Autumn 2020 (September-November) compared to autumn 2019: Temporal reduction (p <0.01)	NA	• No denominator of ER visits • Percent change and p-value results not reported
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for behavioural and emotional disorders of childhood (F90-98)	Autumn 2020 (September-November) compared to autumn 2019: Temporal reduction (p-value<0.01)	NA	• No denominator of ER visits • Percent change and p-value results not reported
Hawrilenko 2021	Linear regression comparing mental health tests scores by type of learning	Child age, household income	Remote learning, hybrid learning	in-person learning	Standardized mean difference (expressed as Cohen d) in Strength and Difficulties Questionnaire score among learning types	Total Strength and Difficulties questionnaire score	Remote learning: Cohen d 0.12 (95%CI 0.01-0.22) Hybrid learning: Cohen d 0.17 (95%CI 0.02-0.31)	Remote learning: child age modified the association (higher age increases the strength and difficulties score) but no effect modification by income and learning pod organization. Hybrid learning: income slightly modified the association (higher income increases the score in hybrid learning) and also learning pod organization modified the association (pod reduces strength and difficulties score in hybrid learning). No effect modification by age.	
Hawrilenko 2021	Linear regression comparing mental health tests scores by type of learning	Child age, household income	remote learning, hybrid learning	in-person learning	Standardized mean difference (expressed as Cohen d) in Strength and Difficulties Questionnaire score among learning types	Strength and Difficulties questionnaire score emotion problems component	Remote learning: Cohen d 0.37 (p =0.02) Hybrid learning: Cohen d 0.52 (p =0.02)	NA	

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Hawrilenko 2021	Linear regression comparing mental health tests scores by type of learning	Child age, household income	Remote learning, hybrid learning	in-person learning	Standardized mean difference (expressed as Cohen d) in Strength and Difficulties Questionnaire score among learning types	Strength and Difficulties questionnaire score peer problems component	Remote learning: Cohen d 0.09 (p =0.57) Hybrid learning: Cohen d 0.01 (p =0.98)	NA	
Hawrilenko 2021	Linear regression comparing mental health tests scores by type of learning	Child age, household income	Remote learning, hybrid learning	in-person learning	Standardized mean difference (expressed as Cohen d) in Strength and Difficulties Questionnaire score among learning types	Strength and Difficulties questionnaire score conduct component	Remote learning: Cohen d 0.11 (p =0.50) Hybrid learning: Cohen d 0.21 (p =0.29)	NA	
Hawrilenko 2021	Linear regression comparing mental health tests scores by type of learning	Child age, household income	Remote learning, hybrid learning	in-person learning	Standardized mean difference (expressed as Cohen d) in Strength and Difficulties Questionnaire score among learning types	Strength and Difficulties questionnaire score hyperactivity component	Remote learning: Cohen d 0.19 (p =0.36) Hybrid learning: Cohen d 0.35 (p =0.18)	NA	
Hawrilenko 2021	Linear regression comparing mental health tests scores by type of learning	Child age, household income	Remote learning, hybrid learning	in-person learning	Standardized mean difference (expressed as Cohen d) in Strength and Difficulties Questionnaire score among learning types	Strength and Difficulties questionnaire score emotion problems component	Remote learning: Cohen d 0.37 (p =0.02) Hybrid learning: Cohen d 0.52 (p =0.02)	NA	
Hertz 2021	Logistic regression comparing mental health indicators by type of learning	Age, race/ethnicity, sex, poverty, school and family connected	Distance learning, hybrid learning	in-person learning	Prevalence Ratios (PR)	High or very high stress past 14 days	Remote learning: PR 1.30 (95%CI 0.98-1.73) Hybrid learning: PR 1.37 (95%CI 0.99-1.90)	NA	
Hertz 2021	Logistic regression comparing mental health indicators by type of learning	Age, race/ethnicity, sex, poverty, school and family connected	Distance learning, hybrid learning	in-person learning	Prevalence Ratios (PR)	7+ days with not good mental health past 14 days	Remote learning: PR 2.72 (95%CI 1.08-6.86) Hybrid learning: PR 1.61 (95%CI 0.48-5.39)	NA	
Hertz 2021	Logistic regression comparing mental health indicators by type of learning	Age, race/ethnicity, sex, poverty, school and family connected	Distance learning, hybrid learning	in-person learning	Prevalence Ratios (PR)	Persistent symptoms of depression	Remote learning: PR 1.58 (95%CI 0.82-3.02) Hybrid learning: PR 1.26 (95%CI 0.57-2.81)	NA	

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

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B. Mental health outcomes: anxiety, depression, psychological distress, sense of loneliness/isolation

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Kishida 2021	Univariate analysis of covariance (ANCOVA) to compare mental health scores between the three situations (full school closure, partial school closure, and full school open) and Cohen d calculation.	Household income, child/parent infection, family member infection, parent self-isolation	School closure in previous week (full or partial)	full school open in previous week	Standardized mean difference (expressed as Cohen d) among school closure situations	Strengths and Difficulties Questionnaire score emotional symptoms	Full school closure: large effect size (Cohen d 1.07) and difference with school open (p-value from Bonferroni test <0.05) Partial school closure: no difference (Cohen d 0.16). No difference with school open (p-value from Bonferroni test >0.05)	NA	• Bonferroni's method used for post-hoc analysis to evaluate comparisons for each pair of school closure situations
Kishida 2021	univariate analysis of covariance (ANCOVA) to compare mental health scores between the three situations (full school closure, partial school closure, and full school open) and Cohen d calculation.	Household income, child/parent infection, family member infection, parent self-isolation	School closure in previous week (full or partial)	full school open in previous week	Standardized mean difference (expressed as Cohen d) among school closure situations	Strengths and Difficulties Questionnaire score conduct problems	Full school closure: large effect size (Cohen d 1.21) and difference with school open (p-value from Bonferroni test <0.05) Partial school closure: small difference (Cohen d 0.20) and no difference from Bonferroni test (p-value >0.05)	NA	• Bonferroni's method used for post-hoc analysis to evaluate comparisons for each pair of school closure situations
Kishida 2021	univariate analysis of covariance (ANCOVA) to compare mental health scores between the three situations (full school closure, partial school closure, and full school open) and Cohen d calculation.	Household income, child/parent infection, family member infection, parent self-isolation	School closure in previous week (full or partial)	Full school open in previous week	Standardized mean difference (expressed as Cohen d) among school closure situations	Strengths and Difficulties Questionnaire score hyperactivity/ inattention	Full school closure: small difference (Cohen d 0.42) (p-value from Bonferroni test >0.05) Partial school closure: no difference (Cohen d 0.01) (p-value from Bonferroni test >0.05)	NA	• Bonferroni's method used for post-hoc analysis to evaluate comparisons for each pair of school closure situations
Kishida 2021	univariate analysis of covariance (ANCOVA) to compare mental health scores between the three situations (full school closure, partial school closure, and full school open) and Cohen d calculation.	Household income, child/parent infection, family member infection, parent self-isolation	School closure in previous week (full or partial)	Full school open in previous week	Standardized mean difference (expressed as Cohen d) among school closure situations	Parent-reported Spence Children's Anxiety Scale (SCAS-P)	Full school closure: large difference (Cohen d 2.13) (p-value from Bonferroni test <0.05) Partial school closure: moderate difference (Cohen d 0.59) (p-value from Bonferroni test <0.05)	NA	• Bonferroni's method used for post-hoc analysis to evaluate comparisons for each pair of school closure situations
Kishida 2021	univariate analysis of covariance (ANCOVA) to compare mental health scores between the three situations (full school closure, partial school closure, and full school open) and Cohen d calculation.	Household income, child/parent infection, family member infection, parent self-isolation	School closure in previous week (full or partial)	Full school open in previous week	Standardized mean difference (expressed as Cohen d) among school closure situations	Depression Parent-Rating Scale for Children (DPRS-C)	Full school closure: large difference (Cohen d 1.10) (p-value from Bonferroni test <0.05) Partial school closure: small difference (Cohen d 0.39) (p-value from Bonferroni test <0.05)	NA	• Bonferroni's method used for post-hoc analysis to evaluate comparisons for each pair of school closure situations

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

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Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Kishida 2021	univariate analysis of covariance (ANCOVA) to compare mental health scores between the three situations (full school closure, partial school closure, and full school open) and Cohen d calculation.	Household income, child/parent infection, family member infection, parent self-isolation	School closure in previous week (full or partial)	Full school open in previous week	Standardized mean difference (expressed as Cohen d) among school closure situations	Oppositional Defiant Behaviour Inventory (ODBI)	Full school closure: large effect size (Cohen d 0.84) (p-value from Bonferroni test <0.05) Partial school closure: no difference (Cohen d 0.10) (p-value from Bonferroni test >0.05)	NA	• Bonferroni's method used for post-hoc analysis to evaluate comparisons for each pair of school closure situations
Ren 2021	Chi^2 for testing differences of symptoms frequency by school reopening yes vs no.	NA	No school reopening following a period of closure	School reopening following a period of closure	NA	Anxiety from Zung's Self-rating Anxiety Scale (SAS)>49	Higher symptoms in no school reopening vs school reopening (46.2% vs 14.6%) (chi^2 p-value =0.008)	NA	• No estimated association measure
Ren 2021	Chi^2 for testing differences of symptoms frequency by school reopening yes vs no.	NA	No school reopening following a period of closure	School reopening following a period of closure	NA	Depression from Patient Health Questionnaire-9 [PHQ-9]>4	32.4% with depression symptoms. No difference in symptoms prevalence by school reopening yes vs no (p-value =0.58)	NA	• No estimated association measure
Verlenden 2021	Logistic regression comparing mental health indicators by type of learning	Parents' race/ethnicity and sex, household income, and child's age	Distance learning, hybrid learning	In-person learning	Prevalence Ratios (PR) of mental health problems in remote/hybrid learning compared to in-person learning	Worsening of mental or emotional health vs better or no change	Remote learning: PR 1.6 (95%CI 1.2-2.2) fully adjusted model Hybrid learning: PR 1.5 (95%CI 1.1-2.0) fully adjusted model	NA	
Verlenden 2021	Logistic regression comparing mental health indicators by type of learning	Parents' race/ethnicity and sex, household income, and child's age	Distance learning, hybrid learning	In-person learning	Prevalence Ratios (PR) of mental health problems in remote/hybrid learning compared to in-person learning	Depression with elevated symptoms vs without elevated symptoms	Remote learning: PR 1.4 (95%CI 0.6-3.1) fully adjusted model Hybrid learning: PR 1.0 (95%CI 0.4-2.5) fully adjusted model	NA	
Verlenden 2021	Logistic regression comparing mental health indicators by type of learning	Parents' race/ethnicity and sex, household income, and child's age	Distance learning, hybrid learning	In-person learning	Prevalence Ratios (PR) of mental health problems in remote/hybrid learning compared to in-person learning	Anxiety with elevated symptoms vs without elevated symptoms	Remote learning: PR 1.1 (95%CI 0.6-2.0) fully adjusted model Hybrid learning: PR 0.7 (95%CI 0.3-1.4) fully adjusted model	NA	
Verlenden 2021	Logistic regression comparing mental health indicators by type of learning	Parents' race/ethnicity and sex, household income, and child's age	Distance learning, hybrid learning	In-person learning	Prevalence Ratios (PR) of mental health problems in remote/hybrid learning compared to in-person learning	Psychological stress with elevated symptoms vs without elevated symptoms	Remote learning: PR 1.0 (95%CI 0.6-1.7) fully adjusted model Hybrid learning: PR 0.9 (95%CI 0.6-1.4) fully adjusted model	NA	

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

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B. Mental health outcomes: anxiety, depression, psychological distress, sense of loneliness/isolation

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Walters 2021	ANOVA to compare symptoms score by type of learning. Bonferroni test (post hoc of ANOVA analysis). t-test to compare symptoms score by 2020 and 2019	NA	Distance learning, hybrid learning, in-person learning.	All learning types were compared among each other with ANOVA.	NA	Peer deviance	No difference by school learning types (p-value 0.976). No difference among 2020 and 2019 (p-value =0.146). No difference among online and in person schooling (p-value from post hoc test >0.05)	NA	• No estimated association measure • 85% of students were in hybrid learning
Walters 2021	ANOVA to compare symptoms score by type of learning. Bonferroni test (post hoc of ANOVA analysis). t-test to compare symptoms score by 2020 and 2019	NA	Distance learning, hybrid learning, in-person learning.	All learning types were compared among each other with ANOVA.	NA	Neutralization	No difference by school learning types (p-value =0.126). Increase in 2020 compared to 2019 (p-value <0.001). No difference between online and in person schooling (p-value from post hoc test >0.05)	NA	• No estimated association measure • 85% of students were in hybrid learning
Walters 2021	ANOVA to compare symptoms score by type of learning. Bonferroni test (post hoc of ANOVA analysis). t-test to compare symptoms score by 2020 and 2019	NA	Distance learning, hybrid learning, in-person learning.	All learning types were compared among each other with ANOVA.	NA	Cognitive impulsivity	No difference by school learning types (p-value =0.975). Increase in 2020 compared to 2019 (p-value =0.006). No difference between online and in person schooling (p-value from post hoc test >0.05)	NA	• No estimated association measure • 85% of students were in hybrid learning
Walters 2021	ANOVA to compare symptoms score by type of learning. Bonferroni test (post hoc of ANOVA analysis). t-test to compare symptoms score by 2020 and 2019	NA	Distance learning, hybrid learning, in-person learning.	All learning types were compared among each other with ANOVA.	NA	Depression	No difference by school learning types (p-value =0.065). No difference among 2020 and 2019 (p-value =0.256). No difference between online and in person schooling (p-value from post hoc test >0.05)	NA	• No estimated association measure • 85% of students were in hybrid learning
Walters 2021	ANOVA to compare symptoms score by type of learning. Bonferroni test (post hoc of ANOVA analysis). t-test to compare symptoms score by 2020 and 2019	NA	Distance learning, hybrid learning, in-person learning.	All learning types were compared among each other with ANOVA.	NA	Bully victimization	no difference by school learning types (p-value =0.394). No difference among 2020 and 2019 (p-value =0.139). No difference between online and in person schooling (p-value from post hoc test >0.05)	NA	• No estimated association measure • 85% of students were in hybrid learning
Rutkowska 2021	Parametric and non-parametric tests (t-test, chi^2).	NA	Distance learning	No comparison	NA	psychological stress from Perceived Stress Scale (PSS-10)	Mean stress level score 20.85 (SD 5.63)	NA	• No estimated association since no comparison is available
Rutkowska 2021	Parametric and non-parametric tests (t-test, chi^2).	NA	Distance learning	No comparison	NA	Depression from Beck Depression Inventory (BDI-II)	Mean depression level score 14.35 (SD 10.22).	NA	• No estimated association since no comparison is available

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

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Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

B. Mental health outcomes: anxiety, depression, psychological distress, sense of loneliness/isolation

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Pelissier 2021	Frequency of symptoms during distance learning. Poisson regression models to evaluate association between symptoms frequency and sociodemographic, educational and medical factors.	Gender, age, seniority in medical studies, financial difficulties, trauma experienced during the COVID-19 crisis, anxiety history, depression history, change in alcohol consumption, change in smoking, paid work outside the university, sense of mutual support and cooperation, impression of recognized work, hospital internship in last 3 months, internship in COVID-19 care units, difficulties in attending distance learning courses, consultation with a general practitioner	Distance learning	No comparison	NA	Psychological distress from 12-item General Health Questionnaire (GHQ)	75% of students during distance learning reported distress symptoms.	Higher frequency of symptoms in females, in students with psychological trauma due to COVID-19, in students with history of anxiety disorder, in students changed alcohol consumption and in students experiencing difficulties with online learning. Lower frequency in students with sense of mutual support and cooperation, in students with impression of recognized work. No association with smoking, age, in 1st year students, in students with depression history, in students with financial difficulties, in students with paid work outside university, students with consultation with a general practitioner, in students with seniority in medical studies, in students with hospital internship within the last three months, in students with hospital internship on a COVID-19 ward in past 3 months.	• No estimated association since no comparison is available
Pieh&Dale 2021	Frequency of symptoms during distance learning. Differences by gender evaluated by chi^2 and ANOVA	NA	Distance learning in previous semester	No comparison	NA	Psychological distress from 12-item General Health Questionnaire (GHQ) from 14 to 26 for moderate stress, from 27 to 40 for high stress	36.5% of students with high stress levels, 52.5% with moderate stress level	Difference of stress level score by gender (p-value <0.001).	• No estimated association since no comparison is available
Pieh&Plener 2021	Frequency of symptoms during distance learning. Differences in symptoms by t tests, chi^2 test, ANOVA	NA	Distance learning in previous semester	No comparison	NA	depressive symptoms from Patient Health Questionnaire-9 [PHQ-9] ≥11	55% of students in distance learning reported PHQ score ≥11.	Higher score in girls and students of diverse gender identity compared to boys (chi^2 p-value <0.001). Higher score in higher smartphone users (chi^2 p-value <0.001)	• No estimated association since no comparison is available
Pieh&Plener 2021	Frequency of symptoms during distance learning. Differences in symptoms by t tests, chi^2 test, ANOVA	NA	Distance learning in previous semester	No comparison	NA	anxiety symptoms from General Anxiety Disorder-7 [GAD-7] ≥ 11	47% of students in distance learning reported with GAD score ≥11.	Higher score in girls and students of diverse gender identity compared to boys (chi^2 p-value <0.001). Higher score for higher smartphone use (chi^2 p-value <0.001)	• No estimated association since no comparison is available
Pieh&Plener 2021	Frequency of symptoms during distance learning. Differences in symptoms by t tests, chi^2 test, ANOVA	NA	Distance learning in previous semester	No comparison	NA	EAT-8, Eating Attitudes Test≥2	59.5% with EAT score ≥2.	Higher score in girls and students of diverse gender identity compared to boys. Higher score for higher smartphone use	• No estimated association since no comparison is available

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

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C. Mental health outcomes: sleep quality, wellbeing as perceived by children or their parents

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Verlenden 2021	Logistic regression comparing mental health indicators by type of learning	Parents' race/ethnicity and sex, household income, and child's age	Distance learning, hybrid learning	In-person learning	Prevalence Ratios (PR) of mental health problems in remote/hybrid learning compared to in-person learning	Worsening in physical health vs better or no change	Remote learning: PR 1.4 (95%CI 0.8-2.3) fully adjusted model Hybrid learning: PR 1.3 (95%CI 0.8-2.2) fully adjusted model	NA	
Pieh&Plener 2021	Frequency of symptoms during distance learning. Differences in symptoms by t tests, chi^2 test, ANOVA	NA	distance learning in previous semester	2018 mental health evaluation	Standardized mean difference expressed as Hedges' g	WHO-5 wellbeing scale	Reduction from a mean (SD) score of 43.7 (19.8) to 35.8 (19.7) in girls (p-value <0.001; Cohen d = −0.40) and from 53.1 (19.5) to 43.9 (22.4) in boys (p-value <0.001; Cohen d = −0.43)	NA	
Pieh&Plener 2021	Frequency of symptoms during distance learning. Differences in symptoms by t tests, chi^2 test, ANOVA	NA	Distance learning in previous semester	2018 mental health evaluation	Standardized mean difference expressed as Hedges' g	Life-satisfaction, measured with an 11-point Cantril ladder	Reduction from a mean (SD) of 7.1 (1.8) to 5.9 (2.0) in girls (p-value <0.001; Cohen d = −0.62) and from 7.6 (1.6) to 6.3 (2.1) in boys (p-value <0.001; Cohen d = −0.66)	NA	
Pieh&Plener 2021	Frequency of symptoms during distance learning. Differences in symptoms by t tests, chi^2 test, ANOVA	NA	Distance learning in previous semester	No comparison	NA	ISI, Insomnia Severity Index≥15	22.8% with ISI score ≥15	Higher score in girls and students of diverse gender identity compared to boys (chi^2 p-value <0.001) and higher smartphone use (chi^2 p-value <0.001)	• No estimated association since no comparison is available

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

D. Health related behaviours: use of tobacco, alcohol, drugs

Reference (first author and year)	Statistical analysis	Adjustment for confounders	School closure measure	Control group/period	Measure of association (metric) (e.g., odds ratio)	Mental health outcome	Point and interval association estimate	Stratified analysis (if available)	Notes
Edgcomb 2021	Period analysis (comparison of ER visits in 2020 to 2019)	None	School closure in March 2020	Same period in 2019	Risk difference expressed as Percent change in number of visits (p-value calculated)	ER visits for mental health disorders due to substances (F10-19)	Autumn 2020 (September-November) compared to autumn 2019: No temporal change (p-value >0.05)	NA	• No denominator of ER visits • Percent change and p-value results not reported

ER: Emergency Room / *pronto soccorso*; **NA:** not available / *non disponibile*

Table 4 (continued). Effect of school closure or distance learning on mental health in children and adolescents in the studies included in the review.
Tabella 4 (continua). Effetto della chiusura delle scuole o della didattica a distanza sulla salute mentale di bambini e adolescenti valutata negli studi inclusi nella revisione.

RASSEGNE E ARTICOLI

Mental Health Symptoms

Five studies[18,19,20,24,27] provided evidence for an increase of some mental health symptoms associated to school closures or online instruction, but the results were inconsistent due to the heterogeneity of the considered outcomes.

In the US study,[18] standardized mean difference (expressed as Cohen d) in the Strength and Difficulties Questionnaire score showed an increased symptom score in children and adolescents attending lessons remotely compared to in-presence education (Cohen d 0.12; 95%CI 0.01-0.22), whereas older children had a higher Strength and Difficulties score. An increased symptoms score was also observed in the group of students attending hybrid learning. A stronger increase was found for emotional problems (Cohen d 0.37; p-value=0.02), while for peer problems, conduct problems, and hyperactivity no differences were observed among educational types.

In another US study,[19] a borderline increase in prevalence of symptoms of high or very high stress in the previous 14 days was shown in remote learning compared to in-presence learning students (PR 1.30; 95%CI 0.98-1.73), and increases were also observed for 7+ days with not good mental health in past 14 days (PR 2.72; 95%CI 1.08-6.86), and for persistent symptoms of depression (PR 1.58; 95%CI 0.82-3.02). Students attending hybrid learning showed a borderline increase in stress symptoms, but no increase in other symptoms.

In Japanese children and adolescents,[20] school closure compared to school opening was related to increased prevalence of emotional symptoms (Cohen d 1.07) and conduct problems (Cohen d 1.21) (from the Strength and Difficulties questionnaire), while hyperactivity/inattention symptoms did not vary between periods. Results for partial school closure were inconsistent. In the same study, depression symptoms (from the Depression Parent-Rating Scale for Children – DPRS-C) increased during school closure (Cohen d 1.10) and similar results were found for partial school closure. An increased score was also found for the Oppositional Defiant Behavior Inventory (ODBI) during a full school closure (Cohen d 0.84), but not for a partial school closure compared to school opening.

A study on Chinese college students[24] compared the prevalence of anxiety (from the Zung's Self-rating Anxiety Scale) and depression symptoms between the period of school closure and the following reopening, showing a reduction in anxiety symptoms after reopening (from 46.2% vs 14.6%; chi[2] p-value=0.008), but no change in depression symptoms. The study evaluated explanatory factors related to anxiety and depression, suggesting that both symptoms were greater in students who drank alcohol 1 or more times in the previous 2 weeks compared to students who did not drink any alcohol at all.

In a US population of children aged 5 to 12 years, Verleden and colleagues[27] found worsening mental or emotional health in students attending distance education (PR 1.6; 95%CI 1.2-2.2) and hybrid education (PR 1.5; 95%CI 1.1-2.0) compared to in-presence learning. However, in the same study, no differences were found between students receiving different types of learning in terms of anxiety, depression, and psychological distress.

Contrary to expectations, school closure was related to reduced emergency department visits for all mental health problems in the US study[17] (-26.5% reduction in autumn 2020 compared to 2019, p-value not reported). A temporal reduction was also observed for developmental disorders, mental health disorders due to physiological conditions, personality disorder, behavioural and emotional disorders of childhood, while for mental health syndromes due to physiologic factors, mental health disorders due to psychotic disorders, mental health disorders due to mood/affective disorders, symptoms involving emotional states, behaviour and for unspecified mental disorders due to physiologic factors, no evidence of temporal changes was reported.[17]

In a US middle school population of adolescents (mean age of 12 years), Walters and colleagues[28] found no difference among students attending different types of learning, neither temporal difference in any symptom considered (peer deviance, neutralization, cognitive impulsivity, depression, delinquency, bully victimization, bully perpetration, neutralization beliefs, and cognitive impulsivity), with only a slight increase in neutralization beliefs and cognitive impulsivity which was found in a subset of students followed longitudinally between November 2019 and November 2020.

In 3 studies conducted in students during school closure or virtual learning, the only prevalence of mental health symptoms, without any effect estimation, was provided.

In the French study,[21] 75% of distance learning university students reported symptoms of psychological distress from the 12-item General Health Questionnaire (GHQ). Higher frequency of symptoms was found in females, in students with psychological trauma due to COVID-19, in students with history of anxiety disorder, in students that changed alcohol consumption and in students experiencing difficulties with online learning.

The Austrian study[22] reported a prevalence of high psychological stress in 36.5% of high school students attending distance learning, while moderate stress rate reached 52.5%. This study showed a prevalence of

55% for depression symptoms (Patient Health Questionnaire-9 – PHQ score ≥ 11), and of 47% for anxiety symptoms (General Anxiety Disorder-7 – GAD score ≥11) in students attending distance learning. For all symptoms, a higher score was found in girls and students of diverse gender identity and in higher smartphone users.

Rutkowska and colleagues[25] evaluated the score of the Perceived Stress Scale (PSS-10) and the Beck Depression Inventory (BDI-II) finding a higher score among young women for both symptoms.

Well-being

Two studies evaluated wellbeing outcomes, providing evidence of worsening of outcomes in distance learning students compared to the pre-pandemic period[23] or to students attending in-presence[27] specifically for children and adolescents.

The Austrian study[23] found a reduction in the score of the WHO-5 wellbeing scale in both high school boys (Cohen d -0.43; p-value<0.001) and girls (Cohen d -0.40; p-value<0.001) attending a virtual education class in the previous semester compared to the mental health status evaluated in the School-Aged Children survey 2018. The study also showed a reduction in life satisfaction measured by an 11-point Cantril's Ladder of Life Scalefor both genders (boys: Cohen d -0.66; p-value<0.001; girls: Cohen d -0.62; p-value<0.001).

Sleep

The only Austrian study[23] evaluated sleeping outcomes, even if only the prevalence, without any effect estimation in students during virtual learning was provided.

The study showed that 22.8% of students had sleep problems, with an Insomnia Severity Index (ISI) score ≥15. A higher score was observed in girls and students of diverse gender identity compared to boys (chi^2 p-value<0.001) and to those with a higher smartphone use (p-value <0.001).

Health related Behaviours

In the US study of Edgcomb 2021,[17] school closure was not related to changes in the number of emergency department visits for mental health disorders due to substance use (ICD-10 code: F10-19) (results are not reported).

Eating problems

Pielh and Plener 2021[23] found a prevalence of 59.5% for eating problems in Austrian high school students receiving distance learning (Eating Attitudes Test – EAT score ≥2). They also found a higher score in girls and students of diverse gender identity compared to boys and to higher smartphone users.

Associations with Socioeconomic Status/inequalities

In some studies, socioeconomic indicators (race, poverty, household income) were included as potential confounders and effect estimates for school closures/virtual learning were adjusted.[18,19,20,27] No study evaluated socioeconomic inequalities indicators as potential modifiers. Only two studies suggested a higher prevalence of mental health symptoms in girls and students of diverse gender identity adolescents attending remote schooling.[23,25] One study evaluated social life and economic variables as potential mediators of gender differences supporting this hypothesis.[25]

Discussion

All 12 studies in this systematic review assessed the impact of school closures or the shift to distance learning (out of the mandatory lockdown or confinement period), as a measure to counter the transmission of SARS-CoV-2 infection, on the psychological well-being of students at all levels of education in the 2020-2021 school/academic year. The studies covered six countries (US, Japan, China, Slovakia, France, Austria). Four studies assessed the relationship between teaching methods, i.e., in person, remote or hybrid learning, and mental health outcomes. Despite the large heterogeneity of the outcomes and effect measures among the studies, the present systematic review showed a clear signal of increasing mental health problems in relation to school closure or virtual instruction. In particular, results support the Authors' hypothesis that school closure may increase suicidal attempts or thoughts,[17,19,26] mental health symptoms such as anxiety, depression, emotional disorders, psychological stress,[18-20] and poor wellbeing.[23,27] Sleeping problems, drug and alcohol addiction were poorly studied. It is worth noting that one study[17] found an unexpected reduction in ED visits for mental health outcomes during school closure; this could be explained by the fact that ED visits as well as other care indicators were reduced in the first months of the pandemic, as shown in other studies, possibly due to delay in care delivery or lack of access due to fear of contagion.[29,30]

Interestingly, 4 studies provided only a description of mental health status of adolescents during the period of school closure or distance learning without any association estimate.[21-23,25] These studies recorded prevalence values which are difficult to interpret without a proper comparison group or period. However, they provide some important information, such as potential inequalities in symptom distribution, suggesting that some population groups suffered most of the adverse consequences of school closure.[23] No study as-

sessed the potential effect modification by socioeconomic indicators and this gap should be addressed in future studies. Other inequalities related to gender could also be plausible: 2 studies showed a higher prevalence of mental health symptoms in girls and students of diverse gender identity among high school and university students, which seems to be only partially explained by social and economic factors.

The potential mechanisms involved in the relationship between school closure or distance learning and mental health consequences arise mainly from the absence and/or loss of social contacts.[7] School closure reduces the amount of time young people can devote to interactions with adults and peers, affecting social integration. The lack of interpersonal opportunities and contacts and the absence of adequate support increased the onset of loneliness, depression, and anxiety with increasing levels of insecurity,[22,23] especially among adolescents and young adults attending university.[25]

In the present review, the evidence for a potential mental health impact of hybrid education or partial school closure is mixed and has been evaluated only in 4 studies, therefore no conclusion can be derived. These results suggest that the psychological consequences found in previous reviews focusing on the first stage of the pandemic[9,10,12,31] or on the wider pandemic period[32,33] could be explained at least in part by the effect of school closure or distance learning education on child mental health. Although no study included in this review evaluated the temporal changes in mental health symptoms based on school closure duration, it can be expected that the negative impact on youths' mental health increases with the prolongation of school restrictions and this aspect should be investigated in further studies.

The results presented in this review could have some other limitations due to the included studies.

Firstly, due to the type of study design (i.e., cross sectional and the uncontrolled pre-post designs), the strength of the evidence from this review is strongly limited as well as the possibility to draw firm conclusions.

Secondly, although studies conducted during the mandatory lockdown or confinement period were excluded, the increased prevalence of mental health symptoms could be due not only to the school closures per se, but it could be a consequences of the pandemic period in general, as an overall effect arise from either the lockdown period or the prolonged restriction and social distancing measures, also implemented after the first wave (such as closure of shops, cinema, restaurants and pubs, restrictions on schedules and travel possibilities).[32,33]

Furthermore, despite a comprehensive bibliographic search and evaluation of several full text articles, only 12 studies were included, because many of the retrieved articles were conducted during a lockdown period, especially implemented in 2019-2020, but also in 2020-2021 school/academic year. In this context, the results here presented could also be affected by a possible publication bias due to the selective publication of studies according to the a priori expectations about the potential worsening in mental health outcomes, by excluding from publication smaller studies or studies showing unclear or unexpected results. With the possibility to update the review, some additional studies could be identified to cover the following school years (e.g., 2021-22), although the changing pandemic situation and vaccination campaign probably limited the use of school closure interventions as part of the efforts to control the COVID-19 pandemic. On the other hand, the mechanisms underlying the occurrence of mental health problems as a consequence of school closure could be delayed in time over a long-term perspective and exposed children, adolescents, and youths could display psychological and mental health problems even several years later.

Conclusions

Despite the limitations of the included studies and possible residual confounding and contamination due to restrictive measures and social isolation implemented during the pandemic, the available evidence confirms the negative impact on students' mental health associated with school closures and distance learning.

Because the evidence supporting the effectiveness of global school closures in controlling COVID-19 is sparse and there is a continued uncertainty about how school children are susceptible to and transmit COVID-19 and thanks to the availability of vaccination also for young children, long periods of school closures should be avoided also in the case of the emergence of new pandemic waves.[5] Moreover, with the persistence of the pandemic, there is the need to protect the mental health of the most vulnerable such as children and adolescents, and to establish a continued monitoring of sensitive mental health conditions, and to generate focused interventions.

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