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Review Paper

Indirect positive health outcomes of COVID-19: a systematic review

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ABSTRACT

Objectives: The aim of this study was to assess the frequency of indirect positive health outcomes as a result of the COVID-19 pandemic.**Study design:** This was a systematic review.**Methods:** Articles were identified from four online databases (Web of Science, Scopus, PubMed and Google Scholar) using predetermined search terms. After studies were systematically identified, the results were summarised narratively. The indirect positive health outcomes associated with the emergence of COVID-19 and measures taken for its prevention were categorised into four health dimensions (physical, mental, social and digital).**Results:** After initial screening, 44 articles were assessed for eligibility, and 33 were included in the final sample. Of the included studies, 72.73% noted a benefit from COVID-19 prevention measures in the physical health dimension. In addition, 12.12%, 9.09%, 3.03% and 3.03% of articles reported a positive impact in the digital, mental, social and combined digital and mental health dimensions, respectively.**Conclusions:** Despite the catastrophic health, socio-economic and political crises associated with the COVID-19 emergency, it has also resulted in some positive health outcomes. Reduced air pollutants, improved disease prevention practices, increased digital health delivery and improved mental and social health dimensions were reported during the pandemic. Integrated and collaborative activities for the persistence of these health benefits are recommended.

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Introduction

Since its emergence at the end of 2019, COVID-19 infection, caused by SARS-CoV-2, has significantly affected individuals, sectors and countries, regardless of their geographic location or economic status.^{1–3} Multidimensional catastrophes have been caused either directly by COVID-19, indirectly by measures adopted for its prevention or both.^{4–7}

Notwithstanding the direct and indirect negative impact of COVID-19, the emergence of this pandemic saw indirect outcomes that resulted in short-term, and potentially long-term, positive impacts.⁸ Haski-Leventhal⁸ argued that there were seven positive

outcomes (reduced environmental pollution, increased level of peace and security, increased social connectedness, increased innovations, increased corporate social responsibilities, transformed educational sector, and increased sense of appreciation and gratitude among people) observed following the emergence of COVID-19.

Furthermore, as noted by Nelson,⁹ the COVID-19 pandemic has resulted in unexpected positive effects arising from behaviour change and a reduction in infectious disease presentations at hospitals. Other examples include a reduction in traffic accidents, crimes rates and environmental pollution.^{9–11}

Recommended COVID-19 prevention practices (e.g. physical and social distancing, quarantining, good ventilation, covering coughs and sneezes, hand washing/sanitising, vaccinations and proper usage of personal preventive equipment) are also suggested infection prevention and control (IPC) strategies for other infectious diseases.¹² Globally, the application of IPC practices during COVID-19 was much higher than in previous years¹³; however, there was still considerable variation reported in compliance rates. For example,

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countries with good COVID-19 transmission prevention compliance included Spain¹⁴ and China,¹⁵ but poor compliance was reported in Uganda¹⁶ and Ethiopia.^{17–19} However, there were contradictory data, with a different study in Ethiopia suggesting high compliance with recommended COVID-19 prevention protocols.²⁰ Nonetheless, the application of IPC for the purpose of COVID-19 prevention appears to have had a positive impact on preventing other infectious diseases, such as *influenza*, *pneumonia* and *Mycobacterium tuberculosis*,²¹ with respiratory infections being dramatically reduced in countries such as Vietnam²² and Pakistan.²³ Similarly, after the easing of COVID-19 restrictions in Israel, respiratory diseases were found to become highly prevalent.²⁴

Reports and evidence regarding the context and types of positive health outcomes of COVID-19 are available, but these are currently in a fragmented state with no compiled and informative summary document on this issue. In addition, analysis of which the health dimensions (i.e. physical, mental, social or digital) benefited most from the emergence of COVID-19, and/or from the measures implemented for the prevention of COVID-19, has not been performed. A preliminary search of Cochrane and PROSPERO databases and the Joanna Briggs Institute (JBI) register was conducted, and no current or proposed systematic reviews, meta-analyses or scoping reviews on this topic were identified.

Objective, research question and hypothesis

The overarching objective of this systematic review was to assess the frequency of indirect positive health outcomes as a result of the COVID-19 pandemic. This objective was achieved by answering the following research question: *What is the frequency of positive health outcomes arising from COVID-19?* This study hypothesised that the restrictions and measures (e.g. lockdown, IPC and social distancing) taken for the prevention and control of COVID-19 had indirect positive health outcomes (e.g. reduction in air pollution, improvement in telehealth, decline in infectious diseases prevalence, reduction of anxiety and improvement in social health).

Methodology

This systematic review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses²⁵ and the JBI systematic review guidelines. The systematic review was preregistered in PROSPERO (registration number CRD42022352438).

Eligibility criteria

This systematic review focused on indirect positive health outcomes achieved due to measures and restrictions implemented for the prevention of COVID-19. Changes in any of the four health dimensions (physical, mental, social and/or digital) were taken as an outcome. A definition for these indirect positive health outcomes (health dimensions) was adopted from the description in the study by Parrish²⁶ in which ‘positive health outcomes include being alive, functioning well mentally, physically, and socially, and having a sense of well-being.’ In addition to these components of positive health outcomes, digital health (a term referring to a variety of technologies that are essential for the treatment of patients, and collect and share their health information) was added by the current review authors. The literature inclusion criteria were primary research articles and written in the English language. No restriction was placed in terms of the study design of articles, and all qualitative, quantitative and mixed method studies

were considered. Studies were only considered relevant if they were published after the nominal emergence date of COVID-19 of 31 December 2019.

Information sources and search strategy

The online databases Medline/PubMed, Scopus, Web of Science and Google Scholar (records from the first 20 pages) were the information sources for this systematic review. The first search was conducted on 25 July 2022, and the search was repeated a month later (25 August 2022). The combination of keywords of this systematic review was taken as search terms for the online databases. These search terms were ‘indirect health outcomes’ OR ‘positive health outcomes’ OR ‘positive health impact’ OR ‘health benefit’ OR ‘health merit’ AND ‘COVID-19’ OR ‘pandemic’ OR ‘Coronavirus disease.’

The literature search was conducted in two phases. Studies were first searched for in PubMed, Scopus and Web of Science. Following database searches, publications were explored using the Google Scholar advanced searching tool using the keywords of the systematic review (‘indirect health outcomes,’ ‘positive health outcomes,’ ‘health benefit,’ ‘COVID-19 pandemic’). All authors independently searched the literature and no disagreements were noted.

Selection process

Identified publications were imported to EndNote version 20.3 and deduplicated using the unique identifier function. Duplicates missed by the EndNote identifier were then manually removed. After deduplication, the first author screened the literature using title and abstract assessment, followed by whole text reading. The same process was repeated by the other three authors, and any disagreements were solved by discussion. The consecutive repetition of the selection process was to ensure the relevance of the selected studies and avoid missing important literature.

Data collection process and data items

The first author extracted the required data from the included publications, and the other authors reviewed this extraction process to enhance the reliability and validity of the data. The extracted variables include the selected studies (author and publication year), country, subjects/participants, objectives, relevant findings (i.e. positive health outcomes of COVID-19) and factors/reasons for the positive health outcome (see Table 1). Proportions of the health dimensions (mental, social, physical and digital health) that had a positive impact were expressed as percentages. The data collection process was performed using the JBI System for the Unified Management, Assessment and Review of Information guideline.²⁷

As the purpose of this review was to identify the frequency of positive health outcomes arising from COVID-19, all primary research articles that reported positive health outcomes in at least one of the four health dimension categories of physical, mental, social and digital health were considered. The primary research articles were considered, both quantitative statistical analysis (descriptive or inferential) and qualitative studies. Studies were considered regardless of the study areas (local, national, regional or global) and study participants (individuals, specific communities, households or general population).

Table 1
General characteristics and main findings of included studies.

Studies	Countries	Participants	Objective of the studies	Findings	Health outcomes	Reason for the health outcomes
Aamir et al. ¹⁰	China	Air pollutants	'To assess the relationships between the concentrations of the six named pollutants and the AQI before, during and after Hubei's COVID-19 lockdown'	'26% PM ₁₀ and 23% PM _{2.5} reduction observed during COVID-19'	Reduced deaths and increased health quality	Air pollution reduction due to lockdown
Allison et al. ²⁹	Wales	Hospital patients	'To compare acute medical admissions during COVID-19 with a comparison cohort from 2017'	'Hospital admission in 2020 was reduced by 43% compared with 2017'	Reduced non-COVID-19 cases	IPC practice for COVID-19 helps preventing other diseases
Alves et al. ³⁰	USA	Children	To investigate how emotional responses (positive/negative affect), physical activity (PA) and sedentary behaviours related to anxiety during the pandemic'	'Child anxiety scores were over five standard deviations greater than prepandemic normative values'	Anxiety level of children is reduced during COVID-19	Engaging in physical activity during lockdown
Amar et al. ²⁴	Israel	Clinics	'To examine incidence rates (IRs) of frequently occurring infectious diseases after a successful SARS-CoV-2 vaccination campaign in Israel and cessation of social restrictions'	'Incidence of non-SARS-CoV-2 infections were significantly increased'	Respiratory and gastrointestinal infection incident rate increased	Easing of COVID-19 prevention restriction
Bacon et al. ³¹	Australia	Stakeholders	'To explore the perceived benefits, challenges and impacts of telehealth placements for key stakeholders in allied health courses'	'Telehealth placements support competency development, person-centred care, and enabled innovation'	Telehealth usage increased and brought multiple health outcomes	Alternative measure for COVID-19 restrictions
Bai et al. ³²	China	PM _{2.5} pollutants	'To evaluate the potential health impacts of air quality changes during the lockdown, especially for PM 2.5 with adverse health effects'	'The national average PM _{2.5} declined by 18 µg/m ³ during 2020 compared with 2015–2019'	'Premature death reduced by 35%'	PM _{2.5} reductions due to lockdown measure
Barreda-Angeles & Hartmann ³³	The Netherlands	Social VR platform users	'To examine the associations between feelings of presence and the activities performed by users and the psychological benefits obtained in the context of the COVID-19 pandemic'	'Socialisation activities such as meeting friends in VR are associated with relatedness and enjoyment'	Aloneness reduced and feeling presence increased	Using social VR platforms increased due to physical distancing
Bowe et al. ³⁴	England	Adult residents	'To explore the relationships between help-giving, community relationships and unity during the pandemic in relation to mental health and well-being'	'Coordinated community helping predicted the psychological bonding of community members during COVID-19'	Depression and anxiety were reduced	Cooperation and helping were increased among fellow residents
Chacon-Quesada et al. ³⁵	Not indicated	Patients	'To analyse the extent of the intensification of hygiene measures affects the rate of surgical site infections (SSI) after neurosurgical procedures'	'Surgical site infection prevalence dropped from 2.9% to 1.4%'	Non-COVID-19 infectious diseases prevalence reduced	COVID-19 IPC strategies reduced other related infections
Chen et al. ¹¹	China	Air pollutants	'To describe air pollution during and after the lockdown periods in 2020 compared with 2018–2019 and estimated the mortality burden indicated by the number of deaths and years of life lost (YLL) related to the air pollution changes'	'The mean air quality index, PM ₁₀ , PM _{2.5} , NO ₂ , SO ₂ and CO declined by 21.2%, 28.9%, 18.3%, 44.2%, 38.8% and 27.3%, respectively'	Air pollution-related premature death is reduced by 1.1 million YLLs	COVID-19-related lockdown reduces the emission of air pollutants
Dragic et al. ³⁶	Serbia	Air pollutants	'To determine the change in outdoor air quality during the COVID-19-related state of emergency resulting in a lockdown and the potential health benefits for the urban population'	'The average daily concentrations of PM _{2.5} , NO ₂ , PM ₁₀ and SO ₂ were reduced by 35%, 34%, 23% and 18%, respectively'	The air pollution-related premature deaths were reduced by 8 YLLs	The COVID-19 lockdown indirectly used as air pollution mitigation measure
Elliott et al. ³⁷	Australia	Isolation beds	'Analysing pre-, during and post-COVID-19 restrictions to evaluate the effectiveness of heightened prevention measures on MRO infections'	MRO transmission reduced during COVID-19	Infectious disease prevalence declined	COVID-19 restrictions (wearing masks, restricting visitors ...) reduced MRO
Giani et al. ³⁸	China and Europe	PM _{2.5} pollutants	'To assess the implications of different lockdown measures on air pollution levels in Europe and China, as well as the short-term and long-term health impact'	'The PM _{2.5} were reduced by 14.5 µg/m ³ across China and 2.2 µg/m ³ across Europe'	24,390 short-term and 316,500 long-term PM _{2.5} -related YLLs avoided	The lockdown interventions led to a reduction in pollution weighted PM _{2.5}
Goel et al. ³⁹	India	PM _{2.5} pollutants	'To quantify the health benefits due to this lockdown'	PM _{2.5} concentrations during 2020 were 46.6%–58.5% lower than the concentration during 2019	29.85 PM _{2.5} pollution-related deaths per 100,000 persons were avoided	PM _{2.5} emission reduced due to COVID-19 lockdown

(continued on next page)

Table 1 (continued)

Studies	Countries	Participants	Objective of the studies	Findings	Health outcomes	Reason for the health outcomes
Han & Hong ⁴⁰	South Korea	PM _{2.5} pollutants	'To estimate the acute health benefits of PM _{2.5} reduction and changes in public behaviour during the COVID-19 crisis'	'The average PM _{2.5} concentration during 2020 (25.6 µg/m ³) was the lowest compared with 5 years before pandemic'	49.3 PM _{2.5} -related non-accidental, cardiovascular and respiratory deaths avoided	PM _{2.5} reduced due to COVID-19 lockdown and wearing filtering masks
Hao et al. ⁴¹	China	PM _{2.5} pollutants	'To predict the monthly PM _{2.5} concentrations in urban cities under permanent lockdown in 2020'	'National mean PM _{2.5} concentration was reduced by 32.2%'	140,200 PM _{2.5} long-term exposure-related deaths were avoided	COVID-19 lockdown reduced PM _{2.5} concentration
Hernandez-Paniagua et al. ⁴²	Mexico	Air pollutants	'To minimise the impact of the air pollutant long-term trends, pollutant anomalies were calculated using as baseline truncated Fourier series, fitted with data from 2016 to 2019, and then compared with those from the lockdown'	'2–10 folds of air pollutants' concentration were reduced and O ₃ concentration increased'	588 deaths related to air pollution exposure were averted	COVID-19 lockdown measure reduced air pollutant's emission
Huang et al. ⁴³	China	PM _{2.5} pollutants	'To estimate the short-term health impacts associated with PM _{2.5} changes over the Yangtze River Delta (YRD) region due to COVID-19 lockdown'	'PM _{2.5} reduced by 22.9%–54.0% during COVID-19 compared with prepandemic concentrations'	42, 400 PM _{2.5} -related premature mortalities were avoided	Strict COVID-19 lockdown reduces air pollutants
Hussain et al. ⁴⁴	England	Patients	To compare the prevalence of sternal wound infections during and before pandemic	'The incidence of sternal wound infection was dropped from 3% to 0.8%'	Infectious diseases prevalence reduced	Strict IPC practice of COVID-19 reduced iatrogenic sternal wound infection
Khomsi et al. ⁴⁵	Morocco	Air pollutants	'To compare the air quality status, before the pandemic and during the confinement'	'The concentration of NO ₂ , PM _{2.5} , and CO were dropped by 12 µg/m ³ , 18 µg/m ³ and 0.04 µg/m ³ , respectively'	PM _{2.5} -, NO ₂ - and CO-induced cardiovascular diseases reduced	The COVID-19 lockdown reduced PM _{2.5} , NO ₂ and CO emissions
Kodros et al. ⁴⁶	USA	Face masks and respirators	'To quantify the potential health benefits of wearing a face covering or respirator to mitigate exposure to particulate air pollution'	'N95 respirators, surgical and synthetic-fibre masks reduced smoke-attributable hospitalisations by 22%–39%, 9%–24% and 7%–18%, respectively'	Smoke-attributable hospitalisations reduced during the pandemic	Enforcement of wearing masks during COVID-19 reduced air pollutant inhalation
Lam et al. ⁴⁷	Global	PM _{2.5} pollutants	'To establish the relationship between cities' baseline concentration and level of premature deaths during the lockdown'	'PM _{2.5} deduced by 12%–49% in different cities of the world'	PM _{2.5} -related premature deaths reduced (example 14,700 YLLs reduction in India)	Due to the COVID-19 lockdown, the PM _{2.5} level is reduced in 15 cities around the globe
Liu et al. ⁴⁸	Global	Air pollutants	'To quantify the causal impacts of eight types of lockdown measures on changes of a range of individual pollutants'	'NO ₂ , PM ₁₀ , SO ₂ , PM _{2.5} and CO air quality index value falls by 23%–37%, 14%–20%, 2%–20%, 7%–16% and 7%–11%, respectively'	99,270–146,649 premature deaths were reduced in 76 countries	Intra/intercity travel restrictions during COVID-19 are curbing air pollution
Metzger et al. ⁴⁹	USA	Surgeons	'To assess the perspectives of surgical providers towards using telemedicine, defined for this study as either synchronous video encounters or synchronous audio only encounters, to evaluate and care for patients'	'Less than 25% of surgeons use telemedicine before COVID-19; but following COVID-19 restrictions 95% of them use it'	Telemedicine has expanded within paediatric surgery during COVID-19	Lockdown, social and physical distancing forced to use alternative health service
Mollaioli et al. ⁵⁰	Italy	Male and female adults	'To evaluate the impact of the community-wide containment and consequent social distancing on the intrapsychic, relational and sexual health'	'Lack of sexual activity during lockdown was associated with a significantly higher risk of developing anxiety and depression'	Anxiety and mood disorders were reduced in sexual partners	COVID-19 lockdown was an opportunity for sexual partners to pass the time together
Pennington et al. ⁵¹	USA	Patients	'To analyse the impact of telemedicine on workflow and care delivery in a neurosurgical department at a quaternary care centre'	'Telemedicine appointment was increased from 0.3% prepandemic to 19.1% postpandemic and customers satisfaction increased from 85.9% to 88.5%'	Telemedicine use significantly increased following the pandemic onset	Social and physical distance restrictions enable the patients to choose alternatives

Perera et al. ⁵²	USA	PM _{2.5} pollutants	'To estimate the potential public health benefits of fine particulate matter (PM _{2.5}) to children and adults and their associated economic benefits'	'23% PM _{2.5} reduction was estimated during the COVID-19 shutdown compared with the average level for in 2015–2018'	\$31.8–\$77 billion estimated illness and death costs will be avoided from 2021 to 2025	Reduction of PM _{2.5} during COVID-19 lockdown increased health quality and length
Sahi et al. ⁵³	USA	Virtual partners	'To shed light specifically on associations between virtual interactions and overall mental health at two time points during the COVID-19 pandemic'	'Having a greater number of virtual interaction partners was associated with better mental health'	Mental health of virtually communicated partners was improved	When in-person interactions were restricted, partners were virtually interconnected
Seo et al. ⁵⁴	South Korea	Air pollutants	'To analyse the impacts of social distancing and transboundary pollutants on air quality changes examined the corresponding health benefits where the spread of coronavirus was severe'	'During COVID-19, PM _{2.5} , PM ₁₀ , and NO ₂ concentrations decreased by 31%, 61% and 33%, respectively, compared with the previous 3 years'	328 air pollution –related premature deaths and \$1162 million health costs were avoided	Due to lockdown, air pollutants emission was reduced
Shah et al. ⁵⁵	Pakistan	Adults	'To investigate the COVID-19 prevention behaviours within the framework of the Health Belief Model'	'Public health interventions attempting to control the spread of COVID-19 affects a change in people's perceived benefits of preventative actions'	Complying with the IPC measures was improved during COVID-19 than before	COVID-19 prevention restrictions improved the IPC practice of people
Toccafondi et al. ¹³	Italy	Patients	'To illustrate how adopting a human factors and ergonomics perspective can provide insights into how clinical work systems have been adapted and reconfigured'	'Clinical work systems have been adapted and reconfigured to keep patients and staff safe from infection'	IPC behaviours of people and healthcare workers are improved	The emergence of COVID-19 leveraged the IPC behaviour of healthcare actors
Wamsley et al. ⁵⁶	USA	Patients	'To discuss current trends and the experience with telehealth at our large academic institution, with a focused analysis of plastic surgery'	'COVID-19 prevention restrictions change the way health care is delivered via telehealth for generations to come'	Telehealth visits, appointments and services were increased during the pandemic	Stay at home order and distance restrictions forced to use telehealth service delivery
Ye et al. ⁵⁷	China	Air pollutants	'To estimate how COVID-19 restrictions impacted ambient air pollution and the subsequent consequences on health and the health-related economy'	'1239, 2777, 1587 and 4711; PM _{2.5} -, PM ₁₀ -, CO- and NO ₂ -related deaths were avoided, respectively'	Air pollutant–related deaths were avoided during COVID-19	COVID-19–induced lockdown reduces the air pollutants emission

AQI, Air Quality Index; CO, carbon monoxide; IPC, infection prevention and control; MRO, multidrug-resistant organisms; NO₂, nitrogen dioxide; PM_{2.5}, particulate matter with a diameter of 2.5 µm or less; PM₁₀, particulate matter with a diameter of 10 µm or less; VR, virtual reality.

Study risk of bias assessment

The JBI critical appraisal checklist for cross-sectional studies was used to assess the risk of bias (Supplementary file S1). The eight items of the JBI checklist were designed to assess the risk of bias in reviewing cross-sectional primary studies with ‘Yes’, ‘No’, ‘Unclear’ or ‘Not Applicable’ answers.

Synthesis methods

A narrative synthesis was used to report the results of the included publications. The data extracted from the literature were presented in tables and texts. The indirect positive health outcomes in the context of the emergence of COVID-19 were synthesised, and the proportion of the health dimensions was described. The results of the included literature were qualitatively expressed, with numerical findings included when applicable.

Reporting bias assessment

The Agency for Healthcare Research and Quality tool for evaluating the risk of reporting bias in systematic reviews was used. Using the checklists in the tool, the authors independently assessed the risk of bias as a result of unreported results.²⁸ Using the checklists as a guide, studies were identified as potentially

reporting bias (labelled ‘suspected’) and or with minimal chance of reporting bias (noted as ‘undetected’).

Certainty assessment

The certainties of evidence were assessed using the GRADE Pro handbook. The alignment of study findings with the current review objective, the consistency of evidence with each other, the level of suspected publication biases of each reviewed study, the limitations of reviewed studies and the inclusion of indirect health outcomes due to the emergence of COVID-19 were considered as factors for certainty. Based on the criteria (i.e. availability of pre- and post-COVID-19 emergence health outcome information, identification of indirect health benefits of COVID-19 occurrence and the comparison of pre-COVID-19 health situation with the post-COVID-19 emergence health status), the review had set for GRADE domains, the certainty of the evidence was assessed as high, moderate, low or very low. All the authors independently conducted the certainty assessment, and no disagreements were reported.

Results

Selection process and characteristics of studies

Of the initial 1613 potential articles, approximately half (n = 806) were found in the Web of Science database; the

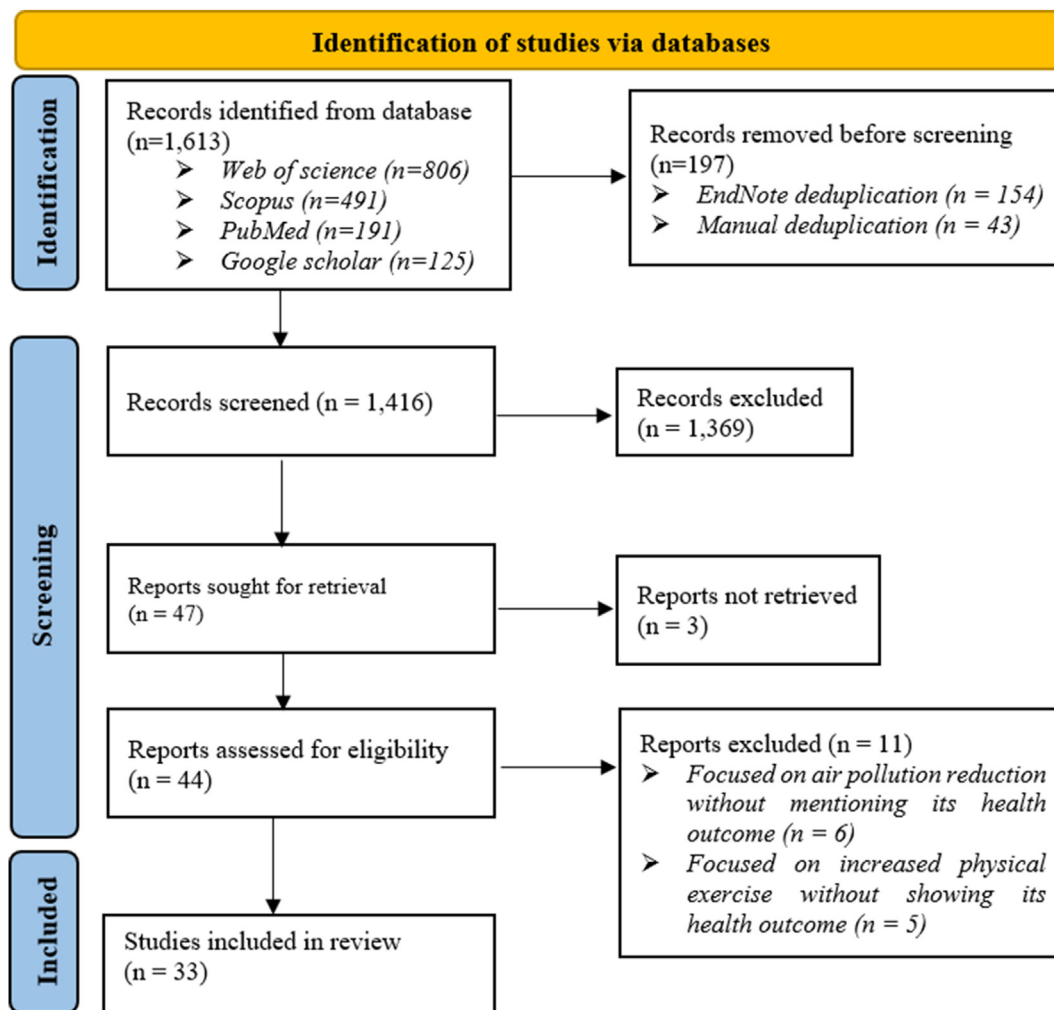


Fig. 1. The literature selection process diagram as recommended by Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020.

remaining 491, 191 and 125 papers were identified in Scopus, PubMed and Google Scholar, respectively (Fig. 1). From the 44 potentially eligible articles arising from the initial search, 11 were removed, as they did not report any health outcomes, leaving a final sample of 33 articles to be included in the review (Fig. 1). The majority (63.63%) of the studies were published in 2021 and the remaining 12.12% and 24.25% were published in 2020 and 2022, respectively (Table 1). All articles included in the review used cross-sectional study designs.

Risk of bias of studies

Based on the JBI critical appraisal checklist for cross-sectional studies, 23 studies were assessed as having a low risk of bias in all eight items of the checklist, whereas nine studies^{11,24,31,39,40,42,43,49,51} demonstrated an unclear risk of bias in two items (identification of confounding factors and strategies to deal with confounding factors) of the checklist (Supplementary file S1). The remaining study³⁷ had a high risk of bias in identifying confounding factors and did not have strategies to mitigate confounding factors.

Health dimension and focus of literature

The majority (72.73%) of the reviewed literature focused on physical health, followed by 12.12% on digital health issues (Table 2, Fig. 2). Three studies reported on mental health^{30,34,50} and one study³³ indicated the positive health impact of COVID-19 on social health (Table 2). One study⁵³ focused on both social and mental health dimensions (multihealth concepts). A high proportion (70.83%) of the studies were conducted on the physical health benefit of COVID-19 and reported the positive impact of lockdown in reducing air pollutants and the indirect contribution to health, with the remaining 29.16%^{29,24,36,37,44,55,13} noting the merits of COVID-19 in improving infection prevention practices (Table 2, Fig. 2). Because family members were often spending more time together and helping each other during the pandemic, anxiety and depression were reduced due to increased feelings of togetherness and reduced loneliness.^{34,50} In addition, physical exercise within families reduced the anxiety level of children during the pandemic.³⁰ Barreda-Angeles and Hartmann³³ reported that social reality platform interactions improved the social health of users

during COVID-19. The digital health–related studies^{31,49,51,56} were focused on the increase of telehealth/telemedicine usage as an alternative to face-to-face health service delivery during the pandemic (Table 2, Fig. 2).

Compared with pre-COVID-19 times, infectious disease prevalence was reduced in the range of 1.4%³⁵ to 43%²⁹ during COVID-19. In addition to infectious diseases, the prevalence of antimicrobial resistance was also reduced during COVID-19.³⁷ Particulate matter with a diameter of 2.5 μm or less (PM_{2.5}) air pollutants during COVID-19 was reduced in the range of 12%⁴⁷ to 58.5%,³⁹ compared with the prepandemic PM_{2.5} status. In the range of 29.85³⁹ to 340,500³⁸ years life lost due to premature death, long- and short-term air pollutant–related deaths were reduced during the pandemic compared with prepandemic mortality status. Lockdown measures during COVID-19 reduced air pollutant–related premature mortality by 35%³² (Table 1). In relation to health costs, \$31.8 to \$77 billion estimated air pollutant–related illness and death crises will be avoided between 2021 and 2025.⁵²

Telemedicine usage increased from 0.3% prepandemic to 19.1% postpandemic.⁵¹ Due to regular physical activity during COVID-19, the anxiety score of children was under five standard deviations from the prepandemic normative value.³⁰ In addition, reduced work commitments or work-from-home situation during the COVID-19 lockdown increased the sexual activity of couples, which, in turn, improved their anxiety level.⁵⁰

Risk of reporting bias

Using the Agency for Healthcare Research and Quality reporting bias assessment criteria, each reviewed study was assessed for the three types of reporting biases (publication, selective outcome reporting and/or selective analysis bias). The reporting biases were assessed as ‘suspected’ or ‘undetected’.²⁸ Based on this assessment, eight of the included studies^{24,31,33,34,50,53,13,56} were suspected of having a risk of bias, whereas the remaining 25 were judged as having an undetected risk of bias. Except for Amar et al.,²⁴ seven studies with a suspected risk of bias did not compare the pre-COVID-19 health situation to post-COVID-19 emergence health statuses. The research conducted by Amar et al.²⁴ reported an analysis of the prevalence of respiratory and gastrointestinal diseases based on hospital/clinic admission; however, patients who

Table 2
The proportion of reviewed literature in terms of the health concepts/dimensions.

Health dimensions	Focus of literature	List of studies	Percentage of studies	
Physical health	Air pollution	<ul style="list-style-type: none"> • Aamir et al.¹⁰ • Bai et al.³² • Chen et al.¹¹ • Dragic et al.³⁶ • Giani et al.³⁸ • Goel et al.³⁹ • Han & Hong⁴⁰ • Hao et al.⁴¹ • Hernandez-Paniagua et al.⁴² 	<ul style="list-style-type: none"> • Huang et al.⁴³ • Khomsi et al.⁴⁵ • Kodros et al.⁴⁶ • Lam et al.⁴⁷ • Liu et al.³⁸ • Perera et al.⁵² • Seo et al.⁵⁴ • Ye et al.⁵⁷ 	72.73%
	Infection prevention and control	<ul style="list-style-type: none"> • Allison et al.²⁹ • Amar et al.²⁴ • Chacon-Quesada et al.³⁵ 	<ul style="list-style-type: none"> • Elliott et al.³⁷ • Shah et al.⁵⁵ • Toccafondi et al.¹³ • Hussain et al.⁴⁴ 	
Social health	Virtual reality platform	<ul style="list-style-type: none"> • Barreda-Angeles & Hartmann³³ 		3.03%
Mental health	Anxiety	<ul style="list-style-type: none"> • Alves et al.³⁰ • Bowe et al.³⁴ 	<ul style="list-style-type: none"> • Mollaioli et al.⁵⁰ 	9.09%
Digital health	Telemedicine/telehealth	<ul style="list-style-type: none"> • Bacon et al.³¹ • Metzger et al.⁴⁹ • Wamsley et al.⁵⁶ 	<ul style="list-style-type: none"> • Pennington et al.⁵¹ 	12.12%
Multihealth	Multi-electronic health Digital and mental health	<ul style="list-style-type: none"> • Sahi et al.⁵³ 		3.03%

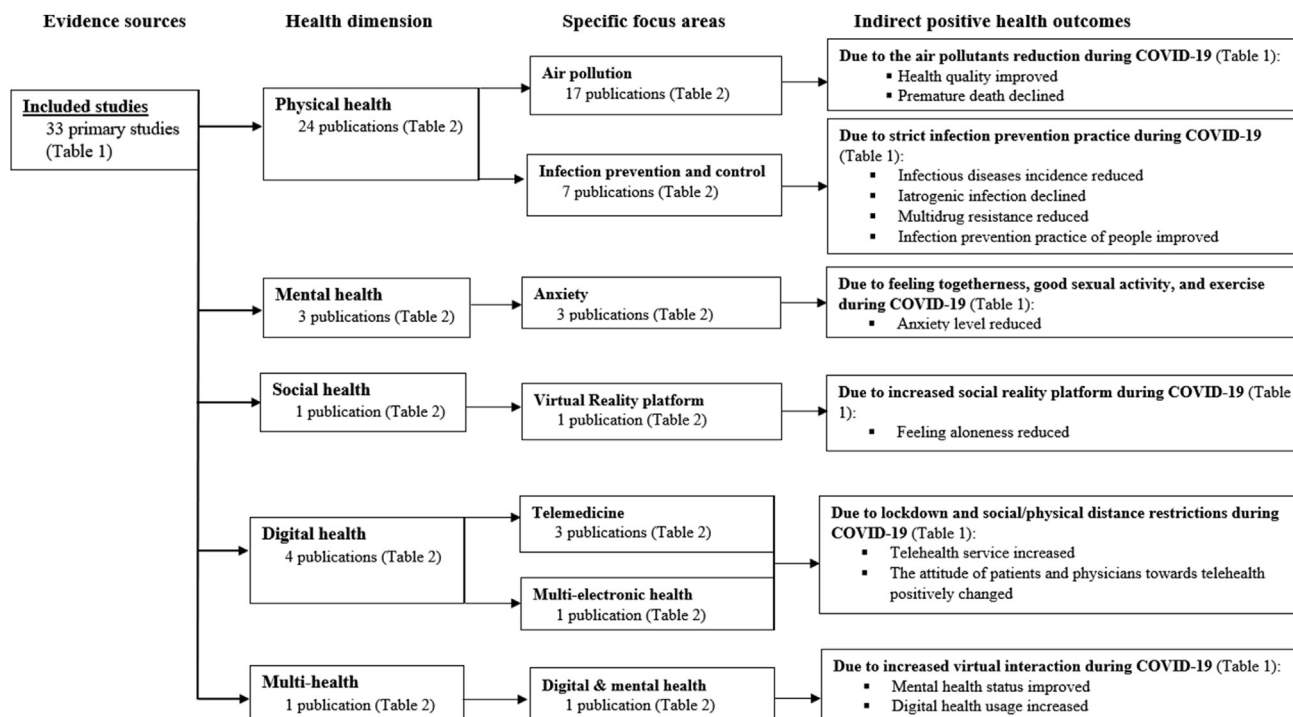


Fig. 2. Evidence map of included publications by health dimension, study focus area and indirect positive health outcomes.

did not attend clinics and recovered by themselves and those who did not attend health facilities due to fear of COVID-19 were not considered. In addition, COVID-19 was the main priority around the world, and some minor health conditions were prohibited from attending health facilities during the pandemic. As these issues were not actively considered, reporting biases were suspected.

Certainty of evidence

Using the GRADE Pro handbook as a guideline, the certainty of results was judged as ‘high’, ‘moderate’, ‘low’ or ‘very low’. The majority (75.75%) of the literature had high levels of certainty, whereas 21.21%^{31,33,34,50,53,13,56} had low levels of certainty of evidence. The studies judged as having a low level of certainty were due to failure of pre-COVID-19 health situation assessments. Only one study²⁴ was judged as having a moderate level of certainty. This study only included cases admitted to health facilities and did not consider those who were not admitted due to COVID-19 restrictions or who had mild and home recovery situations.

Discussion

The objectives of this systematic review were to investigate the frequency of positive health outcomes and identify the health dimension(s) that most benefited from the emergence of COVID-19. Although COVID-19 caused substantial multidimensional crises, its preventive measures also, unexpectedly, contributed to positive health outcomes. The positive health outcomes were mostly attained indirectly by measures adopted for its prevention and control. According to the reviewed literature, the emergence of COVID-19 resulted in some improvements in all four health dimensions (physical, mental, social and digital) whilst also acknowledging that this is clearly counter-balanced by the significant negative impact of COVID-19.

Most (72.73%) of the reviewed literature corroborated that COVID-19 contributed to some physical health improvements. This

was due to the indirect benefit of lockdown in reducing air pollution^{10,32,11,36,45,48,52,54,57} and the critical application of infection prevention protocols.^{30,35,37} During COVID-19 lockdown, vehicles, industries and factories were ceased usual activities. As a result, air pollutant emissions, especially PM_{2.5}, were reduced, and associated health crises, such as premature deaths due to these air pollutants, declined.^{38–41,43,45,47,54} This improvement was not limited to PM_{2.5}, the health burden from other air pollutants, such as nitrogen dioxide,^{45,54} carbon monoxide⁴⁵ and PM₁₀,⁵⁴ were also reduced during COVID-19 when compared with pre-COVID-19 outcomes.

In addition to the positive health outcomes from air pollution reduction, health benefits from improved IPC practices were reported. The IPC practices implemented to reduce COVID-19 also had a positive impact on reducing other infectious diseases.^{35,55,13} COVID-19 IPC practices, such as wearing a facemask, also indirectly minimised inhalation of air pollutants.⁴⁶ The contributions of COVID-19 IPC practices in reducing iatrogenic⁴⁴ and surgical wound³⁵ infections were substantial. Infected and recovered persons from COVID-19 appeared to have an improved immune response to other related viral infections.⁵⁸ Thus, the causative agent of COVID-19 (SARS-CoV-2) may cross-react with other viruses, and the host immune responses subsequently improve due to immune reactions. This indicates that COVID-19 may have a direct positive health impact in addition to improving health through indirect causation.

In addition to the benefits on physical health, the emergence of COVID-19 positively impacted the delivery of digital health care. Specifically, 12.12% of the reviewed literature confirmed that face-to-face healthcare delivery was replaced by digital health during the pandemic. The reviewed literature^{31,49,51} reported that telehealth/telemedicine was often the main health service delivery mechanism during COVID-19 lockdowns. With the need to find alternative health services due to lockdown and physical distancing measures, digital health usage by both health workers and consumers was improved. Electronic media, including social virtual

reality platforms, went beyond existing digital health structures and significantly improved the social health of societies.³³ Communication through virtual platforms was associated with a reduction in feelings of loneliness and contributed to both digital and social health.⁵⁶ Owing to feelings of togetherness and cooperation³⁵ and improved sexual activities,⁵⁰ some anxiety levels among individuals were reduced during the COVID-19 pandemic, although it is acknowledged that mental health was also potentially impaired by COVID-19 isolation. An increase in physical exercise during the pandemic positively impacted child mental health compared with the mental health status associated with physical exercise before COVID-19.³⁰ Virtual communication (digital health) was increased during COVID-19 that in turn benefited patients by reducing anxiety (mental health).⁵³

A wide range (1.4%–43%) of infectious disease prevalence reductions were observed during the pandemic^{29,35} as a result of the strict application of COVID-19 IPC strategies.⁵⁹ In addition to infection reduction, the implementation of COVID-19 infection prevention measures also indirectly reduced antimicrobial resistance development.³⁷ Furthermore, air pollutants, such as PM_{2.5}, were substantially reduced in a range of 12%–58.5%^{39,47} during the pandemic compared with pre-COVID-19 air pollutant levels. Lockdown was the main factor in the reduction of air pollutants emission from vehicles, industries and factories. Owing to air pollutant decline during the pandemic, a significant number (29.85–340,500) of years life lost due to premature deaths associated with air pollutants were avoided.^{38,39} As estimated by Perera et al.,⁵² \$31.8–\$77 billion in health costs will be saved due to reduced PM_{2.5}-related illnesses and deaths. This indicated that COVID-19–related restrictions (lockdown, distance and movement restrictions) indirectly benefited the health and economy of the society. Owing to lockdown measures and distance restrictions, telehealth was deemed to be an appropriate alternative to face-to-face health services. As a result, prepandemic telehealth usage (0.3%) in the United States increased to 19.1% during COVID-19.⁵¹ Similar to telehealth usage, telehealth customer satisfaction increased from 85.9% to 88.5%.⁵¹ Following the emergence of COVID-19, physical activity of individuals³⁰ and sexual activity of couples⁵⁰ increased, which, in turn, reduced anxiety levels compared with the prepandemic situations. The lockdown and social and physical distancing measures promoted virtual reality platform usage, which, in turn, increased social relatedness and improved the mental⁵³ and social health of individuals.³³

Recommendations and implications

COVID-19 resulted in significant behavioural changes around the world that have led to some unexpected positive health benefits. These behavioural changes were as a result of a variety of interventions and personal factors, including government enforcement, the fear of COVID-19, self-induced motivations and self-realizations with time.⁶⁰ Using the theory of reasoned action to this phenomenon, the world population has passed the ‘pre-contemplation’ stage and is currently in the ‘action’ stage.⁶⁰ It is time to invest and support these COVID-19–induced changes to maintain the positive health benefits.

The crises and positive outcomes due to COVID-19 can be taken as a lesson for future pandemic early preparedness. The continuation of COVID-19 prevention and control practices is crucial to limit and/or prevent future pandemics. The persistence of positive COVID-19–induced health outcomes reduces the impact of not only emerging and re-emerging pandemics but also mitigates re/emerging endemics and epidemics.

All the studies included in this review used cross-sectional study designs with short duration (<1 year). As a result, it was not

possible to report the annual status of the positive health outcomes for each study. Further studies on the direct and indirect positive health benefits of COVID-19 with measurable impact on health outcomes are suggested. Possible strategies for the persistence of the COVID-19-induced positive health outcomes, the long- and short-term positive health outcomes, the immune cross-reaction of COVID-19 infection, and the multidimensional positive health impact of COVID-19-like impacts on food safety are recommended for future studies.

Limitations of the literature and review

Some articles did not investigate the pre-COVID-19 health situation, and, equally, in some cases, no comparisons were made with the post-COVID-19 emergence health outcomes. As a natural consequence of the time frames, the reviewed studies were not able to show whether the reported positive health impacts are sustainable in the long-term or merely a short-term outcome. None of the articles reported the intention of the participants to persist with their activities in the future. It is acknowledged that the limitations of this study are not only from the source of evidence, but there are also potentially both study selection and inclusion-related issues. As the English language was an inclusion criterion, some valuable literature published in languages other than English may have been excluded. Finally, it is noted that the studies were initially identified using the title and abstract screening technique, and this approach is prone to missing evidence.⁶¹

Conclusions

Despite the devastating and multidimensional impact of COVID-19 and the measures adopted for prevention, there have been unexpected positive health outcomes. Prevalence, morbidity and mortality for some health conditions were reduced due to a reduction in air pollution, increased personal preventive equipment usage, improved digital health approaches, reduced anxiety and improved social health. The continuation of activities that led to COVID-19–associated positive outcomes, while still reducing the adverse effects of the pandemic, should be promoted. In addition, it is recommended that further integrated studies are carried out to investigate the COVID-19 crisis and associated benefits.

Author statements

Ethical approval

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Competing interests

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2023.02.005>.

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