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REVIEW ARTICLE

Non-Pharmacologic Interventions in COVID-19 Pandemic Management; a Systematic Review

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Abstract: **Introduction:** Different countries throughout the world have adopted non-pharmacologic interventions to reduce and control SARS - CoV-2. In this systematic approach, the impact of non-pharmacologic interventions in management of COVID-19 pandemic was assessed. **Methods:** Following Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines, systematic search was carried out on the basis of a search strategy on PubMed, Web of Science, Scopus, and WHO databases on COVID-19. The impact of travel ban, personal protective equipment, distancing, contact tracing, school closure, and social distancing and the combined effect of interventions on COVID-19 were assessed. **Results:** Of the 14,857 articles found, 44 were relevant. Studies in different countries have shown that various non-pharmacological interventions have been used during the COVID-19 pandemic. The travel ban, either locally or internationally in most of the countries, movement restriction, social distancing, lockdown, Personal Protective Equipment (PPE), quarantine, school closure, work place closure, and contact tracing had a significant impact on the reduction of mortality or morbidity of COVID-19. **Conclusion:** Evidence shows that the implementation of non-pharmacologic interventions (NPIs), for example, social distancing, quarantine, and personal protective equipment's are generally effective and the best way to prevent or reduce transmission. However, this study suggests that the effectiveness of any NPI alone is probably limited, thus, a combination of various actions, for example, social distancing, isolation, and quarantine, distancing in the workplace and use of personal protective equipment, is more effective in reducing COVID-19.

Keywords: physical distancing; quarantine; social isolation; COVID-19; SARS-CoV-2; prevention and control; systematic review

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1. Introduction

The recent surge of a novel coronavirus (2019-nCoV or SARS-CoV-2, which causes COVID-19) was started in December 2019 in Wuhan, China, and was introduced by the World Health Organization as a pandemic and public health issue [1, 2]. The victims of this disease are all humans, and COVID-19 not only disturbed the health systems of all countries, but also disrupted the balance of socioeconomic systems [3]. By the time of writing this article (3 May 2023), based on the dashboard statistics report of WHO, there were 765,222,932 definite diagnoses and 6,921,614 deaths caused by COVID-19, worldwide [4].

Over a century has passed since the last time a pandemic (influenza pandemic H1N1) had occurred without access to the vaccine in the world [5]. According to John Hopkins University report, in the absence of health interventions, COVID-19 could cause 40 million deaths in the world in 2020 [2]. Although similar to many viral diseases, medication therapy seems to be a viable solution to control the pandemic infec-

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tion, there is no definitive treatment to cure COVID-19 infection and the treatments are almost supportive and to eliminate symptoms of the disease [6].

In the absence of proper treatment and effective vaccines, non-pharmacologic interventions (NPIs) can be considered as the main pillar of pandemic control [7]; NPIs can cover a wide range of measures, generally in four groups: 1. Personal protective equipment's such as using mask and hand hygiene; 2. Environmental measures such as disinfecting and ventilation; 3. Social distancing in public places and school closure; 4. The actions associated with travel ban [8].

One of the main objectives of non-pharmacologic interventions was reducing the average number of infections generated at time by any infected cases during the infection period as well as the reduction of the incidence of infection and mortality rates [9]. The results of some studies show that lock down has led to 42% to 81% reduction in disease transmission cases [9-11]. It is, therefore, necessary to conduct an assessment of the effectiveness of NPIs, most of which are local or within a country; however, the evidence obtained from these studies is not yet conclusive as to which NPI was specifically effective [12]. Due to heterogeneity in the intensity and quality of the NPIs in different countries, the effectiveness of these methods is different so that the results of some studies suggest that the complete lock down at the national level has contributed to a drop of 81% (CI95%: 75-78) in the transfer of new cases [13]. Some other studies have described social distancing and travel ban as ineffective and school closure, wearing face masks, and quarantining cities (at the same time) as better methods than complete lock down [14]. An overall and comprehensive evaluation of these measures is necessary to determine the effectiveness of each of the NPIs, thus, this study was carried out with the aim of "evaluating non-pharmacologic interventions of COVID-19 in the world ".

2. Methods

2.1. Search strategy

A systematic search was performed in PubMed, Web of Science, Scopus, and WHO databases on COVID-19, from February 2020 to May 2021, in English. Two researchers independently searched for studies.

PICO included: Participants: Countries that used non-pharmacological interventions, Interventions: Non-pharmacologic interventions, Comparison: countries that did not use NPIs for epidemic control, Outcomes: Effectiveness of NPIs on COVID-19 outcomes such as morbidity and mortality and disease transmission; study design: Observational studies such as cohort, case-control, and community trail. The database searches were conducted using the keywords shown in table 1.

2.2. Inclusion and exclusion criteria

The inclusion criteria were as follows: 1) studies published in English, 2) studies that included the desired indicators and interventions. The exclusion criteria were as follows: 1) duplicate articles, 2) gray literature such as non-peer-reviewed dissertations, conference proceedings/papers, letters, news, editorials, and so forth.

2.3. Study selection and data collection

After retrieving articles from the mentioned databases and eliminating duplicate articles, two authors conducted the screening and data collection process, independently, based on inclusion criteria. The following information was extracted from the selected studies: the first author's name, year of publication, place of study, country of origin, aim of the study, interventions (school closing, workplace closing, public event cancelation, social gathering restrictions, public transport closure, stay-at-home requirements, internal movement restrictions, international travel restrictions, public information campaigns, testing policies, contact tracing policies, and facial covering policies) and outcome (morbidity rate, mortality rate, disease transmission rate, hospitalization rate, basic reproduction number rate).

2.4. Quality assessment

The quality assessment was performed by two reviewers that assessed the quality of data in the included studies. We used the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) checklist to ensure the quality of selected studies. After a full-text quality assessment of selected studies, studies with high and medium quality were included in the analyses and finally, the key findings were extracted.

2.5. Risk of bias and certainty of evidence assessment

The colleagues who cooperated in the search of articles and data extraction are all epidemiologists and also received the necessary training before starting the study; and in several sessions, based on the knowledge and science of the panel members, who were all epidemiologists, the articles for the next stage were selected and then checked for quality. In addition, since the heterogeneity between the studies regarding the outcomes and types of studies was high, the authors decided not to perform a meta-analysis and to be satisfied only with a systematic review.

2.6. Data analysis

Meta-analysis was not feasible due to the heterogeneous set of interventions studied, as well as substantial differences in study designs, outcomes, and effect measures. We described results narratively.

3. Results

Of the 14,857 articles found, 44 were relevant. The study selection process is shown in Figure 1. Studies in different countries have shown that various non-pharmacological interventions have been used during the COVID-19 pandemic. The effects of these interventions on various epidemiological outcomes including morbidity, mortality, and disease transmission were systematically evaluated and the following results were obtained.

3.1. Travel ban

Most studies were consistent in the travel ban intervention. Thus, the travel ban, either locally or internationally, had a significant impact on the reduction of new cases of COVID-19 in most countries. In the Bendavid study (2021), travel ban intervention in Germany at the local level and the Netherlands at the international level, and Italy and the United States at the local and international levels had a significant effect on reducing new cases of COVID-19 [15]. The Costantino and et al. (2020) study also showed that travel restrictions were very effective in curbing the COVID-19 epidemic in Australia at the peak of the epidemic wave from China (when COVID-19 was predominantly in China), reducing the incidence of new cases and death up to 87% [16].

3.2. Social distancing

In a longitudinal pretest – posttest study, 0.9% reduction in the daily new cases of COVID-19 was found, 4 to 21 days after applying social distancing intervention in the United States [17]. Another study in the United States and 134 other countries found an overall 65% reduction in the spread rate of COVID-19 cases after 2 weeks of social distancing intervention (which included the closure of non-essential workplaces and schools, as well as policies for physical distancing when attending a gathering) [18]. Also, in another study, which was performed as a cohort and examined the number of infected people (based on syndromic symptoms diagnosis) in two similar groups in terms of basic characteristics but different in terms of location and social distancing intervention (soldiers' barracks). In the first group, 15% were exposed to SARS-CoV-2 cases and their symptoms were zero, but in the second group, 64% were exposed, 27% of whom had symptoms (in the same time period and barracks) [19]. Table 2 shows impact of social distancing interventions on COVID-19 in different countries.

3.3. Lockdown

In Lock down intervention, most studies were consistent; for example, in Bendavid (2021), Lockdown in France, the United States, Iran, Germany and the Netherlands significantly reduced the number of new cases [15]. Also, 81% reduction in rate of transmission (Rt) in Europe (data from 11 European countries) [9] and 50% reduction in reproduction number (R0) in Australia [16] were the effects of lockdown over the time. Table 3 shows the impact of lockdown on COVID-19 in different countries.

3.4. Isolation

Only one study examined the impact of segregation policies on the spread of COVID-19. A study by Huang et al. (2020), with dynamic modeling of disease transmission in Wuhan Province, China, found that full case identification and isolation can reduce deaths up to 92% (from 0.0166 to 0.0012 in one month (January 28 to February 28)) [20].

3.5. Personal protective equipment

The impact of Personal Protective Equipment (PPE) intervention was examined in 3 studies. A study by Yang et al. (2021) from the United States found that the use of PPE reduced the rate of transmission or proliferation (Rt) by 7% in the general population and by 20% in over 65 year-olds population [11]. Ta-Chou Ng et al. (2020) in Taiwan showed a decrease in basic reproduction number (R0) from 2.5 to 1.30 after one month (April 20 to December 20, 2020) [21]. Cases were reduced from 12.11 to 7.67 (per 10,000) and mortality was reduced from 0.75 to 0.22 (per 10,000) and hospitalization was reduced from 1.54 to 0.97 (per 10,000) in Delaware [22]; Significant decrease in transfer rate to 0.0151 in Ohio (minimum interquartile range (IQR) = 0.0005 and maximum IQR = 0.0439 from January 8 to January 23, 2020) and reduction of transfer rate to 0.0639 (minimum IQR = 0.05597 and maximum IQR = 0.0637 from April 17 to May 15 ,2020) in New York were also reported [23].

3.6. Quarantine

Decrease in the transfer rate to 0.0603 with minimum IQR = 0.0513 and maximum IQR = 0.0708 in Hubei from January 23 to February 23 and decrease in transfer rate to 0.1531 with minimum IQR = 0.1408 and maximum IQR = 0.1642 in Hubei from February 2 to February 17, And the reduction of the transfer rate to 0.1798 with minimum IQR = 0.1525 and maximum IQR = 0.2055 in Hubei from February 17 to March 31 has been one of the effects of quarantine intervention [23]. In Wuhan, China, the R0 after the quarantine intervention was studied from June 23 to February 1 and from February 2 to February 16, which decreased from 3.8 to 1.37 and from 1.24 to 0.49, respectively [24].

3.7. Restriction of movement

Reducing the transfer rate to 0.0603 with minimum IQR = 0.0513 and maximum IQR = 0.0708 in China's Hubei Province from January 23 to February 2 has been the effect of a movement restriction intervention [23]; In another study in

Wuhan, China, a traffic ban from January 10 to January 22 increased R0 from 2.91 to 3.82 [24].

3.8. School closure

Existing studies show that school closures can potentially reduce transmission during an epidemic. In the study by Klimek-Tulwin et al. (2020), there was a statistically significant correlation between school closure with the reduction of COVID-19 incidence in the general population. The countries analyzed included data from 18 countries (Argentina, Belgium, Poland, Romania, Estonia, Hungary, Lithuania, Latvia, Japan, Brazil, Czech, Finland, France, Germany, Italy, Norway, Spain, and UK) [25]. In the study by Bendavid et al. (2021), single or combined non-pharmacological interventions were studied and analyzed at the general population level in England, France, Germany, Iran, Italy, the Netherlands, Spain, the United States, South Korea and Sweden. The school closure intervention showed a significant reduction in new cases of COVID-19 for Sweden only [15].

3.9. Work place closure

The study by Bendavid et al. (2021) showed a significant reduction for new cases of COVID-19 due to work place closure intervention in the United States [15]. Another study in New York found that after the reduction of the Business Activity Index from 100 to 39 in early February to late May (the average number of visits to a favorite place such as a store, restaurant, park, hospital, or museum Per 1,000 people), the rate of positive cases decreased from 53.4% at the beginning of April to 4.7% at the end of May; In other words, the reduction in the daily growth of COVID-19 infection rate was estimated to be 0.12 (standard linear regression coefficient) [26].

3.10. Contact tracing

Cases reduced from 7.51 to 3.35 (per 10,000) and mortality reduced from 0.31 to 0.09 (per 10,000) and hospitalization reduced from 0.97 to 0.53 (per 10,000) was observed after contact tracing in Delaware from May 12 to January 1 2020 [22].

3.11. Mixed Interventions

The decrease in Rt due to mixed interventions has shown different values in studies. The Rt reduced from 36% to 96% in different countries based on different mixed interventions. The lowest and highest decrease belonged to quarantine and restriction movement intervention in France; and comprehensive intervention measures, social distancing, rapid reaction by the prevention and control system, use of masks, travel ban, screening and isolation of outsiders in Jilin, china, respectively. Table 4 shows the effects of mixed interventions on Rt in details.

4. Discussion

In total, four studies on social distancing intervention have been carried out in Korea, America, Iran, and several European countries, and their studied outcomes were disease incidence, mortality, reduction of the epidemic process, and R-value (reproductive number). In all these studies, social distancing reduced the studied outcomes.

Three studies were conducted on the lock down intervention in South Africa, India, and Spain, and their studied outcomes included: R0, the rate of disease, and the rate of death and hospitalization; and with the implementation of the intervention, the values of the studied outcomes decreased. It has been found that when the implementation of this intervention is canceled, the rate of disease attack increases.

Two studies have been conducted on the intervention of closing schools in the United States and several other countries, and the results of these studies showed reduction in the first wave of the epidemic and the incidence of the disease, which we observed that the sooner this intervention is implemented, the greater the reduction of daily cases.

In two studies, the effect of mask use intervention in America and Delaware has been investigated and, in both studies, we have observed that the use of masks reduces the daily incidence of diseases and the implementation of this intervention together with other public interventions has a significant effect on reducing cases of infection.

The impact of non-pharmacologic interventions in preventing COVID-19 is one of the most important and serious issues that impose uncertainty among politicians, economists, and professionals [2]. In general, since the transmission rate at the early stages of the disease is lower, the disease spreads in certain groups at the early stages of the disease, and then enters the general population in the later stages. Hence, if health systems continue to identify groups at risk as soon as possible through investigation, interventions such as quarantine and contact tracing in the early stages of the epidemic may be able to slow the epidemic. However, if the disease enters the public population, population-based interventions such as travel ban, physical distancing, and ... should be used. It is therefore necessary to draw an overall conclusion regarding the types of non-pharmacologic interventions, given the implementation of different non-pharmacologic interventions throughout the world, which impose different costs to the governments and many challenges to individuals, industries, and organizations. These studies provide a foundation for the use of targeted actions and interventions to make connection between effective factors and non-pharmacologic interventions, and reducing the transmission of the disease. It is imperative for us to apply appropriate efforts to strengthen the primary health care system in order to counter COVID-19 epidemic to reduce the chances of other epidemics in the future [2]. A better understanding of non-pharmaceutical interventions will help politicians learn how to implement interventions at the regional level [27]. In general, the purpose of non-pharmacologic interventions is to decrease transmission (R0) and reduce R0 to < 1 or to keep the disease in manageable condition [28]. All countries have implemented non-pharmacologic interventions to control COVID-19. However, there is a significant shift in the amount and type of implemented interventions. In some countries, only some interventions such as travel ban and quarantine are implemented, but in others, a combination of types of interventions, such as school closure, travel ban, lock down, and ... are implemented. The impact of any intervention alone may be limited, but a combination of these interventions can be very effective and have a huge impact on reducing the transmission of disease, exhaustion of the health care system, and mortality due to the disease. In a study in China it was mentioned that without non-pharmacologic interventions, the number of cases diagnosed with the disease would be 51 times in Wuhan, 92 times in Hubei, and 125 times in other states [29]. The results of the study conducted in China showed that the travel ban causes 3-5 days delay in the progress and growth of the disease. A New York study also showed that the use of a mask could reduce deaths by 17%-45% over two months. A study in China showed that compliance with social distancing and the closure of the epidemic center reduced the incidence of new infection by 98.9%. While, another study showed that social distancing reduced the growth rates of definite cases of infection in five countries (Australia, Belgium, Italy, Malaysia, and South Korea) by an average of 52.37%. The results of the studies show that social distancing intervention and its combination with other non-pharmacologic are correlated with the sharp reduction of Rt rate of COVID-19, and it seems that social distancing can be adopted as one of the primary non-pharmacologic interventions to combat the disease [30]. Following up and contact tracing, and quarantining cases have been identified as highly effective guidelines in controlling new cases of COVID-19. Most modeling methods and the results of previous experiences of health systems from epidemics have shown that if social interactions attain their normal level, the disease can be increased again. Therefore, some non-pharmacologic interventions such as social distancing should continue for several months [29].

Travel ban (either partially or locally) can be very effective to curb the COVID-19 epidemic, preventing a very larger epidemic. The effectiveness of the travel ban in countries with high incidence of disease is the claim [31], and the prohibition of trips from countries with high incidence of disease at the international level and from provinces with red status is defined as an attempt to control the COVID-19 epidemics.

In general, public-based and high-risk group interventions, such as social distancing, lock down, and personal protection equipment were more effective compared to public-based interventions including detection, contact tracing, and 14-day quarantine [32, 33]. In other words, population-based interventions can be increased as a supplement to case-based and marker-based strategies to compensate the ineffectiveness of case-based interventions. However, “pandemic fatigue" resulting from the maintenance of behavioral changes, such as physical distance and covering the face, may result in reduction of population-based effects.

Several limitations should be considered in the conclusion of this review study: most studies were based on epidemiologic modeling, so the results may be influenced by the assumptions and the input parameters of those models. Different countries with various geographical, political, economic, belief status and ... conditions have implemented some of these interventions but the same effects were not necessarily exhibited, so generalizations should be addressed by considering all these components. Various studies had no agreement on the definitions and scope of social distancing, and this may cause incorrect conclusion regarding this intervention. For example, in the study by Siedner and colleagues in the United States, the cancellation of public events and school closure are defined as social distancing acts [34]; while, in the study by McGrail et al., policies for social distancing including workplaces and school closure were not essential and physical distance when present in the public was used for preventing the transmission of the virus [18]. Several factors such as population density, health care infrastructure, number of tests, weather, demographic characteristics, and other cases are likely to contribute to the extent of COVID-19 spread, which are not considered in these studies. Different levels of intervention (county / state or country / country), percentage of coverage of interventions, and even the administrative differences of interventions (optional or compulsory) cause widespread differences in conclusions and we observe the variations in the size of effects.

5. Conclusion

In this study, the combined effect of case-based interventions and population-based interventions in succeeding to control COVID-19 epidemics were investigated. Evidence shows that the implementation of non-pharmacologic interventions, for example, social distancing, quarantine, and personal protective equipment’s are generally effective and the best way to prevent or reduce transmission. However, this study suggests that the effectiveness of any NPI alone is probably limited, thus, a combination of various actions, for example, social distancing, isolation, and quarantine, distancing in the workplace and use of personal protective equipment’s, is more effective in reducing COVID-19 cases. In addition, both the government and the public should follow the policy of testing, tracking, and treatment as well as other public health measures, including physical distancing and use of face masks and sanitizers for safety. Therefore, research helps to compare the effectiveness of interventions to provide us with more evidence for future pandemics.

6. Declarations

6.1. Acknowledgments

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6.2. Conflict of interest

The authors declare that they have no competing interest.

6.3. Funding

None.

6.4. Authors' contribution

Parisa Mohseni, Saeideh Shojaei, Seyed Ali Mousavi, and Shakiba Taherkhani wrote the manuscript and participated in the literature review. Fatemeh Fallah Atatalab, Hadis Ghajari and Mahmoud Hajipour participated in the literature review. Koorosh Etemad, Seyed Saeed Hashemi Nazari, Manoochehr Karami, Neda Izadi, and Mahmoud Hajipour supervised, and checked the quality of the study. All authors read and approved the final manuscript.

6.5. Using artificial Intelligence chatbots

None.

6.6. Ethics Statement

The study protocol was approved by the ethics committee of Shahid Beheshti University of Medical Sciences with code: IR.SBMU.RETECH.REC.1400.090.

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Table 1: Search strategy

Search Terms
1. COVID COVID 19 OR COVID 19 OR SARS cov 2 OR SARS cov 2 OR severe acute respiratory syndrome coronavirus 2 OR ncov OR 2019 ncov OR coronavirus infections OR coronavirus OR coronavirus OR coronaviruses OR betacoronavirus OR betacoronavirus OR betacoronaviruses OR wuhan coronavirus COVID-19 pandemic OR COVID-2019 OR 2019-nCoV OR Betacoronavirus SARS coronavirus2 SARS cov OR SARS virus OR SARS virus OR SARS OR SARS2 OR SARS-2 OR SARS coronavirus 2 OR SARS-corona-virus2
2. Non-pharmaceutical Interventions Social Isolation OR isolation strategy OR isolation OR patient isolation OR patient isolation OR patient isolators OR patient isolators OR cohorting OR community containment OR isolation strategy OR isolation OR Home Isolation OR physical contact OR physical distancing OR quarantine OR quarantines OR quarantine OR social distance OR quarantines OR quarantined OR quarantining OR social distance OR Social distancing OR Banning OR distancing OR Contact tracing OR Contact Investigation OR Contact Screening School closures OR Workplace closure OR University closure OR University closures OR Travel restrictions OR Public events banned OR Event ban OR Gathering ban Venue closure OR Border closure OR lockdown OR Curfews OR non-pharmaceutical interventions
3. Reduce transmission reduce OR reduced OR reduces OR transmission [MeSH Subheading] OR transmission OR transmissions OR Coronavirus Infections/prevention and control [MAJR] OR Pandemics/prevention and control [MAJR] OR prevention and control (MeSH Subheading) OR prevention and control OR prevention OR reduce infection OR Coronavirus Infections/prevention and control [MAJR] OR Pandemics/prevention and control [MAJR]
1 AND 2 AND 3

Table 2: Effects of Social distancing interventions on COVID-19 pandemic management

Intervention	**Place**	**Impact of intervention**
Social distancing	South Korea [35]	RT reduction from 3.53 to 0.45 (February 18 to April 29)
	Brazil [36]	RT reduction from 1.76 to 0.71 in Ceara area (March 14 to March 28) RT Reduction from 1.45 to 0.87 in Maranhão region (May 5 to May 19) From 0.87 to 0.5 (after 15 days)
	United States of America [37]	51% reduction in the number of new COVID-19 cases (January 22 to April 25)
	Iran [38]	82% reduction in COVID-19 cases (February 20 to May 13) 7% reduction in deaths (February 20 to May 13)
	United States [17]	0.9% reduction in daily COVID-19 incidence (4 to 21 days after intervention)
	The United States and 134 other countries [18]	65% reduction in the spread rate of COVID-19 cases (after 2 weeks)
	Austria, Belgium, Italy, Malaysia, and South Korea [39]	52.37% reduction in growth rate of confirmed cases
	Brazil [36]	RT reduction from 1.76 to 0.71 in Ceara area (March 14 to March 28) RT Reduction from 1.45 to 0.87 in Maranhão region (May 5 to May 19) From 0.87 to 0.5 (after 15 days)

RT: Rate of transmission

Table 3: Impact of lockdown on COVID-19 pandemic management

Intervention	Place	Impact of intervention
Lockdown	11 European countries [9]	81% reduction in RT
	Australia [16]	50% reduction R0
	India [40]	Reduction of R0 from 3.36 to 1.27
	India [41]	Reduction of R0 from 2.38 to 2.04 with an average coverage of 18% of the intervention (March 25 to May 18)
	Singapore [42]	Reduction of R0 from 1.03 to 0.85 with 100% coverage of the intervention (April 4 to April 14)
	Delaware (United States) [22]	Reduction of cases from 11.71 to 4.72 Mortality reduction from 0.75 to 0.31 Hospitalization reduction from 1.5 to 1.24 (per 10,000 people) (March 24 to April 24)
	South Africa [43]	Exposure rate reduced from 3.28% to 1.53% (April 1 to April 30)
	Huangshi (China) [44]	Decrease in the number of cases from 103.9 to an average of 37 and the number of deaths from 51.1 to an average of 10.5 (after 3 weeks)
	South Africa, Germany, Spain, Italy, New Zealand [45]	Reduction rate (per million) in South Africa: from 3.7 to 1.7 Germany: from 37.5 to 33.7 Spain: from 176.3 to 82 Italy: from 0.92 to 52.1 New Zealand: from 7.5 to 1.7
	United States of America [46]	Reduction of daily infection growth rate from 0.19 to -0.08 (standard linear regression coefficients) (March 19 to April 19)
	New York [26]	Decrease in the number of positive cases from 53.4% at the beginning of April to 4.7% by increasing the lockdown index (restriction of business activity and staying at home)
	Spain [47]	Average percentage change in daily incidence, hospitalization cases, and ICU hospitalization of -3.62, -6.2 and -8.83, respectively (March 15 to April 25)

RT: Rate of transmission; R0: Reproductive number; ICU: Intensive Care Unit.

Table 4: Effects of mixed interventions on COVID-19 pandemic management

Impact of intervention	Place	Mix intervention
36% reduction in RT (from 1.7 before intervention to 1.1 after intervention)	France [48]	Global quarantine, restriction of movement
96% decrease in RT (from 1.64 to 0.05)	Jilin (China) [49]	Comprehensive intervention measures, social distancing, rapid reaction by the prevention and control system, use of masks, travel ban, screening and isolation of outsiders
57% decrease in RT (2.53 to 1.07)	Japan [50]	Voluntary cancellation of events and gatherings, school closures
74% decrease in RT (2.68 to 0.7)	Thailand [51]	Social distancing, telecommuting, hand washing, face masks, quarantine
70.7% decrease in RT	New York [11]	School closures, voluntary or forced stay at home
38% reduction in R0 from 2.5 to 1.53 (April 20 to December 20, 2020)	Taiwan [52]	Case detection, contact tracing, 14-day quarantine Reduction of cases to 82%, mortality to 100%
Hospitalization to 88% (April 20 to January 20)	Delaware (United States) [22]	Use of mask, contact tracing
Reduction of RT to less than 1	11 European countries [9]	Case-based isolation, encouragement of social distance, quarantine, closure of schools and universities, prohibition of public events
53.2% decrease in R0 from 0.71 to 0.33 (January 17 to February 10)	Xi'an (China) [53]	Isolation of confirmed cases, cessation of public transport within the city, cessation of travel between cities, reporting of confirmed cases, quarantine, forced social distance
88.6% decrease in R0 from 0.7 to 0.08 (January 21 to February 14)	Nanjing (China) [53]	
Overall reduction in the incidence of COVID-19 by 13%	Data from 149 countries [54]	School and workplaces closures, cessation of public transportation, restrictions on public gatherings and public events, restrictions on travel, social distancing

RT: Rate of transmission; R0: Reproductive number; ICU: Intensive Care Unit.

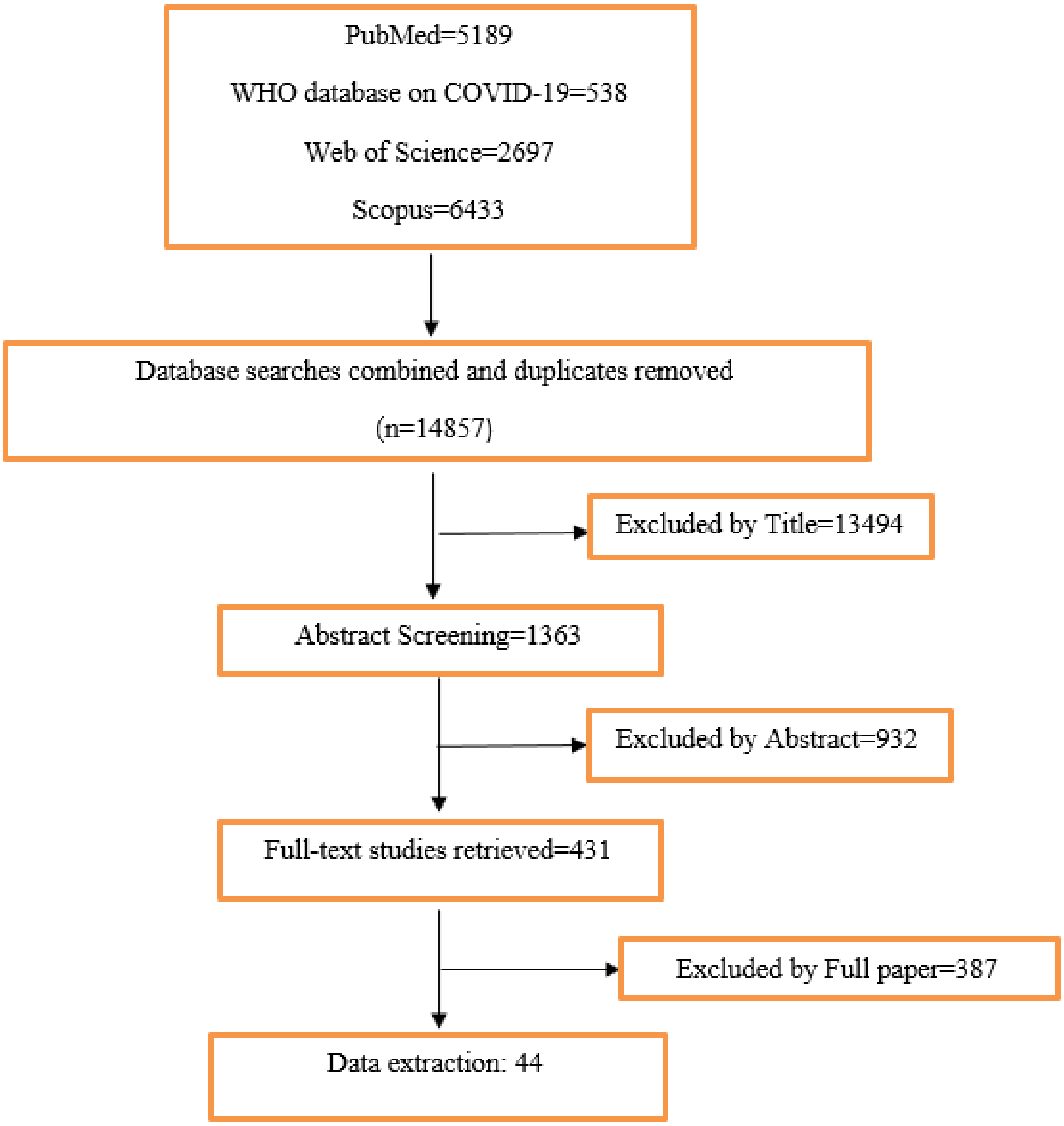

Figure 1: Flow diagram for the selection process of identified articles.