ISSN: 2588-4115; Infection Epidemiology and Microbiology. 2024;10(4):335-343 doi 10.52547/iem.10.4.335

Influenza Co-Infection among COVID-19 Patients in Iran: A Systematic Review

ARTICLE INFO

Article Type
Review Article

Authors
Elahe Derakhshan-Nezhad, *MD*[1*]
Amin Mansoori, *PhD*[2]

[1] Student Research Committee, Mashhad University of Medical Sciences, Mashhad, Iran.
[2] Department of Applied Mathematics, School of Mathematical Sciences, Ferdowsi University of Mashhad, Mashhad, Iran.

** Correspondence*
Student Research Committee, Mashhad University of Medical Sciences, Mashhad, Iran.
E-mail:derakhshanne962@mums.ac.ir

How to cite this article
Derakhshan-Nezhad E., Mansoori A. Influenza Co-Infection among COVID-19 Patients in Iran: A Systematic ReviewI. nfection Epidemiology and Microbiology. 2024;10(4): 335-343.

Article History
Received: September 28, 2024
Accepted: December 20, 2024
Published: December 20, 2024

ABSTRACT

Background: Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is an infectious disease with an unprecedented transmission rate. Considering that there is limited information about the prevalence of influenza co-infection among SARS-CoV-2 positive Iranian patients, and that SARS-CoV-2 co-infection with other respiratory pathogens complicates its diagnosis, prevention, and treatment, this systematic review aimed to evaluate the prevalence of influenza co-infection among SARS-CoV-2 positive Iranian population to facilitate rapid disease management. .
Materials & Methods: A comprehensive search was conducted in Web of Science, PubMed, Scopus, and Google Scholar databases using relevant keywords to find all relevant articles published in English from December 2019 to July 2024. Patients of various ages with influenza-SARS-CoV-2 co-infection were evaluated. This study was conducted according to PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines.
Findings: Totally, 631 articles were recognized in electronic databases, among them nine articles meeting the inclusion criteria were reviewed in this research. The prevalence of influenza co-infection among SARS-CoV-2 positive patients was 4.38%. The majority of SARS-CoV-2 positive patients were male, while the frequency distribution of influenza-SARS-CoV-2 co-infection was almost the same in both sexes. The viral load was the highest in patients aged 18-60 years.
Conclusion: The findings suggest that the prevalence of influenza co-infection among SARS-CoV-2 positive patients is low. However, the significance of this issue should not be ignored, and influenza vaccination in high-risk groups including hospitalized patients and the elderly is highly recommended due to the probability of serious complications.

Keywords: COVID-19, SARS-CoV-2, Influenza B virus, Influenza A virus, Coinfection.

CITATION LINKS

[1] Ghaznavi H, et al. SARS-CoV-2 and influenza viruses... [2] Li LQ, et al. COVID-19 patients' clinical ... [3] Zoran MA, Assessing the relationship between surface... [4] Drews AL, Dual respiratory virus infections... [5] Gold MS, COVID-19 and comorbidities... [6] Konala VM, et al. Co-infection with influenza A and COVID-19... [7] Nuwarda RF, Alharbi AA, Kayser V. An overview of influenza... [8] Klimov AI, et al. WHO recommendations for the viruses to... [9] Banning M. Influenza: Incidence, symptoms, and... [10] Monto AS. Clinical signs and symptoms... [11] Iqbal MM. The effects of regional climatic condition... [12] Sameni F, et al. COVID-19 and skin manifestations... [13] Khorramdelazad H. Immuno-pathological similarities between... [14] Dadashi M , et al. COVID-19 and influenza co-infection... [15] Yue H , et al. The epidemiology and clinical... [16] Moher D. Preferred reporting items for systematic... [17] Joanna Briggs Institute. JBI critical appraisal checklist for... [18] Rezaee D. Coinfection with severe acute respiratory... [19] Alborzi E. Low prevalence of SARS-CoV-2... [20] Veisi P, Malekshahi SS, Choobin H, Jabbari MR, Torbati PM. Simultaneous detection of... [21] Eilami O, et al. A new perspective: Co-infection of... [22] Pourmomen M. Frequency of influenza infection in symptomatic... [23] Hashemi SA. High prevalence of SARS-CoV-2 and influenza A... [24] Hashemi SA, et al. Co-infection with COVID-19... [25] Heshmat-Ghahdarijani K. Co-infection between the severe... [26] Khodamoradi Z. Co-infection of coronavirus disease... [27] Akhtar Z, et al. Seasonal influenza... [28] Faury H, et al. Medical features of COVID-19... [29] Mukherjee S, Pahan K. Is COVID-19 gender-sensitive? J Neuroimmune... [30] Kim D, Quinn J, Pinsky B, Shah NH, Brown I. Rates of co-infection... [31] Wu C, Chen X, Cai Y, Zhou X, Xu S, Huang H, et al. Risk factors... [32] Ding Q. The clinical characteristics of... [33] Alosaimi B, et al. Influenza co-infection associated with ... [34] Yu C, et al. Lopinavir/ritonavir is associated... [35] Cox NJ, Subbarao K. Global epidemiology of influenza...

Introduction

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is an infectious disease that emerged in December 2019 in China and rapidly spread worldwide with an unprecedented transmission pattern and nonspecific clinical symptoms [1]. The disease clinical symptoms may include cough, fever, myalgia, and fatigue [2]. Several studies have reported the co-infection of SARS-CoV-2 with other pathogens like fungi, bacteria, and viruses. Co-infection of SARS-CoV-2 with other respiratory pathogens complicates its diagnosis, prognosis, and treatment. These co-infections could lead to increased symptoms, hospitalization rates, and mortality rates [3]. Most co-infections have been reported to occur with influenza A/B viruses [4].

Influenza is a highly transmissible seasonal disease and a global public health concern caused by influenza viruses of the *Orthomyxoviridae* family. It is associated with a high prevalence of chronic respiratory syndrome, malnutrition, and cardiovascular conditions, imposing a high financial and economic burden on patients [5, 6]. Influenza viruses are groups into four types, A, B, C, and D. Influenza A virus (IFV-A) often causes lethal respiratory diseases, regional epidemics, and global pandemics due to circulation among different hosts [7, 8], but influenza B virus (IFV-B) is considered as the cause of seasonal flu, which is due to its circulation only among human hosts. The main clinical symptoms of influenza infection include loss of appetite, nasal congestion, chills, myalgia, sore throat, cough, headache, and fever [9, 10].

Both SARS-CoV-2 and influenza are transmittable respiratory infections that have similar clinical symptoms and transmission modes and require similar public health guidelines to prevent their spread. They are mainly spread through contaminated surfaces, respiratory droplets, and close contact and cause a broad spectrum of clinical manifestations ranging from asymptomatic/mild cold-like symptoms to serious flu-like symptoms, pneumonia, and even death. The co-occurrence of influenza and COVID-19 as two epidemics could occur in the cold months of the year [11, 12]. Recent studies have reported immuno-pathological similarities between SARS-CoV-2 and influenza viruses [13]. Despite these similarities, the treatment strategies for these two infections are different. Given that rapid and accurate detection of etiological agents is critical for early treatment and patient survival, several investigations have been performed worldwide to investigate influenza co-infection with SARS-CoV-2, but no specific clinical symptoms have been found to differentiate influenza from COVID-19 [14], which makes differential diagnosis and treatment more complicated. Studies have shown that during the COVID-19 pandemic, the spread of influenza viruses in various parts of the world decreased significantly due to people's adherence to hygiene principles [15].

Objectives: Several studies worldwide have investigated the co-infection of SARS-CoV-2 with other respiratory pathogens, particularly influenza A/B viruses. Given that there is limited information about the prevalence of influenza co-infection among SARS-CoV-2 positive Iranian patients, and that SARS-CoV-2 co-infection with other respiratory pathogens complicates its diagnosis, prevention, and treatment, this systematic review aimed to evaluate the prevalence of influenza co-infection among SARS-CoV-2 positive Iranian population to facilitate rapid disease management.

Materials and Methods

Search strategies: The present systematic

review was performed following PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines [16]. A comprehensive and systematic search was conducted in Web of Science, PubMed, Scopus, and Google Scholar electronic databases to find all articles relevant to the scope of this research using a combination of relevant keywords and Boolean operators as follows: "COVID-19" OR "novel coronavirus 2019" OR "2019 ncov" OR "nCoV" OR "severe acute respiratory syndrome coronavirus 2" OR "SARSCoV-2" AND "influenza" OR "influenza virus" OR "flu" OR "flu virus" AND "co-infection" AND "Iran". The search strategy was limited to original scientific articles published in English during the last five years from December 2019 to July 2024. Moreover, the reference lists of the selected articles were reviewed to prevent missing relevant studies.

Study selection criteria: All clinical studies investigating the frequency of influenza co-infection among SARS-CoV-2 positive Iranian patients were selected. Studies were then subjected to title, abstract, and full-text analysis independently by two reviewers for eligibility considering the inclusion criteria, and any disagreement was resolved by discussion. After removing duplicates, irrelevant, and ineligible articles, the remaining studies were subjected to in-depth analysis. Relevant studies meeting the inclusion criteria were reviewed in this research. The inclusion criteria were as follows: original studies, case reports, and case series conducted on Iranian patients co-infected with laboratory-confirmed SARS-CoV-2 and influenza viruses and published in English from December 2019 to July 2024. The exclusion criteria were as follows: studies on the prevalence of influenza or SARS-CoV-2 alone, meta-analysis studies, studies with insufficient data or no access to their full-text, and studies conducted in other countries.

Quality assessment and data extraction: The quality assessment of the selected articles was performed independently by two reviewers using a 9-point checklist provided by the Joanna Briggs Institute (JBI) [17], and any discrepancies were resolved by discussion. Items associated with different sections of the articles, including introduction, title and abstract, methods, discussion, results, and other information were specified. The following data were collected from the selected studies: first author's name; study type; geographic location; publication date; gender, age, number, and clinical symptoms of patients infected with SARS-CoV-2 or co-infected with both influenza and SARS-CoV-2; and influenza virus serotype if available. Two reviewers independently recorded the data to avoid any bias. If the full text of the articles was not available, the corresponding author was contacted via email to request the full text. After three unanswered emails with an interval of one week, the related articles were excluded from the study.

Findings

A total of 631 articles were identified in Google Scholar (n=328), Scopus (n=259), PubMed (n=26), and Web of Science (n=18) electronic databases. After removing duplicate articles, the remaining 358 studies were subjected to title, abstract, and full-text analysis for eligibility, leading to the removal of 289 irrelevant and 60 ineligible studies. Finally, nine articles meeting the inclusion criteria were evaluated in this review, comprising a total of 18069 patients. The literature search strategy is shown in Figure 1.

The types of studies were as follows: six retrospective studies, two case reports, and one case series. Among them, two studies were conducted in each of the cities of Tehran, Shiraz, and Mashhad, and one study was conducted in each of the cities

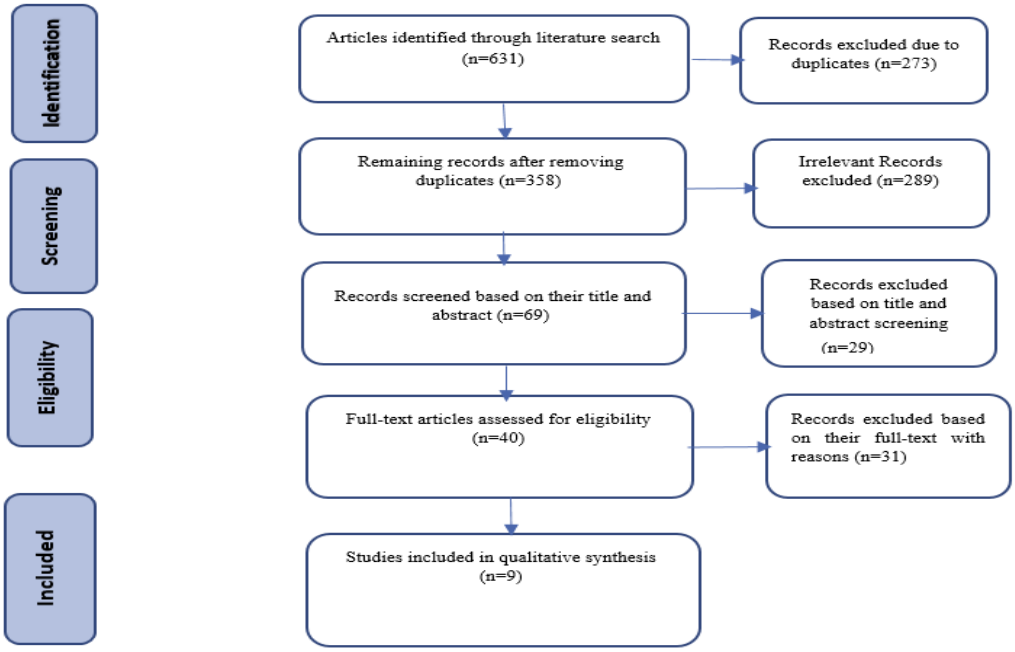

Figure 1) Flow chart of the study selection process in this review

of Bojnurd, Isfahan, and Hamadan, which were almost representative of the Iranian population. Their publication dates ranged from April 2020 to February 2023. The quality assessment scores varied from 4 to 9. PCR (polymerase chain reaction) and RT-PCR (reverse transcription polymerase chain reaction) were the most common molecular techniques used to detect influenza and SARS-CoV-2 viruses. Almost all studies used oropharyngeal/nasopharyngeal swabs to detect these viruses. Overall, the incidence rate of influenza co-infection among SARS-CoV-2 positive patients ranged from 0.12 [25] to 33% [26] in the reviewed studied. Among the nine reviewed studies, two studies investigated SARS-CoV-2 co-infection with various respiratory viruses, which were not our target, and only co-infection with influenza was evaluated [20, 23].

Of the nine eligible articles, five articles evaluated not only the prevalence of influenza-SARS-CoV-2 co-infection but also the symptoms and prevalence of SARS-CoV-2 and non-SARS-CoV-2 infections (including influenza) among 15713 patients with COVID-19-like symptoms [18-22]. In these studies, males were more likely to be infected with SARS-CoV-2 and non-SARS-CoV-2 viruses, including influenza, while sex distribution between co-infected patients was not substantially different. Most of the SARS-CoV-2, non-SARS-CoV-2, and co-infected patients were in the age range of 18 to 60 years. However, patients with non-SARS-CoV-2 infections (<18 and 18-60 years) seemed to be younger than patients with SARS-CoV-2 infection (18-60 and >60 years). In these studies, 12835 cases were infected with non-SARS-CoV-2 viruses, with 2101 influenza cases specifically reported in three studies comprising a total of 15061 patients [18, 19, 22]. Also, 2839 patients were infected with SARS-CoV-2 virus, of whom 197 cases were co-infected with both influenza and SARS-CoV-2 pathogens. Among these five reviewed studies, three studies did not report the gender of their co-infected cases (n=4) [20-22]. Table 1 shows descriptive data of SARS-CoV-2 and non-SARS-CoV-2 cases in these five reviewed studies. The remaining four studies reported only the symptoms

and prevalence of influenza-SARS-CoV-2 co-infection among a total of 2356 laboratory-confirmed COVID-19 patients, of whom 31 cases were co-infected with both influen-

Table 1) Descriptive characteristics of SARS-CoV-2 and non-SARS-CoV-2 cases reported in five of the nine reviewed studies.

Studies	SARS-CoV-2 (+) N	Male/ Female N/ N	Non-SARS-CoV-2/ Influenza N	Male/ Female N/ N	Total
Rezaee et al. [18]	2409	1195/ 1214	Non-SARS-CoV-2: 11668 Influenza: 2004	6338/ 5325 Vs. 1198/ 806	14,116
Alborzi et al. [19]	46	23/ 23	Non-SARS-CoV-2: 38 Influenza: 3	NR Vs. 0/ 3	84
Veisi et al. [20]	91	48/ 43	Non-SARS-CoV-2:106 Influenza: NR	61/ 45 Vs. NR	197
Eilami et al. [21]	203	Mostly male	Non-SARS-CoV-2: 252 Influenza: NR	Mostly female Vs. NR	455
Pourmomen et al. [22]	90	44/ 46	Non-SARS-CoV-2: 771 Influenza: 94	NR Vs. 50/ 44	861

NR: not reported, IFV-A: influenza virus A, IFV-B: influenza virus B

Table 2) Descriptive characteristics of co-infected patients in all nine reviewed studies included in this research

Studies	Publication Date/ Study Type	Province/ City	SARS-CoV-2 (+) N	SARS-CoV-2 (+) & Influenza (+) N (%)	Male/ Female N (%)/ N (%)	Influenza Virus Serotype N	QAS
Rezaee et al. [18]	2023/ Retrospective	Hamedan	2409	191 (7.92)	95 (49.74)/ 96 (50.26)	NR	7
Alborzi et al. [19]	2022/ Retrospective	Tehran	46	2 (4.34)	0 (0)/ 2 (100)	IFV A: 2	5
Veisi et al. [20]	2022/ Retrospective	Tehran	91	1 (1.1)	NR	NR	6
Eilami et al. [21]	2021/ Retrospective	Shiraz	203	1 (0.49)	NR	IFV A: 1	4
Pourmomen et al. [22]	2023/ Retrospective	Golestan, Gorgan	90	2 (2.22)	NR	NR	6
Hashemi et al. [23]	2021/ Retrospective	Mashhad	105	23 (21.9)	14 (60.86)/ 9 (39.13)	IFV A: 23	9
Hashemi et al. [24]	2020/ Case report	Bojnurd	600	2 (0.33)	1 (50)/ 1 (50)	IFV A: 2	9
Heshmat-Ghahdarijani et al. [25]	2021/ Case report	Isfahan	1639	2 (0.12)	1 (50)/ 1 (50)	IFV B: 2	7
Khodamoradi et al. [26]	2020/ Case series	Shiraz	12	4 (33.33)	3 (75)/ 1 (25)	IFV A: 4	7
Total			5195	228	114 (39.53)/ 110 (38.19)	IFV A: 32 IFV B: 2	

NR: not reported, IFV-A: influenza virus A, IFV-B: influenza virus B, QAS: quality assessment score
.3 co-infection are shown in Table 2-Demographic characteristics of patients with influenza-SARS-CoV

za and SARS-CoV-2 viruses [23-26]. Most of the co-infected patients in these four reviewed studies were male and belonged to the age group above 60 years.

Table 2 shows the prevalence of influenza co-infection among SARS-CoV-2 positive patients in all nine reviewed studies. Overall, 228 patients with influenza-SARS-CoV-2 co-infection were identified in all nine reviewed studies with varying levels of completeness of demographic and clinical information. According to the results, the prevalence of influenza co-infection was 4.38% (n=228) among 5195 SARS-CoV-2 positive patients. Most of the co-infected cases were caused by influenza A virus. The prevalence of co-infection was higher in patients aged 18-60 and over 60 years than in patients younger than 18 years, respectively. The frequency distribution of co-infection was almost the same in both sexes.

Among the reviewed studies, only five studies reported the clinical symptoms of co-infected patients [18, 19, 24-26]. Dyspnea was the most common symptom reported in all five studies, followed by fever, headache, and cough, respectively. Less common symptoms reported in some of the five reviewed studies were chest pain, sweating, chills, and gastrointestinal symptoms, respectively. In some studies, hypertension, diabetes mellitus, heart disease, renal disorders, and asthma were reported as the most common underlying diseases among co-infected patients; however, due to insufficient data in the reviewed articles, it was not possible to precisely evaluate clinical symptoms and underlying diseases.

Table 3) Demographic characteristics of co-infected patients in this review

Variable		SARS-CoV-2 (+) & Influenza (+) N=228 N	Percentage (%)
Sex	Male	114	50
	Female	110	48.24
Age	< 18	12	5.26
	18-60	149	65.35
	> 60	67	29.38

*The gender of four co-infected cases was unclear.

Discussion

The prevalence of SARS-CoV-2, particularly during cold seasons, might increase the incidence of SARS-CoV-2 co-infection with other respiratory pathogens. The transmission mechanisms, clinical symptoms, and seasonal prevalence of influenza and SARS-CoV-2 viruses are often similar. Thus, co-infection of SARS-CoV-2 with influenza viruses could occur and increase the seriousness of COVID-19 infection and the risk of mortality among high-risk groups [3]. The present research evaluated the prevalence of influenza co-infection among SARS-CoV-2 positive Iranian patients. All the studies evaluated in this research employed molecular techniques to verify the presence of influenza and SARS-CoV-2 pathogens. Overall, the incidence rate of influenza co-infection among SARS-CoV-2 positive patients was 4.38%. The low prevalence of influenza-SARS-CoV-2 co-infection might be a result of preventive measures taken to combat COVID-19 disease.

Most of the SARS-CoV-2 and non-SARS-CoV-2 patients in the reviewed studies were male and in the age range of 18 to 60 years. The frequency of co-infection was also higher in patients aged 18 to 60 years, followed by people over 60 years. However, the frequency distribution of co-infection was almost the same in both sexes. In a meta-analysis of influenza-SARS-CoV-2 co-infection, Dadashi et al. (2021) also reported that the frequency of co-infection was higher among patients over 50 years of age [14]. Akhtar et al. (2021) in Bangladesh also showed that people over 60 years of age were at higher risk of developing COVID-19; in their study, males were more likely to

be infected with SARS-CoV-2 than females, these results are in line with the present study findings [27]. Although studies have shown no substantial difference in gender and age between COVID-19 and influenza patients [28], the mortality and severity of COVID-19 disease have been shown to be higher in male patients [29].

Several studies have been performed worldwide to investigate the co-infection of SARS-CoV-2 with influenza viruses. However, these studies have reported substantially different findings. In a study by Kim et al. (2020) in California, 116 out of 1206 patients were infected with SARS-CoV-2, among them only one patient was co-infected with both SARS-CoV-2 and influenza type A viruses (0.9%) [30]. A meta-analysis of 11 studies found a prevalence of 0.8% for influenza co-infection among COVID-19 patients [14]. In another investigation by Wu et al. (2020), only one out of 201 SARS-CoV-2 positive patients was co-infected with influenza A virus (0.5%) [31]. In another study by Ding et al. (2020), 5 out of 115 SARS-CoV-2 positive patients were co-infected with influenza (4.34%) [32]. In contrast to these studies reporting a low prevalence of influenza co-infection, the incidence rate of co-infection has been reported to be high in some other studies. For example, Alosaimi et al. (2021) in Saudi Arabia reported a prevalence of 35.4% (n=17) for influenza co-infection among 48 ICU and non-ICU SARS-CoV-2 positive patients [33]. In another research, 64 out of 128 hospitalized COVID-19 patients (50%) were co-infected with influenza viruses, among them 84.4% (n=54) and 15.6% (n=10) were co-infected with influenza A and B viruses, respectively [34].

The difference in the frequency of co-infection in different countries and regions could be attributed to differences in the study population, underlying conditions of patients, seasonal and geographic variation, study period, methods used, preventive and control strategies applied, and targeted pathogens.

In this study, most of the co-infected cases were caused by influenza A virus. This could be attributed to the higher prevalence of influenza type A virus [35]. Among the reviewed studies, two studies investigated SARS-CoV-2 co-infection with various respiratory pathogens. Hashemi et al. (2021) evaluated the co-infection of SARS-CoV-2 with various respiratory pathogens in 105 SARS-CoV-2 positive dead cases in North Khorasan using PCR and RT-PCR. Co-infection of SARS-CoV-2 with influenza was found in 22.3%, with respiratory syncytial virus (RSV) and bocavirus (BoV) in 9.7%, with parainfluenza virus (PIV) in 3.9%, with human metapneumovirus (hMPV) in 2.9%, and with adenovirus (AdV) in 1.9% of SARS-CoV-2-positive dead patients [23]. In another study by Veisi et al. (2022), among 91 COVID-19 patients, 17 patients were co-infected with other respiratory pathogens as follows: one (1.09%) with each of AdV, BoV, PIV, IFV-B, and HKU-1; two (2.19%) with RSV; three (3.29%) with NL63; and seven (7.69%) with hMPV. According to the results, hMPV was the most common pathogen among both SARS-CoV-2-negative and SARS-CoV-2-positive patients [20].

It should be noted that co-infection of SARS-CoV-2 with other respiratory pathogens might have been underestimated in some regions due to false-negative results or lack of hospitalization and home treatment due to increased public awareness of personal protection guidelines, including self-isolation, social distancing, hand washing, mask wearing, etc. The findings suggest that other respiratory viruses should be considered in COVID-19 patients, as it seems that co-infection with other respiratory viruses could complicate disease diagnosis and treatment. Therefore, more extensive viral testing is needed to identify the exact

etiological agents in COVID-19 patients, especially for clinical decision-making.

This research like other studies had some limitations, including the small number of studies on this topic in Iran and the small sample size. Due to insufficient data in the reviewed articles, it was not possible to precisely evaluate clinical symptoms of co-infected cases as well as underlying diseases and influenza vaccination coverage, which might have affected the results. In addition, only published studies were included in this review, which may potentially underestimate the true incidence rate of co-infection**.** Incomplete data in some studies may lead to detection bias. It is recommended that further studies with larger sample sizes be conducted in Iran to precisely evaluate influential factors such as underlying diseases and vaccination coverage, which play an important role in the occurrence of concurrent infections.

Conclusion

The findings suggest that the prevalence of influenza co-infection among SARS-CoV-2-positive patients is low. The most likely reason for this finding could be compliance with personal hygiene principles, especially during the pandemic, leading to a significant reduction in the prevalence of other respiratory pathogens. However, the importance of this issue should not be ignored, and influenza vaccination in high-risk groups including the elderly and hospitalized patients is highly recommended due to the probability of serious complications.

Acknowledgments

The authors would like to thank the experts who assisted in data collection and quality assessment of the studies.

Ethical permissions: Not required.

Author's contributions: Derakhshan-Nezhad E: study conceptualization and design, investigation, resources, writing, reviewing, supervision and original draft preparation. Mansoori A: reviewing, editing and original draft preparation. The authors read and approved the final version of the manuscript.

Conflicts of interest: The authors declare no competing interest.

Fundings: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Consent to participate: Not required.

References

1. Ghaznavi H, Shirvaliloo M, Sargazi S, Mohammadghasemipour Z, Shams Z, Hesari Z, et al. SARS-CoV-2 and influenza viruses: Strategies to cope with coinfection and bioinformatics perspective. Cell Biol Int. 2022;46(7):1009-20.
2. Li LQ, Huang T, Wang YQ, Wang ZP, Liang Y, Huang TB, et al. COVID-19 patients' clinical characteristics, discharge rate, and fatality rate of meta-analysis. J Med Virol. 2020;92(6):577-85.
3. Zoran MA, Savastru RS, Savastru DM, Tautan MN. Assessing the relationship between surface levels of PM2.5 and PM10 particulate matter impact on COVID-19 in Milan, Italy. Sci Total Environ. 2020;738:139825.
4. Drews AL, Atmar RL, Glezen WP, Baxter BD, Piedra PA, Greenberg SB. Dual respiratory virus infections. Clin Infect Dis. 1997;25(6):1421-9.
5. Gold MS, Sehayek D, Gabrielli S, Zhang X, McCusker C, Ben-Shoshan M. COVID-19 and comorbidities: A systematic review and meta-analysis. Postgrad Med. 2020;132(8):749-55.
6. Konala VM, Adapa S, Gayam V, Naramala S, Daggubati SR, Kammari CB, et al. Co-infection with influenza A and COVID-19. Eur J Case Rep Intern. 2020;7(5):001656.
7. Nuwarda RF, Alharbi AA, Kayser V. An overview of influenza viruses and vaccines. Vaccines. 2021;9(9):1032.
8. Klimov AI, Garten R, Russell C, Barr IG, Besselaar TG, Daniels R, et al. WHO recommendations for the viruses to be used in the 2012 Southern Hemisphere Influenza Vaccine: Epidemiology, antigenic and genetic characteristics of influenza A (H1N1) pdm09, A (H3N2), and B influenza viruses collected from February to September 2011. Vaccine. 2012;30(45):6461-71.
9. Banning M. Influenza: Incidence, symptoms, and treatment. Br J Nurs. 2005;14(22):1192-7.
10. Monto AS, Gravenstein S, Elliott M, Colopy M, Schweinle J. Clinical signs and symptoms pre-

dicting influenza infection. Arch Intern Med. 2000;160(21):3243-7.
11. Iqbal MM, Abid I, Hussain S, Shahzad N, Waqas MS, Iqbal MJ. The effects of regional climatic condition on the spread of COVID-19 at global scale. Sci Total Environ. 2020;739:140101.
12. Sameni F, Hajikhani B, Yaslianifard S, Goudarzi M, Owlia P, Nasiri MJ, et al. COVID-19 and skin manifestations: An overview of case reports/case series and meta-analysis of prevalence studies. Front Med. 2020;7:573188.
13. Khorramdelazad H, Kazemi MH, Najafi A, Keykhaee M, Emameh RZ, Falak R. Immuno-pathological similarities between COVID-19 and influenza: Investigating the consequences of co-infection. Microb Pathog. 2020;152:104554.
14. Dadashi M, Khaleghnejad S, Abedi Elkhichi P, Goudarzi M, Goudarzi H, Taghavi A, et al. COVID-19 and influenza co-infection: A systematic review and meta-analysis. Front Med. 2021;8:681469.
15. Yue H, Zhang M, Xing L, Wang K, Rao X, Liu H, et al. The epidemiology and clinical characteristics of co-infection of SARS-CoV-2 and influenza viruses in patients during COVID-19 outbreak. J Med Virol. 2020;92(11):2870–3.
16. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann Intern Med. 2009;151(4):264–9.
17. Joanna Briggs Institute. JBI critical appraisal checklist for studies reporting prevalence data. Adelaide: University of Adelaide. 2017.
18. Rezaee D, Bakhtiari S, Jalilian FA, Doosti-Irani A, Asadi FT, Ansari N. Coinfection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and influenza virus during the COVID-19 pandemic. Arch Virol. 2023;168(2):53.
19. Alborzi E, Monavari H, Kiani J, Karbalaie Niya MH, Tavakoli A. Low prevalence of SARS-CoV-2 and influenza virus coinfection during COVID-19 disease pandemic in Iran. Iran J Virol. 2022;16(2):35-40.
20. Veisi P, Malekshahi SS, Choobin H, Jabbari MR, Torbati PM. Simultaneous detection of multiple respiratory viruses among SARS-CoV-2-positive and negative patients by multiplex TaqMan one-step real-time PCR. Jundishapur J Microbiol. 2022;15(1):e122090.
21. Eilami O, Emami A, Amiripour A, Taghipour K, Hemmati A, Akbarzadeh M, et al. A new perspective: Co-infection of influenza with COVID-19 during the COVID-19 pandemic in southern Iran. 2021:1-14.
22. Pourmomen M, Younesian O, Hosseinzadeh S, Hosseini Alarzi SS, Pourmomen M, Joshaghani H. Frequency of influenza infection in symptomatic patients suspected of having COVID-19. Iran J Med Microbiol. 2023;17(1):112-6.
23. Hashemi SA, Safamanesh S, Ghasemzadeh-moghaddam H, Ghafouri M, Azimian A. High prevalence of SARS-CoV-2 and influenza A virus (H1N1) coinfection in dead patients in northeastern Iran. J Med Virol. 2021;93(2):1008-12.
24. Hashemi SA, Safamanesh S, Ghafouri M, Taghavi MR, Heydari MS, Ahmadabad HN, et al. Co-infection with COVID-19 and influenza A virus in two died patients with acute respiratory syndrome, Bojnurd, Iran. J Med Virol. 2020;92(11):2319-21.
25. Heshmat-Ghahdarijani K, Vaseghi G, Nasirian M, Javanmard SH. Co-infection between the severe acute respiratory syndrome coronavirus 2 and the influenza Type B in Isfahan, Iran. J Res Med Sci. 2021;26(1):51.
26. Khodamoradi Z, Moghadami M, Lotfi M. Co-infection of coronavirus disease 2019 and influenza A: A report from Iran. Arch Iran Med. 2020;23(4):239-43.
27. Akhtar Z, Chowdhury F, Rahman M, Ghosh PK, Ahmmed MK, Islam MA, et al. Seasonal influenza during the COVID-19 pandemic in Bangladesh. PLoS One. 2021;16(8):e0255646.
28. Faury H, Courboulès C, Payen M, Jary A, Hausfater P, Luyt C, et al. Medical features of COVID-19 and influenza infection: A comparative study in Paris, France. J Infect. 2021;82(2):e36-9.
29. Mukherjee S, Pahan K. Is COVID-19 gender-sensitive? J Neuroimmune Pharmacol. 2021;16(1):38-47.
30. Kim D, Quinn J, Pinsky B, Shah NH, Brown I. Rates of co-infection between SARS-CoV-2 and other respiratory pathogens. JAMA. 2020;323(20):2085–6.
31. Wu C, Chen X, Cai Y, Zhou X, Xu S, Huang H, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Intern Med. 2020;180(7):934-43.
32. Ding Q, Lu P, Fan Y, Xia Y, Liu M. The clinical characteristics of pneumonia patients coinfected with 2019 novel coronavirus and influenza virus in Wuhan, China. J Med Virol. 2020;92(9):1549-55.
33. Alosaimi B, Naeem A, Hamed ME, Alkadi HS, Alanazi T, Al Rehily SS, et al. Influenza co-infection associated with severity and mortality in COVID-19 patients. Virol J. 2021;18(1):1-9.
34. Yu C, Zhang Z, Guo Y, Shi J, Pei G, Yao Y, et al. Lopinavir/ritonavir is associated with pneumonia resolution in COVID-19 patients with influenza coinfection: A retrospective matched-pair cohort study. J Med Virol. 2020;93(1):472-80.
35. Cox NJ, Subbarao K. Global epidemiology of influenza: Past and present. Ann Rev Med. 2000;51(1):407–21.