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REVIEW

The relative prevalence of the Omicron variant within SARS-CoV-2 infected cohorts in different countries: A systematic review

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ABSTRACT

The Omicron variant of SARS-CoV-2 was detected in October 2021 and exhibited high transmissibility, immune evasion, and reduced severity when compared to the earlier variants. The lesser vaccine effectiveness against Omicron and its reduced severity created vaccination hesitancy among the public. This review compiled data reporting the relative prevalence of Omicron as compared to the early variants to give an insight into the existing variants, which may shape the decisions regarding the targets of the newly developed vaccines. Complied data revealed more than 90% prevalence within the infected cohorts in some countries. The BA.1 subvariant predominated over the BA.2 during the early stages of the Omicron wave. Moreover, BA.4/BA.5 subvariants were detected in South Africa, USA and Italy between October 2021 and April 2022. It is therefore important to develop vaccines that protect against Omicron as well as the early variants, which are known to cause more severe complications.

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Introduction

The beginning of the COVID-19 pandemic dates back to December 2019, in Wuhan, China. Since then, it has spread globally, and has become a matter of concern.[1,2] The pandemic is still ongoing, with new variants emerging periodically. Multiple vaccine developers have introduced vaccines to help confer personal and herd immunity against the SARS-CoV-2 virus, which causes the COVID-19 infection. The virus, which belongs to the *Coronaviridae* family, contains a positive-sense, single-stranded RNA as its genome.[3] The virus is composed of four main structural proteins, which are the envelope (E), membrane (M), nucleocapsid (N) and the spike (S) proteins. The S gene that codes for the spike protein is highly variable. The spike protein has a receptor binding domain (RBD) that binds to the angiotensin converting enzyme-2 (ACE-2) receptor and facilitates the entry of the virus into the cell following an S1/S2 cleavage. Additional viral proteins help in replicating the viral RNA in the endoplasmic reticulum and translating viral structural and accessory proteins, which are later incorporated into virions that are newly synthesized. The virions also contain the viral RNA and are secreted from the plasma membrane to infect a new cell.[3,4]

Variations or mutations in the spike (S) protein are the basis of some of the main variants of the SARS-CoV-2 virus. These mutations occur spontaneously during the replication cycles by the SARS-CoV-2 replication complex. Some of the well-known variants of the SARS-CoV-2 apart from the original untyped variant are Alpha, Beta, Gamma, Delta, and the Omicron.[5] The Omicron variant was correlated with an S-gene target failure or SGTF on PCR assay due to the mutation 69-70del.[6] Some of the characteristics of the new Omicron variant and its sub-lineages include high transmissibility, low severity of infection, and lower effectiveness of vaccines on this variant. Three Omicron subvariants (BA.1, BA.2, and BA.3) were discovered near simultaneously as the Omicron wave started where BA.1 and BA.2 have many common mutations. More recently, both BA.4 and BA.5 were detected in South Africa.[7]

The spike and RBD of the Omicron variant have about 30 mutations. Among these, the N501Y and Q498R influence the transmissibility of the variant. Both mutations increase the binding affinity of the RBD to the ACE-2 receptor, facilitating easy entry into the host cell. Mutations H655Y and N679K near the furin cleavage site increases S1/S2 cleavage. The P681H mutation also increases S1/S2 cleavage, thereby leading to the higher level of transmissibility of the Omicron variant.[8]

Some other mutations also confer partial resistance to vaccines. Omicron contains mutations in addition to the ones seen in previous variants that confer these characteristics to the variant.[8] The K417N, S371L, S373P, and S375F mutations allow immune evasion, while the E484A mutation provides resistance to antibodies. These mutations lead to a decrease in humoral immunity and the immunogenic potential to epitopes that result in CD8+ T cell immune response. Additionally, an overall decrease in flexibility of the spike protein was seen, which may have an effect on the stability of the protein, and subsequently its function as well. This may also alter the ability of the vaccines to recognize their targets.[9]

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Several studies reported that the Omicron variant causes less severe infections than the earlier variants of SARS-CoV-2. Divino et al.[10] attributed this to the high immunity due to vaccinations or previous infections, along with the characteristics of the variant itself. Shishir et al. conducted an in-silico analysis, which revealed no pro- or anti-inflammatory properties of the epitopes, the two factors combined was proposed to result in the lower severity of the Omicron infection.

Rzymski et al.[11] suggested that the high transmissibility of the Omicron and its lesser clinical severity led to the assumption that Omicron could be the final evolutionary step of SARS-CoV-2. The low vaccine effectiveness against Omicron as well as its reduced severity created vaccination hesitancy among the public especially for those who have not received the booster dose or the parents of children below the age of 12 who have not received the COVID-19 vaccines before the Omicron wave. Qin et al.[12] reported that 17.2 of people aged 60 or higher in China were less receptive to the vaccine booster dose.

Therefore, it is important to trace and map the relative prevalence of the Omicron variant as compared to the early variants of SARS-CoV-2 and to investigate whether the early variants may pose current and/or future infection risk. This may give an insight into the existing variants, which should shape the decisions concerned with the targets of the newly developed vaccines. This may also give evidence-based recommendations to the public regarding their vaccination regimens whether related to the booster doses or to the vaccination of their children under the age of 12.

Methods

The preferred reporting items for systematic reviews and meta-analysis (PRISMA) statement was used to develop the protocol of this systematic review.[13]

Information sources and search strategy

A comprehensive search was conducted with the aim of targeting any studies about the new variant of SARS-CoV-2 using only two key words, which are Omicron or B.1.1.529. The following databases were searched in March 2022: PubMed, Medline, Embase, Scopus, Web of Science, Science Direct, MedRxiv, and Lens.org. The search was updated in December 2022 using the PubMed and Scopus databases with more specific keywords ([Omicron or B.1.1.529] and [prevalence or predominance]. All searches were limited by year to 2020 through 2022.

Eligibility criteria

No restrictions were made based on country, age, or gender. After removing the duplicates, articles that did not have primary data, such as review articles, or those not written in English were excluded from the study. During the full text screening, any studies that reported the prevalence of the Omicron variant (number of cases infected with Omicron) within a cohort of individuals infected with SARS-CoV-2 within a specific time frame were included. Furthermore, studies that reported the relative prevalence of Omicron and different variants of SARS-CoV-2 within the same cohort within a certain period were included. Any studies that reported the prevalence of the different variants in separate cohorts were included only if the Omicron prevalence was reported in one of the cohorts. However, comparison was made between the reported prevalence values of the different variants only when the variants were detected all in one cohort. Studies that reported the prevalence of the different variants in cohorts of mixed populations of infected and uninfected individuals were excluded.

Study selection and data collection

Title and abstract screening, full-text screening, and data extraction were conducted by two independent reviewers for each study using Covidence and disagreements were resolved by consensus.

Data items

Data reported as rates of prevalence (%) of the different variants of SARS-CoV-2 within a certain time frame in a certain country/region. The actual number of cases for each variant out of the total sequenced samples was reported whenever the data was available in the original studies.

Risk of bias and quality assessment

Quality assessment (QA) of each included study was performed using the Newcastle-Ottawa QA Scale (NOS).[14]

Results

Figure 1 shows the flow diagram of the study selection protocol. After the duplicates were removed, the titles and abstracts of 2751 studies were screened, of which 750 full texts were screened. Only 72 studies met our inclusion criteria. Of the 677 excluded studies, 504 were irrelevant, 49 did not have enough data, 118 had no primary data, 3 were not in English, and 3 were duplicates of other studies.

Study characteristics and demographic data

Supplementary Table S1 summarizes the types of studies, their countries and the number of subjects in each study whenever reported.[15–86]

The 72 included studies were conducted in the USA, Canada, Mexico, Chile, Ecuador, North Africa, South Africa, Australia, UK, France, Italy, Norway, Denmark, the Netherlands, Belgium, India, Brazil, Russia, Hong Kong, China, and Japan.

Prevalence of the Omicron variant in cohorts infected with SARS-CoV-2

Tables 1–5 summarize the relative prevalence of the Omicron variant in USA and Canada, Latin America, Africa and Australia, Europe, and Asia, respectively.

Figure 2 shows the most recently reported prevalence of the Omicron variant infections in cohorts from various countries as reported by the included studies. The prevalence is reported as a percentage of the individuals infected with Omicron in a cohort infected with SARS-CoV-2 at certain periods of times.

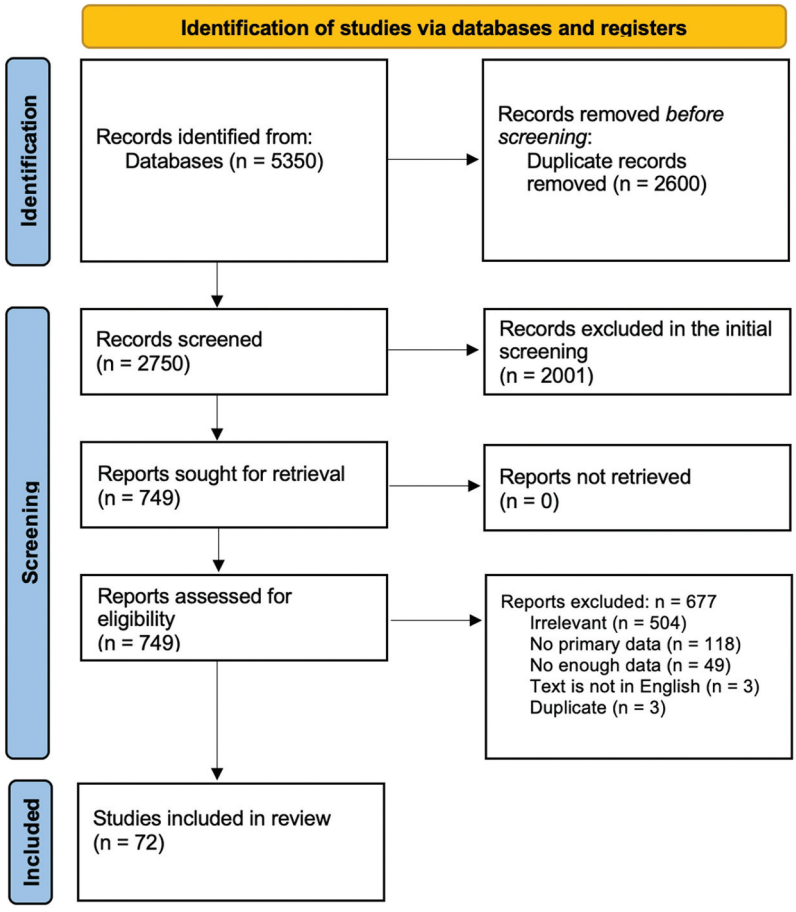

Figure 1. Screening and study selection protocol.

The exact dates are specified to reflect the meaning of "most recently reported" for each country. In many countries, the most recently reported values were also the highest values except South Africa and the Netherlands. The importance of this is to see whether the Omicron variant is progressively replacing the older variants or whether it started to get replaced by older or newer variants.

In order to look at a broader and a more realistic picture about the Omicron's prevalence, Figure 3 shows the prevalence of Omicron in each country as compiled from various studies at two different time frames if data were available. It was challenging to look at the kinetic of the Omicron variant overtime using the extracted data due to the overlap between the time periods reported by various studies and the varying length of the time frames. To overcome this problem, two broad time frames were used to compile the data, June 2021–January 2022 and December 2021–June 2022. Data was compiled from various studies and the total prevalence was calculated only if the number of subjects was reported. This was to calculate the average prevalence across the studies while considering the size of each cohort. Studies reporting the prevalence as percentages only were not compiled in Figures 3 and 4. Percentages were used for graphical presentation only if the relevant data for one country was reported by one study. In general, it was observed that some countries such as the USA and the UK were more extensively studied as compared with the other countries. Therefore, data for such countries was compiled from multiple studies at various dates. However, a single data point was used if reported by a single study or if the data from the other studies could not be compiled due to the lack of the number of subjects. Some studies had relatively large cohorts while others had smaller cohorts, which is one of the limitations of this study. Supplementary Table S2 summarizes the number of studies and subjects compiled in Figure 3. Any data extracted from a single study with a sample size smaller than 500 were highlighted in the text of the results section.

Figure 4 shows the relative prevalence of the Omicron subvariants. Due to the scarcity of such data, only 9 countries were included. Supplementary Table S3 summarizes the number of studies and subjects included in Figure 4 for each of the 9 countries.

USA and Canada

Overall, it was observed that the relative prevalence of the Omicron variant peaked during 2022 as reported by the included studies where the highest reported prevalence was 100% in May 2022[77] (Table 1 and Figure 2).

Data compiled from studies conducted in the USA revealed 55.2% prevalence between June 2021 and January 2022[17,30,31,33,37,39,40,43,72,83] and 59.6% between December

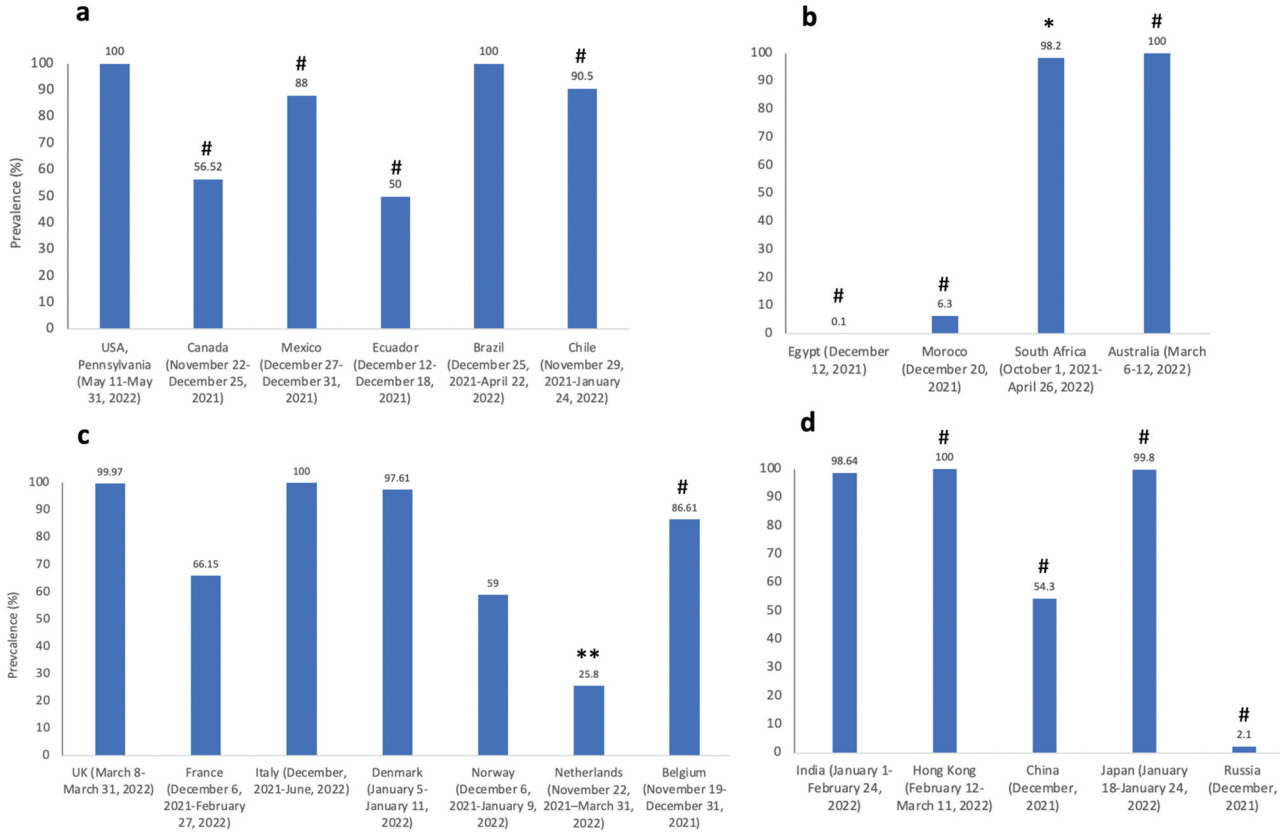

Figure 2. The most recently reported prevalence of the Omicron variant infections in cohorts in different countries as reported by the included studies. The prevalence is reported as a percentage of the individuals infected with Omicron in a cohort infected with SARS-CoV-2. The dates are specified for each country.
Recent values are different from the highest value in the following countries:
*USA: The highest is 92.2% (January 22, 2022).
**Netherlands: The highest is 46.2% (November 22, 2021 – January 19, 2022).
***South Africa, the highest value is 99% (November 7, 2021 - November 29, 2021).
Only one study reported the relative prevalence of the Omicron infections in these countries.

2021 and June 2022.[53,62,77,78,84] Only Ulloa et al.[18] reported the Omicron's prevalence in Canada as 56.2% during November and December 2021 (Figure 3(a)).

Latin America

Table 2 summarizes the reported prevalence of Omicron in some countries of Latin America. Figure 3a shows the data compiled from various studies for each country. Cedro-Tanda et al.[38] reported the Omicron's prevalence at three various dates in Mexico during November and December 2021 as 2%, 65% and 88%. The average was not obtained as the sample size was not known for each date. In Brazil, the prevalence of the Omicron variant increased from 0.4% between December 2021–2022 (n = 241)[25] to 85% between February and March 2022 (n = 67)[64] while in Ecuador the prevalence was 50% in December 2021 (n = 66).[56] Only one study reported the prevalence of the Omicron variant in Chile as 90.8% between November 2021 and January 2022 (Figure 3 (a)). Ranzani et al.,[79] reported the increase in the prevalence of Omicron in Brazil from 1% (September – December 2021) to 100% (December 2021-April 2022). However, data was reported as percentages only and therefore it is not compiled in Figure 3.

Africa and Australia

Only Menasria et al.,[76] reported the prevalence of the different variants of SARS-CoV-2 in some North African countries as 0.1 and 6.3% for Omicron in Egypt and Morocco, respectively, in December 2021. However, multiple studies reported the prevalence in South Africa, which was 24.74% between June and December 2021[22,23,26,44] and increased to 89.2% between October 1, 2021, and April 26, 2022.

Rathinasamy et al.[43] reported a prevalence of 11% during November 2021–January 2022 in a large cohort (n = 34360). However, 100% was reported by Wattiaux et al.[54] during the period January 22, 2022 and February 19, 2022. However, only 35 samples in total were sequenced in this study (Table 3, Figure 3(b)).

Europe

Figure 3(c) shows the compiled relative prevalence of Omicron in Europe. UK, France, Italy, and Denmark showed an increase in the Omicron's prevalence from the first to the second time frame. For example, in the UK, the prevalence increased from 25.7% (September 2021-January 2022)[21,24,28,34,41,46,66,67] to 73.9% (January–March 2022).[65,66,68,85] In France, the prevalence increased from 4.8% (November 2021-Janaury 2022)[19,36,43,48] to 66.15% (December 2021-February 2022).[63] In Italy, the

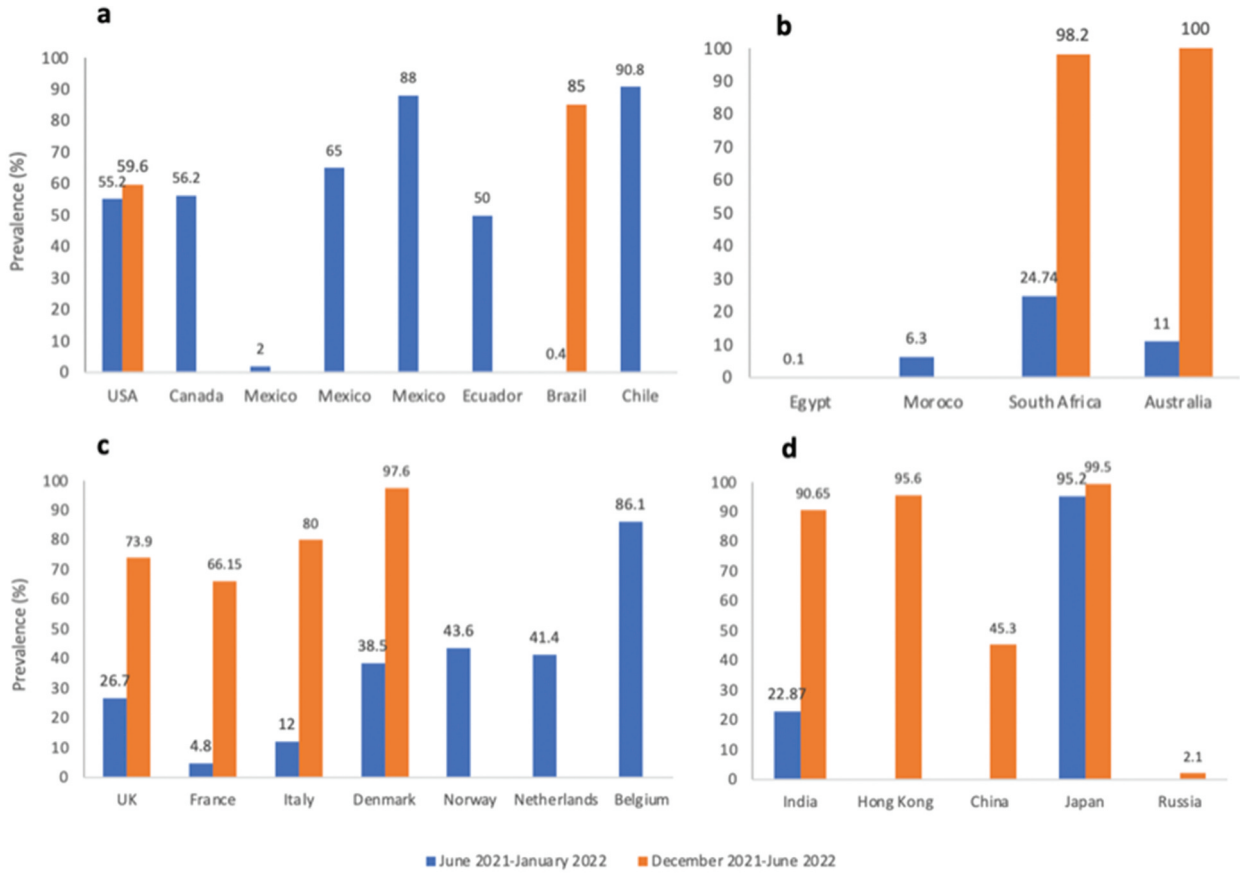

Figure 3. Prevalence of the Omicron variant in different countries during the periods, June 2021 – January 2022 and December 2021 – June 2022. Results were complied from multiple cohorts infected with SARS-CoV-2 in each country (if available). (a) North and Latin America, (b) Africa and Australia, (c) Europe, (d) Asia.

prevalence increased from 12% (November 2021–Janaury 2022)[55,81] to 80% (January 2022).[81] In Denmark, the prevalence increased from 38.5 (November 2021–Janaury 2022)[16,29,43] to 97.6% (January 2022).[16] The prevalence of Omicron was reported in Norway, the Netherlands, and Belgium as 43.6% (December 2021–January 2022),[49] 41.4% (November 2021–January 2022)[27,35] and 86.1% (November–December 2021)[15] respectively (Table 4, Figure 3(c)).

Asia

The Omicron variant predominated during the second time frame in India 90.65% (n = 460, January–February),[86] Hong Kong 95.6% (n = 383, December, 2021-March, 2022)[51] and Japan 99.5% (January 2022).[82] In China and Russia, the prevalence was reported as 45.3% (n = 278) and 2.1%, respectively, in January 2022[69,71] (Table 5, Figure 3(d)).

The subvariants of Omicron

Figure 4 shows the relative prevalence of the subvariants of Omicron in cohorts from various countries at various time periods. Data was reported only for the USA and Brazil representing North and Latin America, respectively. Between January and March 2022, BA.1 predominated and BA.2 started to be detected in the USA.[77] However, BA.2 predominated from March to June 2022 while BA.4 and BA.5 started to emerge.[62,78] In Brazil, BA.1 predominated between December 2021 to April 2022 while BA.2 started to appear[64,80] (Figure 4(a)). Similarly, BA.1 predominated in South Africa over BA.2 and BA.5 emerged between October 2021 and April 2022)[22,61] (Figure 4(b)).

The same pattern was observed in Europe where BA.1 was predominant by December 2021/January 2022 while BA.2 appeared then predominated later in 2022.[66,67] Eales et al.,[66] and Elliot et al.[68] reported different data in March 2022 as BA.1 or BA.2 (respectively) predominated. Francesconi et al.[70] reported similar ratios of BA.1 and BA.2 in Italy between December 2021 and June 2022 in addition to the emergence of the other subvariants of Omicron; BA.3, BA.4 and BA.5. Mattuzzi et al.[74] reported that BA.4 and BA.5 formed >50% of the subvariants during June–July 2022 (Table 3). In Denmark, both BA.1 and BA.2 were reported between December 2021 and January 2022 with BA.1 being predominant[16] (Figure 4(c)).

BA.1 was 93.3% prevalent in India in January 2022 which was taken over by BA.2 between January and February 2022.[80,86] Hong Kong showed a similar predominance of the BA.2 subvariant between December 2021 and March 2022[50] (Figure 4(d)).

Discussion

This review compiled data from 72 studies covering 22 various countries to investigate the relative prevalence of the Omicron

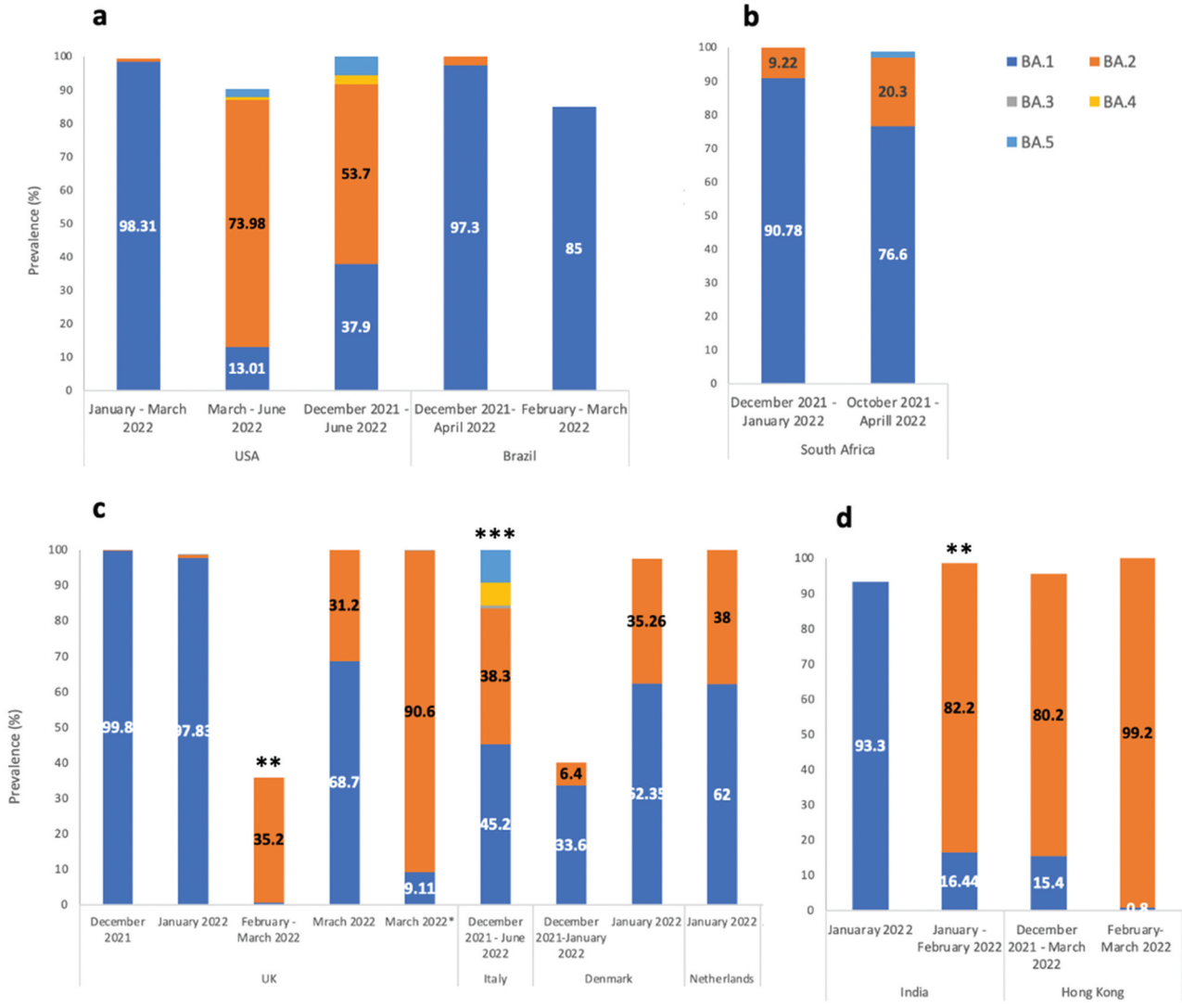

Figure 4. Prevalence of the subvariants of Omicron in different countries during different time periods. Results were either compiled from multiple cohorts infected with SARS-CoV-2 (if available) or reported from single studies in each country. (a) North and Latin America, (b) Africa and Australia, (c) Europe, (d) Asia.
*Data could not be compiled at the same date (March 2022) as only percentages were reported.
**BA.1 and BA.2 may include any subvariants start with BA.1 or BA.2, such as BA.1.1 or BA.2.1 respectively.
***The relative prevalence of the subvariants was calculated in an Omicron only infected cohort (100% Omicron).

infections as compared to the earlier variants of SARS-CoV-2 within infected cohorts. The results varied among the various countries and within each country even within the same time frame. This could be attributed to either the different levels of predominance at the different regions of each country and/or to the different study designs including the sample size. We clustered the data based on the geographical location as USA & Canada, Latin America, Europe, Africa & Australia, and Asia. Furthermore, data concerned with the relative abundance of the different Omicron subvariants including BA.1, BA.2, BA.3, BA.4, and BA.5 were compiled whenever reported by the included studies.

Data were collected from any study reporting the proportions of the different variants of SARS-CoV-2 within an infected cohort regardless of the cohort size or the aim of the study. Many of the included studies did not directly aim at studying the prevalence of the Omicron. However, the prevalence was reported as part of comparing the severity of the different variants, assessing the effectiveness of the vaccines against the Omicron variant as compared to the other variants or had other aims. Those studies were still informative and were therefore included to maximize the pooled data and to cover longer time frames during which the prevalence was determined. Due to the great level of overlap between the reported time frames and the variation in the length of these durations, only two broad time frames were created, and data was compiled for each country within each of the two time frames. The ranges of the two time frames were from June 2021 to January 2022 and from December 2021 to June 2022. The start and the end month of each time frame is based on the earliest and the latest dates reported by all studies. However, narrower time frames are specified for each country in the results and the discussion sections. The following sections summarize the Omicron infection relative prevalence profile in SARS-CoV-2 infected cohorts as reported by the included studies.

Table 1. The relative prevalence of the Omicron variant as compared to the Delta and other variants of SARSCoV-2 in the USA and Canada between July 2021 and June 2022. The studies are ordered based on the earliest date in each study.

			Omicron					
Study	Region	Dates	BA.1	BA.2	BA.4	BA.5	Omicron total	*Delta (or other variant)
Boucau et al.[37]	Massachusetts	July, 2021 – January, 2022					33.9% (19/56)	66.1% (37/56)
Ferdinands et al.[31]	NR	August 26, 2021 – January 22, 2022					23.03% (55552/241204)	76.97% (185652/241204)
Tang et al.[83]	Missouri	October 1, 2021 – January 27, 2022					38% (174/462)	51% (237/462) Other 5.8% (27/462)
Lai et al.[72]	NR	November 2021 – January 2022					74.6% (8,870/11,849)	22.2% (2,630/11,849) Other 0.886% (105/11,849)
Rathinasamy et al.[43]	NR	November 21, 2021 – January 7, 2022					4.5% (84431/1876940)	
Chaguza et al.[39]	Connecticut	November 22, 2021 – December 27, 2021	31.07% (216/695)				31.07% (216/695)	68.92% (479/695)
Fall et al.[30]	Maryland	November 22, 2021 – December 31, 2021					55.2% (1119/2027)	44.79% (908/2027)
Christensen et al.[40]	Texas	November 27, 2021 – January 5, 2022					22.1% (4468/20196)	77.9% (15728/20196)
		November 27, 2021 – January 5, 2022					58.7% (4468/7617)	(41.3%) (3149/7617) (Alpha)
	Texas	December 1, 2021 – December 23, 2021					90%	
		December 30, 2021 – January 5, 2022					98%	
**Haan et al.[52]	Alaska	November 29, 2021 – January 16, 2022	66.3%	2.7%			69.0%	<1%
	Alaska	February 13, 2022		25.3%			25.3%	
	Alaska	February 27, 2022		47.8%			47.8%	
	Alaska	March 13, 2022		67.9%			67.9%	
	Alaska	March 29, 2022		74.3%			74.3%	
	California	February 13, 2022		2.2%			2.2%	
	California	February 27, 2022		>40%			>40%	
	California	March 13, 2022		16.2%			16.2%	
	New York	February 13, 2022		1.8%			1.8%	
	New York	March 13, 2022		5.5%			5.5%	
	Washington	March 13, 2022		17.6%			17.6%	
	Washington	March 29, 2022		2.4%			2.4%	
	Lower 48	November 29, 2021 – January 16, 2022	67.2%	0.3%			67.5%	<1%
	Lower 48	February 13, 2022		1.8%			1.8%	
	Lower 48	February 27, 2022		15.5%			15.5%	
	Lower 48	March 13, 2022		10.9%			10.9%	
	Lower 48	March 29, 2022		19.2%			19.2%	
Tseng et al.[17]	California	December 6, 2021 – December 31, 2021					84% (22414/26683)	16% (4269/26683)
Accorsi et al.[33]	Washington	December 10, 2021 – January 1, 2022					55.99% (13098/23391)	44.00% (10293/23391)
Lambrou et al.[47]	NR	December 11, 2021					>1%	
		December 25, 2021					>50%	

(*Continued*)

Table 1. (Continued).

			Omicron					
Study	Region	Dates	BA.1	BA.2	BA.4	BA.5	Omicron total	*Delta (or other variant)
		January 22, 2022					99.2%	0.7%
Petros et al.[42]	Massachusetts	December 12, 2021					10%	
		December 19, 2021					50%	
		December 27, 2021					90%	
Wang et al.[58]	NR	December 15 – 24, 2021	22.5–58.6%				22.5% to 58.6%	
		December 26, 2022 – January 16, 2022	92–99.5%				92–99.5%	
Adams et al.[62]	NR	December 26, 2021 – June 30, 2022	37.9% (351/981)	53.7% (497/981)	2.8% (26/981)	5.6% (52/981)	94.4% (926/981)	5.6% (55/981)
Coelho et al.[53]	NR	December 27, 2021 – February 7, 2022					59.5% (367145/616318)	25.61% (157858/61631) 11.9% (73476/616318) (Alpha)
Tsao et al.[84]	Stanford University	January 1, 2022 – January 11, 2022					95.7% (44/46)	
Phan et al.[78]	Pennsylvania	January 26, 2022 – February 7, 2022	95% (38/40)	2.5% (1/40)			97.5% (39/40)	2.5% (1/40)
	Pennsylvania	February 8, 2022 – February 22, 2022	97.2% (35/36)	2.8% (1/36)			100% (36/36)	
	Pennsylvania	February 23, 2022 – March 8, 2022	100% (23/23)				100% (23/23)	
	Pennsylvania	March 9, 2022 – March 22, 2022	100% (13/13)				100% (13/13)	
	Pennsylvania	March 23, 2022 – April 5, 2022	60% (6/10)	40% (4/10)			100% (10/10)	
	Pennsylvania	April 6, 2022 – April 19, 2022	10.5% (2/19)	84.2% (16/19)	5.3% (1/19)		100% (19/19)	
	Pennsylvania	April 20, 2022 – May 10, 2022		95.5% (21/22)	4.5% (1/22)		100% (22/22)	
	Pennsylvania	May 11, 2022 – May 31, 2022		95.5% (41/43)		4.5% (2/43)	100% (43/43)	
Phan et al.[77]	Allegheny County, Pennsylvania, USA	January 25, 2022 – February 7, 2022	95% (38/40)					2.5% (1/40)
		February 8, 2022 – February 22, 2022	97.2% (35/36)				97.2% (35/36)	2.8% (1/36)
		February 23, 2022 – March 8, 2022	100% (23/23)				100% (23/23)	
		March 9, 2022 – March 22, 2022	100% (13/13)				100% (13/13)	
		March 23, 2022 – April 5, 2022	60% (6/10)	40% (4/10)			100% (10/10)	
		April 6, 2022 – April 19, 2022	10.5% (2/19)	26.3% (5/19)	5.3% (1/19)		42.1% (8/19)	57.9% (11/19) (other)
Ulloa et al.[18]	Canada	November 22, 2021 – December 25, 2021					56.52% (29594/52363)	43.48% (22769/52363)

*The name of the variant will be mentioned only if it is not Delta.
**In this study, each state was reported from the earliest date to the most recent.

Table 2. The relative prevalence of the Omicron variant as compared to the Delta and other variants of SARSCoV-2 in Latin America between December 2020 and April 2022. The studies are ordered based on the earliest date in each study.

Study	Country	Dates	Omicron		Omicron	Delta (or other variant)
			BA.1	BA.2		
Cedro-Tanda et al.[38]	Mexico	November 16, 2021 – November 21, 2021			2%	98%
		December 13, 2021 – December 19, 2021			65%	35%
		December 27, 2021 – December 31, 2021			88%	12%
Mella-Torres et al.[75]	Chile	November 29, 2021 – January 24, 2022			B.1.1529 (534/588) 90.5%	9.1%(54/588) Alpha (B.1.1.7) 0.2% (1/588) Gamma (P.1) 0.2% (1/588)
Carrazco-Montalvo et al.[56]	Ecuador	December 12, 2021 – December 18, 2021			50% (33/66)	50% (33/66)
De Souza et al.[25]	Brazil	December 21, 2020 – December 16, 2021			0.4% (1/241)	27.8% (67/241) 32.4% (78/241) (Gamma)
Ranzani et al.[79]	Brazil	September 6, 2021 – December 14, 2021	<1%		<1%	~99%
		December 25, 2021 – April 22, 2022	97.3%	2.7%	100	
Bezerra et al.[64]	Brazil	February 15, 2022 – March 29, 2022	85% (57/67)		85% (57/67)	14.9% (10/67) (unverified strains)

Prevalence of the Omicron variant in cohorts infected with SARS-CoV-2

The study by Rathinasamy et al.[43] reported that by mid-January 2022, the Omicron variant was spread across 170 countries worldwide with the highest Omicron prevalence detected in the UK and the USA (46% and 31%, respectively). They predicted the predominance of Omicron in several countries indicated by the high propagation rates.

USA and Canada

Several studies reported the level of prevalence of the Omicron Variant in different areas of the USA within different time periods. It was observed that the relative prevalence of Omicron peaked toward the end of December 2021 and January 2022 as reported by several studies[17,40,42,47,58] where the highest reported prevalence was 99.2% in January 2022.[47] Starting early November, the relative prevalence of Omicron started to increase drastically, reaching its peak of 92%–99.5% by late December and throughout January.[47,58] The predominance of the Omicron variant continued until May 2022 which was the most recently reported for the USA.[77,78]

When data were pooled from 10 studies[17,30,31,33,35,37,39,40,72,83] the Omicron's prevalence was 55.2% between June 2021 and January 2022 which increased to 59.6% between December 2021 and June 2022.[53,62,77,78,84] The reported prevalence in Canada was 56.2% during November and December 2021.[18] The similar prevalence values observed in the USA and Canada could be explained by the close geographical location and the lack of travel restrictions from the USA to Canada starting from August 2021.

The progression of the predominance of the Omicron variant in the USA over time was supported by Petros et al.[42] who carried out a cross-sectional study to investigate the trajectory and dynamics of omicron infection in highly vaccinated university populations in Massachusetts between December 12 and 27 2021. They reported that the prevalence of omicron increased from 0% to 91% within the length of the study while Delta dropped from 100% to 9% within the same cohort.

Latin America

Mexico had a progressively increasing prevalence of the Omicron variant during the period of November to December 2021 where the prevalence increased from 2% to 88%.[38] Phylogenetic analysis of the Omicron variant showed that independent exchanges between Mexico and the world then local transmission contributed to Omicron diversity in the country. Likewise, the prevalence of the Omicron variant increased in Brazil from 0.4% between December 2021–2022,[25] to 85% between February and March 2022.[64] However, both studies had small cohorts of 241 and 67 individuals, respectively. Another sharp increase was reported in Brazil by Ranzani et al.,[79] who reported the increase in the prevalence of Omicron from 1% (September–December 2021) to 100% (December 2021-April 2022). Furthermore, Chile had a relatively similar level of prevalence during the periods, November 2021–January 2022 (90.8%).[75] In Ecuador, Carrazco-Montalvo et al.[56] reported that in a cohort of 66 subjects infected with SARS-CoV-2, 50% were infected with Omicron and 50% were

Table 3. The relative prevalence of the Omicron variant as compared to the Delta and other variants of SARSCoV-2 in Africa and Australia between June 2021 and April 2022. The studies are ordered based on the earliest date in each study.

			Omicron				
Study	Country	Dates	BA.1	BA.2	BA.4	Omicron total	Delta (or other variant)
Rufino et al.[44]	South Africa	June 14, 2021				0.00% (0/1101)	45.23% (498/1101)
		July 12, 2021				0.00% (0/2226)	88.90% (1978.9/2226)
		August 9, 2021				0.00% (0/1601)	95.19% (1524/1601)
		September 6, 2021				0.00% (0/1269)	97.01% (1231.1/1269)
		October 4, 2021				0.00% (0/513)	93.57% (480/513)
		November 1, 2021				0.48% (0/208)	95.67% (199/208)
		December 13, 2021				95.92% (940/980)	0.92% (9/980)
Wolter et al.[23]	South Africa	October 1, 2021 – November 30, 2021				93.7% (10547/11255)	6.3% (948/11255) (another variant)
Cloete et al.[26]	South Africa	November 7, 2021 – November 29, 2021				99% (74/75)	1% (1/75)
Wolter et al.[22]	South Africa	December 1, 2021 – January 20, 2022		8.7% (8276/95470)		8.7%(8276/95470)	
		December 5, 2021 – January 20, 2022	91.3% (87194/95470)			91.3%	
		December 5, 2021		3% (931/31271)		3% (931/31271)	
		January 29, 2022		80% (2425/3031)		80% (2425/3031)	
Wolter et al.[61]	South Africa	October 1, 2021 – April 26, 2022	76.6% (57563/98,710)	20.3% (20,086/98710)	1.8% (1,806/98,710)	98.2% (79455/98710)	1.3%(1273/98710)
Menasria et al.[76]	North Africa Egypt	December 12, 2021				0.1% (1/971)	13.1% Delta (21J) 41.2% 20D 29.1% 20A
	Morocco	December 20, 2021	6.3% (22/352)			6.3% (22/352)	29.5% B.1.17 (104/352) 20.7% (73/352) B.1 9.4% B.1.1 6.0% B.1.528
Wattiaux et al.[54]	Australia	January 22, 2022 – February 19, 2022				100% (35/35)	
		March 6, 2022 – March 12, 2022				100% (82/82)	0% (0/82)
Rathinasamy et al.[43]	Australia	November 26, 2021 – January 5, 2022				11% (3,779.6/34,36	85% (29206/34360)

infected with the Delta variant between December 12, 2021 and December 18, 2021. Furthermore, they identified 12 sub-lineages of the Omicron variant circulating in Ecuador, each with different mutation numbers and worldwide origins. More studies are required to make a conclusion about the pattern of the prevalence in Latin America.

Africa and Australia

North Africa was poorly studied as only Menasria et al.,[76] assessed the prevalence of the different variants of SARS-CoV-2 in some North African countries which was 0.1 and 6.3% for Omicron in Egypt and Morocco, respectively, in December 2021 while Omicron was not detected in Libya or Sudan.

The Omicron variant (B. 1.1. 529), was first identified in South Africa as responsible for a fourth wave of COVID-19. On November 24, 2021. Rufino et al.[44] conducted a cross-sectional study in South Africa and found that Omicron prevalence rose from 0.00% to 93.85% while Delta prevalence dropped from 45.23% to 0.00% within the length of the study in the same cohort. The study reported similar prevalence of COVID-19 in December 2021, when Omicron was predominant among the unvaccinated population to the prevalence of COVID-19 during the August–September wave, in which Delta was predominant variant. However, the prevalence of COVID-19 in December is much higher than in the previous wave among the vaccinated.

Table 4. The relative prevalence of the Omicron variant as compared to the Delta and other variants of SARSCoV-2 in Europe between September 2020 and July 2022. The studies are ordered based on the earliest date in each study.

			Omicron						
Study	Country	Dates	BA.1	BA.2	BA.3	BA.4	BA.5	Omicron total	Delta (or other variant)
Smallman-Raynor et al.[46]	UK	September 5, 2020 – December 18, 2021						2.4% (23,137/958,420)	75.3% (722,133/958,420) 16% (Alpha) (153,405/958,420)
		October 23, 2021 – January 9, 2022						7.93% (124532/1570879)	
Elliott et al.[67]	UK	October 19, 2021 – November 5, 2021							Reported as 100% (841/960)
		November 23, 2021 – December 14, 2021						7.3% as reported (56/1240)	92.7% as reported (714/1240)
		January 5, 2022 – January 20, 2022	76.14% (1822/2393) 21.69% (519/2393) BA.1.1 0.54% (13/2393) B.1.1.529	0.79% (19/2393)	0.04% (1/2393)			98.07% (2374/2393)	0.79% (19/2393)
Elliott et al.[28]	UK	November 23, 2021 – December 14, 2021						7.3% (56/770)	92.7% (714/770)
UK Health Security Agency[41]	UK	December 1, 2021 – December 18, 2021						31.5%	68.5%
Ward et al.[21]	UK	December 1, 2021- December 31, 2021						78.6% (814011/1035163)	21.4% (221152/1035163)
Spensley et al.[24]	UK	December 1, 2021 – January 16, 2022						92.9% (145/156)	7.1% (11/156)
Allen et al.[34]	UK	December 5, 2021 – December 11, 2021						22.2% (25401/114232)	77.8% (88831/114232)
		December 5, 2021 – December 11, 2021						39.3% (4790/37601)	60.7% (22811/37601)
Eales et al.[66]	UK	December 14, 2021						50%	
		December 23, 2021						90%	
		December 30, 2021	84.6% 15.2% BA.1.1	0.2%				84.8	
		February 14, 2022						>99.82%	
		March 1, 2022	9.6% 21.6% BA.1.1	68.7%				99.9%	
Chadeau-Hyam et al.[66]	UK	January 5, 2022 – January 20, 2022						99% (2374/2393)	0.7% (19/2393)
		February 8, 2022 – March 4, 2022	64.8%	35.2%				99% (1615/1616)	
Whitaker et al.[85]	UK	March 9, 2022 – March 22, 2022						61.4% (10,709/17,448)	(1493/17,448) 8.55% Wild Type (2971/17,448) 17.02% Alpha (2275/17,448) 13.03%

(*Continued*)

Table 4. (Continued).

Study	Country	Dates	Omicron					Omicron total	Delta (or other variant)
			BA.1	BA.2	BA.3	BA.4	BA.5		
Elliott et al.[68]	UK	March 8, 2022 – March 31, 2022	9.11% (405/4445)	90.6% (4026/4445)	0.29% (13/4445)			99.8% (4444/4445)	0.2% (1/4445)
Rathinasamy et al.[43]	France	November 12, 2021 – January 4, 2022						2.51% (3863/153357)	
Houhamdi et al.[48]	France	November 28, 2021 – December 31, 2021						26.7% (1,119/4,194)	73.3% (3,075/4,194)
Auvigne et al.[36]	France	December 6, 2021 – January 28, 2022						11.7% (109/931)*	88.3% (822/931)
Vieillard-Baron et al.[19]	France	December 1, 2021 – January 18, 2022						46.40% (2385/5140) All cases	
		December 1, 2021 – January 18, 2022						36.4% (229/629) ICU only	
		December 1, 2021 – January 18, 2022						28.9% (154/533) subgroup of ICU patients with pneumonia	
Ouafi et al.[50]	France (Lillie)	February 15, 2021 – January 30, 2022						61.5% (128/208)	28.8% (60/208) 0.0% (1/208) (B.1.640) 9.1% (19/208) (Alpha)
		October 18, 2020 – December 12, 2021							21.28% (32640/153357) (Alpha)
Bal et al.[63]	France	December 6, 2021 – February 27, 2022						66.15% (14149/21387)	28.1% (6011/21387)
		December 6, 2021 – February 27, 2022							0.088% (19/21387) (other lineages)
Novazzi et al.[55]	Italy	December 3, 2021 – January 27, 2022						26.91% (81/301)	73.09% (220/301)
Francesconi et al.[70]	Italy	December, 2021 – June, 2022	45.2% (124/274)	38.3% (105/274)	0.73% (2/274)	6.5% (18/274)	9.2% (25/274)	100%	
Stefanelli et al.[82]	Italy	December 6, 2021						(4/2127) 0.2%	Delta (4/2127) 0.2%
	Italy	December 20, 2021						(462/2139) 21.6%	Delta (1,676/2139) 78.4% B.1640 (1/2139) 0.046%
	Italy	3 January 2022						(2058/2571) 80%	Delta (512/2571) 19.9% B.1.639 (1/2571) 0.04%

(*Continued*)

Table 4. (Continued).

Study	Country	Dates	Omicron					Omicron total	Delta (or other variant)
			BA.1	BA.2	BA.3	BA.4	BA.5		
	Italy	17 January 2022						(2262/2377) 95.2%	Delta (114/2377) 4.8% B.1.639 (1/2377) 0.042%
Mattiuzzi et al.[60]	Italy	January 12, 2022	>80%					>80%	
Boscolo-Rizzo et al.[59]	Italy	January 17, 2022 – February 14, 2022	>95%					>95%	
Loconsole et al.[73]	Italy	January 17, 2022 – January 23, 2022		0.5%				0.5%	
		February 7, 2022 – February 13, 2022		<5%				<5%	
		February 14, 2022 – February 20, 2022		<10%				<10%	
		February 21, 2022 – February 27, 2022		>10%				>10%	
Mattiuzzi et al.[74]	Italy	January, 2022 – May, 2022 June, 2022 – July 2022						>50% BA.1/BA.2 >50% BA.4/BA.5	
Espenhain et al.[29]	Denmark	November 22, 2021 – December 7, 2021						3.94% (785/19922)	96.06% (19137/19922)
Rathinasamy et al.[43]	Denmark	November 22, 2021 – January 5, 2022						5.76% (18253/316889)	
Lyngse et al.[16]	Denmark	December 1, 2021 – December 7, 2021	3.49% (707/20253)	0.025% (5/20253)				3.51% (802/20253)	96.48% (19541/20253)
		December 8, 2021 – December 14, 2021	19.60% (1825/9284)	0.42% (39/9284)				20.02% (1864/9284)	80.23% (7449/9284)
		December 15, 2021 – December 21, 2021	56.10% (3826/6820)	3.89% (265/6820)				59.99% (4091/6820)	40.01% (2729/6820)
		December 22, 2021 – December 28, 2021	70.96% (4373/6163)	14.18% (874/6163)				85.14% (5247/6163)	14.86% (916/6163)
		December 29, 2021 – January 4, 2022	71.67% (6754/9439)	22.70% (2139/9439)				94.37% (8893/9439)	5.78% (546/9439)
		January 5, 2022 – January 11, 2022	62.35% (4468/7166)	35.26% (2527/7166)				97.61% (6995/7166)	2.39% (171/7166)
Veneti et al.[20]	Norway	December 6, 2021 – January 9, 2022						43% (39524/ 91005)	57% (51481/ 91005)
Jalali et al.[49]	Norway	December 14, 2021 – January 23, 2022						59% (662/1122)	41% (460/1122)
Andeweg et al.[35]	Netherlands	November 22, 2021 – January 7, 2022						25.86% (13915/53804)	74.137% (39889/53804)
		January 26, 2022 – Mach 31, 2022	61.96% (67887/ 109557)	38.03% (41670/ 109557)				100%	
Eggink et al.[27]	Netherlands	November 22, 2021 – January 19, 2022						46.24% (80615/174349)	53.76% (93734/174349)
Kremer et al.[15]	Belgium	November 19, 2021 – December 31, 2021						86.61% (2161/2495)	13.39% (334/2495)

Table 5. The relative prevalence of the Omicron variant as compared to the Delta and other variants of SARSCoV-2 in Asia between November 2021 and March 2022. The studies are ordered based on the earliest date in each study.

			Omicron			
Study	Country	Dates	BA.1	BA.2	Omicron total	Delta (or other variant)
Sharma et al.[45]	India (Rajasthan)	November 24, 2021 – January 4, 2022			27.6% (291/1053)	72.4% (762/1053)
		November 29, 2021 – December 5, 2021			6.2% (9/145)	93.7% (136/145)
		December 6, 2021 – December 12, 2021			3.4% (8/239)	96.6% (231/239)
		December 13, 2021 – December 19, 2021			2.2% (5/228)	97.8% (223/238)
		December 20, 2021 – December 26, 2021			24% (24/100)	76% (76/100)
		December 27, 2021 – January 2, 2022			57.2% (75/131)	42.7% (56/131)
		January 3, 2022 – January 4, 2022			81% (170/210)	19% (40/210)
Garg et al.[32]	India	November 25, 2021 – December 23, 2021			31.06% (82/264)	68.94% (182/264)
Singh et al.[80]	India	January 11- January 20, 2022	99.03% (103/104)		99.03% (103/104)	
Zaman et al.[86]	India	January 1, 2022 – February 24, 2022	6.2% (9/146) 2.7% (4/146) BA.1.1 0.7% (1/146) BA1.1.1 5.5% (8/146) BA1.1.7 0.7% (1/146) BA.1.17.2 0.7% (1/146) BA.1.18 Total 16.44% (24/146)	30.8% (45/146) 50.7% (74/146) BA.2.10 0.7% (1/146) BA.2.12 Total (82.2%120/146)	98.64% (144/146)	1.37% (2/146)
Chen et al.[51]	Hong Kong	December 31, 2021 – March 11, 2022	15.4% (59/383)	80.2% (307/383)	95.6%	4.4% (17/383)
		February 12, 2022 – March 11, 2022	0.8% (1/127)	99.2% (126/127)	100%(127/127)	
Feng et al.[69]	China	December, 2021			54.3% (151/278)	<50%
Tanaka et al.[82]	Japan	December 28, 2021 – January 11, 2022			BA.1 and BA.2 95.2% (1311/1377)	
	Japan	January 12, 2022 – January 17, 2022			99.3% (1291/1304)	
	Japan	January 18, 2022 – January 24, 2022			99.8% (4282/4283)	
Gladkikh et al.[71]	Russia	December, 2021			2.1%	Delta 97.9%

Multiple studies reported data for South Africa revealing an average of 24.74% between June and December 2021[22,23,26,42,44] which increased to 89.2% between October 1, 2021, and April 26, 2022.

Omicron's prevalence data for Australia was obtained from the study conducted by Wattiaux et al.[54] who conducted a randomized household cluster survey in the Gold Coast region of Australia between January 22, 2022 and 19 February 2022. The study recruited members from random households in 5 total visits across the aforementioned period with a total number of participants amounting to 1,379 individuals. Out of the 1,379 specimens obtained, 63 were positive for SARS-COV-2 (4.5%) - of which 35 were sequenced and were all identified as the Omicron variant. However, Rathinasamy et al.[43] reported a prevalence of 11% during November 2021-January 2022 in a large cohort (n = 34360). It is therefore not clear whether the Omicron's prevalence increased in Australia in January–February 2022. More studies are required to gain a clearer understanding of the dynamics of the Omicron in Australia.

Europe

The UK was the most extensively studied among the European countries. The Delta variant was reported by most of the studies as the predominant variant of SARS-CoV-2 in the UK until December 2021. The highest reported prevalence of the Omicron variant was 39.9% between December 5 and 11 2021.[28,34,41,46] However, the Omicron was found to be predominant as compared to Delta with prevalence rates 61.4–99.9% between December and March 2022 as reported by Ward et al.,[21] Eales et al.,[66] Chadeau-Hayam et al.,[65] Whitaker et al.,[85] Elliott et al.[67,68] and Spensley et al.[24]

The Real-time Assessment of Community Transmission (REACT) is an important research study aimed at tracking the spread of SARS-CoV-2 in England through 19 distinct rounds of data collection from May 1, 2020 to March 31, 2022. REACT-1 analyzed the prevalence and dynamics of SARS-CoV-2 in England during the period November-mid-December 2021. Elliott et al.[28] documented their data from the Round 16 of the REACT-1 study from November 23, 2021 to December 17, 2021. Among almost 100,000 participants, prevalence was high with rapid growth particularly in London during December 2021 with lower rates of infection among vaccinated children (5–12 years) and boosted adults.[28]

When the extracted data was pooled in our study, it was found that in the UK, the prevalence increased from 25.7% (September 2021-January 2022)[21,24,28,34,41,46,66,67] to 73.9% (January–March 2022).[65,66,68,85] The pooled results revealed that the prevalence of Omicron in the UK, France, Belgium, and Italy was relatively similar which could be explained by the close geographical location among the four countries. In Denmark, Espenhain et al.[29] reported a rapid increase and spread of the SARS-CoV-2 Omicron variant in Denmark despite an early and comprehensive public health response. They suggested that community transmission was more widespread than reported revealed from the earlier travel-related cases, with no travel history to Africa.

Overall, Omicron was the predominant variant of SARS-CoV-2 in the UK, France, Italy, and Denmark during the second time frame (December 2021-January 2022). However, Omicron did not predominate during the first-time frame in these countries (December 2021–June 2022).[16,19,21,24,28,29,34,36,41,43,46,48,55,63,65–68,82,85] Furthermore, Omicron was the predominant variant in Belgium during the earlier time frame as reported by Kremer et al.[15] It is therefore concluded that the Omicron was gradually replacing the other variants of SARS-CoV-2 in several countries in Europe during the period December 2021-June 2022.

Asia

India was the most extensively studied country in Asia where the replacement of Delta and other variants with Omicron was also reported. Sharma et al.[45] conducted a cross-sectional study in India and reported the prevalence of SARS-CoV-2 between November 24, 2021 and January 4, 2022 as 27.6% vs 72.4 for Delta. The prevalence the Omicron variant was reported at different time intervals where it reached 81% in January 3–4, 2022. Throughout December, the prevalence of the Omicron variant increased from 3.4% in early December to 57.2% toward the end of December. The gradual replacement of Delta and the other variant with Omicron was also supported by Garg et al.[32] They conducted a cross-sectional cohort study to present evidence of the spread and early transmission where they reported a definite shift from Delta to Omicron predominance during November and December 2021.

Overall, the Omicron variant predominated during the second time frame in India 90.65% (January-February),[80,86] Hong Kong 95.6% (December, 2021-March, 2022)[51] and Japan 99.5% (January, 2022)[82] but not in China or Russia where prevalence was reported as 45.3% and 2.1%, respectively, in January 2022.[69,71]

Overall, the included studies did not show any specific global trends for the Omicron's regional distribution/prevalence.

The Omicron's subvariants

The Omicron variant of COVID-19 has given rise to multiple subvariants that have been identified through genomic sequencing. These subvariants are denoted by different names based on the genetic mutations that differentiate them from the original Omicron variant. The first subvariant of Omicron was dubbed BA.1 (B.1.1.529.1), which was the original strain that was first detected in South Africa in November 2021. Since then, several other subvariants have been identified and studied, with over 100 subvariants estimated to exist. Some of these subvariants include BA.1.1, BA.2, BA.2.12.1, BA.2.75, BA.2.75.2, BA.2.3.20, BJ.1, XBB, BA.3, BA.4, BA.4.6, BA.5, BF.7, BQ.1, and BQ.1.1. These subvariants exhibit distinct properties and have been associated with different epidemiological trends (Xu et al.).[87]

This section summarizes the reported prevalence of the Omicron's subvariants in each country whenever reported.

USA

Haan et al.[52] investigated the differences in patterns of the emergence of the SARS-CoV-2 variants in Alaska as compared to other regions of the USA. A total of 11,971 sequences were downloaded from Alaskan samples, along with metadata limited to the period of time from November 28, 2021, to April 12, 2022, from lower 48 contiguous states from GISAID. Data was also analyzed between New York, California, and Washington. During November, 2021, to January, 2022, Delta was found to be prevalent in less than 1% of the cases in Alaska and lower 48 states. Among Omicron variants, BA.1.1, BA.2, and BA.2.3 were found to be in 66.3%, 0%, and 0.1% of the cases in Alaska, and 67.2%, 0.2%, and 2.7% of the cases in the Lower 48 contiguous states, respectively. By mid-February, 2022, BA.2.3 was found to be 25.3%, 1.8%, 1.8%, 2.2%, and 2.4% of the cases in Alaska, Lower 48 contiguous states, New York, California and Washington, respectively. By the end of February, BA.2.3 became more prevalent than BA.2 in Alaska, while the converse was true for the Lower 48 states. By March 2022, BA.2.3 became more prevalent in Alaska, Lower 48 contiguous states, New York, California, and Washington. However, the prevalence of BA.2.3 in Alaska is much higher than the other regions. Haan et al.[52] concluded that the pattern of emergence in Alaska was unique and suggestive of founder event for BA.2.3 due to an absence of other lineages from BA.2, along with being influenced by its geographical and population differences compared to contiguous United States. Phan et al., was the first to report the presence of BA.5 circulating in Western Pennsylvania in May 2022. They also detected low levels of BA.4 in April–May 2022. They suggested that the low level of BA.4 could be attributed to its inability to outcompete BA.2.

UK

Chadeau-Hayam et al.[65] reported the results of round 17 and 18 of the REACT revealed that the high prevalence of SARS-CoV-2 infections continued in England during February 2022 with an ongoing replacement of the Omicron sublineages by BA.2 that demonstrates a transmission advantage for BA.2. They suggested that this high transmission advantage alongside the opening up of society as all domestic legal restrictions related to COVID-19 in England were lifted, could be behind the observed high rates of infection. This was supported by the findings of Elliott et al.[67] as part of the REACT-1 study in England. They observed a growth rate advantage for BA.2 compared to BA.1 or BA.1.1 in January 2022.

Italy

In Italy, Francesconi et al.,[70] suggested that BA.1 predominated while the other sub-lineages of Omicron (BA.2, BA.3, BA.4, and BA.5) were also detected. Their phylogenetic analysis suggested multiple independent viral introductions following national and international human mobility.

Denmark

Lyngse et al.[16] calculated the prevalence of Omicron variant strain in the population along with the relative prevalence of the subtypes of Omicron every week starting from December 1, 2021, continuing until January 11, 2022. As the weeks progressed the prevalence of Omicron variant increased from 3.51% to 97.61% with subtype variant BA.1 accounting for vast majority of the prevalence associated with the Omicron variant. Specifically, Espenhain et al.,[29] using data from COVID-19 routine Danish surveillance found the prevalence of Omicron variant to be 3.94% compared to 96.06% of Delt and other Delta variants November 22, 2021 – December 7, 2021 within the same cohort. Lyngse et al.[16] attempts to analyze the differences in the susceptibility and transmissibility of the BA.2 subvariant of Omicron compared to the BA.1 subvariant. The data on infection and vaccination status was obtained from the Danish Microbiology Database and the Danish Vaccination Register using registered positive cases between December 20, 2021 and January 11, 2022. The prevalence of the BA.1 subvariant was shown to be 75.16% while the prevalence of the BA.2 subvariant was shown to be 24.84%

Netherlands

Andeweg et al.[35] conducted a test-negative cohort study in the Netherlands. Data collected from November 22, 2021 to January 7, 2021 revealed that Delta variant was predominant over Omicron BA.1. However, during the period January 26, 2021 to March 31, 2022 the Omicron BA.2 variant was predominant over Omicron BA.1. No risk factors or comorbidities were mentioned as statistically associated with any of the tested variants. Eggink et al.[27] utilized a case-only approach, in which they compared the vaccine effectiveness and immune status of patients infected with the Delta or the Omicron variant in the Netherlands from November 22, 2021 to January 19, 2022. Out of 174, 349 individuals, 80615 cases were that of the Omicron variant, while 93,734 cases were of the Delta variant. Andeweg et al.[35] investigated the effectiveness of previous infection and COVID-19 vaccination against the Omicron BA.1 compared to Omicron BA.2 and Delta variants of SARS-CoV-2 in the Netherlands. Data collected throughout 22 November 2021 to 7 January 2022 compared Omicron BA.1 and Delta. The Delta variant was predominant over Omicron BA.1 in this cohort. Data collected throughout 26 January 2022 to 31 March 2022 compared Omicron BA.1 and Omicron BA.2. The Omicron BA.2 variant was predominant over Omicron BA.1 in this cohort.

South Africa

Wolter et al.[22] mainly focused on the comparison between the BA.1 and the BA.2 subvariants. Their testing period began on December 1, 2021 and ended on January 29, 2022 and found that the prevalence of the BA.1 subvariant was much higher than the prevalence of the BA.2 subvariant at 91.3% and 8.7%, respectively. Similarly, another study conducted by Wolter et al.[61] in South Africa between October 1, 2021 and April 26, 2022 revealed the predominance of the Omicron variant (98.2%) as compared to the Delta variant. In this study, the BA.4/BA.5 variants were reported; however, the BA.1 variant was still the predominant variant as compared to the BA.2 and BA.4/BA.5.

India

Zaman et al., reported the predominance of the Omicron BA.2 variant outcompeting the over BA.1 in January–February 2022 in North India.

Overall, the compiled results of the included studies revealed that BA.1 predominated at the beginning of the Omicron wave, which was followed by the predominance of BA.2. BA.4, and BA.5 started to appear later in some countries, but they never predominated in any country within the study time frame. Data were reported only for the USA and Brazil representing North and Latin America, respectively. Between January and March 2022, BA.1 predominated and BA.2 started to emerge in the USA.[77] However, BA.2 predominated from March to June 2022, while BA.4 and BA.5 started to appear.[62,78] In Brazil, BA.1 predominated between December 2021 to April 2022 while BA.2 started to appear.[64,79] Similarly, BA.1 predominated in South Africa over BA.2 and BA.5 started to appear between October 2021 and April 2022.[22,61]

The same pattern was observed in Europe where BA.1 was predominant by December 2021/January 2022[66,67] while BA.2 appeared then predominated later in 2022. Eales et al.,[66] and Elliot et al.,[68] reported different data in March 2022 as BA.1 or BA.2 (respectively) predominated. Francesconi et al.[70] reported similar ratios of BA.1 and BA.2 in Italy between December 2021 and June 2022 in addition to the emergence of the other subvariants of Omicron; BA.3, BA.4 and BA.5. Mattuzzi et al.[74] reported that BA.4 and BA.5 formed >50% of the subvariants during June-July 2022. In Denmark, both BA.1 and BA.2 were reported between December 2021 and January 2022 with BA.1 being predominant.[16]

BA.1 was 93.3% prevalent India in January 2022, which was replaced by BA.2 between January and February 2022. Hong Kong showed similar predominance of the BA.2 subvariant between December 2021 and March 2022.

Transmissibility and the predominance of the Omicron variant

Many of the included studies investigated the transmissibility of the Omicron variant as compared to the other variants of SARS-CoV-2. Lambrou et al.[47] suggested that a combination of viral and host population factors likely influences variant emergence and growth. Omicron's surge in prevalence could likely be linked to the increased transmissibility.[41,57]

Smallman-Raynor et al.[46] revealed substantial (7.6-fold) difference in the average rate of spatial growth, with the slowest being Delta AY.4.3 and the fastest Omicron BA.1. Spatial growth of the Omicron (B.1.1.529 and BA) variant was found to be 2.81 times faster than the Delta (B.1.617.2 and AY) and 3.76 times faster than the Alpha (B.1.1.7 and Q) variants, which may support the higher transmissibility of the Omicron as compared to the previous variants. Furthermore, Petros et al.[42] investigated the trajectory and dynamics of omicron infection in 3 highly vaccinated university populations in which prevalence of omicron increased from 0% to 91% within the length of the study, while Delta dropped from 100% to 9% within the same cohort. The researchers found that Omicron samples did not have lower Cts (greater viral loads) than Delta samples, implying that increased Omicron transmission is not driven by larger viral loads. Allen et al.[34] identified Omicron and Delta variant COVID-19 infections in England during December 5–11, 2021 and investigated the secondary attack rates and risk of transmission for the infections using contact tracing data. The investigation was applied to both household and non-household settings. The household setting cohort representing subjects with primary infections showed a greater prevalence of the Delta variant (77.8%) compared to the Omicron variant (22.2%). Similarly, the non-household setting cohort representing subjects with primary infections showed a greater prevalence of the Delta variant (60.7%) compared to the Omicron variant (39.3%). Following analysis of secondary infections and transmission in both household and non-household settings the study confirmed that transmission rates of the Omicron variant are greater compared to Delta. It is suggested that the increased risk of transmission of Omicron may explain its displacement of the Delta variant. Furthermore, the study attributed the rapid spread of Omicron to the decreased effectiveness of vaccination in reducing the transmission risk of the variant. Similarly, Jalali et al.[49] compared the secondary attack rate, in Delta and Omicron from December 2021 to January 2022, where the secondary attack rate was investigated in households using data from the Norwegian contact tracing system. The secondary attack rate was higher for Omicron (51%) than Delta (36%), and the relative risk (RR) was 1.41 (95% CI 1.27–1.56).

Why is Omicron highly transmissible?

The high transmissibility of Omicron could be attributed primarily to immunological escape.[26] This immune evasion may also reduce the effectiveness of monoclonal antibodies and vaccines.[37,88] However, preliminary research suggests that the relative severity of disease attributed to Omicron infections is lower than that resulting from infections with other SARS-CoV-2 variants. Cloete et al.[26] conducted a multicenter observational study in a single cohort from October 31, 2021, to December 11, 2021 to investigate the clinical outcomes and manifestations of patients aged 19 years or younger, hospitalized for any reason in the Tshwane district of South Africa. The increase in the number of positive cases was linked to the displacement of the Delta variant by the Omicron variant. There was a correlation of low vaccine effectiveness, less neutralization of antibodies and a high infection rate with the Omicron variant. In addition, this variant also has a short doubling time and a high tendency to evade the immune system. This coupled with the low availability of vaccines for children when the Omicron wave started, which may explain the spike in infections and hospitalizations among children. Suggested mechanisms by Cloete et al.[26] for transmission include higher virus shedding, increased environmental survival, ability to enter efficiently with a lower infectious dose, ability to evade immune responses, ability to infect a new subset of the population, change in tropism, or a combination of the above. Although most of the pediatric cases were incidental or moderate, the rapid increase in infected children suggests that hospitals need to be prepared for other highly infectious SARS-CoV-2 variants, as this population remains largely unvaccinated in other countries as well.

Evasion of immunity and the reduced severity of the Omicron variant

Sharma et al.[45] reported that Omicron spreads at a rate 70 times faster than the Delta variant. Because of mutations that promote transmission, immunological escape, and binding affinity, it can evade the immunity provided by vaccination as well as natural infection. Their results revealed that Omicron is highly transmissible and causes mostly asymptomatic to mild sickness in people who have been vaccinated, but severe disease in people who have comorbidities. Another finding revealed that a significant immune response was observed after omicron breakthrough infection against other variants. Persons infected with Omicron could neutralize not only the Omicron, but also other variants of concern, including the most common Delta variant, reducing the likelihood of reinfection and, as a result, replacing the Delta variant in the population.

It was reported that patients infected with the Delta variant of the SARS-Cov-2 virus had more severe symptoms than the patients infected with the Omicron variant.[89] Vieillard-Baron et al.,[19] for example, found that Omicron patients were 64% less likely to develop pneumonia than Delta patients. Ulloa et al.[18] also determined that the risk of hospitalization amongst Omicron patients was reduced by 65% (compared to Delta patients), and the risk of admission to the ICU (intensive care unit) or death was reduced by 83% (compared to Delta patients). Wolter et al.[61] reported that people infected with BA.4/BA.5 had a similar odds of hospitalization (aOR 1.24, 95% CI 0.98–1.55) and severe outcome (aOR 0.72, 95% CI 0.41–1.26) compared to BA.1 infected individuals. It was therefore concluded that BA.4/BA.5 have similar severity to the BA.1 variant, which was reported to be less severe than the Delta variant.

Omicron and the COVID-19 vaccines

Veneti et al.[20] reported that the increased transmissibility of Omicron and the reduced protective effect that vaccines have against it should be a cause of concern (in terms of hospitalization rates) despite its reduced severity – especially during large waves of infection. Overall, it was found that the vaccines administered for the SARS-Cov-2 virus were less effective against the Omicron variant of the virus when compared to the Delta variant. Chaguza et al.[39] reported that between December 12 and December 26, 2021, Omicron was the predominant variant over Delta for the overall cohort. The study found that, among unvaccinated individuals, Delta cases were predominant while Omicron was more predominant among individuals that received 2 doses less than 5 months, individuals that received 2 doses more than 5 months before the study, and individuals that received 3 doses before the study. This was attributed to the Omicron's ability to escape vaccine-induced immunity. Espenhain et al.[29] corroborated these findings, as only 14% of the Omicron cases were unvaccinated and 86% were at least partially vaccinated, whereas 44% of the Delta cases were unvaccinated and 56% were at least partially vaccinated. Interestingly, it was shown that the vaccine was less effective against the BA.2 subvariant than the BA.1 subvariants because the BA.2 subvariant was better at evading immune response either caused by the vaccine or previous infection.

Clinical trials have assessed the Vaccine Effectiveness (VE) of first-generation SARS-CoV-2 vaccines against the Omicron B.1.1.529 variant. In a test-negative case-control study of 134, 435 adults in Canada infected with either Delta or Omicron, findings demonstrated that in people who were fully vaccinated (with two doses of an mRNA vaccine, from either Moderna or Pfizer-BioNTech), the estimated effectiveness of the COIVD-19 vaccine was significantly lower in symptomatic Omicron infections as compared to Delta infections (Buchan et al., 2022).[88] Additionally, estimated VE against symptomatic Omicron infection experienced a steeper decline as compared to Delta 7–180 days after the second dose, amounting to just 61% 7 days after a third dose. First-generation vaccines have shown consistent patterns of rapid VE warning against Omicron infection. After receiving two doses of the Pfizer BioNTech (BNT162b2) in Hong Kong, patients' VE against BA.2 waned from 13% just 7 days after immunization to 7% after 100 days. After three doses, this number changed from 48% to 26%, and after four doses from 69% to 35% (Lau et al).[90] Additionally, the Omicron Variant demonstrated a breakthrough infection rate of 17.8% while the Delta variant had a rate of just 9.9% (Tang et al).[91]

Paul et al.[92] reported that the pre-Omicron mRNA vaccine boosters were reported to reestablish effectiveness, although to a lower extent against Omicron. Nonetheless, primary vaccination was shown to preserve strong protection against Omicron-associated hospitalization, severity, and death, even months after last dose. However, boosters provide more robust and longer-lasting protection against hospitalizations due to Omicron as compared to only primary series.

The CDC[93] has recently announced the availability of the updated COVID-19 boosters, which contain Omicron BA.4 and BA.5 spike protein components in addition to the current vaccine components. This will provide protection against the Omicron subvariants in addition to the older variant of SARS-CoV-2 which were reported with relatively high prevalence by several studies in various countries.

A clinical trial assessed the safety and immunogenicity of a new bivalent omicron-containing booster containing mRNA-1273.214 (containing ancestral Wuhan-Hu-1 and omicron B.1.1.529 (BA.1) spike messenger RNAs) compared to the existing mRNA-1273 booster. The new bivalent booster did not elicit any safety concerns and resulted in a stronger neutralizing antibody response against omicron compared to the existing vaccine (Chalkias et al).[94] Another new vaccine, UB-612, is designed to activate both B and T cell immunities UB-612 blocks virus entry into cells, eliminates infected cells, and ensures more rapid recall of memory cells upon reinfection or revaccination. The clinical trial demonstrated synergistic effect of activating both B and T cell immunities that induced a long-lasting neutralizing antibody response with a half-life of 187 days. UB-612's long-lasting response highlights its efficiency as a durable vaccine that can protect against the most recently circulating variants for longer time than standard vaccines (Wang et al).[95]

Study limitations

This study has several limitations. One limitation was the incomparable number of published studies in various

countries. While the USA and UK were extensively studied, some others, such as Australia, Canada, and others were only covered by one study each. Another limitation was the small sample size of the cohorts in some studies. Furthermore, it was hard to use the data reported by different studies for one country to create an overall picture about the time of emergence of the Omicron variant and when it peaked and how the early variants of SAR-CoV-2 were gradually partially or almost completely substituted by the Omicron variant. There are two reasons for this limitation; first is the wide time frame that was used by some studies, which made it very hard to monitor the time of transition. Secondly, some studies did not specify the exact region/city the study was conducted in. Therefore, it was not realistic to use the data reported by different studies to look at the progression of the variants relative prevalence as they may have been collected from different areas with different prevalence profiles.

Conclusion and recommendations

As mentioned in the limitations section, it was not easy to draw a clear picture about the relative prevalence of the Omicron variant as compared to Delta and the other variants of SARS-CoV-2 in the various countries and how the prevalence progressed over time. However, our compiled data show that in each of the 16 countries covered in this study (except for the Netherlands), Omicron was reported in one or more studies with a prevalence higher than 50%, which reached 100% in some countries. Omicron has a higher rate of transmission as compared to the other variants of SARS-CoV-2, which is responsible for its reported predominance by at least one study for each country. This transmissibility could be attributed to multiple reasons such as the ability of the Omicron variant to evade the host immune system, which made the COVID-19 vaccines less effective against its infections. Another reason is the reduced severity of the Omicron variant as compared to the Delta and the other variants. The BA.1 subvariant predominated over the BA.2 during the earlier stages of the Omicron wave while BA.2 took over the BA.2 as reported in some studies during the later stages. A few studies reported the detection of the BA.4 and BA.5 subvariants in the USA, Italy, and South Africa during the period October 2021 to May 2022. Although the predominance of the Omicron variant was reported by several studies in various countries, several other studies showed that the pre-Omicron variants have not completely disappeared. Furthermore, the highest reported relative prevalence values in some countries were not the most recently detected. This may indicate that the rates of infection with the other variants may have lately started to increase on the cost of the Omicron infections.

The spread of the Omicron variant and its sub-variants has been impacted by a complex interplay of factors, including travel restrictions, geographical locations, and politics. For example, many countries have implemented travel restrictions in an effort to slow the spread of the Omicron variant such as the requirements for quarantine, negative COVID-19 tests, or vaccine certificates for travelers. The spread of the Omicron variant has been influenced by geographical locations, with some areas being more heavily impacted than others. For example, the variant was first identified in South Africa and spread rapidly throughout the country, likely due in part to factors like population density and travel patterns. Similarly, some regions may be more susceptible to the spread of the virus due to factors like poor healthcare infrastructure or high rates of poverty. Political factors have also played a role in the spread of the Omicron variant. For example, in some countries, leaders may have been slow to implement measures like mask mandates or vaccination requirements due to political concerns or pressure from interest groups. Additionally, political tensions between countries can make it more difficult to coordinate an effective global response to the pandemic.

It is therefore important to develop vaccines that provide protection against Omicron as well as the early variants, which are known to cause more severe complications such as Delta. It was evident that some countries were under-represented in this review due to the lack of reporting studies. Furthermore, despite updating the search in December 2022, relevant data was only found up to March/April 2022 in many countries and only a few studies reported data within the period of May–July 2022. It is therefore essential to conduct more studies to update the relative prevalence data of the different variants of SARS-CoV-2 in various countries.

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Data sharing

The data that supports the findings of this study are available in the supplementary material of this article.

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