DOI: 10.4149/BLL_2021_086

Bratisl Med J 2021; 122 (8)
538 – 547

SYSTEMATIC REVIEW

Acceptance of a vaccine against COVID-19 – a systematic review of surveys conducted worldwide

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ABSTRACT

OBJECTIVES: The most promising strategy for managing COVID-19 pandemic is achieving sufficient vaccination rate worldwide. The question is how many people will be willing to get vaccinated.

STUDY DESIGN: We systematically reviewed peer-reviewed manuscripts monitoring people´s intention to receive a vaccine against COVID-19.

METHODS: Up to December 28, 2020 we identified 62 relevant peer-reviewed articles in PubMed, Web of Science, Scopus and GoogleScholar.

RESULTS: Total sample size was 118 855 respondents with overall average COVID-19 vaccine acceptance rate of 72.5% which is "just" the level estimated to be sufficient for reaching herd immunity threshold. Surprisingly, healthcare workers showed smaller interest in receiving the vaccine when compared to general adult population and university students. On the other hand, their attitude to vaccination did not change over time. In case of general adult population, the longer the pandemic lasts, the smaller proportion of population wants to get vaccinated. Vaccination intentions were independent of gross domestic product and human development index.

CONCLUSION: Willingness of population to receive COVID-19 is just at the herd immunity threshold and it is decreasing over time *(Tab. 2, Fig. 3, Ref. 110)*. Text in PDF *www.elis.sk*

KEY WORDS: vaccination, survey, COVID-19, pandemic, review.

Introduction

A lot of work has been done in the field of vaccination since 1796, when Edward Jenner performed the first internationally recognized vaccination. Most of the progress has been made especially in 20th and 21st century when scientific advances in microbiology and immunology enabled targeted vaccine development (1–3). Unfortunately, despite undisputable benefits of vaccination (4) conspiracy theories concerning vaccination have emerged and resulted in increasing vaccine hesitancy worldwide (5). Vaccine hesitancy is defined as delay in acceptance or refusal of vaccination despite availability of vaccination services (6). WHO (World Health Organization) enlisted vaccine hesitancy among top ten threats to global health in 2019 (7).

Vaccination rates against many vaccine-preventable diseases are considerably low in adults (8-10). For example, 50000–70000 adults die of vaccine-preventable diseases in United States of America every year (11). Several campaigns and initiatives such as ADVICE (Adult Vaccination Campaign in Europe) or Healthy People 2020 try to improve vaccination rates worldwide (12, 13). Official webpages of organizations such as WHO (World Health Organization) or CDC (Centers for Disease Control and Prevention) spend considerable room for explanation of benefits of vaccination (14, 15).

The topic of vaccination has gained enormous public interest during 2020 due to spread of COVID-19.

COVID-19 started in late 2019 in Wuhan, China and since then it spread worldwide. On 11.3.2020 WHO made the assessment that COVID-19 can be characterized as a pandemic (16). The infection primarily affects respiratory tract (17) ranging from asymptomatic course of the disease up to very severe health conditions requiring hospitalization at intensive care unit (18). COVID-19 may not only affect respiratory tract but may also result in hepatic, cardiac, renal, gastrointestinal, neurologic and musculoskeletal complications (19–26). The most effective long-term strategy for prevention of future outbreaks of the novel coronavirus is the development of a vaccine (27). During 2020 many pharmaceutical companies, universities and scientists all over the world attempted to create a safe and effective vaccine against COVID-19. In December 2020

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Acknowledgements: This work was supported by the grant project IGA_LF_2020_015 and by the European Regional Development Fund – Project ENOCH (No. CZ.02.1.01/0.0/0.0/16_019/0000868).

the U.S. Food and Drug Administration issued an emergency use authorization for the Pfizer-BioNTech COVID-19 vaccine and also for the Moderna COVID-19 vaccine (28). In late 2020 and early January 2021 many countries worldwide started to vaccinate their citizens, usually starting with healthcare professionals. The question is: What will be the acceptance rate of COVID-19 vaccine across global population?

Aim

The main aim of this work is to systematically search for studies covering the intentions of people to receive a vaccine against COVID-19 according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) statement (29). Only the studies that had undergone peer-review process will be assessed.

Methods

Searching for relevant articles

The search was conducted on December 28, 2020 in English. We searched for relevant articles in PubMed®, Web of Science and Scopus databases. The searching strategy was following: (covid*[Title/Abstract] OR corona*[Title/Abstract] OR SARS*[Title/Abstract]) AND vaccin*[Title/Abstract] AND (survey*[Title/Abstract] OR question*[Title/Abstract] OR opinion*[Title/Abstract] OR attit*[Title/Abstract]). The results were restricted to year range 2019–2020 (2021 respectively). Additional searching with aforementioned key words was also conducted in GoogleScholar.

Result synthesis

Results of searching from PubMed®, Web of Science and Scopus were exported in BibTex format and imported to Mendeley Desktop software. Duplicities were removed.

Eligibility criteria for inclusion of studies to this review

Eligibility of studies was assessed at two levels. Firstly, we went through a title and abstract of each article. Articles that were excluded at this level mainly covered biological experiments and e-learning topics. Also, the articles that obviously did not use any type of survey methods were excluded. In case of any hesitancy, particular manuscript was forwarded to the next level of assessment.

For the second level of assessment we acquired full-text version of all articles that passed the first level. Among these (detailed PRISMA Flow Diagram is shown in results) we looked for the ones covering the intentions of people to receive a vaccine against COVID-19 for themselves. The ones asking for example parents if they would have their children vaccinated against COVID-19 were excluded. Several articles assessed people´s willingness to pay for a COVID-19 vaccine. These articles were included in our work (marked as "wtp" note in Table 1). Also, the articles designed as discrete choice experiments and the ones giving irrelevant data on the acceptability of COVID-19 vaccine (mainly the ones showing just the correlations between COVID-19 vaccine acceptance and other factors and also the ones giving just the average of values on various Likert scales in absence of any supplementary data) were excluded.

In few cases the same data were published in more than one manuscript. In such case only one of these works was included in the analysis.

Only the articles that underwent full peer-review process were included in this work. Preprints that had not undergone peer-review process yet were excluded.

Anytime necessary we further searched for supplementary materials and appendices of particular manuscripts.

Analysis of articles included in this work

Each article that passed both levels of eligibility assessment was analysed and following information were extracted: country

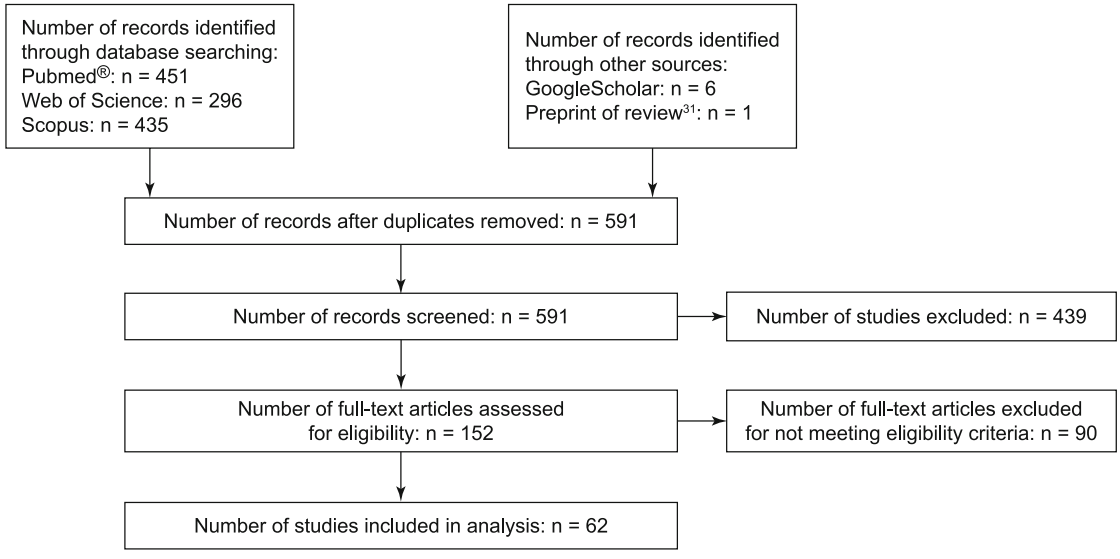

Fig. 1. PRISMA Flow Diagram.

Tab. 1. Summary of all 62 identified studies.

Note	Country	Time	Population	Number of respondents	Vaccine acceptance	Source
	Arabian Gulf Countries (Bahrain, Kuwait, Saudi Arabia, United Arab Emirates)	28.3.2020–4.4.2020	general adult	5677	72.0%	(56)
	Australia	2.3.2020–9.3.2020	general adult	2174	81.1%	(57)
A	Brazil	16.6.2020–20.6.2020	general adult	717	85.4%	(58)
	Canada	6.5.2020–19.5.2020	general adult	1902	80.0%	(59)
A	Canada	16.6.2020–20.6.2020	general adult	707	68.7%	(58)
	Congo	20.3.2020–30.4.2020	hcw	613	27.7%	(48)
B	Denmark	2.4.2020–15.4.2020	general adult	≈ 1000	80.0%	(60)
wtp	Ecuador	2.4.2020–7.4.2020	general adult	972	85.0%	(61)
A	Ecuador	16.6.2020–20.6.2020	general adult	741	71.9%	(58)
	Egypt	March 2020	general adult	559	88.6%	(62)
C	Finland	30.3.2020–12.4.2020	general adult	194	77.8%	(63)
C	Finland	3.4.2020–17.4.2020	general adult	1319	72.9%	(63)
C	Finland	May 2020	parents	780	73.9%	(63)
	France	26.3.2020–20.4.2020	general adult	3259	77.6%	(64)
	France	26.3.2020–2.7.2020	hcw	2047	76.9%	(65)
B	France	2.4.2020–15.4.2020	general adult	≈ 1000	62.0%	(60)
A	France	16.6.2020–20.6.2020	general adult	669	58.9%	(58)
	Germany	27.3.2020–11.4.2020	hcw	2827	91.1%	(66)
B	Germany	2.4.2020–15.4.2020	general adult	≈ 1000	70.0%	(60)
D	Germany	18.5.2020–2.8.2020	hcw	213	83.1%	(67)
D	Germany	18.5.2020–2.8.2020	university students	1457	84.8%	(67)
A	Germany	16.6.2020–20.6.2020	general adult	722	68.4%	(58)
	Greece	10.2.2020–25.2.2020	hcw	461	43.3%	(49)
	Greece	15.4.2020–2.5.2020	general adult	1811	81.1%	(68)
wtp	Chile	18.4.2020–5.5.2020	general adult	566	90.6%	(69)
	China	10.02.2020	university students	472	92.0%	(70)
	China	26.2.2020–31.3.2020	hcw (nurses)	806	40.0%	(50)
	China	16.3.2020–29.4.2020	hcw (nurses)	1205	63.0%	(71)
	China	March 2020	general adult	2058	91.3%	(72)
	China	1.5.2020–19.5.2020	general adult	3541	83.5%	(47)
A	China	16.6.2020–20.6.2020	general adult	712	88.6%	(58)
A	India	16.6.2020–20.6.2020	general adult	742	74.5%	(58)
	India	1.10.2020–31.10.2020	general adult	351	86.3%	(73)
	Indonesia	25.3.2020–6.4.2020	general adult	1359	93.2%	(74)
	Iran	25.2.2020–25.4.2020	general (above 10 years of age)	1480	73.2%	(75)
E	Israel	26.3.2020–8.4.2020?	hcw	549	71.5%	(76)
E	Israel	26.3.2020–8.4.2020?	general adult	1112	75.0%	(76)
	Italy	27.2.2020–8.3.2020	general adult	2223	70.4%	(77)
B	Italy (Lombardy)	2.4.2020–15.4.2020	general adult	≈ 500	79.0%	(60)
B	Italy (not Lombardy)	2.4.2020–15.4.2020	general adult	≈ 1000	74.0%	(60)
	Italy	April 2020	general adult	624	75.8%	(78)
	Italy	reopening after lockdown (May 2020)	general adult	1004	58.6%	(79)
	Italy	6.6.2020–20.6.2020	general adult	885	92.0%	(80)
A	Italy	16.6.2020–20.6.2020	general adult	736	70.8%	(58)
	Italy	N/A	university students	735	86.1%	(81)
	Italy	16.9.2020 -28.9.2020	general (above 15 years of age)	1055	53.7%	(82)
	Jordan	20.6.2020–25.7.2020	university students (medicine + dentistry)	483	81.6%	(83)
	Malaysia	3.4.2020–12.4.2020	general adult	1159	94.3%	(84)
	Malta	11.9.2020–16.9.2020	hcw	1002	52.0%	(51)
	Malta	16.9.2020–22.9.2020	university students + staff of faculties of medicine, dentistry and health sciences	852	44.2%	(85)

Note	Country	Time	Population	Number of respondents	Vaccine acceptance	Source
	Malta	25.9.2020–29.9.2020	hcw (general practitioneers and their trainees)	123	61.8%	(86)
F	Mexico	April–May 2020	general adult	700	73.7%	(87)
A	Mexico	16.6.2020–20.6.2020	general adult	699	76.2%	(58)
	Nepal	April–May 2020	hcw	230	94.3%	(88)
B	Netherlands	2.4.2020–15.4.2020	general adult	≈ 1000	73.0%	(60)
A	Nigeria	16.6.2020–20.6.2020	general adult	670	65.3%	(58)
	Nigeria	2nd–3rd week of lockdown	general adult	589	29.0%	(89)
A	Poland	16.6.2020–20.6.2020	general adult	666	56.3%	(58)
B	Portugal	2.4.2020–15.4.2020	general adult	≈ 1000	75.0%	(60)
A	Russia	16.6.2020–20.6.2020	general adult	680	54.8%	(58)
	Saudi Arabia	N/A	general adult	992	64.7%	(90)
A	Singapore	16.6.2020–20.6.2020	general adult	655	67.9%	(58)
A	South Africa	16.6.2020–20.6.2020	general adult	619	81.6%	(58)
A	South Korea	16.6.2020–20.6.2020	general adult	752	79.8%	(58)
F	Spain	April–May 2020	general adult	700	79.7%	(87)
A	Spain	16.6.2020–20.6.2020	general adult	748	74.4%	(58)
A	Sweden	16.6.2020–20.6.2020	general adult	650	65.2%	(58)
G	Turkey	May 2020	general adult	3936	66.0%	(91)
	Turkey	10.6.2020–10.7.2020	general adult	759	55.5%	(92)
	Turkey	17.9.2020–20.9.2020	hcw	1138	68.6%	(93)
	United Arab Emirates	4.7.2020–4.8.2020	general adult	1109	22.1%	(94)
	United Kingdom	1.4.2020–10.4.2020	older adults (mean 59.5 years of age)	527	85.6%	(95)
B	United Kingdom	2.4.2020–15.4.2020	general adult	≈ 1000	79.0%	(60)
	United Kingdom (England)	19.4.2020–11.5.2020	parents and guardians above 16 years of age	1252	90.1%	(96)
	United Kingdom (England)	4.5.2020–11.5.2020	general adult	2501	69.6%	(97)
F	United Kingdom	11.05.2020	general adult	1150	78.7%	(87)
G	United Kingdom	May 2020	general adult	1088	83.0%	(92)
A	United Kingdom	16.6.2020–20.6.2020	general adult	768	71.5%	(58)
	United Kingdom	14.7.2020–17.7.2020	general adult	1500	64.0%	(98)
	United Kingdom	24.9.2020–17.10.2020	general adult	5114	71.7%	(99)
	USA	13.4.2020–14.4.2020	general adult	845	85.8%	(100)
	USA	16.4.2020–20.4.2020	general adult	991	57.6%	(101)
	USA	April 2020	general adult	113	74.1%	(102)
	USA	April 2020	general adult	2233	75.5%	(103)
F	USA	April–May 2020	general adult	700	74.6%	(87)
	USA	4.5.2020–11.5.2020	general adult	3159	66.2%	(104)
	USA	6.5.2020–19.5.2020	general adult	1772	75.0%	(59)
	USA	May 2020	general adult	2006	69.0%	(105)
	USA	May 2020	general adult	672	67.0%	(52)
A	USA	16.6.2020–20.6.2020	general adult	773	75.4%	(58)
	USA	July 2020	general adult	788	59.9%	(106)
	USA	14.9.2020–27.9.2020	general adult	2730	61.4%	(107)
	USA	14.11.2020–17.11.2020	hcw (nursing home staff including administrative and other staff)	8243	69.2%	(108)
	USA	N/A	general adult (7 participants below 18 years of age)	316	68.6%	(109)
	USA	N/A	university students (medical students)	167	77.0%	(110)

wtp = the study assessed willingness to pay for a vaccine against COVID-19, A, B, C, D, E, F, G – studies monitoring COVID-19 vaccine acceptance in different countries with results published in one study, hcw = healthcare workers, N/A = not available

where the survey was conducted, time of the survey, population (mainly general adult population, healthcare workers and university students), sample size and percentage of people interested in receiving a vaccine against COVID-19.

The scales for assessment of COVID-19 vaccine acceptance differed across the articles. Some studies offered just dichotomous Yes/No choice forcing the respondents to take a clear stand whereas other used multi-point Likert scales with possibility of "I do not know" or "Neutral" answer. For purpose of this work we dichotomized the answers to vaccine acceptance group ("Yes", "Very likely", "Likely", "Leaning towards yes" and similar answers) and vaccine hesitant group ("No", "Definitely not", "Unlikely", "Leaning towards no" and similar answers and also "Neutral" and "I do not know" answers).

Statistical analysis

The relations between the willingness to take COVID-19 vaccine (% of acceptance) and several parameters were statistically analysed. The parameters that were correlated with COVID-19 vaccine acceptance rate encompassed number of cases per million and number of deaths per million at the time of conduction of particular survey, number of beds per thousand in particular country, duration of pandemic, GDP (gross domestic product) per capita and HDI (human development index). The correlations were evaluated by Spearman's correlation coefficient. The data were acquired at https://ourworldindata.org/ (30). We assessed all data all together and then healthcare workers (including healthcare students) and general population (including non-healthcare students) separately. The level of significance ($P < 0.05$) was used for all performed tests. The analysis included only articles from which complete data (all parameters) could be obtained. Statistically significant results are marked directly in Figure 3 by an asterisk (*). We used following scale: * $p < 0.05$, ** for $p < 0.01$, *** for $p < 0.001$ and **** for $p < 0.0001$. All calculations were performed with GraphPad Prism 8 software.

Results

PRISMA 2009 Flow Diagram

We identified 451 articles in PubMed®, 296 articles in Web of Science and 435 articles in Scopus database giving a total of 1182 manuscripts. After removing duplicities (Mendeley Desktop software) we received a total count of 584 articles. Additional searching revealed other 7 relevant articles (6 from GoogleScholar and 1 from other source (31)) giving a total of 591 manuscripts assessed for their eligibility. At the first level of eligibility assessment 439 articles were excluded. After full-text analysis (second level of eligibility assessment) another 90 articles were excluded resulting in a total of 62 manuscripts included in the analysis. PRISMA Flow Diagram is shown in Figure 1.

Identified studies

The surveys were conducted in 40 countries (most of the surveys were conducted in United States of America, United Kingdom, Italy, China and Germany). Total sample size was 118 855 respondents with overall average COVID-19 vaccine acceptance rate of 72.5 %. The overall average COVID-19 vaccine acceptance rate was calculated as a sum of multiples of number of respondents and acceptance rate in each study all divided by total number of respondents.

Summary of all 62 identified studies is shown in Table 1.

Figure 2 shows COVID-19 vaccine acceptance rates in particular countries. In case of more studies conducted in one country we calculated the overall average of COVID-19 vaccine acceptance rate reported by all studies in particular country.

The surveys were mostly conducted among general adult population. Several studies were conducted either among healthcare workers or among university students. Total sample sizes with overall average COVID-19 vaccine acceptance rates among these groups are shown in Table 2.

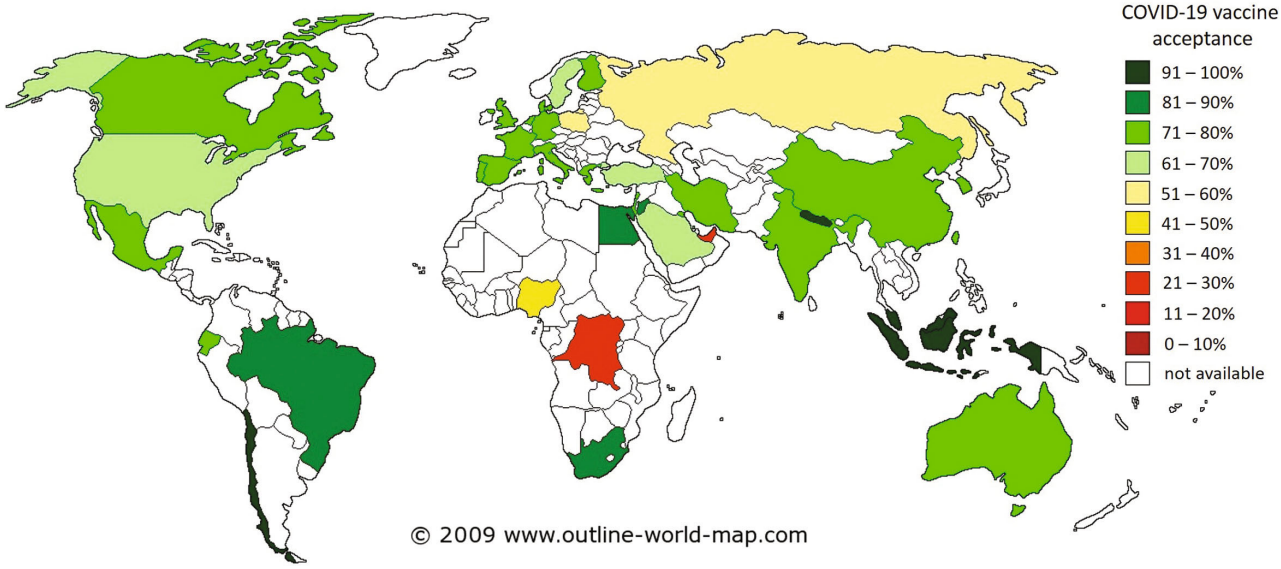

Fig. 2. COVID-19 vaccine acceptance rates worldwide.

Tab. 2. COVID-19 vaccine acceptance rates among general adult population, healthcare workers and university students.

	Total sample size	COVID-19 vaccine acceptance rate (overall average)
General adult population	95 232	73.0%
Healthcare workers	19 457	69.2%
University students	4 166	76.9%

Statistical analysis

All obtained correlation coefficients and corresponding p are shown in Figure 3. We found weak, but statistically significant negative correlation between number of cases per million, deaths per million, beds per thousand, duration of pandemic and acceptance of COVID-19 vaccine in total population. There was no significant relation between acceptance of COVID-19 vaccine and economic parameters (GDP per capita and HDI) of particular country.

When the data were assessed according to population surveyed (i.e. healthcare workers including healthcare students and general population), the results differed. We did not find any significant relation between acceptance of COVID-19 vaccine and all parameters in group of healthcare workers. In general population, Spearman´s coefficients showed similar trend as in total population but the correlation was slightly stronger. We found moderate negative correlation between acceptance of COVID-19 vaccine and number of cases per million and duration of pandemic. Moreover, there was weak negative correlation for vaccine acceptance and GDP per capita. On the contrary to total population, there was no significant relation between vaccine acceptance and number of beds per thousand.

Discussion

According to official WHO webpage until February 26, 2021 COVID-19 spread into 223 countries, infected 112 649 371 people and caused death of 2 501 229 people (32). The level of immune response after COVID-19 infection remains a question. For seasonal coronaviruses the immunity is short-lasting (33). In case of COVID-19 there is an emerging amount of case reports reporting re-infections (34–37). Some of the re-infections may present with milder course of the disease whereas other may develop to more severe health conditions (38). Moreover, there is no evidence that Swedish strategy in managing COVID-19 by attempting for herd immunity by not implementing strong restrictive regulations would be successful (39, 40). Thus, the main hope for managing COVID-19 pandemic is vaccination.

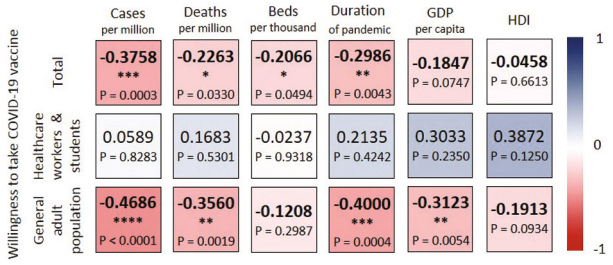

Fig. 3. Relations between acceptance of COVID-19 vaccine and following parameters: number of cases per million in time of conduction of surveys, number of deaths per million in time of conduction of surveys, number of beds per thousand in particular country, duration of pandemic, GDP per capita and HDI. The relations were evaluated by Spearman's correlation coefficient at level of significance p < 0.05. We evaluated all data all together (n = 89) and then healthcare workers (including healthcare students; n = 16) and general population (including non-healthcare students; n = 74) separately. Statistically significant results are marked by an asterisk (*). We used following scale: * p < 0.05, ** for p < 0.01, * for p < 0.001 and **** for p < 0.0001. The colour indicates the strength of correlation coefficient.**

If the proportion of the population that is immune (by vaccination or natural infection) exceeds certain level the incidence of the disease will start to decline. This is known as the "herd immunity threshold" and arises because a subset of the susceptible population benefits from "indirect protection" by the immunization of individuals that surround them (41). Vaccination programs help mankind to control the incidence of many infectious diseases based on two main principles: 1) directly through protection of an individual by building up the immune response and 2) indirectly by providing herd immunity for those who cannot be vaccinated. Many examples of indirect protection have been described (42).

In 2020 scientists, universities and pharmaceutical companies raced to develop an efficient and safe vaccine against COVID-19. At the end of 2020 and in early 2021 many countries started to vaccinate their citizens against COVID-19. Vaccination rate providing herd immunity in case of COVID-19 is estimated to be around 70 % (43, 44). In this review we covered COVID-19 vaccine acceptance rates reported in peer-reviewed manuscripts worldwide.

Surveys from 40 countries with a total sample size of 118 855 respondents were identified with overall average acceptance rate of 72.5 %. Most of the countries showed COVID-19 vaccine acceptance rate higher than 61 % (Fig. 2). However, several surprising and striking results were revealed.

In total population, our analysis showed that the intention to be vaccinated against COVID-19 decreased over time (negative correlation coefficient in case of duration of the pandemic). The longer the pandemic lasted (i.e. the later the survey was conducted), the smaller proportion of people was willing to be vaccinated. This phenomenon may also explain decreasing willingness to be vaccinated with increasing number of total cases and deaths per million (Fig. 3). In accordance with our analysis there are several reports showing similar trends (45–47). On the contrary to the parameters related to severity and duration of the pandemic, there was no correlation found between the intention to be vaccinated and degree of development of particular country (GDP per capita or HDI).

The COVID-19 vaccine acceptance rate was surprisingly lower in healthcare workers than in general adult population and students (Tab. 2). This result is affected by several studies carried out in Congo, Greece, Malta and China which showed COVID-19 vaccine acceptance far below 60 % (48–51). When potential relations between willingness to take COVID-19 vaccine and monitored parameters are evaluated separately in general adult population and healthcare workers (and students), there are several differences in the attitudes between these two groups. Although the acceptance of COVID-19 vaccine is lower in healthcare workers,

none of the factors correlated with COVID-19 vaccine acceptance rate affected their willingness to be vaccinated. On the contrary to healthcare workers, in the general adult population the obtained results showed similar trend as in total population but with slightly stronger correlation coefficients, i.e. willingness to get COVID-19 vaccine decreased over time. We also found a statistically significant negative correlation between acceptance of vaccine and GDP per capita in general adult population.

Several reviews of surveys monitoring people´s willingness to be vaccinated against COVID-19 have already been published either after full peer-review process or in the form of a preprint (52–55). However, to the best of our knowledge these studies either included in the analysis also non-peer-reviewed source of data or have identified considerably smaller number of peer-reviewed manuscripts.

If the interest of people to receive a COVID-19 vaccine follows current trend and decreases further, the vaccination rate may not achieve herd immunity threshold. This may result in necessity of implementation of legislative measures making COVID-19 vaccination compulsory in future.

Moreover, current vaccines may not protect against future mutations. Thus, ongoing surveillance of new mutations and prompt improvements (potentially requiring other emergency use authorizations) of the vaccines may be needed to manage the pandemic efficiently.

Conclusion

Vaccination is considered to be the most promising way of managing COVID-19 pandemic. The interest of people in being vaccinated against COVID-19 is "just" at the level of estimated herd immunity threshold. However, the willingness to be vaccinated is decreasing with increasing time of the pandemic. Surprisingly, interest of healthcare workers in receiving COVID-19 vaccine is smaller than in general adult population and students. On the contrary to general population, healthcare workers (and healthcare students) do not change their attitude to COVID-19 vaccine over time and their attitude to COVID-19 vaccine is not affected by any of the monitored parameters.

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Received February 27, 2021.
Accepted March 16, 2021.