Trends in COVID-19 Vaccine Intentions during the COVID-19 Pandemic; a Systematic Review and Meta-Analysis of Cross-Sectional Studies

Emily Terry (✉ elt724@student.bham.ac.uk)

University of Birmingham

Sapphire Cartledge

University of Birmingham

Dr Sarah Damery

University of Birmingham

Professor Sheila Greenfield

University of Birmingham

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Abstract

Background

A high COVID-19 vaccine uptake is essential to achieve herd immunity to combat the current strain of COVID-19 and potential future variants. This review aimed to identify factors associated with public intention to receive COVID-19 vaccines until February 2021 to provide accessible data to policymakers to inform framing and targeting of messages designed to optimise vaccine uptake.

Methods

Medline, Embase, CINAHL, PsycINFO, PsycARTICLES, Sociological Abstracts and Applied Social Sciences Index and Abstracts were searched for cross-sectional studies reporting data regarding COVID-19 vaccine intentions, published between 01/01/2020 and 12/02/2021. Title/abstract and full-text screening were performed independently by two authors. The Appraisal Tool for Cross-sectional Studies (AXIS) was used to assess bias and quality. Both random-effects meta-analysis and narrative synthesis were used to describe vaccine intentions and associated factors. A subgroup analysis assessing the impact of sex, sampling method and time of survey on COVID-19 vaccine intention was performed.

Results

Searches identified 4739 studies, and 23 cross-sectional studies were deemed eligible for the review; 22 used online surveys and one used a mixed-methods study design. Eighteen surveys were conducted in the first half of 2020 and five were conducted in the latter half of 2020. Fifteen countries were represented, with the most common being the United States (n=4) and the United Kingdom (n=4) sampling 41403 participants across all surveys. Most studies employed convenience sampling and 11 non-responder rates raised concerns over non-response bias. From the 18 studies included in the meta-analysis, the pooled proportion of survey participants willing to receive the COVID-19 vaccine was 73.3% (n=18, 95% Confidence Interval 64.2% to 81.5%, $I^2 = 99.7\%$). Factors associated with a higher COVID-19 vaccine acceptance included greater perceived risk of COVID-19, lower level of perceived vaccine harm, higher educational attainment and household income, older age, being of White ethnicity and male sex.

Conclusions

There was a high willingness to receive the COVID-19 vaccine which was influenced by multiple sociodemographic factors and individual risk perceptions. The findings suggest that future research should explore the reasoning behind vaccine intentions for different sociodemographic groups to allow targeted communication strategies to be formulated by public health agencies.

Background

Since coronavirus disease 2019 (COVID-19) was first identified in Wuhan, China in December 2019¹, there have been numerous coronavirus case surges around the globe². The development of effective COVID-19 vaccines has given hope to the global community, with the vaccine rollout marking a 'turning point' in the battle against coronavirus³.

Mass vaccination programmes aim to vaccinate a large proportion of the population so that disease transmission is slowed and vulnerable individuals who cannot be vaccinated are still protected⁴. This phenomenon is known as herd immunity and can only be achieved when a substantial proportion of the population is vaccinated⁵. The threshold to achieve herd immunity against COVID-19 is estimated at between 60–70%⁴. However, due to the viral nature of COVID-19, mutations are inevitable and the main 'Delta' variant in India has taken over as the dominant strain in many countries⁶. New variants may be more transmissible which will require a higher herd immunity threshold, and/or more likely to cause severe infection⁷. The situation is constantly evolving hence a high vaccine uptake is essential to combat the current dominant strain of COVID-19 and any potential future strains⁸.

Global public trust in governments has rapidly declined throughout the pandemic, with the Edelman Trust Barometer reporting a significant decline in trust between both the Chinese and American government and their own citizens between May 2020 and January 2021⁹. Together with the increasingly prominent role of social media, pandemics are a breeding ground for fearmongering and rumours to circulate¹⁰. Online misinformation circulating on social media regarding COVID-19 is a growing problem¹¹. In the case of COVID-19 (as in past pandemics), the dissemination of vaccine misinformation has been particularly prevalent in fuelling a growing anti-vaccination movement^{12,13}. A recent analysis of social media identified that 39% of online rumours regarding the COVID-19 pandemic were about the COVID-19 vaccine, with 76% of such rumours reported to be false¹⁴.

The term 'vaccine hesitancy' refers to a delayed acceptance or complete refusal of a vaccine¹⁵. The effects of vaccine hesitancy can be devastating. The diphtheria-tetanus-pertussis (DTP) vaccine was routinely used in the UK for over 20 years¹⁶. However, following the publication of case-series linking the vaccine to a rare neurological side-effect, there was a dramatic fall in immunisation rates against DTP from 77–33%^{16,17}. This was followed by three whooping-cough epidemics in the UK¹⁷. Therefore, historic evidence suggests that uncertain times can increase individual and societal vaccine hesitancy.

Many factors may contribute to vaccine hesitancy¹⁵. A systematic review of adults aged 65 years and older in the United States of America (USA) identified female sex, older age, higher education, higher household income and White ethnicity all increase the likelihood of seasonal influenza vaccination uptake¹⁸. It is currently unclear whether COVID-19 vaccine intentions are influenced by the same trend in socio-demographic factors. Public Health England (PHE) reported large disparities in mortality and morbidity risks of COVID-19 infection between different sociodemographic groups, with more deprived areas and ethnic minority individuals (particularly Black ethnic groups) shown to be at a higher risk¹⁹. Arguably, these groups would benefit the most from the COVID-19 vaccine.

Since the beginning of the COVID-19 pandemic, several systematic reviews have been conducted into COVID-19 vaccine uptake and adherence^{20–24}.

Lin et al. (December 2020) evaluated 126 cross-sectional surveys of vaccine intentions dating from February to October 2020²⁰. A narrative synthesis of results described a declining trend in vaccine intention and highlighted socioeconomic and ethnic issues pertaining to vaccine availability. Due to the dynamic nature of public opinion during the pandemic, the review recommends continuous monitoring of vaccine intentions, especially following the introduction of mass-vaccination programmes.

Robinson et al. (December 2020) published a smaller review of 28 international cross-sectional studies and survey dates ranged from March–October²¹. The review reported a high rate of vaccine intention across survey participants (72.9% of total participants were prepared to have a COVID-19 vaccine, 95% confidence interval (CI) 66.6–78.4%, $I^2 = 99.6\%$) and found a declining trend in vaccine willingness over time. It searched only two online databases and only one author conducted all stages of screening and data extraction. Limited database searching can introduce selection bias²⁵ and the absence of conventional double screening can result in the omission of key studies²⁶. This review included surveys with a large sample size only ($n \geq 100$)²⁴, compared to Lin et al.’s review which included surveys with smaller sample sizes²³. Overall, the review conducted by Robinson et al. provides a systematic summary of the global populations’ acceptance towards the COVID-19 vaccine up until October 2020²¹.

Given the rapidly evolving course of the pandemic, ongoing research is needed to reflect the changing evidence base and summarise public opinion later in the pandemic. Therefore, this systematic review will provide an updated summary of public opinion towards the COVID-19 vaccine around the globe up until February 2021, with the intention of providing readily accessible data to policymakers.

Aims

This review aimed to assess: (1) general population intention to receive the COVID-19 vaccine around the world up until February 2021 and changes over time; (2) factors associated with COVID-19 vaccine acceptance; (3) reasons behind individuals’ vaccination intention.

Methods

Eligibility Criteria

As recommended by the Cochrane Collaboration, the research question and eligibility criteria were framed using the SPIDER search tool, to maintain a focused review (Table 1)²⁷.

Table 1
Eligibility criteria for the research question

SPIDER	EXPLANATION
Sample	Adults from the general population. Studies were excluded if limited to healthcare professionals and medical students only as this would have restricted the generalisability of the review findings to the general population.
Phenomenon of Interest	Beliefs about the COVID-19 vaccine including, but not limited to, vaccine hesitancy or acceptance, factors influencing acceptance and reasoning behind vaccine intentions.
Design	Cross-sectional studies based on survey data.
Evaluation	Surveys must have reported some metric relating to COVID-19 vaccine intentions and/or respective determinants and/or reasoning. This includes any type of COVID-19 vaccine. This must have been presented as extractable raw data. Where sociodemographic factors were reported, data on these were extracted for analysis. Studies must have detailed the specific survey questions used to assess attitudes, to allow for appropriate analysis.
Research Type	Studies published in peer-reviewed journals were eligible for inclusion. Unpublished journal articles were not included due to the low quality of data they were likely to provide, affecting the validity of the analysis and discussion. Grey literature was not included, as due to the high level of misinformation surrounding the subject of COVID-19, it would have been inappropriate to include this datatype in the evidence base of the systematic review. This did not limit the generalisability of the literature search, as the initial scoping searches retrieved 19 cross-sectional studies, published in peer-reviewed journals. Editorials, reviews, or commentaries were excluded. Dissertations and theses were not considered as there would have been no literature available in this evidence area due to the recent emergence of COVID-19.

Search Methods

This review was developed and structured in line with the 2020 Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines²⁸.

Information Sources

A literature search of Medline (Ovid)²⁹, Embase (Ovid)³⁰ and CINAHL (EBSCO)³¹ was undertaken by one author (ET). Specialist social sciences databases were also searched: APA PsycINFO (Ovid)³², APA PsycARTICLES (Ovid)³³, Sociological Abstracts (ProQuest)³⁴ and Applied Social Sciences Index and

Search Strategy

Search strategy development was guided by a librarian specialist. Several scoping searches were conducted on Medline²⁹ and Embase³⁰ to identify relevant literature and understand any differences in standardised subject terms across the databases. Development of search terms were guided by the results of the scoping review. The search strategy was subsequently piloted using Medline²⁹ and refined until all key papers identified in the scoping review were retrieved from the first 100 search results. A combination of text words and standardised subject terms were used, adjusted for each database, to avoid missing key literature.

For the purpose of this review, studies investigating vaccine intentions were included, with vaccine hesitancy defined as “a delay in acceptance or refusal of vaccination despite availability of vaccination services”³⁶ and vaccine acceptance defined as “outcome behaviour resulting from a complex decision-making process that can be potentially influenced by a wide range of factors”³⁶. We searched explicitly for papers that included data on these terms, using the search terms ‘COVID-19’, ‘Pandemics’, ‘Intention’, ‘Attitude to Health’, ‘Mass Vaccination’, ‘Vaccination Refusal’, ‘Anti-Vaccination Movement’ and ‘Vaccination’. Search terms were combined with the Boolean operators ‘AND’ or ‘OR’, the explosion function was used where possible, and truncation was utilised to capture all alternative spellings of the terms. Searches were conducted on 12/02/2021.

Limits

Date of publication was limited from 1st January 2020 to the day the search was undertaken. The study-type was limited to cross-sectional studies. No geographical limits were applied, but only studies published in English were eligible.

Data Management

Endnote was used to store references and remove duplicates automatically³⁷. The web-based reviewing platform Rayann was used for title/abstract and full-text screening³⁸.

Selection Process

Title and abstract screening were performed independently by two authors (ET and SC), who both performed full-text assessment of potentially eligible studies (Table 1). All discrepancies in inclusion/exclusion decisions at both stages of screening were discussed by ET and SC over the online video platform Zoom initially and with SD as a third reviewer when a decision could not be made³⁹. As screening was undertaken by two novice reviewers, inter-rater reliability was measured using Cohen’s Kappa coefficient at both stages, with a Kappa value of > 0.6 deemed to represent substantial agreement⁴⁰.

Data Extraction and Synthesis

Data Collection Process

A data extraction form (Additional File 4) was developed and piloted prior to use. Data were extracted by ET and a random sample of 10% of studies was co-assessed by SD, to minimise data extraction errors. Any differences of opinions were discussed, to ensure that all relevant data were extracted. For each study, study characteristics were extracted including study design, sample size, location, survey timescale, method of recruitment, participant demographics, validation and standardisation of the survey instruments, the specific survey questions used to capture attitudes towards the COVID-19 vaccine, response scales, recorded proportions of vaccine intentions and any other relevant information.

Risk of Bias and Quality Assessment

Study quality and risk of bias were assessed using the Appraisal Tool for Cross-Sectional Studies (AXIS) (Additional File 5)⁴¹ which was piloted for suitability on two studies. ET assessed all studies, with 10% co-assessed independently by a second author (SC). Again, Cohen’s Kappa coefficient was calculated to test inter-rater reliability.

Data Synthesis

Data were summarised using narrative syntheses and meta-analyses as appropriate. Where response proportions were represented as raw numbers, data were converted to percentages of total survey participants in each included study.

All studies were assessed to determine whether it was appropriate to statistically combine the survey findings. Guided by Lin et al., surveys were excluded from analysis if questions included persuasive or influencing language; if they included phrases similar to ‘if a safe and effective vaccine was available’²⁰. The remaining surveys were included in a random-effects meta-analysis using the ‘metaprop’ command⁴², to estimate the proportion of total survey participants reporting vaccine acceptance (including 95% confidence intervals). For studies that included a 5-point Likert scale, vaccine acceptance represented the proportions of both ‘strongly agree’ and ‘agree’ responses. Percentage proportions were presented using forest plots, including statistical heterogeneity. Substantial heterogeneity ($I^2 > 85\%$) was expected due to the nature of the survey outcome; an individual’s decision on vaccine uptake may be influenced by multiple and potentially overlapping factors simultaneously. Publication bias was not assessed; instead, sub-group analyses of the meta-regression by sample size ($n < 1,000$ vs $n \geq 1,000$) and sampling method (non-probability vs probability sampling) were performed.

Across studies that included four response categories (variations of ‘strongly agree’, ‘agree’, ‘disagree’ and ‘strongly disagree’), the mean proportion of responses in each category were compared. Across studies that included a hesitant response category (variations of ‘maybe’), the overall proportion of survey participants reporting COVID-19 vaccine hesitant and improbable/very improbable were compared.

For all studies, the influence of health beliefs and sociodemographic variables (age, gender, ethnicity, education, and income level) on vaccine acceptance, and reasons for vaccine hesitancy were summarised narratively. Of the studies included in the meta-regression, further sub-group analyses of participants reporting vaccine acceptance by gender and time of survey were performed on studies that reported the relevant data.

Statistical significance for all analyses was set at the 5% level ($p = 0.05$) and all statistical analyses were conducted using STATA16⁴².

Results

Study Selection

The literature search returned 5447 studies and following removal of duplicates, 4739 studies were considered for title and abstract screening. Following title and abstract screening, 55 full-text articles were assessed for eligibility. Of these, 23 studies met the inclusion criteria and were deemed eligible for the review^{43–65}. Reasons for exclusion at full-text screening included a lack of specific focus on the COVID-19 vaccine and the absence of extractable raw data (Fig. 1). Cohen's Kappa was 0.7 at title and abstract screening and 0.8 at full-text screening.

Summary of Included Studies

All studies had a cross-sectional study design: 22 used online surveys^{43–46, 48–65} and one study used a mixed-methods approach, including both an online survey and semi-structured interviews⁴⁷. Eighteen surveys were conducted in the first half of 2020 (January–June)^{43–46, 48–53, 55–58, 62–65} and five were conducted in the latter half of 2020 (July–December)^{45, 54, 59–61}. Fifteen countries were represented in the review, the commonest being the USA ($n = 4$)^{50, 54, 58, 59} and the UK ($n = 4$)^{47, 56, 61, 63}. In total, 41,403 participants were sampled across all surveys, with sample sizes ranging from 525⁵⁴ to 5677⁴⁴ participants. The majority of participants were aged between 25–50 years old, and all surveys reported a higher proportion of female participants with one exception⁵⁴. Ethnicity data were only reported in nine studies^{47, 50, 54, 56–59, 61, 64}, with Black, Asian and Minority Ethnic (BAME) representation ranging from 3.6%⁶⁴ to 36.7%⁵⁰ (Additional File 1).

Survey questions used to assess vaccination intentions could largely be categorised into two; 18 studies used neutral questions such as 'Will you get the coronavirus vaccine when available?'^{43, 46–50, 52–55, 57, 58, 60–64}; five studies used persuasive language that may have potentially influenced self-reported vaccine acceptance, for example 'If a new vaccine for COVID-19 was released that was proven to be safe and effective, I would get vaccinated immediately'^{44, 45, 56, 59, 65}. Fifteen studies recorded responses using a Likert-scale, adopting variations of the terms 'Strongly Agree to Disagree'^{43–45, 47, 49, 53, 55, 58, 59, 61–65}, seven studies utilised a simple 'Yes', 'No' and/or 'Maybe' response scale^{46, 48, 50–52, 56, 57, 60} and one study used a best-fit statement response⁵⁴ (Additional File 2).

Quality Assessment and Risk of Bias

Of the 23 studies included in the review, 17 studies used piloted, trialled or previously published survey instruments (Additional File 3)^{43, 44, 47, 48, 50–61, 64, 65}. Only 11 studies used an adequate sampling frame to achieve a representative sample^{45, 46, 50, 51, 54–56, 58, 59, 61, 62} and 10 studies were deemed to use an adequate selection process^{47, 50, 51, 54–57, 59, 61, 62}. Of the studies that used adequate sampling frames, eight used existing online research panels^{46, 50, 54, 56, 58, 59, 61, 62} (two most common being Qualtrics, $n = 2$ ^{54, 56} and the AmeriSpeak panel, $n = 2$ ^{50, 59}). Sixteen studies did not categorise non-responder rates^{43, 45, 47–49, 51, 52, 54, 56, 58, 60–64} and 11 non-responder rates raised concerns over non-response bias^{44–46, 49, 53, 55, 59, 60, 62, 63, 65}. Non-responder bias could not be determined for six studies due to lack of adequate information^{43, 48, 52, 56, 61, 62}.

Vaccine Intentions

Five studies were removed from the meta-analysis due to the use of persuasive questions to assess vaccine intentions^{44, 45, 56, 59, 65}. From the 18 studies included in the meta-analysis, the pooled proportion of survey participants willing to receive the COVID-19 vaccine was 73.3% ($n = 18$, 95%CI 64.2–81.5%, $I^2 = 99.7\%$, $p = 0.00$ Fig. 2)^{43, 46–50, 52–55, 57, 58, 60–64}. Only two studies included in the meta-analysis reported a higher proportion of participants unwilling to receive the vaccine (71.3% in Sallam et al.⁶⁰ and 51.9% in Mouchtouri et al.)⁵⁵

Across the 10 studies that included four response categories (variations of 'strongly agree', 'agree', 'disagree' and 'strongly disagree'), individuals were more confident in accepting the vaccine than rejecting the vaccine^{43–45, 47, 49, 53, 55, 58, 63, 64}. A mean proportion of 51.3% participants were definitely willing, compared to only 30.7% participants possibly willing to receive the COVID-19 vaccine. Contrastingly, a higher proportion of participants reported improbable rather than very improbable intentions to receive the COVID-19 vaccine, a mean proportion of 6.0% and 4.9% respectively.

Across the 15 studies that included a hesitant response choice (variations of 'maybe'), participants were more likely to be vaccine hesitant than either improbable/very improbable, with a mean proportion of 22.2% and 9.4% respectively^{43–45, 49, 50, 55–59, 61, 63–65}.

Factors Associated with Vaccine Intentions

1. Health Beliefs

A lower perceived individual risk and perceived severity of COVID-19, lower levels of worry regarding the pandemic and lower perceived likelihood of becoming infected with COVID-19 were all found to be major variables reducing vaccine acceptance in all eight studies investigating these factors^{46, 49, 53, 57, 58, 62, 64, 65}. One survey reported that personal fear about COVID-19 meant the individual was almost 2.5 times significantly more likely to accept the vaccine (Odds Ratio (OR) 2.5, 95%CI 2.0–3.0, $p < 0.001$) compared to individuals with no fear⁴⁹. Additionally, positive attitudes towards past influenza vaccines significantly increased

the likelihood of COVID-19 vaccine acceptance^{46,50,61}. Higher levels of perceived vaccine harm, concerns about side-effects and vaccine efficacy significantly contributed to a reduced vaccine acceptance in four out of four studies^{53,58,61,64}. One survey reported a significant increase in the likelihood of vaccine acceptances if individuals perceived the vaccine to reduce the risk of COVID-19 infection (OR 3.1, 95%CI 2.1 to 4.8, $p < 0.001$)⁵³.

1. Sociodemographic Variables

Sex

Males were significantly more willing to receive the COVID-19 vaccine than females in all seven studies investigating this variable^{46,50,53,58,60,62,64}. One survey reported that males were almost twice as likely as females to receive the COVID-19 vaccine (OR 1.9, 95%CI 1.5–2.3, $p < 0.001$)⁴⁹. A subgroup analysis by gender across the seven studies reporting gender proportions revealed a similar trend; the pooled proportion willing to vaccinate for males was 71.9% (95%CI 59.4–83.0%) and 58.0% (95%CI 37.1–77.4%) for females, but this was not statistically significant ($p = 0.247$, Fig. 3)^{46,50,53,58,60,62,64}. Similarly, females were consistently recorded as more likely to be vaccine hesitant than their male counterparts^{45,46,56} with an Australian survey recording females as almost twice as likely to be vaccine hesitant than males (Relative Risk Ratio (RRR) = 2.0, 95%CI 1.5 to 2.6, $p < 0.001$)⁴⁶.

Ethnicity

BAME individuals reported lower vaccination intentions than White individuals in all four studies that assessed acceptance by ethnicity^{47,50,56,58}. Specifically, individuals of Black ethnicity were reported to be less accepting than White ethnic individuals in both studies investigating specific ethnicities^{50,58} and less accepting than both Hispanic and White ethnic individuals in one survey⁵⁸. One study reported Black individuals to be up to 6.4 times more likely to be either hesitant or resistant (RRR 6.4, 95%CI 3.2 to 13.0, no p -value reported) than their White counterparts⁵⁰.

Household Income

Individuals with a lower household income were significantly less willing to receive the vaccine in three out of four studies^{47,54,58}. One study reported that lower income households were over two times more likely to reject the vaccine than higher income households (OR 2.1, 95%CI 1.3–3.3, $p < 0.001$)⁴⁷. However, one survey appeared to contradict this trend, suggesting that individuals in the lowest income band were significantly more likely to express vaccine hesitancy than rejection compared to individuals in higher income brackets⁵⁶.

Educational Attainment

In all three studies investigating education, lower education was associated with lower vaccine acceptance^{45,50,60}. In one study, the risk of individuals with no high school diploma rejecting and/or hesitating over the vaccine was almost eight times higher than those with a diploma or higher (RRR 7.8, 95%CI 3.1 to 19.6, no p -value reported)⁵⁰.

Age

Four out of seven studies reported younger individuals to be less vaccine willing^{49,54,61,62}. However, there were substantial variations in the age groupings used by included studies. Two studies reported individuals aged < 30 years⁴⁹ and < 35 years old⁶² to be the least willing age group to receive the vaccine (OR 1.5, 95%CI 1.3–1.9, $p < 0.001$ and OR 1.2, 95%CI 1.1–1.5, $p < 0.001$ respectively). One study opposed this trend, reporting individuals aged 35–44 years as most likely to reject (OR 3.3, 95%CI 1.2–9.5, $p < 0.05$)⁵⁶. Another conflicting study drew conclusions from proportions alone, suggesting individuals aged < 35 years old were more vaccine willing than those in older age groups⁴⁴.

1. Time of Survey

Across the 11 studies adopting a large sample size ($n \geq 1,000$), the proportion reporting vaccine acceptance reduced significantly over time^{46,47,49,52,53,55,58,60,61,62,64}. The nine surveys conducted between March-June had a pooled mean proportion of 76.8% survey participants reporting vaccine acceptance ($n = 9$, 95%CI 68.5–84.1%, $p = 0.0$)^{46,47,49,52,53,55,58,62,64} compared to 39.1% survey participants reporting vaccine acceptance ($n = 2$, 95%CI 39.1–40.5%, $p = 0.0$) across the two studies conducted between July-December (Fig. 4)^{60,61}. Smaller studies ($n < 1,000$) were more likely to increase the heterogeneity of the results, so following the example of Robinson et al.²⁴, the authors chose to restrict the subgroup analysis to larger studies which may have had more robust estimates of vaccine acceptance.

1. Sampling Type

A subgroup analysis assessing study methodology used for recruitment reveals that survey participants recruited via probability sampling^{50,54,55,60,62} were significantly less willing to receive the COVID-19 vaccine than survey participants recruited via non-probability sampling^{43,46–49,52,53,57,58,61,63–65} ($p = 0.029$, Fig.5), 55.6% (95%CI 34.0–76.1%) compared to 79.3% (95%CI 73.0–85.1%) respectively.

Reasons for Vaccine Hesitancy

Concern over vaccine safety was the most common reason reported for both vaccine hesitancy and rejection cited in all six studies investigating vaccine reasoning^{47,50,53,54,58,63}. Three studies explicitly stated that fears of potential side-effects were the main cause for concern^{53,54,58}. Other reasons include concern over vaccine efficacy^{53,58}, speed of vaccine production and lack of evidence^{47,62}, a lack of trust in both scientific and governmental bodies⁶⁵, and

general anti-vaccination attitudes^{47,62}. For all studies investigating reasons for vaccine willingness, the main justification for vaccine acceptance was for the protection of both the individual and others^{47,53,63}.

Discussion

Comparison to Existing Literature

Guidance on how to achieve high vaccine uptake could be based on existing evidence regarding uptake of previous vaccines and specific research on COVID-19 vaccine intention. This systematic review investigated intentions to receive the COVID-19 vaccination across the global population and the relevant influencing factors, as reported in eligible international cross-sectional studies published between March and December 2020. A total of 4739 journal articles were screened and 23 cross-sectional surveys were selected for inclusion in the review^{43–65}. Twenty-one out of the twenty-three studies reported high intentions to receive the vaccine across survey participants^{43–54,56–59,61–65}, with a significant trend towards a declining willingness to vaccinate over time; concordant with the findings of existing reviews investigating COVID-19 vaccine willingness^{20–24}. Consistent with similar reviews, the main reasons behind COVID-19 vaccine acceptance reported in this review are for the protection of oneself and others, suggesting that receiving the vaccine is regarded as a social responsibility^{20–24}.

Compared to self-reported acceptance to receive past-vaccines, the rate of COVID-19 vaccine acceptance was generally higher^{68–70}. It is important to note the significant effect of sampling bias on self-reported vaccine acceptance in surveys included in the review. The inclusion of cross-sectional studies that used non-probability recruitment methods may have further limited the generalisability of the review findings to the general population.

Risk perception is a well-established determinant in vaccine decision-making^{71,72}. This pattern of behaviour is reported as being no different for the COVID-19 vaccine and can be explained by the Health Belief Model; individuals are more likely to engage in health-protective behaviours if they perceive themselves to be at a higher risk from the disease in question^{73,74}. The high level of uncertainty towards the threat of COVID-19 and rapid rate of transmission of the virus substantially increased individuals' perceived risk of ill-health and state of anxiety during the pandemic, motivating individuals to perform health-protective behaviours^{75–77}.

This review confirms the majority of findings reflected in existing literature investigating the sociodemographic trends in COVID-19 vaccine acceptance with higher educational attainment and household income, older age and being of White ethnicity to be associated with a higher acceptance^{20–24}. Furthermore, this pattern is consistent with literature investigating attitudes towards past-vaccines^{78–81}. Literature investigating past-vaccines consistently reports that females are likely to express higher vaccine acceptance in general compared to males^{82,83}. However, the findings of this review investigating attitudes towards the COVID-19 vaccine report the opposite. Research has suggested that females are more likely to lower their intention to vaccinate following exposure to vaccine misinformation than males. The widespread conspiracy that the COVID-19 vaccine causes infertility may have contributed to this significant difference^{84,85}. This same misconception posed an obstacle to uptake of the Polio vaccine in Nigeria, India and Pakistan⁸⁶. Females are more likely to express greater levels of concern towards their personal health than males which could explain why females are more inclined to believe COVID-19 vaccine conspiracies⁸⁷. Social media is reported to be the main source of vaccine misinformation⁸⁸. The narrative of social media is rapidly changing, suggesting that the influence of social media on vaccine intentions is subject to change. The findings of this review are supported by two recent systematic reviews conducted in 2021^{22,23}. Interestingly, Lin et al.'s narrative review reported inconsistent findings towards the influence of sex on COVID-19 vaccine acceptance²⁰. Similarly, Robinson et al. stated that whilst seven out of fourteen studies reported that females have significantly lower COVID-19 vaccine intentions than males, five studies reported no significant association between COVID-19 vaccine acceptance and sex²¹.

Further Research

This review has contributed to the literature in providing the most recent representation of the public's views towards the COVID-19 vaccine around the globe. The findings of this review suggest that global policymakers cannot rely on the findings of existing literature about past-vaccines to formulate public health campaigns regarding COVID-19 vaccine uptake. Despite similar social pressures and the influence of risk perception on the uptake of both existing vaccines and the COVID-19 vaccine, there are several sociodemographic aspects specific to the COVID-19 vaccine that need to be considered and further researched, particularly in terms of sex and age. Public attitudes towards the COVID-19 vaccine around the globe need to be continuously explored as there appears to be evidence that attitudes can change rapidly, for example, the influence of social media on differences in vaccine acceptance between males and females. Consequently, we cannot rely solely on existing findings of past-vaccines and early COVID-19 vaccine research to guide government advice.

Both the UK and USA government are planning for a booster vaccine programme, as the duration of protection provided by the vaccine is currently unknown^{89,90}. There are currently no surveys investigating intentions and motivation to receive a booster vaccination. This must be investigated and closely monitored by public health officials to guarantee the success of the vaccine and achieve herd immunity.

Translation into Practice

Following the subsequent roll-out of mass-vaccination programmes across the globe, uptake of the COVID-19 vaccine has been higher than anticipated. As of August 2021, Israel has successfully vaccinated over 70% of all adults over the age of 16⁹¹ and the UK has almost achieved 80% of all adults over the age of 16 double vaccinated⁹². The literature suggests there are considerable discrepancies between decision-making in real-life and hypothetical situations, with individuals more likely to focus on the outcome of decisions in real-life situations⁹³. As evidenced in this review, a major reason behind an individual's intention to receive the COVID-19 vaccine may be the protection of others as well as themselves. This suggests that receiving the vaccine may be seen as a

social responsibility⁹⁴. The UK no longer recommends the use of AstraZeneca in under-40s with no underlying health conditions following reports that the AstraZeneca vaccine may have a higher risk of blood clots than other vaccines^{95–97}. However, this association was later disproved following a review by the European Medicines Agency⁹⁸. Nevertheless, the Pfizer vaccine is the only vaccine authorised for young adults aged 12–17 years old in the UK⁹⁹ and numerous European countries have stopped administering the AstraZeneca vaccine across all age-groups¹⁰⁰. It is important to acknowledge the political implications that Brexit may have had on the decision of the European Union to discontinue the use of AstraZeneca, a UK-made vaccine^{101,102}. This decision may have fuelled vaccine hesitancy, with several European polls reporting a substantial drop in perceived vaccine safety following the AstraZeneca blood clot scares¹⁰¹. Following the development of several licenced vaccines, vaccine acceptability and personal risk perceptions may be further affected by the type of vaccine offered to individuals. Thus, the reporting of vaccine risk assessments must be carefully navigated and the prevention of vaccine misinformation across social media is imperative if a high vaccine uptake is to be achieved across the globe.

This review has identified sub-groups of the population that are at a higher risk of vaccine hesitancy and low vaccine uptake. There is therefore a continued risk of pockets of local outbreaks across sub-groups of the population despite the vaccine now being available¹⁰³. The findings of this review can guide local policy-makers towards the close monitoring of vaccine uptake amongst sub-groups of the population at risk of vaccine hesitancy, now vaccines are available. This review has highlighted the dangerous impact that vaccine misinformation can have on vaccine hesitancy, and thus can be used by local policy-makers to control the spread of COVID-19 misinformation on social media, focusing particularly on debunking COVID-19 vaccine myths targeted towards individuals at a higher risk of vaccine hesitancy. This review contributes to the growing evidence base suggesting that males are more likely to receive the COVID-19 vaccine than females^{22,23}, opposing the trend in past-vaccine hesitancy across the sexes reported in existing literature^{82,83}.

Strengths and Limitations

This systematic review has several strengths. Multiple databases were searched and there was a high level of agreement between screeners. Thorough quality and risk of bias assessments were also undertaken using validated tools that were piloted before use. However, searches were limited to English language studies and grey literature was explicitly excluded to ensure a manageable volume of literature was retrieved. This may have led to the exclusion of relevant literature. It is important to acknowledge the fast-moving nature of the COVID-19 pandemic; four licenced vaccines are now available whereas there were either no/limited vaccines available at the time when eligible studies were conducted¹⁰⁴. The availability of vaccines may have a role in vaccine intentions.

Conclusion

Overall, the review discovered positive attitudes towards the COVID-19 vaccine before February 2021, with 73% of the total survey participants reporting a high intention to receive the COVID-19 vaccine. COVID-19 vaccine acceptance can be influenced by many sociodemographic factors and individual risk perception towards COVID-19. The findings of this review imply that future research should explore the reasoning behind vaccine intentions for different sociodemographic groups, to allow targeted communication strategies to be formulated by governments and public health agencies. The impact of both vaccine availability and reported adverse effects must be monitored so public health policies can address these concerns. A high vaccine uptake to current mass-vaccination programmes and potential booster vaccinations is essential to achieve the end goal of herd immunity and combat any potential future variants.

Abbreviations

Abbreviation	Meaning
COVID-19	Coronavirus Disease 2019
WHO	World Health Organisation
UK	United Kingdom
DTP	Diphtheria-tetanus-pertussis Vaccine
A/H1N1	Influenza A Virus subtype H1N1
PHE	Public Health England
CI	Confidence Interval
SPIDER	Sample, Phenomenon of Interest, Design, Evaluation, Research Type
PICO	Population, Intervention, Comparison, Outcomes
AXIS	Appraisal Tool for Cross-Sectional Studies
USA	United States of America
BAME	Black, Asian and minority ethnic
OR	Odds Ratio
RRR	Relative Risk Ratio
NHS	National Health System

Declarations

Ethics Approval and Consent to Participate

Not Applicable

Consent for Publication

Not Applicable

Availability of Data and Materials

Not Applicable

Competing Interests

The authors declare they have no competing interests.

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Authors' Contributions

ET undertook the literature searches, all stages of screening, data-extraction and quality and risk of bias assessment. ET analysed and interpreted the survey data and was responsible for the writing of the manuscript.

SC participated in both independent title and abstract and full-text screening of eligible papers, and independently undertook quality and risk of bias assessment for 10% of studies.

SD participated in the resolution of screening, quality and risk of bias assessment disagreements between ET and SC and advised throughout all stages of searching, data collection and extraction, and data analysis. SD participated in decisions regarding the review focus, search strategy and points of discussion.

SG participated in decisions regarding the focus of the review, search strategy and points of discussion.

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Figures

Figure 1. PRISMA Flow Diagram illustrating the summary of search strategy results from initial search to included studies²⁸.

Figure 1

PRISMA Flow Diagram illustrating the summary of search strategy results from initial search to included studies²⁸.

Figure 2

Random-effects meta-analysis of 18 cross-sectional studies^{43,46-50,52-55,57,58,60-64}: Estimated proportion of survey participants reporting vaccine acceptance (% of total sample). Vaccine 'acceptance' is defined as either definite (responding 'yes/ accepting/ strongly agree/ very likely') or possible (responding 'agree/ probably yes/ somewhat likely/ unsure but leaning towards yes'). Vaccine 'unwillingness' is defined as hesitant (responding 'not sure/ neither agree nor disagree/ neutral/ I don't know/ Maybe/ Hesitant), improbable (responding 'somewhat unlikely/ disagree/ unsure but leaning towards no/ probably no) or very improbable (responding 'no/ very unlikely/ strongly disagree/ resistant'). CI=confidence interval.

Figure 3

Subgroup analysis by gender of 7 studies^{46,50,53,58,60,62,64}: Estimated proportion of survey participants reporting COVID-19 vaccine acceptance (% of total sample in each gender group). Group 1=Female Participants, Group 2=Male Participants, CI= confidence interval. Seven studies presented proportions of total survey participants willing to receive the COVID-19 vaccine by gender and hence data was collated in a subgroup analysis. Response proportions were combined into 2 categories; vaccine 'acceptance' (responding with either strongly agree or agree to receiving the COVID-19 vaccine) and vaccine 'unwillingness' (responding with either maybe, disagree, strongly disagree to receiving the COVID-19 vaccine).

Figure 4

Subgroup analysis by time of survey of 11 studies^{46,47,49,52,53,55,58,60,61,62,64}: Estimated proportion of survey participants reporting COVID-19 vaccine acceptance (% of total sample). Only the 11 studies with a sample size $\geq 1,000$ were included in the analysis. Group 1=March-June 2020, Group 2=July-December 2020, CI= Confidence Interval.

Figure 5

Subgroup analysis of vaccine acceptance by method of recruitment of 18 studies^{43,46-50,52-55,57,58,60-64}: (ES) estimated proportion of total survey participants reporting COVID-19 vaccine acceptance (% of total sample). 1=Non-Probability Sampling, 2=Probability Sampling, CI= Confidence Interval.

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