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How Early Onset of COVID-19 Changed Vaccine-Related Attitudes: A Longitudinal Study

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Supplementary Materials: Data [see [Index of Supplementary Materials](#)]



Abstract

The paper investigates how the onset of the global COVID-19 pandemic has influenced the attitudes and beliefs of a previously anti-vaccine and vaccine-undecided population: how it changed their anti-vaccine beliefs and related arguments, perceptions of scientists' credibility, as well as what their beliefs about COVID-19 are and what protective action they undertake against it. We used preexisting data from a 2018 study, where we identified groups of anti-vaccine and vaccine-undecided individuals ($N = 365$) whom we reached out to again in April/May 2020 (during the first months of the pandemic, when no COVID-19 vaccine was available). An online survey was used to measure changes in attitudes toward vaccination, reasons for vaccine rejection, attitudes toward scientists, and (at Measure 2) to measure attitudes toward COVID-19 and protective action against it. Results indicated a general pro-vaccine shift in attitudes, as well as reduced support for all anti-vaccine arguments. Surprisingly, we also found a negative shift in the sample's perceptions of scientists' agency and communion. Anti-vaccine individuals were also much less likely to employ any protective measures and had the lowest levels of fear associated with COVID-19. These results show that the initial stages of the COVID-19 outbreak caused a positive change in vaccine attitudes, especially in the vaccine-undecided group. At the same time, strongly anti-vaccine individuals were likely to reject protection against COVID.

Keywords

vaccination attitudes, COVID-19, vaccine hesitancy, attitudes toward science



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Highlights

- Anti-vaccine attitudes are known to influence vaccine uptake and associated health risks. These attitudes are known to be caused or influenced by cognitive and motivational factors.
- The current study applied a longitudinal design to investigate how the early onset of COVID-19 (April–May 2020) influenced the attitudes and beliefs of previously identified anti-vaccine and hesitant individuals, including six previously identified widespread arguments used by anti-vaccine movements.
- Results indicate that COVID-19 significantly shifted anti-vaccine and undecided attitudes to pro-vaccine ones and significantly reduced support for all anti-vaccine arguments.
- Anti-vaccine individuals declared less fear about COVID-19 and less declared protective action against COVID-19.

In 2019, not long before the outbreak of the coronavirus pandemic (COVID-19), the World Health Organization identified vaccine hesitancy as one of the top ten global health risks. Explicit opposition to vaccination was widely observed after Andrew Wakefield's infamous 1998 article in "The Lancet", which described a link between the mumps, rubella and measles (MMR) vaccine and the occurrence of Crohn's disease and autism in children. As a consequence, anti-vaccine movements and refusal to vaccinate children began to emerge in many countries. Wakefield's research was quickly proven fraudulent and retracted, but anti-vaccine attitudes have increased, and this tendency was particularly prominent during the last 10 years (Dubé & MacDonald, 2020; Dubé et al., 2015; Larson, 2013). For example, in Poland (where we conducted the current study), the number of parents who refused to vaccinate their children increased nearly eightfold between 2012 and 2018 (from 5340 in 2012 to 40342 in 2018; NIPH, 2018). According to the Polish National Public Health Institute, the percentage of children vaccinated against measles in 2018 fell below the herd immunity threshold of 95%. A similar decrease in childhood vaccination was present for diphtheria/tetanus, haemophilus influenzae B, polio and whooping cough, which all dropped from 95.6% in 2010 to 86.6% in 2019 (full vaccinations of three-year-olds).

Apart from the strictly anti-vaccine individuals, another important group is people undecided about vaccination (i.e., those who express doubts, but do not outright reject vaccines). This group is larger than the strictly anti-vaccine group, and its members are prone to anti-vaccine argumentation, which may turn them fully anti-vaccine.

The year 2020 brought about a global critical event—the COVID-19 pandemic. It affected the lives of most people worldwide, both as a health concern and a cause of drastic changes to people's lifestyles. Lockdowns were implemented in many countries,

closing whole branches of economies and often forcing people to not leave their homes for any reason except the most basic necessities.

At the beginning of the pandemic, the problem of vaccine rejection took on additional importance in the context of the willingness to vaccinate against COVID-19. At the time, no vaccines against COVID were available, but mass vaccination was considered one of the potential solutions to the pandemic (Dubé & MacDonald, 2020). Epidemiological models (Fontanet & Cauchemez, 2020; Gumel et al., 2021; Randolph & Barreiro, 2020) indicated that at least 67% of the population would need to be vaccinated in order to achieve herd immunity and contain the pandemic, therefore investigating the causes of vaccine hesitancy was of high importance.

The main aim of our research was to investigate whether and how the outbreak of the COVID-19 pandemic itself influenced the willingness to vaccinate and vaccine-related beliefs in an already vaccine-undecided and anti-vaccine population. We particularly measured attitudes toward the main arguments proclaimed by activists of anti-vaccination movements (risks associated with side effects of vaccination, doubts about the effectiveness of vaccination in preventing diseases, critique of the quality of scientific research on vaccines, etc.). Given that vaccine hesitancy can be fueled by a general lack of trust in science and scientists (Dubé et al., 2015; Hornsey et al., 2018; Rutjens et al., 2018), we also wanted to see whether perceptions of scientists' credibility have changed after the onset of the pandemic.

Additionally, we wanted to investigate the beliefs of vaccine-undecided and anti-vaccine individuals about COVID-19, and whether they took any protective action against it. Apart from practical implications for COVID-19 prevention, measuring the change of these attitudes and beliefs under the extraordinary circumstances of a pandemic may provide insight into how certain people cope with stressful events and unexpected change in general.

Attitudes and Their Changes With the Experience of Important Life Events

Attitudes are not stable over the course of one's life and change with important life events. It has been shown, for example, that after experiencing the birth of their first child, both men and women become more likely to support the opinion that being a mother is a woman's most important role in life (Baxter et al., 2015) and tend to present more traditional gender-role beliefs, in accordance with their new life situation (Schober & Scott, 2012). In a health-related domain, one critical event that may lead to a change in attitudes is becoming seriously ill. For instance, people who found out that they had AIDS dramatically changed their attitudes towards religion (Plattner & Meiring, 2006).

Although there is ample research on the change of attitudes (for a review, see Albarracin & Shavitt, 2018) it is very rare to observe a global event able to cause a mass shift in attitudes, and it is even more difficult to capture this shift scientifically—one

needs to have data on attitudes and beliefs prior to the event, and needs the event to be relevant for the attitudes in question. Since many significant global events are unpredictable, this makes data collected during these events extremely rare and important. Having a relevant set of data collected on a sample of anti-vaccine and vaccine-undecided individuals gave us a unique occasion to investigate how this very particular group of people reacted to the pandemic.

The COVID-19 pandemic created a serious common threat. The vast majority of people treated the outbreak of the pandemic as a catastrophic event which was not caused by intentional human action (Mertens et al., 2020), but by pure chance. Therefore, according to the emotion appraisal model, people should react with anxiety rather than with anger. However, this may be different for people who have preexisting doubts about vaccines. There is empirical evidence that anti-vaccine individuals believe in various conspiracy theories. They may believe that someone has deliberately spread the virus and/or that someone is intentionally misleading the public by lying that the virus is dangerous, which implies a belief that some people are responsible for the current difficult situation (Sowa et al., 2021; Yang et al., 2021). It is possible that according to the opinion of anti-vaccine and vaccine-undecided individuals, scientists allowed the pandemic to spread, are not able to stop it, and they do not provide clear and unambiguous information about the disease and vaccines. Moreover, anti-vaccine individuals who are inclined to conspiratorial thinking may suspect that scientists are ‘under the thumb’ of pharmaceutical companies and suspect them of putting profits above public interest, using the pandemic to do so (Stasiuk et al., 2021).

Own Research

We planned a longitudinal study in 2018 (to be conducted again on the same group of people in 2022). The initial main subject of the research was the attitudes of anti-vaccine and vaccine-undecided people toward the main arguments proclaimed by activists of anti-vaccination movements—investigating the dynamics of changes in attitudes over the span of several years. We conducted the first survey in August 2018. The outbreak of the pandemic accelerated the second part of the longitudinal study and changed its main focus from a ‘natural’ change of attitudes over time to the impact of COVID-19 on these attitudes. The second survey was conducted in April–May 2020, just after COVID-19 became a global issue.

At the time of writing this paper, we know much about COVID-19, there are several working vaccines, and many people consider the pandemic contained. The picture was completely different during the first months of the pandemic, when a lack of reliable information created massive uncertainty and fear, in some cases leading to panic. Our research question was how this uncertainty, and the looming epidemiological risk of a potentially deadly disease (early media reports indicated an over 10 per cent mortality rate (e.g., an Italian Ministry of Health tweet from 27/03/2020 reported 86498 total

cases and 9134 deaths, see [Ministry of Health Italy, 2020](#)) influenced attitudes regarding vaccines and vaccination in particular groups (as identified in 2018)—anti-vaccine individuals, as well as those who were undecided about whether vaccines are good or bad. We investigated whether attitudes toward vaccination in already anti-vaccine and vaccine-undecided groups shifted following the outbreak of COVID-19. In addition to simply measuring vaccine hesitancy, we investigated how these individuals perceive the six arguments against vaccination, and whether some of these perceptions changed following the COVID-19 outbreak. Questions about participants' views on vaccines were based on existing arguments most often used by Polish anti-vaccine activists, collected by attending conferences organized by the STOP NOP anti-vaccine group, as well as analyzing social media. This measure has been used in previous research and has a slightly different goal than the SAGE VHS (Vaccine Hesitancy Scale) ([Larson et al., 2015](#))—it is aimed specifically at measuring support for anti-vaccine arguments postulated by anti-vaccine groups in Poland. We have distinguished six main areas of argumentation: General support for anti-vaccination activists, 2) beliefs about side effects of vaccination, 3) doubts about whether vaccines are needed, 4) doubts about whether vaccines are effective, 5) doubts about the quality of vaccination research, and 6) doubts about the intentions of medical professionals. Note that these arguments refer to general vaccines (directly mentioning tuberculosis, polio, measles and smallpox) and not to COVID-19 vaccines, as COVID-19 did not exist when we analyzed the anti-vaccine arguments.

The onset of the pandemic could affect attitudes toward these six arguments differently. For instance, doubts about whether vaccines are needed should drop significantly, since a contagious disease is immediately observable. On the other hand, beliefs about side effects may remain unaffected, while doubts about research and intentions may even increase if one believes that COVID-19 was man-made, which can be expected of our target population of vaccine-undecided and anti-vaccine individuals.

A separate question was how the outbreak of the pandemic influenced scientists' credibility and whether these opinions would change in line with any potential shifts in attitudes toward vaccination.

We also investigated how currently anti-vaccine individuals perceive risks associated with COVID-19, whether they take any protective action, and whether they believe in misinformation about scientifically unproven ways to protect themselves against the coronavirus.

Since there were no COVID vaccines at the time of the second survey (April–May 2020), we asked respondents whether they would vaccinate themselves against COVID-19 if such a vaccine were developed. Answering this question requires making many assumptions about the potential vaccine, and these assumptions will most likely be based on preexisting attitudes toward vaccines. On the one hand, anti-vaccine attitudes assume that vaccines are ineffective and carry a high risk of side effects, and these assumptions may be carried over to the COVID-19 vaccine, which would cause anti-vaccine individu-

als to remain anti-vaccine and not vaccinate against COVID-19. Additionally, individuals who are hesitant to vaccinate themselves with well-known and well-tested vaccines may be even more wary of a newly developed vaccine, the side effects and effectiveness of which have not yet been evaluated. On the other hand, if some of these anti-vaccine individuals behave out of self-interest (i.e., are abusing herd immunity to protect themselves both from contagious diseases and side effects of vaccines), they may be tempted to vaccinate against COVID-19 specifically, in absence of herd immunity. Additionally, some of the anti-vaccine individuals may have perceived vaccines as unnecessary simply because there were no lethal contagious diseases plaguing their immediate area (mostly due to vaccination), and an outbreak of such a contagious disease may cause them to reconsider the risks and benefits associated with vaccines—therefore making their attitudes more pro-vaccine.

Method

Participants

Three hundred and sixty-five respondents (189 women and 176 men) took part in both phases of the study, aged 20–74 years ($M = 43.36$, $SD = 13.15$). The survey was run online by the Ariadna Research Panel—a Polish company specialized in polling large samples, with previous experience in running studies for academic purposes. The panel enables random selection of the representative sample from among 200,000 registered and verified users. For participation in the survey, respondents received credit points that they could exchange for gifts. The participant selection procedure uses random quota sampling in order to achieve a representative demographic profile based on the requirements of particular research.

The first phase was conducted on 493 participants, meaning a 26% dropout rate. In August 2018, vaccine-hesitant individuals were drawn from a randomized sample ($N = 3000$)¹ of the Polish general population, using two selection criteria: The first selection criterion was the answer to the question ‘What is your stance on mandatory vaccination’, which could be either ‘I agree’, ‘I am ambiguous, as I see positive and negative sides of it’ or ‘I oppose’. Effectively, we rejected participants who supported mandatory vaccination from the study, as they were not considered vaccine hesitant. The second selection criterion was the opinion regarding the statement “Vaccines do more harm than good”. Answers to this statement were measured on an eleven-point Likert scale (0-strongly disagree – 10-strongly agree). In line with previous research, we only included participants with scores higher than 4, rejecting those who considered vaccines

1) Partial results of this first survey were published in another article [redacted for review anonymization purposes, citation will be provided here after review]

more beneficial than harmful (a score of 5 is the middle of the scale between Strongly disagree and Strongly agree, indicating indifference). In line with our previous research, participants who were 'ambiguous' about mandatory vaccination and had scores of 5–7 on the above Likert scale were considered 'undecided', and participants who 'opposed' mandatory vaccination and had scores of 8–10 on the Likert scale were considered 'anti-vaccine'. Participants not fitting these categories were dropped from the study.

In April 2020, we used the same polling company to reach out to the previously surveyed individuals. We obtained electronic informed consent from the participants at both measurement times. Research was approved by the Ethics Committee at the Jagiellonian University Institute of Applied Psychology.

Materials and Procedure

The survey was run twice on the same participants, at the second time we included additional questions. The first version of the survey contained the following parts: (I) five questions concerning demographics (age, gender, place of residence, education, profession), (II) two questions which were the selection criteria described earlier. (III) To test how people evaluate the credibility of scientists we used measures based on social perception research (Abele & Wojciszke, 2014). Following this, we asked respondents to assess the scientists' agency (two items: *Thanks to the work of scientists, the world develops more* and *Thanks to the achievements of medical science, people live longer*) and communion (two items: *Scientists are honest* and *Scientists' inventions are used by them to harm people rather than help them* [reversed item]). (IV) Respondents were also asked 22 questions measuring six aspects of vaccine hesitancy, based on arguments frequently used by anti-vaccine activists (firstly mentioned in the Introduction):

1) Support for anti-vaccination activists (Anti-vaccine movement support) – three statements which measured the general opinion and support for anti – vaccine movements and their leaders. Cronbach's $\alpha = .84$ (Measure 1), $\alpha = .90$ (Measure 2)

2) Beliefs about side effects of vaccination (Side effects) - five statements measured beliefs that vaccines have harmful side effects, especially those shown by anti-vaccine movements as arguments against mandatory vaccination. Cronbach's $\alpha = .80$ (Measure 1), $\alpha = .88$ (Measure 2)

3) Doubts about whether vaccines are needed (Need) – five statements about what would happen if people would not vaccinate, and whether vaccines were historically useful in preventing epidemics. Cronbach's $\alpha = .79$ (Measure 1), $\alpha = .74$ (Measure 2)

4) Doubts about whether vaccines are effective (Effectiveness) – two statements measuring doubts about whether vaccines protect against diseases. This category was separate from Need, as it directly questioned whether vaccines work. Cronbach's $\alpha = .86$ (Measure 1), $\alpha = .71$ (Measure 2)

5) Doubts about research on vaccines (Research) – three statements reflecting doubts about the quality of vaccination research. Cronbach's $\alpha = .79$ (Measure 1), $\alpha = .87$ (Measure 2)

6) Doubts about the intentions of medical professionals (Intentions) – four statements which addressed doubts about the intentions of pharmaceutical companies and medical professionals who endorse vaccination. Cronbach's $\alpha = .75$ (Measure 1), $\alpha = .83$ (Measure 2)

Total Cronbach's alphas for the entire scale were $\alpha = .67$ for the first measurement and $\alpha = .71$ for the second one.

Responses to statements within the above categories were measured on an 11-point Likert scale from 0 (strongly disagree) to 10 (strongly agree).

Particular questions related to these six arguments are presented in Appendix 1 in the Supplementary Materials (see Polak et al., 2024b). Correlations between subscales are presented in Table 1.

Table 1

Correlations Between Anti-Vaccine Argument Subscales in the First and Second Measurement

Argument	Support for anti-vaccine arguments		Side effects		Intentions		Need		Effectiveness	
	r_1	r_2	r_1	r_2	r_1	r_2	r_1	r_2	r_1	r_2
Research	.48	.47	.47	.51	.69	.67	.63	.61	.36	.45
Support for anti-vaccine arguments			.77	.79	.67	.74	.60	.71	.57	.75
Side effects					.66	.72	.57	.62	.64	.71
Intentions							.70	.76	.54	.68
Need									.51	.67

Note. Pearson correlations. r_1 = first measurement; r_2 = second measurement. All $N = 365$, all $p < .001$.

The second survey carried over all of the questions from the first survey, and we added the following items related specifically to the COVID-19 pandemic, measured on an 11-point Likert scale from 0 (strongly disagree) to 10 (strongly agree): (V) 'Would you vaccinate against the coronavirus if it was available', (VI) measures of perceived risk of being infected, fearing for one's health and economic well-being, (VII) four questions measuring beliefs in misinformation about COVID and its treatments, and (VIII) nine questions pertaining to what protective action the participants take to protect

themselves against COVID (washing hands, avoiding shaking hands, avoiding public transport, reducing church attendance, avoiding seeing close ones, reducing shopping frequency, wearing a face mask, other, none). Particular questions related to COVID-19 are presented in Appendix 2 in the Supplementary Materials (see Polak et al., 2024b).

Results

Sample Demographics

The sample consisted of 164 initially anti-vaccine and 201 initially undecided individuals (as measured in 2018). The initially anti-vaccine group consisted of 92 women and 72 men, aged $M = 41.8$, $SD = 13.4$. None of these participants had primary education as their highest level of education; 12 had vocational, 44 finished high school, 26 had tertiary education, 19 had a bachelor's degree and 63 had a master's degree or above.

The initially undecided group consisted of 97 women and 104 men, aged $M = 41.0$, $SD = 13.0$. Four of these participants had primary education, 19 vocational, 55 finished high school, 18 had tertiary education, 25 had a bachelor's degree and 80 had a master's degree or above.

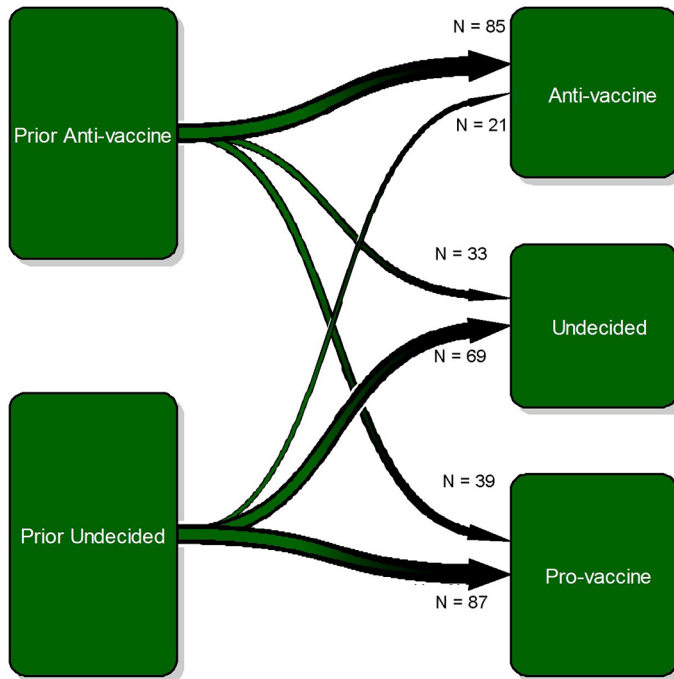
Change in Attitudes Toward Vaccination During the COVID-19 Pandemic

Prior to the pandemic, the sample consisted of 164 anti-vaccine individuals and 201 undecided. During the pandemic, the same sample consisted of 106 anti-vaccine individuals, 102 undecided, 126 vaccination supporters and 31 who stated that they did not care (and were therefore treated as missing values). All statistical analyses were conducted in SPSS, power sensitivity analyses were conducted using G*Power. Sign test (two-tailed) indicated 21 negative differences, 154 ties and 159 positive differences, $Z = -10.211$, $p < .001$; wherein negative differences corresponded to a change from a more pro-vaccine to a more anti-vaccine attitude, and vice versa. Vaccine hesitancy was significantly reduced in the sample during the COVID-19 pandemic.

Further analyses indicated that eighty-four of the previously anti-vaccine individuals remained anti-vaccine during the pandemic, thirty-three of them became undecided and forty became pro-vaccine. Seventy of the previously undecided individuals remained undecided, seventeen became anti-vaccine and ninety became pro-vaccine. Results are presented in Figure 1.

Figure 1

Changes in Attitudes Toward Vaccination During COVID-19 Outbreak



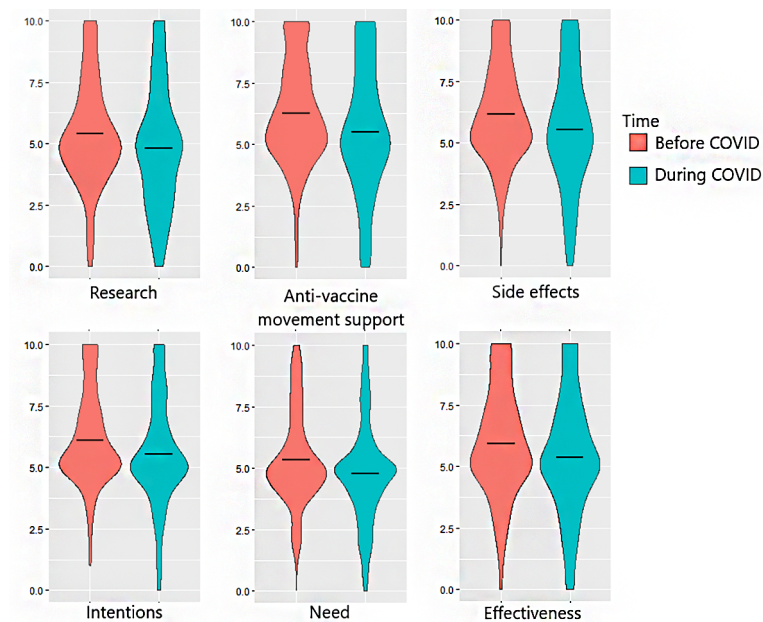
A paired samples *t*-test of responses to the statement “Vaccines do more harm than good” also indicated a significant reduction of anti-vaccine attitudes (from $M = 7.03$, $SD = 2.28$ prior to the pandemic to $M = 5.52$, $SD = 3.00$ during the onset of the pandemic, $t(364) = 9.62$, $p < .001$; Hedges’ $g = 0.56$). Sensitivity analysis with assumed $\alpha = .05$ and $\beta = .05$ indicated a required effect size of $g = 0.19$, confirming a suitable sample size.

We then analyzed changes in the six arguments against vaccination: Opinion about anti-vaccination activists (Anti-vaccine movement support), beliefs about side effects of vaccination (Side effects), doubts about whether vaccines are needed (Need), doubts about whether vaccines are effective (Effectiveness), doubts about the quality of research on vaccines (Research) and doubts about the intentions of medical professionals (Intentions). All of the above opinions significantly correlated with one another (Kendall’s tau ranging from $\tau = .20$ to $\tau = .75$, all $p < .001$). Higher scores in each category indicated a more anti-vaccine/negative opinion, and we treated the middle of the scale (5, representative of the answer ‘Neither agree nor disagree’) as the point of indifference, with higher scores considered anti-vaccine and lower scores pro-vaccine.

The analysis was conducted using a repeated-measures ANOVA. Results indicated significant differences between participants' responses prior to and during the pandemic, $F(1,364) = 66,170, p < .001, \eta_p^2 = .15$. Pairwise comparisons of estimated marginal means (Bonferroni corrected) indicated that participants' opinions became more pro-vaccine in all categories (all $p < .001$): Research $M = 5.39, SE = .11$ vs. $M = 4.80, SE = .13$; Anti-vaccine movement support $M = 6.28, SE = .11$ vs. $M = 5.51, SE = .14$; Side Effects $M = 6.16, SE = .10$ vs. $M = 5.54, SE = .13$; Intentions $M = 6.10, SE = .10$ vs. $M = 5.53, SE = .11$; Need $M = 5.35, SE = .10$ vs. $M = 4.79, SE = .11$; Effectiveness $M = 5.93, SE = .12$ vs. $M = 5.36, SE = .13$, measured prior to and during the pandemic, respectively. Results are presented in Figure 2. A sensitivity analysis with assumed $\alpha = .05$ and $\beta = .05$ indicated a required effect size of $\eta_p^2 = 0.009$, confirming a suitable sample size.

Figure 2

Beliefs Related to Vaccination Prior to and During the COVID-19 Outbreak



Willingness to (Potentially) Vaccinate Against COVID-19 and Aspects of Vaccine Hesitancy

We ran a multiple regression analysis with 'Would you vaccinate yourself against COVID-19' (0-strongly disagree to 10-strongly agree) as the dependent variable, and the six anti-vaccine arguments (Anti-vaccine movement support, Need, Effectiveness, Side effects, Intentions and Research) during the pandemic (in 2020) as the predictors. It

turned out that the model explained 48.9% of the variance, $R^2 = .489$, $F(6,358) = 57,173$, $p < .001$, Cohen's $f^2 = 0.96$. The strongest predictors were Need ($\beta = -.478$, $p < .001$) and Research ($\beta = .439$, $p < .001$), followed by Intentions ($\beta = -.262$, $p = .024$), while Anti-vaccine movement support, Side effects and Effectiveness were nonsignificant (all $p > .10$).

We also ran an identical regression analysis with the six anti-vaccine arguments measured before the pandemic (2018) as predictors of the willingness to vaccinate against COVID-19 in 2020. The model explained 21.7% of the variance, $R^2 = .217$, $F(6,358) = 16.509$, $p < .001$, Cohen's $f^2 = 0.28$. The only significant predictor was Research ($\beta = -.167$, $p = .015$). A sensitivity analysis for both regression analyses, with assumed $\alpha = .05$ and $\beta = .05$ indicated a required effect size Cohen's $f^2 = 0.058$, confirming a suitable sample size

Attitudes Toward Scientists' Agency and Communion Prior to and During COVID-19

We compared participants' general attitude toward scientists (not just related to vaccines), measured on the axes of agency and communion. Paired samples *t*-tests (two-tailed) indicated that perceived communion of scientists decreased from $M = 5.65$, $SD = 1.90$ to $M = 4.89$, $SD = 1.86$, $t(364) = 7.091$, $p < .001$, Cohen's $d = .371$, and perceived agency decreased from $M = 3.90$, $SD = 2.21$ to $M = 3.52$, $SD = 2.35$, $t(364) = 3.007$, $p = .003$, Cohen's $d = .157$ —these results are surprising given the positive change in attitudes toward vaccination.

Analyzing the initially anti-vaccine and undecided individuals (as of 2018) separately, we found that in the anti-vaccine group, perceived communion of scientists decreased from $M = 6.37$, $SD = 2.03$ to $M = 5.35$, $SD = 1.94$, $t(163) = 6.008$, $p < .001$, Cohen's $d = .469$, and perceived agency decreased from $M = 4.45$, $SD = 2.49$ to $M = 4.00$, $SD = 2.47$, $t(163) = 2.184$, $p = .03$, Cohen's $d = .171$. In the undecided group, perceived communion of scientists decreased from $M = 5.07$, $SD = 1.57$ to $M = 4.52$, $SD = 1.72$, $t(200) = 4.053$, $p < .001$, Cohen's $d = .286$, and perceived agency decreased from $M = 3.46$, $SD = 1.84$ to $M = 3.12$, $SD = 2.18$, $t(200) = 2.063$, $p = .04$, Cohen's $d = .145$.

Beliefs About COVID-19 in the Currently Pro-Vaccine, Anti-Vaccine and Undecided Individuals

We investigated several categories of beliefs about the COVID-19 pandemic (all measured on 0–10 response scales from “strongly disagree” to “strongly agree”), comparing them between the currently anti-vaccine, pro-vaccine and undecided groups (regardless of their previous attitudes toward vaccination) using ANOVAs with Bonferroni-corrected post-hoc tests. Please take into account that the ‘currently pro-vaccine’ group used to belong to either the anti-vaccine or the undecided group prior to COVID-19.

Results indicated that the anti-vaccine individuals also rejected the possibility of vaccinating themselves specifically against COVID-19 ($M = 1.50$, $SD = 2.39$), while pro-vaccine individuals generally stated they would do so ($M = 6.82$, $SD = 2.42$) and the undecided were in the middle, $M = 5.09$, $SD = 2.42$; $F(2,331) = 127,768$, $p < .001$, $\eta_p^2 = .44$, all pairwise comparisons $p < .001$.

We also investigated fears associated with the pandemic - about the health of the participants and their relatives, and about the economic well-being of the participants and their relatives. Fears about the health of participants and their relatives, $F(2,331) = 20.569$, $p < .001$, $\eta_p^2 = .11$, were lowest in the anti-vaccine group ($M = 4.96$, $SD = 3.50$, both pairwise comparisons $p < .001$), and did not significantly differ between the undecided and pro-vaccine groups ($M = 7.12$, $SD = 2.36$ vs. $M = 7.03$, $SD = 2.43$, $p > .95$). Fears about economic well-being were not significantly different across groups, $F(2,331) = .284$, $p = .753$.

Beliefs in Misinformation About COVID-19 and Attitudes Toward Vaccination

We investigated whether participants believed that the coronavirus is man-made and created in a laboratory, and found that participants generally agreed (total sample $M = 7.02$, $SD = 2.8$), but while an ANOVA indicated the presence of significant differences between groups, $F(2,331) = 3.173$, $p = .043$, $\eta_p^2 = .02$, post-hoc tests did not confirm this indication (lowest $p = .083$), meaning that attitudes toward vaccination were not significantly associated with the assumption that COVID-19 is man-made.

We also asked participants about whether they believe select pieces of misinformation on how to protect oneself against the coronavirus. At the time of the study (April 2020) in Poland, the most prevalent misinformation included taking large doses of vitamin C or D, drinking alcohol to 'disinfect oneself', and drinking large quantities of water. The belief that vitamin C or D can protect against the coronavirus was highest in the anti-vaccine group ($M = 6.11$, $SD = 3.30$, both pairwise comparisons $p < .001$), while there were no differences between the undecided ($M = 4.61$, $SD = 2.82$) and pro-vaccine groups ($M = 4.16$, $SD = 2.65$; $p = .747$). We found no significant differences between groups regarding the belief that drinking alcohol protects against the coronavirus (lowest post-hoc $p = .10$), or regarding the belief that drinking water protects against it (lowest post-hoc $p = .695$).

Declared Protective Action Against COVID-19 and Attitudes Toward Vaccination

Finally, we asked participants about the various actions they take to protect themselves against the coronavirus (washing hands, avoiding shaking hands with other people, avoiding public transport, reducing church attendance, not visiting relatives and close

ones one does not live with, reducing the frequency of shopping, wearing a protective mask and not taking any action). These were yes/no questions, hence analyses were conducted using chi-square tests. We compared declared protective action taken between pro-vaccine, anti-vaccine and undecided groups at the time of the pandemic (2020). Results are presented in Table 2. The anti-vaccine group declared taking all types of protective action less frequently than the other groups.

Table 2

Protective Action Against COVID-19 Taken by Pro-Vaccine, Anti-Vaccine and Undecided Individuals as of 2020

Protective action taken	Anti-vaccine N(%)	Undecided N(%)	Pro-vaccine N(%)	χ^2	<i>p</i>
Washing hands	70(66%)	91(89%)	107(85%)	20.408	< .001
Not shaking hands	66(62%)	86(84%)	96(76%)	13.616	.001
Avoiding public transport	56(53%)	78(76%)	87(69%)	13.727	.001
Reducing church attendance	36(34%)	61(60%)	64(51%)	14.446	.001
Not visiting relatives	50(47%)	77(75%)	85(67%)	19.369	< .001
Reducing shopping frequency	60(57%)	83(81%)	94(75%)	16.779	< .001
Wearing a mask	27(25%)	56(55%)	66(52%)	23.164	< .001
No action	16(15%)	1(1%)	1(0.8%)	28.689	< .001

We also ran an identical analysis between anti-vaccine and undecided groups from before the pandemic (2018). Results of this analysis are presented in Table 3. Anti-vaccine attitudes from 2018 also related to a lower frequency of most types of protective action, as compared to undecided attitudes.

Table 3

Protective Action Against COVID-19 Taken by Previously Pro-Vaccine, Anti-Vaccine and Undecided Individuals (as of 2018)

Protective action taken	Anti-vaccine N(%)	Undecided N(%)	χ^2	<i>p</i>
Washing hands	120 (73%)	173 (86%)	9.489	.002
Not shaking hands	109 (66%)	164 (82%)	10.964	< .001
Avoiding public transport	98 (60%)	139 (69%)	3.503	.061
Reducing church attendance	62 (38%)	114 (57%)	12.936	<.001
Not visiting relatives	96 (59%)	131 (65%)	1.692	.193
Reducing shopping frequency	102 (62%)	152 (75%)	7.693	.006
Wearing a mask	54 (33%)	106 (53%)	14.395	< .001
No action	12 (7%)	8 (4%)	1.942	.163

Discussion

The current study aimed to investigate how the outbreak of COVID-19 influenced attitudes toward vaccination in previously undecided and anti-vaccine individuals, as well as the associated beliefs about vaccines. It turned out that the outbreak of the pandemic significantly reduced vaccine hesitancy in our sample, with around a third of it becoming pro-vaccine. This is in line with the assumption that vaccine hesitancy may have been partially caused by the absence of serious contagious diseases (i.e., people did not see the need to vaccinate), and the immediate threat of infection caused some of them to reconsider. On the other hand, 106 out of the 365 participants (29%) remained anti-vaccine despite the epidemiological circumstances. That said, results indicate that COVID-19 had a positive effect on attitudes toward various types of vaccination in previously anti-vaccine and undecided individuals (not just toward the vaccine against COVID-19), which is in line with existing research (Fisher et al., 2020; Malik et al., 2020). This optimistic conclusion is consistent with research on the dynamics of social impact (Vallacher & Nowak, 1997, 2007). In situations in which certain beliefs or behaviors become far more pronounced (popular, common) in society, one should expect the trend (as in the intensification of such stances) to continue. Therefore, the positive shift in attitudes toward vaccination caused by COVID could become stronger over time. However, becoming more pro-vaccine is not the same as becoming pro-vaccine entirely, and there is still a substantial number of doubts in the previously anti-vaccine and undecided people we investigated, many of whom could be considered 'less anti-vaccine' rather than supporters of vaccinations. Moreover, the current study provides no insight into whether these attitude changes persist over time. Crucially, all of the results are applicable only to previously anti-vaccine and undecided populations, and they should not be generalized to the pro-vaccine population. For all we know, it could be that while the anti-vaccine and undecided sample became more pro-vaccine, the opposite could have happened to the already pro-vaccine individuals, for example, with the pandemic causing doubt about the effectiveness and state of modern medicine, which could have led pro-vaccine individuals to a more anti-vaccine stance.

Results concerning the change in reasons to (not) vaccinate (i.e., supporting anti-vaccine movements, doubting the need to vaccinate, doubting the effectiveness of vaccines, doubting the quality of research, doubting the intentions of pharmaceutical companies and worrying about side effects) showed that the observed positive change in attitudes toward vaccination was associated with a general positive shift in these six opinions. This shows that the pandemic caused the participants to reconsider all aspects of vaccines and become more favorable toward them, as opposed to reconsidering only particular aspects (e.g., the need to vaccinate because of COVID-19). Vaccine hesitancy may therefore be considered one coherent attitude, and beliefs regarding anti-vaccine arguments shift according to changes in this attitude.

However, and this should also be emphasized, the shift towards acceptance of vaccines occurred mainly among the previously undecided. Most of those who were strictly anti-vaccine did not change their attitudes during the pandemic. This result is consistent with previous research showing that neutral or ambivalent attitudes are more likely to change than unambiguously negative attitudes (e.g., Armitage & Conner, 2004). The negative attitudes of anti-vaccine individuals seem to be particularly strong and based on many doubts regarding vaccines (as shown in our study), therefore the onset of the COVID pandemic did not change them.

The results obtained in the study indicate that attitudes toward vaccination may change to a more positive one in the face of a pandemic threat. However, during the Covid-19 pandemic, a substantial amount of conspiracy theories and misinformation emerged. On the one hand, the pandemic may have caused people to appreciate the role of science and technology more, seeing that vaccines are one of the key tools in fighting the virus and protecting public health; trust in scientific technologies, including vaccines, may be an attempt to satisfy psychological needs, such as the need to feel safe and in control of the situation (e.g., Leotti et al., 2010). Vaccination can give people a sense that they are taking active steps for their health and the health of society as a whole, helping to reduce the uncertainty and anxiety associated with the pandemic (e.g., Sauer et al., 2020). On the other hand, people are most susceptible to conspiracy theories in crisis situations, during events that have a significant impact on their lives (such as pandemics), when they feel anxious, and unable to influence events around them. Belief in conspiracy theories is a way of making sense of a complex situation and helps satisfy the need for meaning and predictability in an unstable world (Earnshaw et al., 2020). However, conspiracy thinking as a means of restoring psychological well-being negatively affects attitudes toward the COVID-19 pandemic and vaccination. For example, belief in conspiracy theories about the pandemic was associated with a decreased likelihood of getting a coronavirus test and a lower propensity to follow government and medical recommendations (Pummerer et al., 2022; van Prooijen et al., 2023).

The measure of vaccine-related arguments we used in our research is not the same as the SAGE Vaccine Hesitancy Scale, as we wanted to capture the Polish specifics of anti-vaccine arguments and refer to the country's dominant anti-vaccine group (STOP NOP). Looking at the reliability analyses, one can see that while Cronbach's alphas for subscales are acceptably high, the total Cronbach's alpha for the entire scale is lower ($\alpha = .66$ for first and $\alpha = .70$ for second measurement), which may indicate that adherence to the anti-vaccine arguments is not uniform—some participants believe in some arguments and not others, and causes of anti-vaccine statements may be different in various people. This is also supported by the moderate correlations between subscales (r s ranging from .36 to .75). Therefore, we should think of vaccine hesitant individuals as a slightly heterogeneous group with somewhat varying opinions.

Research during the later stages of the pandemic also confirmed the prevalence of conspiracy theories in the anti-vaccine population (Allington et al., 2023; Jennings et al., 2021; Pertwee et al., 2022). From a general point of view, conspiratorial thinking and belief in misinformation also serve as means of reducing cognitive dissonance, which arose when anti-vaccine individuals were faced with the new reality of an actual pandemic.

Participants' perceived credibility of scientists decreased following the onset of COVID-19. While it could be expected that these perceptions would increase along with attitudes toward vaccination, perhaps the lowered agency estimates were caused by participants observing the scientists' inability to accurately predict the pandemic in its early stages, and to quickly propose effective countermeasures. The lowered communion estimates may have been a result of blaming scientists for 'inhumane' measures such as lockdowns, or for their cooperation with pharmaceutical companies. It must be noted that these explanations are speculative and need more research. It is also an open question as to whether the deterioration of opinions about scientists is a short-term effect related to the pandemic, or whether it has deeper roots and the trend will continue in the upcoming years. Moreover, as Gligorić et al. (2022) show, "scientists" are not a homogeneous group, and people can have different attitudes towards different groups of scientists. It is possible that the ambivalent or "hesitant" attitude of a certain group of people towards vaccinations is mediated by their attitudes towards medical practitioners. These attitudes may be unflattering for various reasons (bad personal experiences, rumors about doctors' morally reprehensible behavior, etc.). In a pandemic, the role may be played not by the attitude towards medical practitioners, but towards medical researchers, i.e., inventors of drugs and vaccines, and this attitude may be unequivocally positive. Of course, verifying the validity of this assumption would require separate studies.

We also investigated attitudes toward COVID-19 and related issues in the targeted sample. Declared interest in vaccinating oneself against COVID-19 specifically was lowest in the anti-vaccine group (1.5 on a 0–10 scale, indicating strong rejection), but even pro-vaccine individuals (i.e., those who shifted from anti-vaccine or undecided to pro-vaccine) had some doubts (6.82 out of 10 indicates somewhere between 'I don't know' and 'I somewhat agree'). Such conclusions are consistent with existing research. Situations that are new and rapidly change in unexpected ways cause people to become insecure about how they should act (Osman, 2010; van Dijk et al., 2004). Such a lack of conviction is especially intensified when the individual is subject to contradictory information (Keller et al., 2020; Rains & Tukachinsky, 2015), which was the case when we conducted the second wave of our research—information about COVID during its early stages was very inconsistent.

We must take into account that the above-mentioned results were obtained prior to any vaccine being created, so they are not indicative of the now-present worries that

vaccines were rushed or not properly tested, and doubts may be attributable to people not thinking that the coronavirus is dangerous enough to get vaccinated against it. Moreover, we found that attitudes toward vaccinating oneself against COVID-19 were predicted by beliefs that vaccines are needed, research on vaccines is of good quality and intentions of pharmaceutical companies are prosocial, rather than selfish. Interestingly, beliefs regarding support for anti-vaccine movements, side effects of vaccines and their effectiveness did not affect the will to vaccinate against COVID. Knowing that these three beliefs are strongly associated with general attitudes toward vaccination, we can see that COVID-19 vaccines are specific in this regard. Perhaps doubts about the need to vaccinate against COVID, about whether the vaccine would be properly researched and whether it would be prepared mainly to benefit the population were the strongest in our sample.

Looking at data concerning the currently pro-vaccine, anti-vaccine and undecided individuals, one can see that vaccine rejection was associated with lower fears about own health due to COVID-19: ignoring or underestimating the epidemiological threat allowed these participants to remain anti-vaccine without significant cognitive dissonance or fear of contracting COVID. Moreover, this group was the most susceptible to misinformation about alternative, easy treatments for COVID-19, which may have allowed them to underestimate the risks associated with infection. Finally, we found that anti-vaccine individuals were less likely to take any protective action against COVID-19. This indicates that the anti-vaccine group may create additional epidemiological risks for others, and effort should be put into both reducing the number of anti-vaccine individuals in the general population and identifying them as potential risk factors. Moreover, vaccine rejection prior to the pandemic was also associated with a lower propensity to take protective action against COVID-19 when it appeared. Participants who declared being anti-vaccine in 2018, when compared to those who were undecided, were less likely to wash their hands frequently, avoid shaking hands, reduce their church attendance, reduce their shopping frequency and wear a face mask. These declarations are compared to the undecided group, which already demonstrated some anti-vaccine inclinations, so one would expect an even stronger effect if compared to a pro-vaccine group. This indicates that preexisting vaccine hesitancy predicts other types of behavior posing health risks to the public.

Please keep in mind that the second part of the research was conducted during the first months of the COVID-19 pandemic, where uncertainty was at its highest, there was yet no reliable scientific information about how to handle the pandemic, and there was no vaccine against it. While this means that the results of this research may no longer represent the current attitudes of our participants, we see it as a strength, rather than an issue. We were able to capture the effects of an outbreak itself, with all the associated uncertainty, stress, fear and lack of information. In essence, this gives us insight into the participants' reaction to a stressful global event, which can partially

be generalized to other such potential events and our reactions to them. Less than a year into the COVID-19 pandemic, several working vaccines have been developed, and while the initial uncertainty and fear of COVID has been significantly reduced, doubts about the properties of the available vaccines (side effects, effectiveness, safety, quality of clinical trials, etc.) have then become potential reasons for anti-vaccine attitudes, in a way returning them to the root causes we know from existing research from before COVID (Hornsey et al., 2018; Rutjens et al., 2018), and from recent research on COVID vaccination specifically (e.g., Maciuszek et al., 2022).

The presented study has some limitations. Primarily, we did not plan on conducting a longitudinal study on the effects of COVID-19 on vaccine hesitancy, therefore our questions were limited by the original research design from 2018, and some important questions remain unanswered (especially regarding the underlying psychological mechanisms). Another limitation may be that attitudes towards vaccination were measured in a general way (we did not specify exactly which vaccines we meant, although some questions did include reference vaccines). Thus, it is possible that the change in attitudes among vaccine hesitant people was not due to the pandemic, but to a change of reference point when thinking about vaccination. In the first measure, respondents may have been thinking about children's vaccines when answering questions about vaccination, while in the second measure they may have been thinking about the COVID-19 vaccine (which was more cognitively accessible at the time, due to the prevalence of this topic. However, it should be remembered here that the survey was longitudinal, so in both measurements we had to ask questions formulated in the same way. Furthermore, the dynamic changes in various aspects of life caused by COVID-19 in recent months (including the manufacturing of vaccines, worries about their side-effects, the emergence of mutated variants of SARS-nCoV-2, etc.) may have again changed the attitudes we measured in our sample, and we plan on reaching out to the same people for a third time when the situation stabilizes. The second limitation may however be considered a strength of the presented study, as we managed to capture a timeframe in which uncertainty was the highest, measuring the effects of an ongoing, uncontained pandemic on people's attitudes and perceptions regarding vaccines and the pandemic itself. Hopefully we will not have another chance to do so for many years.

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Ethics Statement: Research has been approved by the Ethics Committee at the Faculty of Management and Social Communication, Jagiellonian University. Informed consent has been obtained from all respondents prior to their participation in the study.

Data Availability: For this article, data is freely available (see Polak et al., 2024a).

Supplementary Materials

For this article, data (see Polak et al., 2024a) and supplementary appendices (see Polak et al., 2024b) are available.

Index of Supplementary Materials

Polak, M., Maciuszek, J., Doliński, D., & Stasiuk, K. (2024a). *Supplementary materials to "How early onset of COVID-19 changed vaccine-related attitudes: A longitudinal study"* [Data]. PsychOpen GOLD. <https://doi.org/10.23668/psycharchives.15499>

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