Master thesis

# Vaccination Concerns during the COVID-19 Pandemic in Germany: Topic Modelling of Interviews

by

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**Abstract**

From the beginning of the COVID-19 pandemic in April 2020, vaccinations were considered essential to reduce morbidity and mortality in the population and as the most effective measure to manage the pandemic by the German government. However, the vaccination willingness in the German population fluctuated with people being in favour, being hesitant and others being opposed to getting the COVID-19 vaccination. To be able to understand varying vaccination willingness in Germany and how it changed over time, this study explored the attitudes and concerns towards COVID-19 vaccinations of forty German citizens with differing levels of vaccination willingness pre-vaccination start. A mixed-method approach was utilized that combined qualitative longitudinal research with a LDA topic model analysis. Through the topic model analysis, 42 topics over three timepoints (December 2020, April 2021 and September 2021) in three groups (Pro vaccination/Contra vaccination/Undecided) were produced that reflect COVID-19 vaccine-specific concerns and attitudes. Interesting patterns in these topics were revealed which show that each of the three groups had a unique trajectory through the pandemic. The participants who had a high vaccination willingness in December 2020, still had initial concerns about the safety and efficacy of the vaccination in the beginning but were increasingly confident towards the vaccination over time due to trust in decision-makers and a high collective responsibility. The undecided participants were initially doubtful and reluctant but largely decided to get the COVID-19 vaccination with individual health considerations as well as social processes playing a role. The participants who disapproved vaccination at the beginning did not change their attitudes. In some cases, they even became more opposed to getting a vaccination due to a perceived unjustified social pressure and overall low confidence in decision-makers and vaccinations. Pathways on how to enhance vaccination willingness in the future are outlined like enhancing trust in the institutions that deliver and recommend vaccinations. Promoting vaccination willingness is a crucial element of public health endeavours by the German government and this study contributes to this aim by providing psychological insights underlying varying vaccination willingness to be able to better address hesitancy and opposition to vaccinations. Future research could further investigate why hesitant people decide in favour of vaccination due to social pressure while opposing people become even stronger in their rejection and how public health interventions could manage this tension.

*Keywords*: vaccination willingness, COVID-19, Germany, qualitative longitudinal research, topic modelling, LDA

## Introduction

The COVID-19 pandemic has caused a significant disruption in the daily lives of people worldwide. In many countries, restrictions were implemented fast and society came to a halt, leading to a need for adaptation to new norms and practises to combat the virus (Herbig et al., 2022). People around the world had to form attitudes and make sense of sudden societal changes and uncertainties. To fight the pandemic, the development of the COVID-19 vaccines has been a pivotal moment and from the perspective of epidemiologists and virologists vaccination was the most effective way to bring an end to the pandemic (Fontanet & Cauchemez, 2020). Further, it was early on considered that COVID-19 vaccinations are essential to reduce morbidity and mortality in the population (Swan et al., 2021). Accordingly, in Germany, vaccination against COVID-19 was highlighted as a crucial step to returning to normality by the government and a main strategy to control the detrimental effects of the pandemic (Bundesministerium für Gesundheit, 2020).

The effectiveness of the vaccination effort depended on the willingness of the population to be vaccinated (Anderson et al., 2020). However, before the official start of the German vaccination campaign in December 2020 decreasing levels of self-reported intentions to get a vaccine were observed (79% in April 2020 and 48% in December 2020) which increased again in the course of the next year in which vaccinations were made available for most German citizens (73% in April 2021 and 86% in September 2021 (incl. vaccinated people)) (COSMO, n.d.). These numbers illustrate that COVID-19 vaccination willingness fluctuated across the span of the pandemic and, even though a majority of the population was in favour, many people seemed to be hesitant or refused to receive a COVID-19 vaccination. The vaccination willingness is formed by people's attitudes and concerns towards the newly developed COVID-19 vaccines. To be able to understand vaccination willingness in Germany, how it changed over time and how it can be enhanced by addressing specific attitudes and concerns of undecided and opposing people, qualitative research is particularly useful. In this study, the attitudes and concerns influencing vaccination willingness during the COVID-19 pandemic between December 2020 and September 2021 are therefore investigated in-depth. Understanding individuals' attitudes and concerns towards a newly developed vaccine may help to understand diverse perspectives on vaccinations, to inform communication about vaccines, establish confidence in vaccinations and improve vaccination coverage.

At the background of lagging vaccination willingness during the first year of the COVID-19 pandemic, the topic of vaccination hesitancy became more and more important and was the focus of public and academic discourse (Herbig et al., 2022). The concept of vaccination hesitancy has been described and applied in numerous ways throughout the scientific literature. In the current study, we focus on the definition of Bussink-Voorend et al. (2022) who claim that vaccine hesitancy is a "psychological state of indecisiveness that people may experience when making a decision regarding vaccination" (p. 1639). Vaccine hesitancy is not a new phenomenon and has existed since vaccines were first introduced. In 2019, the World Health Organization even recognized vaccine hesitancy as

one of the top ten global health threats, following the rise of vaccine-preventable diseases, the introduction of new vaccines, the spread of misinformation about vaccination, and suboptimal vaccination coverage (Sweileh, 2020; WHO, 2019). Since 2020, the COVID-19 pandemic has further intensified the attention on the role of vaccine hesitancy in limiting vaccine uptake and lagging vaccination willingness (Dror et al., 2020). In the case of the COVID-19 vaccines, the concerns underlying hesitancy are likely to be more complex than with other vaccines as they were developed and approved faster than any other vaccine before (Ball, 2021). Moreover, the vaccination effort was organised and communicated by political decision-makers which led to tensions between individual autonomy and state power in many countries including Germany (Lange & Monscheuer, 2022).

Despite numerous studies conducted on the topic of vaccine hesitancy, research has primarily relied on survey data (Troiano & Nardi, 2021). While survey research offers a large number of respondents and helps identifying people's willingness to get vaccinated against COVID-19, it also limits the depth of the research. The COVID-19 pandemic presented a methodological opportunity to study the attitudes and concerns underlying vaccination hesitancy for a newly developed vaccine pre- and post-vaccination start. Therefore, it was possible to explore how people make sense of and form attitudes toward the newly developed COVID-19 vaccine and how concerns were shaped and fluctuated over time. Similarly, Fadda et al. (2022) argue that it does not matter solely whether one gets vaccinated (outcome of decision) but also how one decides to or not. An exclusive focus on the outcome of the decision may be limiting and the position that is constructed over time needs more attention. For example, Larson et al. (2011) emphasize that it is important to listen “to the concerns and understanding the perceptions of the public to inform risk communication and to incorporate public perspectives in planning vaccine policies and programmes”. Additionally, Fada et al. (2022) argue that people develop subjectively meaningful attitudes regarding the COVID-19 vaccination that do not always align with official recommendations. For example, a hesitant attitude towards vaccinations is not necessarily synonymous with being anti-vax. It is possible that an individual believes in the general effectiveness of established vaccines but has concerns about whether a specific newly introduced vaccine reduces the risk of a severe illness or infection (Sorell & Buttler, 2022). Altogether, attempting to understand hesitancy to vaccination by simply labelling it as a result of scientific ignorance or abnormal behaviour as it has been frequently done in public discourse is not a sufficient way to understand the complexity and specificities of the issue. Especially in a situation like a global health crisis in which attitudes have to be formed rapidly. To promote vaccinations, public health institutions and political decision-makers therefore need to understand and consider the coherent and diverse attitudes that underlie vaccination decisions (Fadda et al., 2022).

### 1.1 Vaccine hesitancy

Vaccine hesitancy can be seen as an attitude or motivational state, while vaccination is a behaviour that may or may not align with expressed attitudes toward vaccination (Brewer et al., 2017). Therefore, the act of getting vaccinated is distinct but not mutually exclusive form the attitude of vaccine hesitancy (Dubé et al., 2013). A person can, for example, "accept certain vaccines, refuse others, delay initiation, or accept, but feel unsure about doing so" (Walker et al., 2021, p. 3357).

Research conducted in high-income countries suggests that there are five main psychological determinants of vaccine hesitancy: Complacency, convenience, confidence, collective responsibility, and calculation (Betsch et al., 2018). These five determinants, called "5C's" in scientific literature, uniquely interact in every individual to create a dynamic psychological state somewhere along the continuum of full acceptance to full rejection. Betsch et al. (2018) note that the 5C's "provide insights in the individual, psychological antecedents and are not suitable to identify systems-related factors - beyond the effect they have on mental representations" (p. 7). *Complacency* describes the individually perceived risk of getting infected and becoming very sick, i.e., the extent to which one feels vulnerable and see vaccinations as necessary. Where risk perception is low, vaccination hesitancy increases (Dror et al., 2020). Concerning the COVID-19 pandemic, complacency was salient as populations experienced COVID-19 in different ways. Because the mortality rate for COVID-19 was initially low in some populations, especially the young, some individuals perceived COVID-19 as of low severity which negatively influenced vaccine willingness (Reiter et al., 2020). *Convenience* describes the individually perceived structural barriers in everyday life and whether vaccination is considered important enough to overcome these barriers. In Germany, for example, the convenience factor significantly predicts influenza vaccination (Betsch et al., 2018). The COVID-19 vaccinations were for some individuals, without reliable internet access or with low computer literacy, difficult to access despite being free because appointments oftentimes had to be made online (Iyasere et al., 2021). *Confidence* is an individual's level of trust in the effectiveness and safety of vaccinations, the health care system and the motives of decision-makers who decide which vaccinations are recommended (Lee et al., 2016). People who are willing to get a vaccine trust that the vaccine is needed, that it will work, and that it is safe (Freeman et al., 2020). Confidence remained critical as the COVID-19 pandemic has been characterized by shifting information that seeds doubt in science and medicine (Dib et al., 2021). For example, there is evidence suggesting that people's belief in misinformation about the virus, specifically their beliefs about the origin of COVID-19 (i.e., that it was manufactured), reduced their willingness to accept a vaccine (Lockyer et al., 2021). Quantitative studies have further established that COVID-19 vaccination willingness was predicted by various factors related to confidence, such as the quality of government COVID-19 communication, the source of the COVID-19 information, the evaluation of the governmental measures as useful and the adherence to them (Brailovskaia et al., 2021). Altogether, according to this framework, vaccine hesitancy can arise when an individual perceives a low need for vaccination due to a low risk perception (complacency),

questions a vaccination's efficacy or safety (low confidence), or faces obstacles to accessing a vaccination (convenience) (MacDonald, 2015). Researchers have recently further recommended two additional "C's". *Collective responsibility* describes an individual's willingness to protect others by getting a vaccine, for example, to contribute to the reduction of disease transmission through one's own vaccination and thereby protect young children or sick people indirectly. The flip side of this is free riding, i.e., the idea that others provide sufficient protection and that one can benefit from indirect protection but do not contribute to it in society (Betsch et al., 2018). *Calculation* describes an individual's enactment of extensive information searching that prompts evaluation of the risks of infections and vaccination to derive a reasoned decision (Betsch et al., 2018). However, the quality of information inputs can negatively affect decisions. Extensive information-seeking can expose individuals to repeated misinformation, after which they may miscalculate and remain vaccine-hesitant. Therewith, hesitancy has been associated with a poor ability to detect "fake news" (Montagni et al., 2021). Moreover, even if there is an increased desire to search for information and make a conscious decision, people who more extensively search for information do not show a higher ability to deal with statistics which could lead to misjudgements (Betsch et al., 2018).

### 1.2 Current study

While there are many quantitative studies on vaccine willingness based on large surveys, there are so far only a few studies that focus on in-depth interviews to explore the attitudes and concerns regarding COVID-19 vaccinations over time. Therefore, the present study investigates the concerns and attitudes regarding the COVID-19 vaccination among German citizens with different levels of vaccination willingness pre-vaccination start (pro/contra/undecided) in a time frame between December 2020 and September 2021 in which the vaccination against COVID-19 evolved from a state where it was still in development to its availability for all people in Germany. This can contribute to the understanding of the diverse concerns behind vaccine hesitancy and the reasons for getting or not getting a COVID-19 vaccination. Further, this research helps to identify enablers and barriers to vaccination uptake and provides valuable insights for planning vaccine programmes and therefore promoting the uptake of vaccines in the future.

## 2. Method

In this study, a mixed-methods approach was used that combined qualitative research with computer-assisted text analysis. Further, aspects of qualitative longitudinal research (QLR) were used to be able to illustrate the process of change over time. A significant advantage of QLR research is that data can be analyzed at various points in time (across several phases of interviews), providing insights into key topics across the entire sample. Additionally, QLR data can be analyzed over time, examining people's narrative across all waves of data collection to explore how key topics emerge and evolve (Shirani & Henwood, 2011). Elliot et al. (2008) refer to these two temporal dimensions as diachronic, meaning across several timepoints, and synchronic, meaning within a specific point in time. The longitudinal aspect of data collection further allows the researcher to tailor interviews for each participant based on their previous responses, gaining insightful data on how participants reflect back on their past thoughts and affects about vaccinations (Shirani & Henwood, 2011). Therefore, QLR provides the opportunity to investigate fluctuations and changes, allowing for an understanding of ongoing and sometimes evolving concerns about COVID-19 vaccinations (Shirani & Henwood, 2011).

### 2.1 Description of the larger study

The used dataset was collected within the longitudinal interview study *Trajectories of experience through the pandemic* (Herbig et al., 2022) that has been conducted as part of the larger project *Viral Communication* (viralcomm.info), exploring (changing) public attitudes and behaviours during the COVID-19 pandemic in Germany. The researchers of the Viral Communication study consider their data to be especially suitable for conducting qualitative longitudinal research and natural language processing techniques like topic modelling. Participants in the project's main nationally representative survey study were given the option to take part in three follow-up interviews. The semi-structured interviews were developed with the aim of exploring the responses in the project's main survey in more detail. They also intended to offer additional insights into topics and controversies related to the COVID-19 pandemic in Germany, like information/misinformation, trust/distrust, compliance, vaccination, and conspiracy beliefs.

From the main survey respondents (N = 1480), 278 respondents indicated their willingness to participate in the interview study. A purposive sampling approach was applied to select 40 interview participants aiming for a balanced sample concerning sociodemographic variables as well as attitudes and beliefs. For this purpose, two sets of selection criteria were employed to select the interview participants. The primary set of selection criteria included balancing age group, gender and socio-economic status (SES). SES categorization was based on the self-reported annual income, grouping participants into either a high SES (above the survey median) or low SES (below the survey median). Additionally, a second set of criteria was applied, focusing on attitudes and backgrounds such as the level of trust, migration background, vaccination willingness, and attitudes toward protective measures (i.e., wearing masks). Through this approach, it was ensured that the sample represented a wide spectrum of attitudes and beliefs across different sociodemographic groups in the Germany.

### 2.2. Participant selection current study

In the current study, the participants were split into three groups according to their vaccination willingness (pro/contra/undecided). In the selection process of the interview study, the participants indicated if they would 'definitely', probably', 'maybe', 'probably not' or 'definitely not' get vaccinated against COVID-19 on a voluntary basis. Participants met the selection criteria 'Pro vaccination' if they indicated that they would 'definitely' or 'probably' get vaccinated. The selection criteria 'Contra vaccination' was met when participants indicated that they would 'probably not' or 'definitely not' get vaccinated against COVID-19. If participants indicated 'maybe' they belonged to the 'Undecided' group. Overall, 20 participants were sampled for the 'Pro vaccination' group, 11 participants for the 'Contra vaccination' group and 9 participants for the 'Undecided' group. These three groups were used for the analysis in the current study. A summary of the sample characteristics at the start of the interview study can be seen in Table 1.

**Table 1**

*Sample characteristics*

| | | | Group | | |
|---|---|---|---|---|---|
| **Variable** | **Levels** | **n** | **Pro n=20** | **Contra n=11** | **Undecided n=9** |
| Age group | 16-29 years | 12 | 10 | 1 | 1 |
| | 30-44 years | 10 | 5 | 3 | 2 |
| | 45-59 years | 9 | 1 | 7 | 1 |
| | 60+ years | 9 | 4 | 0 | 5 |
| Gender | Female | 22 | 8 | 8 | 6 |
| | Male | 18 | 12 | 3 | 3 |
| SES | High SES | 20 | 13 | 3 | 4 |
| | Low SES | 18 | 7 | 7 | 4 |
| Trust | High trust | 13 | 13 | 0 | 0 |
| | Medium trust | 20 | 6 | 6 | 8 |
| | Low trust | 6 | 0 | 5 | 1 |

*Note.* N = 40. Adapted from Herbig et al.

## 2.3 Materials: interviews

Each participant was interviewed three times within a time span of 10 months (December 2020, April 2021, and September 2021), with the exception of two participants who dropped out of the study. All interviews were conducted in German either via the phone or Zoom. Initially, four pilot interviews were performed to ensure a good flow between questions and to guarantee that each interview lasted approximately 40 minutes aiming at a balance between sufficient detail and not excessively burden the participants (Herbig et al., 2022). The average duration per interview was 41 minutes in phase 1, 42 minutes in phase 2, and 45 minutes in phase 3. All interviews were conducted using a semi-structured interview guide with a fixed set of open-ended questions. The topics covered in the interviews were information/misinformation, trust/distrust in various political/scientific actors and institutions, compliance, vaccination, the cause of the outbreak, and conspiracy beliefs (Herbig et al., 2022).

In the current study, only the interview parts concerning vaccination were used in the analyses, namely questions 11 to 14 in timepoint 1, questions 14 to 19 in timepoint 2 and questions 10 to 17 in timepoint 3. Questions regarding vaccinations were for example, "[Do/did] you have any concerns about being vaccinated?" or "In your survey response, you mentioned that you'd [not] get a voluntary coronavirus vaccination. Could you explain why you're feeling that way?". For a full list of the interview questions used, see Appendix A.

## 2.4 Data Analysis

Using the selected interview answers from the data set by Herbig et al. (2022), topic modelling was employed to identify patterns and topics in the interviews. Then, the results of the computational analysis were further qualitatively analysed.

### *2.4.1 Topic modelling*

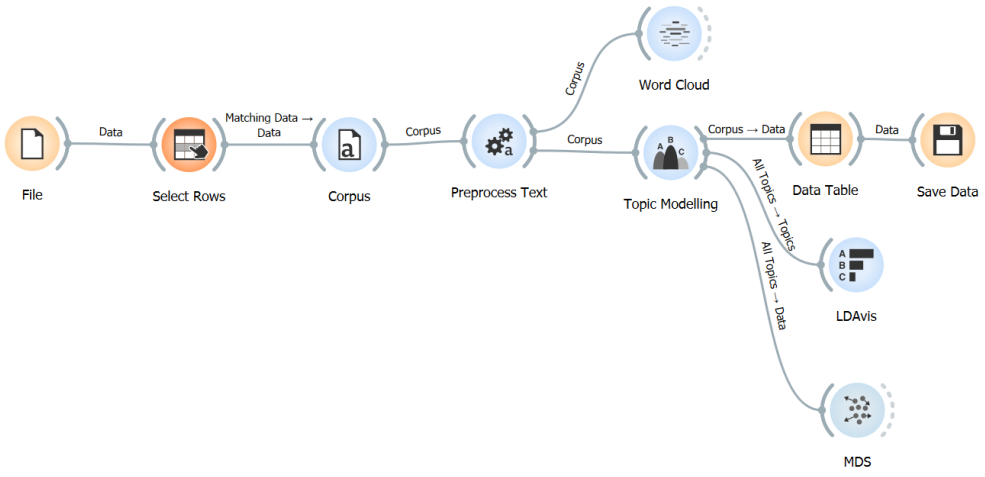
To analyse the data in a scalable and reproducible manner, a text mining approach was used. The term text mining refers to computer-assisted methods for extracting potentially valuable insights from extensive amounts of textual data (Schmiedel et al., 2019). As a specific form of text mining, topic modelling is a methodological approach for revealing global co-occurrence patterns in text corpora. These patterns are then assigned to a specific number of (previously unknown) categories that represent semantic connections and can be interpreted as topics (Blei et al., 2003). In topic modelling, abstract topics within a text corpus are identified by analyzing word clusters present in each document and their corresponding frequencies. Typically, a document encompasses several topics in different proportions and the model provides information on the weight of each topic per document. Latent Dirichlet Allocation (LDA), one of the most popular topic modelling algorithms, was performed to pursue text mining. LDA employs joint probability distributions to discover the "hidden structure" of topics within documents and words within topics (Tirunillai & Tellis, 2014). The approach is entirely statistical in nature which means it does not involve an analysis or interpretation of the context, grammar, or meaning of words. Instead, it focuses solely on the prevalence of words within the corpus

(Leeson et al., 2019). Therefore, the term “topic” does not necessarily correspond to an intuitive understanding of the term (Rüdiger et al., 2022). Because LDA captures texts based on statistical features, it sometimes produces topics that merely reflect linguistic features in the text. Therefore, the topics themselves have to be identified by manual labelling by the researcher after the application of LDA (Rüdiger et al, 2022). Overall, topic modelling can provide great utility in describing “the broad themes of a corpus (set of texts) and quantifying the degree to which a theme is present in a specific text” (Weston et al., 2023, p. 1). However, it is less useful in uncovering subtle nuances, which still require human coding (Weston et al., 2023).

This study utilized the Orange Data Mining Software version 3.35.0 (Orange, n.d.) to do the text processing and topic modelling. Orange is an open-source component-based visual programming package for data visualization, machine learning, data mining, and data analysis toolkit. Orange is a visual programming package, using an open-source approach and designed for tasks such as data visualization, machine learning, data mining, and data analysis. It builds data analysis workflows visually with a large and diverse toolbox (Demšar et al., 2013). On the visual interface of Orange, users can place pipeline components called widgets. Each widget provides fundamental functions, like reading the data, choosing data features or pre-processing the data. The pipeline used in this study can be seen in Figure 1.

**Figure 1**

The Orange pipeline used in this study




***2.4.1.1 Pre-processing.*** To prepare the data for the text analyses, several pre-processing steps were applied. It is important to consider that pre-processing can have considerable effects on the results (Müller-Hansen et al., 2021). First, the word files (.doc) were converted to text files (.csv) and then to excel files (.xls) in order to use the data in Orange. Also, non-verbal communication and metatext like “laughing” or “sighing” were deleted. Then, several standard pre-processing tasks were performed in Orange like the conversion to lowercase (transformation), the removal of stop characters such as

periods and commas (filtering) and the separation of the text into words (tokenization). Furthermore, other pre-processing steps were tested to evaluate if such steps contributed to the interpretability of the topics. Lemmatization or stemming to reduce duplicate topic terms was tested but not used for the final analyses because it did not enhance the topic quality in the German language. Stop words were removed using a list of 598 German standard stop words (Götze & Geyer, 2016). Stop words transport no meaning as they are so common that they can be removed without significantly changing the meaning of a text (i.e. articles and prepositions).

Additionally, for every timepoint, the standard list was customized to include terms that did not add to the interpretability of the topics. One difficulty of topic modelling is that topics are oftentimes too broad or too specific and therefore hard to understand. This is often caused by too many common words or too many specific words. As this study investigated vaccination hesitancy, the terms Impfung (vaccination), impfen (to vaccinate) and geimpft (vaccinated) were very frequent and led to overlaps in the topic keywords between the different topics. Also, these terms did not add information to the topics themselves because vaccination was the overarching topic in all interview parts used in this study. Therefore, they were removed to allow interpretability. The stop word removal is an iterative process as it can be difficult to identify all non-value-adding words before running the topic model (Asmussen & Møller, 2019). Therefore, several topic models were run involving adding and removing stop words to create the most suitable list for the analyses at each of the three timepoints. The customized stop words can be found in Appendix B.

A crucial, albeit challenging, last step of pre-processing is to identify the optimal number of topics to extract by LDA topic modelling. Topic modelling needs the researcher to set the number of topics before the analysis and therefore requires subjective decision-making informed by the data and research questions. According to Weston et al. (2023), there is no single correct number of topics for any corpus but several good options, each of which may be useful. In this study, coherence scores and exclusivity were used to evaluate the topic models. Topic coherence scores indicate how often the most probable words of a given topic co-occur close to each other in the texts (Korenčić et al., 2021). A good coherence score is associated with the interpretability of a topic indicating topic's correspondence to a single concept and human judgments of topic quality (Mimno et al., 2011). The value depends on the data that it is calculated from which means that a score of, e.g., 0.5 is good in one case but not acceptable in another. Therefore, a rule used in this study was to maximize the coherence score. Further, exclusivity was used to select an appropriate number of topics. According to Weston et al. (2023), a topic is considered exclusive when it is unlikely that its key words appear among the key words of other topics. Topics with very similar word distributions may have a high coherence score if their top words frequently co-occur in documents but low values for exclusivity indicating that the overall topic model contains redundant information and performs poorly in distinguishing between topics present in the text corpus.

In this study, the researchers narrowed down the ideal number of topics by plotting the coherence scores of models with three to twenty topics per time point. The coherence scores indicated optimal numbers of ten or more topics. However, the output was very difficult to interpret because many key words were associated with multiple topics (low exclusivity). As the data set in this study is rather small and the interview prompts specific it was therefore decided to choose five topics as the optimum number for timepoints 1 and 3 and four topics for timepoint 2. This maximized the difference in key words between the topics.

***2.4.1.2 Topic interpretation.*** A problem with interpreting topics solely using the key words is that common words in the corpus often appear near the top of key word lists for multiple topics. This makes it difficult to differentiate the meanings of the topics (Sievert & Shirley, 2014). Therefore, LDAvis was used to aid the interpretability of the topics and to infer topic meanings. LDAvis is an Orange implementation that is derived from the R package LDAvis by Sievert and Shirley (2014). It is a method that allows one to visualize words that occur with a high probability in a topic, weighting for words that do not appear frequently in other topics by setting a relevance metric. In this study, a metric of 0.6 was employed to visualize topic key words that were represented more commonly in the topic than in the general corpus (Noble et al., 2021). The LDAvis output revealed some more subtle detail identifying words. Especially, words that mostly appear in a single topic were useful for interpreting the meaning of a topic.

Further, the Orange widget Multidimensional Scaling (MDS) was used to create a low-dimensional projection of the topics as circles and to fit the distances between these circles (Abayomi-Alli, 2022). The area of each circle and corresponding values indicate the Marginal Topic Probability (MTP) of each topic in the corpus (Sievert and Shirley, 2014). The bigger the size of the circle, the stronger the topic is represented by the terms in the corpus (Abayomi-Alli, 2022). The proximity of the circles indicates shared words among topics and thereby how closely related topics are to each other (Shrader, 2021). In the current study, the MTP values were used to differentiate between small and big topics. A value of 0 means that a topic is not represented in the corpus at all and a value of 1 means that solely one topic is represented in the corpus.

### 2.5 Reflexivity statement

Text mining algorithms can create more consistent and reliable results than a human coder per hand. Nevertheless, in both computational and qualitative analyses, there is a high degree of subjectivity in the coding of open-ended interview responses (Yu et al., 2011) and in interpreting the output of a topic model. One way to deal with this subjectivity in the coding and interpretation process is to be reflexive. According to Olmos-Vega et al. (2023), “their subjective perspective (or “bias”) is fundamentally intertwined with qualitative research processes” (p. 241). Qualitative researchers can engage in reflexivity to account for how subjectivity shapes their research which can aid in making and communicating nuanced and ethical decisions throughout the research process (Olmos-Vega et al., 2023).

In this study, the research topic of COVID-19 vaccine hesitancy was chosen with the goal of getting a nuanced understanding of the reasons why people are pro, contra or undecided towards a COVID-19 vaccination *in order* to be able to counteract vaccine hesitancy in, e.g., future health crises. Moreover, this study was conducted by a person who is generally an advocate of vaccines and was a supporter of the newly developed COVID-19 vaccines during the pandemic. Especially in times of a crisis, it is, in the author's opinion, especially important to focus on the health of the entire population and to adopt a public health perspective that supports vulnerable people and protects from health hazards on a societal level. This perspective differs, for example, from one that focuses primarily on promoting individual autonomy and freedom of choice (Schoemaker et al., 2020). The author's position will probably, for example, influence the interpretation of the topic model results and the conclusions drawn from the results. However, it is believed that a shift from a 'top-down' approach with central planning by 'experts' towards engaging diverse perspectives and moving towards a dialogue is important to improve vaccination services and communication. This is in line with the aim of the researchers of the research project *Trajectories through the pandemic,* from which the dataset in this study is derived, which is to develop integrative and effective strategies to best mitigate the negative impacts of the pandemic. The researchers surveyed the population to actively involve them in the design process of countermeasures (bottom-up approach), giving civil society more co-determination rights and supporting solidarity-based behaviours (viralcomm.info).

## 3. Results

Overall, nine topic models were conducted. For each of the three subgroups, namely vaccination supporters, vaccination opponents and undecided participants one topic model was run at the three timepoints (December 2020, April 2021 and September 2021). In the following paragraphs, the topic modelling output and topic labels created by the researchers can be seen in the table. Furthermore, the topics are interpreted and contextualized.

### 3.1 Timepoint 1

Data collection for timepoint 1 took place in December 2020. At this time, the second wave of the COVID-19 pandemic was at its peak and severe restrictions were introduced like school closures, closing stores, and limited social contact (called "lockdown"). Additionally, measures such as mandatory masks on public transport were introduced. Despite those measures, the number of daily infections was rising and there were major concerns about the finite capacity of the health care system to treat people with severe cases of COVID-19 (Herbig et al., 2022). The German Hospital Federation reported instances where hospitals declined non-COVID patients and reached maximum capacity due to a shortage of hospital staff. In some states, the number of hospitalized COVID cases exceeded the levels observed during the springtime by factor five (Reif & Schubert, 2023). Concerning vaccines, on December 21$^{st}$, the European Commission authorized the BioNTech/Pfizer vaccine and the first

vaccines in Germany were administered from the 26th of December on prioritizing medical personnel and vulnerable groups (Herbig et al., 2022).

### *3.1.1 Pro vaccination group*

Throughout the group of vaccination supporters at timepoint 1, there is a consistent emphasis on a general trust in and support for vaccinations. They associate the hope of ending the pandemic with the COVID-19 vaccination and sometimes even see the vaccination as the only option to end the pandemic. Many participants believe that the vaccination is a good way to protect themselves and others. A main theme is also the comparison of the COVID-19 vaccination with vaccinations they already know and their vaccination behaviour in the past, especially with the Influenza vaccination (3 out of 5 topics are about Influenza vaccinations). Some participants are of the opinion that getting vaccinated is a social responsibility but think that mandatory vaccinations would have a negative impact on society.

**Topic 1: Influenza Vaccination Decision During the COVID-19 Pandemic.** Key words in this topic are “Grippe” (Influenza), “Risiko” (risk), “schwer” (difficult) and “Corona”. Overall, it seems to be about the Influenza vaccination decision during a time of a unique health crisis. A common theme that runs through the keywords and related text examples is that the participants are concerned with the risk of contracting both Influenza and COVID-19 which makes it necessary to assess the importance of vaccination not only for themselves but also for the whole society to reduce the burden on the health care system. For example, one participant wrote, “Yes, and I also believe that this [Influenza vaccination] also provides a certain degree of protection. Because if I have Influenza and then get a Corona infection, that will certainly be more serious than if I don't have Influenza.” (14, male, 60+).

**Topic 2: Influenza Vaccination and Personal Immunization.** Important key words in topic 2 are “Grippeimpfung” (Influenza vaccination), “Virus” (virus), “Grippe” (Influenza). Topic 2 is like topic 1 about the Influenza vaccination and further discusses individual perspectives about  One participant expresses a strong belief in the importance of vaccinations, considering them valuable for preventing diseases like . Another participant, however, is more sceptical and bases her vaccination decisions on the perceived strength of her own immune system. She says, “With the Influenza vaccination, for example, it makes sense for older people or people at risk with any pre-existing conditions. For me personally, the Influenza vaccination made no sense because, as I said, I have a very good immune system, thank God. I think I could get over the flu quite well” (35, female, 30-44).

**Topic 3: Voluntary Vaccination and Freedom of Choice.** Key words in topic 3 include terms like “freiwillig” (voluntary), “geimpft” (vaccinated), “Bevölkerung” (population) and “Prozent” (percent). One participant, for example, discusses the potentially negative impact of mandatory vaccinations on the protest movement in Germany and advocates voluntary vaccinations which, in his eyes, are sufficient to reach a critical percentage of vaccinated people to control the pandemic. Overall, the topic revolves around the balance between individual freedom and the collective need to

manage a pandemic through vaccination strategies. Several participants emphasize that vaccination decisions should be made willingly without coercion and the importance of personal freedom in making vaccination decisions.

**Topic 4: Influenza Vaccination Decision (Workplace).** Topic 4 is the topic with the lowest MTP and therefore a rather small topic in the corpus. Key words like “Entscheidung” (decision), “Grippe” (Influenza), “persönliche” (personal) and “Arbeit” (work) indicate that the topic is about Influenza vaccination decisions in the context of the workplace. For some individuals, the COVID-19 pandemic prompted them to get an Influenza vaccination for the first time. For example, one participant talks about the experience of getting vaccinated at the workplace. She explains her personal decision to not get an Influenza vaccination for a long time because she had not experienced severe infections in the past and does not belong to a risk group. However, as she works in a health care facility, she recently got vaccinated because she now views Influenza vaccinations as a way to potentially reduce the additional burden on hospitals and doctors during the pandemic.

**Topic 5: Confidence in Vaccinations in the Fight Against Infectious Diseases.** Topic 5 is the topic with the highest MTP and is therefore strongly represented in the corpus of this group. In this topic, an overall very positive sentiment is expressed regarding vaccinations. Several participants express high trust in regulatory authorities and pharmaceutical companies. This is also reflected in the key word “gut” (good) which is oftentimes used in the context of expressing a favourable opinion about vaccinations. For example, one participant says, “I think vaccination is a fundamental scientific achievement that we have researched over the last 100 years and, in my opinion, we have come a long way. A lot of research is being done in this direction. I now have the utmost confidence in the relevant regulatory authorities that they will not release a substance onto the market that will cause people to die en masse. And then I would say that the EMA [European Medicine Agency] is well positioned. It knows what it's doing. And I think the two companies are also more interested in bringing a well-functioning vaccine onto the market that also works” (33, male, 16-29). Another participant mentions that she struggles sometimes to remain confident in vaccinations in the face of negative opinions and panic but highlights the importance of scientific advancements in vaccines.

**Table 2**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the pro vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.10 | grippe, thema, risiko, beispiel, sage, schwer, macht, generell, deutlich, corona | Influenza Vaccination Decision During the COVID-19 Pandemic |
| 2 | 0.13 | grippeimpfung, gesagt, gemacht, virus, wahrscheinlich, beispiel, zwei, grippe, relativ, bekommen | Influenza Vaccination and Personal Immunization |
| 3 | 0.23 | denke, gemacht, leute, menschen, geimpft, freiwillig, sehe, nebenwirkungen, prozent, bevölkerung | Voluntary Vaccination and Freedom of Choice |
| 4 | 0.04 | wahrscheinlich, moment, entscheidung, grippe, persönliche, gemacht, gewisser, jahr, arbeit, gedacht | Influenza Vaccination Decision (Workplace) |
| 5 | 0.48 | leute, grippe, geht, fall, geimpft, beispiel, corona, gut, generell, impfungen | Confidence in Vaccinations in the Fight Against Infectious Diseases |

### *3.1.2 Contra vaccination group*

The main concerns of the vaccination opponents revolve around the side effects and effectiveness of the COVID-19 vaccination due to its rapid development. Doubts about the Influenza vaccination are mentioned and a natural immunization is oftentimes preferred to a vaccination. Moreover, several participants have an unfavourable opinion on mandatory vaccinations for children and on a potential mandatory vaccination for COVID-19.

**Topic 1: Mandatory vaccination in kindergarten.** Keywords like “Kind” (child), “Pflicht” (obligation), “Kindergarten” (kindergarten), “Arte” are associated with discussions around mandatory vaccinations for children. One participant expresses a lack of understanding of the mandatory measles vaccination in kindergarten in Germany: “For example, if […] I don't vaccinate my child, but all the other children are vaccinated at the kindergarten. What danger do I pose? Why can't my child go to kindergarten?” (24, female, 45-59 years). Another participant also expresses a negative opinion on the mandatory vaccination of measles in kindergarten and his belief that there will be some sort of vaccination requirement for COVID-19 in the future without being explicitly mandatory.

***Topic 2: Concerns about Influenza Vaccination.*** In this topic, the participants express their reservations about vaccinations and their overall reluctance to get vaccinated against Influenza and COVID-19. Their concerns revolve around the safety and efficacy of vaccines, potential side effects, and the speed of vaccine development. For some, prior personal experience with an adverse side effect from a vaccine shaped their evaluation. This is reflected in key words like “krank” (ill), “Hirnhautentzündung” (meningitis) and “Tochter” (daughter) and related text examples from the

participants. One participant mentions two personal negative experiences with vaccinations. One experience involves her father who, according to the participant, became ill for 14 days after receiving an Influenza vaccination which already left her skeptical about vaccinations. Another experience was that her daughter allegedly suffered from meningitis at the age of three years following a meningitis vaccination. This personal experience further fueled her concerns about vaccine safety. Moreover, she is of the opinion that a mandatory vaccination against meningitis in Bergamont led to the many deaths in this city at the beginning of the COVID-19 pandemic.

***Topic 3: Concerns about Long-Term Effects of Vaccinations.*** Topic 3 seems to be about the participant's concerns about the long-term effects of vaccinations as indicated by the key words "Impftstoff" (vaccine), "Wahrscheinlichkeit" (probability) and "Langzeitfolgen" (long-term effects). One participant expresses scepticism about the COVID-19 vaccine due to its rapid development and is worried about potential long-term effects, which could be cancer or neurological disorders in his eyes. Some participants see the COVID-19 vaccine rollout as an experiment in which they do not want to participate in. Moreover, the same participant contrasts his openness to the Influenza vaccination with his scepticism about the COVID-19 vaccine: "When it comes to Influenza vaccines, I'm not as critical as I am now with the Corona vaccine. Because, as I said, Influenza vaccines have been in use for years. If there were serious side effects, we would know about them by now. That's why I wouldn't tell anyone who says I'm getting the Influenza vaccine to reconsider. If someone said, I'm getting vaccinated against Corona tomorrow […] I would say, man, are you really sure you want to do this?". Thus, overall, the topic seems to delve into the worries surrounding the unknown or potential lasting effects of getting vaccinated against COVID-19.

***Topic 4: Mandatory Vaccination and Travel Restrictions.*** Topic 4 is with a MTP of 0.10 the topic with the lowest prevalence in the corpus. The key words "Urlaub" (vacation), "lässt" (allow) and "Impfpflicht" (compulsory vaccination), and related text examples are about mandatory vaccinations and how these could affect travel plans in the future. One participant speculates that some countries may require proof of vaccination to enter the country which raises the dilemma for him to choose between getting vaccinated or forgoing to travel to that country, "that you can only go on vacation or do certain other things if you are vaccinated. I wouldn't like that." (6, male, 30-44 years).

***Topic 5: Side-effects of COVID-19 vaccine.*** Topic 5 has a MTP of 0.36 and is therefore the topic with the highest prevalence in the group of vaccine opponents. The participants express several concerns about potential side-effects of the COVID-19 vaccine as shown by the key words "Impfstoff" (vaccine) and "Nebenwirkungen" (side effects). A participant is worried about unknown long-term effects due to the lack of extensive research. She further compares the COVID-19 vaccine with past cases where seemingly safe medications later had adverse effects: "But I don't know what the long-term effects are because it simply hasn't been researched. And then I think of things like Contergan and so on. That was also a supposedly safe drug and then it turned out afterwards that it wasn't." (39, female, 45-59). Another participant also expresses scepticism due to the speed of COVID-19 vaccine

development and potential side-effects. Moreover, she questions the necessity of exposing a large population to these side-effects when, according to her, only the elderly and people with pre-existing conditions are affected by the virus. She feels for the people who are at risk of dying but thinks it is in a normal range.

**Table 3**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the contra vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.13 | corona, kind, arte, geben, fahre, pflicht, kindergarten, grippe, virus, jahr | Mandatory Vaccination in Kindergarten |
| 2 | 0.26 | gesagt, geimpft, grippe, leute, möchte, tochter, drei, pflicht, krank, hirnhautentzündung | Concerns about Influenza Vaccination |
| 3 | 0.13 | corona, grippe, impfstoff, getestet, wahrscheinlichkeit, langzeitfolgen, erkranke, krankheit, kriegt, wahrscheinlich | Concerns about Long-Term Effects of Vaccinations |
| 4 | 0.10 | gut, urlaub, denke, darf, nebenwirkungen, lässt, impfpflicht, wahrscheinlich, sagt, grippe | Mandatory Vaccination and Travel Restrictions |
| 5 | 0.36 | grippe, impfstoff, geht, virus, leute, gut, nebenwirkungen, geimpft, menschen, denke | Side-effects of COVID-19 vaccine |

### *3.1.3 Undecided vaccination group*

The undecided group is characterized by an ambivalence toward vaccination-related topics. They are not fundamentally against vaccinations but have especially many concerns about the fast development of COVID-19 vaccines and resulting safety and efficacy issues of the vaccine. The sentiment that normal procedures were bypassed in the rush for a vaccine was quite common. Overall, many participants have a tendency towards getting vaccinated but do not want to be the first to get one because of the perceived risks and a perceived information shortage. They want to wait until it is administered to other people to evaluate if it is safe enough.

**Topic 1: Ambivalence towards COVID-19 vaccine.** The participants express several different ambivalences in the text examples of this topic. One participant expresses personal doubts about the COVID-19 vaccination while at the same time advocating mandatory vaccinations. He is aware of the contradiction himself but thinks that mandatory vaccination could be necessary to overcome the challenges posed by the virus itself and by widespread delays in vaccination decisions and vaccination hesitancy like his. The key words “Stand” (state) and “Jahr” (year) are about another participant who says concerning a vaccination decision: “Well, certainly not in the next six months. Maybe next year. Anything beyond that, I'm more open to it. But at this state, I would say no.” (25, male, 30-44 years). He is not fundamentally against vaccinations but thinks it is unreasonable to get a

vaccine that, in his eyes, has not been sufficiently tested. Therefore, he postpones the decision to get vaccinated to a later point in time.

**Topic 2: Safety and Efficacy Concerns.** The key words “Angst” (fear), “schnell” (fast), “Nebenwirkungen“ (side effects) and „Erfahrung“ (experience) once more indicate concerns about the fast development of COVID-19 vaccines and the resulting doubts about their safety and effectiveness. One participant, for example, has medical pre-conditions and is fearful that the vaccines are not sufficiently tested for people like her. Because of such vaccine concerns, several participants pursue a cautious approach to the COVID-19 vaccine, e.g., “I'll wait and see, and […] the others are already gaining experience in the meantime. They already have experience […] what side effects it might have. I think to myself that by the time I get the chance and am invited […] I'll be able to undergo the vaccination without fear or anything like that.” (34, female, 60+ years).

**Topic 3: Influenza Vaccination Attitudes.** The key words of this topic, namely “Grippe” (flu), “gehabt” (experienced), “Influenza” (Influenza) and “Kinder” (children) are mainly used by two participants who have differing attitudes towards Influenza Vaccination. One participant recounts a childhood experience with a severe Influenza infection and contrasts this experience with having minimal symptoms a few years ago when he got Influenza. He is now reluctant to get vaccinated against Influenza because he believes he is immune to it because of his childhood experience. Another participant describes past experiences of getting vaccinated against Influenza which resulted in severe cold symptoms each time. As a result, she stopped getting vaccinated in the past. However, given the pandemic and the fear of getting Influenza and COVID-19 at the same time, she reconsidered vaccination.

**Topic 4: Concerns about Fast Development and Safety.** Topic 4 is according to the MTP the most prevalent topic in the corpus of undecided people. Keywords like “Impfstoff” (vaccine), “Risiko” (risk) and expressions from participants like “nicht erprobt” (not tested) suggest that there are concerns about the safety of the COVID-19 vaccination. Again, the speed of the development is one main concern of the participants: “But of course you have a bit of doubt because it is a vaccine that is being developed at record speed, several vaccines that are being developed at record speed. Of course, you can't know the long-term consequences. It's impossible because it would have to be tested for years and not just a few months.” (9, male, 60+ years). Further, like in topic 2, these concerns lead to a cautious attitude towards the COVID-19 vaccine and a preference to wait until the vaccine is tested for a longer period.

**Topic 5: Opinions on Mandatory Vaccination.** The keywords “Impfpflicht” (mandatory vaccination) and “entscheiden” (to decide) are used in a context in which several participants express their opinion about potential mandatory COVID-19 vaccinations. One participant thinks that there will be no mandatory vaccination because no decision-maker will have the courage to enforce it because of residual health risks of a COVID-19 vaccination. However, he thinks that there will be “a pseudo compulsory vaccination, so that certain companies, like airlines, will say, okay, we'll only take people

who have been vaccinated" (28, male, 45-59 years). Another participant has doubts about the implementation of mandatory vaccination for COVID-19 because there are already parents who are resisting mandatory vaccinations for childhood diseases. She therefore believes that unless issues like these are resolved, a mandatory vaccination is not realistic. A third participant further thinks that mandatory vaccinations could have positive effects and that even though there would be a few victims of the vaccines, overall, the total mortality would decrease. In total, these participants do seem to have a neutral or even positive opinion on mandatory vaccinations.

**Table 4**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the undecided vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.22 | gemacht, wahrscheinlich, möchte, impfe, entscheiden, gesagt, stand, seite, jahr, gut | Ambivalence towards COVID-19 vaccine |
| 2 | 0.11 | denke, angst, geimpft, lange, erfahrung, getestet, passiert, schnell, grippe, nebenwirkungen | Safety and Efficacy Concerns |
| 3 | 0.21 | grippe, gehabt, influenza, denke, virus, zwei, kinder, leben, jahre, gehen | Influenza Vaccination Attitudes |
| 4 | 0.32 | gesagt, impfstoff, gut, sage, leute, risiko, geht, jahr, menschen, grund | Concerns about Fast Development and Safety |
| 5 | 0.13 | schnell, heute, impfpflicht, moment, irgendwelche, geimpft, leute, risiko, entscheiden, impfstoff | Opinions on Mandatory Vaccination |

### 3.2 Timepoint 2

Data collection for timepoint 2 was conducted in April 2021, at a time in which COVID-19 cases remained consistently high in Germany. Vaccinations were still not available to everyone and were prioritised based on criteria such as age, health status, and occupation. The vaccinations with the AstraZeneca vaccine started with difficulties. On the 15th of March, the use of the AstraZeneca vaccine was suspended due to reports of rare but serious blood clots. A few days later, on the 19$^{th}$ of March, the AstraZeneca vaccination was resumed in Germany until the 30$^{th}$ of March but only for people over the age of 60. On the 6$^{th}$ of April, the AstraZeneca vaccine was made available to the entire population, regardless of prioritization (Herbig et al., 2022). At the beginning of April, 11.6% of the population had received at least one vaccine shot, and by the end of April, this number had increased to more than 25%. Despite increased vaccination efforts, new infections remained at a high level (Herbig et al., 2022).

### *3.2.1 Pro vaccination group*

In timepoint 2, this group often acknowledges a residual risk due to the fast development of COVID-19 vaccines but regards the benefits higher than the risks, e.g., “So if I were offered a vaccination, I would most likely accept it. And yes, I still have a lot of trust in the testing institutions that they know what they're doing. Although in the last few weeks there has always been this discussion that there are complications or that some things have been revised or restricted to certain age groups.” (male, 16-29 years) or “So it's definitely not just like the flu, it's much more dangerous. It also has, there are also these, there are now more and more findings on the long-term effects of this Long Covid and things like that. So, if you sort of balance that out and put it on the table, then you can't really be reasonably against vaccinations” (male, 60+ years). Vaccination supporters continue to have high levels of trust in vaccinations and the scientific institutions that are testing the vaccines. However, many participants are concerned about the low public trust and therefore potentially low vaccination uptake in parts of society which is reflected in topic 4.

**Table 5**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the pro vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.29 | astrazeneca, gut, beispiel, virus, leute, impfungen, jahr, biontech, wissen, sieht | Balancing Risks and Benefits of Vaccination |
| 2 | 0.23 | risiko, gut, zwei, impfungen, nebenwirkungen, beispiel, wochen, richtig, leute, gerne | Vaccination Risks/Impact on Society |
| 3 | 0.27 | gut, bedenken, astrazeneca, schnell, biontech, anfang, relativ, richtig, wahrscheinlich, menschen | Rapid Development |
| 4 | 0.20 | fall, leute, menschen, astrazeneca, gut, informationen, wissen, gerade, wahrscheinlich, nebenwirkungen | Public Trust/Vaccination Uptake |

### *3.2.2 Contra vaccination group*

In timepoint 2, there is rising dissatisfaction with the government and distrust in the pharmaceutical industry. Attitudes towards vaccinations and particularly towards the COVID-19 vaccine are still mainly negative, first and foremost because of fears of potential short- and long-term side effects like potential thrombosis from the AstraZeneca vaccine. Other reasons for not getting vaccinated that are mentioned less frequently are the fact that vaccination does not offer 100% protection and that natural immunization is preferred. Many participants voice suspicions about the influence of the pharmaceutical industry in driving vaccination efforts and there is concern about profit motives and potential conflicts of interest, e.g.,” Because it's obvious how vaccination is now being pushed through. Against all resistance, against all reservations, it is simply being pushed through. And whether it was a plan that already existed beforehand, whether it was a case of the

vaccination advocates, the pharmaceutical industry, whoever jumped on the bandwagon and used the opportunity, I can't judge that." (male, 45-59 years). Another new topic in comparison to timepoint 1 is that some participants see no duty to potentially contribute to the common good of society and that everyone is responsible for themselves, e.g., "First of all, I would say that I have no duty to protect other people. I have a duty to protect my own life. I am not responsible for the lives of others. And I can't expect others to endanger their lives with a vaccine just so that others can be saved." (female, 45-59 years).

**Table 6**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the contra vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.34 | leute, impfstoffe, kriegen, wahrscheinlich, astrazeneca, wissen, leben, egal, virus, nebenwirkungen | Dissatisfaction with Government Response/Concerns about Vaccination |
| 2 | 0.24 | leute, möchte, corona, regierung, mann, gut, macht, bedenken, geld, pharmaindustrie | Distrust in Government and Pharmaceutical Industry |
| 3 | 0.20 | gut, nebenwirkungen, langzeitfolgen, leute, verstehen, heißt, weit, mache, auftreten, gefährlich | Concerns about Side Effects |
| 4 | 0.21 | leben, leute, schützen, darf, impfungen, möchte, dürfte, braucht, bekommen, zwei | No Obligation to Protect Other's Life |

### *3.2.3 Undecided vaccination group*

During the second round of interviews, most participants are in favour of the vaccine due to various reasons like the re-considerations of risks, the evolving nature of information, the regain of personal freedom through vaccinations and personal experiences with the virus or the vaccination. Participants especially reported indirect experiences with COVID-19 that provided risk-related motivation to vaccinate. Exemplarily, two participants say, "Yes, and above all, you sometimes see in reports what it looks like in the hospital wards, how sick corona patients lie there, how they have to be rolled around. And that even if you survive the illness for the time being, the after-effects can still be enormous and that a normal life is not necessarily possible afterwards. So there's no guarantee of that. And then I thought to myself, maybe the vaccination is the smaller problem." (female, 60+ years) and "Simply, that would be the ticket to a bit more normality and freedom. (laughs) Yes, although I don't know of any personal cases that have turned out so blatantly, but it does worry me what's going on at the moment. If you can do your bit by getting a little injection like that, then that's fine." (female, 16-29 years). Two topics which are new in timepoint 2 and reflect the pandemic situation in Germany at this time are a dissatisfaction with the vaccination distribution and the uncertainty regarding the safety of the AstraZeneca vaccine. The unclear communication regarding the AstraZeneca vaccine causes

uncertainty for some participants and leads to a negative stance towards getting a vaccination, e.g., “Yes, this fuss about vaccines. The vaccine is good and it's not good or it only helps or it only has 80%. These are all things that I just can't see through clearly. If I can't see clearly and someone wants to inject something into my body and I don't know what the result will be. I mean, you've seen that really intensively with AstraZeneca. This is my body (laughs). Nobody can give me the certainty that it will work properly for me and won't cause any harm.” (female, 60+ years). As a result, there is a desire for more clarity about vaccine options and associated risks among some participants.

**Table 7**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the undecided vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.21 | gut, leute, nebenwirkungen, irgendwelche, johnson, entscheiden, bekommen, nehme, kriege, möchte | Individual Decision-Making about COVID-19 Vaccination |
| 2 | 0.25 | hauptgrund, zwei, wochen, teilweise, biontech, nebenwirkungen, bekommen, praxis, leute, ging | Vaccination Distribution |
| 3 | 0.27 | gut, astrazeneca, wissen, nebenwirkungen, virus, impfungen, leute, läuft, vertrauen, menschen | Evolved Trust in Vaccination |
| 4 | 0.26 | dürfen, astrazeneca, bekommen, gerne, abgesagt, kriege, worden, beispiel, termine, gerade | Uncertainty regarding AstraZeneca |

### 3.3 Timepoint 3

Data collection for timepoint 3 took place in September 2021. At this time, vaccines were available to all adults and 84% of the German population had received at least one dose of vaccination (Herbig et al., 2022). From the 23rd of August on, the so-called 3G rule gave those who were vaccinated more freedom in their daily lives to, e.g., visit restaurants or events again. The case numbers were comparatively low, leading to a shift in public discourse towards discussions on the "Re-opening" of society and the implementation of mandatory vaccination (Herbig et al., 2022). On September 26th, federal elections were held in Germany, resulting in a change of government after the 16-year-long chancellorship of Angela Merkel.

#### *3.3.1 Pro vaccination group*

In timepoint 3, most of the participants in the group have been vaccinated and the main topic is no longer their own vaccination decisions but concerns about the state of society. This becomes evident in the new topic 2 “Individual Responsibility in the Community” and topic 5 “Societal Impact of Vaccinations and Measures”. Many participants emphasize the idea that individuals have a role to play in addressing the pandemic, such as considering vaccination, taking tests, and following public health guidelines. At the same time, some participants see a division within society between people

who got vaccinated and people who did not, creating a "two-fronts" mentality where one group may feel disadvantaged or stigmatized compared to another. There is also a recognition of the role of social pressure in influencing individual decisions about vaccination. This social pressure can act in their opinion as a motivator for vaccination for some but also as a source of concern for those who feel hesitant. Furthermore, the concept of feeling responsible for the health and well-being of others and the broader community is evident, e.g., “We are a solidarity-based community in Germany, which means that everyone has to contribute to the common good. In my opinion, restricting the basic rights of people who have been vaccinated is no longer acceptable” (male, 16-29 years). Some participants are even frustrated and have little understanding for non-compliers: “My freedom ends where someone else's freedom is restricted, and that's something you have to think about, everyone has to think about. I think the world would look a little different then” (male, 60+ years). One thing that has not changed since timepoint 1 and 2 is the favourable opinion for vaccination, believing that it has been successful in reducing the impact of the pandemic.

**Table 8**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the pro vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.22 | glaube, gut, maske, testen, menschen, gemacht, geimpften, macht, beispiel, letztendlich | Opinions on Vaccination and COVID-19 Measures |
| 2 | 0.19 | gerade, menschen, gut, risiko, treffen, gehen, maske, relativ, leben, abstand | Individual Responsibility in the Community |
| 3 | 0.11 | gut, impfstoff, glaube, fühle, corona, worden, genauso, angst, vorbehalte, menschen | Global Equity |
| 4 | 0.19 | biontech, impfstoff, gut, glaube, fall, nebenwirkungen, beispiel, impfstoffe, moderna, astrazeneca | Vaccination Preferences (and gained Personal Safety) |
| 5 | 0.27 | gut, glaube, tests, sage, menschen, gerade, test, beispiel, gesellschaft, impfstoff | Societal Impact of Vaccinations and Measures |

### *3.3.2 Contra vaccination group*

In timepoint 3, important new topics are a perceived pressure to receive a vaccination and perceived exclusion due to the personal vaccination status. For example, for some participants it is a burden that they are not allowed to access some services anymore without being vaccinated and they feel stigmatized. They still doubt the safety of vaccines and it seems that the pressure to get vaccinated acts as a drawback for participants because they feel like their personal autonomy is impaired, e.g., “Well, how voluntary is that? I mean, there's a group that says I'm going to get vaccinated because otherwise I won't be allowed to go to the movies. The word ‘health’ is completely missing. It's: if you don't do what I want, then you're not allowed to do it anymore. It's like a child: you do your

homework, then you get something tasty. It's almost a matter of being raised and that has nothing to do with free choice." (female, 45-59 years). Overall, at this timepoint, most of the participants stated that they were uncomfortable with the social and political pressure on them and it seems that this pressure creates more resistance to being vaccinated.

**Table 9**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the contra vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.22 | pause, tests, astrazeneca, gut, glaube, kriegen, corona, test, testen, leben | Social Exclusion due to Vaccination Status |
| 2 | 0.23 | gedacht, geimpfte, panne, möchte, glaube, passiert, wahrscheinlich, pause, jahren, geworden | Vaccination Scepticism/Concerns about Societal Division |
| 3 | 0.17 | bekommen, nebenwirkungen, beweisen, glaube, gut, fall, schützt, kinder, jahr, geimpfte | Vaccination Skepticism |
| 4 | 0.21 | kinder, testen, test, beispiel, gut, krank, corona, virus, vorbei, leben | Skepticism against Vaccination (for Children) and Measures |
| 5 | 0.16 | corona, passiert, zwei, gefahr, ungeschützt, ungeimpften, macht, getestet, bevölkerung, drei | Perceived Pressure to Receive Vaccination |

### *3.3.3 Undecided vaccination group*

In timepoint 3, the participants reflect on their vaccination decision which is mostly in favour of getting a vaccination: "By April I was actually already convinced that I wanted to be vaccinated. At the very beginning, if we go back, one year ago, when the first vaccinations came, that was December, I still had some doubts because it was something totally new, also in terms of the method with this BioNTech vaccination. There was still a bit of doubt but then I saw that […] it works and the people who are vaccinated don't die. Then I was very quickly convinced. I've always been convinced that most vaccinations make sense" (male, 60+ years). Another participant says in a similar vein that she has no fear anymore that the vaccination will have strong negative consequences and some vaccinated participants feel more relaxed since they are vaccinated, especially when being among large groups of people again. Concerning a mandatory vaccination, the opinions in this group at timepoint 3 are diverse. One participant expresses opposition to the 3G approach and criticises it as hypocritical. He is open to a mandatory vaccination but suggests that there should be a clear mandate rather than a gradual implementation that restricts the unvaccinated from social life. Another participant shares their personal experience of having the decision to get vaccinated essentially made for them due to a family member's health condition. Despite lacking a personal choice, she expresses relief and a willingness to get vaccinated for the community's well-being and a return to normalcy.

**Table 10**

*Top-10 key terms, Marginal Topic Probability (MTP), topic labels for each of the 5 topics for the undecided vaccination group*

| Topic | MTP | Key words | Label |
|---|---|---|---|
| 1 | 0.18 | glaube, gehen, sagt, impfstoff, beispiel, kinder, gut, getestet, moment, schlecht | Vaccination Concerns |
| 2 | 0.15 | glaube, astrazeneca, persönlich, überzeugt, biontech, gehen, frage, gut, anfang, gehe | Personal Vaccine Decision and Confidence |
| 3 | 0.24 | impfpflicht, bekommen, fühle, schwierig, möchte, beste, nebenwirkungen, sicherer, gerade, gut | Differing Opinions on Mandatory Vaccinations |
| 4 | 0.24 | menschen, glaube, gefühl, museum, frage, sagt, gemacht, anstecken, pandemie, gehen | Experiences with the Re-opening |
| 5 | 0.18 | test, zahlen, entschieden, rein, druck, fall, gehe, mache, astrazeneca, unangenehm | Doubts about Government Decisions |

## 4. Discussion

The current study aimed to investigate the attitudes and concerns towards the COVID-19 vaccination to better understand the fluctuating vaccination willingness during the COVID-19 pandemic in Germany in a time frame between December 2020 and September 2021 and improve future public health campaigns for vaccinations. The participants with high vaccination willingness in December 2020 were initially sceptical about the safety and effectiveness of the vaccination, but as time went on, their confidence in vaccinations grew because of trust decision-makers and a high collective responsibility. The undecided participants were hesitant and doubtful first but mostly made the decision to receive the COVID-19 vaccination due to a combination of social and personal factors. The participants who disapproved vaccination at the beginning did not change their attitudes. In some cases, they even became more opposed to getting a vaccination due to a perceived unjustified social pressure and overall low confidence in decision-makers and vaccinations. In the following, the evolving perspectives on vaccinations of each of the three groups are outlined in more detail and important attitudes and concerns underlying their differing vaccination willingness are discussed.

### 4.1 Main findings

The pro vaccination group had a high willingness to get a COVID-19 vaccination before the start of the vaccination campaign in Germany which is also reflected in a general trust in and support for vaccinations during the first interview phase in December 2020. Moreover, in line with official announcements from the federal government, they see the COVID-19 vaccination as the best option to end the pandemic and as a good way to protect themselves and others. However, the pro vaccination group is not completely without concerns regarding the COVID-19 vaccines as they often mention

residual worries about the safety and efficacy of the vaccines due to their fast development. During the second interview phase in April 2021, the discourse in this group shifted from reflecting on past vaccinations to a risk-benefit assessment concerning the COVID-19 vaccine which results in favour of getting a vaccination. Reasons are the perceived personal risk of getting infected and becoming very sick and high trust in scientific institutions which outweigh the perceived risks of the COVID-19 vaccine during the first interview phase. Already in April 2021 (timepoint 2), the concern is mentioned that low public trust in parts of the society could lead to a overall low vaccine uptake. In September 2021, vaccination supporters mentioned frustration about unvaccinated people and tend to have negative views about non-compliers. Individual responsibility in the community is important to most participants in this group and they feel responsible for the health and well-being of other people.

In the undecided group, one can see how initial COVID-19 vaccine hesitancy is overcome by most participants. In December 2020 (timepoint 1), the undecided group is characterized by an ambivalence toward vaccinations. They are like the other groups concerned about the safety and efficacy of COVID-19 vaccines because of their fast development. Furthermore, they have a tendency towards getting vaccinated but do not want to be the first to get one because of the perceived risks and a perceived information shortage. In the second interview phase in April 2021, most participants are in favour of the vaccine due to various reasons like the re-considerations of risks, the evolving nature of information, the regain of personal freedom through vaccinations and personal experiences with the virus or the vaccination. However, one source of worry and uncertainty is the safety of the AstraZeneca vaccine and the unclear communication regarding the vaccine. In September 2021 during the third interview phase, individual factors motivating them to receive the COVID-19 vaccine were linked with a strong social component like contributing to the re-opening of society, comfortable social contact and a positive attitude towards vaccination mandates of some participants.

The main concerns of the vaccination opponents in December 2020 (timepoint 1) are about the side effects and effectiveness of the COVID-19 vaccination. The participants mostly do not specify these concerns about the vaccine's safety and efficacy but rather hold more generalized concerns in relation to the speed of development. In April 2021 (timepoint 2), there is a rising dissatisfaction with the government and distrust in the pharmaceutical industry. Further, the attitudes about vaccinations and particularly about the COVID-19 vaccine are still mainly negative and the risk of a thrombosis from the AstraZeneca vaccine which is being publicly discussed at this time seems to strengthen the rejection. In timepoint 3, the vaccination opponents feel a social and political pressure on them to vaccinate but it seems that this pressure only creates at this time in the pandemic more rejection of getting vaccinated and lowers the trust in political actors.

Concerning the psychological determinants underlying vaccination hesitancy we found that especially confidence, complacency and collective responsibility significantly influenced the vaccination willingness in this study. Moreover, there were considerable differences in the salience of these determinants in the three groups. The contra vaccination group was characterized by low

confidence in the effectiveness and safety of vaccinations, the health care system and the motives of decision-makers who decide which vaccinations are recommended. Also, they had a high complacency, therefore did not feel vulnerable and saw COVID-19 vaccinations as unnecessary. For example, immunization through a COVID-19 infection was oftentimes preferred to a vaccination. According to Lalot et al. (2023), individuals tend to be more inclined to adopt protective behaviours when they have a heightened level of concern about a situation. This heightened concern is characterized by viewing the situation as more important, causing worry, and having a direct impact on them. For the contra group, it seems like they have more concerns about the protective behaviour (in this case getting COVID-19 vaccination) and are not that concerned about the risk of getting an infection. Overall, low confidence not only in science but also in the government and the pharmaceutical industry appears to be together with high complacency regarding a COVID-19 infection key factors underlying the low vaccination willingness in this group. These findings are in line with the Distrustful Complacency Hypothesis. This hypothesis, which supported by Lalot et al. (2023), suggests that either a heightened concern or political trust alone should be adequate for vaccine acceptance, as the presence of one can compensate for the absence of the other. However, the absence of both, called distrustful complacency, would lead to increased vaccine hesitancy. The basic idea is that when specific levels of concern and confidence *both* imply a common behavioural tendency (e.g., refusing the COVID-19 vaccination), that tendency will be significantly strengthened compared to situations where only one or neither implies such a tendency.

This suggests two pathways to enhance vaccination willingness in the group of vaccination opponents. Firstly, information campaigns could establish levels of concern that remain above a threshold sufficient to offset any lack of political trust (Lalot et al., 2023). However, this would require careful targeting to those who feel low concern because invoking even greater concern among those who are already sufficiently concerned could backfire. Also, the question arises as to whether such an approach would be ethical. The other pathway would be to increase confidence in political actors. Confidence can easily be lost if government action fails to meet citizens' expectations (Lalot et al. 2023). Especially in the group of vaccination opponents, measures seem to be perceived as too strong and impeding their personal freedom and therefore express their dissatisfaction by refusing vaccinations. Dubé et al. (2018) claim that in high-income countries “notions of empowerment and individual choices are predominant health themes and frame health as ‘lifestyle choices’ or within an ethos of ‘consumerism’ that views the state as a violation on individual freedom” (p. 1001). Public health recommendations are in direct contradiction with the worldview that health is individualized, and decisions are solely a matter of individual choice. Protection of the community and vaccination promotion discourses often do not enter into this ‘personalized’ decision equation (Dubé et al., 2018). This is noticeable in this study as many vaccination opponents see no obligation to protect the lives of other people (low collective responsibility) and feel constrained and pressured by the government and people in their social environment. Therefore, the idea that social agreements and dependencies, which

make the freedom of all, their mutual recognition and realization possible in the first place, should be strengthened in the long run to boost public health measures like vaccinations. Future research could further investigate how public health recommendations could better reach people who have individualized health views to strengthen public health and increase vaccination uptake for example through messages about illness prevention and individual and social benefits of vaccination. Also, according to Fiske et al. (2022), "reassurance from both national and local health professionals that any vaccine made available in Germany is safe and effective" (p. 12) could be beneficial.

The confidence in the pro vaccination group was generally high. They not only show a high willingness to receive a COVID-19 vaccination in December 2020 but also have a positive attitude concerning vaccines in general. For example, many participants seem to support Influenza vaccinations especially in times of the COVID-19 pandemic and have already been vaccinated against Influenza in the past. This is in line with research by Garza et al. (2023) who demonstrated that there is a strong association between receiving an Influenza vaccine as well as a COVID-19 vaccine. Interestingly, the pro vaccination group is not completely without concerns regarding the COVID-19 vaccines as they oftentimes mention residual worries about the safety and efficacy of the vaccines due to their fast development during the first interview phase in December 2020. This indicates that health-seeking behaviours like vaccination decisions are an ongoing and dynamic process and that even vaccination supporters can have concerns about vaccines, especially during the unique situation of the COVID-19 pandemic. This finding indicates that vaccine-related concerns exist across the full spectrum of vaccine hesitancy. Nevertheless, it appears that these concerns are significantly buffered by widespread confidence in political decision-makers. That confidence in public institutions increases the likelihood of getting vaccinated and ensuring compliance with public health measures in general is well established in previous literature (Sterl et al., 2023).

People who express levels of hesitancy but also receive a vaccination are called 'hesitant adopters' in scientific literature. In this study, undecided participants at timepoint 1 (April 2020) moved from being hesitant towards getting vaccinated due to norms in their social environment and a societal pressure to end the restrictions through high vaccination uptake. Moore et al. (2022) identified that structural motivators like vaccine mandates can serve to motivate hesitant adopters to get the COVID-19 vaccine. Together, it seems like some level of societal pressure has a positive impact on the vaccination decision of hesitant adopters. This is in contrast to the contra vaccination group which partly got stronger over time in their resistance to COVID-19 vaccines due to the social pressure through the 3G rules (more freedom in daily life through getting vaccinated) and vaccinated people. A topic for future research could be to further investigate why social pressure appears to influence the hesitant people towards getting a vaccine but increases the resistance of vaccination opponents. Also, it is unclear to what extent this finding is specific only to COVID-19 vaccines as the COVID-19 pandemic was a unique situation when it comes to social processes and new norms or if it may be generalized to other vaccines. Even though hesitant adopters got vaccinated they may not be fully

confident in their decision which future vaccination programs should consider. Interventions to target social processes (e.g., descriptive norm messages or messages that change altruism or free-riding beliefs) and interventions that target direct behaviour change (e.g., school and work requirements or reminders and recalls) could be especially useful in this group. This is also in line with the extensive research by Brewer et al. (2017) who state that interventions that directly change behaviour without trying to change what people think or feel are reliably effective ways to increase vaccine uptake. However, it is important to consider that such measures could on the other side lower the vaccination willingness of vaccination opponents because mandates from political actors could erode their trust further. Therefore, the findings of this research imply that pro-vaccine campaigns should carefully target their interventions. For vaccine opponents it seemed liked (re)gaining trust in public health institutions and political decision-makers is most important, whereas for hesitant people interventions that directly change behaviour are promising.

One psychological determinant of vaccine willingness that did not play a considerable role for all groups was convenience. Only for the undecided participants was convenience, meaning the individually perceived structural barriers to vaccination in everyday life, a topic of concern during the second interview phase in April 2021. Therefore, reducing possible barriers and making vaccines more easily accessible with, for example, mobile vaccine clinics seems especially important for more hesitant people during pandemics. The pro vaccination was presumably more likely to tolerate structural barriers such as travelling to vaccination centres and problems making appointments because of a higher personal motivation to get vaccinated. For the contra vaccination group, convenience was not a matter of concern because they did not consider getting vaccinated in the first place and therefore did not have to overcome structural barriers to receive a vaccination.

### 4.2 Strengths and limitations

A strength of the current study is the strong sample of forty German participants with diverse sociodemographic backgrounds and attitudes towards vaccinations. This study therefore covers a very broad spectrum of different perspectives on vaccinations. Another strength is the longitudinal design which helped to gain insights into how themes concerning vaccinations emerge and play out over time which has not often been done qualitatively.

Computational methods like topic modelling can have many advantages, like gaining an overview of the main themes in a large data set in a scalable way. However, due to the relatively small size of the data used in this study, this method of analysis had several limitations. Finch et al. (2018) suggest that “75 and 100 terms per document is sufficient for accurate parameter recovery, when there are at least 100 documents in the corpus” (p. 408). Even though the interview answers were mostly longer than 75 terms, the corpora used for each group at each timepoint were smaller than 100 documents. This could have impeded the identification of topics by the statistical model. Furthermore, one weakness is that many pre-processing decisions had to be made which can strongly influence the results and are often not assessable for a researcher who is not a data scientist. According to Lee et al.

(2017), seemingly small changes on the user side can have unpredictable side effects. The researcher needs to assess the validity and utility of a particular solution (e.g., number of topics) mainly by interpreting and labelling the topics (Weston et al., 2023). However, there is little concrete guidance in the scientific literature on how to conduct an unsupervised topic modelling analysis of an interview dataset and therefore required a lot of iteration and trial and error by the researcher in this study. For example, whereas lemmatization improved results in past research (e.g., May et al., 2016), it did not improve the model fit in the present study.

Another limitation was that the topics were even after an extensive search for the best suitable pre-processing steps still difficult to interpret solely by the topic keywords because they were often too similar between topics. Therefore, the researcher had to spend considerable time on reading the most representative documents of a topic to be able to arrive at a suitable topic label - an activity that should have been minimized by the topic modelling analysis. According to Ying et al. (2019), inferring coherent topics and placing a label on them is an open-ended process that has the potential for creative interpretation and seeing patterns even where none exist. The qualitative nature of this interpretation makes it difficult to complete this task in a replicable fashion and to justify the decisions in a way that can be assessed by the readers (Ying et al., 2019). To counteract this issue, it is advisable in future research that two researchers label the topics independently and agree on the labelling to ensure reliable results (Chen et al., 2023). Overall, these limitations are indicators that topic modelling can only augment human analysis and not replace it and that considerable time still needs to be spent to arrive at satisfying results. It is a useful method to gain an understanding of a complex issue as can be seen in the current study, however, to find subtle nuances in textual data sets human coding is still required.

### 4.3 Conclusion

In conclusion, the study provides valuable qualitative longitudinal insights into attitudes and concerns towards COVID-19 vaccinations in a diverse sample of German citizens with differing levels of vaccination willingness pre-vaccination start. Additionally, the current study illustrates the use of topic modelling as an alternative to traditional methods such as thematic analysis which can, if carefully applied, produce a holistic overview of relevant topics from large corpora of textual data. In the analysis of participant interviews, several attitudes and concerns were found that illustrate hesitancy towards COVID-19 vaccination in this sample and which can be used as reference points for future research such as vaccine safety, freedom of choice, and trust. Furthermore, the psychological determinants of vaccine hesitancy, particularly confidence, complacency and collective responsibility significantly influenced vaccination willingness in this study.

Each of the three groups had a unique trajectory through the pandemic and constructed their own position towards vaccinations along these determinants. Due to a high level of collective responsibility and trust in decision-makers, the participants who had a high vaccination willingness in December 2020 eventually became more confident about the vaccination despite their initial concerns

about its safety and effectiveness. The majority of the undecided participants ultimately chose to receive the COVID-19 vaccination despite their initial reluctance and doubts due to a combination of social norms and personal health considerations. The individuals who initially opposed vaccination did not change their mind. For many, the disapproval of vaccinations even intensified as a result of a perceived unjustified social pressure and a general lack of trust in decision-makers and vaccinations. Future research could investigate why hesitant people decide in favour of vaccination due to social pressure, while opposing people become even stronger in their rejection and how public health institutions could manage this tension.

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## Appendix A

## Interview questions

### Timepoint 1

Q11: In your survey response, you mentioned that you'd X get a voluntary coronavirus vaccination. Could you explain why you're feeling that way? (Rationale: Motives to (not) get a vaccination)

Q12: Can you think of reasons you might go ahead and get vaccinated for the coronavirus?

Q13: You also indicated that you X a mandatory coronavirus vaccination. Why is that?

Q14: In your survey response, you indicated that you will X get the seasonal influenza (flu) vaccination this year. Why (not)? (Rationale: These responses reveal what is unique about attitudes towards COVID vaccination)

### Timepoint 2

Q12: In your first survey response, you mentioned that you'd X get a voluntary coronavirus vaccination. In the second survey you indicated that you'd Y get a voluntary coronavirus vaccination. Could you explain why you're feeling different about the vaccination? (ONLY ASK WHEN LEVEL OF AGREEMENT HAS CHANGED)

Q13: How are you feeling about the vaccine today? Would you say that your feeling towards the vaccine has changed since we last talked? (ONLY ASK WHEN LEVEL OF AGREEMENT HAS CHANGED)

Q14: What was/is your main reason to (not) get vaccinated? (PAST TENSE IF THEY ALREADY GOT VACCINATED)

Q15: Do/did you have any concerns about being vaccinated? ➔ If yes: What exactly are/were you concerned about? ➔ Is the producer of the vaccine relevant to you?

Q16: Vaccinations have started now. Do/did you feel well informed about the process? ➔ What information are/were you missing?

Q17: Since you already got vaccinated: What was the experience like for you? (ONLY ASK THOSE THAT ALREADY GOT VACCINATED)

Q18: Some people say it is dangerous to get vaccinated because we don't know much about its effects. What would you say to those people? (ONLY ASK THOSE IN FAVOR OF VACCINATION) or Some people say we have a duty to get vaccinated in order to protect others. What would you say to those people? (ONLY ASK THOSE AGAINST VACCINATION) (Rationale: Dialogical thinking)

Q19: Concerning the vaccination is there anything we didn't address yet that you would like to add?

### Timepoint 3

Q10: In your second survey response, you mentioned that you'd X get a voluntary coronavirus vaccination. In the third survey you indicated that you'd Y get a voluntary coronavirus vaccination. (ONLY ASK WHEN LEVEL OF AGREEMENT HAS CHANGED) Could you explain why you're feeling different about the vaccination? (Rationale: Motives to (not) get a vaccination)

Q11: How are you feeling about the vaccine today? Would you say that your feeling towards the vaccine has changed since we last talked? (ONLY ASK WHEN LEVEL OF AGREEMENT HAS NOT CHANGED OR INTERVIEWEE DID NOT PARTICIPATE IN SECOND SURVEY)

Q12: Has anything changed for you since you have received full vaccination protection? ➔In what way? ➔How has your behaviour changed since then? (ONLY ASK THOSE THAT ALREADY ARE FULLY VACCINATED) (Rationale: Personal implications of being vaccinated)

Q13: Are there situations in which you feel unprotected against the virus? (Rationale: Risk Perception)

Q14: Approximately 60% of the population is now vaccinated. Has this changed anything for you? (Rationale: Risk Perception)

Q15: Which of the COVID vaccines do you think is the best and which is the worst? Why? (Rationale: Perceptions of different vaccines)

Q16: What is your opinion of the (planned) tightened measures (e.g. tests for a fee or quarantine measures) for those that are unvaccinated? (Rationale: Solidarity/Polarization)

Q17: Concerning the vaccination, is there anything we didn't address that you would like to add?

## Appendix B

### Customized stop words

| Timepoint 1 | Timepoint 2 | Timepoint 3 |
|---|---|---|
| a | mal | mal |
| b | halt | halt |
| ah | ne | ne |
| mal | sagen | sagen |
| halt | gibt | gibt |
| ne | bisschen | bisschen |
| sagen | überhaupt | überhaupt |
| gibt | ganz | ganz |
| bisschen | genau | genau |
| sozusagen | okay | okay |
| überhaupt | glaube | 80 |
| ganz | lassen | mhm |
| genau | finde | na |
| okay | 80 | 60 |
| glaube | mhm | her |
| lassen | na | quasi |
| finde | 60 | sag |
| mhm | her | naja |
| na | quasi | ach |
| her | sag | unverständlich |
| quasi | naja | nö |
| sag | ach | unk |
| naja | unverständlich | s |
| ach | nö | ehm |
| unverständlich | unk | hm |
| nö | s | nee |
| unk | ehm | lacht |
| äh | hm | seufzt |
| s | lacht | ironisch |
| eh | seufzt | zustimmend |
| ehm | ironisch | gesagt |
| hm | zustimmend | denke |
| lacht | gesagt | geht |

| | | |
|---|---|---|
| seufzt | denke | 100 |
| ironisch | geht | 40 |
| zustimmend | 100 | geimpft |
| impfen | 70 | impfung |
| impfung | 40 | impfen |
| | 16 | lassen |
| | 19 | leute |
| | 000 | finde |
| | et | |
| | eh | |
| | e | |
| | impfstoff | |
| | geimpft | |
| | impfen | |
| | impfung | |