**MASTER THESIS**

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# Structure of motivational factors for vaccination against COVID-19

# Struktura motivačních faktorů k očkování proti onemocnění covid-19

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I declare that I carried out this master thesis independently, and only with the cited sources, literature and other professional sources. It has not been used to obtain another or the same degree.

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In ..... date .....  .....

Author's signature

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Abstract:

This thesis studies the structure of motives for receiving the vaccine against the novel coronavirus disease, COVID-19, which caused a pandemic beginning in 2020. A survey was conducted on a representative sample of the Czech Internet population aged 18-64. Networks were constructed using partial correlations. On these networks, centralities of motives (represented by nodes) were measured (strength, betweenness, closeness, and Expected Influence). It found that groups based on socio-demographic characteristics did not differ from each other, while groups defined by their time of registration for the vaccine did differ significantly. Four groups of motives were identified with factor analysis: vaccine benefits, outside forces, medical assessment, and accessibility. In the networks, however, there was little tendency for clustering, suggesting well connected belief systems. Generally a central motive was the belief that vaccination is generally a right thing to do, combined with a recommendation from a medical authority. The vaccination decision of people around had no influence in the system of motives. Results of this and similar studies can be used for effective targeting of future vaccine campaigns.

Tato práce se věnuje struktuře motivací pro rozhodnutí nechat se očkovat proti onemocnění covid-19, které způsobilo celosvětovou pandemii počínající v roce 2020. Bylo provedeno dotazníkové šetření na reprezentativním vzorku české internetové populace ve věku 18-64 let. Pomocí parciálních korelací byly získány sítě a změřeny centrality jednotlivých uzlů (síla, mezilehlost, blízkost a očekávaný vliv). Výsledky se nelišily na základě sociodemografických charakteristik, ale lišily se na základě času registrace na očkování. Faktorovou analýzou byly určeny čtyři skupiny motivací: benefity vakcíny, vnější síly, zdravotní hodnocení a dostupnost. V sítích však byla velmi malá tendence ke shlukování, což naznačuje silně propojené systémy. Jedním z častých centrálních motivací bylo přesvědčení, že očkování je obecně správné, společně s doporučením lékařských autorit. Rozhodnutí okolí očkovat se nemělo v systému motivací žádnou roli. Výsledky této a podobných studií mohou být použity pro efektivní cílení komunikace o vakcínách.

Keywords: vaccination covid covid-19 motivation motivational factors

# Contents

# Chapter 1

# Introduction

In 2020 the world grappled with a challenge that has not been seen in generations: a worldwide pandemic, caused by the new coronavirus, named SARS-CoV-2. It quickly spread to all corners of the world, changing the lives of billions of people. By its speed and magnitude, the resulting pandemic became a social concern, rather than solely a medical one.

From the earliest days of the pandemic, hope was directed towards one weapon of fighting it: a vaccine. Vaccines against COVID-19 appeared in record speed, the first ones being manufactured and distributed within a year of the pandemic's outbreak. It was an immense scientific achievement, but the true challenge has only just begun. How can the vaccine be provided quickly and effectively to billions of people? Apart from being a logistical challenge, it is also a social one: vaccines have long been a center of controversy, especially in Western society, with surging vaccine hesitancy reversing decades of progress reached in infectious disease control.

A scientific, public and political debate about effective vaccine communication had started even before vaccines were available. Attention of both the scientific and public debate has been concentrated on combating vaccine hesitancy – convincing those to some degree opposed to the idea of receiving the vaccine. This is understandable, especially in a crisis situation where the speed of vaccination uptake has a large role in the progression of the pandemic. There is however one aspect this angle omits: is receiving the vaccine truly the "default option"?

Vaccination is widespread in today's world, most countries having adopted some vaccination scheme, mostly for children, to varying degress of success. This vaccination is generally expected, and those who consciously refuse it, whatever their reason may be, push against social, and in some cases legal, norms. However, this may not be the case for a novel vaccine aimed at adults, where the "default option" is not as clearly defined.

The COVID-19 vaccine does only not represent protection against the disease itself. Context of the ongoing pandemic is also crucial to consider. Many countries, the Czech Republic included, began implementing measures treating the vaccinated and unvaccinated populations differently. At the same time, vaccination remained voluntary, leaving the decision to receive the vaccine or not up to the individual.

Those who received the vaccine were not a uniform block. Some may have felt vulnerable to the disease, some wanted to protect those close to them, some may have wanted to travel easily, some felt forced. While there possibly is a group of individuals who were motivated by a single reason, it is likely that a larger portion of the population was motivated by a combination of reasons.

This thesis therefore asks, what reasons may have motivated those who are vaccinated and what was the structure of these beliefs. Furthermore, it explores to which degree they vary by demographic characteristics. To study these issues, known motives from empirical literature concerning vaccine acceptance were combined with motives specific for the COVID-19 pandemic and vaccines. An innovative method, Belief Network Analysis, was chosen to study the structure, since it allows us to visualize and analyze the relationships between the motives.

# Chapter 2

# Overview of the COVID-19 pandemic in the Czech Republic

This thesis is focused on a specific vaccine, protecting against the disease COVID-19, therefore, it is necessary to understand the development of the pandemic. It has consisted of multiple paralel processes – the progression of the virus and the disease through the world population, health and safety measures implemented by governments and vaccine development and distribution. Since the data analyzed come from the Czech Republic, the overview will concentrate on the succesion of events in this country. This overview is not an exhaustive timeline, rather, attention is given to events that have a primary connection to the uptake of the vaccine.

## 2.1 Coronavirus disease 19 (COVID-19)

COVID-19 (an acronym for coronavirus disease 19) is a disease of the respiratory system, evidence suggests it also attacks other organs, such as the heart. Typical symptoms include shortness of breath, cough, fatigue, and loss of smell and taste (Mair et al., 2020, p.1254). Its fatality rate varies widely by location and age. From data before the massive outbreak of different variants, a median estimate of age-standardized infection-fatality ratio was 0.54%, but for older age groups the estimates are much higher – from 1% at age 60 to 42.79% at age 100 (COVID-19 Forecasting Team, 2022). It is caused by a virus SARS-CoV-2 from the family

of coronaviruses which was first recorded in the Wuhan region in China (Mair et al., 2020, p.1254). As of May 2022, the WHO has declared 5 variants of concern worldwide (World Health Organization, 2022). New variants are often connected with a new wave of cases and/or deaths (Zawbaa et al., 2022).

The presence of the virus can be detected by a variety medical tests. The most precise is the PCR method, which is however logistically complicated and more expensive than other options. The antigen method is cheaper, faster, but less precise Both testing methods have been used, often complementarily, throughout the pandemic (Dhar, 2022).

## 2.2 Progression of the pandemic

The regional WHO China office was first informed about a pneumonia of unknown causes on 31st of December 2019. The original source is unknown, but first clusters are believed to have been detected in the Chinese city of Wuhan. Public Health Emergency of International Concern was declared on 30th of January 2020. During February the WHO has been increasing its calls for countries to prepare for the potential health threat. On 4th of March 2020, 100 000 diagnosed cases was surpassed globally. On 11th of March 2020 the WHO declared COVID-19 a pandemic (World Health Organization, 2020). Apart from China, Italy, South Korea and Iran struggled with a surge of cases in the early days of the pandemic (Sighvi et al., 2020).

First cases in the Czech Republic were detected on 1st March (Sviták & Fiala, 2020). On 12th March the government of Czech Republic announced a country-wide state of emergency (Fiala, 2020).

As of 1st of May 2022, more than half a billion cases of COVID-19 reported worldwide, with more than 6 million resulting deaths ("WHO Coronavirus (COVID-19) Dashboard", 2022). In the Czech Republic, 3 906 113 cases have been reported, with 40 173 deaths ("COVID-19: Kumulativní přehledy dle hlášení KHS a dle pozitivních nálezů laboratoří, které jsou určeny pro další šetření", 2022).

## 2.3 Pandemic measures implement by the government of the Czech Republic

As first cases were being reported in the Czech Republic, the government started implementing restrictions aimed at curbing the spread of the virus. The protective measures were introduced by the Czech government were among the fastest implemented in the world, banning mass events, closing schools and stores, limiting travel across borders, and requiring the wearing of masks in public spaces (Kouřil & Ferenčuhová, 2020, p.589-590). In summer most measures were lifted, but reintroduced in the autumn of 2020. With exceptions of December 2020 and summer 2021, measures of varying intensity stayed in effect until spring 2022 ("Anatomie selhání: Dva roky covidu v Česku ve faktech a výrocích", 2022).

The vaccination campaign started in the Czech Republic on 27th of December 2020 ("Česko zahájilo očkování proti covidu. Objednáno je na 16 milionů dávek, první dostal Babiš", 2020). As the vaccination campaign progressed, more restrictions were hinged upon the vaccination status of an individual. In the spring of 2021 proof of vaccination status has started to become proof of noninfectiousness. In the autumn the Czech government started to apply similar rules to accessing other space, such as cultural venues or restaurants ("Anatomie selhání: Dva roky covidu v Česku ve faktech a výrocích", 2022). Unvaccinated individuals or those who did not contract the disease in the last 180 days were allowed to enter into bars and restaurants only with a negative antigen or PCR test, later changed to only PCR tests being approved (Dolejší & Sobola, 2021). In November of 2021, the government announced a change in the rules, which excluded the possibility of proving one's uninfected status with a PCR test, with some exceptions ("Volnočasové aktivity pouze s O-N. Vláda schválila nová opatření – Ministerstvo zdravotnictví", 2021). Preventive testing first became widely available in December 2020, when those insured under public health insurance were provided with antigen testing ("Začalo dobrovolné antigenní testování zdarma. Kvůli zájmu se budou zvyšovat kapacity", 2020). Later a certain number (from 1 to 5) of PCR tests per month was also provided for free (Kottová Anna, 2022, "Přehledně: Více lidí na hromadných akcích, jeden PCR test zdarma", 2022, Šindlerová, 2021). In November 2021 free testing stopped being covered (unless ordered by a medical professional)

for unvaccinated individuals, as a part of a strategy to increase vaccine coverage (Ondráčková, 2021). Blanket testing of employees and in schools was conducted several times over the course of the pandemic. Vaccinated individuals were generally excluded from the obligation ("Archiv Testování zaměstnanců ve firmách", 2021) ("Archiv Testování zaměstnanců ve firmách," 2021).

## 2.4 Vaccine development and distribution

In December the Comirnaty vaccine from the companies Pfizer and BioNTech received emergency authorization from the U.S. Food & Drug Administration, with the vaccine from Moderna following just days after ("FDA Takes Key Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for First COVID-19 Vaccine", n.d.,"FDA Takes Additional Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for Second COVID-19 Vaccine", n.d.). European Medical Agency issued emergency authorizations for both vaccines soon after that ("Comirnaty", n.d.,"Spikevax (previously COVID-19 Vaccine Moderna)", n.d.). Up to the collection of data (early December 2021), four vaccines against COVID-19 have been approved in the European Union: Comirnaty (Pfizer-BioNTech), Spikevax (Moderna), Vaxzevria (AstraZeneca), Janssen (Johnson & Johnson)[1] . In December 2021, a fifth vaccine was approved, by the company Novavax ("COVID-19 vaccines: authorised", n.d.). The vaccines represent different types of vaccine technology, which has impacted public opinion on them. The Comirnaty and Spikevax vaccines are the first widely used vaccines using the mRNA technology (Corum and Zimmer, 2021d,Corum and Zimmer, 2021a), which delivers messenger RNA to the cells, which subsequently manufacture an antigen the immunity system can learn the response to (Park et al., 2021). Vaxzevria and Janssen are based on an older technology, vector vaccines, which combine the spike protein with a different, harmless, virus (in these cases an adenovirus), serving as a vector for transmission (Corum and Zimmer, 2021c, Corum and Zimmer, 2021b). All vaccines require two doses in the basic vaccination scheme, except for Janssen, which only requires only a single dose ("COVID-19

[1]In the public sphere the vaccines are commonly known and reported on by their manufacturer's name.

vaccines: authorised", n.d.).

The COVID-19 vaccines have been subject to conspiracy theories (Pertwee et al., 2022), with some people feeling hesitant towards the newly employed mRNA technology (Salerno et al., 2021). Due to reports of side-effects, some countries have stopped the usage of certain types of vaccines (for example Denmark stopped using the Vaxzevria and Janssen vaccines after reports of trombosis (Skydsgaard, 2021)). These controversies could have slowed impacted the uptake of the vaccine. The vaccination campaign started in the Czech Republic on 27th of December 2020, with the first priority group including health-care workers and senior citizens ("Česko zahájilo očkování proti covidu. Objednáno je na 16 milionů dávek, první dostal Babiš", 2020). The date of eligibility for the vaccine was dependent on one's age and occupation. The complete timeline can be found in table 2.1. While officially it was not possible for a person to receive a vaccine before their age or occupational group became eligible, there have been instances of early vaccination due to either malpractice or in an effort to avoid wasting vaccine doses (Perlínová & Hovorková, 2021). A network of vacination centers was created around the country, many being established in cultural venues and public spaces ("Přehled očkovacích míst", 2022). Those interested in receiving the vaccine registered via the webpage of the Ministry of Health ("Registrace na očkování", 2021), and by July 2021 it became possible to receive the vaccine without prior registration ("Harmonogram očkování v České republice", 2021).

| **date (dd.mm.yyyy)** | **group** |
|---|---|
| **Registration first available** | |
| 15.01.2021 | over 80 years old |
| 26.01.2021 | health-care workers |
| 27.02.2021 | school employees (until 28.03.2021) |
| 01.03.2021 | over 70 year old |
| 24.03.2021 | patients with selected chronic diseases (until 30.04.2021) |
| 07.04.2021 | social workers |
| 12.04.2021 | patients with selected chronic diseases (until 15.05.2021) |
| 14.04.2021 | over 65 year old |
| 23.04.2021 | over 60 year old |
| 28.04.2021 | over 55 year old |
| 05.05.2021 | over 50 year old |
| 11.05.2021 | over 45 year old |
| 17.05.2021 | over 40 year old |
| 24.05.2021 | over 35 year old |
| 26.05.2021 | over 30 year old |
| 04.06.2021 | over 16 year old |
| 01.07.2021 | over 12 year old (only Comirnaty vaccine) |
| 12.07.2021 | vaccination without registration |
| 13.12.2021 | over 5 year old (only Comirnaty vaccine) |
| **Booster dose** | |
| 29.09.2021 | booster dose (at least 8 months since first scheme done) |
| 18.10.2021 | booster dose (at least 6 months since first scheme done) |
| 29.11.2021 | booster dose (over 60 years old and patients with chronic disease at least 5 months since first scheme done) |
| 29.11.2021 | booster dose (pre-registration for all) |

Table 2.1: Timeline of vaccination in the Czech Republic ("Harmonogram očkování v České republice", 2021)

In the fall of 2021, a booster dose was introduced after reports of waning immunity. At the moment of data collection, individuals became eligible for a booster shot 6 months after the last dose of the initial vaccination scheme and 5 months (resp. 2 months in case of the Janssen vaccine) for persons over 60 years of age and chronically ill patients. The recommended booster dose vaccines are those based on the mRNA technology, i.e. Comirnaty and Spikevax. ("Harmonogram očkování v České republice", 2021)

At the time of data collection for this thesis, 62.78% of the population was at least partially vaccinated, with 60.21% being fully vaccinated (two doses of a two-dose scheme vaccine or one dose of a one-dose scheme vaccine), 11.32% had received the booster dose ("Souhrnné statistiky", 2022)[2]. As of 1st of May 2022, 13 415 691 doses have been administered as first of second doses, and 4 159 353 booster doses ("COVID-19: Přehled vykázaných očkování v ČR", 2022). This translates to 64.2% of the population being fully vaccinated (two doses of a two-dose scheme vaccine or one dose of a one-dose scheme vaccine), with an additional 0.8% being partially vaccinated (one dose of a two-dose scheme vaccine), and 38.8% having received a booster dose ("Souhrnné statistiky", 2022).

## 2.5 Vaccination intentions

As the vaccine was being developed and distributed, a question of its uptake among the general public was being discussed, both in public and expert spheres. In the Czech Republic multiple surveys were conducted before and during its distribution, finding a clear upward trend in the public's willingness to receive the vaccine (Čadová, 2021a, Čadová, 2021b, Čadová, 2021c, Čadová, 2022,PAQ Research, 2022). While in September 2020 there were 56% of respondents that said they definitely or maybe will receive the vaccine when it is available, in November 2021, when data was collected for this thesis, almost 80% of respondents said they either were vaccinated or wanted to receive a vaccine (PAQ Research, 2022).

[2]The absolute number of vaccinated individuals provided by the source was divided by the number of inhabitants of the Czech Republic on 1st of January 2021 as the last documented number by the Czech Bureau of Statistics (*Česko v číslech*, 2021)

# Chapter 3

# Theoretical approaches to the vaccination decision

## 3.1 Vaccination as a social and individual phenomenon

Vaccination as a method of disease prevention has two aspects: the individual and social. By receiving a vaccine, the recipient is protected by the disease, to a certain degree. The compounded effect of multiple individuals being vaccination is larger than the sum of the individual protections, through the effect of herd immunity. Herd immunity is a term used in epidemiology to decribe "the indirect protection from infection conferred to susceptible individuals when a sufficiently large proportion of immune individuals exist in a population." (Randolph & Barreiro, 2020, p.738).

Thanks to the combination of its direct and undirect effects, vaccination is upheld as one of the greatest achievement of modern medicine and public health. It enabled total erradication of smallpox (Henderson, 2011) and a radical decrease in cases of many infectious diseases. For example, data from the USA show over a 90% reduction in several infectious diseases after widescale vaccination (Roush et al., 2007). Toor et al. estimate that about 97 million deaths worldwide would be avoided thanks to vaccination between 2000 and 2030, not including data about COVID-19 (Toor et al., 2021). Estimates of lives saved thanks to the COVID-19

vaccine are not yet fully available, preliminary ones show that around 240 thousand lives were spared in the USA and about 469 thousand lives in the European WHO region in those over the age of 60 (Meslé et al., 2021).

As Brewer et al. say, "Vaccination is an inherently social activity because it takes place in the context of human interactions, and receiving a vaccination (or not) affects the health of others." (Brewer et al., 2017, p.19). It should be understood as an action not only through its "objective features of a health issue but rather of the features that people attribute to the issue." (Rothman & Salovey, 1997, p.3). Although it is a process largely influenced by social forces, the ultimate act of vaccination is individual. It may even be portraied as a "leap of faith", influenced by the legitimacy of medical authorities (Peretti-Watel et al., 2015).

Many theoretical models have been applied to the issue of vaccine acceptancy. This chapter provides an overview theoretical frameworks commonly used to explain health decision behaviors. The Health Belief Model and Theory of Planned Behavior are presented as the most common approaches together with a short overview of vaccine hesitancy related approaches. Theoretical models provide us with an generalized way to think about the process inoculation decision making and also fully appreciate that it should no option should be inherently understood as a default option.

## 3.2 Health Belief Model

The Health Belief Model was originally formulated by Kasl and Cobb in 1966 and has become a popular theoretical framework for the study of health behavior. The framework "seeks to clarify the behavioral accompaniments of changes in health." (1966, p.247). It also poses that health progression (from full health to death) has a sociopsychological component, drawing from Parson's works on social roles, where the health status of an individual brings with it certain roles and expectations, such as changing one's customary diet (ibid., p.247-248).

Health behavior is such a behavior wherein the goal is to maintain the state of self-perceived health (Rosenstock, 1974, p.353). According to Kasl and Cobb, there are two main kinds of preventative health measures – health examinations undertaken as a means to diagnose a disease in its asymptomatic stage and prevent-

ing future illnesses, for example through immunization . Two main contributors to the likelihood that one will engage in a health behavior are the perceived threat of an issue (depending on the subjective importance of the matter to the individual, their perceived susceptibility to the illness or to serious consequences of it) and perceived value, or belief that the behavior will prevent or ameliorate the disease (depending on the probability that the behavior will lead to desired outcomes and judgment of the unpleasantness, or "cost" of performing versus not performing the action) (1966, p.249-250).

Later adjustments to the model postulate six main dimensions predict one's probability to engage in a health behavior (such as prevention or screening). According to Champion and Skinner, those are: *perceived susceptibility*, *perceived severity*, *perceived benefits*, *perceived barriers*, *self-efficacy* (which participate on the formation of health beliefs) and *cues to action* (which influence the behavior directly). Other factors include demographics, sociopsychological and structural variables. Practically put, if "individuals regard themselves as susceptible to a condition, believe that condition would have potentially serious consequences, believe that a course of action available to them would be beneficial in reducing either their susceptibility to or severity of the condition, and believe the anticipated benefits of taking action outweigh the barriers to (or costs of) action, they are likely to take action that they believe will reduce their risks." The relationships between the constructs, however, are not defined by the model (2002, p.47-50).

As Janz and Becker note, the decision whether to undergo vaccination is one of the archetypal applications of the Health Belief Model (1999). It has been, for example, utilized to measure parents‘ vaccination beliefs (Gilkey et al., 2014), and influenza vaccination of adults in Hong Kong (Mo & Lau, 2014). Other applications in the context of COVID-19 include the study of adoption of contact tracing mobile applications (Walrave et al., 2020).

One of the main criticisms of the model are that it does not specify the relations between individual components or the mechanism via which they determine behavior (Carter, Beach, Inui, et al., 1986, p.899). More generally, its weak predictive power and poor construct definitions and omiting certain important factors (such as economic or environmental) have also been critisized (Alhamad & Donyai, 2021, p.2). Methodologically, since the operationalization of the supposed concepts

vary widely across studies, comparabitility is inhibited (McClenahan et al., 2007, p.273).

## 3.3 Theory of Reasoned Action and Theory of Planned Behavior

A more general model for studying the connection between beliefs and behavior is the Theory of Reasoned Action, later expanded to the Theory of Planned Behavior by Ajzen (1985). It "is based on the assumption that human beings usually behave in a sensible manner; that they take account of available information and implicitly or explicitly consider the implications of their actions." (ibid., p.12). It also assumes that behavioral intention is a good predictor of actual (attempted) behavior. The correlations between intent and behavior is supported by evidence from empirical studies (ibid., p.16, 30). These intentions are then derived from a combination of behavioral attitudes and social norms. The attitudes in this case are not general attitudes (for example towards institutions), but those held in connection to the specific behavior in question (for example donating blood or attempting weight-loss), therefore Ajzen calls it *attitude toward the behavior*. The second component is the social pressure experienced by the individual to perform said action, which is why it is called *subjective norm*. Generally, if people have positive attitudes towards a behavior and it is positively socially sanctioned, the intention to perform is increased (ibid.,p.12).

We can symbolically note the description as a set of equations. Behavior ($B$) is expected to be predicted by intention $I$ (denoted by a wavy line $\sim$), which is proportional to the sum of attitudes toward the behavior ($A_B$ and subjective norms ($SN$, both weighted by their relative importance $w_1$ and $w_2$ (Ajzen, 1985, p.13):

$$B \sim I \propto [w_1 A_B + w_2 SN].$$

Attitudes toward behavior ($A_B$) are evaluated as a symbolic sum of multiplying belief strength ($b_i$) and outcome evaluation ($e_i$) for each outcome $i$ from $n$ salient behavioral beliefs (Ajzen, 1985, p.13):

$$A_B \propto \sum_{i=1}^{n} b_i e_i.$$

Similarly, subjective norms $SN$ are also symbolically noted as a sum of multiplication. However, the beliefs ($b_j$) in this sum represent the "person's beliefs that specific individuals or groups think he should or should not perform the behavior." (Ajzen, 1985, p.14). This belief is multiplied by the motivation ($m_j$) to comply with the pressure assigned to person $j$ (ibid., p.14):

$$SN \propto \sum_{j=1}^{n} b_j m_j.$$

The Theory of Planned Behavior adopts the same basic model, but recognizes the factor of control over the behavior. For example, one might have a strong intention to get vaccinated, but the vaccine may not be available for them. Because of that, the theory reformulated the behavior assumed as an outcome in the Theory of Reasoned Action as an attempted behavior $B_t$, which is then corrected by the degree of control over the performance of the behavior $C$, symbolically (Ajzen, 1985, p.30):

$$B \propto B_t \cdot C$$

Attitudes toward behavior and subjective norms are also transformed and are now held not toward the behavior itself, but toward attempting the behavior. The transformed symbolic notation is then:

$$B_t \sim I_t \propto [w_1 A_t + w_2 SN_t].$$

where all parts of the equation ($A_t, SN_t, w_1, w_2$) are equivalent to the ones defined above, only in relation to the attempt to perform the behavior instead of executing the behavior itself (Ajzen, 1985, p.31).

The power of control over the behavior influences not only the outcome, but enters the decision process at an even earlier stage. The attitude toward attempting a behavior is corrected by the assumed probability of success. Attitudes toward success $A_s$ and toward failure $A_f$ are separated and each multiplied by the corre-

sponding probability $p_s$ and $p_f$ of such outcome:

$$A_t \propto [p_s A_s + p_f A_f],$$

where $p_s + p_s = 1$ (Ajzen, 1985, p.31).

On the other hand, Ajzen does not separate in the same manner between subjective norms toward a successful and failed attempt, arguing that the person's belief that the attempt is socially expected is independent of its success. The subjective norm for trying to perform a behavior $SN_t$ is therefore a function of multiplying the subjective norm for the behavioral attempt by $SN$ and its subjective probability $p_r$ (Ajzen, 1985, p.32):

$$SN_t \propto p_t SN.$$

In a later presentation of the theory by Ajzen, he clarifies the suggested flow of influence. While *attitude toward the behavior*, *social norms*, and *perceived behavioral control* interact as well as influence the behavioral intention directly (and therefore resulting behavior indirectly), control also influences the resulting behavior directly (2005, p.118-119).

The Theory of Planned Behavior has a large influence in the area of public health studies. It has been used to study the uptake of the H1N1 and HPV vaccines by college students (Agarwal, 2014; Catalano et al., 2017), smoking, using condoms or dental hygiene (Godin & Kok, 1996). The explanatory power of the theory is rather high, in cited works reaching from 41% (Godin & Kok, 1996) to 58% (Catalano et al., 2017).

The Theory of Planned Behavior has been also widely critisized. One line of criticism stems from the general criticism of social cognition model and their inability to explain behavior based on affect and unconscious influences (Bish et al., 2000, p.36-37; Sniehotta et al., 2014, p.2).. According to one of the most direct critical articles, written by Sniehotta et al., the main issue raised around the Theory of Planned Behavior is its limited predictive validity and falsibiability (2014, p.2-3).

## 3.4 Vaccine specific models

In the literature focused vaccines and society, special care is taken when adressing the issue of vaccine hesitancy. Vaccine hesitancy is commonly defined as "[the] delay in acceptance or refusal of vaccination despite availability of vaccination services. Vaccine hesitancy is complex and context specific, varying across time, place and vaccines" (MacDonald et al., 2015, p. 4163), but some authors raise concerns about this definition. Several theoretical models study, why people remain unvaccinated. Organizations such as the World Health Organization, formulate their own frameworks in order to better promote vaccination for the wide public. Peretti-Watel et al. emphasize the importance of viewing vaccine hesitancy not as a concept but a "catch-all" category describing the population anywhere between radical pro- or anti-vaccine stances. People may have varying reasons to accept a vaccine or not and those may change depending on context or the vaccine in question. Therefore the authors suggest using a two-dimensional framework to study this decision making. One axis describes commitment to concepts of "risk culture" (a term coined by Anthony Giddens, describing the phenomenon when "people in contemporary societies are encouraged to exert autonomy over their own lives, to use available expert knowledge to stay continuously aware of risks and opportunities in their daily life, to assess risks and benefits in order to make their future secure" (Peretti-Watel et al., 2015) and "healthism", a cultural notion of health becoming a super-value in itself and emphasis on the individual responsibility one has over it. The second axis describes one's attitude and trust towards health authorities and mainstream medicine (ibid.).

This framework, the authors argue, helps us to step back from the one-dimensional pro-/anti-vaccination attitudes and differentiate between reasons that people may have for their hesitancy surrounding the issue. It allows us to differentiate between "erratic hesitancy", corresponding to "passiveness, inaction and dependence" and hesitancy as a result of a process of reflection. It also allows us to place specific vaccines in the context of these axes – some are new and controversial (such as ones against H1N1, or COVID-19), others new, but not controversial (HPV), some routine, but controversial (MMR vaccine which was at the core of the vaccine-autism link controversy (Burgess et al., 2006)) and some routine, but relatively not con-

troversial (seasonal flu) (Peretti-Watel et al., 2015).

The last group of theoretical frameworks that will be discussed is a group of models that can be described as the "The C frameworks". They try to identify specific dimensions of psychological antecedents of vaccination. The original "3 Cs" model was developed by a WHO working group. The practical goal of this framework is to help clear pro-vaccination communication aimed primarily at the population that falls on the "vaccine hesitant" spectrum. The authors argue that factors influencing vaccine hesitancy are *complacency*, *convenience* and *confidence* (MacDonald et al., 2015, p.4163).

Vaccine complacency describes the situation, where vaccine-preventable diseases appear in a low rate and vaccination is not viewed as necessary prevention. It is also influenced by other factors of life that are more important in at the time of the vaccination decision. Vaccine convenience includes factors such as physical, geographical and economical affordability, language and health literacy. It recognizes that the deliverance of the vaccine is dependent on the time and place and cultural context. Vaccine confidence is then defined as trust in vaccines, the deliverance system (including the health professionals) and policy-makers (MacDonald et al., 2015, p.4162-4163).

Three dimensions are offered by Betsch et al (2018). Their "5C" framework includes: *confidence*, *complacency*, *constraints* (a suggested substitute for the term convenience, which places responsibility on the individual (ibid., p.3), *calculation* and *collective responsibility*. Its purpose is not to fully explain vaccine behavior, but to help monitor and inform intervention designs (ibid., p.5). A similar "5C" model is offered by Razai et al. in the context of the roll-out of the COVID-19 vaccine Razai et al. The original WHO's "3 Cs", complacency, convenience and confidence, are kept, while *communication* and *context* are added to the model. For a fast, effective and equitable vaccine distribution, vaccine hesitancy should be adressed via this framework and specific factors adressed accordingly (Razai et al., 2021).

As has been discussed previously, the concentration of efforts on explaining vaccine hesitancy is, while being in the immediate time-frame necessary, a too limited approach to vaccination decision making. It is attractive for its practical use and has potential to describe a wider range of vaccine behavior, but does not

attempt to explain the underlying phenomena as theoretical models discussed in this chapter (such as the Health Behavior Model or Theory of Planned Behavior).

## 3.5 Model Comparison

The Health Belief Model and the Theory of Planned Behavior are widely utilized in the field of health behavior research, whereas the vaccine models have a very specific area of application. The Health Belief Model specifically targets only behavior related to health, while the Theory of Planned Behavior is more generally formulated (Alhamad & Donyai, 2021, p.6).

Both theories have certain features in common. They are both concentrated on predicting behavior on the individual-level, and that this decision is "largely a deliberate and rational process" (Gerend & Shepherd, 2012, p.172). Both are based on an expectancy-value framework (Brewer & Rimer, 2002) and the decisions are weighted in terms of perceived consequences (Bish et al., 2000, p.37). In both theories individuals are assumed to balance perceived costs and benefits of the behavior and its alternatives, expectations and values of others are taken into account and self-efficacy is given an important role (Alhamad and Donyai, 2021; Weinstein, 1991).

According to Bish et al. (2000), the main differences lie in the fact that certain concepts are only included in one theory and not the other. The Health Belief Model does not take into account intentions and social norms, Theory of Planned Behavior on the other hand excludes perceived threat of the disease from the decision making process (Bish et al., 2000, p.37; Alhamad and Donyai, 2021, p.6). Originally the Health Belief Model did not include a measure of control or self-efficacy, however, it was added later (Gerend & Shepherd, 2012, p.172).

Conceptually speaking, Theory of Planned Behavior includes one crucial middle-step that the Health Behavior Model does not: behavioral intention, which it specifically points out may not have a direct translation into behavioral action (Gerend & Shepherd, 2012, p.172). Furthermore, the combination of constructs in the Theory of Planned Behavior is explicitly mathematically formulated, whereas for the combination of concepts in the Health Belief Model it is not defined (Bish et al., 2000, p.37; Taylor et al., 2006, p.5; Alhamad and Donyai, 2021, p.7).

Both models have extensive empirical usage, including in combination. Some authors choose to combine measures of both models in a single measuring tool (Krawczyk et al., 2012). For example, by doing this, Shmueli managed to explain 78% of the variance to receive the COVID-19 vaccine (Shmueli, 2021) (2021, p.10). Other studies have set out to specifically judge the performance of one theory over the other. They generally tend to find Theory of Planned Behavior having more explanatory and predictive power (Alhamad & Donyai, 2021, p.7). Hossain et al. received a similar result in the case of the COVID-19 vaccines, with the Theory of Planned Behavior explaining the most variance of the model, while the 5C psychological antecedants and the Health Belief model explained a similar portion (Hossain et al., 2021). Generally the ability of any one model to explain the variance of the observed data is fairly low (Bish et al., 2000, p.45).

Each model lays out a specific understanding of this process, but if we take them all into consideration, we may say, that a person deciding about receiving a vaccine weights the (perceived) benefits of the vaccine, (perceived) outer expectations, personal and cultural attitudes towards it and barriers in accessing it.

While none of the models exclude the possibility of the interaction of the factors involved in the decision, they do not explicitly formulate them (except for the Theory of Planned Behavior which includes an interaction with perceived control). This leaves room for the study of the relationships underlying the eventual behavior. This will be performed by Belief Network Analysis that will be presented in Chapter 5.

# Chapter 4

# Concept operationalization

## 4.1 Statements

The general language of the models needs to be translated into concrete operationalized statements. To obtain them, empirical literature was reviewed. The final set contains motivations found to be relevant to vaccines in general, while some reflect the specifics of the COVID-19 vaccine situation (specifically those concerning pandemic restrictions). As was previously noted, only reasons for vaccination are used. Although many reasons map onto the models explained earlier, as will be exemplified, these models are not fully operationalized, as that would involve reasons speaking against accepting the vaccine.

The final set can be roughly split into 5 categories based on the substance of the statement [1]. These are individual reasons (doctor's recommendation; a medical authority's recommendation; anticipated regret of not receiving the vaccine; protection of oneself against the illness; belonging to a high-risk group; protection of oneself against a severe course of the disease), social motives (herd immunity; protection of others), outside forces (a vaccinated social circle; pandemic measures; being forced by the state, others or one's employer; traveling; paying for testing); opportunity (easy access; the vaccine being free); and general beliefs (vaccination being generally a right thing to do; vaccination as a path to normal life; trust

[1] These categories are only used for the presentation in this chapter and are not used as a methodological tool

in COVID-19 vaccines). This is the order they will be presented in. Most of the concepts can also be related to the factors included in the theoretical models mentioned earlier, which will be discussed in the formulation of them.

The English versions of the statements are presented, with the Czech original in the footnote.

## Individual reasons

### My doctor recommended it to me.[2]

Since vaccination is a health-related behavior, a recommendation by a medical professional is likely to have a large effect, if present. In a study of influenza vaccine acceptance by Carter et al., a doctor's recommendation had a large positive score in the decision to accept a vaccine (1986, p.382-386). A medical provider's recommendation was found in a meta-analysis to be the most significant predictor of parents‘ uptake of the HPV for their children (Newman et al., 2018, p.11).

The categorization of this statement under a factor presented by the aforementioned models is not clear. It depends on the way one views a recommendation by their medical provider, whether in its substance (aligning with their own beliefs or challenging them) or by the outside social expectation it may represent. The first interpretation would then fall under *perceived susceptibility* or *perceived severity* in the Health Belief Model, *attitude toward behavior* in the Theory of Planned Behavior, and confidence in the 5Cs framework. Social expectations, enhanced by the professional authority a medical provider may have in the eyes of the patient, then represent the *cues to action* factor in the Health Belief Model, *subjective norms* in the Theory of Planned Behavior and *complacency* in the 5Cs framework.

### Vaccination was recommended by a medical authority.[3]

Vaccination is not only an individual act, but a social issue, therefore it is common for medical authorities to be present in the public sphere advocating for public health practices. That is even more apparent in the case of highly publicized COVID-19 vaccines. Chi Tam et al. found, that in case of the COVID-19

[2]Doporučil mi to můj lékař/moje lékařka.
[3]Očkování bylo doporučeno lékařskou autoritou

vaccines, recommendations from doctors were more compelling to those more likely to receive the vaccine (Chi Tam et al., 2021, p.150).

A recommendation issued by a medical authority is similar to the one issued by one's personal medical provider, and therefore can fall under the same categories by the same logic. However, we can suppose that its social norm formation powers are probably smaller.

### I would regret not getting vaccinated.[4]

Anticipated guilt is considered a strong predictor of the intention to perform a health behavior. Bish et al.'s overview of literature suggests that it can be a powerful predictor of intentions to perform the behavior (Bish et al., 2000, p.37). According to Brewer et al. it was a stronger predictor than other risk appraisals, such as perceived likelihood, severity and worry. Anticipated inaction regret (regret of not performing an action) predicted strong intentions to performing the action (2016).

Depending on the context of this motivation, it can be characterized either by falling under the *perceived susceptibility* or severity factor, or under *cues to action* of the Health Belief model. With regard to the Theory of Planned Behavior, it would most probably fall under *attitude toward behavior*. The 5Cs framework formulates a category that can be considered as the best fit for this motive – *calculation*.

### I wanted to prevent the disease. [5]

Preventing the target disease is the direct (biological) goal of vaccination. It is one of the most commonly declared reasons to receive a vaccine. The protection a vaccine offers was the primary reason cited in a study of influenza vaccine uptake (Verger et al., 2018, p.4), and one of the highest scores in another study (Carter, Beach, & Inui, 1986, p.382-383, 386). In a study of medical workers in Switzerland, over 70% cited their own protection as a reason to receive an influenza (seasonal or pandemic) vaccine (Dorribo et al., 2015, p.742). In a survey of dentists, conducted

[4]Litoval/a bych toho, kdybych se naočkovat nenechal/a.
[5]Chtěl/a jsem předejít onemocnění.

before the distribution of the COVID-19 vaccine, most of those indicating to be likely to receive the vaccine, cited oneself as a reason for the decision (Belingheri et al., 2021, p.744). Almost a half of respondents in all three waves of the survey of the Center for Public Opinion Research reported staying healthy as the primary motivation for receiving the COVID-19 vaccine (Čadová, 2021b; (Čadová, 2021c); (Čadová, 2022)), although it was grouped with preventing a serious course of the disease.

Protection from the disease can be easily categorizable in the context of the discussed models. In the Health Belief Model it directly relates to *perceived susceptibility* (although it may also be part of the *perceived benefits*, depending on the interpretation), and in the Theory of Planned Behavior it is a part of *attitudes toward the behavior*. It can be also understood as a part of *confidence* in the vaccine, defined by the 5Cs framework.

**I belong to a high-risk group.** [6]

Vaccination was widely recommended to parts of population in which serious illness was more likely to develop, should they contract COVID-19. Groups of patients with pre-existing conditions such as asthma or heart issues, as well as immunosurpressed patients were also given preference in the vaccine distribution plans, as was presented in Chapter 2 ("Harmonogram očkování v České republice", 2021). Brewer et al. found in a meta-analysis that people at a "higher likelihood of harm [..] were more likely to receive a vaccination." (2017, p.10). Sherman et al., however, did not find evidence for the same effect in case of the COVID-19 vaccine (2021, p.1618).

Belonging to a high-risk group is a typical representation of the *perceived severity* concept of the Health Belief Model. In the Theory of Planned Behavior it is most related to the *attitude toward the behavior* in general, as a belief that vaccination is especially useful because of one's health condition. Similar logic can be applied in the 5Cs framework to categorize this motive under the *confidence* category.

[6] Patřím do zdravotně ohrožené skupiny.

**I wanted to prevent a severe illness.**[7]

From the beginning there was an attempt to communicate that vaccines do not prevent disease completely (so-called break-through infections occur), but it was shown that they are highly effective in preventing a serious course of disease. In a study of influenza vaccination, perceiving influenza as a serious disease was the second most cited reason for vaccination (Verger et al., 2018, p.4). Although it was grouped with preventing the disease in general, its serious course was the most cited reason to receive the COVID-19 vaccine among the respondents of the survey of the Center for Public Opinion Research (Čadová, 2021b; (Čadová, 2021c); (Čadová, 2022)).

This motive is directly included in the categorization of the Health Belief Model (*perceived severity*). In the Theory of Planned Behavior it falls under the *attitude toward the behavior*, and similarly in the 5Cs framework under the *confidence* category, as the behavior is believed to prevent severe disease.

## Social reasons

**People around me got vaccinated.** [8]

Brewer et al. suggest that the tendency to immitate behavior may be an important factor in vaccine decision making. Homophily and clustering is a well-known phenomenon in the study of health issues social networks – people who exhibit similar health behaviors, tend to group together, for example smokers who tend to associate with other smokers (Brewer et al., 2017, p.168-169). Dunn et al. found that exposure to negative vaccine messaging made users of Twitter more likely to post anti-vaccine information as well (Dunn et al., 2015).

A study conducted on college students showed that assumed social norms had a positive effect on the respondent's likelihood of vaccination (Graupensperger et al., 2021). In a study of acceptance of the COVID-19 vaccine found that the hesitant population was significantly more receptive to vaccination if they were told larger proportion of the population had already been vaccinated (Argote et al.,

[7] Chtěl/a jsem předejít vážnému průběhu onemocnění.
[8] Lidé v mém okolí se nechali očkovat.

2021, p.4). A study of universty students in China showed a positive association of the willingness to receive a COVID-19 vaccine with the descriptive norm of vaccination, and a stronger effect was present in those students with a lower level of openness to new experiences (Mo et al., 2021). Another study from the USA showed only limited effect of messaging concentrated on norms in comparison to standard messaging about the benefits of the vaccine (Sinclair & Agerström, 2021). Researchers from the Chinese study point out the Chinese population has a tendency to conform to social rules(Mo et al., 2021, p.11), therefore, there may be a moderator effect of culture. A simulation of vaccine decision making in a social network showed that while individual judgment was the most important factor, sensitivity to surroundings also influenced the potential decision outcome (Ni et al., 2021).

By the presented logic, observed vaccination of one's social circles, should represent one of the to *cues to action* in the Health Belief Model, and similarly it produces a *subjective norm* according to the Theory of Planned Behavior. In the 5Cs framework it would probably be categorized as a *complacency* factor, characterizing the need to act in accordance to others' behavior.

**To help reach herd immunity.** [9]

One of the goals of wide-scale vaccination campaigns is not only to create immunity in each vaccinated individual, but to slow the spread of the pathogen via herd immunity, as was explained in Chapter 2. Herd immunity was a term largely mentioned since the beginning of the pandemic, therefore it was assumed respondents would understand its meaning and relate to it in some manner. Achieving herd immunity was the second most cited primary reason for the willingness to receive the COVID-19 vaccine in February (15% of respondents), in June the share fell to 7% and in November to 3%, according to the survey of the Center for Public Opinion Research (Čadová, 2021b; (Čadová, 2021c); (Čadová, 2022)).

Studies often do not measure the explicit motivation for participating in the herd immunity, but rather a general prosocial reasoning. One systematic review found that although only a small fraction of parents ranked benefit to others as the pri-

[9] Abych pomohl/a dosáhnout kolektivní imunity.

mary reason to vaccinate their children, 37% ranked it as second (Quadri-Sheriff et al., 2012). In a different study, male participants were more likely to accept the HPV vaccine, if the messaging was altruistically oriented, emphasizing that vaccination of the male population protected the female population from the risks of HPV (Bonafide & Vanable, 2015). Based on their theoretical model, Becchetti et al. suggest that messages promoting the COVID-19 vaccine should appeal to generativity, such as helping the society reach herd immunity (2021, p.8).

Depending on how literal one's understanding of the contribution to the herd immunity is, it can either be characterized as a *perceived benefit* in the Health Belief Model, or not be included in it at all, as the Health Belief Model is primarily centered around the individual. In the Theory of Planned Behavior, believing in the contribution to herd immunity by one's own vaccination decision, can be understood as an *attitude toward the behavior*. The 5Cs framework explicitly formulates the category of *collective responsibility* of which herd immunity is probably the ultimate representation.

**To protect people around me (family, friends, coworkers) from the disease.** [10]

The concept of herd immunity may feel too abstract for many. Pro-social motives can detected on a smaller scale as well – protection of direct contacts, such as family or friends. It was one of the primary reasons for receiving the COVID-19 vaccine reported by Czech health-workers in a study (Štěpánek et al., 2021, p.6). Similar results were found in studies of influenza vaccine in Switzerland (Dorribo et al., 2015, p.742) and the United States (Carter, Beach, & Inui, 1986, p.382-383, 386). Sherman et al. found that perceived risk to others increased vaccination intention (2021, p.1617). In a survey of dentists, conducted before the distribution of the COVID-19 vaccine, most of those indicating to be likely to receive the vaccine, cited protecting family, friends, and patients as reasons for the decision (Belingheri et al., 2021, p.742-743). Protecting people around was the primary reason for receiving the vaccine for 9% (February), 5% (June) and 10% (November) respondents in the surveys conducted by the survey of the Center for

[10] Abych před nákazou chránil/a své okolí (rodinu, přátele, kolegy v práci).

Public Opinion Research (Čadová, 2021b; (Čadová, 2021c); (Čadová, 2022)).

By being less abstract than herd immunity, protection of others can be categorized in the Health Belief Model much more easily, as one of the *perceived benefits of the behavior*. In the Theory of Planned Behavior it would fall under the *attitude toward the behavior*. In the 5Cs framework it also represents *collective responsibility*, similarly to herd immunity.

## Outside forces

**To not be obliged to follow the [pandemic] measures.** [11]

As vaccination rates grew, several countries began lifting, at least partially, some pandemic measures for the vaccinated population (e.g. mask-mandates in the USA ("Covid-19: C.D.C. Guidance Prompts Caution in Some States", 2021). In other countries certain life activities were easier for the vaccinated, such as attending restaurants and cultural events, which were accessible only with vaccines or a negative PCR test (later the option of the test was largely retracted, for example in the Czech Republic ("Volnočasové aktivity pouze s O-N. Vláda schválila nová opatření – Ministerstvo zdravotnictví", 2021) or Germany ("Covid: Germany puts major restrictions on unvaccinated", 2021)). These measures were not active in Europe until the last third of 2021, meaning it might have not been a motivation factor for those vaccinated earlier, though some may have anticipated such a progression.

In the case of the commonly used vaccines, the evidence of this reason being important is small, patients do not seem to exhibit licensing effects in moral behavior (change of behavior on the basis of being vaccinated) (Brewer et al., 2017, p.11). However, the situation with the COVID-19 vaccine is radically different, since it was often connected with legal restrictions of everyday life. Early research into the acceptance of COVID-19 vaccine acceptance showed a minimal effect of this motive as well, however it was done on medical workers in spring 2021 in Czech Republic, where no measure lifting was being connected with the vaccine roll-out (Štěpánek et al., 2021, str. 2, 6). In November 2021, a survey by the Center for

[11] Abych již nemusel/a dodržovat opatření.

Public Opinion Research reported "Life without restrictions – benefits for the vaccinated" as being the primary reason for vaccination for 9% of their respondents (Čadová, 2021c).

Not being obliged to follow pandemic measures can be viewed as a substantial *perceived benefit*, according to the Health Belief Model. In the Theory of Planned Behavior the categorization is not as straight-forward, but it may be understood as falling under the *perceived behavioral control* category. On the other hand, with the 5Cs framework, not being obliged (albeit to only a certain degree) can be seen as *calculation*.

**I felt forced by the state to get vaccinated.** [12]

The COVID-19 vaccine was a highly politicized issue. Measures that reflected one's vaccination status were introduced (for more information refer to Chapter 2). Especially in the later stages, in fall 2021, as the rate of uptake was stagnating, outside pressures were imposed in place of nudging and presenting vaccine benefits. Interestingly, this resembles a strategy that Becchetti et al. recommend based on a theoretical model (2021, p.9).

Feeling forced to perform a behavior is in a certain sense an extreme case of a *cue to action* (Health Belief Model) and a need for *complacency* (5Cs framework). It also represents limited *behavioral control* (Theory of Planned Behavior). This may be applied to all three versions of this statement (feeling forced by the state, one's surroundings and employer).

**I felt forced by my surroundings to get vaccinated.** [13]

This statement is similar to a previous statement, "People around me got vaccinated.", but it introduces a layer of active pressure, not only social norm formation. At the same time it is different to direct state pressure, as it refers to interpersonal relations. A typical situation may be within a family, where a member feels pressured to receive the vaccine in order to maintain a relationship with their family, even if they would not do so otherwise. In a case of the influenza vaccine,

[12] Cítil/a jsem se státem přinucen/a k očkování.
[13] Cítil/a jsem se přinucen/a k očkování ze strany svého okolí.

Stokes et Ismail found that encouragement from family and coworkers increased the likelihood of receiving the vaccine against H1N1 (2011).

**I felt pressured by my employer to get vaccinated.** [14]

Even though no vaccine mandates carried out via employment status were introduced in the Czech Republic, it was the case in some countries in Europe (such as France and Italy) and the USA ("Covid-19: France suspends 3,000 unvaccinated health workers", 2021). Discussions surrounding mandatory vaccinations for certain occupations were starting around the time data was collected (Neumann, 2021). Some people may have also experienced personal pressure from their employer, regardless of the legal status, for example through mandatory ("Archiv Testování zaměstnanců ve firmách", 2021).

**To be able to travel.** [15]

Vaccination became the center of attention in the context of international travel. Some countries, such as Australia, opened their borders for vaccinated visitors only (POLITICO, 2021), and some required their unvaccinated visitors to present a negative PCR and/or quarantine upon arrival. Holding a vaccination certificate enabled easier access to travel ("International travel and COVID-19", 2021). In the June survey of the Center for Public Opinion Research traveling was the primary reason to receive the vaccine for 10% of respondents, in November it fell to 1% (Čadová, 2021c; Čadová, 2022).

Easier travel could have been one of the most pronounced *perceived benefits* (Health Belief Model) of the vaccination against COVID-19. It may have also influenced the *perceived behavioral control* (Theory of Planned Behavior), by placing requirements motivating people to undergo vaccination. That may have resulted in *calculation* (5Cs framework) about performing the behavior. The same logic can be applied to the next statement – *paying for tests*, since it followed a similar tactic, only not applied to traveling but other areas of life.

[14] Cítil/a jsem se přinucen/a k očkování svým zaměstnavatelem.
[15] Abych mohl/a cestovat.

**To not be obliged to pay for tests.** [16]

During 2021, the Czech government offered free tests for COVID-19 (either PCR or antigen), in varying quantities over the year (Kottová Anna, 2022; ("Přehledně: Více lidí na hromadných akcích, jeden PCR test zdarma", 2022); Šindlerová, 2021). In the end of October, it was announced that since the beginning of November only those (at least partially) vaccinated, under 18 years old, those with medical exemptions for vaccination and those indicated for a test by a medical provider would be eligible for free testing ("Respirátory na hromadných akcích i kratší platnost testů. Vláda schválila nová opatření." 2021). Wanting to avoid these costs could have been an important reason for those deciding to receive the vaccine in October or November 2021.

## Opportunity

**Vaccination was easily available.** [17]

One of the key aspects for wide-spread vaccine success identified by research is accessibility (included for example in the 5A taxonomy and equivalent to the "convenience" factor of the 3/5C models (Betsch et al., 2018, p.3). Practical realization is often connected with setting up vaccination centers in a convenient location outside of the medical setting, such as places of worship, schools or community organizations, as well as assistance with booking appointments and transportation (Scientific Advisory Group for Emergencies (SAGE), 2021, p.8).

When asked about their influenza vaccine, workers in a hospital in Switzerland 51% of those not vaccinated against the seasonal influenza and 69% of the vaccinated against it said that the free and available vaccine was one of the reasons they obtained the vaccine against pandemic influenza (Dorribo et al., 2015, p.742). In a survey of possible factors that may help pursuate those hesitant to a vaccine, easy local access was one of the most cited (Prokop, 2021).

In terms of the Health Belief Model, both easy access to and costlessness of (next statement) the vaccine may have either reduced *perceived barriers*, or be

[16] Abych nemusel/a platit za testy.
[17] Očkování bylo jednoduše dostupné.

a *cue to action*. It is not directly tieable to any of the concepts in the Theory of Planned Behavior, although maybe it could indirectly increase *behavioral control* by removing a barrier. The 5Cs framework includes the *constraints* category, which is specifically aimed at practical accessibility.

**Vaccination was free.** [18]

The factor of the vaccine being free for the end user is often accounted for together with the accessibility, it is however a slightly different question. A vaccine may be readily available but with a prohibiting cost (for example the HPV vaccine (Young et al., 2010)). In the Czech Republic the COVID-19 vaccine was generally payed for by one's health insurance, self-payment became available in July 2021 ("Harmonogram očkování v České republice", 2021).

In survey pre-dating the vaccination campaign, the willingness to receive the vaccine was measured by questions specifically mentioning the vaccine would be free (Čadová, 2021a; Čadová, 2021c; Čadová, 2022; PAQ Research, 2022).

## General beliefs

**Vaccination is a path to normal life.** [19]

The key-point of the official Czech government campaign for the propagation of vaccination against COVID-19, Tečka (meaning "Dot" in Czech), was the promise of the return to normalcy. The official website stated "Vaccination is the path to normal life." ("Česko očkuje", 2021) This message has, however, not resonated strongly in the Czech society – all waves of the Public Opinion Research Centre's survey on vaccination showed that only a low percentage (1% to 6%) of respondents indicated the path to normal life as a primary reason for vaccination (Čadová, 2021b; Čadová, 2021c;Čadová, 2022).

Depending on how one understood the motto of "normal life", it could either be understood (in a more literal sense) as a *perceived benefit* (Health Belief Model) or *attitude toward the behavior* (Theory of Planned Behavior), or (in a more abstract sense) not be included in neither of the models' categorization. Its position in

[18] Očkování bylo zdarma.
[19] Očkování je cesta k návratu k normálnímu životu.

the 5Cs framework is not evident either – it can either be a representation of the *confidence* in the vaccine, *complacency* with the narrative, *calculation* ("If I get vaccinated, normal life will return.") or *collective responsibility*.

**I believe that getting vaccinated is generally a right thing to do.** [20]

One of the best predictors of the likelihood of vaccination is previous vaccination behavior (Seale et al., 2009‘ Chor et al., 2011). This points at not only reasons for specific vaccines, but a possible larger behavioral pattern, connected with a value that vaccination is important (for one reason or another). For some, the specifics of the COVID-19 vaccines may have not been the only factors they considered, but it was another vaccine that fit into a general belief that vaccination is a right thing to do.

A systematic review found that holding general positive attitudes towards vaccination was a reliable predictor of a parental decision to vaccinate their child (Smith et al., 2017, p.6064). Respondents of a 2020 survey in the USA on their vaccination decision regarding the COVID-19 vaccine cited "civic responsibility" as a decisive reason (over 90% of those willing to receive the vaccine) (Benis et al., 2021, p.8). Trust in vaccines in general was the primary motivator for 8% of respondents in the November survey of the Center for Public Opinion Research (3% in June and 5% in February) (Čadová, 2021b; Čadová, 2021c;Čadová, 2022).

A belief that vaccination is generally a right thing to do is not categorizable under the Health Belief Model, although it may be understood as an internal *cue to action* for a specific vaccination. In the Theory of Planned Behavior it is included in the *attitude toward the behavior*, since it implies a general attitude about vaccination to be applied to the vaccination against COVID-19. Depending on how this belief is formed, it can either be an expression of confidence in the vaccines or as a *collective responsibility*, in the context of the 5Cs framework. The Vaccine Hesitancy two-dimensional model (Peretti-Watel et al., 2015) draws on one's values ("healthism" and trust toward medicine), and we may suggest that the belief that vaccination is a generally right thing to do is most probably held by those who view health as a value (high level of "healthism") with a high trust in medicine.

[20] Věřím, že očkovat se je obecně správné.

**I trust the COVID-19 vaccines.** [21]

Distrust in the COVID-19 vaccines specifically is highly cited as a reason not to receive the vaccine (Čadová, 2021b; Čadová, 2021c;Čadová, 2022). On the other hand, is trust towards them also a reason to receive the vaccine? In general, Brewer et al. found that "beliefs that vaccines work, are safe, and are part of a trustworthy medical system" are important in vaccine acceptance (2017, p.11). Over a half of respondents of a 2020 survey in the USA on their vaccination decision regarding the COVID-19 vaccine expressed agreement with the statement "The COVID-19 vaccines are revolutionary and use innovative technology" (Benis et al., 2021, p.8).

Trust in the COVID-19 vaccines specifically is a concept not captioned in the Health Belief Model, by being on one hand very abstract, and on the other being tied to a specific situation. In the Theory of Planned Behavior it falls under *attitude toward behavior*. It can also be viewed as an ultimate expression of *confidence* in the vaccine by the 5Cs framework.

## 4.2 Time of registration

Apart from standard socio-demographic variables, respondents would also be split according to the time they registered for their vaccine. This question draws from the Theory of Diffusion of Inovations, formulated by Everett Rogers. The central thesis of this theory is that innovation is not adopted uniformly. A part of society adopts an innovation early on, some wait until others adopt it. Rogers suggests that this people fall in five different categories differentiated by level of innovativeness as innovators, early adopters, early majority, late majority and laggers (Rogers, 1983, p.22).

An argument may be made that a novel vaccine against a novel infection is a phenomenon that can be described with the process of diffusion of innovations. Groups that receive the vaccine early can differ from those who wait. Since the vaccine distribution was a controlled process, it is impossible to verify this on a universal level. A possible approximation can be made by abandoning the notion of

[21] Důvěřuji vakcínám proti onemocnění covid-19.

a universal timeline and introduce separate timelines for each respondent. The important orientation point is the time a respondent was officially eligible for their vaccine, either because of their age or occupation (i.e. health workers). We can roughly divide the continuum into four parts and assign each to a group defined by the theoretical model. The time of the registration is chosen as reference because the vaccination could occur at a much later date for reasons not under the control of the respondent, but we can suppose that the moment of registration occurred approximately at the same time as the vaccination decision itself.

Those who received the vaccine earlier than they were eligible for it were probably highly motivated, since as discussed in Chapter 2, it was not easily obtainable. This group equates to innovators and early adopters. Those who registered after it became available for their group, can be characterized as the early majority, and an artificial cut-off was chosen to be a month after the date of eligibility. Those who registered after a month can be characterized as late adopters – either late majority (more than a month, but earlier than in November 2021) or laggers (those who registered under the influence of tighter restrictions).

This definition of the spectrum is not perfect, as, for example, some may have received the vaccine early, but at the time were recently recovered from the infection (the government initially imposed a 3 month long period after infection when vaccination was not available ("Lidé po prodělání onemocnění covid-19 se mohou nově očkovat ihned po skončení izolace", 2021). These cases are, however, an exception rather than rule.

# Chapter 5

# Belief Network Analysis

Belief Network Analysis (BNA) is a relatively novel approach to analysing data structures. It can be found in psychometric research (Borsboom & Cramer, 2013), health beliefs (Brogan and Hevey, 2009; Nudelman et al., 2019), studying political beliefs (Zhang et al., 2021; Tabery and Pilnacek, 2021), attitude towards consumer plastics (Zwicker et al., 2020), or even art perception (Specker et al., 2021).

To discover the relationships between different concepts, each concept, attitude or belief (vocabulary varies depending on the application) is perceived as a node and connections (e.g. partial correlations or regression weights (Bringmann et al., 2019, p.893)) between them as edges (Brandt et al., 2019, p.1353). Edges may be undirected or directed (Bang-Jensen & Gutin, 2008), implying the direction of the flow of information or in some cases causality, and they can be assigned weights to differentiate importance of specific edges (Opsahl et al., 2010, p.245). Since the result is a network, we can then apply standard methods of analysis, such as centrality or metrics, which will be defined later in this chapter.

The idea of relating different beliefs to each other is not new. A popular method used widely in social sciences is factor analysis. It is based on the notion of latent variables. We assume that humans don't hold their views in isolation, but they stem from a common background, which is mostly not observable directly. Therefore, we need to measure it by operationalized concepts and construct the original variable, called latent variable, backwards (Borsboom et al., 2003b, p.203).

There is, however, a fundamental difference between the two methods. Accord-

ing to Dalege et al., factor analysis assigns all causal power to latent variables, observable variables serve only as their representations, whereas network analysis permits a causal system between the variables (2016). Where in factor analysis we search for variables explaining the relationship between observed variables, in network analysis we can study the relations directly without the assumption of the existence of a latent variable, or any other particular generating model (Borsboom et al., 2021, p.5).

We can illustrate this on the case of networks of symptoms of mental disorders. The network approach permits researchers to omit the assumption of an underlying diagnoses causing observable symptoms, but lets them study the interactions of the symptoms as individual entities which "form a causal system that is, itself, constitutive of the disorder."(Robinaugh et al., 2016, p.747). Similarly with belief networks we do not need to assume the origin of the beliefs but we can view them as a system that forms the outlook, not the other way around.

Once we view beliefs as a system, we can study its internal structure and its properties – from the macro level such as the small world effect, meso level such as clustering to the micro (node) level like identifying structurally important nodes (Bringmann et al., 2019, p.894). Another possibility the network approach gives us, is the study of dynamics in the system. As Robinaugh et al. propose, a change in one node (in their case symptom of a mental disorder) can cause a change in a different one (2016, p.748). Within the belief system this process is comparable to the concept of parallel constraint satisfaction, which describes the process of self-organisation of beliefs in a system (Monroe & Read, 2008). Suppose a belief is stimulated, for example by agreeing evidence. Another belief that is positively connected to the stimulated belief may become activated, and vice-versa, if a belief is negatively connected, it may become inhibited (Dalege et al., 2016, p.3). McGuire likens this to a physiological process of neuron activation (1990, p.504).

Beliefs are not static. Dynamic constraint can be seen as "the probability that any change in a particular belief would require a compensating change in the structure" (Olivos, 2020, p.5). Evidence for this effect is mixed, as Turner-Zwinkels and Brandt admit, while their own empirical research brings promising results that show that knowledge of the belief network can predict dynamic constraint (2022).

The connectivity hypothesis poses that networks of beliefs that have a higher connectivity are more stable and less prone to changes, even if evidence contradicting one belief is introduced. If that belief is to be changed, it also influenced other beliefs in the system. On the other hand, networks of beliefs that are less connected, are more adaptable in terms of new beliefs (Dalege et al., 2019). It is "a mechanistic explanation of why attitudes differ in their consistency" (Dalege et al., 2019, p.2). Both the parallel constraint satisfaction and the connectivity hypothesis have been empirically tested (Dalege et al., 2016, p.5; Dalege et al., 2019).

As any method, belief network analysis has been criticized. The main issue authors point out is the limited power of explanation of the network metrics. What exactly does it mean when we identify a node as central? Many centrality measures are based on the idea of "flow", which is hard to define in the context of psychometric networks. The author would however argue that at least in case of belief systems, such flow is imaginable. We can view the belief network as a map of available connections, in which articulations of beliefs (either verbal or in thoughts) is represented as the activation of relevant nodes . The connections within them represent the constraint such thoughts have to operate within. Activation of central nodes leads to smoother activation of other nodes – which we can view as the ephemeral flow. Although not directly formulated, this is the theoretical basis for, e.g., the dynamic constraint hypothesis, which attempts to prove this mechanism via indirect measurement of opinion changes.

Another criticism towards the construction of belief networks stems from limited possibility of estimating individual networks from aggregate data, as Brandt and Morgan point out. They do, however, admit that there is utility in comparison across different groups (2022).

## 5.1 Network construction

There are various methodological approaches to constructing such a network, most based on correlation between measured variables. One approach used, for example, by Boutyline and Vaisey (2017), is to construct the network as a correlation network. Correlations as a measure are, however, criticized in Belief Network Anal-

ysis since many of them might be spurious, e.g. arising from a shared connection. Preference is then given to partial correlations, which control the effect of other variables (Costantini et al., 2015, p.15).

Partial correlations can be obtaind from a multiple regression model,

$$y_i = \beta_{i0} + \beta ij y_j + \beta ik y_k + \ldots + \epsilon i,$$

, where $\beta ij$ are proportional to the regression slope predicting $y_i$ from $y_j$, or vice versa (Epskamp & Fried, 2018, p.4). It may be derived directly from the inverse of a variance-covariance matrix (ibid.). The value of the correlation coefficient usually serves as a basis for edge weight and/or path length.

Since both the correlation and partial correlation graphs are constructed on empirical data, it can be expected that there will always be a non-zero correlation between two beliefs, resulting in a fully connected graph (Costantini et al., 2015, p.16). This renders the network uninformative, bluring the relevant connections we are seeking to identify with those present because of irrelevant correlations. To be able to draw useful results, graph regularization is performed by truncating non-important edges. This can be done in several ways.

One approach is to simply decide on a threshold, under which we consider every correlation to be zero. We can also exclude all insignificant correlations (Epskamp, 2022, p.30). Another regularization method of sorts is that of Boutyline and Vaisey, who define path length as the inverse of the squared correlation, truncating small correlations more than larger (2017, p.1381).

Another approach to produce such a network is applying a LASSO penalty, which causes weak connections to shrink to zero and result in a much sparser network (Costantini et al., 2015, p.17). Building on that, an adaptive LASSO generalization, which assigns different penalties according to the weights of different coefficients (Zou, 2006). This technique produces reliable graphs representing the structure of the belief system, producing sparce graphs with only the most important connections (Costantini et al., 2015, p.17). Another adaptation is termed graphical LASSO (gLASSO), which estimates "partial correlation networks by inverting the sample variance–covariance matrix" (Epskamp & Fried, 2018, p.6).

## 5.2 Network Analysis

As Nudelman et al. say, one of the benefits of Belief Network Analysis is, that contrary to other multidimensional algorithms, which focus on grouping variables, network analysis can identify central variables, strongly linked to other ones (2019). These nodes are then "special" – but the nature of their specialty is to be determined by careful interpretation.

As this thesis will be working with small networks (less than 20 nodes), only micro- and meso- level (Bringmann et al., 2019, p.894) characteristics are considered. For the microlevel four centrality measures, and for the mesolevel the concepts of centralization and clustering are presented.

### Centrality measures

Although its precise interpretation is being debated, a node's centrality measure suggests its structural position with the network. High centrality nodes are thought of as hubs, low centrality as being on the periphery. In psychometric research for example, a nodes with high centrality are thought of as being "especially important to the etiology and treatment of mental disorders"(Robinaugh et al., 2016, p.748), this hypothesis however remains largely untested (ibid.). Similarly in belief networks, some authors believe central beliefs may be those from which other beliefs are derived from (Boutyline & Vaisey, 2017, p.1379).

The general concept of centrality has multiple operationalizations. One has to clarify what aspect makes a node central, or important (Brandes, 2016). Four most used measures are presented in the following text: degree (strength if we take weights into account), centrality, betweenness centrality, closeness centrality and Expected Influence. Multiple definitions of these measures exist, for this thesis the versions presented by Opsahl et al. (Opsahl et al., 2010) are used, since these are the ones included in the qgraph package used for the analysis (Epskamp, 2022).

**Strength centrality** is defined as "the sum of the absolute value of the edge weights that directly connect to a node (Barrat et al., 2004; Newman, 2010), and is an indicator of the immediate connections and potential influences a belief system." (Brandt et al., 2019, p.1353).

Strength centrality, when considering weights of nodes, can be formally noted as (Opsahl et al., 2010, p.246):

$$C_s(i) = \sum_{j}^{N} w_{ij},$$

where $w_{ij}(> 0)$ represents the weight of the edge between nodes i and j. Since the graph constructed through partial correlations can contain negative weights, these are firstly made positive using their absolute value (Epskamp, 2022, p.5).

**Betweenness centrality** is defined as the degree to which shortest paths (geodesics) of the network's nodes pass through the measured node. According to Brandt et al., it "thus captures how necessary the belief system component is for linking together the other parts of the belief system." (Brandt et al., 2019, p.1353). It is also used by Boutyline and Vaisey for identifying the central (originating) belief (2017, p.1383).

Betweenness centrality, according to Freeman's definition (which is adopted by Opsahl et al. (2010)) and the qgraph package (Epskamp, 2022)), is defined on the basis of the shortest path between two nodes, also called geodesics. Since the edges are weighted, Dijskra's algorithm is introduced, where distance between nodes i and j is calculated as the minimum of the sum of inverse weights of all edges on the possible paths between these two nodes (Opsahl et al., 2010, p.248):

$$d(i, j) = min(\frac{1}{w_{ih}} + ... + \frac{1}{w_{hj}}).$$

A geodesic between nodes is the path with the shortest distance. Betweenness centrality of a node is given as the number of times it is present on the shortest path between any two nodes. We define $g_{ij}$ as the number of geodesics between nodes $i$ and $j$ and $g_{ij}(k)$ as the number of geodesics between nodes $i$ and $j$ which include node $k$.

Betweenness centrality of node $k$ is then written as (Opsahl et al., 2010, p.247):

$$C_b(k) = \frac{g_{i,j}(k)}{g_{ij}}.$$

**Closeness centrality** represents the distance a node is apart from all other nodes in the network, "representing how "quickly" the influence of a particular component can get from one component of the belief system to the rest of the components in the system" (Brandt et al., 2019, p.1353).

The definition of closeness centrality is based on the same notion of distance as betweenness centrality. Dijskra's algorithm is used to obtain the shortest distance between two nodes. Closeness centrality is then the inverse of the sum of lengths of shortest paths leading from the node to all other nodes in the network, symbolically (Opsahl et al., 2010, p.247):

$$C_c(i) = \left[\sum_{i}^{N} d(i,j)\right]^{-1}.$$

**Expected Influence** is a modification of degree/strength centrality introduced by Robinaugh et al. (2016). It removes the issue of degree centrality not accounting for negative weights. When two nodes are connected through a negative correlation, the influence they have on one another is probable to be small or in opposition. Two measures of Expected Influence are defined: one-step and two-step. One step expected influence characterizes the influence a node has on its immediate neigbors. It is defined as the summed weight of its edges with neighboring nodes:

$$c_{EI}(i) = \sum_{j=1}^{N} a_{ij} w_{ij},$$

where $a_{ij}w_{ij}$ represents the value of the weighted edge between node $i$ and node $j$ (Robinaugh et al., 2016, p.749).

The two-step expected influence is an estimate on the influence of a node of the neighbors of its neighbors. The formula is the same, but with an addition of a weighted sum of the expected influences of the node's neighbors.

$$c_{EI}(i) = \sum_{j=1}^{N} a_{ij} w_{ij} + \sum_{j=1}^{N} a_{ij} w_{ij} \sum_{k=1}^{N} a_{kj} w_{kj},$$

where "$a_{kj}w_{kj}$ indicates the weighted edge between node j and all other nodes in

the network $k$ multiplied by the weighted edge between node $i$ and node $j$ $a_{ij}w_{ij}$" (Robinaugh et al., 2016, p.749).

Although strength centrality is commonly used to assess the centrality of nodes, according to Brandt et al., it is not the most efficient measure, since it only concerns the immediate surroundings of the node. According to them, betweenness and closeness centrality, by capturing the position in the whole network, are theoretically better suited towards interpretation in the context of belief networks (*)Brandt2019. On the other hand, Epskamp et al. showed that betweenness and closeness centrality measures are highly unstable (2018).

### 5.2.1 Network structure

As was said in the begining of this chapter, another way to analyze a network of belief is as a whole structure. This approach is commonly used in pairing with influential node detection (Dalege et al., 2019; Brogan and Hevey, 2009). There are several metrics that serve to quantify this analysis: centralization measures and community detection, also known as clustering.

Centralization "records the extent to which a single actor has high centrality, and the others, low centrality. It also can be viewed as a measure of how unequal the individual actor values are." (Wasserman & Faust, 1994, p.176). This centralization measure is formally denoted by Freeman (Freeman, 1978, p.228) as:

$$C_X = \frac{\sum_n^{i=1}(C_x(p*) - C_X(p_i)}{\max \sum_n^{i=1}(C_x(p*) - C_X(p_i)},$$

where $C_X(p_i)$ is the centrality of node $i$ and $C_X(p*)$ is the largest value of $C_X(p_i)$. This general formula can then be applied to any measure of centrality described above. Boutyline and Vaisey use this measure to estimate how much more central a central belief is in relation to the network (2017).

# Chapter 6

# Methodology

## 6.1 Survey administration

The data for the empirical part of this thesis was obtained by a representative survey. It was conducted from the 6th to 12th of December 2021 in an online omnibus, realized by a research company NMS Market Research (NMS Market Research, 27.12.2021). The target population was the Czech adult population between ages of 18 and 64 (from the Czech National Panel), the size of the sample was 1005 respondents, selected via quotas. It is representative in the variables of sex, age, education, region and size of settlement (Rambousek L., personal communication, 27th of December 2021).

The questionnaire was first released as a pilot version between 25th and 28th of November 2021 within the author's social circles. The data from this pilot version have not been analyzed, as they are not representative, but the comments were used to specify the formulations and add additional statements.

## 6.2 Questionnaire

The questionnaire was administered in Czech, with versions for both genders included in the same sentence. The complete questionnaire in its original and translated version is available in Appendix A.

The first filter question was whether the respondent is vaccinated against

COVID-19[1], where following options were offered: "yes, I am vaccinated with the full first scheme (two doses for two dose schemes and one dose for one dose vaccine schemes"[2],"yes, I have received one dose (in case of a two dose vaccine)"[3], "yes, I have received a booster dose"[4], "no, I have not been vaccinated"[5], and "I don't want to answer"[6].

If a respondent indicated they are vaccinated, but not boosted, the following question was how certain they were to receive a booster dose. As this survey was conducted in the beginning of December 2021, this was still a mostly hypothetical question for most respondents. All at least partially vaccinated respondents were asked when they registered for the vaccine. Unvaccinated respondents were asked how likely it is that they get vaccinated in the future and if it was at least somewhat likely, they were asked how likely it is that they get vaccinated in the following month.

Twenty concepts were chosen to measure respondents' individual motivation for their decision to receive the vaccine against COVID-19. They were chosen based on a review of empirical literature, presented in Chapter 4. The introductory question for respondents, who were at least partially vaccinated, was formulated as "People can have different motivations for getting vaccinated. Please try to remember the situation before your first dose of the vaccine. To what extent do the following statements describe your motivation for the decision to receive the vaccine?"[7] For respondents who said they were not vaccinated but indicated a possibility of getting vaccinated in the future, a slightly modified version was used, "People can have different motivations for getting vaccinated. To what extent do the following statements describe your motivation for the decision to receive the vaccine?"[8] and relevant statements were formulated in present tense. A 7-point

[1]Jste očkován/a proti onemocnění covid-19?

[2]Ano, mám dokončené očkování, bez posilující dávky (jedna dávka u jednodávkové vakcíny nebo dvě dávky u dvoudávkové vakcíny).

[3]Ano, ale jsem očkován pouze první dávkou dvoudávkové vakcíny.

[4]Ano, a jsem naočkován i posilující dávkou.

[5]Ne, nejsem naočkován.

[6]Nechci odpovídat.

[7]Lidé mohou mít k očkování různé motivace. Zkuste si nyní prosím vzpomenout na situaci před vaší první dávkou očkování. Nakolik následující tvrzení vystihují vaši motivaci pro rozhodnutí nechat se očkovat?

[8]Lidé mohou mít k očkování různé motivace. Nakolik následující tvrzení vystihují vaši moti-

scale was used with the ends labeled as "it does not describe my motivation at all"[9] and "it fully describes my motivation"[10]. An open question was left at the end of the questionnaire for any further reasons respondents wanted to indicate for their vaccination decision. A non-response option was not offered.

Unfortunately, during the process of data collection an administrative mistake was done on the side of the author, which lead to the loss of answers of the unvaccinated subpopulation on one statement ("I felt pressured by my employer to get vaccinated."[11]). This statement is therefore omitted from the analysis completely, even for the vaccinated subpopulation.

## 6.3 Data preparation

The data analysis was conducted with the use of the `R` software, version 4.1.2 (R Core Team, 2021). Main packages used for analysis were `qgraph` (Epskamp, Cramer, et al., 2012) and `psych` (Revelle, 2021), plots were generated with `ggplot2` (Wickham, 2016).

The goal of the thesis is to analyze the motivation factors as a network, for which the Belief Network Analysis (see Chapter 5) framework was used. The network representing answers of all vaccinated respondents was constructed as a network of partial correlations with gLASSO constraint, which supresses small irrelevant correlations. Due to sample size gLASSO regularization was not possible for the networks corresponding to the subpopulations and networks based on partial correlations are presented.

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vaci pro rozhodnutí nechat se očkovat?

[9] Vůbec mé motivaci neodpovídá.

[10] Zcela mou motivaci vystihuje.

[11] Cítil/a jsem přinucen/a k očkování svým zaměstnavatelem.

## 6.4 Item names

For a clearer presentation, aliases for all the statements were used. Below in table 6.1 the guide for these short names is presented.

| | |
|---|---|
| My doctor recommended it to me. | doctor |
| Vaccination was recommended by a medical authority. | medical authority |
| I would regret not getting vaccinated. | regret |
| I wanted to prevent the disease. | protection |
| I belong to a high-risk group. | high-risk group |
| I wanted to prevent a severe illness. | serious illness |
| People around me got vaccinated. | people around |
| To help reach herd immunity . | herd immunity |
| To protect people around me (family, friends, coworkers) from the disease. | protection of others |
| To not be obliged to follow the [pandemic] measures. | measures |
| I felt forced by the state to get vaccinated. | forced by state |
| I felt forced by my surroundings to get vaccinated. | forced by people |
| I felt pressured by my employer to get vaccinated. | - |
| To be able to travel. | travel |
| To not be obliged to pay for tests. | paying for tests |
| Vaccination was easily available. | availability |
| Vaccination was free. | free |
| Vaccination is a path to normal life. | normal life |
| I believe that getting vaccinated is generally a right thing to do. | vaccination is right |
| I trust the COVID-19 vaccines. | trust in vaccines |

Table 6.1: Item names

## 6.5 Network construction

All networks are constructed with partial correlations representing edge weights. The first solution is a general network using data from all vaccinated respondents. As was discussed in Chapter 5, belief networks may not be as robust to interpret on their own, but rather in comparison. As we saw previously, only some groups showed statistically significantly different distributions of the measured items' importance, but that does not automatically mean the differences in internal structures of the belief systems are not possible.

Comparing networks between each other is not a trivial task and should be considered carefully. Therefore mainly qualitative assessment is made about the structure of the networks. Measures of centralities are provided on a z-score scale, which enables comparisons - it is not the absolute measure of centrality of the node that is compared, but rather it's score in relation to others.

Four centrality measures, presented in Chapter 5 are measured - strength, betweenness, closeness and Expected Influence.

For comparison between groups, separate networks were created. Five characteristics were chosen to group vaccinated respondents: time of registration, sex, education, age, income, and city size. Unvaccinated respondents were compared according to the level of likelihood they assigned to being vaccinated in the future.

Due to the small size of the subsamples, gLASSO regularization (Epskamp et al., 2018) was no longer possible. Networks we constructed through partial correlations, assigning edges between nodes the value of the Spearman correlation coefficient. All coefficients were included, regardless of their statistical significance. A threshold of 0.1 was introduced, values smaller in absolute values than the threshold were deleted from the network. Other possible values of the threshold (0.2 and 0.3) were experimented with, but the value of 0.1 seems to be the most beneficial. It preserves important structural information without breaking up the networks into isolated subnetworks, while in most cases not being too crowded. Partial correlation values were generally very small. Figures that capture correlation matrixes for all networks are included in Appendix C.

The cut-off for considering a node more or less central in relation to other nodes was set to $|c_x(i)| > 1.5$, where $c_x(i)$ is the centrality (by measure $x$) of node $i$).

# Chapter 7

# Results

## 7.1 Data overview

The dataset contains 1005 respondents. It is representative of the Czech online population between the ages of 18 and 64. In Figure 7.1 we can see the distribution of the socio-demographic variables. Distributions are presented below in Figures 7.2 - 7.5. Colors are assigned to each category which later correspond to centrality analyses.

Data for the variable of city size and income are recategorized to form a smaller number of groups. City size is split into four sections: Less than 1 999 inhabitants, 2 000 - 19 999 inhabitants, 19 999 to 100 000 inhabitants, More than 100 000 inhabitants. Income is categorized as follows: Less than 20 000 CZK, 20 000 to 40 000 CZK, Over 40 000 CZK.

| | n=1005 | % |
|---|---|---|
| **Sex** | | |
| Men | 498 | 49.6 |
| Women | 507 | 50.4 |
| **Education** | | |
| Elementary | 83 | 8.3 |
| Vocational training | 343 | 34.1 |
| Secondary | 363 | 36.1 |
| Tertiary | 216 | 21.5 |
| **City size (number of inhabitants)** | | |
| Less than 999 | 174 | 17.3 |
| 1 000 - 1 999 | 85 | 8.5 |
| 2 000 - 4 999 | 125 | 12.4 |
| 5 000 - 19 999 | 191 | 19.0 |
| 20 000 - 99 999 | 212 | 21.1 |
| More than 100 000 | 218 | 21.7 |
| **Age in years** | | |
| 18 - 24 | 105 | 10.4 |
| 25 - 34 | 213 | 21.2 |
| 35 - 44 | 260 | 25.9 |
| 45 - 54 | 216 | 21.5 |
| 55 - 64 | 211 | 21.0 |
| **Household income in CZK** | | |
| Less than 10 000 | 23 | 2.3 |
| 10 001 - 15 000 | 44 | 4.4 |
| 15 001 - 20 000 | 56 | 5.6 |
| 20 001 - 25 000 | 70 | 7.0 |
| 25 001 - 30 000 | 97 | 9.7 |
| 30 001 - 35 000 | 80 | 8.0 |
| 35 001 - 40 000 | 105 | 10.4 |
| 40 001 - 50 000 | 155 | 15.4 |
| 50 001 - 60 000 | 99 | 9.9 |
| More than 60 000 | 121 | 12.0 |
| Declined to answer | 155 | 15.4 |

Table 7.1: Socio-demographic characteristics of the whole sample

The age distribution of respondents is relatively uniform across the spectrum, although there are visibly less young respondents. The distribution is shown in Figure 7.1. For further analysis the respondents are categorized by their age groups, which are shown in Figure 7.2.

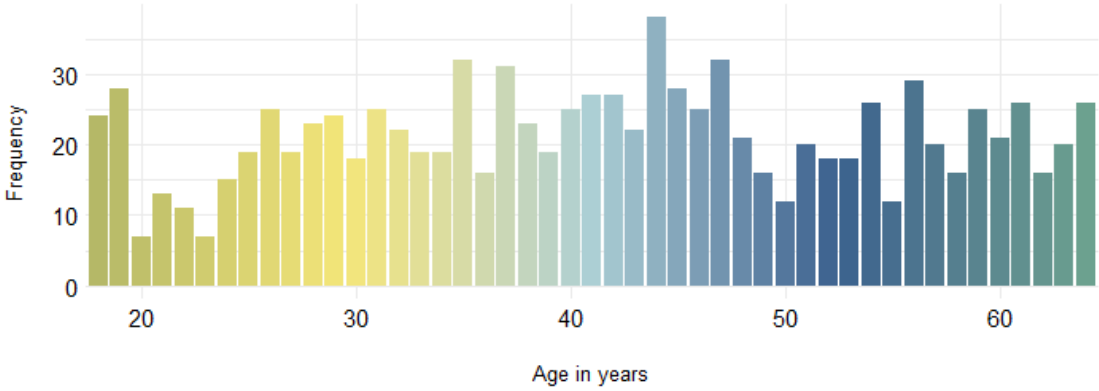



Figure 7.1: Distribution of respondents by age

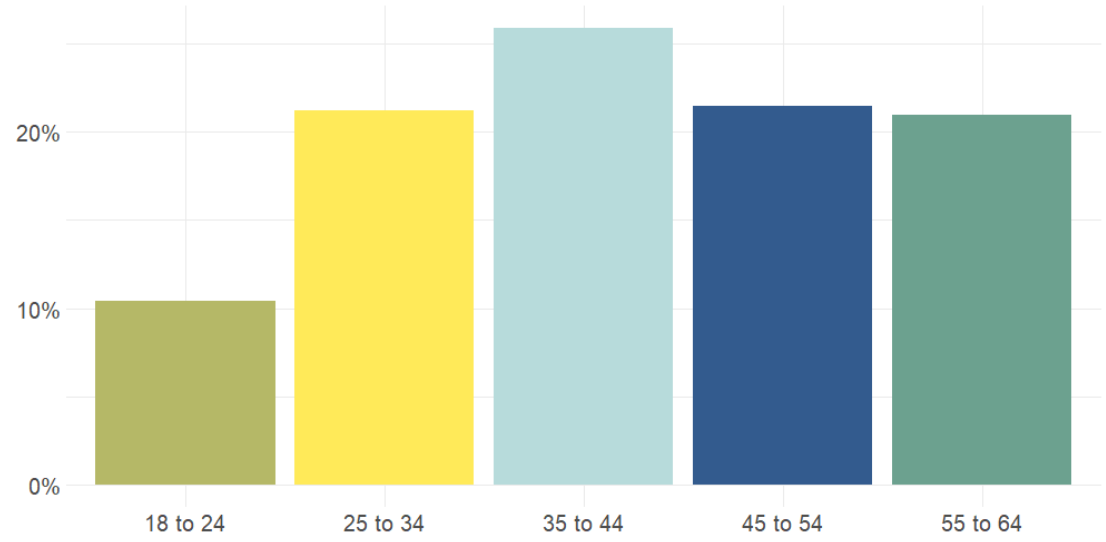



Figure 7.2: Distribution of respondents by age categories

Most respondents came from mid- to large-size cities. The distribution is shown in Figure 7.3.

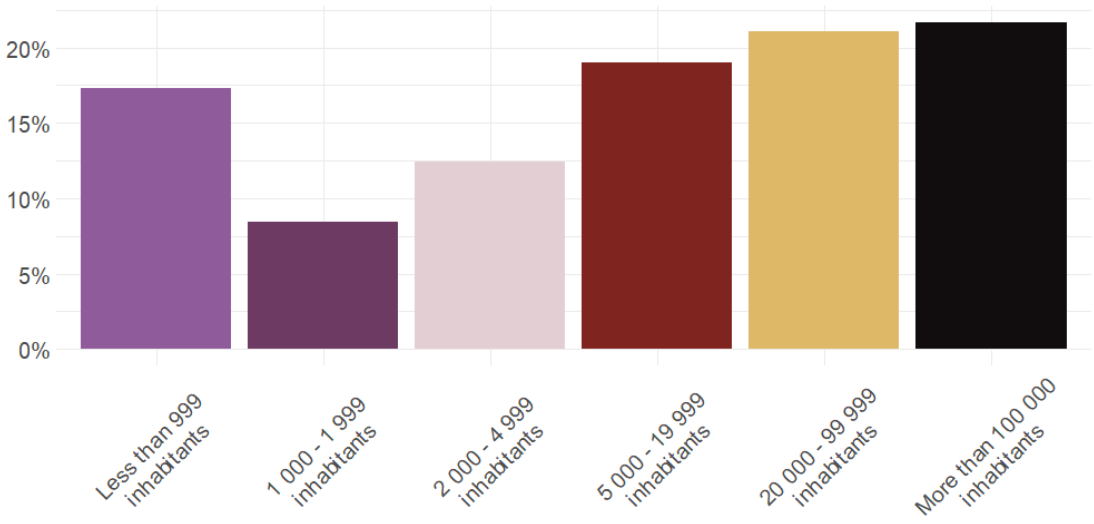



Figure 7.3: Distribution of respondents by city size

Most respondents have finished secondary education - either vocational or general. About a quarter (23.1%) have obtained a diploma from a higher education institution.

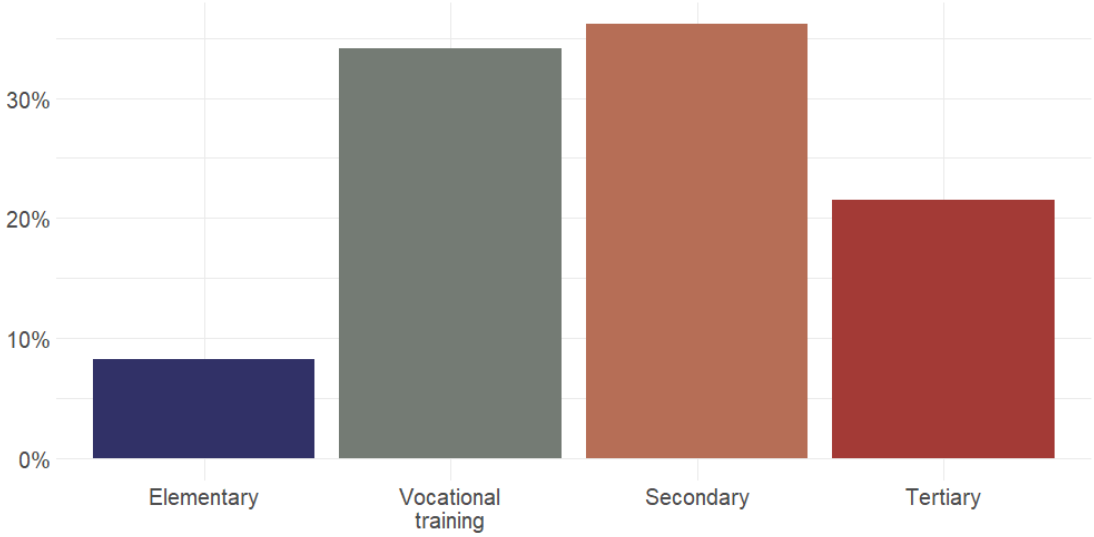



Figure 7.4: Distribution of respondents by education

The household income distribution is negatively skewed. Its median falls between 35 000 and 40 000 CZK. It must be taken into consideration that more than

15.4% respodents declined to answer this question.

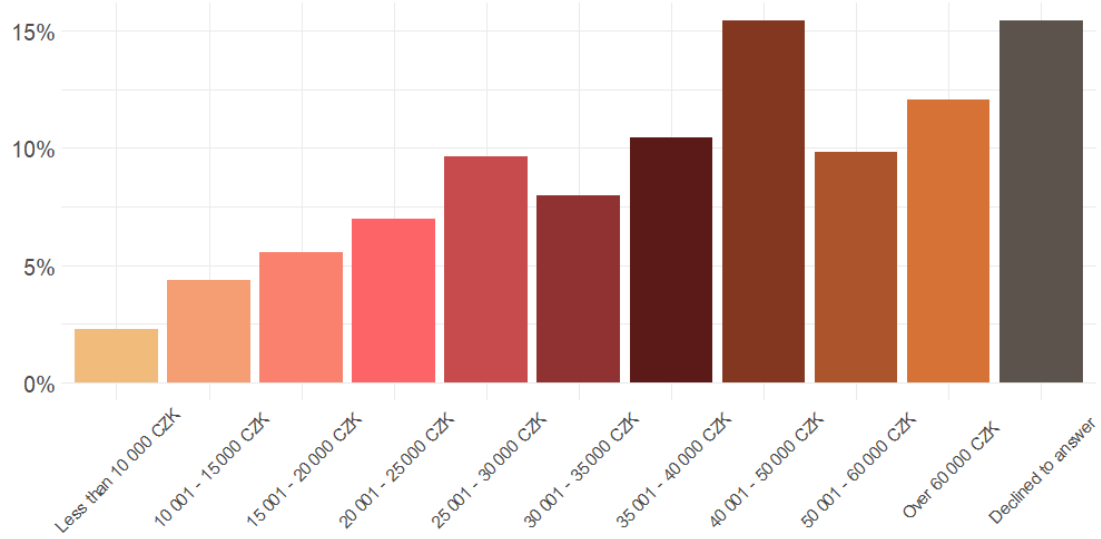



Figure 7.5: Distribution of respondents by income categories

If we split the dataset according to vaccination status - vaccinated and unvaccinated, there are a few differences in the distributions of socio-demographic characteristics, as seen in Figure 7.2. The vaccinated subgroup tends to be slightly more educated (less respondents with vocational training or secondary education, more with tertiary education), come from larger cities (specifically from cities over a 100 000 inhabitants), older, and from households with higher incomes. These differences, however, have not been tested and are only a rough comparison.

| | Vaccinated n=716 | % | Unvaccinated n=261 | % |
|---|---|---|---|---|
| **Sex** | | | | |
| Men | 373 | 52.1 | 117 | 44.8 |
| Women | 343 | 47.9 | 144 | 55.2 |
| **Education** | | | | |
| Elementary | 61 | 8.5 | 22 | 8.4 |
| Vocational training | 237 | 33.1 | 96 | 36.8 |
| Secondary | 251 | 35.1 | 98 | 37.5 |
| Tertiary | 167 | 23.3 | 45 | 17.2 |
| **City size (number of inhabitants)** | | | | |
| Less than 999 | 113 | 15.8 | 56 | 21.5 |
| 1 000 - 1 999 | 63 | 8.8 | 21 | 8.0 |
| 2 000 - 4 999 | 87 | 12.2 | 34 | 13.0 |
| 5 000 - 19 999 | 136 | 19.0 | 49 | 18.8 |
| 20 000 - 99 999 | 148 | 20.7 | 59 | 22.6 |
| More than 100 000 | 169 | 23.6 | 42 | 16.1 |
| **Age in years** | | | | |
| 18 - 24 | 79 | 11.0 | 25 | 9.6 |
| 25 - 34 | 144 | 20.1 | 62 | 23.8 |
| 35 - 44 | 167 | 23.3 | 84 | 32.2 |
| 45 - 54 | 163 | 22.8 | 46 | 17.6 |
| 55 - 64 | 163 | 22.8 | 44 | 16.9 |
| **Income in CZK** | | | | |
| Less than 10 000 | 13 | 1.8 | 9 | 3.4 |
| 10 001 - 15 000 | 25 | 3.5 | 17 | 6.5 |
| 15 001 - 20 000 | 39 | 5.4 | 16 | 6.1 |
| 20 001 - 25 000 | 43 | 6.0 | 24 | 9.2 |
| 25 001 - 30 000 | 62 | 8.7 | 34 | 13.0 |
| 30 001 - 35 000 | 58 | 8.1 | 20 | 7.7 |
| 35 001 - 40 000 | 74 | 10.3 | 28 | 10.7 |
| 40 001 - 50 000 | 122 | 15.6 | 39 | 14.9 |
| 50 001 - 60 000 | 78 | 10.9 | 19 | 7.3 |
| More than 60 000 | 100 | 14.0 | 20 | 7.7 |
| Declined to answer | 112 | 15.6 | 35 | 13.4 |

Table 7.2: Socio-demographic characteristics of the vaccinated and unvaccinated samples

### 7.1.1 Vaccination attitudes

Most respondents answered they were vaccinated (6.9% including the booster dose, 61.5% with the basic scheme, 2.9% with the fisrt dose of a two-dose scheme vaccine). About a quarter (26%) of respondents said they were not vaccinated. Only 2.8% declined to answer.

| | **n=1005** | % |
|---|---|---|
| Vaccinated with booster | 69 | 6.9 |
| Vaccinated without booster | 618 | 61.5 |
| Partially vaccinated | 29 | 2.9 |
| Not vaccinated | 261 | 26.0 |
| Declined to answer | 28 | 2.8 |

Table 7.3: Vaccination status

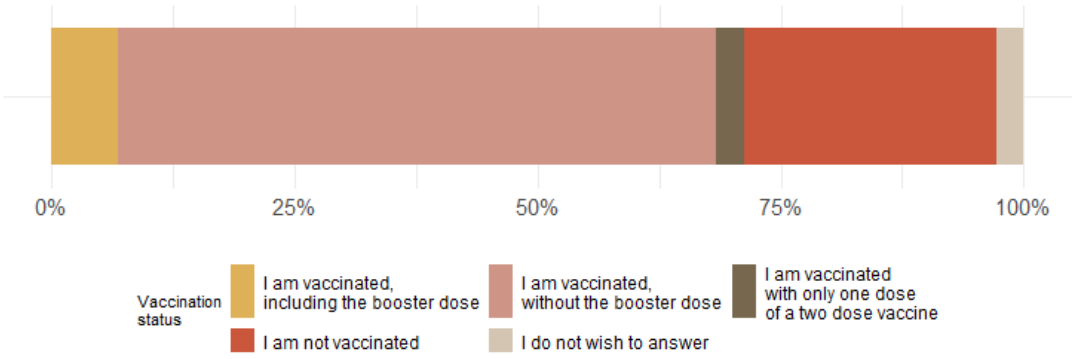



Figure 7.6: Distribution of respondents by vaccination status

When we look within the groups, the rates of vaccination are very similar. There is a tendency for male, older, and more educated respondents to be vaccinated at a higher rate than their counterparts. The distribution can be seen in Table 7.4 and Figure 7.7.

| | I am vaccinated, including the booster dose | I am vaccinated | I am partially vaccinated | I am not vaccinated | I do not wish to answer |
|---|---|---|---|---|---|
| **Sex** | | | | | |
| Men | 6.63 | 65.86 | 2.4 | 23.49 | 1.6 |
| Women | 7.1 | 51.2 | 3.35 | 28.4 | 3.94 |
| **Age** | | | | | |
| 18-24 | 0.95 | 71.43 | 2.86 | 23.8 | 0.95 |
| 25-34 | 3.76 | 58.69 | 5.16 | 29.1 | 3.29 |
| 35-44 | 4.23 | 57.3 | 2.69 | 32.3 | 3.46 |
| 45-54 | 7.87 | 65.28 | 2.31 | 21.3 | 3.24 |
| 55-64 | 15.17 | 60.66 | 1.42 | 20.8 | 1.9 |
| **Education** | | | | | |
| Elementary | 2.4 | 67.47 | 3.61 | 26.5 | 0 |
| Vocational training | 7 | 59.18 | 2.92 | 27.99 | 2.92 |
| Secondary | 6.89 | 59.5 | 2.75 | 27 | 3.86 |
| Tertiary | 8.33 | 66.2 | 2.78 | 20.83 | 1.85 |
| **City size** | | | | | |
| Under 1 999 | 4.25 | 59.85 | 3.86 | 29.72 | 2.32 |
| 2 000 - 19 999 | 7.59 | 60.13 | 2.85 | 26.27 | 3.16 |
| 20 000 - 100 000 | 6.6 | 61.32 | 1.89 | 27.83 | 2.36 |
| More than 100 000 | 9.17 | 65.6 | 2.75 | 19.27 | 3.21 |
| **Household income** | | | | | |
| Less than 20 k | 6.5 | 54.66 | 2.44 | 34.14 | 3.26 |
| 20-40k | 6.65 | 58.8 | 2 | 30.11 | 2.56 |
| over 40k | 8.27 | 65.87 | 3.2 | 20.8 | 1.87 |
| declined | 4.52 | 63.23 | 4.52 | 22.58 | 5.16 |

Table 7.4: Distribution of vaccination status by socio-demographic characteristics

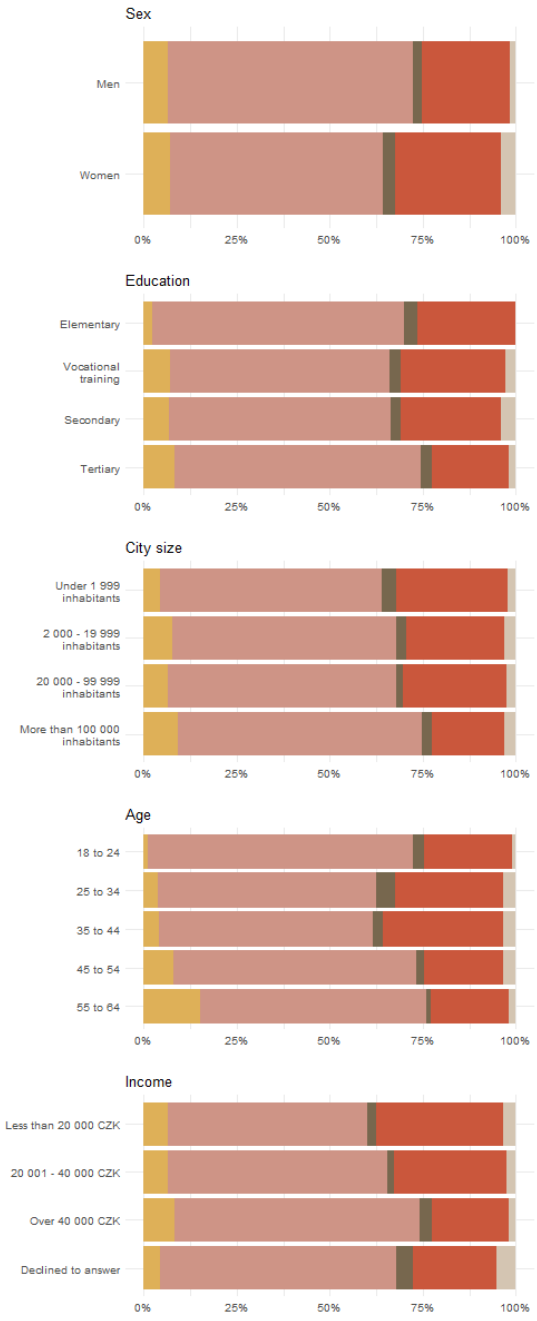



Figure 7.7: Distribution of vaccination status by socio-demographic characteristics

As can be seen in Figure 7.8, from the respondents who were vaccinated, over a half (52.9%) had registered within a month from when the vaccine had become available to them. A significant portion of respondents reported being vaccinated

before it was their official turn, about one fifth. About 6% of respondents registered less than a month before the data was collected. Only a small portion, less than one percent, of respondents declined to answer and less than 5% did not know the answer.

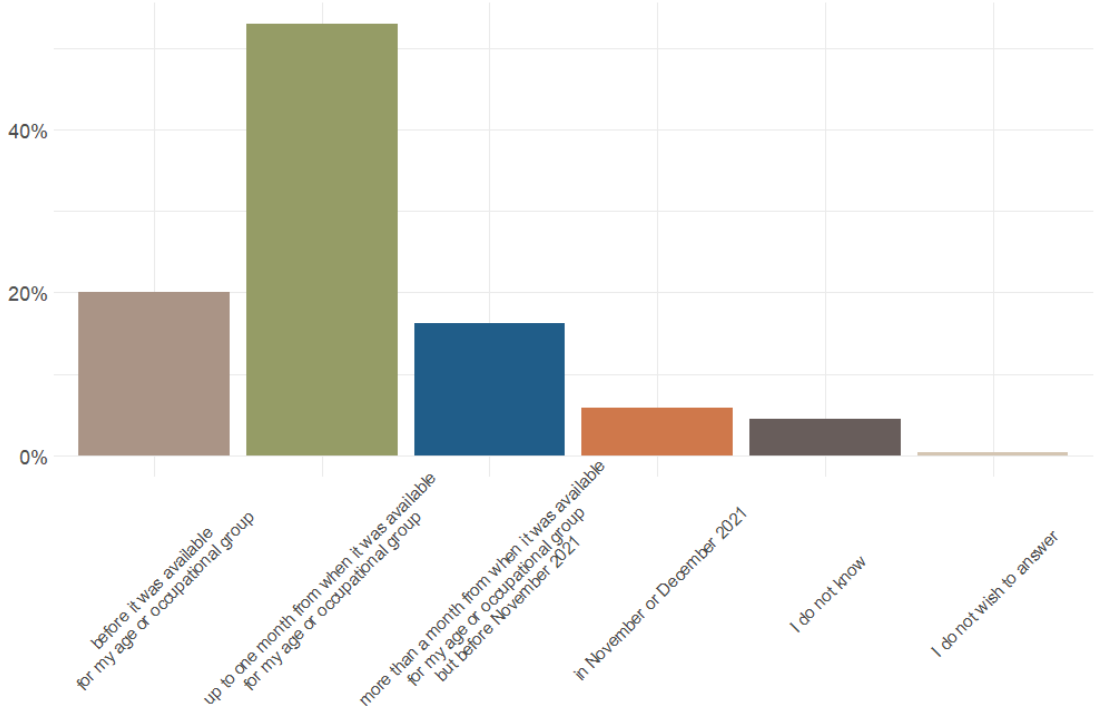



Figure 7.8: Distribution of respondents by time of registration for the vaccine

Vaccinated respondents indicated a strong inclination towards receiving the booster dose, where 55.7% of the respondents (who had not yet received it) answered they were very likely to receive the booster dose, with 78.7% being at least somewhat likely.

The distribution of the respondents according to the time of registration for their vaccination and likelihood of receiving a booster dose in the future is shown in Table 7.5, the graphical distribution of the likelihood of the booster dose is on Figure 7.9.

| | n=716 | % |
|---|---|---|
| **Time of registration** | | |
| before it was available for my age or occupational group | 144 | 20.1 |
| up to one month from when it was available my age or occupational group | 379 | 52.9 |
| more than a month from when it was available my age or occupational group before November 2021 | 116 | 16.2 |
| in November or December 2021 | 42 | 5.9 |
| I do not wish to answer | 3 | 0.4 |
| I do not know | 32 | 4.5 |
| **Booster dose** | | |
| -3 = not likely | 31 | 4.3 |
| -2 | 22 | 3.1 |
| -1 | 26 | 3.6 |
| 0 | 64 | 8.9 |
| 1 | 54 | 7.5 |
| 2 | 94 | 13.1 |
| 3 = very likely | 356 | 49.7 |
| already had a booster dose | 69 | 9.6 |

Table 7.5: Time of registration and likelihood of receiving the booster dose reported by the vaccinated population

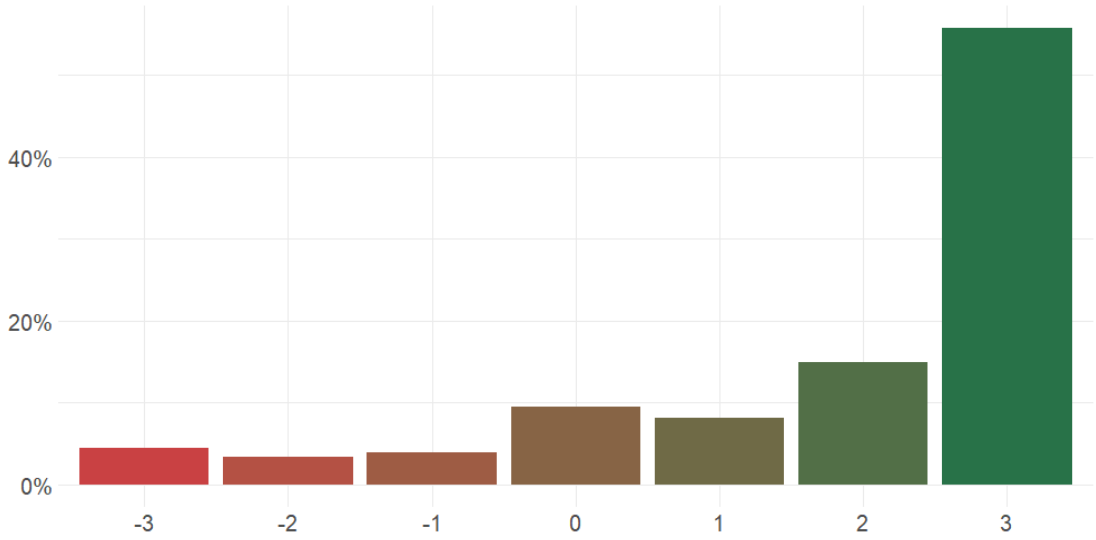



Figure 7.9: Distribution of vaccinated respondents by likelihood of receiving a booster dose

Interestingly, if we compare the distribution to the results of the Public Opinion Research Centre's survey on vaccination position, which was collected in the similar time-frame as data for this thesis (Čadová, 2022), we find that unvaccinated respondents for this thesis showed a more radically negative outlook towards the possibility of their future vaccination. More than half of the respondents said they were not likely to receive the vaccine, whereas in the the Public Opinion Research Centre's survey it was about a third. If we categorize the answers "-1" and "-2" as "likely not to vaccinate" and "1" and "2" as "likely to vaccinate", we can compare the percentages, as shown in Table 7.6. Distribution of answers in the studied dataset is depicted in Figure 7.10.

| likelihood of vaccination | Public Opinion Research Centre (CVVM) | thesis data |
|---|---|---|
| not likely | 37.1% | 51.7% |
| somewhat not likely | 22.9% | 21.3% |
| don't know | 8.5% | 10.7% |
| somewhat likely | 17.1% | 11.1% |
| very likely | 14.2% | 6.1% |

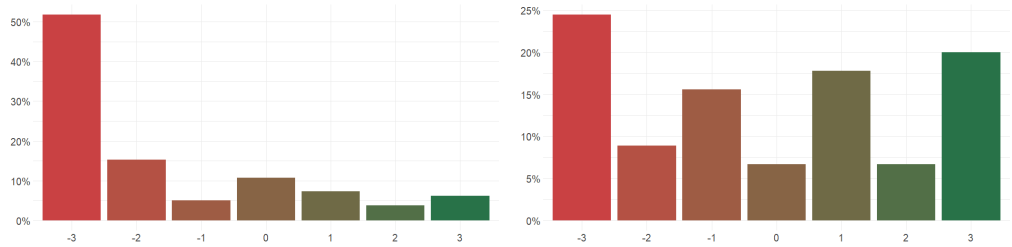
Table 7.6: Distribution of likelihood of future vaccination amongst unvaccinated respondents - comparison between Public Opinion Research Centre and thesis data

The distribution of likelihood of future vaccination can be seen in Table 7.7. While most unvaccinated respondents held a negative position towards their future vaccination, with those who expressed it to be at least somewhat likely there was no clear tendency about the willingness within one month.

| | n=261 | % |
|---|---|---|
| **Future vaccination** | | |
| -3 = not likely | 135 | 51.7 |
| -2 | 40 | 15.3 |
| -1 | 13 | 5.0 |
| 0 | 28 | 10.7 |
| 1 | 19 | 7.3 |
| 2 | 10 | 3.8 |
| 3 = very likely | 16 | 6.1 |
| **Vaccination within a month (from those open to future vaccination)** | | |
| -3 = not likely | 11 | 24.4 |
| -2 | 4 | 8.9 |
| -1 | 7 | 15.6 |
| 0 | 3 | 6.7 |
| 1 | 8 | 17.8 |
| 2 | 3 | 6.7 |
| 3 = very likely | 9 | 20.0 |

Table 7.7: Likelihood of future vaccination reported by the unvaccinated respondents

The distribution is graphically shown below in Figure 7.10.




(a) Generally (b) Within a month

Figure 7.10: Distribution of unvaccinated respondents by likelihood of future vaccination

## 7.2 Motivations overview

One of the goals of this thesis is to explore the variations of the importance of selected motivational factors across different subgroups. Each group of respondents presents a specific pattern of which factors were more or less important in their decision. For clarity, the statements were shortened, a key can be found in Table 6.1.

Motivations have been clustered into four groups, each representing a dimension in deciding whether one should receive the vaccine. These groups are based on a four-factor solution factor analysis, details can be found in Appendix B. The first dimension represents the benefits of the vaccine itself, the second describes outside forces, the third assess one's own medical risk, and the fourth captures the dimension of access to the vaccine.

Which variable belongs to which group can be seen in Table 7.8. For easier comprehension, the groups will be distinguished visually in all relevant figures.

| **vaccine benefits** | **outside forces** | **medical assessment** | **access** |
|---|---|---|---|
| herd immunity | forced by state | doctor | free |
| normal life | forced by people | high-risk group | availability |
| protection | measures | medical authority | |
| protection of others | paying for tests | | |
| regret | traveling | | |
| serious illness | people around | | |
| trust in vaccines | | | |
| vaccination is right | | | |

Table 7.8: Grouping of variables - modified four-factor solution

### 7.2.1 Groups according to time of registration

Generally, we can see a high importance of the vaccine benefits as a motivation to receive the vaccine. The strongest motivation was to prevent serious illness. Items such as "I believe that getting vaccinated is generally a right thing to do.","I wanted to prevent the disease.", "To protect people around me (family, friends, coworkers) from the disease.", and "Vaccination is a path to normal life." also

scored high in average and from the distribution we can also see a high level of agreement. On the contrary, in general the vaccinated population felt low enforcement, be it through state or people around. Medical recommendations were also not a leading motivation.

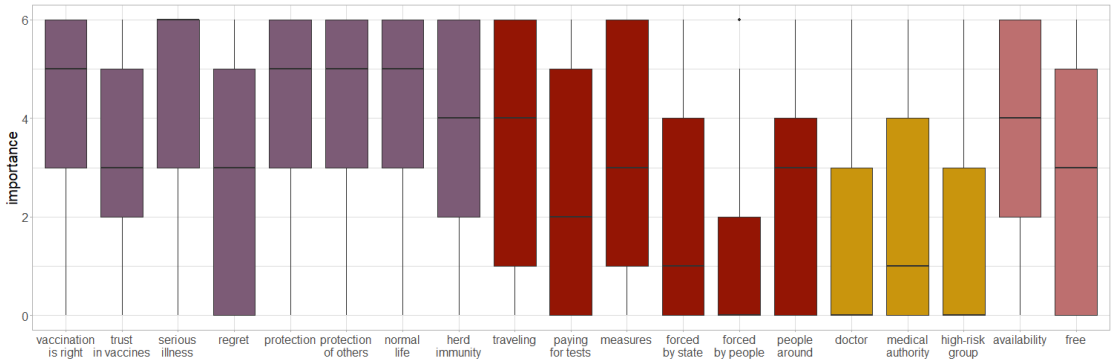



Figure 7.11: All vaccinated

When we look at the group that got vaccinated before it was officially available for their age or occupational group, we see an even higher level of motivation in the group of items describing the benefits of the vaccine. Medical reasons also played a larger role than in the general vaccinated population.

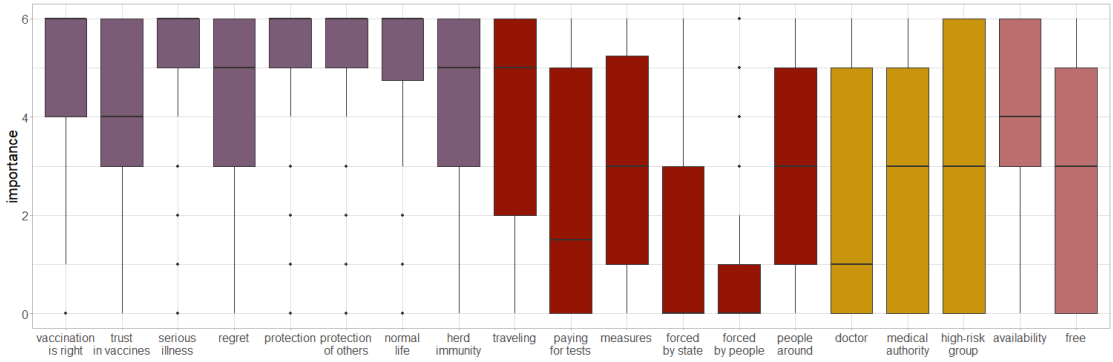



Figure 7.12: Vaccinated, registered before it was available for their age/occupational group

Those, who registered relatively early after it was available to them, still kept a higher level of motivation in the items falling under the vaccine benefits group.

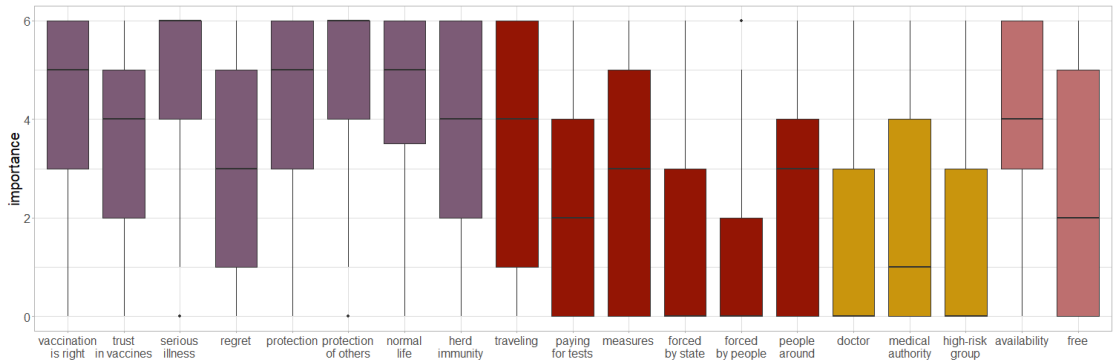



Figure 7.13: Vaccinated, registered up to a month it was available for their age/occupational group

Interestingly, once we start to study the groups that registered relatively late (either more than a month after it was available, or in November or December 2021), we see a drastic fall in the importance of the vaccine benefits motivational items and rise of the importance of outside forces.

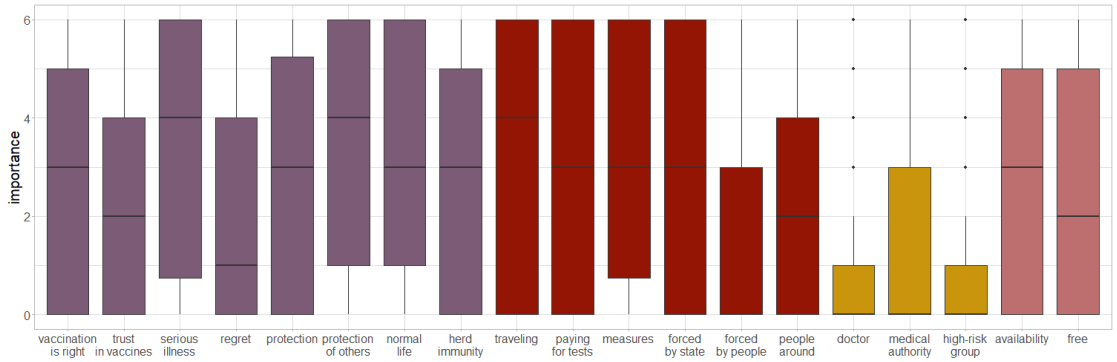



Figure 7.14: Vaccinated, registered after more than a month from it was available for their age/occupational group, but before November 2021

In the group that registered for their vaccination in November or December 2021, the most prominent reason was the feeling of force by the state.

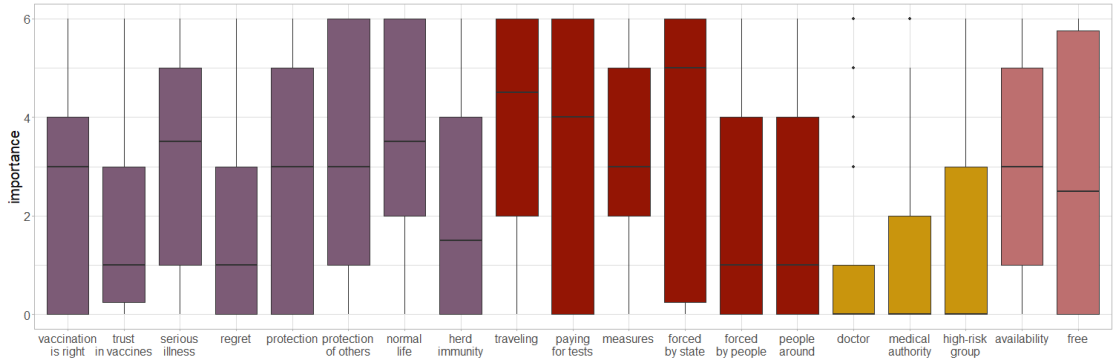



Figure 7.15: Vaccinated, registered in November 2021

Among those who are unvaccinated but considering receiving the vaccine in the future, a continuation of the aforementioned trend is visible - outside forces become a more important motivation than the benefits of the vaccine itself. State force remains the leading motivation. Serious illness is also considered.

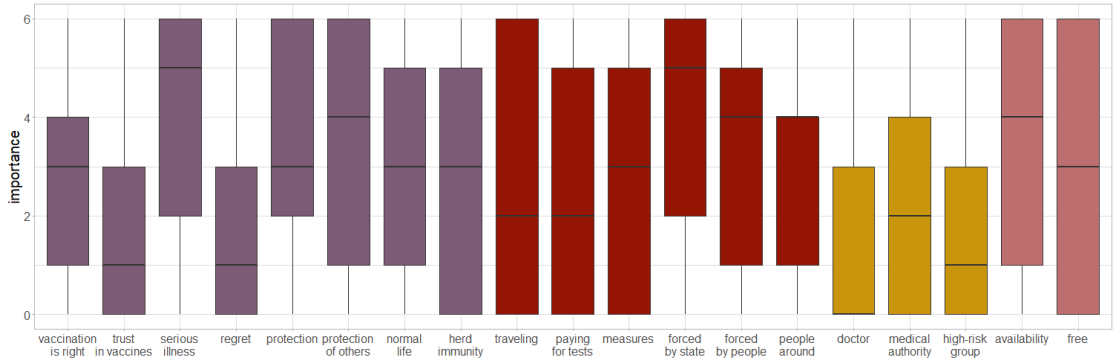



Figure 7.16: Unvaccinated, likely to receive the vaccine in the future

Those who are likely to receive the vaccine within a month score relatively high across most of the items.

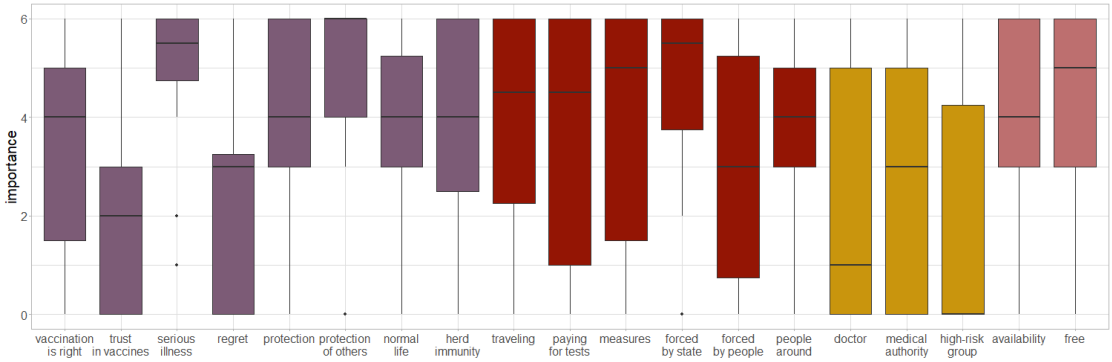



Figure 7.17: Unvaccinated, likely to receive the vaccine within a month

In contrast, those who are considering receiving the vaccine in the future but not within a month, report lower levels of being motivated by most items than those likely to receive the vaccine within a month.

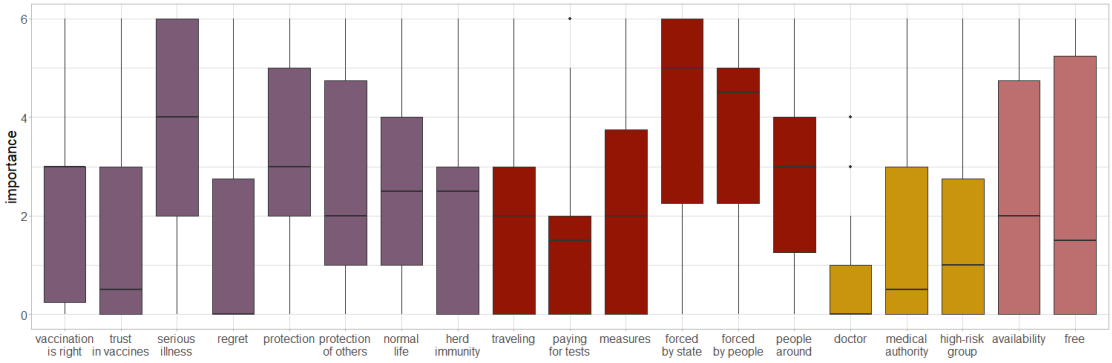



Figure 7.18: Unvaccinated, likely to receive the vaccine in the future but not within a month

The group that is undecided about their future vaccination did not resonate with the majority of the offered statements, except the feeling of being forced by the state. Somewhat important were also medical authorities, protecting others and preventing a serious course of the disease.

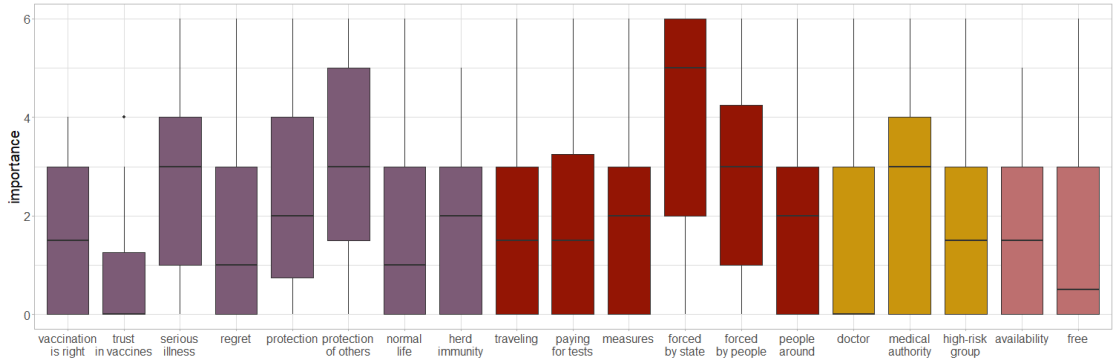



Figure 7.19: Unvaccinated, undecided about future vaccination

We can compare the groups across each other briefly by looking at the means of the distributions. They are presented in Tables 7.9 and 7.10. A graphical representation of this table is offered in Figure 7.20.

| item | all vaccinated | registration before it was available | registration up to a month after if was available | registration more than a month after it was available, but before November 2021 | registration in November or December 2021 |
|---|---|---|---|---|---|
| availability | 3.63 | 3.99 | 3.84 | 2.76 | 3.12 |
| doctor | 1.47 | 2.35 | 1.29 | 0.94 | 1.12 |
| forced by people | 1.20 | 1.02 | 0.99 | 1.61 | 2.26 |
| forced by state | 1.91 | 1.53 | 1.50 | 2.87 | 3.64 |
| free | 2.63 | 2.90 | 2.58 | 2.43 | 2.62 |
| herd immunity | 3.62 | 4.36 | 3.80 | 2.81 | 2.21 |
| high-risk group | 1.77 | 2.84 | 1.60 | 1.07 | 1.81 |
| measures | 3.14 | 3.22 | 3.03 | 3.19 | 3.29 |
| medical authority | 2.04 | 2.78 | 2.05 | 1.35 | 1.14 |
| normal life | 4.25 | 4.80 | 4.50 | 3.16 | 3.57 |
| paying for tests | 2.53 | 2.35 | 2.37 | 2.95 | 3.19 |
| people around | 2.55 | 3.01 | 2.53 | 2.24 | 2.10 |
| protection | 4.12 | 5.05 | 4.33 | 2.97 | 2.74 |
| protection of others | 4.49 | 5.09 | 4.70 | 3.55 | 3.17 |
| regret | 3.13 | 4.19 | 3.25 | 2.03 | 1.76 |
| serious illness | 4.45 | 5.12 | 4.70 | 3.35 | 3.29 |
| traveling | 3.48 | 3.67 | 3.50 | 3.10 | 3.81 |
| trust in vaccines | 3.27 | 3.96 | 3.52 | 2.33 | 1.76 |
| vaccination is right | 4.07 | 4.80 | 4.38 | 2.93 | 2.45 |

Table 7.9: Means of distributions of importance: Vaccinated respondents (across groups by time of registration)

| Row.names | unvaccinated - willing | unvaccinated - undecided | unvaccinated - willing within a month |
|---|---|---|---|
| availability | 3.38 | 1.68 | 4.25 |
| doctor | 1.53 | 1.61 | 2.35 |
| forced by people | 3.33 | 2.82 | 3.15 |
| forced by state | 4.11 | 3.86 | 4.40 |
| free | 3.24 | 1.68 | 4.20 |
| herd immunity | 2.84 | 1.79 | 3.65 |
| high-risk group | 1.64 | 1.89 | 1.85 |
| measures | 2.76 | 1.89 | 3.70 |
| medical authority | 2.24 | 2.36 | 2.80 |
| normal life | 3.07 | 1.71 | 4.00 |
| paying for tests | 2.53 | 2.00 | 3.60 |
| people around | 3.07 | 1.96 | 3.55 |
| protection | 3.53 | 2.43 | 3.85 |
| protection of others | 3.62 | 2.96 | 4.60 |
| regret | 1.87 | 1.50 | 2.50 |
| serious illness | 4.11 | 2.89 | 4.85 |
| traveling | 2.78 | 1.68 | 3.90 |
| trust in vaccines | 1.73 | 0.79 | 2.05 |
| vaccination is right | 2.71 | 1.50 | 3.15 |

Table 7.10: Means of distributions of importance: unvaccinated respondents

A large variability is visible, if we plot all the medians of distributions on one axis. A general tendency is visible (Figure 7.20) as in the previous section - the later the group got vaccinated (or remained unvaccinated), the less important the benefits of the vaccine and more important factors of outside forces are ("Harmonogram očkování v České republice", 2021).

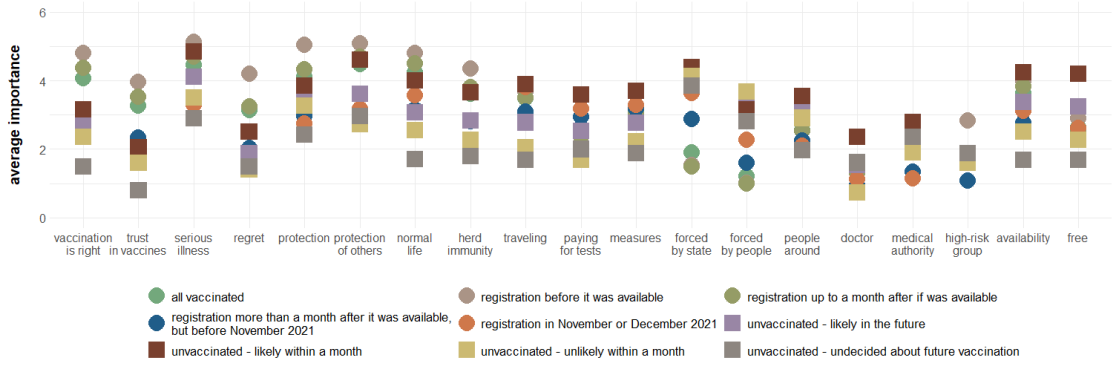



Figure 7.20: Comparison of distribution means

When we plot only the vaccinated and unvaccinated respondents, there is a difference in almost all items, except *serious illness*, *paying for tests*, *doctor*, *medical authority*, *high-risk group*, and *availability*.

Below in Figure 7.21 we see the comparison of the vaccinated and unvaccinated group.

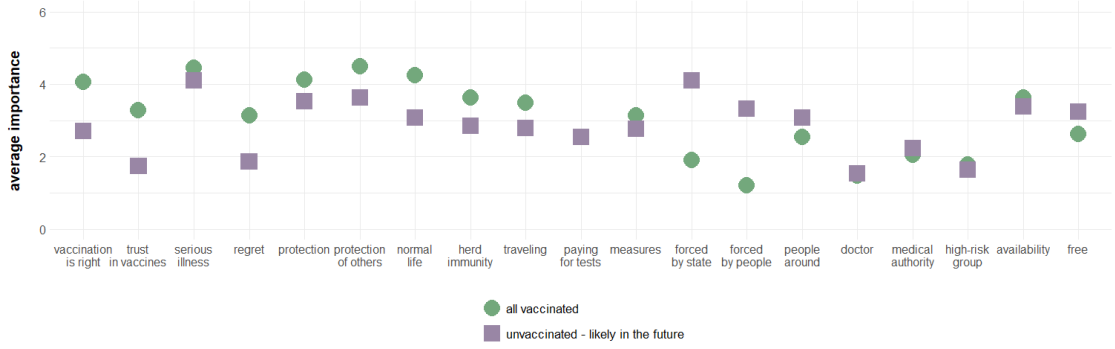



Figure 7.21: Comparison of distribution means: vaccinated and unvaccinated

Generally, the respondents who received the vaccines before they were eligible evaluated all items as the most important in relation to other groups, with the

exception of items from the outside forces category, where they generally scored the lowest.


Figure 7.22: Comparison of distribution means: vaccinated respondents

In the unvaccinated group, those who expressed they are likely to receive the vaccine within a month, evaluated all the items (except *forced by people*) as more important than those who do not plan to receive the vaccine within a month or those who were undecided.

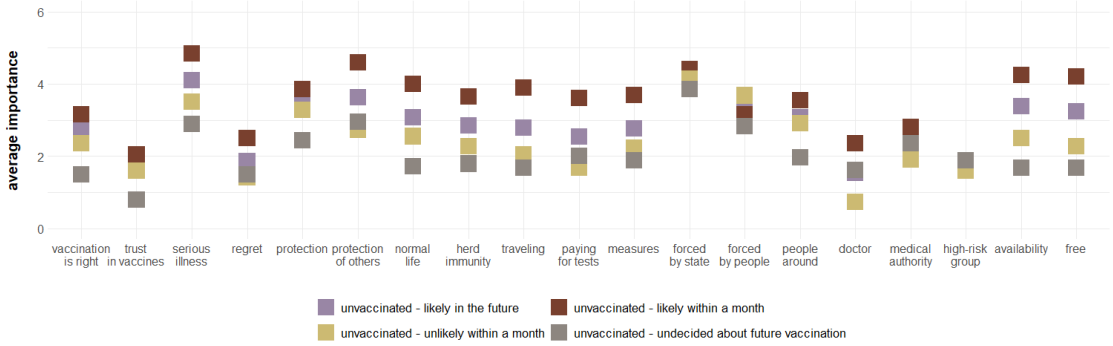



Figure 7.23: Comparison of distribution means: unvaccinated respondents

Most differences are statistically siginificant, when compared across the groups. In Table 7.11 we see the results of the Kruskall-Wallis test for the subgroups of the vaccinated populations by time of registration (p-values $< \alpha = 0.05$ are bolded. Items without a significant difference between the groups are *traveling*, *measures* and *free*.

| item | K-W | p-value |
|---|---|---|
| vaccination is right | 78.80 | **0.00** |
| trust in vaccines | 63.58 | **0.00** |
| serious illness | 64.37 | **0.00** |
| regret | 70.47 | **0.00** |
| protection | 77.46 | **0.00** |
| protection of others | 51.16 | **0.00** |
| normal life | 43.19 | **0.00** |
| herd immunity | 47.68 | **0.00** |
| traveling | 4.26 | 0.24 |
| paying for tests | 8.37 | **0.04** |
| measures | 1.09 | 0.78 |
| forced by state | 52.89 | **0.00** |
| forced by people | 14.38 | **0.00** |
| people around | 11.45 | **0.01** |
| doctor | 32.29 | **0.00** |
| medical authority | 34.81 | **0.00** |
| high-risk group | 37.73 | **0.00** |
| availability | 24.80 | **0.00** |
| free | 3.18 | 0.37 |

Table 7.11: Difference in distribution of evaluated importance across groups by time of registration for vaccine, Kruskall-Wallis test

### 7.2.2 Comparison across socio-demographic parameters

Below in Figures 7.24 - 7.28 we can see a comparison of the distribution means across different subgroups determined by socio-demographic parameters. In most cases the difference is negligible, although there are a few interesting tendencies.

Sex (Figure 7.24) does not seem to have an influence on the motivation for vaccination, except for a small difference in the factors of measures and availability, where it was slightly more important for men. For education (Figure 7.25) we see a clearer pattern. Higher education seems to be connected with a higher motivation in items describing vaccine benefits, but smaller motivation in outside forces. City size (Figure 7.26) of the respondent does not have a clear effect on

the motivations, except for traveling, where it was on average less important for respondents from the smallest cities (under 1 000 inhabitants). In terms of age (Figure 7.27), younger respondents on average evaluated outside forces as more motivating than the benefits of the vaccine, and vice-versa. More items are not statistically significantly different across the groups. Income (Figure 7.28) does not have a clear pattern of differences across groups.

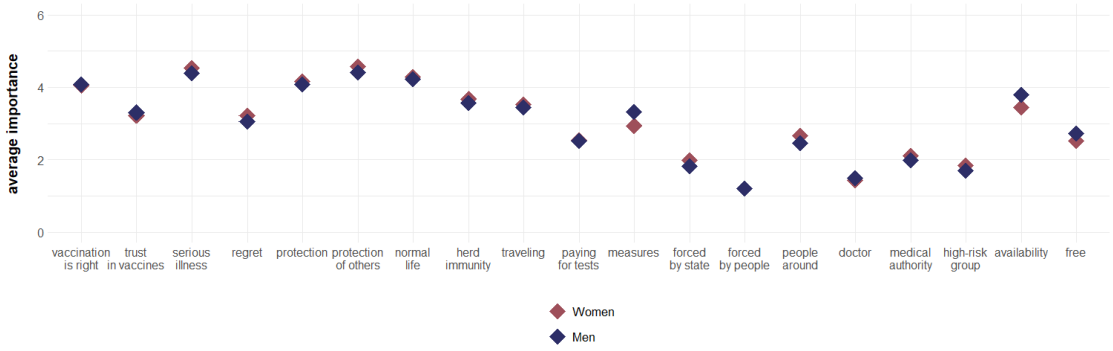



Figure 7.24: Comparison of distribution means: Sex

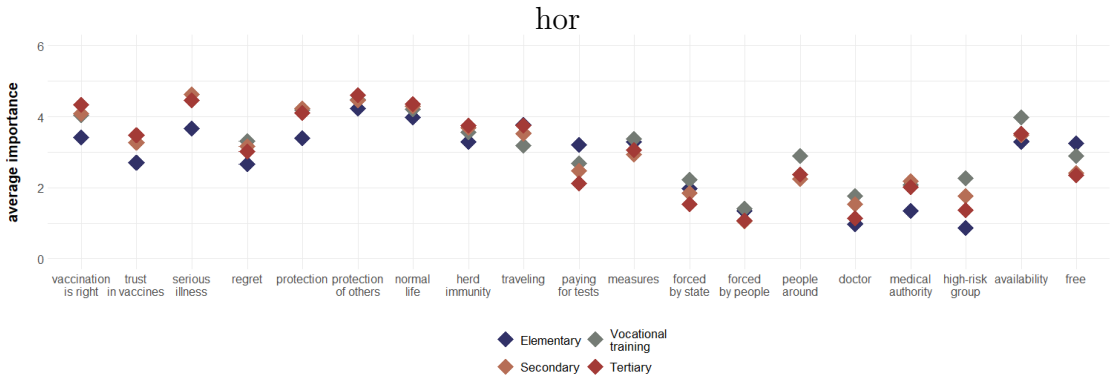



Figure 7.25: Comparison of distribution means: Education

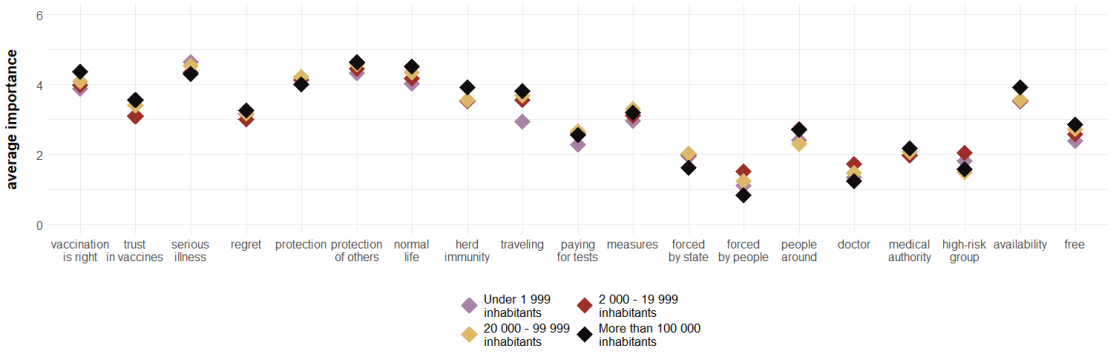



Figure 7.26: Comparison of distribution means: City size

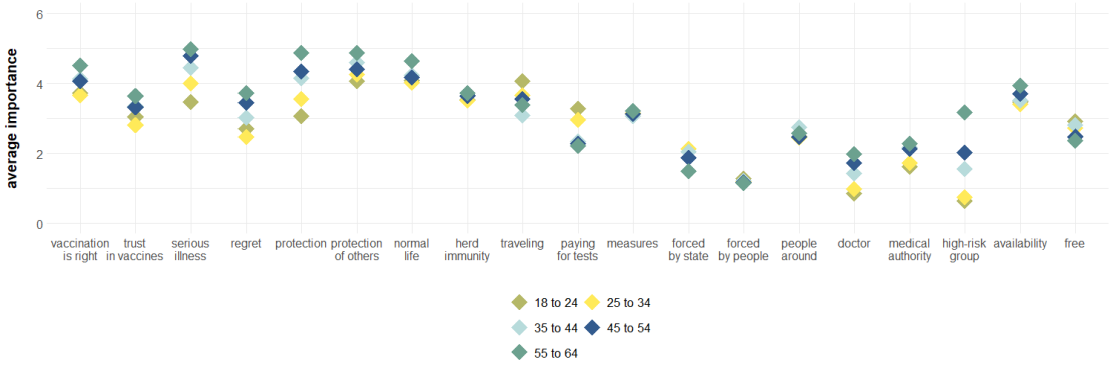



Figure 7.27: Comparison of distribution means: Age

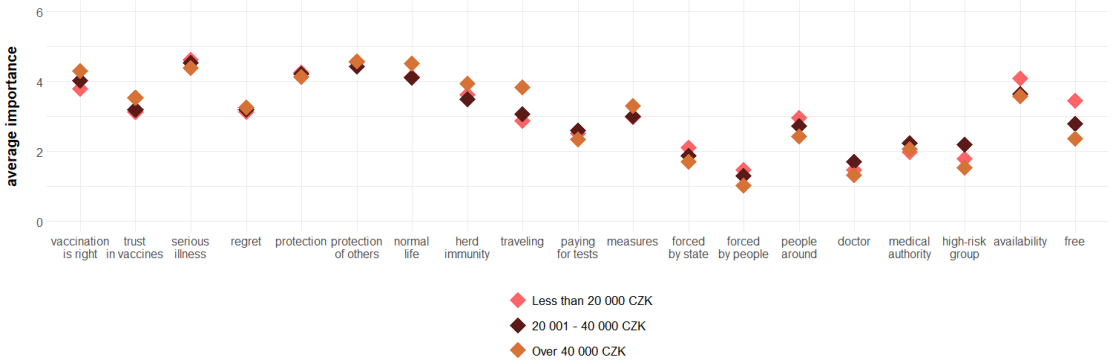



Figure 7.28: Comparison of distribution means: Income

The differences were only seldom statistically significant. Results of the Kruskall-Wallis tests together with their p-value are shown in Table 7.12, statistically sig-

nificant (on a significance level $\alpha = 0.05$) are bolded. Most statistically significant differences were detected in the grouping according to the level of education, in the motivations falling under the "outside forces", "medical", and "access" groups of items (as defined in Appendix B). Across age, statistically significant differences were found in the items describing vaccine benefits.

| | Sex | | Education | | City size | | Age | | Income | |
|---|---|---|---|---|---|---|---|---|---|---|
| item | **statistic** | **p-value** | **statistic** | **p-value** | **statistic** | **p-value** | **statistic** | **p-value** | **statistic** | **p-value** |
| vaccination is right | 0.00 | 0.99 | 5.42 | 0.14 | 5.02 | 0.08 | 15.27 | **0.00** | 3.88 | 0.28 |
| trust in vaccines | 0.30 | 0.58 | 5.48 | 0.14 | 5.26 | 0.07 | 13.84 | **0.01** | 5.75 | 0.12 |
| serious illness | 1.57 | 0.21 | 12.65 | **0.01** | 1.32 | 0.52 | 45.17 | **0.00** | 3.90 | 0.27 |
| regret | 1.21 | 0.27 | 4.67 | 0.20 | 0.14 | 0.93 | 28.98 | **0.00** | 1.42 | 0.70 |
| protection | 0.24 | 0.62 | 9.37 | **0.02** | 0.62 | 0.73 | 55.05 | **0.00** | 1.48 | 0.69 |
| protection of others | 1.52 | 0.22 | 2.25 | 0.52 | 0.87 | 0.65 | 19.87 | **0.00** | 1.75 | 0.63 |
| normal life | 0.77 | 0.38 | 0.73 | 0.87 | 5.12 | 0.08 | 10.35 | **0.03** | 4.73 | 0.19 |
| herd immunity | 0.84 | 0.36 | 1.58 | 0.66 | 4.75 | 0.09 | 1.15 | 0.89 | 3.56 | 0.31 |
| traveling | 0.59 | 0.44 | 5.70 | 0.13 | 15.81 | **0.00** | 10.97 | **0.03** | 14.19 | **0.00** |
| paying for tests | 0.01 | 0.91 | 10.51 | **0.01** | 1.52 | 0.47 | 18.45 | **0.00** | 2.77 | 0.43 |
| measures | 4.84 | **0.03** | 5.44 | 0.14 | 2.50 | 0.29 | 0.41 | 0.98 | 1.59 | 0.66 |
| forced by state | 0.81 | 0.37 | 6.64 | 0.08 | 1.37 | 0.51 | 9.39 | 0.05 | 1.93 | 0.59 |
| forced by people | 0.04 | 0.85 | 3.25 | 0.35 | 4.42 | 0.11 | 0.49 | 0.97 | 15.42 | **0.00** |
| people around | 1.61 | 0.20 | 13.88 | **0.00** | 4.73 | 0.09 | 1.77 | 0.78 | 4.96 | 0.17 |
| doctor | 0.33 | 0.57 | 8.30 | **0.04** | 4.46 | 0.11 | 26.62 | **0.00** | 5.05 | 0.17 |
| medical authority | 0.59 | 0.44 | 8.83 | **0.03** | 1.62 | 0.45 | 8.54 | 0.07 | 1.48 | 0.69 |
| high-risk group | 0.40 | 0.53 | 27.09 | **0.00** | 8.87 | **0.01** | 112.44 | **0.00** | 6.02 | 0.11 |
| availability | 4.10 | **0.04** | 11.94 | **0.01** | 4.37 | 0.11 | 7.32 | 0.12 | 3.21 | 0.36 |
| free | 1.87 | 0.17 | 10.79 | **0.01** | 12.85 | **0.00** | 5.22 | 0.27 | 4.08 | 0.25 |

Table 7.12: Difference in distribution of evaluated importance across socio-demographic groups, Kruskall-Wallis test

## 7.3 Network analysis

### 7.3.1 All vaccinated respondents

In Figure 7.29 the network constructed on the basis answers of all vaccinated respondents (n=716) is shown. There are a few interesting structural remarks. The network is connected, no isolated subnetworks are found, and there are no edges with negative weights. There are a few prominent diads with a strong connection: *vaccination is right* and *trust in vaccines*, *protection* and *serious illness*, *doctor* and *medical authority*, and *free* and *availability*. There are only a few relevant connected triads (a group of three nodes with edges between all sets of two nodes). Groups identified by the factor analysis form only lightly visible clusters - items in the "vaccine benefits" category have very small correlations within each other, the "medical" category is also more connected among its nodes than with other nodes - but it does not form a complete triad. *Trust in vaccines* seems to have a prominent role, connected with items from three categories (expect those from "access"). No other node has a similar position.

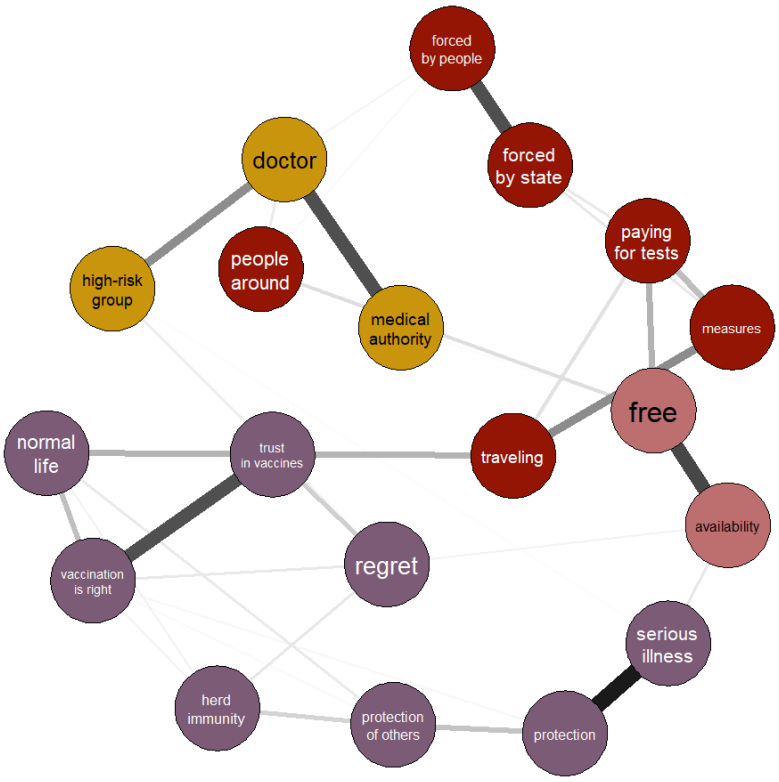



Figure 7.29: Belief network constructed on the base of answers of the vaccinated respondents, gLASSO regularization

Figure 7.30 shows the distribution of centrality measures across nodes. Since all correlations are positive, strength and Expected Influence centralities are equal. Viewed through the lense of strength centrality, *doctor* is the most central node, and by betweenness centrality *normal life*, and *free*. No node is especially central by closeness centrality, which means that no node is significantly closer to others than the rest.

The least connected nodes, measured by strength centrality, are *herd immunity*, and *people around*. Measured by betweenness centrality they are *herd immunity*, and *forced by people*.

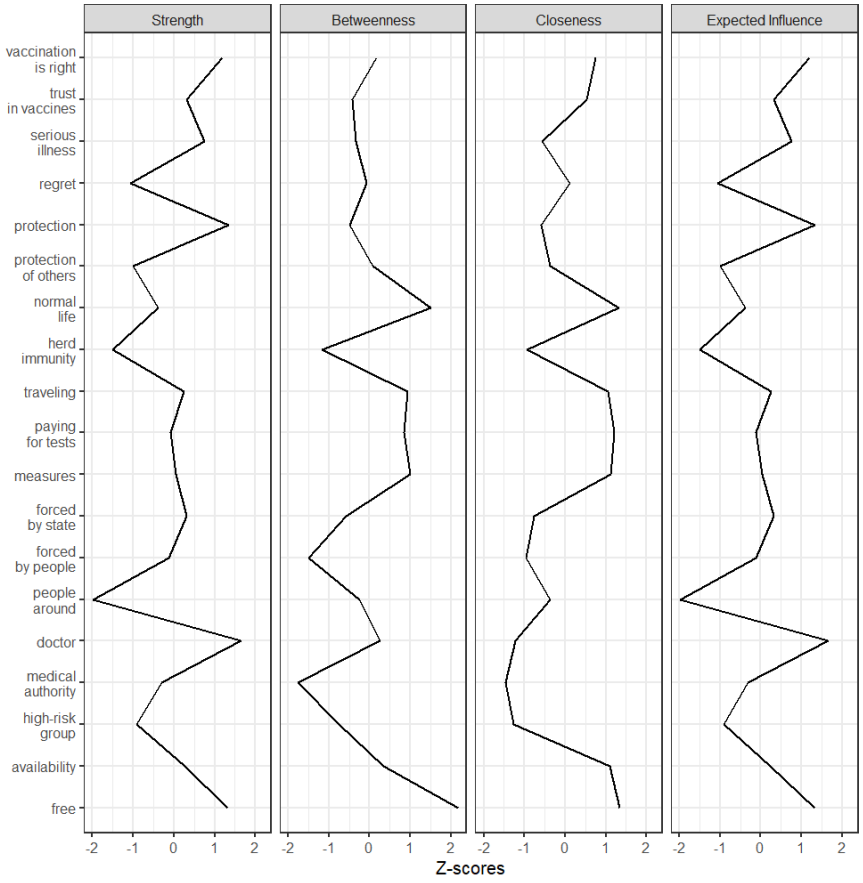
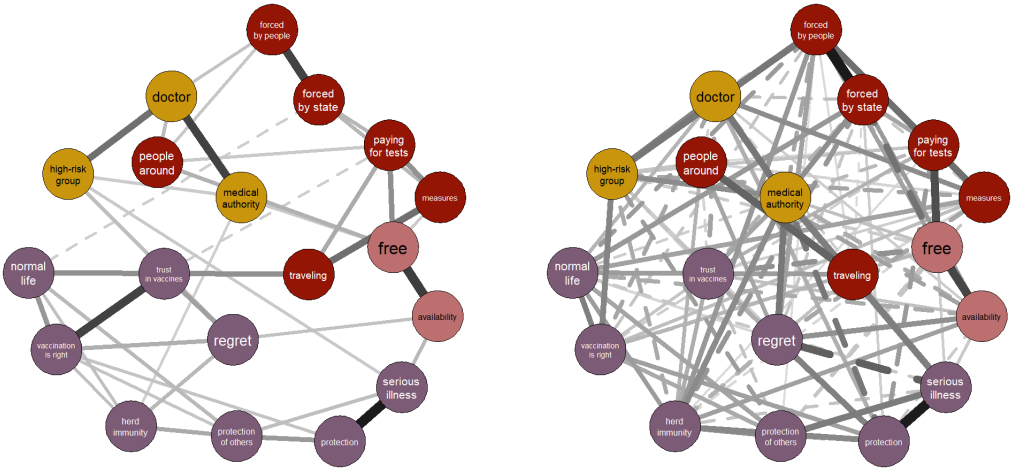



Figure 7.30: Centrality measures: all vaccinated, gLASSO regularization

### 7.3.2 Vaccinated and unvaccinated respondents

In Figure 7.31 networks corresponding to the vaccinated group (n=716; it differs to the one in Figure 7.30, since for comparison it was constructed through partial correlations and a threshold) and unvaccinated (who reported they are likely to receive the vaccine in the future; n=45) are presented. There is a striking difference in density - the belief network of the unvaccinated respondents is much denser than that of the vaccinated respondents. Strong connections between *doctor* and *medical authority*, and *vaccination is right* and *trust in vaccines* are present in the belief network of the vaccinated respondents, but not the unvaccinated. A strong negative correlation is present between *regret* and *serious illness* for the unvaccinated respondents.




(a) Belief network: vaccinated respondents (b) Unvaccinated - likely to receive vaccine in the future

Figure 7.31: Vaccination status

Centrality measures for both networks are depicted in Figure 7.32.

The most central nodes by strength centrality, i.e. local influence on the neighboring nodes, were *vaccination is right* for the vaccinated group and *medical authority* for the unvaccinated group. The least nodes with the least influence on their neighborhood were *people around* for both the vaccinated and unvaccinated and *traveling* for the unvaccinated group.

In the case of betweenness centrality, i.e. how many shortest paths lead through the node and therefore how likely the node is to connect different parts of the network, for the vaccinated group it was nodes *normal life*, *paying for tests*, and *free*, while for the unvaccinated it was *regret* and *people around*.

For closeness centrality, i.e. how close is the node to all other nodes in the network, *paying for tests* and *free* were the most central for the vaccinated group, while *medical authority* - *traveling*, and *people around* for the unvaccinated group.

Nodes with supposed high influence on neighboring nodes (with the assumption of negative edge weights lowering the influence), were *vaccination is right*, and *free* for the vaccinated group and *medical authority*, while in the unvaccinated group *protection of others* was a node with little influence on its neighborhood.

Together, it suggests that for the vaccinated group, a combination of general beliefs and practical aspects were the most central in the belief networks, while for the unvaccinated group, *medical authority* stood out as the most influential across all metrics.

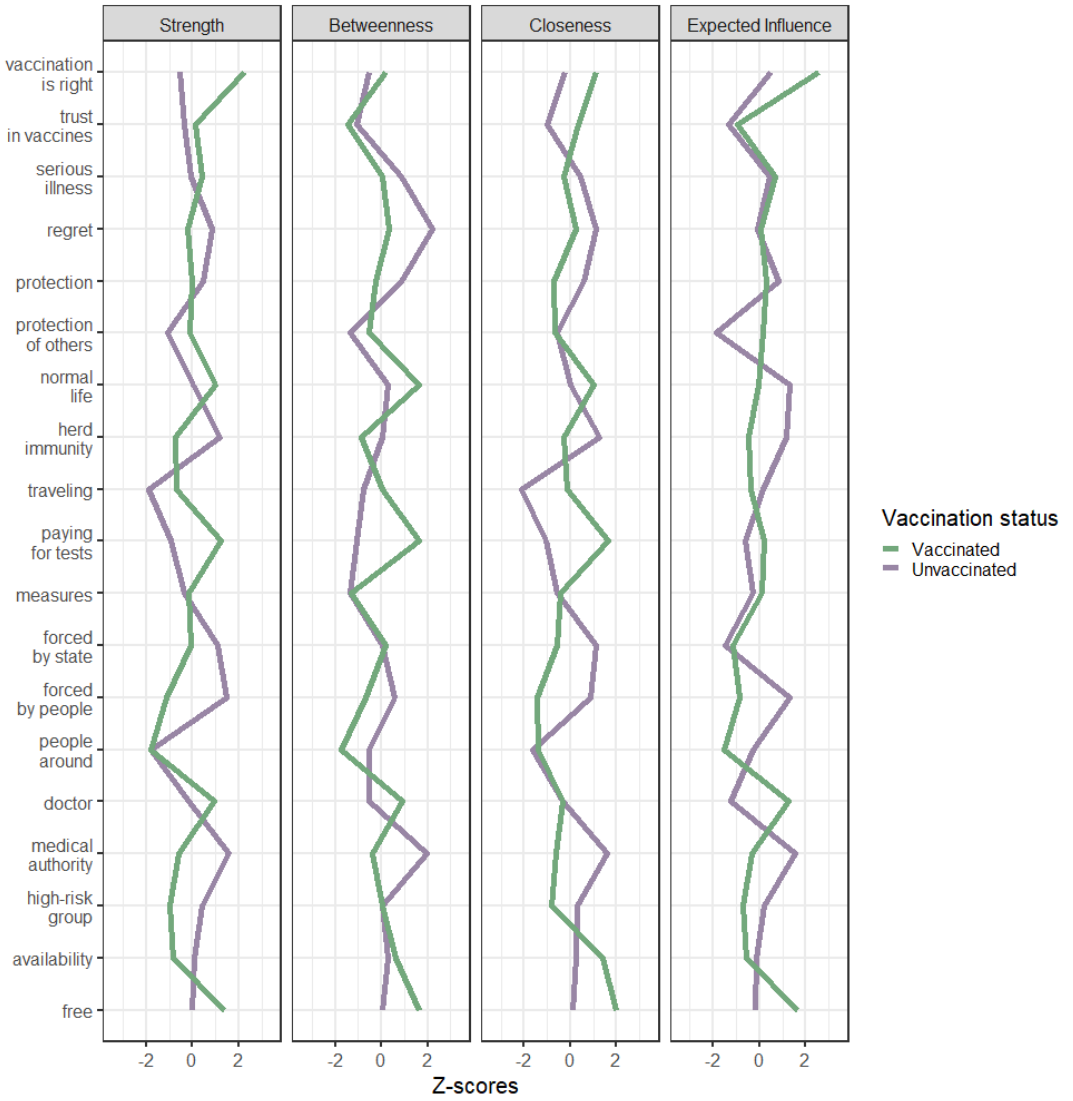



Figure 7.32: Centrality measures: vaccinated vs. unvaccinated

### 7.3.3 Vaccinated grouped by time of registration

In Figure 7.33 four networks are displayed, representing the belief networks for the four defined times of registration: before it was available for the respondent's age or occupational group (n=144), up to one month after it became available (n=379), more than a month from when it became available, but before November 2021 (n=116), and in November or December 2021 (n=42).

There is a noticable difference in the density of the networks. The network representing those registered the latest is visibly denser than the others, the one representing the group registering less than a month after it became available is, on the contrary, relatively sparser than the other two. In contrast to the general network (Figure 7.29) negative edge weights are present.

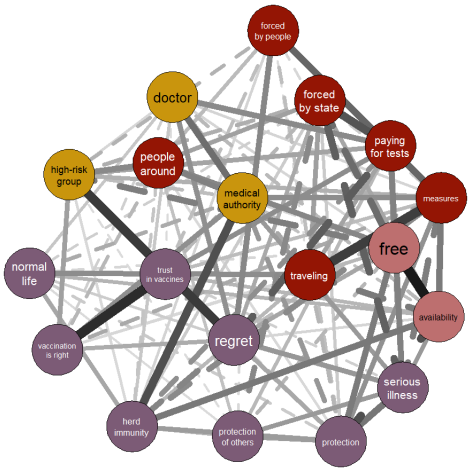
There is are three noticably strong correlation patterns present for the group registering before their turn, that are not present in other networks. One is within items relating to the medical assessment, between *high-risk group* and *doctor*, and *doctor* and *medical authority*, the other between *vaccination is right* and *regret*. While in other networks the correlation between *herd immunity* and *protection of others* is positive, for the group that got vaccinated before their turn it is negative.

There are notable correlation between the items *high-risk group* and *trust in vaccines*, and *trust in vaccines* and *regret* for the group that got vaccinated the latest, that are not present in other networks. For this group the ties between the items belonging to the outside forces group are stronger and more dense than for other groups.


(a) Before it was available for my age or occupational group.


(b) Up to one month from when it was available my age or occupational group


(c) More than a month from when it was available my age or occupational group before November 2021




(d) In November or December 2021

Figure 7.33: Belief networks: time of registration

In general, there is a similar pattern for the centralities of nodes in each network, shown in Figure 7.34, but variability between the values of centrality measures measured in each network is relatively big. We generally see progression from motives of general beliefs towards practical and even outside forces. Notica-

bly, for example, whereas for groups registered before November 2021 *vaccination is right* was a relatively central node, for those registered later it was less central, across all measures, with the difference in Expected Influence being the smallest. The groups did not agree on the position of the item *normal life* - for the group registered shortly after it became possible for them it was a visibly central belief (except for its Expected Influence), for other groups it was less central than other nodes. *Medical authority* scored high in betweenness centrality for those registered latest, in contrast to other groups, at the same time *doctor* scored lower than in other networks. *People around* were less central in Expected Influence than other nodes for those registered early, for those registered later it had a higher centrality. *Availability* was central for groups registered later than a month after it became available and less central for those registered earlier.

Measured by strength centrality, the supposed direct influence on the node's surroundings, *vaccination is right* and *protection* was central to the group that registered before their official eligibility, *vaccination is right* and *normal life* for those registering early after it became available to them, and *forced by people* for those who registered later, while those registering the latest did not have a clear central node by strength centrality. On the other side, the least central nodes were *protection of others* for the early registered eligible group and *normal life* for those registered in November or December 2021.

The most bridging (central by the measure of betweenness centrality) nodes were *vaccination is right*, *protection*, and *paying for tests* for those registered before eligibility, *vaccination is right* and *normal life* for those registered up to a month after first eligible, and *measures* and *medical authority* for those registered the latest.

The closest nodes on average to other nodes in the network (central through closeness centrality) were *trust in vacciness*, *protection*, and *paying for tests* for those registered before their term, *vaccination is right* and *normal life* for those registered early after their eligibility, *protection* and *availability* for those registered later than that but before November 2021. Those registered even later did not present a clearly central node. The nodes on average furthest from the rest of the network were *people around* (pre-eligibility), *availability* (early registration), *herd immunity* (later registration), and *protection of others*, and *normal life* (latest

registration).

The nodes with most Expected Influence were *doctor*, and *medical authority* for those registered before eligibility, *free* for those registered early after eligibility, *regret* for those registered even later and *regret* and *paying for tests* for those who registered in November or December. The least influential nodes were *people around* (pre-eligibility), *availability* (early registration), *high-risk group* (later registration), and *forced by state* (latest registration).

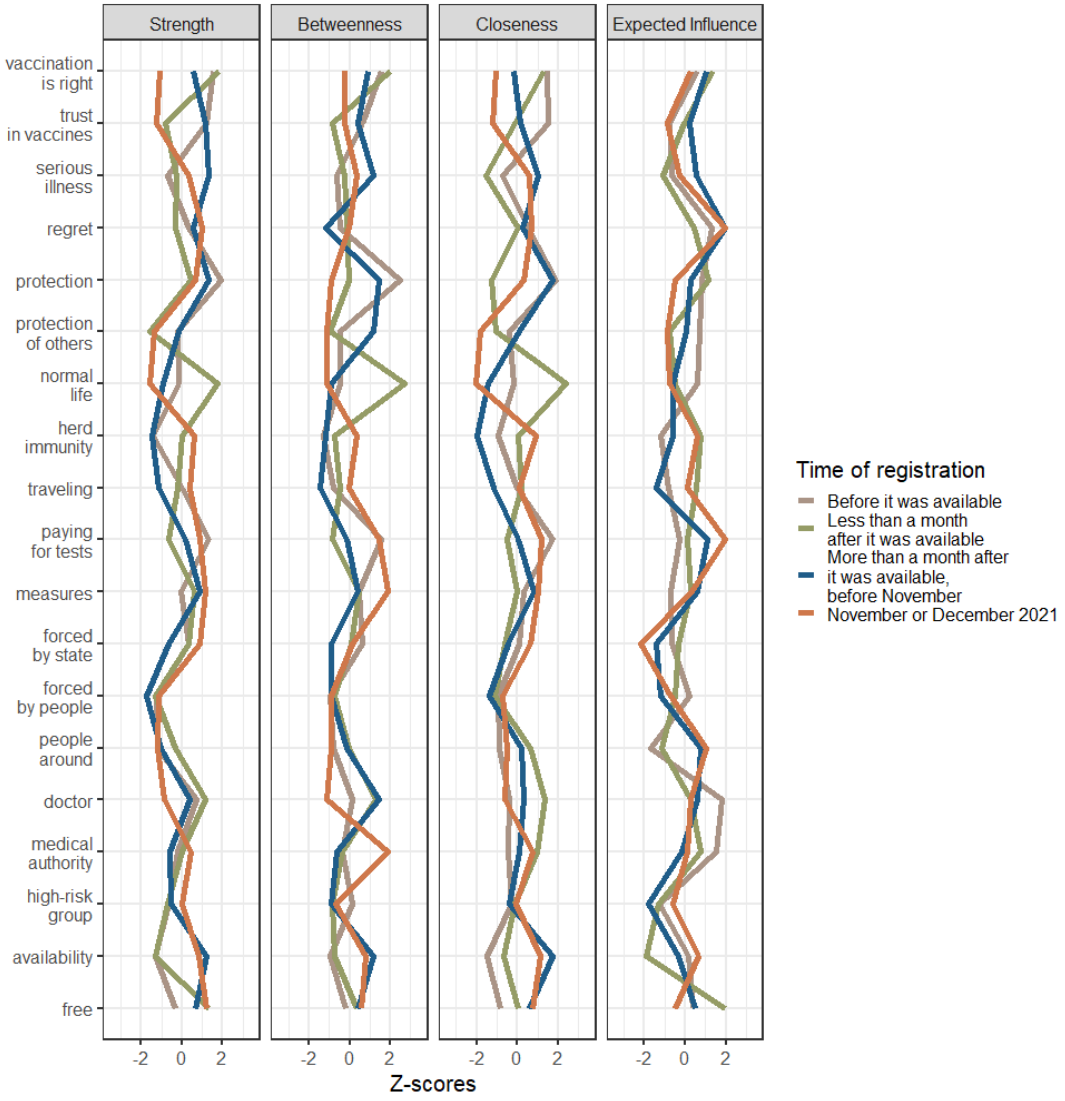
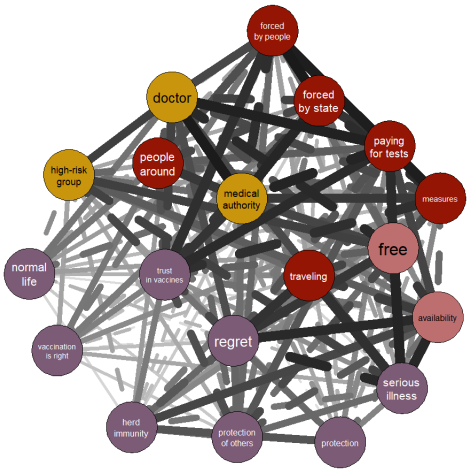


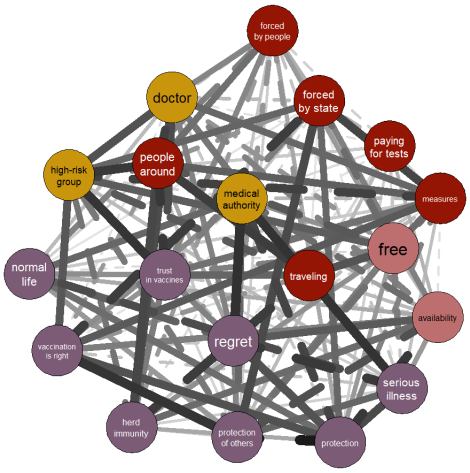

Figure 7.34: Centrality measures: grouped by time of registration

### 7.3.4 Unvaccinated grouped by likelihood of future vaccination

Networks depicting the belief system for unvaccinated respondents are shown below in 7.35. Groups are divided by the likelihood respondents assigned to their future vaccination: either within a month (n=20), in the future, but not within a month (n=22), and undecided about future vaccination (n=28). They are similarly dense, with the network corresponding to those likely to receive the vaccine within a month having visibly larger edge weights, especially concentrating around the nodes describing outside forces.




(a) Likely to receive vaccine within a month




(b) Likely to receive vaccine, but not within a month


(c) Undecided about future vaccination

Figure 7.35: Belief networks: likelihood of vaccination

Probably due to the high density, there are no significantly central nodes by strength centrality in any network, as can be seen in Figure 7.36. There are a few nodes that are significantly less central than other ones. For those likely to receive the vaccine within a month they are *vaccination is right* and *normal life*, for those likely in the future, but not within a month, it is *paying for tests* and for those

undecided it is *forced by people*.

Nodes that occupy the most central position measured by betweenness centrality are *trust in vaccines* and *doctor* for those likely to receive the vaccine in the future, *protection*, *high-risk group*, and *availability* for those likely in the future, but not within a month, and *vaccination is right*, *protection of others*, and *medical authority* for those undecided.

Similarly to strength centrality, there are no notable nodes with high closeness centrality. On the other hand, *normal life* if the least central in the network those likely to receive the vaccine within a month, *paying for tests* for those not likely to receive the vaccine within a month, but likely in the future, and *forced by people* for those undecided about future vaccination.

There is only a small number of nodes high in Expected Influence. For those who are likely to receive the vaccine within a month there is no such node, for those who are not likely to receive it within a month, *high-risk group* is the most central, and *normal life* and *doctor* for those who are undecided. The least influential node in the network of those willing to receive the vaccine in the future, but not within a month, is *paying for tests*, and *high-risk group* for those who are undecided.

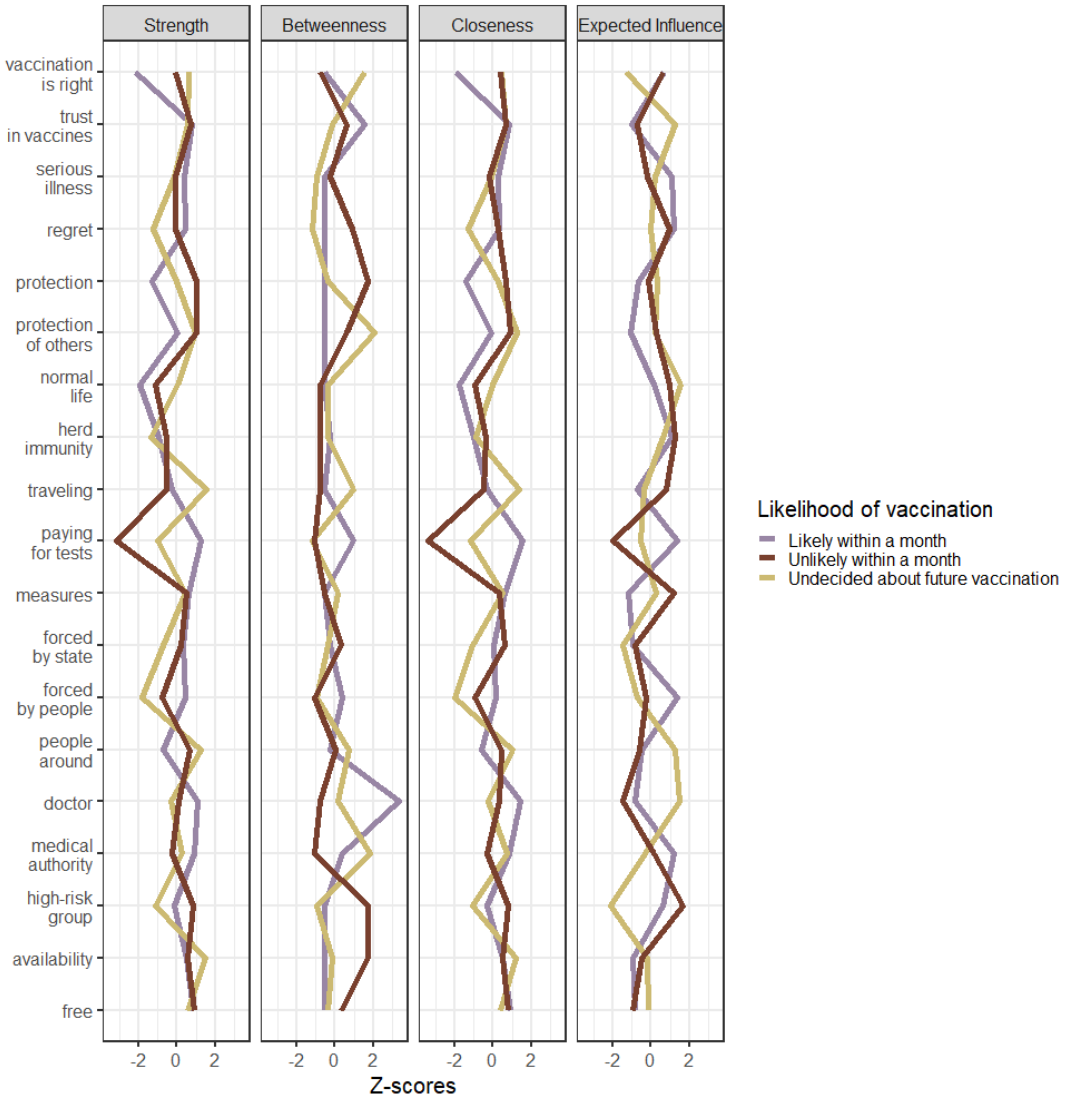
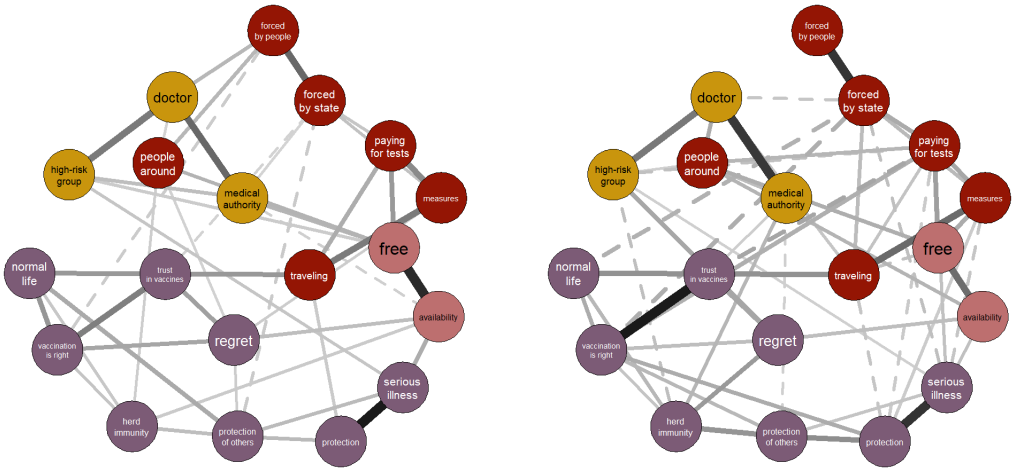



Figure 7.36: Centrality measures: grouped likelihood of future vaccination

### 7.3.5 Vaccinated grouped by sex

As was discussed earlier in this chapter, there were almost no significant differences between the distributions of motivation importance between the respondents grouped by sex (women: n=343; men n=373). Also the belief networks (Figure 7.37) of the two groups show a similar structure and density, with men's network containing slighly more negative edges with larger negative weights. Also for men

the correlation between items *vaccination is right* and *trust in vaccines*, and *doctor* and *medical authority* was relatively larger than for women.




(a) Women (b) Men

Figure 7.37: Belief networks: sex

Centrality measures are depicted in Figure 7.38. Generally, for both sexes practical reasons (costlessness, paying for tests), and alternatively outside forces, seemed to be the most central reasons in their network, although men tended to outside motivations slightly more than women. However, for men *vaccination is right* was one of the most central nodes in their belief network across all measures of centrality.

By strength centrality, i.e. a central position in relation to direct neighbors, *free* was the most central for the women's network, while *paying for tests*, and *vaccination is right* and *forced by state* was the most central for the network of men. The least central nodes for women were *herd immunity*, and *people around*, and for men *forced by people*.

The most central nodes by betweenness, i.e. being likely in a broker position, were *availability*, and *free* for women and *vaccination is right*, *paying for tests*, *forced by state* for men. For men there were also significantly less central nodes, *measures*, and *forced by people*.

The, on average, closest nodes (closeness centrality measure) were *availability* and *free* for women, and *paying for tests for men.*

The node with the suggested biggest influence (Expected Influence measure) were *free* for women and *vaccination is right* for men, while both sexes agreed on *forced by state* to be the least influential node in their networks.

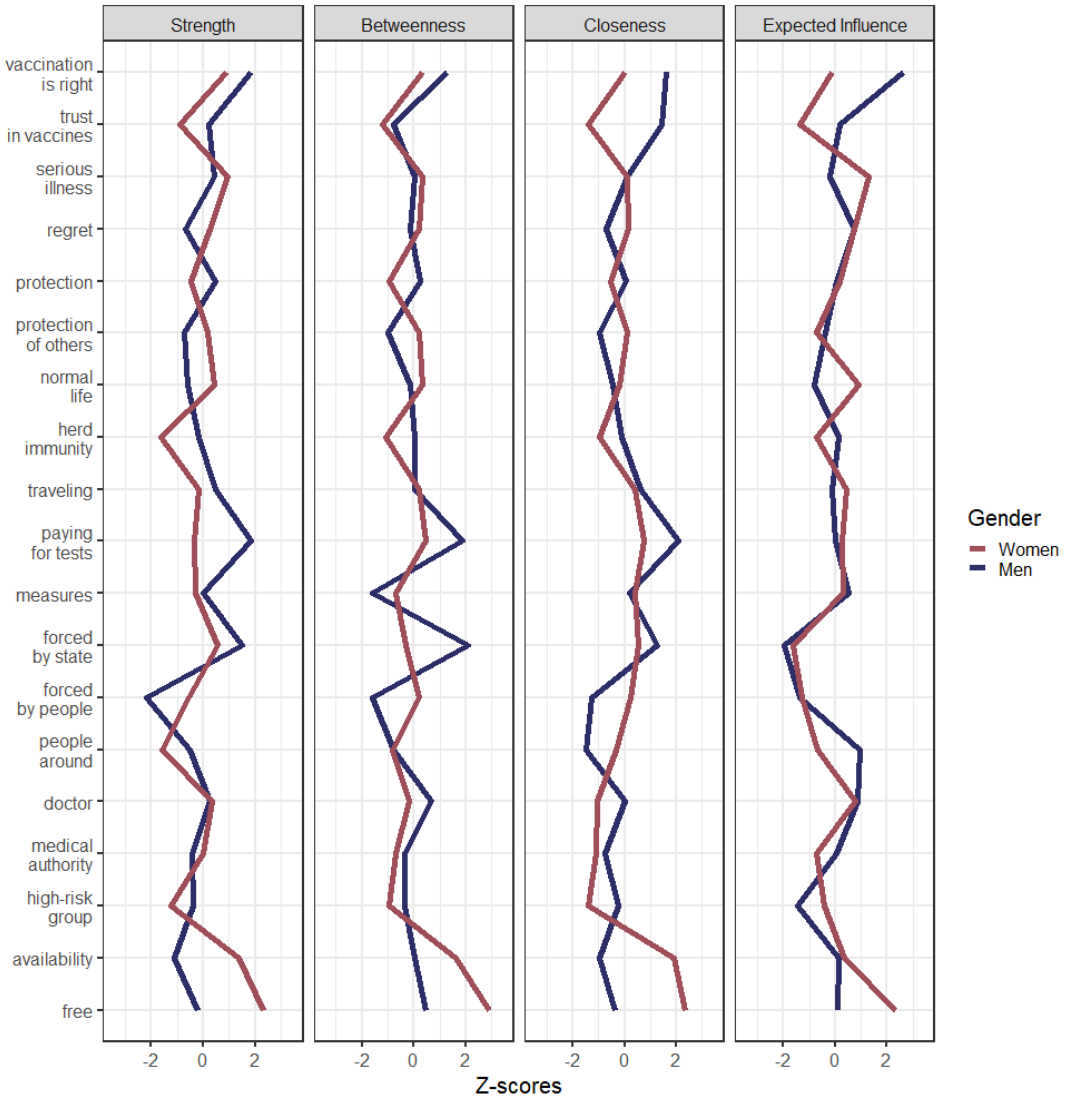
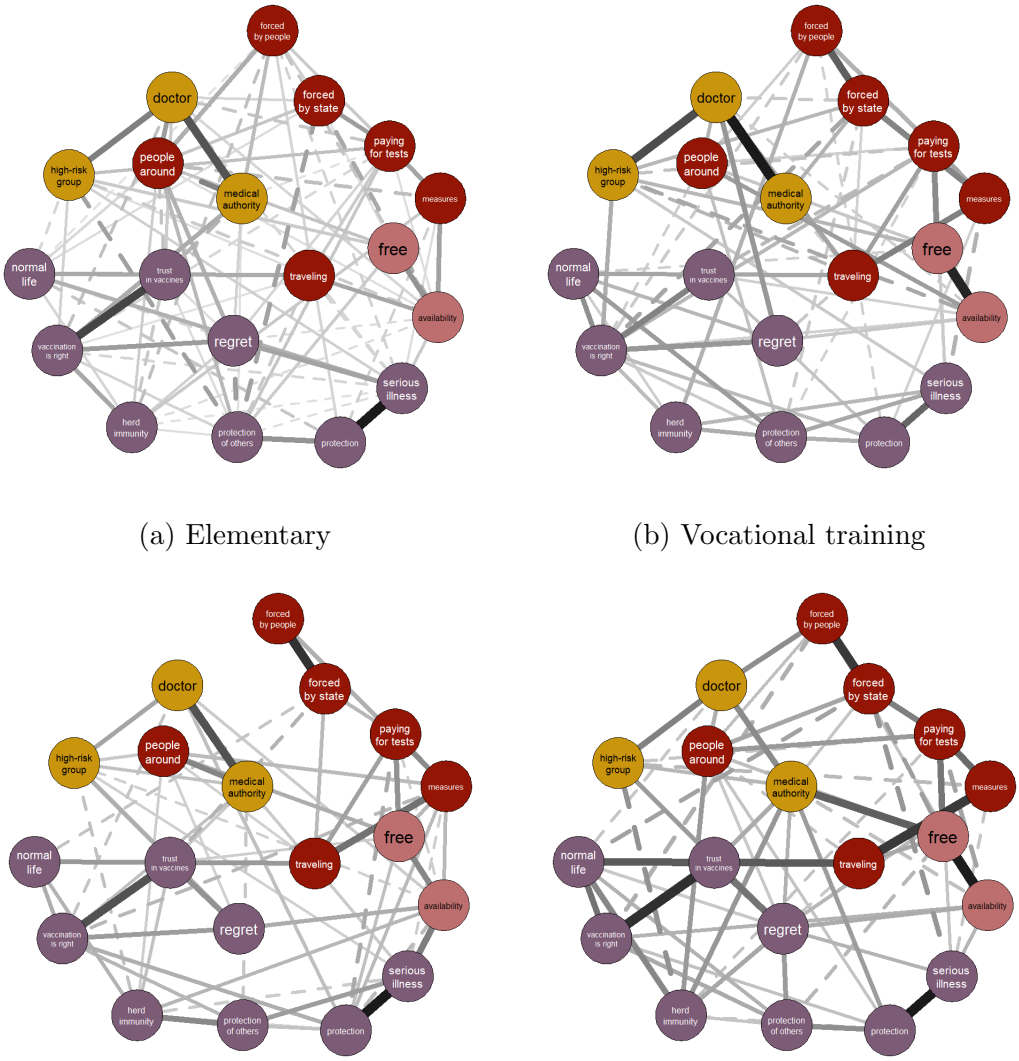



Figure 7.38: Centrality measures: grouped by sex

### 7.3.6 Vaccinated grouped by education

Belief networks corresponding to groups defined by the level of education are shown in Figure 7.39. The levels of education are Elementary (n=61), Vocational training (n=237), Secondary (n=251), and Tertiary (167). The networks are visually very similar, with none being clearly denser. The correlations in the belief network of those with tertiary education seem to be higher, especially those surrounding the node *trust in vaccines* - edges shared with *normal life*, *vaccination is right*, and *traveling* are stronger than in other networks.




(a) Elementary

(b) Vocational training

(c) Secondary

(d) Tertiary

Figure 7.39: Belief networks: education

Centrality measures of items in all networks across different measures of centrality can be seen in Figure 7.40. While there is no clear pattern of behavior, there are a few noteworthy observations. *Protection of others* is high in betweenness and closeness centralities for the group defined by elementary education, but on for others, similarly *people around*. *Regret* is noticably more central in the network corresponding to the respondents with tertiary-level education than others.

The most central nodes by strength centrality, i.e. with the most prominent position within their neighborhood, were *protection of others*, *people around* for respondents with elementary education, *vaccination is right* for those with vocational training, *protection* and *measures* for those with secondary education, and *regret* and *free* for those with tertiary education. On the other hand *free* was the least central node for those with elementary education, and *forced by people* for those with secondary education. There is no clear pattern of certain groups of nodes being central.

The most central nodes by betweenness centrality, were *protection of others* and *people around* for those with elementary education, *vaccination is right* and *doctor* for those with vocational training, *vaccination is right* and *trust in vaccines* for those with secondary education, and *medical authority* and *free* for those with tertiary education. It seems therefore, that nodes most likely to connect different parts of the network are nodes capturing some general belief about the vaccine or a medical recommendation (personal or general), with the exception of those with elementary education, for whom the most central were motives connected with the social surroundings. On the contrary, for those with tertiary degrees, *protection of others* and *people around* were significantly less central than the rest of the nodes, suggesting social motives not being connection points for the belief systems.

By closeness centrality, i.e. the closest nodes to other ones, the most central nodes were *protection of others* and *people around* for those with elementary education, *vaccination is right* for those with vocational training, *vaccination is right* for those with secondary education, and *medical authority* and *free* for those with tertiary education. The least central node, i.e. furthest from other nodes, were *herd immunity* for those with elementary education and vocational training, and *forced by people* for those with secondary education.

The nodes with most Expected Influence were *vaccination is right* for those with elementary education and vocational training, with *doctor* as well for those with vocational training, and *regret* and *medical authority* for those with tertiary education (those with secondary education did not have a most influential node). On the other hand, the least central (influential) nodes were *protection of others* for those with elementary education, *forced by state* for those with secondary education, and *high-risk group* for those with tertiary education.

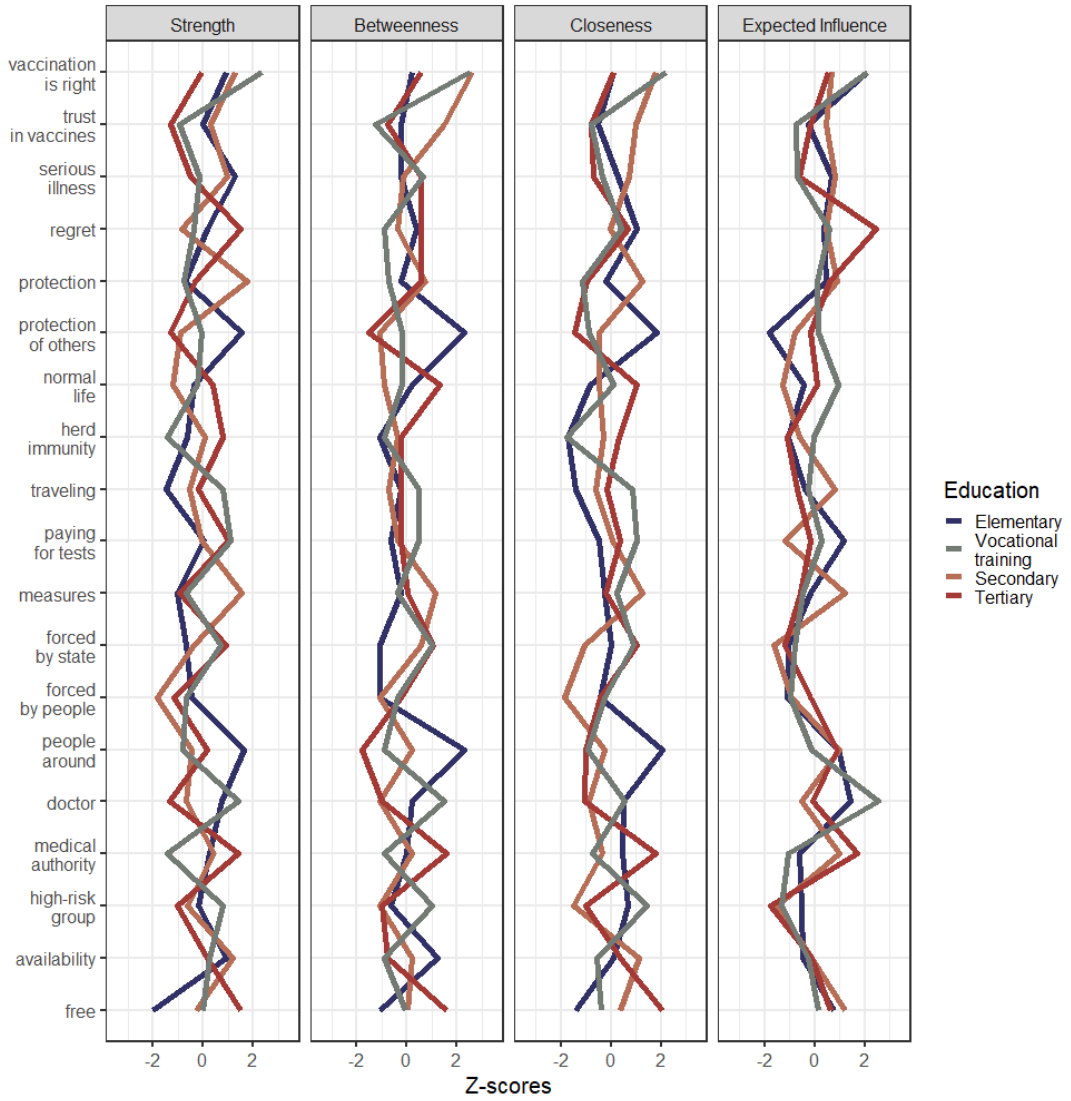



Figure 7.40: Centrality measures: grouped by education

### 7.3.7 Vaccinated grouped by age

Figure 7.41 shows belief networks corresponding to groups divided by their age group - respondents aged 18-24 years (n=79), 25-34 years (n=144), 35-44 years (n=167),45-54 years (n=163), and 55-64 years (n=163). There is a slight difference in density, with the youngest age groups having a slightly sparser network than older groups. The second youngest group also has relatively lower values of edge

weights. A tie between *vaccination is right* and *trust in vaccines* is strong only for the youngest (18-24) and third youngest (35-44). The tie between *doctor* and *medical authority* is the strongest for the oldest age group.


(a) 18 to 24


(b) 25 to 34


(c) 35 to 44


(d) 45 to 54


(e) 55 to 64

Figure 7.41: Belief networks: age

In terms of centrality measures, there seems to be a trend of central nodes becoming more concentrated on practical issues (payment for tests, free vaccine) with the growing age. The trends can be seen in Figure 7.42.

Nodes with the strongest local influence (highest strength centrality) are *measures* for the age group 25-34, *vaccination is right* and *measures* for the age group of 35-44, *vaccination is right* and *paying for tests* for the age group of 45-54, and *free* for the age group of 55-64. The least central nodes for the youngest age group are *paying for tests* and *high-risk group*, *people around* for those aged 25-34, *protection of others* for those aged 35-44, *people around* for those aged 45-54, and *herd immunity* for those aged 55-64, all with the exception of the youngest group being socially directed motives.

Nodes most likely to be positioned between different sections of a network are *vaccination is right*, *protection of others*, and *doctor* for those aged 18-24, *trust in vaccines* and *measures* for those aged 25-34, *serious illness*, *normal life*, *measures*, and *doctor* for those aged 35-44, *vaccination is right*, *paying for tests*, and *measures* for those aged 45-54, and *vaccination is right* and *free* for those aged 55-64. They mostly represent general beliefs about vaccination and the role of the COVID-19 vaccine.

Nodes on average closest to other nodes are *protection of others* for those aged 18-24, *trust in vaccines* for those aged 25-34, *vaccination is right*, *normal life*, and *measures* for those aged 35-44, *vaccination is right* for those aged 45-54, and *free* (54-65). The nodes on average furthest from other nodes are *herd immunity*, *paying for tests*, and *high-risk group* (19-24), *people around* and *medical authority* for those aged 25-34, *doctor* and *medical authority* for those aged 45-54, and *herd immunity* for those aged 55-64.

The nodes that are supposed to have the largest Expected Influence are *vaccination is right* and *doctor* for those aged 18-24, *protection* for those aged 25-34, *regret* for those aged 35-44, *vaccination is right* for those aged 45-54, *free* for those aged 55-64. The nodes with the least Expected Influence are *forced by state* and *high-risk group* for those aged 18-24, *high-risk group* for those aged 25-34, *forced by state* for those aged 35-44, *forced by people* and *high-risk group* for those aged 45-54, and *measures* for those aged 55-64.

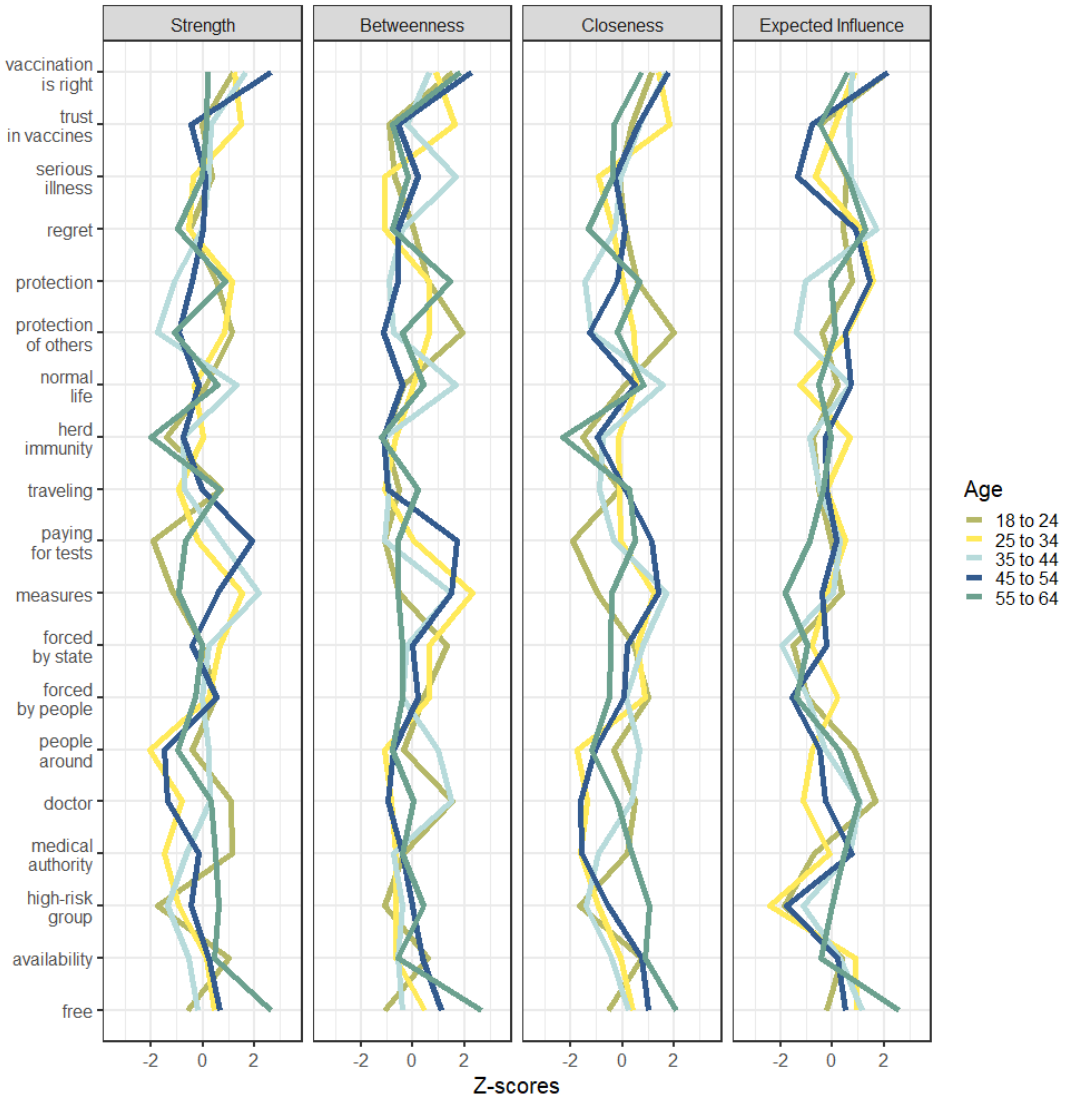



Figure 7.42: Centrality measures: grouped by age

### 7.3.8 Vaccinated grouped by income

All networks constructed on the basis of grouping by income level (as seen in Figure 7.43) are relatively similar in density. There is a notable larger correlation, for the group with the smallest income, between nodes *vaccination is right* and *doctor*, not present in the others. On the other hand, in this network, the correlation between nodes *free* and *available* is smaller than in the other networks. For the middle and

upper income level, a large correlation exists between nodes *protection* and *serious illness*. On the other hand, the connection between *doctor* and *medical authority* is present more in the lowest and middle income networks.


(a) Less than 20 000 CZK


(b) 20 000 CZK - 40 000 CZK


(c) More than 40 000 CZK

Figure 7.43: Belief networks: income

There is no clear pattern of centrality measures within the networks, as can be seen in Figure 7.44. There is one interesting difference between the network -

*protection of others* was a central node (by strength, betweenness and closeness) for respondents from the lowest income category, but not for others.

The nodes with the highest strength centrality, i.e. biggest influence on its neighbors, wree *protection of others* for the group with the lowest household income (under 20 000 CZK), *serious illness* for the group a mid-range household income (between 20 000 and 40 000 CZK), and *vaccination is right* and *measures* for the highest earners (over 40 000 CZK). The least central nodes by strength centrality are *protection* for the group with mid-range income, and *high-risk group* for the group with the highest income.

The nodes that are on average closest to other node (i.e. high in closeness centrality) are *protection of others* and *medical authority* for the lowest earners, *serious illness* for the mid-range earners, and *vaccination is right* and *free* for the highest earners.

The nodes with highest closeness centrality, i.e. on average closest to other nodes in the network, are *protection of others* for the lowest earners, *regret* for mid-range earners, and *vaccination is right* for the highest earners. The nodes with lowest closeness centrality are *regret* for the lowest earners, *protection* and *herd immunity* for mid-range earners, and *high-risk group* for the highest earners.

The nodes with highest Expected Influence in the network are *medical authority* and *free* for the network of those who earn under 20 000 CZK, *regret* for those who earn between 20 000 and 40 000 CZK, and *protection* and *free* for those earning over 40 000 CZK. The least central nodes by Expected Influence are *measures* for the lowest earners, and *high-risk group* for both the mid-range and highest earners.

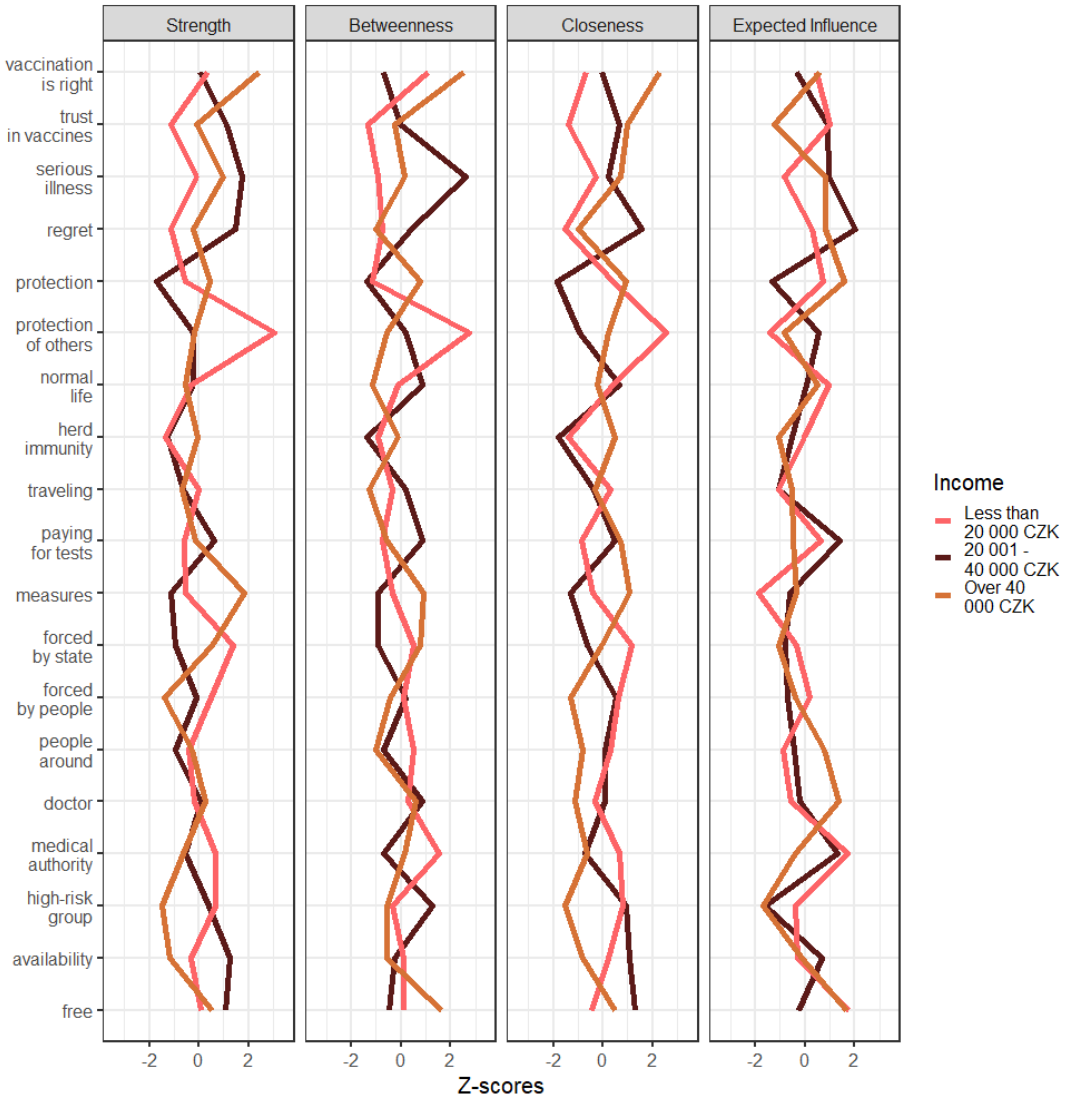
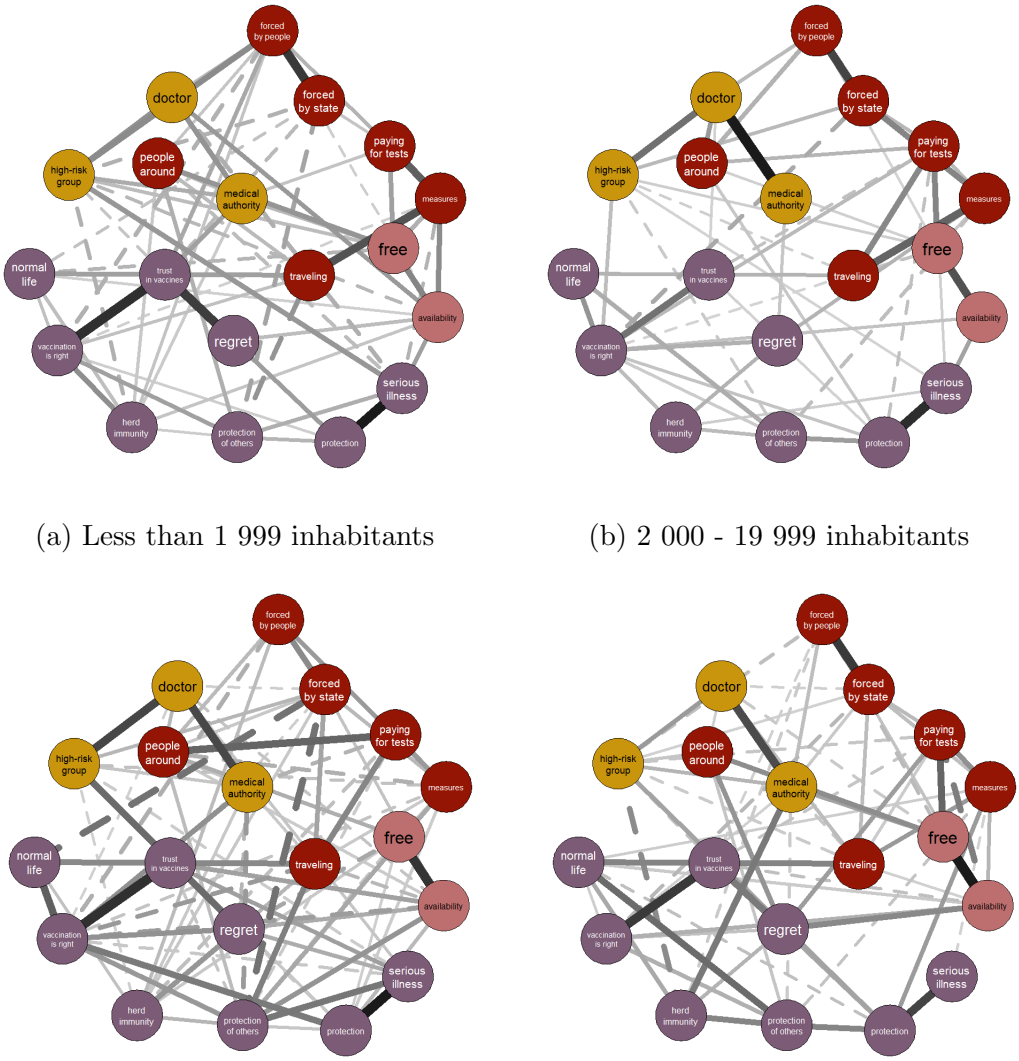



Figure 7.44: Centrality measures: grouped by income

### 7.3.9 Vaccinated grouped by city size

The networks based on the city size of the respondent (shown in Figure 7.45) are relatively similar to each other in the structural manner. The network of those respondents who come from smaller medium-size cities (2 000 to 19 999 inhabitants) is somewhat less dense than the others. While for all the networks there is a large correlation between *trust in vaccines* and *vaccination is right*, it

is not present as much in the network of 2 000 to 19 999 inhabitants. Similarly, although a correlation is present between the nodes *doctor* and *medical authority*, it is not so profound in the belief network of the smallest cities (up to 2 000 inhabitants).




(a) Less than 1 999 inhabitants

(b) 2 000 - 19 999 inhabitants

(c) 20 000 - 100 000 inhabitants

(d) More than 100 000 inhabitants

Figure 7.45: Belief networks: city size

There is an interesting level of agreement across the different measures of cen-

trality (shown in Figure 7.46). The node representing *trust in vaccines* was the most central in the network of respondents from the smallest settlements, while *vaccination is right* was the most central across all measure of centrality in the network of respondents in settlements from 2 000 to 20 000 inhabitants, and in all measures except Expected Influence for those living in cities from 20 000 to 100 000 inhabitants, while it was also accompanied with *protection of others*. For residents of the largest cities, no pattern was present. Across networks there is one striking difference, for residents of the largest cities (over 100 000 inhabitants), serious illness was one of the least central nodes by both strength and closeness centrality, which was not the case for other networks.

By strength centrality, i.e. most prominent position among its neighbors, *trust in vaccines* is the most central in the network of residents of smallest cities, *vaccination is right* and *paying for tests* for residents of towns with 2 000 to 20 000 inhabitants, *vaccination is right*, *protection of others* for residents of town with 20 000 to 100 000 inhabitants. For residents of largest cities, *availability* is the most central by strength centrality. The least central nodes are *regret* (smallest cities), and *serious illness* and *people around* for residents of the largest cities.

Nodes occupying the broker position in the network were *trust in vaccines* for the residents of smallest cities, *vaccination is right* for residents of towns with 2 000 to 20 000 inhabitants, *vaccination is right* and *protection of others* for residents of town with 20 000 to 100 000 inhabitants, and *protection* for residents of largest cities.

Nodes with the highest closeness centrality (i.e. being on average closest to other nodes), are *trust in vaccines* and *availability* for residents of smallest cities, *vaccination is right* and *paying for tests* for residents of towns with 2 000 to 20 000 inhabitants, *vaccination is right* and *protection of others* for residents of town with 20 000 to 100 000 inhabitants. Belief networks of residents of the largest cities did not have a clear central node identifiable by closeness centrality. The least central node by closeness centrality in the network of for residents of towns with 2 000 to 20 000 inhabitants was *herd immunity*, and *serious illness* for those living in the largest cities.

Nodes with the highest Expected Influence were identified only in two networks: for for residents of towns with 2 000 to 20 000 inhabitants it is *vaccination is right*

and *doctor*, and for residents of towns with 20 000 to 100 000 inhabitants it is *protection*. Each network had a least central node by Expected Influence. It is *forced by state* for the residents of smallest settlements and those living in towns with 20 000 to 100 000 inhabitants, *protection of others* for residents of towns with 2 000 to 20 000 inhabitants, and *forced by people* and *high-risk group* for residents of the largest cities.

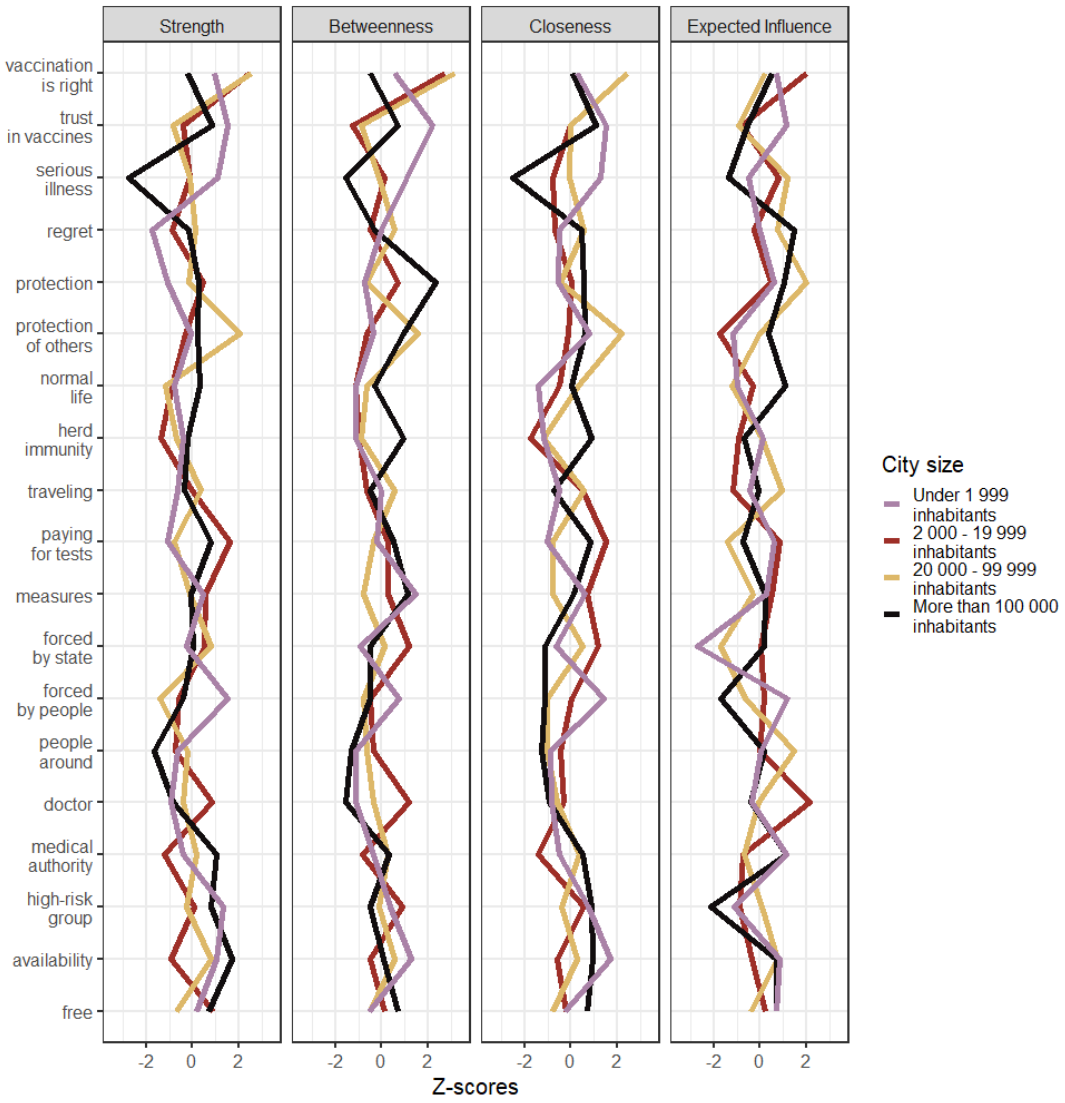



Figure 7.46: Centrality measures: grouped by city size

# Chapter 8

# Discussion

This thesis set out to study the belief network of motivations individuals may have to receive the COVID-19 vaccine. The theoretical background on the study of health behavior was provided through the Health Belief Model, Theory of Reasoned Action and the 3C/5C frameworks. All models try to capture the complexity of a decision carried out by an individual taking different factors into consideration. Each model lays out a specific understanding of this process, but if we take them all into consideration, we may say, that a person deciding about receiving a vaccine weights the (perceived) benefits of the vaccine, (perceived) outer expectations, personal and cultural attitudes towards it, barriers in accessing it, and is influenced by the degree of control over their decision.

For the study of the structure of motivations, the framework of Belief Network Analysis was chosen. Its goal is to model relations between variables and a global structure of the system. We can identify potentially important nodes based on their structural position. It is important to note that the fact that a node is central in the network does not automatically mean that it is important on its own, rather that its power is in its position relative to other nodes. However, if concepts such as dynamic constraint are real, stimulating one item can lead to an activation of another. While belief networks as such should not be taken as an absolute, comparison between belief networks representing different groups is possible (Brandt & Morgan, 2022).

The constructed networks can be characterized as rather similar. None showed

a tendency to cluster, edges were distributed across the networks. Although groups of variables were clearly identified by Exploratory Factor Analysis, they were not found as clusters.

There was a surprising level of similarity of responses across different groupings based on selection variables. Socio-demographic characteristics were not a statistically significant factor of differences between groups in terms of perceived importance of measured items, except for age and education in selected variables. There were however statistically significant differences between groups defined by their time of registration. Groups registered earlier tended to characterize their decision as based on the benefits of the vaccine itself, but with time these motivations lost their importance and were gradually replaced by outside forces.

Networks constructed through partial correlations did not seem to differ between socio-demographic groups. The largest structural differences could be found between groups defined by vaccination status generally, and time of registration or likelihood of future vaccination specifically. Unvaccinated groups tended to denser networks, which was also true for the group registered in November or December 2021.

One of the most apparent features of the data is the lack of clusters present in the networks. Even though factor analysis produced rather well-defined components, a similar pattern is not clear in the network data. This plays into the argument of the complexity of the issue of vaccination decision. No one specific reason is prominent, and all items correlate highly with one another. Arguments for receiving the vaccine must be communicated in broad and target as many topic groups as feasible.

Factor analysis did not show similarity to any of the models presented in Chapter 3. The four-factor solution defined four groups: "vaccine benefits", "outside forces", "medical assessment" and "access". Those do not clearly correspond to neither the Health Belief Model, the Theory of Planned Behavior, nor the 3Cs/5Cs frameworks. This may be, however, connected to the absence of negatively formulated reasons to receive the vaccine.

The networks seem to differ in density (although it was not explicitly measured and judged on a more qualitative basis), specifically in comparison to the vaccinated respondents, the belief networks of the unvaccinated respondents were gen-

erally denser. This may be a result of smaller sample size, but may also suggest a certain level of homogenity within the group (low variance of relationships between variables). It could be skewed by the limited options of motivation: maybe none described the leading potential motivation, and it is yet to be found. We could, however, also hypothesize about the connection with the connectivity hypothesis, which poses that denser, more connected networks, are more stable in structure and less likely to change even when contradictory evidence is introduced (Dalege et al., 2019). It is possible that the belief networks of the unvaccinated population truly are less susceptible to change, which is a hypothesis that could be tested further.

Although the results did not produce clear clusters, they do suggest that different variables play distinct roles in the decision making about receiving the vaccine. In general, the central nodes of the networks are very self-oriented in matter (such as personal vaccine benefit or feeling of force on oneself). Social motivations (such as protecting others and helping build herd immunity) are often the least central. This is in alignment with the perspectives of the models presented in 3, which also concentrate on the individual perspective. This does not mean that protection of others would be unimportant for the respondents, in absolute evaluation it scored highly, but rather that it is not a formative belief. This finding is in sharp contrast to the suggestion of Sherman et al. (2021, p.1617), as well as Becchetti et al. (2021, p.8), that highlighting altruistic reasons should be effective in promotion of the vaccine.

Node position was measured with four different centrality measures, each capturing a different aspect of the notion of "being central". Strength centrality is the most commonly used in research (Nudelman et al., 2019; Zhang et al., 2021; Zhu et al., 2020), as it is easily interpretable. For data in this thesis however, we must be careful about the interpretation, since it does not differentiate between positive and negative correlations. Activation of a node may bring a non-trivial response in a node that is negatively correlated with it. The node that was most often central by strength centrality was *vaccination is right*, while *people around* was commonly the least central node by strength centrality.

Betweenness centrality is difficult to interpret in the context of belief networks. Boutyline and Vaisey (2017) utilize it to locate the origin belief, however, this in-

terpretation does not seem appropriate for the nodes of vaccination beliefs. A node that has high betweenness centrality is likely to be positioned in a brokerage position, having the power to control flow across the network. As was discussed previously, the notion of flow is difficult to contextualize in the context of belief networks. It may be suggested, that these nodes have an important role for the cohesion of the network. The nodes that are highest in betweenness centrality were *vaccination is right*, as well as *free*. That could suggest that were the vaccine not free, the network could have looked different.

Closeness centrality identifies nodes that are on average closest to all other nodes in the network. This method is not commonly used in Belief Network Analysis. It could however be useful in the extreme case of identifying only one node to target (for example with very limited resources). It could be argued that such an attempt was made with the official Czech informational campaign "Tečka", where the main motto was "normal life" ("Česko očkuje", 2021). This node has, however, not emerged as central in the analysis. The most central by closeness centrality were commonly either *vaccination is right* or *paying for tests*. The least central by closeness centrality was *herd immunity*.

Since the classical network measures are not well suited for weighted networks with both positive and negative edge weights, Robinaugh et al. formulate a different measure, Expected Influence (2016). Results for this type of centrality generally differed from those of the other centralities. Overall, *vaccination is right* and *free* were most commonly the nodes with high Expected Influence in the network, while *high-risk group* and *forced by state* were often the least influential nodes.

One of the most prominent motivations for vaccination, in those already vaccinated, was "I believe that vaccination is generally a right thing to do," its corresponding node was highly central across different networks and centrality measures. On the contrary, in the networks of the unvaccinated subset, the belief that vaccination is a right thing to do, was generally not central. This suggests that basing the argument on these grounds may be only effective in that part of the population that is more likely to receive the vaccine anyway. It has potential, however, to be built as a social norm gradually, which could increase its persuasive power.

Medical authorities recommending the vaccine was generally not a highly important motivation, when studying the distributions of evaluation of importance

but showed up as central in several networks. This may suggest that although specific medical authorities promoting vaccination may not have a traceable effect, it plays a major role in the system. When medical authorities speak out for the vaccine, it creates consistency in the public sphere and enables other motivating factors to function.

Protection from the infection itself and protection from serious illness was not a central belief in most networks (it was prominently central for those registered before their eligibility). On its own, it mostly scored highly (except for groups that were not vaccinated), but almost never the highest of all motivations. This is surprising, as protection against infection or its severe course is the primary medical goal of the vaccine. In previous studies it was one of the leading declared reasons to receive a vaccine Čadová, 2021b; Čadová, 2021c; Čadová, 2022; Belingheri et al., 2021; Dorribo et al., 2015; Carter, Beach, and Inui, 1986; Verger et al., 2018). This paradox may be caused by three reasons. Methodologically, most previous research was not done on a representative sample of population, but rather on a defined subpopulation. Medically, while COVID-19 is a serious disease that can cause death, infection can result in a number of different outcomes, many of them rather mild (Macera et al., 2020). Therefore the fear of the disease itself could have been smaller in the population. The COVID-19 vaccine was introduced in the context of many other valid reasons to receive it, not solely to prevent the disease.

The item "People around me got vaccinated," had a surprising role. One's immediate surroundings did not seem to play an influential role in the vaccine decision. According to the theory of diffusion of innovation, the decision of people around should influence one's own decision about the adoption of an innovation (in this case the COVID-19 vaccine). An operationalization of this process was attempted by measuring the time of registration. Significant difference was detected between groups differentiated by this characteristic. However, the data suggest that the decision of people around was not as influential as the theory of diffusion of innovation suggests it to be. Not only did it score very low in the absolute measure of importance, it also appeared as one of the least central nodes in multiple networks and as a central node only for the belief network of respondents with elementary education. This suggests that following other people's example is

neither a conscious nor a latent motivation for the vaccination decision.

As was mentioned before, the largest differences were detected between groups defined by their vaccination status and by the time of registration. It is interesting to note, that although health is generally regarded as a sensitive topic, only a very small portion of respondents declined to answer the question about their vaccination status. This suggests that this topic was viewed as a part of the public sphere, and it was normalized to share one's vaccination status with strangers. Although one may say it is problematic to compare the vaccinated and unvaccinated groups, the Theory of Planned Behavior gives us theoretical backing. Intention to pursue a behavior (which was measures) is a good predictor of the behavior in the future (Ajzen, 1985, p.16, 30). Those who had not received the vaccine by the time of data collection, but were considering it in the future, indicated less interest in motivating factors than their vaccinated counterparts, which is consistent with literature. Chi Tam et al. found that refusal groups found protection and authoritative advice less compeling than those who were decided to receive the COVID-19 vaccine (Chi Tam et al., 2021, p.150).

Those who decided to receive their vaccine early, were more likely influenced by the vaccine benefits themselves, in the network then, the central positions were either value-based (belief that *vaccination is a right thing to do*, *trust in vaccines*, *normal life*), practical (free, paying for tests – this should be however understood in a different context than paying for tests in the fall of 2021, when tests were needed for leisure activities ) or medically ordered (by a doctor or other medical authority). Those who registered later than a month after their eligibility were more likely to be persuaded by outside forces. Interestingly, this corresponds closely to the strategy recommended by the theoretical model of Becchetti et al., who suggest first employ nudging strategies paired with voluntary vaccination and if herd immunity is not reached, then government or private measures can be introduced (2021, p.9).

An interesting relationship can be noted between the motivations of regret and serious illness. The correlation in the unvaccinated group is negative, with serious illness being a potential motivational factor, but regret not found as relevant. This is surprising in the context of the phase of the vaccine promotion campaign that was introduced in fall of 2021 in the Czech Republic. It was purposefully negative

and appealing, introducing photographs of victims of COVID-19 with messages such as "She delayed her vaccine" or "He had many excuses". This messaging's purpose was probably to introduce the fear of regret ("Ministerstvo vyzývá k očkování proti covidu-19 pomocí fotografií z nemocnic", 2021). The analysis of the data in this thesis showed however, that it may not have been an effective strategy. Limits and further directions

There are multiple limits of this study. General critics of the models and techniques used have already been pointed out in the text. It is important to specify that the results, while having an informative character on an aggregate level, are not to be extrapolated to the individuals. It would be a mistake to consider an individual belief network of a member of an aggregate group to be the same. To study the issue of individual belief networks, another method can be employed. Respondents may be asked to arrange a network or consider the existence of a tie between two items, and only then an aggregate network is constructed (Brogan & Hevey, 2009, p.37-39).

Network analysis can serve as a useful exploratory tool for the study of beliefs and attitudes. It is surely very visually attractive and can provide a glance at the problem at hand. Its analytical is however uncertain. There is an ongoing discussion within the scientific community about the interpretations of the metrics, such as centrality, in the context of beliefs (Bringmann et al., 2019). Interpretation of the position of nodes in terms of belief systems should be considered with skepticism.

Especially considering the interpretation of the belief networks of groups that had already been vaccinated, it is important to consider the influence of survival bias (the studied sample contains only observations that have already passed a certain condition, therefore we do not have information about those who do not (Ball & Watts, 1979)). Even though identification of central nodes is pursued to consider effective ways of communicating, a part of the population would have probably received the vaccine anyway. To contextualize this issue, it would be useful to involve a comparison – either between countries or different vaccines and employ a detailed analysis of the messaging in the respective countries or regarding the specific vaccines. It is also important to note that only positive motivations were included, and therefore no assumptions can be made about the negative factors in deciding

about receiving the vaccine.

Furthermore, the results are representative for the population between ages 18 and 64, that is active on the internet. That means it is not representative of the Czech population as a whole, especially the older age groups, which are also the ones whose motive for receiving the COVID-19 vaccine could have differed widely from the younger generations. In terms of technical issues of this study, there are some to acknowledge. The sample size, while being sufficient for some analyses, was not large enough for parallel analyses of the groups. Especially in the smaller groups, the analysis does not have sufficient power to extrapolate the results on the larger population.

A somewhat surprising portion (20.1%) of respondents admitted they were vaccinated before it was their official turn. One possible explanation for this is that some respondents may have understood the question differently, for example, a person aged 25 working in a school was eligible for a vaccine in March but may have subjectively felt as if they were vaccinated inappropriately early for their age.

Some issues may have stemmed from the wording of the questionnaire. Certain statements may have had an inflated zero-response (e.g. "My doctor recommended me to get vaccinated against COVID-19": this motivational factor could be either unimportant for a respondent despite the received recommendation, or the respondent could had not received such recommendation and hence it could have not been an important motivation for them). Some motivations were not included in the questionnaire which could have been important, such as an experience with the disease, either direct (Do & Frank, 2022) or through family or friend (Khubchandani et al., 2021), or the obligation to get tested at the place of work or to be able to participate in leisure activities, which were both mentioned several times in the open-ended question. Others items that had been included in other research (Rönnerstrand, 2013) would be generalized trust in institutions, or the possibility to choose the vaccine, which was found to be a potential motivating factor for those who were unvaccinated (Prokop, 2021).

Only a limited set of socio-demographic characteristics was included (sex, age, education, city size, and income). Political orientation was not included, although research suggests that there is a relationship between political views and vaccine acceptance. For example, a study conducted on the case of the COVID-19 vac-

cine showed that the respondents who said they would not get vaccinated were more likely to be politically conservative (Berg & Lin, 2021). Race and ethnicity seems to also play a role in the level of vaccine acceptance, with members of the minority groups being less likely to express an intention to receive the vaccine (Guidry et al., 2021; Kamal et al., 2021). General health literacy was also shown to influence vaccination decisions (Montagni et al., 2021). In the context of the COVID-19 pandemic, some relationship between the willingness to follow measures and acceptance of the vaccine was found (Umakanthan & Lawrence, 2022). Further research is needed into dynamic constraint in the context of belief networks to be able to determine whether the this thesis' findings' suggestions are making have potential to be useful in real-world applications. The hope is that carefully designed campaigns could target the most central, therefore possessing greater influence, which could then extend to other nodes (Robinaugh et al., 2016; Abhyankar et al., 2008; Schlicht-Schmälzle et al., 2018).

# Chapter 9

# Conclusion

This thesis set out to study a vaccine campaign that at the time of writing was still ongoing. It represents one of the first works on the issue in the Czech Republic and to the author's knowledge the first application of Belief Network Analysis for the study of the COVID-19 vaccine.

While identifying clear groups of reasons through factor analysis, it did not find a pronounced pattern in their network structure. On the node level a few reasons stood out as being of interest. The belief that vaccination is generally a right thing to do occupied a highly central position in many networks, as well as medical authority recommendation. The influence of one's direct surroundings was surprisingly low.

The current COVID-19 pandemic is not the last health crisis humanity will face. New viruses emerge and new vaccines are introduced. Lessons can be learnt from the COVID-19 vaccination campaign that will help design better ones for the future. The results from this thesis, for example, suggest that focusing on building up on the norm of vaccination being a right thing to do, supported by medical authorities, may be a promising strategy. This however requires long-term work, as the strategy may not function when trust in vaccines and medical authorities is not strong in society.

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# Appendix A

# Questionnaire

## A.1 Czech version (original)

Následující část je věnována tématu očkování proti onemocnění covid-19. Vaše odpovědi nám pomůžou pochopit, jaké faktory lidé zvažují při rozhodování o očkování. Dotazování je zcela anonymní.

### O1

**Jste očkován/a proti onemocnění covid-19?**

1. ano, mám dokončené očkování, bez posilující dávky (jedna dávka u jednodávkové vakcíny nebo dvě dávky u dvoudávkové vakcíny)
2. ano, ale jsem očkován pouze první dávkou dvoudávkové vakcíny
3. ano a jsem naočkován i posilující dávkou
4. ne, nejsem naočkován
5. nechci odpovídat

## O2

FILTR pro O1:1,2

**O2A: Jak pravděpodobné či nepravděpodobné je, že se necháte očkovat posilující dávkou, až budete mít možnost?**

Sedmibodová škála: -3 = zcela nepravděpodobné – 3 = zcela jisté.

FILTR pro O1:4

**O2B: Jak pravděpodobné či nepravděpodobné je, že se necháte v budoucnu očkovat proti onemocnění covid-19?**

Sedmibodová škála: -3 = zcela nepravděpodobné – 3 = zcela jisté.

Pro O1:3 a 5 přeskočit.

## O3

FILTR: pro O2B: 1,2,3

**O3A: Jak pravděpodobné či nepravděpodobné je, že se necháte očkovat ve výhledu jednoho měsíce?**

Sedmibodová škála: -3 = zcela nepravděpodobné – 3 = zcela jisté.

FILTR: pro O1: 1,2,3

**Kdy jste registrovala k očkování první dávkou vakcíny?**

1. ještě předtím, než to bylo možné pro mou věkovou nebo profesní skupinu
2. do jednoho měsíce od chvíle, kdy to bylo možné pro mou věkovou nebo profesní skupinu
3. později než měsíc od chvíle, kdy to bylo možné pro mou věkovou nebo profesní skupinu, ale dříve než v listopadu 2021
4. v listopadu nebo prosinci 2021
5. nevím
6. nechci odpovídat

Pro O1:5 přeskočit.

## O4

FILTR Pro O1:1,2,3

**O4A: Lidé mohou mít k očkování různé motivace. Zkuste si nyní prosím vzpomenout na situaci před vaší první dávkou očkování. Nakolik následující tvrzení vystihují vaši motivaci pro rozhodnutí nechat se očkovat?**

Sedmibodová škála: 0 = vůbec mé motivaci neodpovídá – 6 = zcela mou motivaci vystihuje. Nabídka tvrzení:

- Doporučil/a mi to můj lékař/moje lékařka.
- Očkování bylo doporučeno lékařskou autoritou.
- Litoval/a bych toho, kdybych se naočkovat nenechal/a.
- Chtěl/a jsem předejít onemocnění.
- Abych nemusel/a již dodržovat opatření.
- Věřím, že očkovat se je obecně správné.
- Lidé v mém okolí se nechali očkovat.
- Cítil/a jsem se státem přinucen/a k očkování.
- Cítil/a jsem se přinucen/a k očkování ze strany svého okolí (blízkých či známých).
- Cítil/a jsem přinucen/a k očkování svým zaměstnavatelem.
- Abych mohl/a cestovat.
- Abych pomohl/a dosáhnout kolektivní imunity.
- Očkování bylo jednoduše dostupné.
- Očkování bylo zdarma.
- Abych před nákazou chránil/a své okolí (rodinu, přátele, kolegy v práci).
- Patřím do zdravotně ohrožené skupiny.
- Očkování je cesta k návratu k normálnímu životu.
- Chtěl/a jsem předejít vážnému průběhu onemocnění.

- Abych nemusel/a platit za testy.
- Důvěřuji vakcínám proti onemocnění covid-19.

FILTR pro O2B: 1,2,3

**O4B: Lidé mohou mít k očkování různé motivace. Nakolik následující tvrzení vystihují vaši motivaci pro rozhodnutí nechat se očkovat?**

Sedmibodová škála: 0 = vůbec mé motivaci neodpovídá – 6 = zcela mou motivaci vystihuje.

Nabídka tvrzení:

- Doporučil/a mi to můj lékař/moje lékařka.
- Očkování bylo doporučeno lékařskou autoritou.
- Litoval/a bych toho, kdybych se naočkovat nenechal/a.
- Chci jsem předejít onemocnění.
- Abych nemusel/a již dodržovat opatření.
- Věřím, že očkovat se je obecně správné.
- Lidé v mém okolí se nechali očkovat.
- Cítím se státem přinucen/a k očkování.
- Cítím se přinucen/a k očkování ze strany svého okolí (blízkých či známých).
- Cítím se přinucen/a k očkování svým zaměstnavatelem.
- Abych mohl/a cestovat.
- Abych pomohl/a dosáhnout kolektivní imunity.
- Očkování je jednoduše dostupné.
- Očkování je zdarma.
- Abych před nákazou chránil/a své okolí (rodinu, přátele, kolegy v práci).
- Patřím do zdravotně ohrožené skupiny.
- Očkování je cesta k návratu k normálnímu životu.
- Chci jsem předejít vážnému průběhu onemocnění.

- Abych nemusel/a platit za testy.
- Důvěřuji vakcínám proti onemocnění covid-19.

Přeskočit pro O1:5 a pro O2B:-3, -2, -1, 0.

### O5

**O5: Pokud v seznamu chybí pro vás důležitá motivace k očkování proti onemconění covid-19, zde ji můžete doplnit:**

Otevřená otázka.

## A.2 English version (post-administration translation by author)

The following section is dedicated to the topic of vaccination against COVID-19. Your answers will help us understand what factors people consider when deciding about vaccination. The survey is completely anonymous.

### O1

**Are you vaccinated against COVID-19?**

1. yes, I am completely vaccinated, without a booster dose (one dose in case of a one-dose vaccination scheme or two doses in case of a two-dose vaccination scheme)
2. yes, but I am vaccinated only with the first dose of a two-dose vaccine
3. yes, and I have received a booster dose
4. no, I am not vaccinated
5. I do not wish to answer

## O2

FILTER for O1:1,2

**O2A: How likely or unlikely is it that you will get vaccinated by the booster dose, when you have the possibility?**

7-point scale: -3 = completely unlikely – 3 = completely likely.

FILTER pro O1:4

**O2B: How likely or unlikely is it that you will get vaccinated against COVID-19 in the future?**

7-point scale: -3 = completely unlikely – 3 = completely likely.

For O1:3 and 5 skip.

## O3

FILTER: pro O2B: 1,2,3

**O3A: How likely or unlikely is it that you will get vaccinated against COVID-19 in the following month?**

7-point scale: -3 = completely unlikely – 3 = completely likely.

FILTER: pro O1: 1,2,3

**When did you register for the first dose of the vaccine?**

1. before it was available for my age or occupational group
2. up to one month from when it was available for my age or occupational group
3. more than a month from when it was available for my age or occupational group but before November 2021
4. in November or December 2021
5. I do not know
6. I do not wish to answer

For O1:5 skip.

## O4

FILTR Pro O1:1,2,3

**O4A: People can have different motivations for getting vaccinated. Please try to remember the situation before your first dose of the vaccine. To what extent did the following statements describe your motivation for the decision to receive the vaccine?**

7-point scale: 0 = does not describe my motivation at all – 6 = completely describes my motivation.

Statements:

- My doctor recommended it to me.
- Vaccination was recommended by a medical authority.
- I would regret not getting vaccinated.
- I wanted to prevent the disease.
- To not be obliged to follow the [pandemic] measures.
- I believe that getting vaccinated is generally a right thing to do .
- People around me got vaccinated.
- I felt forced by the state to get vaccinated.
- I felt forced by my surroundings to get vaccinated.
- I felt pressured by my employer to get vaccinated.
- To be able to travel.
- To help reach herd immunity .
- Vaccination was easily available. .
- Vaccination was free.
- To protect people around me (family, friends, coworkers) from the disease.
- I belong to a high-risk group.
- Vaccination is a path to normal life.
- I wanted to prevent a severe illness.

- To not be obliged to pay for tests.
- I trust the COVID-19 vaccines.

FILTR pro O2B: 1,2,3

**O4B: People can have different motivations for getting vaccinated. To what extent do the following statements describe your motivation for the decision to receive the vaccine?**

7-point scale: 0 = does not describe my motivation at all – 6 = completely describes my motivation.

Statements:

- My doctor recommended it to me.
- Vaccination was recommended by a medical authority.
- I would regret not getting vaccinated.
- I want to prevent the disease.
- To not be obliged to follow the [pandemic] measures.
- I believe that getting vaccinated is generally a right thing to do .
- People around me got vaccinated.
- I feel forced by the state to get vaccinated.
- I feel forced by my surroundings to get vaccinated.
- I feel pressured by my employer to get vaccinated.
- To be able to travel.
- To help reach herd immunity .
- Vaccination is easily available. .
- Vaccination is free.
- To protect people around me (family, friends, coworkers) from the disease.
- I belong to a high-risk group.
- Vaccination is a path to normal life.

- I want to prevent a severe illness.
- To not be obliged to pay for tests.
- I trust the COVID-19 vaccines.

Přeskočit pro O1:5 a pro O2B:-3, -2, -1, 0.

## O5

**O5: If there is a motivation that in your opinion is missing from the list, you can add it here:**

Open-ended question.

# Appendix B

# Factor analysis

In the following section, a comprehensive explanation of the variable grouping process using factor analysis is found.

Factor analysis function `fa()` from the package psych was used, with the choice of the *varimax* rotation.

The analysis was performed only on already vaccinated respondents. The size the sample size of the vaccinated population was 716, the sample size of the unvaccinated, but willing to receive the vaccine, was only 45. The analysis derived only from the vaccinated population offered a better differentiation between the factors.

Across all solutions we can see a stable tendency of grouping. The first factor in all solutions contains a multitude of reasons, in total they can be characterized as benefits arising directly from the vaccine - being it personal (protection of oneself) or collective (herd immunity formation). Another clear group appears, that of practical reasons for receiving the vaccine, connected with the specific situation of the COVID-19 pandemic - feeling forced, pandemic measures, traveling, etc. In the three- and four- factor solution a cluster of three motivations emerges: doctor's recommendation, medical authority, and belonging to a high-risk group. We can identify this factor as an assessment of one's personal medical risks, a specific sub-category of the vaccine benefits (it is however interesting that neither the motivation of general protection nor the threat of serious illness is included in this group).

A motivation that is not categorizable in any of the solutions is "People around

me got vaccinated." Its factor loadings are similar across all factors.

A modified version of the four-factor solution will be used for clearer visual communication of the variables.

## B.1 Two factors

| | Factor 1 | Factor 2 | Communalities |
|---|---|---|---|
| availability | 0.60 | 0.19 | 0.40 |
| doctor | 0.39 | 0.19 | 0.19 |
| forced by people | -0.15 | 0.51 | 0.28 |
| forced by state | -0.48 | 0.58 | 0.57 |
| free | 0.41 | 0.43 | 0.35 |
| herd immunity | 0.71 | -0.01 | 0.51 |
| high-risk group | 0.36 | 0.05 | 0.13 |
| measures | -0.05 | 0.64 | 0.41 |
| medical authority | 0.52 | 0.17 | 0.30 |
| normal life | 0.72 | -0.08 | 0.53 |
| paying for tests | 0.00 | 0.61 | 0.37 |
| people around | 0.42 | 0.41 | 0.34 |
| protection | 0.78 | -0.13 | 0.63 |
| protection of others | 0.75 | -0.14 | 0.58 |
| regret | 0.79 | 0.00 | 0.62 |
| serious illness | 0.76 | -0.17 | 0.61 |
| traveling | 0.05 | 0.41 | 0.17 |
| trust in vaccines | 0.80 | -0.18 | 0.67 |
| vaccination is right | 0.86 | -0.18 | 0.78 |

Table B.1: Two factor solution - factor loadings

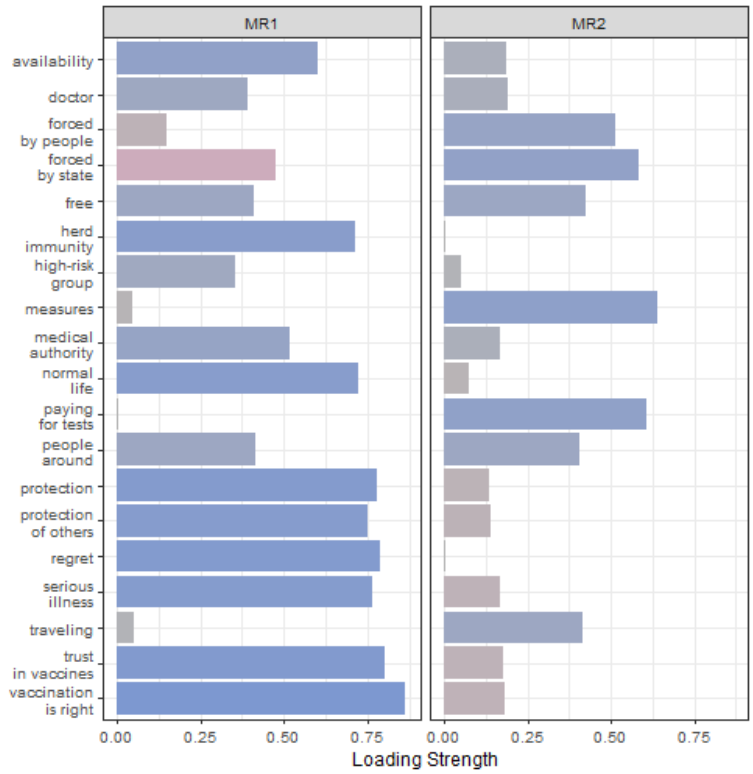



Figure B.1: 2 factors

| **vaccine benefits** | **outside forces** | **uncategorized** |
|---|---|---|
| availability | forced by state | free |
| doctor | forced by people | people around |
| herd immunity | measures | |
| high-risk group | paying for tests | |
| medical authority | traveling | |
| normal life | | |
| protection | | |
| protection of others | | |
| regret | | |
| serious illness | | |
| trust in vaccines | | |
| vaccination is right | | |

Table B.2: Two-factor solution

## B.2 Three factors

| | Factor 1 | Factor 2 | Factor 3 | Communalities |
|---|---|---|---|---|
| availability | 0.58 | 0.27 | 0.12 | 0.42 |
| doctor | 0.15 | 0.05 | 0.75 | 0.59 |
| forced by people | -0.28 | 0.42 | 0.23 | 0.31 |
| forced by state | -0.57 | 0.49 | 0.05 | 0.56 |
| free | 0.33 | 0.45 | 0.20 | 0.35 |
| herd immunity | 0.69 | 0.07 | 0.17 | 0.52 |
| high-risk group | 0.18 | -0.07 | 0.57 | 0.36 |
| measures | -0.09 | 0.68 | -0.02 | 0.47 |
| medical authority | 0.33 | 0.08 | 0.61 | 0.49 |
| normal life | 0.75 | 0.04 | 0.08 | 0.57 |
| paying for tests | -0.04 | 0.65 | -0.01 | 0.42 |
| people around | 0.28 | 0.37 | 0.35 | 0.34 |
| protection | 0.74 | -0.07 | 0.25 | 0.62 |
| protection of others | 0.76 | -0.04 | 0.13 | 0.60 |
| regret | 0.73 | 0.06 | 0.29 | 0.62 |
| serious illness | 0.75 | -0.10 | 0.21 | 0.61 |
| traveling | 0.06 | 0.49 | -0.09 | 0.25 |
| trust in vaccines | 0.79 | -0.10 | 0.20 | 0.67 |
| vaccination is right | 0.87 | -0.08 | 0.18 | 0.79 |

Table B.3: Three factor solution - factor loadings

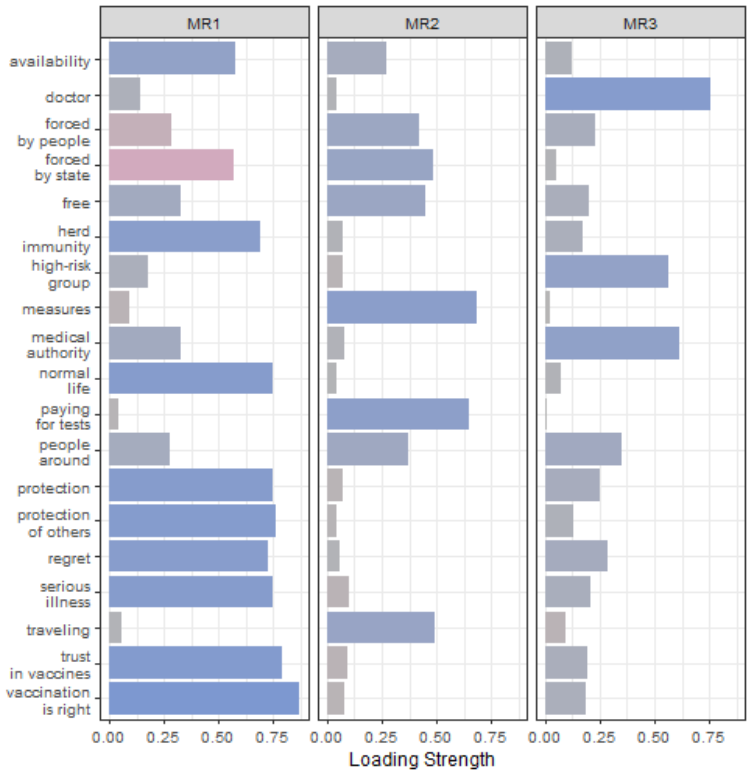



Figure B.2: 3 factors

| **vaccine benefits** | **outside forces** | **medical motivations** | **uncategorized** |
|---|---|---|---|
| availability | forced by state | doctor | people around |
| herd immunity | forced by people | high-risk group | |
| normal life | free | medical authority | |
| protection | measures | | |
| protection of others | paying for tests | | |
| regret | traveling | | |
| serious illness | | | |
| trust in vaccines | | | |
| vaccination is right | | | |

Table B.4: Three-factor solution

## B.3 Four factors

| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Communalities |
|---|---|---|---|---|---|
| availability | 0.50 | 0.11 | 0.08 | 0.51 | 0.52 |
| doctor | 0.15 | 0.03 | 0.75 | 0.06 | 0.59 |
| forced by people | -0.27 | 0.44 | 0.24 | 0.02 | 0.32 |
| forced by state | -0.55 | 0.52 | 0.07 | -0.03 | 0.58 |
| free | 0.20 | 0.25 | 0.16 | 0.73 | 0.67 |
| herd immunity | 0.68 | 0.04 | 0.17 | 0.15 | 0.52 |
| high-risk group | 0.18 | -0.08 | 0.56 | 0.04 | 0.36 |
| measures | -0.08 | 0.68 | -0.02 | 0.13 | 0.48 |
| medical authority | 0.32 | 0.04 | 0.60 | 0.13 | 0.48 |
| normal life | 0.78 | 0.07 | 0.07 | 0.02 | 0.62 |
| paying for tests | -0.06 | 0.60 | -0.01 | 0.22 | 0.41 |
| people around | 0.24 | 0.28 | 0.34 | 0.31 | 0.34 |
| protection | 0.72 | -0.13 | 0.24 | 0.16 | 0.62 |
| protection of others | 0.75 | -0.09 | 0.12 | 0.14 | 0.60 |
| regret | 0.72 | 0.03 | 0.28 | 0.13 | 0.62 |
| serious illness | 0.72 | -0.15 | 0.20 | 0.15 | 0.61 |
| traveling | 0.10 | 0.57 | -0.09 | -0.02 | 0.34 |
| trust in vaccines | 0.79 | -0.11 | 0.19 | 0.07 | 0.68 |
| vaccination is right | 0.86 | -0.10 | 0.18 | 0.10 | 0.80 |

Table B.5: Four factor solution - factor loadings

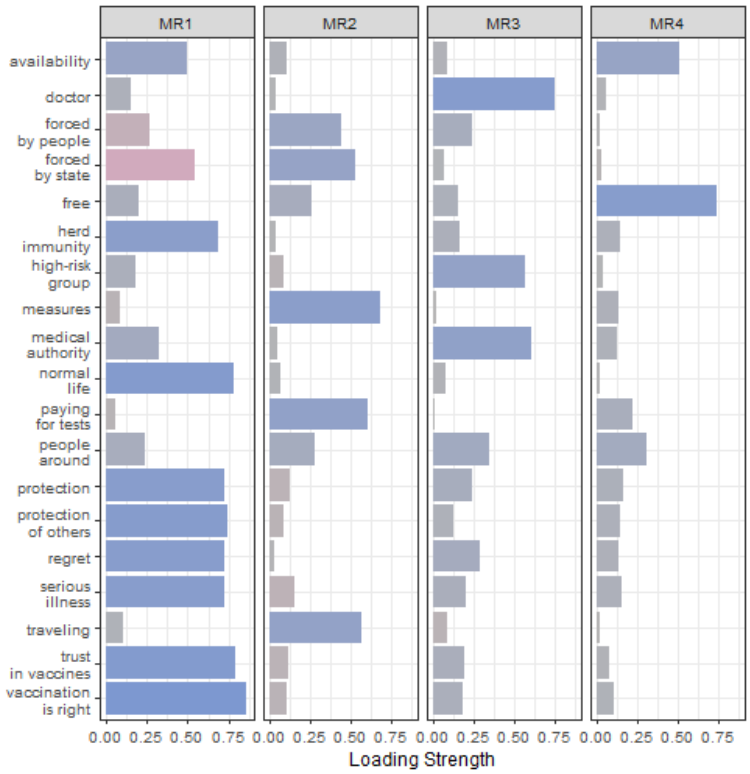



Figure B.3: 4 factors

| **vaccine benefits** | **outside forces** | **medical assessment** | **access** | **uncategorized** |
|---|---|---|---|---|
| herd immunity | forced by state | doctor | free | people around |
| normal life | forced by people | high-risk group | | availability |
| protection | measures | medical authority | | |
| protection of others | paying for tests | | | |
| regret | traveling | | | |
| serious illness | | | | |
| trust in vaccines | | | | |
| vaccination is right | | | | |

Table B.6: Four-factor solution

## B.4 Grouping

The factor analysis performed served as a tool for establishing a grouping to clearly communicate the variables. For this, the four-factor solution seems as a reasonable base, with a modification. There are two variables that do not correlate with any factor (*people around*) or correlate with two with a reasonable loading (*availability*). The influence of people around can be put together with the "outside forces" factor. Availability appears often in conjunction with cost.

The resulting grouping used in the thesis can be seen in Table B.7:

| **vaccine benefits** | **outside forces** | **medical assessment** | **access** |
|---|---|---|---|
| herd immunity | forced by state | doctor | free |
| normal life | forced by people | high-risk group | availability |
| protection | measures | medical authority | |
| protection of others | paying for tests | | |
| regret | traveling | | |
| serious illness | people around | | |
| trust in vaccines | | | |
| vaccination is right | | | |

Table B.7: Grouping of variables - modified four-factor solution

# Appendix C

# Partial correlations

## C.1 All vaccinated

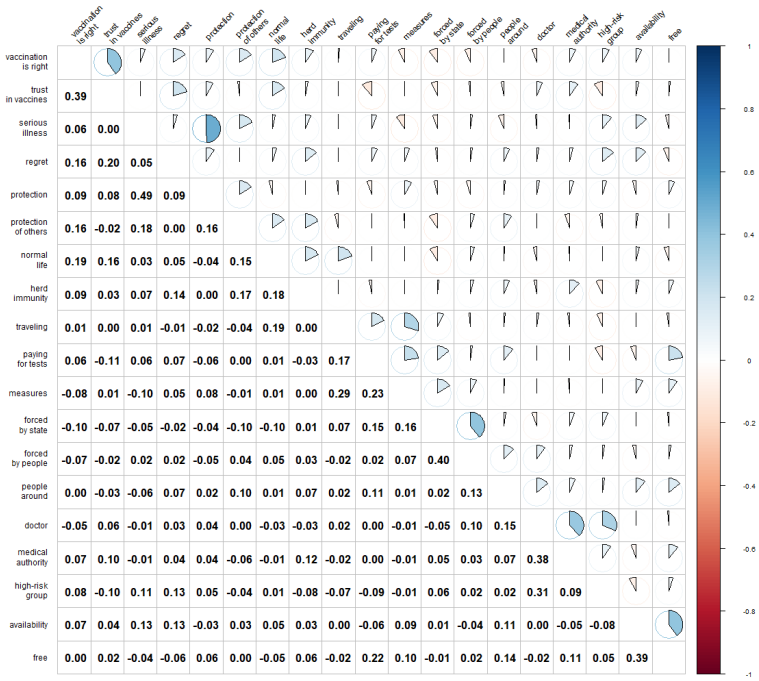
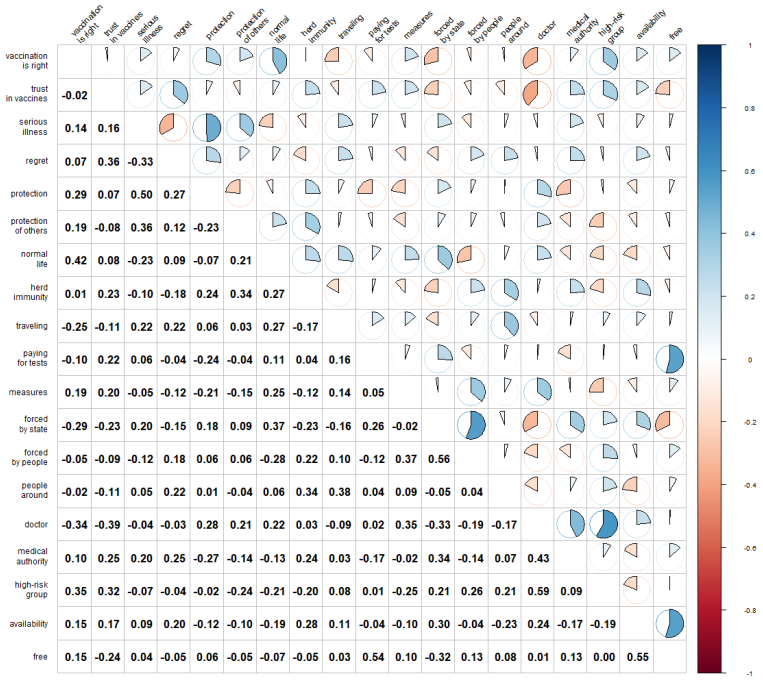



Figure C.1: Correlations: all vaccinated

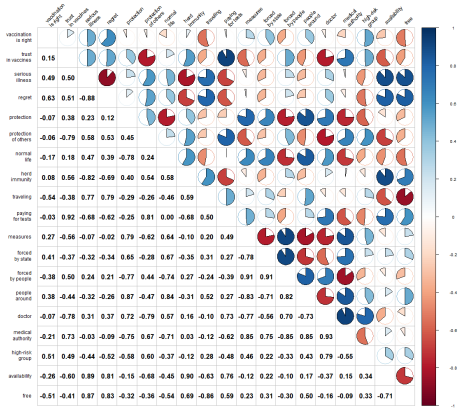
## C.2 All unvaccinated



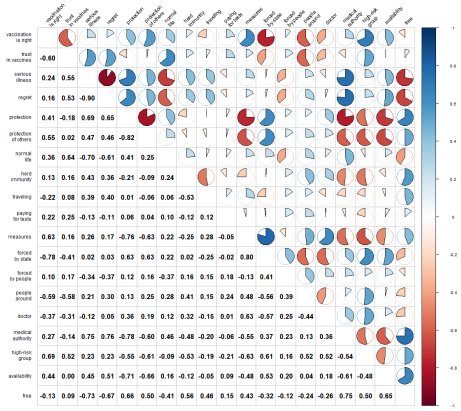

| | vaccination is right | trust in vaccines | serious illness | regret | protection | protection of others | normal life | herd immunity | traveling | paying for tests | measures | forced by state | forced by people | people around | doctor | medical authority | high-risk group | availability | free |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| vaccination is right | | | | | | | | | | | | | | | | | | | |
| trust in vaccines | -0.02 | | | | | | | | | | | | | | | | | | |
| serious illness | 0.14 | 0.16 | | | | | | | | | | | | | | | | | |
| regret | 0.07 | 0.36 | -0.33 | | | | | | | | | | | | | | | | |
| protection | 0.29 | 0.07 | 0.50 | 0.27 | | | | | | | | | | | | | | | |
| protection of others | 0.19 | -0.08 | 0.36 | 0.12 | -0.23 | | | | | | | | | | | | | | |
| normal life | 0.42 | 0.08 | -0.23 | 0.09 | -0.07 | 0.21 | | | | | | | | | | | | | |
| herd immunity | 0.01 | 0.23 | -0.10 | -0.18 | 0.24 | 0.34 | 0.27 | | | | | | | | | | | | |
| traveling | -0.25 | -0.11 | 0.22 | 0.22 | 0.06 | 0.03 | 0.27 | -0.17 | | | | | | | | | | | |
| paying for tests | -0.10 | 0.22 | 0.06 | -0.04 | -0.24 | -0.04 | 0.11 | 0.04 | 0.16 | | | | | | | | | | |
| measures | 0.19 | 0.20 | -0.05 | -0.12 | -0.21 | -0.15 | 0.25 | -0.12 | 0.14 | 0.05 | | | | | | | | | |
| forced by state | -0.29 | -0.23 | 0.20 | -0.15 | 0.18 | 0.09 | 0.37 | -0.23 | -0.16 | 0.26 | -0.02 | | | | | | | | |
| forced by people | -0.05 | -0.09 | -0.12 | 0.18 | 0.06 | 0.06 | -0.28 | 0.22 | 0.10 | -0.12 | 0.37 | 0.56 | | | | | | | |
| people around | -0.02 | -0.11 | 0.05 | 0.22 | 0.01 | -0.04 | 0.06 | 0.34 | 0.38 | 0.04 | 0.09 | -0.05 | 0.04 | | | | | | |
| doctor | -0.34 | -0.39 | -0.04 | -0.03 | 0.28 | 0.21 | 0.22 | 0.03 | -0.09 | 0.02 | 0.35 | -0.33 | -0.19 | -0.17 | | | | | |
| medical authority | 0.10 | 0.25 | 0.20 | 0.25 | -0.27 | -0.14 | -0.13 | 0.24 | 0.03 | -0.17 | -0.02 | 0.34 | -0.14 | 0.07 | 0.43 | | | | |
| high-risk group | 0.35 | 0.32 | -0.07 | -0.04 | -0.02 | -0.24 | -0.21 | -0.20 | 0.08 | 0.01 | -0.25 | 0.21 | 0.26 | 0.21 | 0.59 | 0.09 | | | |
| availability | 0.15 | 0.17 | 0.09 | 0.20 | -0.12 | -0.10 | -0.19 | 0.28 | 0.11 | -0.04 | -0.10 | 0.30 | -0.04 | -0.23 | 0.24 | -0.17 | -0.19 | | |
| free | 0.15 | -0.24 | 0.04 | -0.05 | 0.06 | -0.05 | -0.07 | -0.05 | 0.03 | 0.54 | 0.10 | -0.32 | 0.13 | 0.08 | 0.01 | 0.13 | 0.00 | 0.55 | |

Figure C.2: Correlations: all unvaccinated

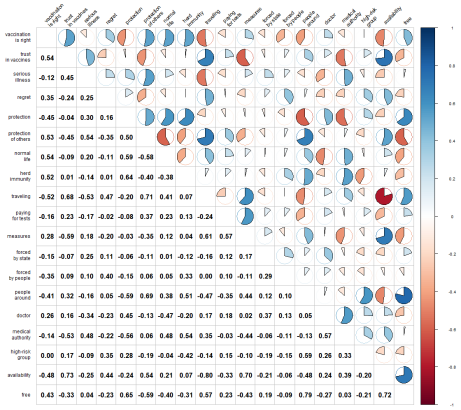
## C.3 Unvaccinated - likelihood of vaccination



(a) Likely to receive vaccine within a month



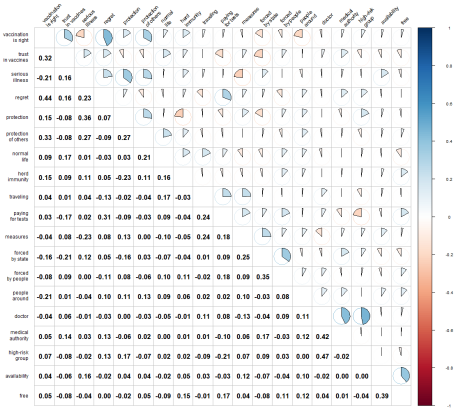
(b) Likely to receive vaccine, but not within a month



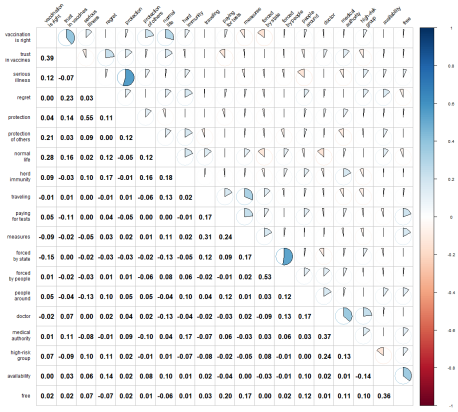
(c) Undecided about future vaccination

Figure C.3: Likelihood of vaccination

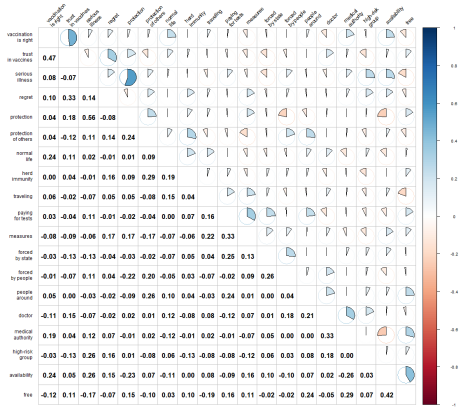
## C.4 Time of registration



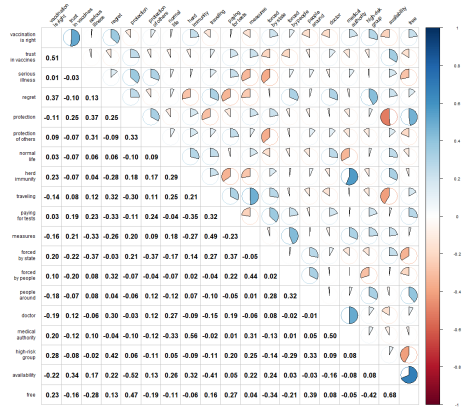
(a) Before it was available for my age or occupational group.



(b) Up to one month from when it was available my age or occupational group



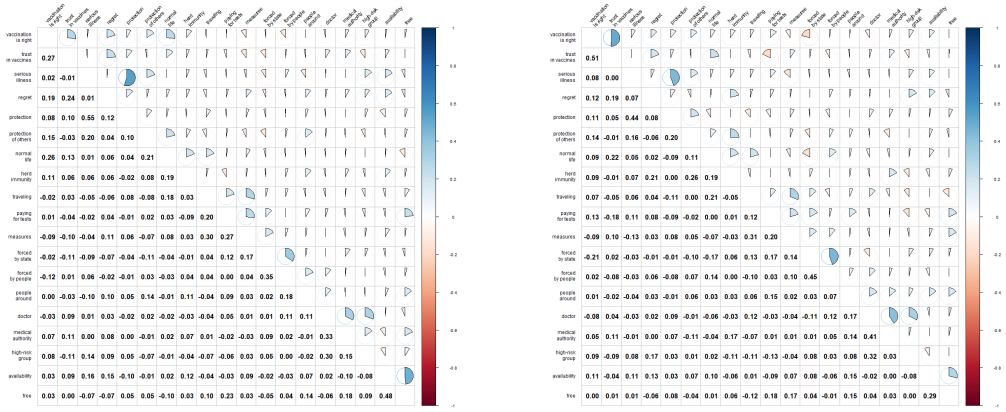
(c) More than a month from when it was available my age or occupational group before November 2021



(d) In November or December 2021

Figure C.4: Correlation tables: Time of registration

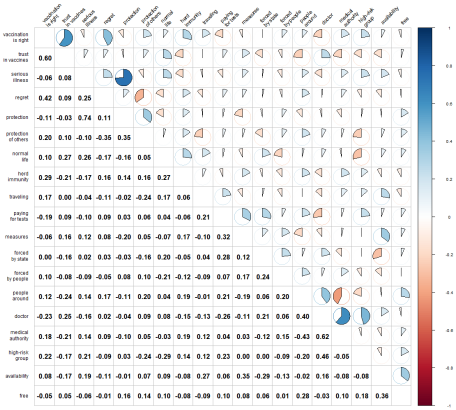
## C.5 Sex



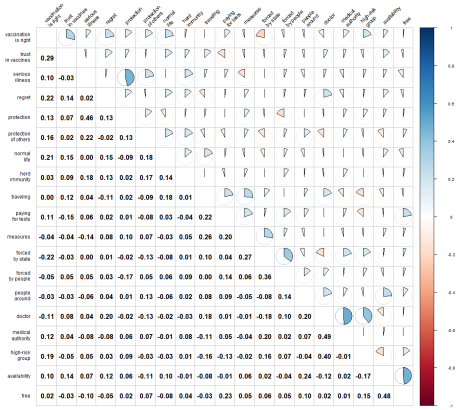
(a) Women (b) Men

Figure C.5: Sex

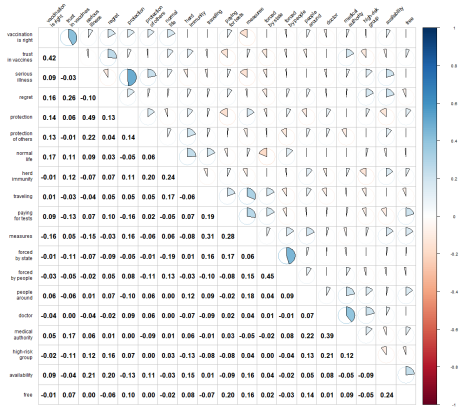
## C.6 Education



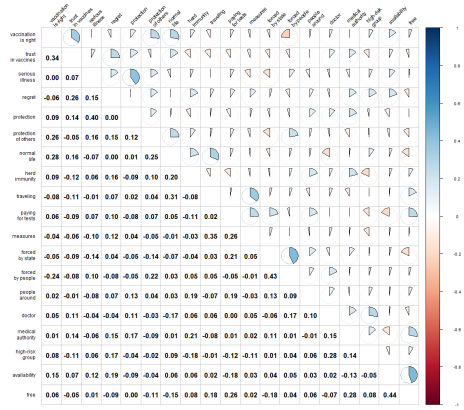
(a) Elementary



(b) Vocational training



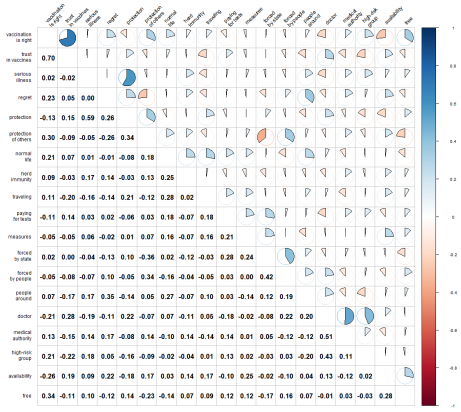
(c) Secondary



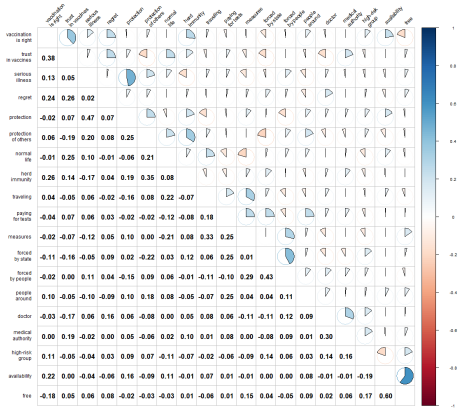
(d) Tertiary

Figure C.6: Correlations: Education

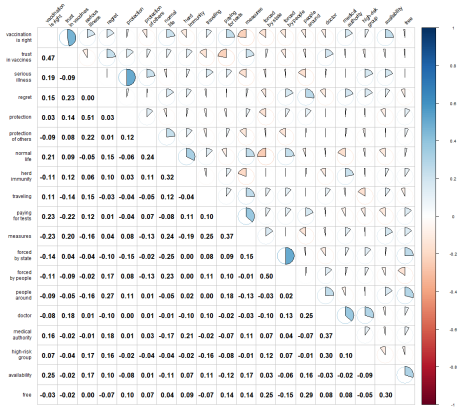
## C.7 Age



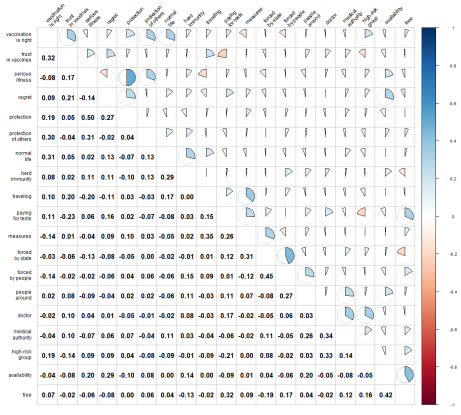
(a) 18 to 24



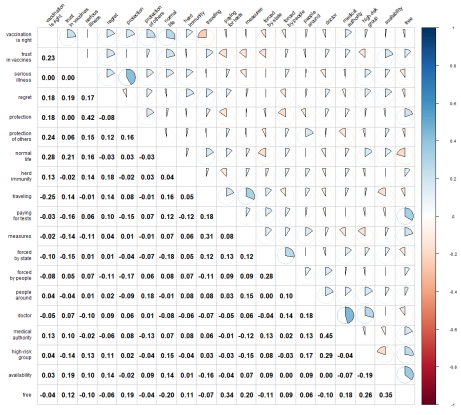
(b) 25 to 34



(c) 35 to 44



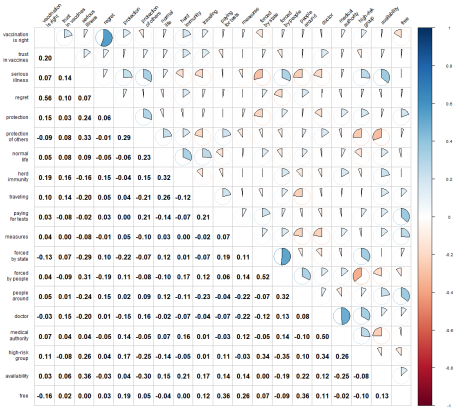
(d) 45 to 54



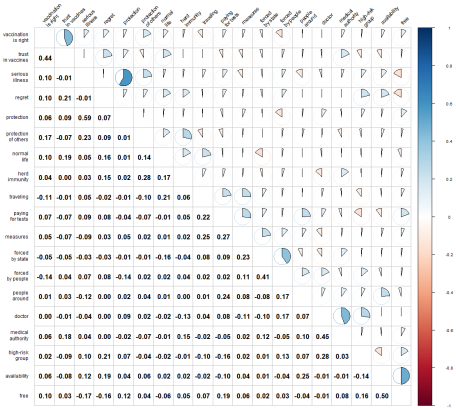
(e) 55 to 64

Figure C.7: Correlations: Age

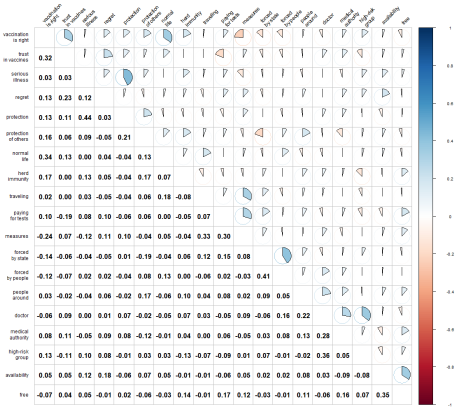
## C.8 Household income



(a) Less than 20 000 CZK



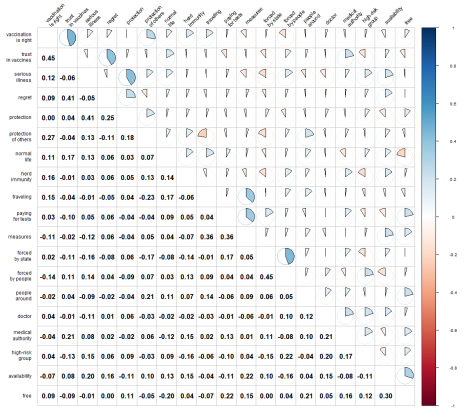
(b) 20 000 CZK - 40 000 CZK



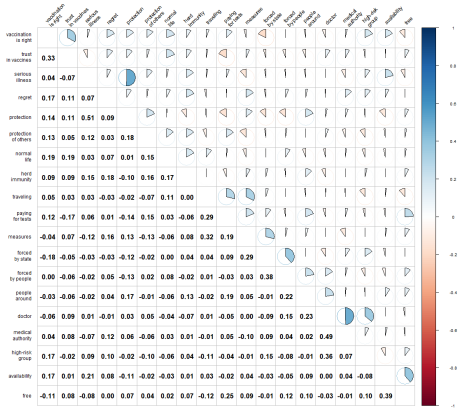
(c) More than 40 000 CZK

Figure C.8: Correlations: Income

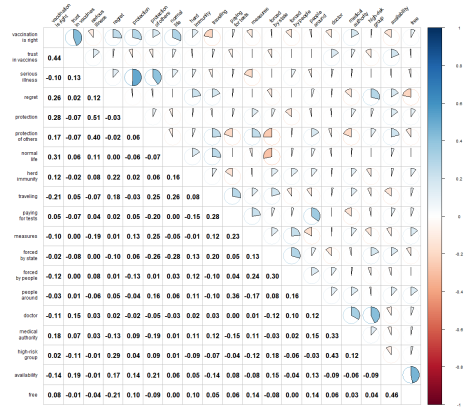
## C.9 City size



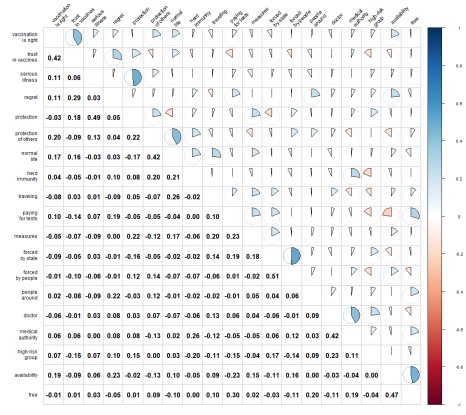
(a) Less than 1 999 inhabitants



(b) 2 000 - 19 999 inhabitants



(c) 20 000 - 100 000 inhabitants



(d) More than 100 000 inhabitants

Figure C.9: Correlations: City size