BACHELOR THESIS

Preparing for a COVID-19 vaccine

In the Netherlands

Author:
Tom Corne WITTE

Student number:
483622

Supervisor:
W.Q. TOH

Second assessor:
V. MOGHANI

Department of Behavioural and Health economics
ERASMUS SCHOOL OF ECONOMICS (ERASMUS UNIVERSITY ROTTERDAM)

A dissertation submitted to the Erasmus University Rotterdam in accordance with the requirements of the degree of BACHELORS in the Faculty of Economics and Bussiness.

SEPTEMBER 2020

Abstract

Currently, the urge for a vaccine that ends the COVID-19 pandemic and protects the population, cannot be overstated. However, to end this pandemic it is necessary that at least 74% of the population would accept to be vaccinated to obtain herd immunity. By an online survey we gathered nationally representative data for age and geographical distribution. We found that 58% of the total population is accepting, 28.5% is hesitant and 13.5% is resistant to be vaccinated. Besides, the level of acceptance is even lower for children and those who are first in line for the vaccine. We show that now the demand is insufficient to obtain herd immunity. To increase the demand, we made a profile of hesitant and resistant individuals. Based on this profile we see it is more likely to be vaccine resistant than accepting if you have an underlying health condition or work in the health or social care sector. All in all, this study gives insights in the population that is hesitant or resistant to be vaccinated against COVID-19.

Acknowledgments

First, I would like to thank my supervisor Wally Toh for her insight and mentorship during the process of my Thesis.
Special thanks also goes to my roommates Jelmer, Milan, Sofyan & Jeroen that have never left my side and were the inspiration for this thesis.

Dedication

I dedicate my dissertation to my Parents & all close friends that helped me with the distribution of my survey.
Besides, I want to thank PhD candidate Sebastian Neumann for his time and help with the design of my survey.
Lastly, I have a special feeling of gratitude to be in this position to make my contribution to the research in the field of a COVID-19 vaccine.

Tom Corne Witte
Erasmus school of Economics
September 2020

AUTHOR'S DECLARATION

I Tom Corne Witte, declare that this thesis titled, 'Preparing for a COVID-19 vaccine in the Netherlands.' and the work presented in it is my own. I confirm that this work submitted for assessment is my own and is expressed in my own words. Therefore, the views stated in this thesis are mine and not necessarily those of Erasmus School of Economics or Erasmus University Rotterdam. Any uses made within it of the works of other authors in any form (e.g., ideas, equations, figures, text,tables, programs) are properly acknowledged at any point of their use. A list of the references employed is included.

SIGNED: TOM CORNE WITTE DATE: 11 SEPTEMBER 2020

Table of Contents

Page

List of Tables **ix**

List of Figures **xi**

1 Introduction **1**

2 Theoretical Framework **5**

2.1 Herd immunity & sufficient demand 6

2.2 The supply of a COVID-19 vaccine 7

2.2.1 Supply constraints & priority populations 7

2.3 The demand for a COVID-19 vaccine 9

2.3.1 Will there be sufficient demand for a COVID-19 vaccine? 9

2.3.2 What is the willingness to be vaccinated in the Netherlands? 9

2.3.3 Why are individuals not receptive to a COVID-19 vaccine? 9

2.3.4 What factors distinguish vaccine hesitant and resistant individuals from vaccine accepting individuals? 10

2.3.5 Currently, there seems to be insufficient demand 10

3 Methodology: Data & Method **13**

3.1 Data 14

3.1.1 Participation procedure 16

3.2 Method 17

3.2.1 Survey 17

3.2.2 Data analysis 18

3.2.3 Summary statistics variables 19

3.2.4 Variables 20

3.2.5 Model specification 21

3.2.6 assumptions multinomial logistic regression 22

4 Results **23**

4.1 What is the willingness to be vaccinated in the Netherlands? 24

4.1.1 Demand in the prioritized population . . . 26
4.2 Why are individuals not receptive to a COVID-19 vaccine? . . . 27
4.2.1 Reasons for hesitancy to be vaccinated against COVID-19 . . . 27
4.2.2 Reasons for resistance to be vaccinated against COVID-19 . . . 28
4.3 What factors distinguish vaccine hesitant and resistant individuals from vaccine accepting individuals? . . . 28
4.4 Regression outcomes . . . 30
4.4.1 Vaccine hesitant compared to vaccine accepting . . . 31
4.4.2 vaccine resistant compared to vaccine accepting . . . 32
4.4.3 vaccine hesitant compared to vaccine resistant . . . 32

5 Discussion & conclusion **37**
5.1 Discussion . . . 37
5.2 Conclusion . . . 39

A Appendix A **41**
A.1 Survey: Willingess to be vaccinated in the Netherlands . . . 41

Bibliography **51**

List of Tables

Table **Page**

2.1 Priority populations, and rationale for vaccine prioritization 7
2.2 Risk groups for COVID-19 8

3.1 Sociodemographic characteristics of the sample (=>16) & the actual Dutch population (=>16) 14
3.2 source: open database 2019 population characteristics CBS. High = completed bachelor, master or Ph.D. Middle = completed MBO or did not complete bachelor degree. Low = completed mandatory schooling or less 14
3.3 Sociodemographic characteristics of the sample (0-15) & the actual Dutch population (0-15) 15
3.4 Descriptive statistic of participants in the sample 19

4.1 Results multinomial logistic regression 30

List of Figures

Figure **Page**

1.1 Race to the vaccine 1

4.1 Willingness to be vaccinated against COVID-19 24
4.2 Willingness to be vaccinated against COVID-19 by age groups (Adults) 25
4.3 Willingness to be vaccinated against COVID-19 by age groups (Children) 26
4.4 Willingness to be vaccinated against COVID-19 in the prioritized population 27
4.5 Reasons for hesitancy to be vaccinated against COVID-19 28
4.6 Reasons for resistance to be vaccinated against COVID-19 29

CHAPTER 1

INTRODUCTION

Considering that I specialized in health & behavioural economics for my bachelor's and will continue in the field of health economics for my master's. This thesis will be health-related and regarding the corona virus disease (COVID-19) pandemic. It will address whether it is possible to effectively end this pandemic by vaccination once a vaccine becomes available. This study assesses vaccine hesitance & resistance by examining the demand for a vaccine against the COVID-19 virus. Thereby predetermining if there will be sufficient support for a corona vaccine to achieve herd immunity and end this pandemic.

FIGURE 1.1. From https://www.neweurope.eu/article/covid-19-latest-news-on-the-vaccine-and-drug-treatment-regular-updates/

An overview of this thesis

I began writing this thesis on the 2^{nd} March. I followed all news on a corona vaccine ever since. In the absence of a vaccine, the Dutch government took necessary lock-down measures to prevent the spread of the virus. For weeks everyone was bounded to their homes. So, for the first weeks, I did all the research from home. Fortunately, the lock-down measures were relaxed, such that everyone could continue with their lives as if normal, including me.

Objective of my thesis

The main objective of my thesis is to find out if there will be sufficient demand for a COVID-19 vaccine in the Netherlands. By doing this, we assess if it is possible to obtain herd immunity through a vaccination program, once the vaccine becomes available. Thereby ensuring the protection of everyone and the end of this pandemic.

Research question

This thesis intends to answer one question, namely: Will there be sufficient demand for a COVID-19 vaccine?
By answering three sub-questions:
(1). What is the willingness to be vaccinated in the Netherlands?
(2). What is the main reason for being hesitant about and resistant to a vaccine against COVID-19?
(3). What are the key sociodemographic, health-related and psychological factors that distinguish hesitant and resistant individuals from vaccine accepting individuals?

Methodology of the thesis

This thesis consists of 3 parts, namely one confined to a purely mathematical method of finding the fraction of the population that is accepting, hesitant, or resistant to be vaccinated. The second part is done by assessment of the most prevalent arguments for not accepting vaccination for COVID-19. For the last part, a multinomial logistic regression model is used to distinguish accepting, hesitant and resistant individuals based on their characteristics.

Significance of the thesis

Current findings indicate that an insufficient proportion of the Dutch population will decide to get vaccinated against the corona virus (Neumann et al., 2020). On the grounds of this insufficient demand, it is of utmost importance to get a clearer insight in the demand for a vaccine and it's influencing factors in the Netherlands. Such that this information can be used to address vaccine hesitancy and resistance. And in doing this increase the potential of establishing herd immunity by vaccination.

Introduction

Since the outbreak of COVID-19, caused by the SARS-CoV-2 virus, the disease has spread rapidly around the globe and has critically impacted global health systems and economies. On the 1^{th} August 2020, the virus spread to 215 countries, causing about 26 million infected cases that lead to approximately 850.000 deaths (Worldometers, 2020). The economic loss of the crisis is estimated to be around 9 trillion dollars. And will result in 7% less global economic activity by the end of 2021 which would be causing the biggest economic crisis after World War 2 (IMF, 2020).

In the Netherlands, the first confirmed case was in February and our country was taken over by the corona virus ever since. On the 28^{th} July, the government reported 55,000 confirmed cases, of whom 12,000 are hospitalized, resulting in more than 6000 deaths in 5 months (RIVM, 2020a). Due to this enormous disease burden and in the absence of an effective COVID-19 vaccine, the Dutch government decided to go into a state of "intelligent Lock-down", by enforced semi-strict physical distancing and quarantine measures to slow the spread of the virus, protect the most vulnerable in society and manage health care service demand and provision. These semi-strict measures were imposed because the dutch cabinet were trying to reduce the social and economic burden caused by the restriction measures.

Even though it is possible to curb the threat of the corona virus through quarantine and other social distancing measures, to eliminate COVID-19 in its entirety a sizable vaccination program is needed (Neumann et al., 2020). So, the urge for a vaccine that protects the population from COVID-19, and stops the further disruption of economies, cannot be overstated.

The necessity of a vaccine is reflected by the world's scientific effort to develop the COVID-19 vaccine. The Chinese military, for example, made an unprecedented move to find the antibody by already approving a Phase 2 tested vaccine before ensuring it's safety in a Phase 3 trial. Next to the Chinese vaccine, 27 vaccines are in human trial with 6 of them being in large-scale (Phase: 3) efficacy tests (Times, 2020). The reason for the whole world to be searching for a vaccine is that vaccines have historically been proven to be the most successful and cost-effective public health tool against infectious diseases (Thunstrom, Ashworth, Finnoff, & Newbold, 2020). A vaccine works by giving someone a small amount of a harmless form of a disease such that your body starts making antibodies to fight it off. Then if you get exposed to the virus again, your body already has the antibodies such that instead of becoming ill you will become immune. (for immunology, 2020). Whoever is first in the race to produce a safe and effective vaccine could make as many people immune to the corona virus as doses they can produce.

However, the possible effectiveness of a vaccine that controls the spread of COVID-19 also depends on the uptake level of the vaccine in the population (Thunstrom et al., 2020). In one of the most important articles for this research by (Neumann et al., 2020) the willingness to be vaccinated in the Dutch population is estimated. In our research we give a more in depth analysis of the demand for a COVID-19 vaccine by analyzing the demand is for those that are first in line for vaccination, and identify the factors that affect and individuals choice for being hesitant or resistant to a COVID-19 vaccination. So, next to safe development, it is crucial to look at the willingness to be vaccinated for the prioritized subgroups in the population and what factors affect their willingness to be vaccinated against COVID-19. For this reason, the study examines the following; What is and what affects the demand for a COVID-19 vaccine in the Dutch population?

To give an extensive answer, we delve into the reasons for -and determinants of not accepting a COVID-19 vaccine in the Dutch population. By doing this, the study shows how the level of vaccine

hesitance and resistance affects the ability to generate herd immunity by vaccination.

To show the sequence of this study, we present four related parts. The first part shows how the main objective and three corresponding sub-questions follow from the literature. Second, we represent the methodology in a step by step approach, by providing insight into the data and methods used for the replication of our study. Third, the sub-questions are answered by showing the results. Fourth, the conclusions are stated, given the obtained results. Fifth, and last, the findings are discussed and compared to similar research to show evidence for the current demand for a vaccine against COVID-19.

CHAPTER 2

THEORETICAL FRAMEWORK

For the purpose of getting a clear idea of the research, this chapter embeds the main objective of this thesis in the literature. Based on previous research, arguments are given for the main question of this COVID-19 study, namely:

Will there be sufficient demand for a COVID-19 vaccine in the Netherlands?

To obtain the required results, three objectives are set that provide important knowledge at a critical point in time.

2.1 Herd immunity & sufficient demand

First, it is important to know that before the outbreak of the COVID-19 pandemic, the World Health Organization (WHO) already declared that one of the 10 biggest threats to global health is that people are hesitant to be vaccinated (WHO, 2019). By being hesitant towards vaccination is meant that there exist doubts in the population about the safety and appropriateness of vaccines (Neumann et al., 2020). It is known that hesitancy is prevalent in the Dutch population, as some communities in our population refused vaccination for vaccine-preventable diseases such as measles which caused it's re-occurrence (van den Hof et al., 2001). Even more so, vaccine hesitancy and resistance is not a new phenomenon, as the Rijksinstituut for Volksgezondheid & Milieu declared that in the years up to 2018, the vaccination rate for most vaccines had dropped by a total of approximately 2 to 3 percent (RIVM, 2019). So, for the COVID-19 vaccine decline of the vaccination rate could be problematic to attain herd immunity against the corona virus (Fine, Eames, & Heymann, 2011).

We want to generate herd immunity through vaccination (Murphy et al., 2020) because when this is achieved the total population is protected against COVID-19. Most important is to attain a sufficiently high uptake of the vaccine that ensures the protection for those who are not vaccinated, so that both vaccinated and not vaccinated individuals are protected (Fine et al., 2011). For a COVID-19 vaccination program, it is desirable that there is a large proportion of the population that is vaccinated, as the potential death toll could be enormous as a result of an increase in the number of infections (Neumann et al., 2020). Besides, now more then ever, health systems are overwhelmed by a large number of patients with severe COVID-19 symptoms, stressing the need for immunization through vaccination instead of getting infected with the virus intentionally, as is done for milder diseases (Souza & Dowdy, 2020). To show what would be a sufficient proportion of the population for a successful vaccination program against the corona virus, a herd immunity threshold is calculated. The herd immunity threshold describes the proportion of the population that needs to be immune such that the infectious disease will cause no harm anymore when no physical distance measures or restrictions are in place (Rothman, Greenland, & Lash, 2008).

A European study recently (Flaxman et al., 2020) showed that 74% of the population should become immune to attain herd immunity. However, others argue that the actual threshold is higher than this 74%. Based on data from Chinese outbreaks, Sanche et al. (2020), show that herd immunity will be reached after 82.5% of the population is inoculated. Still, the research on Europe's immunity threshold should provide the best estimate for the Dutch basic reproduction number seeing that it is dependent on contact rates that reflect how humans organize themselves both geographical and social (Delamater, Street, Leslie, Yang, & Jacobsen, 2019). For that reason, the most reasonable threshold for herd immunity in the Netherlands is 74%. Given the evidence, the demand for the COVID-19 vaccine would be sufficient if at least 74 % of the Dutch population would be willing to be vaccinated.

2.2 The supply of a COVID-19 vaccine

2.2.1 Supply constraints & priority populations

Second, in this paper we must acknowledge that the supply of a COVID-19 vaccine is subject to constraints, and as a result of this some must be prioritized for inoculation over others. In this part we show who those are that are first in line for the vaccine and why. There is a supply constraint because it is practically impossible to make enough doses of the potential vaccine available to end the pandemic by generating herd immunity (Berkley, 2020). This is stressed by Berkley (Head of GAVI, the Vaccine Alliance), who stated that: "supply constraints for a vaccine, both physically and politically are a big worry" (Khamsi, 2020). Due to this, it is impossible to attain herd immunity within a short time. As achieving herd immunity would require to inoculate about 12,8 million Dutch people (74% of ±17.2 million people), without even knowing how many doses one person might need. Due to this short term supply constraint, the WHO categorized those who should be prioritized to be vaccinated. According to the WHO, the COVID-19 vaccine must be allocated in such a way that the benefit of the vaccine is maximized, presented by table 2.1 (WHO, 2020). (Those that fall in multiple categories should receive even higher priority for vaccination against the corona virus).

Table 2.1: Priority populations, and rationale for vaccine prioritization

Priority population	**Rationale for prioritization**
Those at greatest risk of becoming infected and seriously ill	Maximize benefit of vaccine
Those who, if vaccinated, would prevent the greatest spread of the virus	Maximize benefit of vaccine
Those who have volunteered to participate in research aimed at developing the vaccine	Reciprocal obligation to those who were voluntarily put at risk to aid in this effort

2.2.1.1 Risk groups

For the purpose of this thesis, it is specified who the people are that are at greatest risk of becoming infected and seriously ill in the Netherlands. The latest RIVM report specified that being in the risk group meant having pre-existinrfyg health conditions or being over 70 years old, as can be seen in table 2.2 below (RIVM, 2020b):

Now that we have an understanding of the people that are at greatest risk of becoming infected and seriously ill, it is necessary to ascertain whether the group of people who should be vaccinated are actually willing to be vaccinated. Hence a complete specification of the prioritized population is of utmost importance. By evaluating their willingness to be vaccinated we assess if there will be sufficient demand for the vaccine in the short run.

Table 2.2: Risk groups for COVID-19

People over 70 years old
• This group has a higher risk of severe illness from COVID-19 as half of the patients that were admitted to the hospital with COVID-19 were over the age of 69.
Adults with underlying health conditions
Adults with certain underlying health conditions also have a higher risk of severe illness from COVID-19. This includes people who have one or more of the following health conditions: • Chronic respiratory or pulmonary problems. • Chronic heart problems. • Diabetes mellitus. • A serious Kidney disease. • An intellectual disability • An untreated HIV infection. • A serious liver disease. • Morbid obesity.

2.2.1.2 Responsible individuals for preventing the greatest spread

As the prioritized population also consists of those who would prevent the greatest spread of the virus, we define that population by looking into the transmission dynamics of the virus. Despite the fact that there is limited information, it is widely known that health and social care workers are at increased risk of exposure and therefore of transmitting the COVID-19 infection (UKgovernment, 2020). Consequently, they are the ones that would prevent the greatest spread of the virus, if vaccinated.

2.2.1.3 Priority population

All in all, as long as it cannot be said who volunteered for the research aiming at the development of the vaccine. The priority population for a COVID-19 vaccine, consists of the following groups (UKgovernment, 2020):

- Frontline health and social care workers
- Those at greater risk of infection and serious illness from COVID-19 infection stratified according to age and risk factors

2.3 The demand for a COVID-19 vaccine

2.3.1 Will there be sufficient demand for a COVID-19 vaccine?

At this point, you may wonder why we gave such an extensive explanation of how the corona vaccine will be supplied before giving the objectives of our research. The evaluation of the supply is to get a clear insight into who will be prioritized and what a sufficient amount of demand for a COVID-19 vaccine would be. Knowing when there will be enough demand and how to distribute the vaccine, we can move towards the main purpose of this study, which is to answer the question: ***will there be sufficient demand for a COVID-19 vaccine in the Netherlands?***. More than that, this paper identifies supply constraints and in doing this we anticipate prioritized vaccine groups. As a result, we are able to measure differences in the demand for a COVID-19 vaccine generated by those at greatest risk and those that cause the greatest spread of the virus, i.e. health and social care workers.

2.3.2 What is the willingness to be vaccinated in the Netherlands?

Since the aim of the Dutch government is to generate herd immunity through a COVID-19 vaccination program, ***the first objective of this study is to determine the willingness to be vaccinated in the Netherlands, both for the total population and for the priority groups***. It will do so by determining what proportion of the population is receptive, hesitant, or resistant to a vaccine for COVID-19. In the end, these outcomes indicate if the current demand for the vaccine is sufficient to attain herd immunity by vaccination in the Netherlands.

2.3.3 Why are individuals not receptive to a COVID-19 vaccine?

Given the history of declining vaccination rates in the Netherlands due to vaccine refusal and hesitancy about vaccination in general (RIVM, 2019; van den Hof et al., 2001), it is argued whether enough Dutch citizens trust the effectiveness and safety of the potential vaccine and the healthcare system that delivers them (Neumann et al., 2020). Therefore, it is key to *identify* and *understand* resistance to a COVID-19 vaccine and hesitance about the vaccine before it becomes available. This process of *profiling* to prepare for vaccine distribution is done to approach refusal and hesitancy. The need for this is highlighted by the WHO's Strategic Advisory Group of Experts on Immunization (SAGE) who declare that: "*proactive preparation and nimble response based on social and behavioural insights requires the analytical capacity to detect, assess, and address hotspot areas of hesitancy that can quickly become explosive... too often, this sort of outreach is only done in reaction to a problem that has finally grown too big to ignore*" (Murphy et al.,

2020). Therefore, it is important to take preparatory steps to ensure that a COVID-19 vaccination program will succeed in ending the pandemic. Which makes it crucial to understand hesitance and resistance toward a corona vaccine. Hence, ***the second objective is to find the main reasons for being hesitant about and resistant to a vaccine for COVID-19***

In the existing literature (Neumann et al., 2020), the most common method of trying to understand someone's reason for not accepting a vaccine is by using frequently mentioned reasons for vaccine hesitancy and resistance. Based on previous research by Neumann et al. (2020), we used the reasons that their participants indicated to be the most important for their hesitancy, namely:

- I am concerned about potential side effects
- I think a COVID-19 vaccine may not be safe
- The best is to leave nature take it's course
- I do not think COVID-19 is dangerous to my health
- Religious reasons
- Other, namely:

Furthermore, participants that indicated to be resistant to a COVID-19 vaccine, had similar reasons as those mentioned above. However, in this group there was one extra reason, described by the following option:

- I am against vaccination in general

Due to these most frequently used reasons, we are able to understand the logic behind being vaccine hesitant. It also makes it possible to recognize indicators for not getting vaccinated against COVID-19. Meaning that by the use of these answer options we predetermine and understand why people are not willing to accept a corona vaccine. In doing so, we take the first step in the *profiling* process of non-receptive individuals.

2.3.4 What factors distinguish vaccine hesitant and resistant individuals from vaccine accepting individuals?

In order to complete the *profiling* process of those that are hesitant about and those that do not accept a possible COVID-19 vaccine, it is essential to identify distinguishing characteristics of those who are vaccine accepting, hesitant and resistant. So, ***the third and final objective of this thesis is to identify the key sociodemographic, health-related, and psychological factors that distinguish hesitant and resistant individuals from those that are willing to accept a COVID-19 vaccine***. By analyzing these differences it becomes possible to find determinants of hesitance about and resistance towards the corona vaccine.

2.3.5 Currently, there seems to be insufficient demand

Finding determinants of hesitancy and resistance are extremely valuable, considering that a recent study on the willingness to be vaccinated in Europe found out that only 73% of the adult Dutch population is vaccine accepting, 19% is hesitant about vaccination and 8% is resistant to be vaccinated against

the corona virus (Neumann et al., 2020). These findings suggest that considerable policy effort may be required to generate sufficient demand for the vaccine. However, the study did not include individuals under the age of 18, who do contribute to the spread of the virus and therefore should be taken into account when developing a vaccine program for the corona virus (RIVM, 2020a). Therefore, an assessment of the demand for both the prioritized and younger population can be used as supplementary information.

All things considered, these three objectives provide an understanding of whether there will be sufficient demand for a COVID-19 vaccine, by estimating the proportion of vaccine accepting, hesitant and resistant people in the Dutch population. Along with deciphering the reason why some are not receptive to be vaccinated and identifying distinguishing characteristics we uncover what determines the demand for a COVID-19 vaccine. By doing this, we aim to make a *profile* of *vaccine hesitant* and *vaccine resistant* individuals. Such that, in the end, these findings could be used to reduce vaccine hesitancy and resistance to ensure that there is sufficient demand for the potential vaccine to obtain herd immunity.

CHAPTER 3

METHODOLOGY: DATA & METHOD

Having introduced the objectives of our work, in this chapter, we present the methodology used to achieve the objectives of our study. All the data is described and the used methods are explained such that this study could be replicated.

3.1 Data

Table 3.1: Sociodemographic characteristics of the sample (=>16) & the actual Dutch population (=>16)

Sample characteristics (N = 446)	%	Actual characteristics (N = 14338038)	%
Gender		**Gender**	
Male	26.68 %	Male	49.33 %
Female	73.32 %	Female	50.66 %
Age group		**Age group**	
16-24	8.30 %	16-24	13.44 %
25-34	14.35 %	25-34	15.34 %
35-44	15.92 %	35-44	14.34 %
45-54	30.95 %	45-54	17.52 %
55-64	20.40 %	55-64	16.24 %
65-74	4.49 %	65-74	13.3 %
75+	5.39 %	75+	9.82 %
Region		**Region**	
Zuid-Holland	32.06 %	Zuid-Holland	21.10 %
Noord-Holland	10.54 %	Noord-Holland	16.53 %
Noord-Brabant	19.51 %	Noord-Brabant	14.83 %
Gelderland	11.43 %	Gelderland	11.99 %
Utrecht	9.87 %	Utrecht	7.63 %
Overijssel	3.36 %	Overijssel	6.62 %
Limburg	4.93 %	Limburg	6.68 %
Friesland	1.79 %	Friesland	3.74 %
Groningen	1.35 %	Groningen	3.45 %
Drenthe	1.35 %	Drenthe	2.86 %
Flevoland	1.79 %	Flevoland	2.32 %
Zeeland	2.02 %	Zeeland	2.23 %
Highest education level		**Highest education**	
High*	54.26 %	High*	33.0 %
Middle*	38.12 %	Middle*	38.7 %
Low*	7.62 %	Low*	28.3 %

Table 3.2: source: open database 2019 population characteristics CBS. High = completed bachelor, master or Ph.D. Middle = completed MBO or did not complete bachelor degree. Low = completed mandatory schooling or less

To examine the willingness to be vaccinated in the Netherlands, we designed a survey in Qualtrics. In this anonymous and online questionnaire, Dutch adults were asked whether they would be willing to be vaccinated against COVID-19 once a vaccine becomes available. We posed a similar question for their children if respondents indicated to have children below the age of 16. All data were collected approximately five months after the first official announcement of the virus in the Netherlands (from 15^{th} July to the 1^{th} August) (NU.nl, 2020). For a nationally representative sample of the Dutch population, we aimed for as many participants as possible. To see whether the sample is representative, we summarized the sample characteristics in table 3.1 and assessed whether it matches the known population parameters. For the actual population parameters, we used the 2019 open database from the Dutch Bureau of Statistics (CBS, 2020).

As can be seen in table 3.1 the sample is somehow representative of the Dutch population (16 years or older) in terms of age groups and geographical distribution. However, we do not claim the sample to be nationally representative because the sample is not representative in terms of gender as the sample characteristics do not match the approximate 50/50 distribution of Males and females. On the other hand, for the age groups the sample is representative of the Dutch population. Still, the group between the ages of $65-74$ and those between $45-54$ are under -and over-represented, respectively. Besides, in terms of geographical distribution, the sample reveals similar characteristics to the actual ones, only not for *Zuid-Holland*. Lastly, the highest education level is skewed towards the higher educated in our sample. Therefore we do not consider the sample to be representative of the highest educational level that people have completed in the Dutch population.

Table 3.3: Sociodemographic characteristics of the sample (0-15) & the actual Dutch population (0-15)

Sample characteristics ($N = 252$)	%	Actual characteristics ($N = 2944125$)	%
Age group		**Age group**	
0-4	22.62 %	0-4	29.42 %
5-9	29.76 %	5-9	31.16 %
10-15	47.62 %	10-15	39.42 %
Region		**Region**	
Zuid-Holland	34.52 %	Zuid-Holland	21.10 %
Noord-Holland	7.94 %	Noord-Holland	16.41 %
Noord-Brabant	20.24 %	Noord-Brabant	14.16 %
Gelderland	13.49 %	Gelderland	11.98 %
Utrecht	7.94 %	Utrecht	8.48 %
Overijssel	3.17 %	Overijssel	7.05 %
Limburg	3.97 %	Limburg	5.29 %
Friesland	0.79 %	Friesland	3.78 %
Groningen	1.98 %	Groningen	2.99 %
Drenthe	1.98 %	Drenthe	2.76 %
Flevoland	2.78 %	Flevoland	2.87 %
Zeeland	1.19 %	Zeeland	2.13 %

From table 3.3 can be concluded that the sample is quite representative of the Dutch population (under 16 years) in terms of age groups and geographical distribution. The age group $10-15$ years old is however a little over-represented and those that are between 0 and 4 years old a little under-represented. In terms of regions, the characteristics of the sample are close to the actual characteristics, except *Zuid-Holland* that is over-represented by more than 10%. Since this is the case we cannot claim a nationally representative sample for children.

3.1.1 Participation procedure

Before starting the survey, participants had to give their consent for the analysis of their data. If they gave consent, the average duration of completing the survey was about 206 seconds, which is shorter than similar research done in this field (Murphy et al., 2020). The main reason for a short survey is to reduce the attrition rate and as a result, get as many respondents. Participants were eligible to start the survey under several conditions, namely; (1) being 16 years or over, (2) being able to complete the survey in Dutch, and (3) giving consent to participate. There were no financial incentives for participating in this study. Still, we were able to get as many as 446 respondents and have information about 252 children provided by 135 parents from our sample.

Some of the data could not be used for analysis. Therefore, we dropped those that did not give consent, did not complete the survey and those that filled in to be a sex other than male or female.

3.2 Method

3.2.1 Survey

To show how the research was conducted, and how the variables were determined, we show the sequence of the study following a step by step approach:

Step 1*: First, the respondents were asked for their consent to participate, thus agreeing that their answers will be used for the purpose of this research and that they will be treated according to the European Unions general data protection regulation (GDPR EU).*

Step 2*: To investigate the sociodemographic characteristics participants were asked for their age, gender, the region of residence and their highest education level, to assess whether the sample is representative for the national population.*

Step 3*: To examine whether someone is in the prioritized population, we first ask in which sector someone works to see if the person is frontline health or social care worker. Next, we examine if the participant is at greater risk of infection and serious illness from COVID-19 infection by asking whether or not they have underlying health conditions.*

Step 4*: Before the most important question, participants were asked to answer a set of questions underlying the psychological scale for vaccinations (for measles and flu vaccines) designed by (Betsch et al., 2020).*

Step 7*: For the crucial question of the study, participants had to indicate whether they would be willing to be vaccinated against COVID-19. They could either answer* ***Yes****,****I don't know yet*** *or* ***No****.*

Step 8*: Conditional on answering the previous question with either,* ***I don't know yet*** *or* ***No****, participants were asked to give their main reason for not accepting the COVID-19 vaccine. Here participants could choose from a set of most frequently used reasons for vaccine hesitancy/resistance by Neumann et al., or could give an open text explanation under the option other.*

Step 9*: In the next question, participants had to answer whether they have children under 16 over whom they decide to be vaccinated.*

Step 10*: Conditional on answering* ***yes*** *on the previous question, participants were asked for their children's age and whether they would be willing to let their children get vaccinated.*

Step 11*: Similar to for themselves they were asked for their main reason for not accepting the vaccine, if they answered* ***No*** *or* ***I don't know yet*** *in the previous question regarding willingness to be vaccinated for their children.*

The full survey can be found in appendix A.

3.2.2 Data analysis

The strategy of analyzing the data from the survey above involved the following three related components.

The first thing that was done in the analysis was clustering the participants in groups that were classified as being *"vaccine accepting"*, *"vaccine hesitant"* or *"vaccine resistant"*. The first objective is attained by calculating the proportion of the groups compared to the total sample population.

Second, the prevalence of the reasons that people gave for not *"accepting"* the COVID-19 vaccine are given for the *"vaccine hesitant"* and the *"vaccine resistant"* group. By doing this, we show what the most common reasons are for hesitating about or being resistant to vaccination for COVID-19. By analysis, we examine the proportion of the *"vaccine hesitant"* group for example, that are *"concerned about the potential side effects"* or had *"other"* reasons for being unsure if they would like to be vaccinated against COVID-19.

Third, and last, a multinomial logistic regression analysis is performed to identify sociodemographic, health-related, and psychological indicators associated with vaccine hesitancy and resistance. In this analysis, the vaccine acceptance group was set to be the reference category to identify factors that are associated with vaccine hesitancy and vaccine resistance, respectively. Afterward, a re-estimation of the models was done, but with the vaccine hesitant group set as the reference category to identify which factors distinguished vaccine resistant respondents from vaccine hesitant respondents. Thereby accomplishing the last objective by distinguishing the characteristics of all three groups. The associations between the outcome and predictor variables are shown as adjusted odds ratios (AOR) with 95% confidence intervals.

3.2.3 Summary statistics variables

Table 3.4: Descriptive statistic of participants in the sample

Variable	N (# obs.)	Avg.	St. dev.	Min.	Max
No Vaccine	446	0.55	0.72	0	2
Female	446	0.73	0.44	0	1
Age group					
16-24	446	0.09	0.28	0	1
25-34	446	0.15	0.36	0	1
35-44	446	0.16	0.37	0	1
45-54	446	0.31	0.46	0	1
55-64	446	0.20	0.40	0	1
65-74	446	0.06	0.23	0	1
75+	446	0.03	0.17	0	1
Region					
Zuid-Holland	446	0.32	0.47	0	1
Noord-Holland	446	0.11	0.31	0	1
Noord-Brabant	446	0.2	0.4	0	1
Gelderland	446	0.11	0.32	0	1
Utrecht	446	0.1	0.3	0	1
Overijssel	446	0.03	0.18	0	1
Limburg	446	0.05	0.22	0	1
Friesland	446	0.02	0.13	0	1
Groningen	446	0.01	0.12	0	1
Drenthe	446	0.01	0.12	0	1
Flevoland	446	0.02	0.13	0	1
Zeeland	446	0.02	0.14	0	1
Highest education level					
High	446	0.54	0.5	0	1
Middle	446	0.38	0.49	0	1
Low	446	0.08	0.27	0	1
Underlying health condition	446	0.7	0.3	0	1
Health and social care sector	446	0.3	0.46	0	1
Children	446	0.2	0.4	0	1
5C					
Vaccine confidence	446	0.51	0.5	0	1
Vaccine complacency	446	0.07	0.26	0	1
Vaccine calculation	446	0.8	0.4	0	1
Vaccine collective responsibility	446	0.12	0.32	0	1
Vaccine constraint	446	0.04	0.2	0	1

3.2.4 Variables

In table 3.4 we show the descriptive statistics of all the variables that will be discussed in this section. We explain how both the outcome -and all predicted values are measured. Besides, each variable is given a clear name that reflects the content. All these variables are included in our regression model. Based on similar research, on acceptance, hesitance, and resistance to a COVID-19 vaccine in the UK and Ireland by Murphy et al. (2020), we chose to include these particular variables in our regression.

3.2.4.1 No Vaccine

For the outcome variable "no vaccine", participants were asked, "If they would be willing to be vaccinated against COVID-19?" and were classified as *"vaccine accepting"* if they responded (**YES**), *"vaccine hesitant"* if they responded (**I DON'T KNOW YET / UNSURE**), and *"vaccine resistant"* if they responded (**NO**). This variable, called *"Vaccine"* is a variable that takes on the values 0, 1 and 2. Meaning that *"Vaccine"* having the value: (0) corresponds to **YES**, (1) to **I DON'T KNOW YET** and (2) to **NO**.

3.2.4.2 Female

The variable *"Female"* indicates the participants' gender by a dummy variable that is either (0) if the person is a Male, or (1) if the person is a Female. In the survey respondents were given the option to denote their gender by "other" than male or female. Since these results were not valuable to use, these values were dropped from the data.

3.2.4.3 Age group

To include age as a factor in the regression, we made seven age groups for adults and three for children. These groups are named according to the ages that are included in the group, (i.e.) *"16-24"*. The dummy variable takes the value (1) if the participant falls into that specific age category and (0) if not.

3.2.4.4 Region

For the regional distribution, 12 dummy variables were made for all 12 regions separately. These variables are called according to their name, (i.e.) *"Noord-Brabant"* and take the value (1) if the person resides in that particular region, and (0) otherwise.

3.2.4.5 Highest education level

We include a respondents highest level of education in the regression by grouping education level into; *"High"*, *"Middle"* and *"Low"*. One has a *"High"* level of education if they responded to have completed a bachelor's/master's degree or being a Ph.D. graduate. The *"Middle"* level of highest education consists of those that either didn't finish their University/HBO or finished the Dutch level of MBO. In the final, *"Low"* level of completed education, participants finished mandatory schooling or less. For the classification of these groups, we followed the recommendations of the CBS (OnderwijsInCijfers, 2020).

3.2.4.6 Underlying health condition

The variable *"health condition"* is a dummy variable and reflects whether someone has 1 or more underlying health conditions as defined in table 2.2. The variable takes the value (1) if this is the case and (0) if someone has none of the health conditions that cause having a higher risk of severe illness from COVID-19.

3.2.4.7 Health and social care sector

Since working in this sector means contributing to a greater spread of the virus, we created a dummy variable called *"Care sector"* that takes (1) if the respondent works in the health/social care sector and (0) if not.

3.2.4.8 Children

The variable *"children"* reflects whether the person has children under the age of 16 over whom they decide if they are to be vaccinated and is (1) if that is the case and (0) otherwise. Because according to Dutch law, from the age of 16 children decide for themselves whether or not they want to be vaccinated. So, parents decide for those under the age of 16 (Trouw, 2020).

3.2.4.9 5C

The variables denoted by 5C represent the five key components of the psychological scale for vaccinations by Betsch et al. (2020). The five statements regarded: *Vaccine confidence*, *Vaccine complacency*, *Vaccine calculation*, *Vaccine collective responsibility*, and *Vaccine constraint*, respectively. For *Vaccine confidence* the statement was "I am completely confident that vaccines are safe" the answer options were: (1) "Totally agree" - (2) "Agree" - (3) "Neutral" - (4) "Disagree" - (5) "Totally disagree". All other statements had similar answer options. *Vaccine complacency* reflects the following statement: "Vaccination is unnecessary because the virus does not cause a big threat"; *Vaccine calculation* follows from the statement "When I think about getting vaccinated, I make a trade off between the benefits and risks to make the best decision possible"; *Vaccine collective responsibility* is measured by "When everyone is vaccinated, I do not have to get vaccinated." Lastly, the statement "Everyday stress prevents me from getting vaccinated" illustrates the *Vaccine constraint*.

All five components are transformed into a dummy variable that takes the value (1) if someone answered "totally agree" or "Agree", and (0) if otherwise. All in all, the dummy variable is (1) if the participant agrees with the statement.

3.2.5 Model specification

Note that our dependent variable "no vaccine" is a categorically ordered multinomial variable with three levels. Specifically the answer is either Yes (0), I don't know yet/Unsure (1), or No (2). Therefore, we apply a multinomial logistic regression. To effectively distinguish characteristics, we use Relative Risk Ratios that compares two groups in terms of the likelihood of a given outcome.

In the context of our logistic regression, we compute the relative risk as a ratio of the probability of an adult falling into a reference group to the probability of the person belonging to the *hesitant*, or *resistant* group, conditioned on our predictor variables (Osborne, 2015).

The relative risk ratio (RRR) represents the predicted multiplicative change in the relative likelihood, which is also the risk of falling into a comparison group relative to the risk of falling into the reference category if the independent dummy variable takes (1) instead of (0).

If an RRR is greater than 1, then this indicates that there is an increased likelihood of a case falling into the comparison category and a decreased likelihood of falling into the baseline category. If the RRR is less than 1, then this indicates that there is a decreased likelihood of a case falling into the comparison group and am increased likelihood that the case falls into the baseline category. If the RRR equals 1, then there is no relationship between a variable in the model and the likelihood of falling into the comparison group in relation to the baseline group.

3.2.6 assumptions multinomial logistic regression

Actually, our data is better fitted for an ordered logistic regression because the outcome variables are ordered, however to use this type of regression analysis the data must meet the proportional odds assumption. This assumption means that the relationship between each pair of the 'No vaccine' variable (0, 1 2) must be the same. So, it assumes that the coefficients that describe the relationship between 'Vaccine Accepting' & 'Vaccine hesitant' are the same as those that describe the relationship between the 'vaccine hesitant'& 'vaccine resistant' variable. We assessed that the ordered logit coefficients are not equal across our levels of outcome, therefore we do not use this model.

For this reason, we use a multinomial logistic regression to achieve the last objective. We can use this model because the outcome variable is on a multinomious scale (0,1,2). Next to that, the use of this model is justified because of the fact that all the independent variables are on a dichotomous scale (0,1).

This regression model calculates the relative probability of being in a certain outcome group compared to another. These relative risk ratios are the coefficients of in regression model (Relative risk ratios) and are determined by Maximum likelihood Estimation (MLE). For MLE to hold, it is necessary that the observations are identically and independently distributed (IID), or in other words random. For our sample we cannot claim that it fulfils the IID condition as it is not random who filled in the survey. Therefore we cannot say that there is no correlation between the independent variables.

Moreover, we do not use an ordinary least squares (OLS) model because we look for the probability that we observe that someone is in one of the outcome groups and do not look for the outcome itself. Because our outcome variable should not be interpreted as being continuous. Morover, the problem with OLS is that the model suggests that the outcome could be between 0 & 2, but this is not the case as it can only be 0, 1 or 2. For this reason, a multinomial logistic regression model instead of an OLS model is used.

CHAPTER 4

RESULTS

In this section, all objectives are obtained, by showing the results that follow from the used methods that are explained in the previous section. These results are justifications for the conclusions in the next part.

4.1 What is the willingness to be vaccinated in the Netherlands?

This subsection shows the results for the first objective that ***determines the willingness to be vaccinated in the Netherlands, both for the total population and for the priority groups***. Remember, for the analysis of the willingness, participants are clustered in groups and classified as: *"vaccine accepting"*, *"vaccine hesitant"* or *"vaccine resistant"*. In figure 4.1 we show the reported vaccination decision for COVID-19 for the *Adult* population (=> 16) and the population consisting of *Children* (< 16). For the *Adult* population, the proportion *"vaccine accepting"* individuals is 58% , the proportion that is *"vaccine hesitant"* is 28.5% and 13.5% is *"vaccine resistant"*. 16% of the children have parents who chose not to have the vaccine for their children Comparatively, parents chose different for their children then they did for themselves. The proportion of parents that were *"vaccine accepting"* for their children is 20% lower than in the total *Adult* population. As a result, the levels of *"vaccine hesitancy"* and *"vaccine resistancy"* for Children and are higher than in the total adult population and are 46% & 16%, respectively.

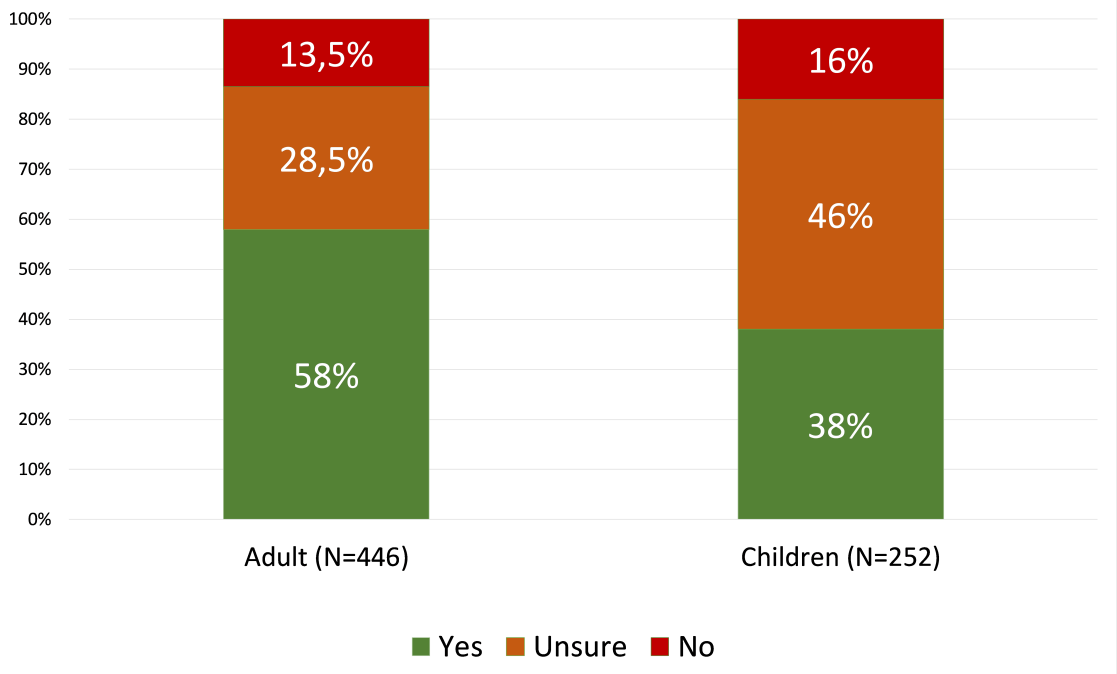

FIGURE 4.1. Willingness to be vaccinated against COVID-19

To investigate the willingness even further we assess willingness across different age groups for both *Adults* and *Children*. As can be seen in figure 4.2, the proportion of *hesitant* and *resistant* adults is exceptionally large in the age group *25-34*, and only 4% op that age group is *vaccine accepting*. Moreover, the younger adults are 10% more *vaccine accepting* than the average adult. Also, *vaccine hesitance* is the most prevalent among adults between the ages 25 and 54 (>30%). Next, a trend can be seen in declining hesitancy and resistance from age group *25-34* and upwards. This shows, that the older age groups become more *vaccine accepting*. Even more so, there are no *vaccine resistant* individuals that are 75 years and older.

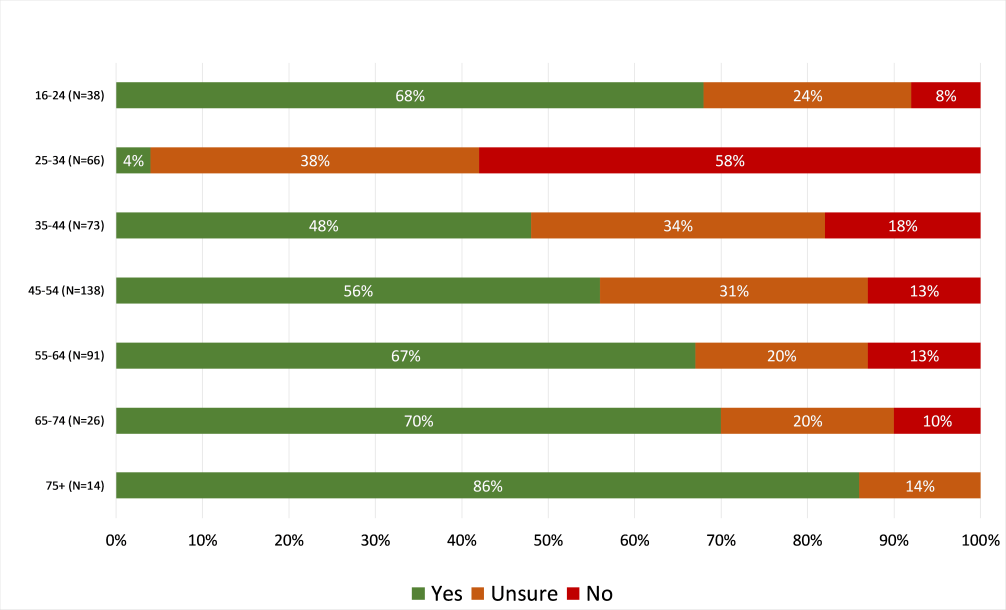

FIGURE 4.2. Willingness to be vaccinated against COVID-19 by age groups (Adults)

From figure 4.3 can be concluded that within the younger population (aged below 16), parents are the least willing to let their children between the ages of *5-9* receive a COVID-19 vaccination. Just 25% want their children to be vaccinated, and more than half of the young population between *5-9* is still hesitant. For the youngest and oldest children in the sample, parents are more receptive to vaccination and less hesitant than average.

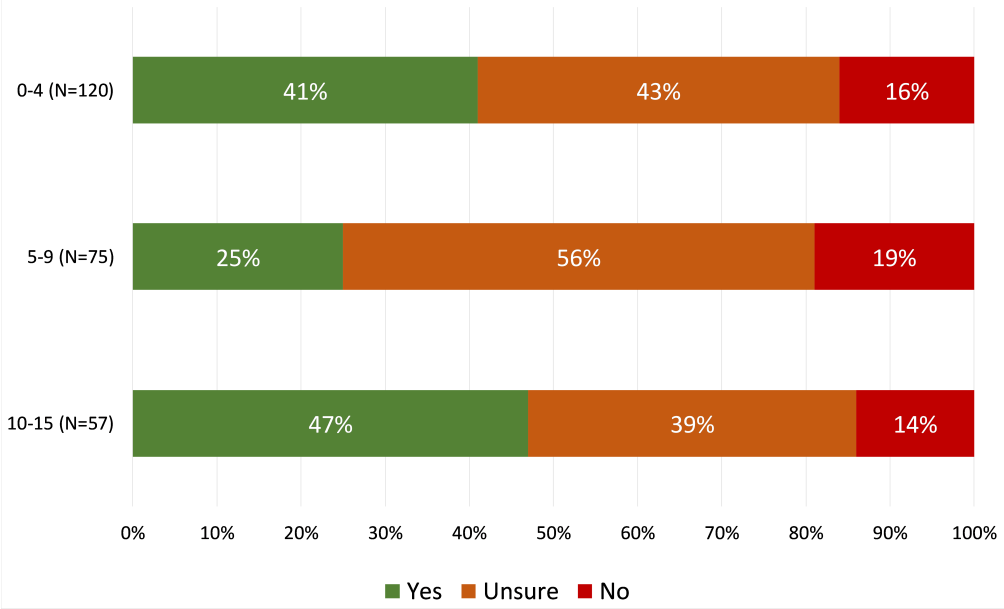

FIGURE 4.3. Willingness to be vaccinated against COVID-19 by age groups (Children)

4.1.1 Demand in the prioritized population

Due to the supply constraint of a COVID-19 vaccine, we determined a prioritized population. Consisting of those that are at greatest risk of becoming infected and seriously ill, i.e. the *risk group* and those that would prevent the greatest spread of the virus, if vaccinated: *health and social care workers*. In figure 4.4 the demand of a COVID-19 vaccine is examined among those that should be first in line for a vaccination.

Overall, figure 4.4 shows that the prioritized population is more *vaccine resistant*, more vaccine hesitant and less *vaccine accepting* compared to the *Adult* population. This implicates that those who are first in line are less willing to accept a COVID-19 vaccine. Therefore it will be even more difficult to reach herd immunity as the individuals that are to be vaccinated in the short term have a low willingness to be vaccinated. The low willingness in the prioritized group is bad for the effectiveness of the vaccine, because these individuals contribute to the greatest spread. Besides, a low willingness in the prioritized group also means a foregone chance for those that the vaccine would be the most beneficial in terms of reduction of the disease burden.

When we look within the prioritized group, we find more acceptance and less hesitance/resistance in the risk group than in the Adult population. Still, the reason the prioritized population is less accepting and more hesitant/resistant is that health and social care workers) are way less accepting and more hesitant & resistant compared to the *adult* population.

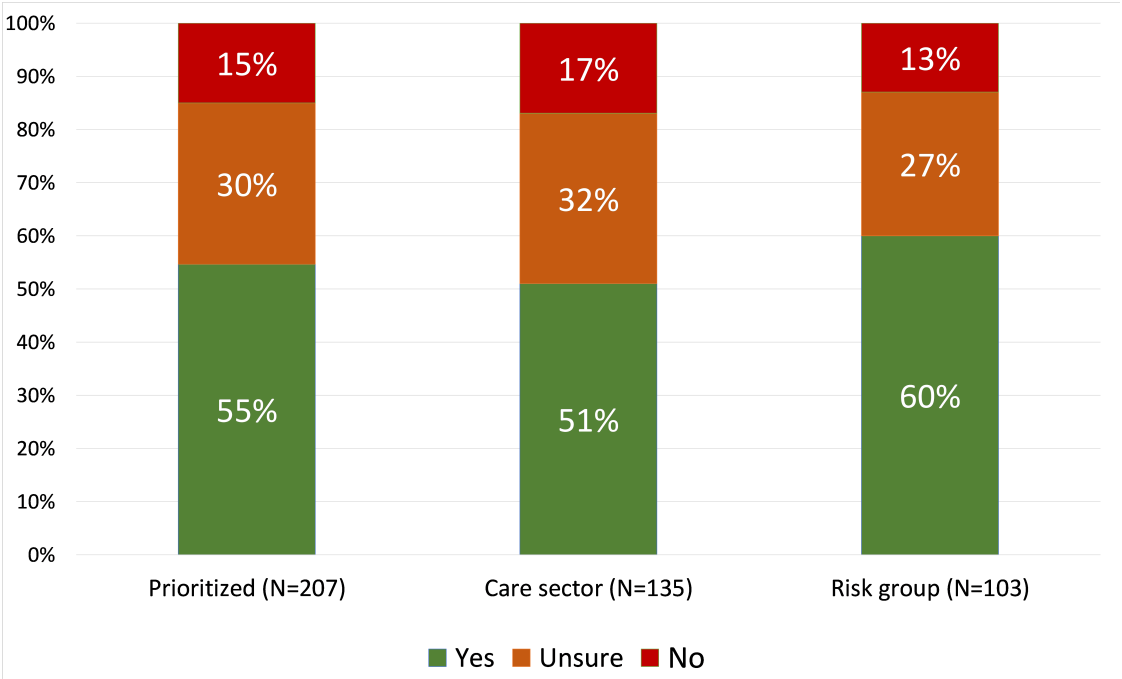

FIGURE 4.4. Willingness to be vaccinated against COVID-19 in the prioritized population

4.2 Why are individuals not receptive to a COVID-19 vaccine?

Since we now extensively assessed the demand for a COVID-19 vaccine we proceed to the next objective: ***Finding the main reasons for being hesitant about and resistant to a vaccine for COVID-19***. These results are the start of the *profiling* process to understand hesitance and resistance toward a corona vaccine.

4.2.1 Reasons for hesitancy to be vaccinated against COVID-19

The most common reasons that are given for hesitancy are displayed in figure 4.5 above. From the figure becomes clear that more than half (52%) of the hesitant participants indicated to be "concerned about potential side effects" of the vaccine. Besides, 15% gave "I think a COVID-19 vaccine may not be safe", as their argument for hesitancy. Next to that, a quarter of the hesitant group had other arguments for being hesitant. Delving into those arguments that 25% of the hesitant participants provided, we see that those people are hesitant because they have a lack of information about the vaccine.

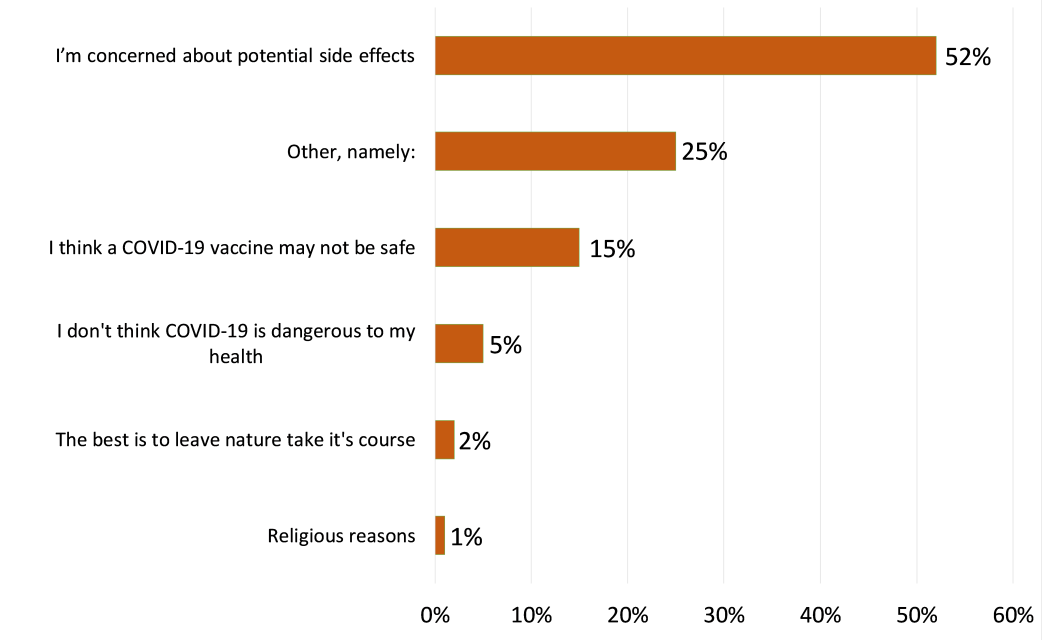

FIGURE 4.5. Reasons for hesitancy to be vaccinated against COVID-19

4.2.2 Reasons for resistance to be vaccinated against COVID-19

In the figure 4.6 above can be seen that in the *vaccine resistant* group, 31% of the respondents gave "I think a COVID-19 vaccine may not be safe" as their main reason for not wanting to be vaccinated. While 25% said to be concerned about potential side effects of the COVID-19 vaccine. Also, 21% of the respondents had other reasons than the most common reasons for vaccine resistance. When taking a look at the open text answers of those that chose other, we found that conspiracy beliefs were prevalent and that the vaccine will be produced too fast.

4.3 What factors distinguish vaccine hesitant and resistant individuals from vaccine accepting individuals?

For the third and final objective, we summarized two multinomial logistic regression in table 4.1 on page 30. In this regression, we ***identify the key sociodemographic, health-related, and psychological factors that distinguish hesitant and resistant individuals from those that are willing to accept a COVID-19 vaccine***. By doing this we aim to examine predictors of vaccine hesitancy and vaccine resistance. With these predictor values, we can make a profile of those that are more likely to be hesitant or resistant to COVID-19 vaccination.

From the model statistics in the last rows of table 4.1 can be concluded that both regressions are statistically significant, since they shows that (Wald $\chi^2(56) = 1299.68$, $p < .000$) and (Wald $\chi^2(56) = 1287.44$, $p < .000$). Based on the Wald χ^2 test, we can say that our model with the full set of predictors represents a significant improvement in fit relative to a model without predictors. By this, we can infer that at least one of the population slopes is non-zero.

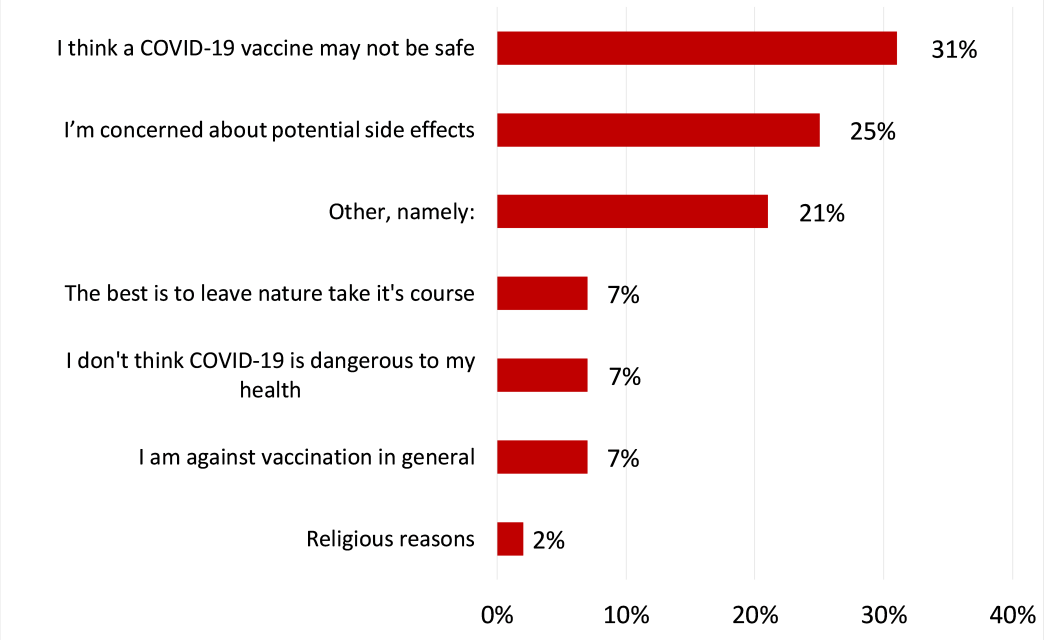

FIGURE 4.6. Reasons for resistance to be vaccinated against COVID-19

4.4 Regression outcomes

Table 4.1: Results multinomial logistic regression

	"Are you willing to be vaccinated against COVID-19?"					
	Reference = Vaccine accepting				Reference = Vaccine hesitant	
	Vaccine hesitant		Vaccine resistant		Vaccine resistant	
	RRR	SE	RRR	SE	RRR	SE
Female	2.12	(0.86)	2.19	(1.8)	1.04	(0.74)
Age						
16 - 24	4.02	(4.76)	2.82e+07**	(3.96e+07)	7008713**	(8926118)
25 - 34	4.65	(5.07)	3.80e+07**	(4.42e+07)	8164369**	(8607896)
35 - 44	1.78	(1.94)	2.71e+07**	(3.47e+07)	1.53e+07**	(1.80e+07)
45 - 54	2.14	(2.22)	2.62e+07**	(3.05e+07)	1.22e+07**	(1.32e+07)
55 - 64	1.27	(1.36)	1.99e+07**	(2.34e+07)	1.57e+07**	(1.68e+07)
65 - 74	0.65	(0.86)	574470**	(7335628)	8856689**	(1.15e+07)
75+	(reference)					
Region						
ZH	1.75	(1.69)	0.76	(1.18)	0.43	(0.5)
NH	1.04	(1.08)	0.47	(0.75)	0.45	(0.55)
NB	0.9	(0.9)	0.25	(0.39)	0.28	(0.32)
Gelderland	0.75	(0.77)	0.47	(0.73)	0.61	(0.73)
Utrecht	0.54	(0.57)	0.74	(1.22)	1.38	(1.76)
Overijssel	5.13	(8.59)	2.53	(5.9)	0.49	(0.71)
Limburg	0.34	(0.4)	1.89	(3.01)	5.52	(7.55)
Friesland	5.33	(6.28)	1.01	(1.83)	0.19	(0.26)
Groningen	9.97	(13.29)	5.92	(10.93)	0.59	(0.83)
Drenthe	0.28	(6.69)	4.02	(11.55)	0.76	(2.09)
Flevoland	0.15	(0.19)	2.92e-08**	(4.98e-08)	1.98e-07**	(2.57e-07)
Zeeland	(reference)					
Education						
High	2.13	(1.46)	7.03	(7.06)	3.3	(3.15)
Middle	2.48	(1.69)	5.49	(5.68)	2.22	(2.18)
Low	(reference)					
Health	1.82	(0.63)	2.66*	(1.33)	1.46	(0.69)
Care sector	1.78	(0.64)	3.64**	(1.72)	2.04	(0.86)
Children	1.77	(0.68)	1.38	(0.79)	0.78	(0.39)
5C						
Confidence	0.06**	(0.02)	0.01**	(0.01)	0.2	(0.18)
Complacency	3.56	(2.67)	44.11**	(37.84)	12.38**	(9.06)
Calculation	7.85**	(4.28)	1.3	(0.8)	0.17**	(0.1)
Collective	20.01**	(16.07)	109.79**	(92.54)	5.49**	(2.5)
Constraint	2.57	(2.02)	2.23	(2.18)	0.87**	(0.79)
Model stats						
N	446				188	
prob > χ^2	0				0	
Wald $\chi^2(56)$	1299.68				1287.44	

Note: RRR = relative risk ratios; SE = standard errors; statistically significant associations;*p < 0.05, **p < 0.01.

4.4.1 Vaccine hesitant compared to vaccine accepting

Looking at figure 4.1 on page 30, you see that we included the significance, but do not interpret variables based on this because by itself, a p-value does not provide a good measure of evidence regarding a model or hypothesis. In the second and third column we compare individuals that were *vaccine hesitant* with those that were *vaccine accepting*. In this comparison group we find that women are 2.12 times as likely to be vaccine hesitant compared to vaccine accepting as men. Because the 95% standard error (SE) is 0.86 it is quite likely that women are more vaccine hesitant compared to men.

Between the age categories, we observe that is is 4.65 times more likely for people aged 25 to 35 to be vaccine hesitant than accepting compared to the eldest (75+) in the population. But due to the fact that the SE is greater than the relative risk we cannot say with certainty that it is on average more likely for younger people to be vaccine hesitant than accepting. For all other age groups it is approximately the same that we cannot say much about the likeliness of being hesitant compared to vaccine accepting due to the high standard errors. Despite the low certainty of the estimations the younger generations seem to be more vaccine hesitant compared to vaccine accepting. So, the older someone is the more likely it is that they will accept the vaccine instead of not knowing whether they want to be vaccinated.

For the willingness to be vaccinated we see that there are a lot of regions for which we cannot make strong claims. For instance: ZH, NH, NB, Gelderland, Utrecht, Overijssel, Friesland, groningen & Drenthe all show a high SE compared to the relative risk ratio and therefore it is very hard to say in whether it is more likely for those who live in this area compared to Zeeland if they are more or less hesitant to be vaccinated. Though the magnitude of the RRR of Groningen and Friesland indicate that living in this region makes you more prone to be hesitant than accepting. We can make some stronger claims for both Flevoland & Limburg because the data seems to indicate that if you live in this area compared to Zeeland you are less likely to be vaccine hesitant and thus more willing to accept a COVID-19 vaccine due to the low SE.

For educational differences we see that the higher the education, meaning middle compared to low or high compared to low, there is higher hesitancy than acceptance. But looking at the SE, it again is quite high and therefore it is hard to say if it more likely for people with a higher educational background than the lowest are more or less likely to be hesitant to vaccination.

When it comes to having an underlying health problem, working in the health care sector or having children the magnitude of all RRR's is low, but because the SE also is quite low we can carefully say that it is a little more likely to be vaccine hesitant compared to accepting if one of these apply to you.

Lastly, the psychological indicators: complacency & constraint have a moderate positive magnitude and a high SE therefore we cannot make conclusions for these variable. However, the variables calculation & collective responsibility have a high magnitude which could despite the high SE indicate that it is more likely if you take more collective responsibility or be more calculative when making decisions you are more likely to be hesitant towards a COVID-19 vaccine than accepting. Finally, the results show that having confidence in vaccination in general makes you 0.06 times less likely to be hesitant to the COVID-19 vaccine than that you would accept it. So, based on the low SE we can say that people with confidence are more likely to be vaccine accepting than hesitant.

4.4.2 vaccine resistant compared to vaccine accepting

Looking at the fourth and fifth column we compare the resistant to the vaccine accepting population. As can be seen in table 4.1, women are 2.19 times more likely to be resistant towards the COVID-19 vaccine than accepting. But the SE is so high that it is impossible to say that the actual RRR is like this.

For All age groups the values of the relative risks are extremely high, for example being between the ages 65 to 74 makes it 574470 times more likely to be vaccine hesitant than vaccine accepting compared to the people aged 75 and over. This is highly unlikely to be actually true also due to the SE that is even higher. We can solve what goes wrong by identifying that there is no vaccine resistant person in the oldest age group, which is also hard to believe. Therefore interpretation of these RRR's is basically impossible.

We see that there are regional differences in the attitude towards a COVID-19 vaccine, namely that it is less likely for people that live in NB and also Flevoland to be vaccine resistant compared to vaccine accepting than when living in Zeeland. People in NB are 75% less likely to be vaccine resistant than hesitant. Even more, in Flevoland people are almost 100% less likely to be hesitant than resistant compared to Zeeland with an SE of almost 0. This extremely low but positive number is due to the fact that there are no vaccine resistant individuals in our sample from Flevoland. Unfortunately, this is the result of an insufficient sample size and therefore we have to acknowledge that this is one of the major weaknesses of this research. For the other regions the RRR shows a magnitude that is not that high or low, and combined with a high SE it is hard to make conclusions based on these numbers, therefore we do not draw any conclusions for the other regions.

For differences between being accepting or hesitant we see that being higher educated means that you are more likely to be resistant than accepting (for both middle and high education). But even though the high magnitude of the RRR, the SE also is very large which means that the certainty of the RRR reflecting the actual value is low. So, when this study is repeated many times you will probably find extremely different RRR values that are much lower or higher than ours.

Moreover, for people with children there is no reason to say that they will be more resistant than accepting based on the RRR of 1.38 and SE of 0.79. For the care sector the magnitude of 3.64 shows that those working there are 3.64 times as likely to be resistant than accepting towards a COVID-19 vaccine. Also the standard error of 1.72 indicates that even on the lower bound those people will be 1.92 times as likely to be resistant compared to accepting of the vaccine. Also for having an underlying health condition there is some evidence that the chance is higher to be vaccine resistant than accepting based on the magnitude and the SE.

Finally, for the psychological indicators the variables calculation and constraint shows no big difference in RRR from 1 and both have a relatively high SE. On the other hand having confidence in vaccination again means that someone is very much less likely (0.01) to be resistant than accepting of a COVID-19 vaccine. And the SE is so low that there is a high chance of this being true. On the other hand the high magnitude of complacency and collective responsibility shows that it is times more likely (44.11 & 109.97 respectively) to be vaccine resistant than accepting. Even though the high magnitude, their high SE does not show that this can be interpreted with much confidence.

4.4.3 vaccine hesitant compared to vaccine resistant

Finally, women are 1.04 times more likely to be resistant than hesitant toward COVID-19 vaccination. Combined with the high SE we cannot make any conclusions if it will be more or less likely for women to

be resistant than hesitant.

Besides, we again have extremely high values for all age groups due to 0 observations in the age group over 75 that are vaccine resisting. So, just like in the previous section we have to say that we cannot make conclusions by interpretation of these variables and therefore we do not do this.

For regional distribution, the only relevant regions that show that people in these areas are less likely to be resistant than hesitant are NB & Friesland. On the other hand, it seems that people in Limburg are 5.52 times more likely to be vaccine resistant than hesitant compared to those in Zeeland. However, again here goes that the SE is quite large and therefore a conclusion that people in Limburg are more likely to be resistant than hesitant compared to other regions is difficult to draw.

Next, for different education levels we cannot say whether they are more likely to be resistant than hesitant, because the SE is just too high compared to the magnitude of the possible chance of being in the resistant group compared to the hesitant group. The same goes for having an underlying health condition, working in the health care sector and having children.

Lastly, we can conclude based on the regression table that being confident or calculating your decisions makes it less likely to be resistant than hesitant. On the other hand we see high magnitude RRR's for complacency and collective responsibility, meaning that it is more likely to be resistant than hesitant toward a COVID-19 vaccine if your general thought about vaccination are like this.

So, based on these findings we show that women are more likely to be vaccine hesitant compared to vaccine accepting. On the other hand, we find that it is less likely for people from Limburg or Drenthe to be vaccine hesitant than vaccine accepting compared to those from Zeeland. Also in this comparison group, there are some psychological factors that distinguish the *vaccine hesitant* group from the *vaccine accepting* group. For *vaccine resistant* compared to *vaccine accepting* individuals there are also socio-demographic and even health related factors that distinguish those individuals. For example, having an underlying health condition slightly increases the chance that individuals are resistant to be vaccinated against COVID-19 compared to accepting the vaccine. Next to that, we find that working in the health or social care sector makes it more likely to be *vaccine resistant* than *vaccine accepting*. Lastly, when we compare the resistant with the hesitant group, we again, find both distinguishing demographic and psychological factors.

All in all, it becomes clear that just 58% of the adult population and 38% of the younger population is willing to be vaccinated against COVID-19. Besides, we find an even lower willingness to be vaccinated in the prioritized population (55%), due to higher *vaccine resistance* compared to *vaccine acceptance* among health and social care workers, and people with an underlying health condition. Next, we find concerns about the side effects of the vaccine and that the COVID-19 vaccine is potentially not safe to be the main reason for both hesitance about and resistance to a COVID-19 vaccine. Finally, we show that psychological indicators for vaccination (5C) are distinguishing factors for all three categories that reflect the willingness to be vaccinated.

Thus, given the evidence that the demand for the COVID-19 vaccine would be sufficient if at least 74% of the Dutch population would be willing to be vaccinated. We find that the current demand (58% for adults and 38% for children) for a COVID-19 vaccine is insufficient to attain herd immunity in the long run. In the short run, due to the supply constraints, the COVID-19 vaccine will be prioritized to maximize the benefit of the vaccine. In this prioritized population, we find an even lower demand (55%) than in the adult population. By this, we show that there is too much hesitancy about and resistance to a COVID-19

vaccine, which negatively influences the effectiveness of the potential vaccine.

To ensure that a COVID-19 vaccination program will succeed in ending the pandemic we must increase the demand by reducing hesitancy and resistance to the vaccine. Therefore we show the profile of *vaccine hesitant* and *vaccine resistant* individuals. The profile consists of the reason for being part of that group and factors that distinguish those groups from *vaccine accepting* individuals.

The profile of the *vaccine hesitant* group:

- Parents have a more hesitant attitude towards vaccination against COVID-19 than there exists in the total adult population (46% > 28.5%).
- Hesitancy is the more likely among women than it is to accept a vaccine
- Living in either Limburg or Drenthe makes someone less likely to be hesitant than vaccine accepting
- Hesitancy to be vaccinated goes for more than half of the children between the ages of 5 and 9.
- Hesitancy about a COVID-19 vaccine, mainly (52%) comes forth out of concerns for the potential side effects of the vaccine
- 25% of these individuals are *vaccine hesitant* because they have a lack of information about the vaccine.
- 15% is Hesitant to be vaccinated because they think a COVID-19 vaccine may not be safe
- The *vaccine hesitant* group can be distinguished from the *vaccine accepting* group by three psychological indicators for vaccination (5C), namely: *vaccine confidence*, *vaccine calculation*, and *vaccine collective responsibility*

The profile of the *vaccine resistant* group:

- Resistance to a COVID-19 vaccine is just like hesitancy a more common attitude for parents to have for their children than Resistance is for the total adult population (16% > 13.5%)
- More than half of the adults between the ages of 25 and 34 (58%) are resistant to a COVID-19 vaccine.
- Children between the ages of 5 and 9 are the most resistant to be vaccinated against COVID-19 (19%)
- 31% of the *vaccine resistant* group gives the possibility that a COVID-19 vaccine may not be safe as their main reason for being resistant
- A quarter of this group is resistant because they are concerned about the potential side effects
- 21 % of these individuals are *vaccine resistant* because of conspiracy beliefs and concerns that the vaccine will be produced too fast
- Individuals that work in the health and social care sector are a little more likely to be *vaccine resistant* compared to *vaccine accepting*
- Those with an underlying health condition are also more likely to be resistant than to accept a COVID-19 vaccine

- The *vaccine resistant* group can be distinguished from the *vaccine accepting* group by three psychological indicators for vaccination (5C), namely: *vaccine confidence*, *vaccine complacency*, and *vaccine collective responsibility*
- The *vaccine resistant* group can be distinguished from the *vaccine hesitant* group by vaccine confidence, calculation, complacency & collective responsibility.

By these *profiles*, we gives an insight into the *vaccine hesitant* and the *vaccine resistant* groups. With this knowledge, an effective way to address hesitancy about and resistance to a COVID-19 vaccine could be to target those individuals that comply with these *profiles*. Especially the *vaccine hesitant* group who should be the most easily persuaded to accept the COVID-19 vaccine (Neumann et al., 2020). So, in the end, by these profiles, we try to make it more plausible to obtain herd immunity through vaccination to end this COVID-19 pandemic.

CHAPTER 5

DISCUSSION & CONCLUSION

5.1 Discussion

We obtain the first objective, which is the willingness to be vaccinated in the Netherlands, by examining that 58% of the adult population is *vaccine accepting*, 28.5% is *vaccine hesitant*, and 13.5% is *vaccine resistant* (figure 4.1). When comparing these outcomes to the literature (Neumann et al., 2020), we find that our *vaccine accepting* population is 15% smaller, the *vaccine hesitant* population is 9.5% larger, and the *vaccine resistant* population is 5.5% larger. Besides, if we compare our results with a similar study in the UK & Ireland we find lower rates of acceptance and higher rates of hesitancy and resistance to a COVID-19 vaccine in our study (Murphy et al., 2020). This could be indicating that the willingness to be vaccinated against COVID-19 reduced over time. This would be even more concerning, considering that the rates of vaccine acceptance found in the literature were already lower than the herd immunity threshold (74% of the population is immune to COVID-19). And as a result insufficient for a successful vaccination program against the coronavirus.

Besides, similar to the UK Ireland study by Murphy et al. (2020) we find that younger age (< 16) is related to *vaccine hesitance* and *vaccine resistance* (see figure 4.1). Moreover, we find a decreasing trend in hesitancy and resistance to a COVID-19 vaccine in the groups aged between 25 - 34 and higher. Remarkably, we find no *vaccine resistance* whatsoever in the (75+) age group, which is likely to be due to the small amount of respondents (N = 14) in that category (figure 4.2).

The willingness to be vaccinated for those that are first in line, or in the prioritized population, is lower (55%) than for the adult population (58%). For this reason, we assess the effect of the workers in the health and social care sector, and those in the risk group separately. Our results show that the lower willingness to be vaccinated is partly due to individuals that work in the health and social care sector, under whom we see less *vaccine acceptance* (51%) and significantly greater resistance to a COVID-19 vaccine (see table 4.1). Besides, the lower willingness in the prioritized population is due to a part of the risk group, namely: individuals with an underlying health condition, as they are more likely to be *vaccine resistant* than *vaccine accepting* (4.1), (Murphy et al., 2020). A reason for this could be that those

with an underlying health condition think the side effects of the vaccine could be more severe for them. Lastly, we show that the others in the risk group (people over 70 years old) have a relatively higher level of willingness than the adult population (figure 4.2).

For the second objective, we discuss whether the reasons that are given for being hesitant about a COVID-19 vaccine are similar to those in the literature. For example, in our sample, 52% is hesitant to be vaccinated because of the potential side effects, which is similar to the 55% found by Neumann et al. (2020). Also, the reason that "a COVID-19 vaccine might potentially not be safe" is given by exactly the same proportion hesitant individuals (15%). The open text explanations that were given by 25% of the hesitant individuals didn't match with those in the literature.

Next, for resistance to a COVID-19 vaccine, we again find the most common reasons: "I think a COVID-19 vaccine may not be safe", "I am concerned with the potential side effects", and "Other" to reflect the literature on vaccine resistance by Neumann et al. (2020).

For the last objective, we find that the distinguishing factors for *vaccine hesitancy* and *vaccine resistance* compared to both *vaccine accepting* and *vaccine hesitancy* are sex and demographic indicators and psychological indicators of vaccination (5C). For *vaccine resistant* compared to *vaccine accepting* individuals however, we found underlying health conditions and working in the health or social care sector to be distinguishing variables. However, due to our small sample size, the highest age category (75+) which was set to be the reference category did not contain any vaccine resistant individuals. Similarly, there were no *vaccine resistant* individuals residing in Flevoland. Since we do not observe any resistant individuals, we conclude that a major limitation of this research is that the sample is insufficiently large and not representative enough of the actual Dutch population. Due to this limitation, we cannot say whether a certain age category or residing in the region Flevoland is a distinguishing factor of being resistant compared to being accepting or hesitant.

Next to the insufficiently large and not quite representative sample, these findings should be interpreted considering other limitations. The data in our sample is collected 5 months after the first outbreak, and after the lock-down measures were just relaxed. As a result, our findings could be affected by a perception of decreased danger of the virus. The second limitation could be that the research is regarding an expected vaccine, whose potential side effects and efficacy is yet to be determined. Therefore, it is key to continue with similar research that determines the demand for a COVID-19 vaccine as we come to know more about the vaccine and closer to finding one. Lastly, we measured the demand which is an indicator of the actual uptake and cannot be seen as a perfect estimate of the uptake. Especially because this uptake depends on potential constraints, like the price and access to places to receive the vaccine (Neumann et al., 2020).

Even though, the limitations we mentioned, this study provides important knowledge about the levels of acceptance, hesitance, and resistance to a COVID-19 vaccine at a critical point in time. In doing such, we find that there is insufficient demand for a COVID-19 vaccine in the Netherlands. With this knowledge, we suggest that effort is needed to obtain herd immunity through vaccination. So, while there is still a race going on to develop a COVID-19 vaccine we show that it is necessary to persuade a large proportion of the Dutch population (16%) to obtain herd immunity. To persuade and convince people of the necessity of COVID-19 immunization, we made a profile for individuals in the *vaccine hesitant* and *vaccine resistant* group. This profile makes it possible to effectively target the *vaccine hesitant* group who are the most promising and cost-effective in increasing demand for a COVID-19 vaccine. All in all, convincing hesitant

and resistant individuals to a COVID-19 vaccine will be a necessary, but difficult task to obtain herd immunity through vaccination.

5.2 Conclusion

Concluding, the main objective of this study is to examine if there will be sufficient demand for a COVID-19 vaccine in the Netherlands. Given the history of vaccine hesitancy and resistance it is questioned whether a COVID-19 vaccination program will be able to obtain herd immunity (74% > of the population is immune to COVID-19). To examine the demand we designed a survey to ask participants for their willingness to be vaccinated against COVID-19. The results show that 58% accept the vaccine, 28.5% is hesitant, and another 13.5% is resistant to the vaccine. So, given the evidence that the demand for the COVID-19 vaccine would be sufficient if at least 74% of the Dutch population would be *vaccine accepting*. We find that the current demand for a COVID-19 vaccine is insufficient to obtain herd immunity. As a result, it is necessary to increase demand by reducing hesitancy and resistance to the vaccine. Therefore, we made a profile of *vaccine hesitant* and *vaccine resistant* individuals, to effectively persuade them to accept the COVID-19 vaccine.

Since there is insufficient demand it is necessary to persuade individuals to a COVID-19 vaccine. Future research should be aimed at decreasing *vaccine hesitancy* and *vaccine resistance* to ensure that the demand for the vaccine will be high enough to end this pandemic once it becomes available. Therefore, we suggest the use of our profiles to target currently hesitant and resistant individuals, such that they eventually choose to accept a COVID-19 vaccine.

APPENDIX A

A.1 Survey: Willingess to be vaccinated in the Netherlands

https://erasmusuniversity.eu.qualtrics.com/jfe/form/SV_5goh22q4QmUuW4R

Willingness to be vaccinated against COVID-19 (translated survey)

Dear participant, Thank you for participating in this Coronavirus (COVID-19) Survey. The aim of this research is to find out whether the Dutch want to be vaccinated against the corona virus .

Before you start::
• Allow about 5 minutes uninterruptedly;
• Maximize your browser window;

Your data will be treated in accordance with the provisions of the General Data Protection Regulation (GDPR EU).

CONSENT FORM
• I agree to participate in this survey .
• I understand that all data will be treated confidentially by the researcher.
• My personal information is not saved.
• I can withdraw at any time without giving a reason.

- ○ Yes, I agree
- ○ No, I do not give permission

What is your age?

_____

What is your gender?

- ○ man
- ○ Woman
- ○ Different

Which province are you from?

▼ North Holland ... Gelderland (scroll down menu with all 12 regions)

What is the highest level of education you have completed or the highest degree you have obtained?

- ○ Lower than high school diploma
- ○ High school diploma or equivalent
- ○ Middelbaar beroepsonderwijs (MBO)
- ○ HBO or university but no diploma
- ○ Bachelor's degree
- ○ Master’s degree
- ○ Candidates / Phd

Which of the following sectors best describe your profession (or education if you are a full-time student):

- ○ Health sector (medical staff, pharmacist, medical student)
- ○ Education (schools, childcare)
- ○ Food industry (supermarkets)
- ○ Researcher
- ○ Otherwise, namely; _____

Do any of the following conditions apply to you?

- [ ] An intellectual disability
- [ ] A chronic abnormality in the airways
- [ ] A chronic heart condition
- [ ] Diabetes mellitus
- [ ] Severe kidney disease
- [ ] Morbid obesity (BMI> 40)
- [ ] An untreated HIV infection
- [ ] Severe liver disease

How do you feel about the following 5 statements?

	Totally agree	agree	Neutral	Disagree	Totally disagree
I have complete confidence that the corona vaccine is going to be safe.	○	○	○	○	○
Vaccination against corona is unnecessary, because the virus is not a major threat.	○	○	○	○	○
Daily stress prevents me from getting vaccinated against the corona virus.	○	○	○	○	○
I carefully weigh the pros and cons when making a decision whether or not to get vaccinated.	○	○	○	○	○
If everyone is vaccinated against the corona virus, I choose not to be vaccinated.	○	○	○	○	○

Would you be vaccinated against the corona virus?

- ○ Yes
- ○ I do not know yet
- ○ No

What is the reason that you do not yet know whether you want to be vaccinated against the corona virus?

- ○ I am concerned about the potential side effects of the vaccine.
- ○ I DO NOT think the vaccine is safe.
- ○ Het is beter om de natuur zijn werk te laten doen
- ○ I don't think the corona virus is dangerous to my health.
- ○ For religious reasons.
- ○ Otherwise, namely; _____

What is the reason that you do not want to be vaccinated against the corona virus?

- ○ I am concerned about the potential side effects of the vaccine.
- ○ I DO NOT think the vaccine is safe.
- ○ It is better to let nature do its job.
- ○ I DO NOT think the corona virus is dangerous to my health.
- ○ I am against all forms of vaccination.
- ○ Om religieuze redenen
- ○ Otherwise, namely; _____

Do you have children under the age of 16? (about which you decide if they will be vaccinated)

- ○ Yes
- ○ No

Would you have your child vaccinated against the corona virus?

	Child	Vaccine?		
	Age	Yes	I do not know yet	No
1		○	○	○

Possible to fill in for as many children as the parents have.

What is the reason that you do not yet know whether you would have your child vaccinated against the corona virus?

- ○ I am concerned about the potential side effects of the vaccine
- ○ I DO NOT think the vaccine is safe
- ○ It’s better to let nature do it’s job
- ○ I don't think the corona virus is dangerous to my child's health
- ○ For religious reasons
- ○ Otherwise, namely; _____

What is the reason that you should not have your child vaccinated against the corona virus?

- ○ I am concerned about the potential side effects of the vaccine
- ○ I DO NOT think the vaccine is safe
- ○ It is better to let nature do its job
- ○ I DO NOT think the corona virus is dangerous to my child's health
- ○ I am against all forms of vaccination
- ○ Om religieuze redenen
- ○ Otherwise, namely; _____

BIBLIOGRAPHY

Berkley, S.

(2020).

Covid-19 needs a manhattan project.

American Association for the Advancement of Science.

Betsch, C., Korn, L., Felgendreff, L., Eitze, S., Schmid, P., Sprengholz, P., ... others

(2020).

German covid-19 snapshot monitoring (cosmo)-welle 13 (26.05. 2020).

CBS.

(2020).

Bevolking; geslacht, leeftijd en burgerlijke staat, 1 januari.

Retrieved 2020-07-13, from https://opendata.cbs.nl/statline/?dl=308BE#/CBS/nl/dataset/7461bev/table

Delamater, P. L., Street, E. J., Leslie, T. F., Yang, Y. T., & Jacobsen, K. H.

(2019).

Complexity of the basic reproduction number (r0).

Emerging infectious diseases, *25*(1), 1.

Fine, P., Eames, K., & Heymann, D. L.

(2011).

Herd immunity: a rough guide.

Clinical infectious diseases, *52*(7), 911–916.

Flaxman, S., Mishra, S., Gandy, A., Unwin, H., Coupland, H., Mellan, T., ... others

(2020).

Report 13: Estimating the number of infections and the impact of non-pharmaceutical interventions on covid-19 in 11 european countries.

for immunology, B. S.

(2020).

How vaccines work.

Retrieved 2020-08-04, from https://www.immunology.org/celebrate-vaccines/public-engagement/guide-childhood-vaccinations/how-vaccines-work#:~:text=Vaccines%20contain%20a%20harmless%20form,response%20without%20making%20you%20sick.

IMF.

(2020).

The great lockdown: Worst economic downturn since the great depression.

Retrieved 2020-07-10, from https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/

Khamsi, R.

(2020).

If a coronavirus vaccine arrives, can the world make enough.

Nature, *580*(7805), 578.

Murphy, J., Vallières, F., Bentall, R. P., Shevlin, M., McBride, O., Hartman, T. K., ... others

(2020).

Preparing for a covid-19 vaccine: Identifying and psychologically profiling those who are vaccine hesitant or resistant in two general population samples.

Neumann, S., Varghese, N., Sabat, I., Barros, P., Brouwer, W., Exel, J., ... Stargardt, T.

(2020, 06).

Once we have it, will we use it? a european survey on willingness to be vaccinated against covid-19.

The European Journal of Health Economics.

NU.nl.

(2020).

Tijdlijn: Het coronavirus in nederland.

Retrieved 2020-07-23, from https://www.nu.nl/coronavirus/6040831/tijdlijn-het-coronavirus-in-nederland.html

OnderwijsInCijfers.

(2020).

Opleidingsniveau van de bevolking.

Retrieved 2020-07-13, from https://www.onderwijsincijfers.nl/kengetallen/internationaal/opleidingsniveau-bevolking

Osborne, J. W.

(2015).

Curvilinear effects in logistic regression.

Best Practices in Logistic Regression. Thousand Oaks, CA: Sage Publications.

RIVM.

(2019).

Vaccination rate again drops slightly vaccination rate.

Retrieved 2020-07-15, from https://www.rivm.nl/en/news/vaccination-rate-again-drops-slightly-hpv-vaccination-rate-drops-considerably

RIVM.

(2020a, July).
Epidemiologische situatie covid-19 in nederland.
Author.
Retrieved 2020-07-28, from https://www.rivm.nl/documenten/wekelijkse-update-epidemiologische-situatie-covid-19-in-nederland

RIVM.
(2020b).
Risk groups and covid-19.
Retrieved 2020-07-15, from https://www.rivm.nl/en/novel-coronavirus-covid-19/risk-groups

Rothman, K. J., Greenland, S., & Lash, T. L.
(2008).
Modern epidemiology.
Lippincott Williams & Wilkins.

Sanche, S., Lin, Y. T., Xu, C., Romero-Severson, E., Hengartner, N., & Ke, R.
(2020).
Early release-high contagiousness and rapid spread of severe acute respiratory syndrome coronavirus 2.

Souza, G., & Dowdy, D.
(2020).
What is herd immunity and how can we achieve it with covid-19.
Johns Hopkins School of Public Health Expert Insights.

Thunstrom, L., Ashworth, M., Finnoff, D., & Newbold, S.
(2020).
Hesitancy towards a covid-19 vaccine and prospects for herd immunity.
Available at SSRN 3593098.

Times, N. Y.
(2020).
Coronavirus vaccine tracker.
Retrieved 2020-08-04, from https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html

Trouw.
(2020).
De 16-jarige moet zelf beslissen over vaccinaties, niet de ouders.
Retrieved 2020-07-16, from https://www.trouw.nl/nieuws/de-16-jarige-moet-zelf-beslissen-over-vaccinaties-niet-de-ouders~b75a6a1b/

UKgovernment.
(2020).

Joint committee on vaccination and immunisation: interim advice on priority groups for covid-19 vaccination.
Retrieved 2020-07-18, from https://www.gov.uk/government/publications/priority-groups-for-coronavirus-covid-19-vaccination-advice-from-the-jcvi/interim-advice-on-priority-groups-for-covid-19-vaccination

van den Hof, S., Meffre, C., Conyn-van Spaendonck, M., Woonink, F., de Melker, H. E., & van Binnendijk, R. S.
(2001).
Measles outbreak in a community with very low vaccine coverage, the netherlands.
Emerging infectious diseases, *7*(3 Suppl), 593.

WHO.
(2019).
Top ten threats to global health vaccine hesitancy.
Retrieved 2020-07-16, from https://www.who.int/news-room/feature-stories/ten-threats-to-global-health-in-2019

WHO.
(2020).
Ethics and covid-19: resource allocation and priority-setting.
Retrieved 2020-07-24, from https://www.who.int/ethics/publications/ethics-covid-19-resource-allocation.pdf?ua=1

Worldometers.
(2020).
coronavirus pandemic statistics.
Retrieved 2020-08-04, from https://www.worldometers.info/coronavirus/