Investigating the Causality and Perceptions of Adverse Events Following Immunization (AEFI) and the awareness of the Novel mRNA COVID-19 Vaccine in Tallinn Upper Secondary Schools

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Abstract

The COVID-19 pandemic launched a multi-billion dollar and highly time-sensitive global search for a vaccine, leading to the world's first mRNA vaccines, which employed a revolutionary method of inoculation. Although mRNA vaccines have proven to be highly effective against COVID-19, their impact on the human body is still being investigated and there have been instances of public distrust of the vaccine, leading to some people refusing to take it. This study investigates three aspects in Tallinn secondary school students: how well they understand the basics of mRNA vaccination technology, why those who refused vaccination did so, and their perception of adverse reactions to the vaccine they received. For the practical part of the research, a questionnaire was used, among students of the 10th and 12th grades of a total of 20 schools. The questionnaire consisted of 13 questions: 10 multiple-choice and three open-ended. Each of the multiple-choice questions also had an "Other" option, which allowed students to input their own answer. The questionnaire was bilingual, including both Estonian and Russian speakers. A total of 168 10th grade students participated in the questionnaire, representing 61.5% of the respondents, and 105 12th grade students, representing 38.5% of the respondents. The results showed that awareness of mRNA vaccines among students in Tallinn was low, and adverse reactions to vaccination consisted mainly of fatigue and muscle pain. Parental refusal was the main reason for not vaccinating, and information was mainly obtained from social media.

I. Introduction

The aim of this research project was to determine how aware students in Tallinn are of the new mRNA vaccine. Additionally, the objective was to find out what side effects or AEFI resulting from vaccination have been experienced by 10th and 12th-grade students in Tallinn, according to their own opinions. “Tallinn students” refers to data collected from 20 schools across the city. This work presents, based on a thorough literature review

and data analysis, an overview of mRNA-based vaccines from a biological perspective and a practical study of AEFI based on the personal experiences of Tallinn's 10th and 12th-grade students. It also investigates the impact of this technology on the human body and the reasons why COVID-19 vaccination is feared.

A. Research Questions:

1. How many 10th and 12th-grade students in Tallinn are vaccinated against COVID-19?
   Hypothesis: Over 60% of Tallinn's 10th and 12th-grade students are vaccinated.
2. How many 10th and 12th-grade students in Tallinn have, according to their own assessment, experienced AEFI after COVID-19 vaccination?
   Hypothesis: Less than 40% of Tallinn's students have experienced AEFI resulting from vaccination, according to their own assessment.
3. How many 10th and 12th-grade students in Tallinn are aware of the use of mRNA technology in vaccines and understand what mRNA technology is?
   Hypothesis: Less than 40% of Tallinn's 10th and 12th-grade students are aware of the use of mRNA technology in vaccines, and less than 20% understand what mRNA technology is.

II. Vaccination and its history

The history of attempts to develop immunity against disease begins in 1549, when the smallpox virus was used in China to create an immune response. The history of vaccination, as we understand it today, began more than two centuries ago when Edward Jenner created the first smallpox vaccine. This was preceded in the 1720s by a child vaccinated under the supervision of a doctor in a diplomatic family in Constantinople, which turned out to be better than contracting smallpox. (WHO.int. A Brief History of Vaccination 2023)

In 1789, the United States opened the country's first public health agency, which began offering health services such as treating sailors and began protecting ports from various diseases like smallpox and cholera, also using vaccines. That same year, Edward Jenner published a study showing it was possible to make a smallpox vaccine using the live virus. This was a revolutionary breakthrough in the world of medicine. (Sphweb.bumc.bu.edu. A Brief History of Public Health 2015)

Almost 100 years later, Louis Pasteur began making discoveries and improving vaccine effectiveness. He was the first to develope a vaccine for rabies using the live virus. Afterward, he tried to use this vaccine with cows and discovered that cows vaccinated did not acquire the disease and developed immunity. In 1885, Louis Pasteur tested the vaccine on humans with success. In fact, it can be said that Pasteur was the "father" of

vaccines. From his first vaccine (against rabies) to the use of the term "pasteurization," which refers to heating milk in factories to kill bacteria, Pasteur was the first person to notice the microbial world living around us and proved that these small cells cause diseases. He made many discoveries about bacteria in animals and described the fermentation process. The history of real vaccines as we know them today starts with him. His laboratory became an institute that continues to operate today. Vaccines have been made there for 200 years. Since then, vaccines have become one of the most effective tools against many diseases. (Immunize.org. Vaccine History Timeline 2024)

Over the past two hundred years, many vaccines have been developed, significantly reducing the incidence and mortality of many infectious diseases such as measles, polio, hepatitis B, flu, and others. Through vaccination, the smallpox virus was eradicated completely in 1980. (WHO.int. A Brief History of Vaccination 2023) In 2020, the world faced a new threat – the COVID-19 pandemic. Scientists quickly developed a new type of vaccine, the mRNA vaccine.

Today, vaccination is one of the main public health methods for preventing the spread of infectious diseases and saving many lives. Mass vaccination has also sparked numerous conspiracy theories. For example, in 2019, the WHO listed as one of the top ten threats the refusal of vaccination, which could lead to the return of diseases that had already been eradicated in developed countries. (WHO.int. Ten threats to global health in 2019 2023)

III. Types of Vaccines

There are several types of vaccines. Each type is designed to teach your immune system to fight specific microbes and the serious diseases they cause. When scientists create vaccines, they consider how the immune system responds to the microbe that needs to be vaccinated against and what is the best technology or approach to use for creating the vaccine. Based on these factors, scientists decide which type of vaccine they will produce. There are six known types of vaccines. Inactivated vaccines use a killed version of the microbe that causes the disease. Inactivated vaccines usually do not provide as strong an immunity (protection) as live vaccines. Therefore, several doses over time (injections) may be needed to achieve long-lasting immunity against the disease. (HHS.gov. Vaccine Types 2022)

Live vaccines use a weakened form of the microbe that causes the disease. Because these vaccines are so similar to the natural infection, they produce a strong and long-lasting immune response. Only 1 or 2 doses of most live vaccines can provide lifelong protection against the microbe and the disease it causes. However, live vaccines also have some limitations. Because they contain small amounts of the weakened virus, people with weakened immune systems should talk to their doctor before getting vaccinated. (HHS.gov. Vaccine Types 2022)

mRNA vaccines produce proteins to trigger an immune response. mRNA vaccines have several advantages over other types of vaccines, such as being quicker to produce, taking about 2 days to a week, with most of the time spent on testing the vaccine. Also, because they do not contain live viruses, there is no risk that the vaccinated person will get sick. (HHS.gov. Vaccine Types 2022)

Subunit, recombinant, polysaccharide, and conjugate vaccines use specific pieces of the microbe, such as protein, sugar, or capsid (the outer shell of the microbe). Because these vaccines use only certain pieces of the microbe, they produce a very strong immune response targeting the core parts of the microbe. These vaccines can be used for almost anyone who needs them, including people with weakened immune systems and those with long-term health problems. One limitation of these vaccines is that booster shots may be needed to provide long-term protection against the disease. (HHS.gov. Vaccine Types 2022)

Toxoid vaccines use toxins produced by the disease-causing microbe. These vaccines generate immunity against the disease-causing parts of the microbe, not the microbe itself. This means the immune response is directed at the toxin, not the whole microbe. Like some other types of vaccines, a patient may need a booster shot to get lasting protection against the disease. (HHS.gov. Vaccine Types 2022)

Viral vector vaccines use a modified version of another virus to carry the antigen (protein) that, when the immune system destroys the vector virus in the body, also creates immunity to the antigen, i.e., the disease that the vaccine is designed for. Various viruses have been used as vectors, including the flu virus, the measles virus, and the adenovirus, which causes the common cold. Adenovirus is one of the viral vectors used in some clinical trials of COVID-19 vaccines. (HHS.gov. Vaccine Types 2022)

IV. COVID-19 Vaccine Mechanism

The COVID-19 vaccine uses mRNA technology to deliver genetic information that encodes the proteins of the virus that causes COVID-19. (CDC.gov. Understanding How COVID-19 Vaccines Work 2023) After the vaccine is injected into the body, the mRNA enters human cells (often in muscle cells of the arm), where it enters the ribosome, starting the process of decoding and creating the virus's antigens (amino acids, see Figure 1). The ready-made virus antigens then go through the proteasome, which checks that each virus antigen matches the original mRNA; any virus antigens that do not match the mRNA are destroyed. (Chop.edu. How mRNA Vaccines Work 2023) Then, MHC I and MHC II molecules switch on and carry the virus antigen out of the cell. MHC I binds with a killer T-cell, which aims to destroy the damaged cell, and MHC II binds with a helper T-cell, which triggers an immune response. (Udayangani et al., 2017) In particular, a new technology developed for COVID-19

vaccines uses mRNA to allow vaccines to be created and produced quickly. The speed of development and production is one of the key advantages of this technology. (Yangzhuo et al., 2022)

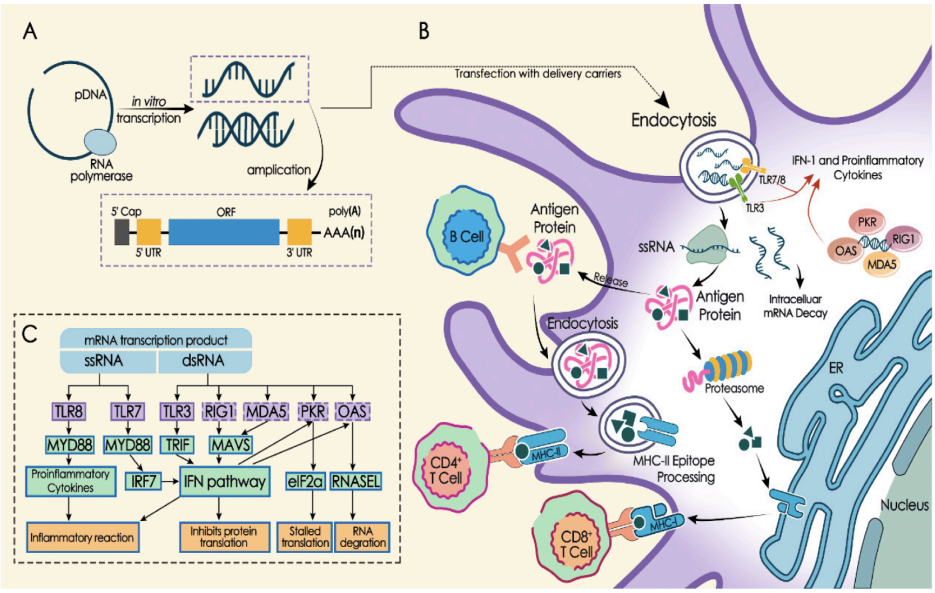


FIGURE 1. The mechanism of mRNA in the human body Source: Xu, S.; Yang, K.; Li, R.; Zhang, L. mRNA Vaccine Era—Mechanisms, Drug Platform and Clinical Prospection. Int. J. Mol. Sci. 2020, 21, 6582.

A. Vaccine causality assessment of an adverse event following immunization (AEFI)

Any untoward medical occurrence which follows immunization, and which does not necessarily have a causal relationship with the usage of the vaccine is called AEFI. The adverse event may be any unfavorable or unintended sign, abnormal laboratory finding, symptom or disease. (WHO.int. Causality assessment of an adverse event following immunization (AEFI) 2021) In other words, AEFI is any untoward medical occurrence in a vaccinated person that follows immunization. It does not necessarily have a causal relationship with the vaccine or the immunization process. Local and systemic reactions are the two main categories that cover a variety of AEFI. Local reactions, which are common, indicate a direct interaction between the body and the vaccine components. The appearance of pain, redness, or swelling at the injection site points to a local reaction. It is important to note that these local reactions usually resolve without external intervention. In contrast, systemic reactions are rapid and provide clear evidence of an immune response. Symptoms such as fever, fatigue, headache, muscle aches, and increased body temperature indicate that the immune system is being activated. These systemic reactions provide tangible evidence that the immune system has recognized the virus in the vaccine and is beginning to build immunity. The range of side AEFI expands as we move to specific types of vaccines. (Spencer et al., 2017).

Inactivated vaccines, such as those for polio or hepatitis A, usually cause mild AEFI, including localized pain or a mild fever. Live attenuated vaccines, such as the MMR vaccine, may cause symptoms similar to the disease. The appearance of a rash or fever highlights the vaccine's ability to stimulate an immune response that mimics the natural infection process, offering protection without causing serious illness. mRNA vaccines, which are new and have gained popularity due to their effectiveness, have characteristic AEFI. Commonly reported occurrences include pain at the injection site, fatigue and fever. (CDC.gov. Safety information by Vaccine 2020).

B. Impact of mRNA Technology on the Human Body

Based on the two previous figures and explanations, it is clear that COVID-19 vaccines, like all mRNA-based vaccines, cannot cause diseases such as cancer because they do not interact with the cell nucleus where DNA is stored. (Mskcc.org. 7 Myths about COVID-19 Vaccines 2021)

mRNA technology is completely new in human history, and scientists have made unprecedented discoveries and conducted research. Thanks to global mobilization of resources, Pfizer and Moderna created two vaccines that are the first to have received emergency use authorization from governments. (Immunology.org. How have COVID-19 vaccines been developed so fast? 2023)

Due to the pandemic and the emergency situation, mass vaccination began, the consequences of which no one could fully foresee. mRNA theoretically can initiate the production of various antigens in the body, which can then be distributed systemically. These differ radically from conventional vaccines, where the produced antigen and its distribution are more predictable. (Trougakos et al., 2022) Now, three years later, we can start discussing the effects.

The most common AEFI are redness and swelling at the injection site, fever, chills, and limb pain, which occurred in fewer than 1 in 10 people. Lymph node enlargement, elevated blood pressure, rash, redness, and itching at the injection site, and itching occurred occasionally (less than 1 in 100 people). These occurrences after the immunization indicate that the immune system is fighting the disease; they are characteristic of almost all vaccines and should not cause fatal outcomes.

However, very rare serious AEFI have also been reported. Vaccination has been associated with an increased risk of myocarditis (2.7 cases per 100,000 people), appendicitis (5.0 cases per 100,000 people), and herpes simplex virus (15.8 cases per 100,000 people). Various syndromes, such as Bell's palsy or Guillain-Barré syndrome, have also occurred, but these are very rare. (Barda et al., 2021)

For example, between December 24, 2020, and February 12, 2021, Mexico administered 704,003 first doses of COVID-19, of which 6,536 had AEFI (0.5% of all vaccinated), of which 6,503 (99.5%) were not

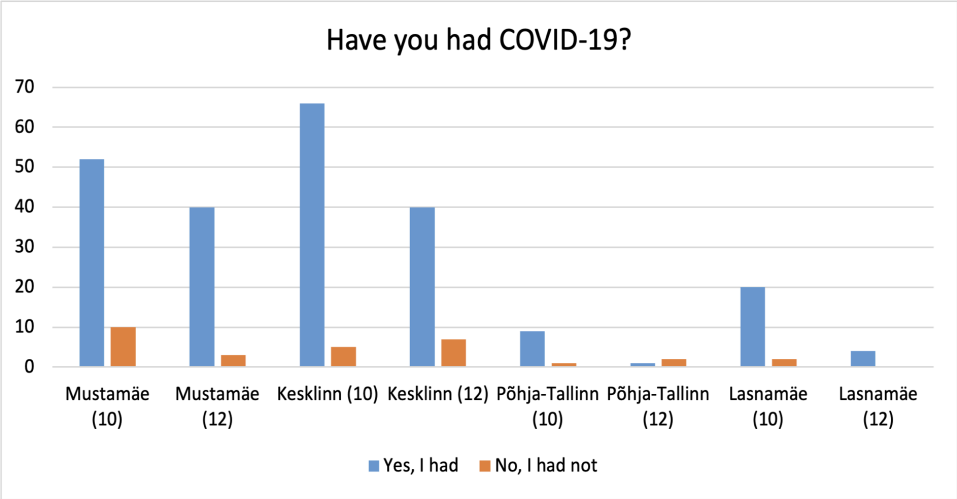
considered severe, and only 33 (0.005%) were considered severe. These 33 cases included Guillain-Barré syndrome. Meanwhile, the risk of myocarditis after contracting COVID-19 was 11 cases per 100,000 people, which is four times higher than with vaccination. (García-Grimshawaetal et al., 2021) Based on the data presented above, the benefits of the vaccine outweigh the risks, especially since, for example, the risk of myocarditis caused by COVID-19 is much higher than due to vaccination. It can already be said that mass vaccination is not capable of causing long-term health problems in human societies. (Wesolowski, 2021)

V. Questionnaire results

For the practical part of the study, a questionnaire was conducted at the schools in Tallinn, covering a total of 20 schools. Students in the 10th and 12th grades were selected, because the average age of entering the 10th grade is 16, which is when Estonians get the right to make their own decision about vaccination. However, their views will develop significantly by the end of high school, which is 12th grade. The survey was conducted in April 2024 and consisted of 13 questions: 10 multiple-choice and three open-ended. Each multiple-choice question also had an "Other" option, allowing students to write their own answers. The survey was conducted in both Estonian and Russian languages. A total of 168 10th-grade students participated in the survey, which constitutes 61.5% of the respondents, and 105 12th-grade students, making up 38.5% of the respondents. The 20 schools were divided into the districts in which they are geographically located so that the full picture of the study could be compared. (Note: numbers in the graphs represents quantity of students, who responded)

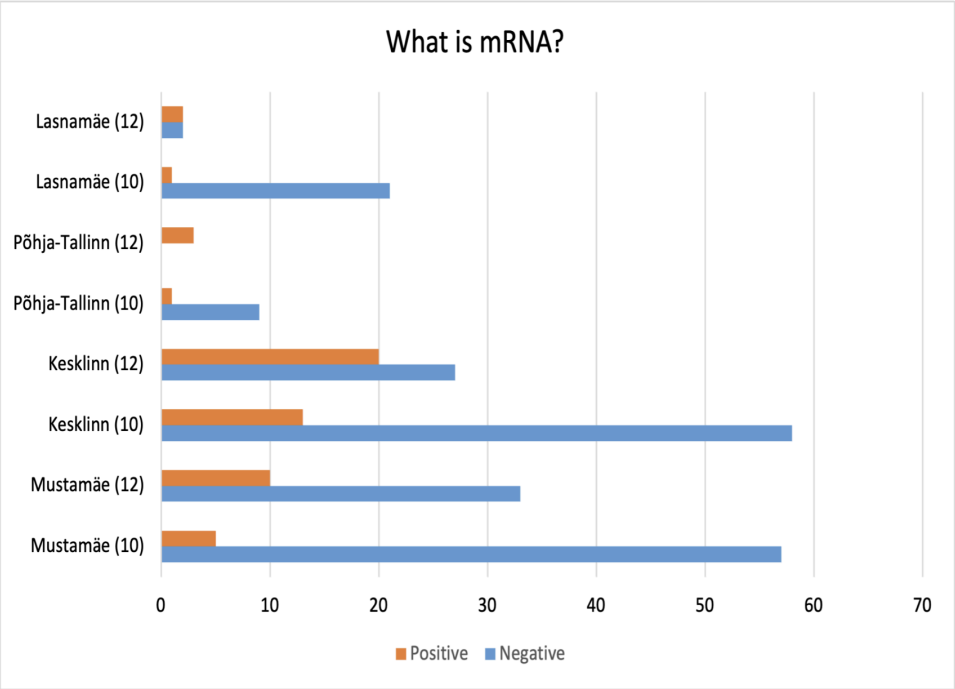
A. Distribution by Districts:

- **Mustamäe**: Tallinna Mustamäe Gümnaasium, Tallinna 32. Keskkool, Tallinna Arte Gümnaasium, Tallinna 53. Keskkool and Tallinna Mustamäe Humanitaargümnaasium. A total of 105 students.
- **Kesklinn**: Tallinna Juudi Kool. Gustav Adolfi Gümnaasium, Tallinna Humanitaargümnaasium, Vanalinna Hardisukolleegium, Tallinna Realkool, Tallinna Ühisgümnaasium, Tallinna Prantsuse Lütseum and Tallinna Tõnismäe Reaalkool. A total of 129 students.
- **Põhja-Tallinn**: Tallinna Pelgulinna Riigigümnaasium and Ehte Humanitaargümnaasium. A total of 13 students.
- **Lasnamäe**: Tallinna Laagna Gümnaasium, Lasnamäe Vene Gümnaasium and Lasnamäe Gümnaasium. A total of 26 students.



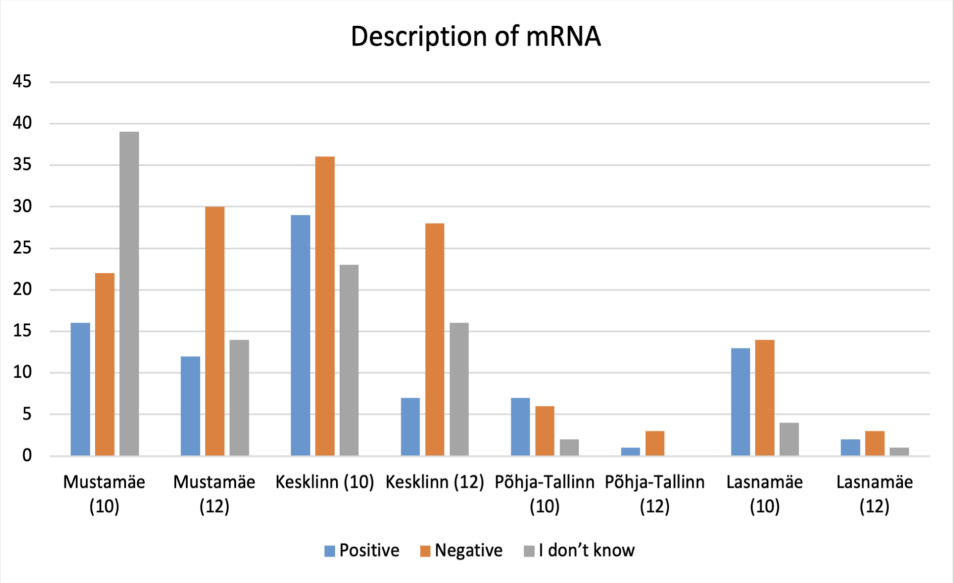
B: Figure 2: COVID-19 incidence

The question was designed as a multiple-choice question, meaning that each student could choose one of two options. The aim of this question was to explore whether there is a correlation between having had the disease and refusing vaccination, as well as awareness of mRNA technology. Across various districts, a significant majority of both 10th and 12th-grade students had experienced COVID-19. In most cases, over 80% of students in each grade level had contracted the virus, indicating a widespread impact on the student population. While this trend was consistent in several districts, there were notable exceptions; for instance, one district reported a lower percentage of 12th-grade students affected by COVID-19 compared to others.



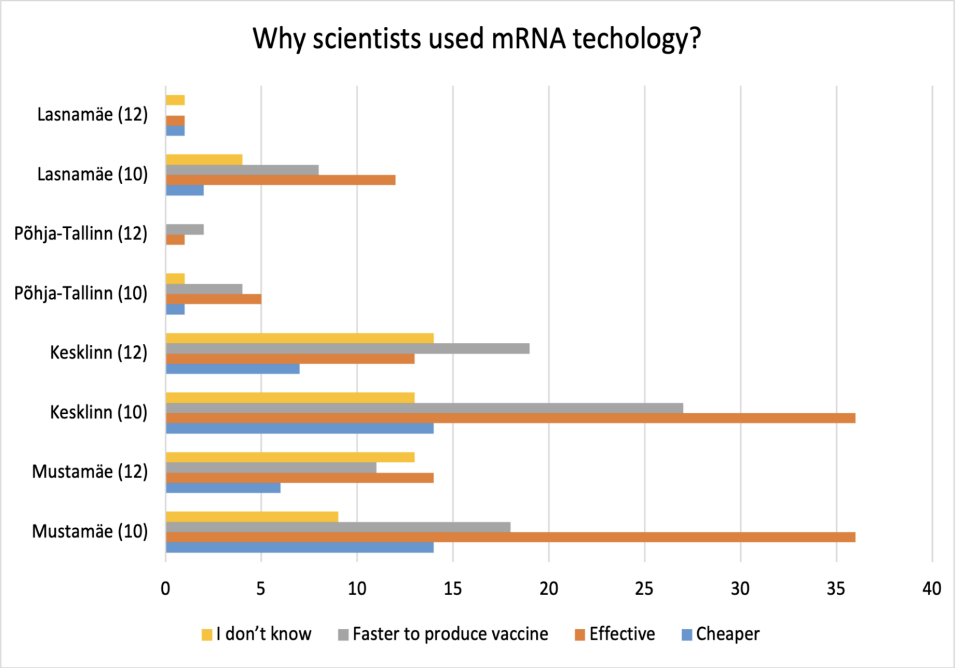
C: Figure 3: Explanation of the mRNA technology

This question was designed as an open-ended response, meaning that each student wrote their own answer. The goal of this question was to either confirm or reject the hypothesis 3. For comparison purposes, the author analyzed all 273 responses and rated whether the student could correctly explain what mRNA is or not. The responses were then categorized as follows: Negative – "I don't know" and Positive – "I know." Across various districts, a majority of 10th-grade students did not know what mRNA is, with percentages ranging from 82% to 96% lacking awareness. In contrast, 12th-grade students demonstrated a higher level of understanding. The author believes that there is no need for schools to make special efforts because, despite the initially low statistics for 10th-grade students, it is clear that by the time students finish high school, more people will know about mRNA.



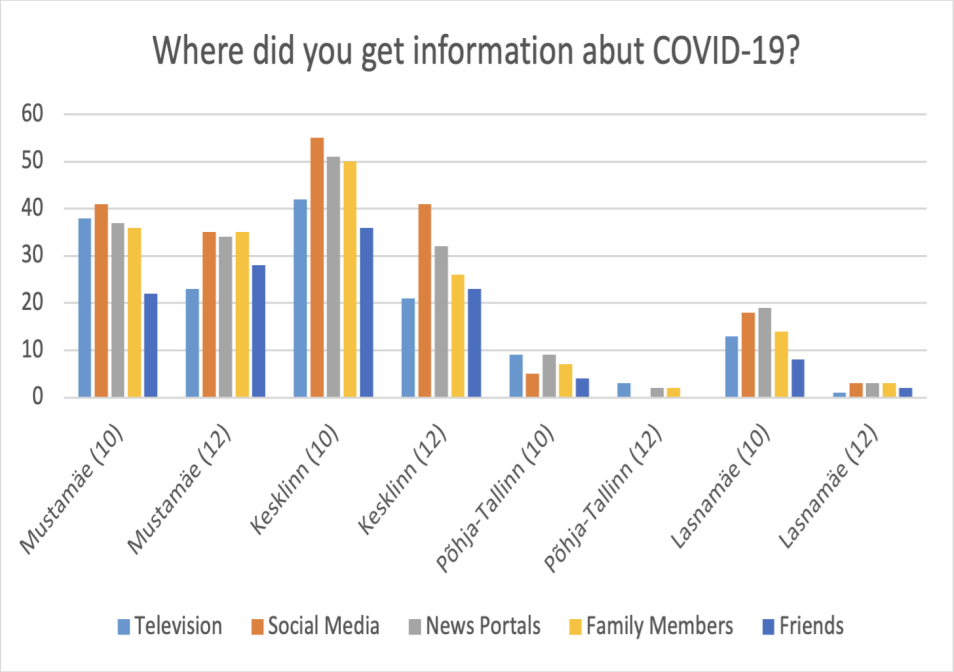
D: Figure 4: Description of mRNA technology

This question was designed as a multiple-choice question, meaning that each student could choose from four given options plus "Other" as an option. For easier analysis, the author categorized the responses into three groups: Positive (Effective and reliable), Negative (Needs further research and is dangerous to the human body), and "I don't know.". The aim of this question was to either confirm or reject the hypothesis 3 (see Introduction). Across multiple districts, both 10th and 12th-grade students exhibited varied perceptions of mRNA, with a notable tendency toward negative descriptions. In most districts, a higher percentage of students described mRNA negatively rather than positively. Additionally, a significant portion of 10th-grade students either had negative perceptions or were unaware of what mRNA is, though the percentage of those who "did not know" generally decreased in 12th grade. This trend suggests that while awareness of mRNA increases with grade level, misconceptions or negative perceptions remain prevalent among the student population.



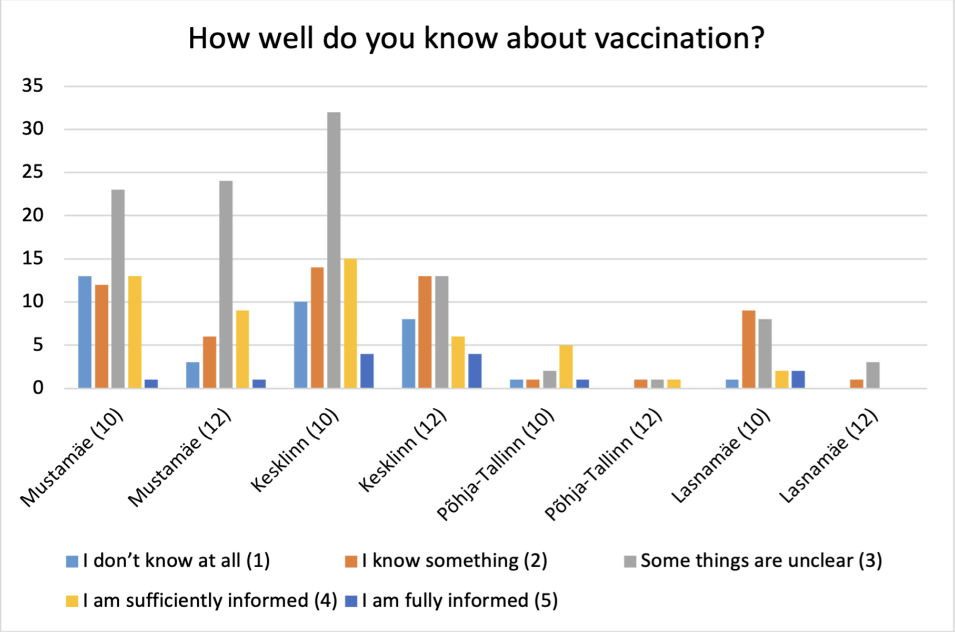
E: Figure 5: Why did scientists used mRNA technology specifically to develop a vaccine?

This question was designed as a multiple-choice question, where each student could choose from three given options: "mRNA technology is much cheaper," "mRNA technology is more effective," and "Using mRNA technology, the vaccine can be made faster," plus "I don't know." Students could also write their own answers in the "Other" option. The goal of this question was to either confirm or reject the hypothesis 3 (see Introduction). Among 10th-grade students, a significant portion—ranging from approximately 31.5% to 47%—believed that mRNA technology is more effective. Additionally, between 23% and 36% thought it allows for quicker vaccine production, while a smaller percentage (8% to 18.5%) perceived it as being much cheaper. A minority, ranging from 9% to 16.25%, indicated that they did not know the advantages. For 12th-grade students, similar trends were observed but with some variations. In districts like Mustamäe and Kesklinn, a notable percentage (25% to 37%) recognized that mRNA technology allows for faster vaccine production. The perception of it being more effective was also common, with 25% to 33% of students selecting this option. However, fewer students believed it is much cheaper, and a significant portion—up to 33% in some districts—expressed that they did not know. Overall, while a considerable number of both 10th and 12th-grade students are aware of certain advantages of mRNA technology, such as its effectiveness and quicker production capabilities, there remains a notable percentage who are either unaware or uncertain.



F: Figure 6: Obtaining information about COVID-19

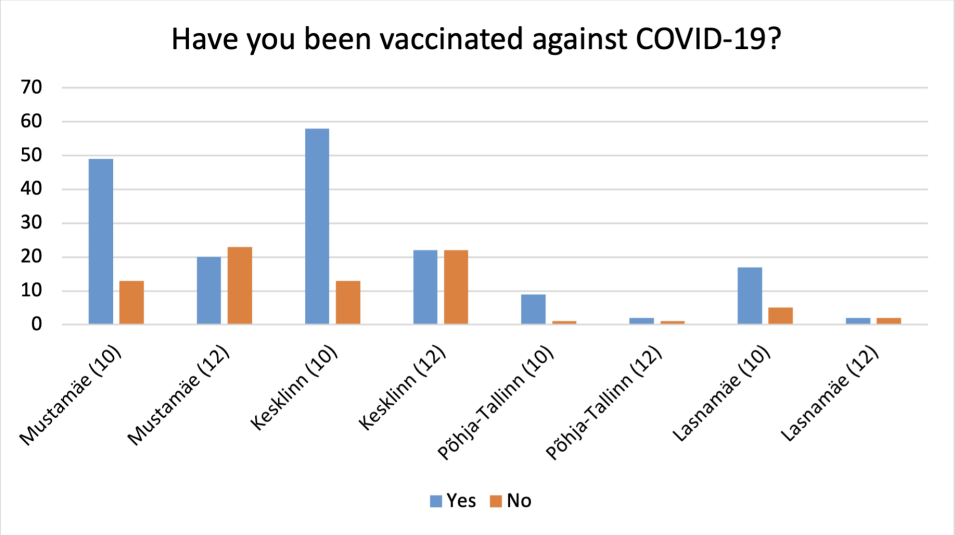
The following question was designed as a multiple-choice question, with students selecting from five options: "Television," "Social Media," "News Portals," "Friends," and "Family Members". The goal of this question was to either confirm or reject the hypothesis 3 (see Introduction). Among 10th-grade students, social media emerged as a leading source, particularly in Kesklinn District where 24% cited it. News portals were also significant, especially in Lasnamäe District where 26% of 10th-graders obtained information from them. Family members contributed notably to students' information, with percentages ranging from 19% to 23% among 10th-graders across districts. Television remained an important source, especially in Põhja-Tallinn District, where it was the top source for 10th-graders at 26% and even higher for 12th-graders at 43%. Friends were a less common source overall, generally cited by around 11% to 18% of students. Among 12th-grade students, social media and news portals continued to be significant, with social media being the top source in Kesklinn District at 29%. The data suggests that while traditional media like television still plays a role, digital platforms such as social media and news portals are increasingly influential among students, alongside information from family members.



G. Figure 7: How well do students know about the vaccination?

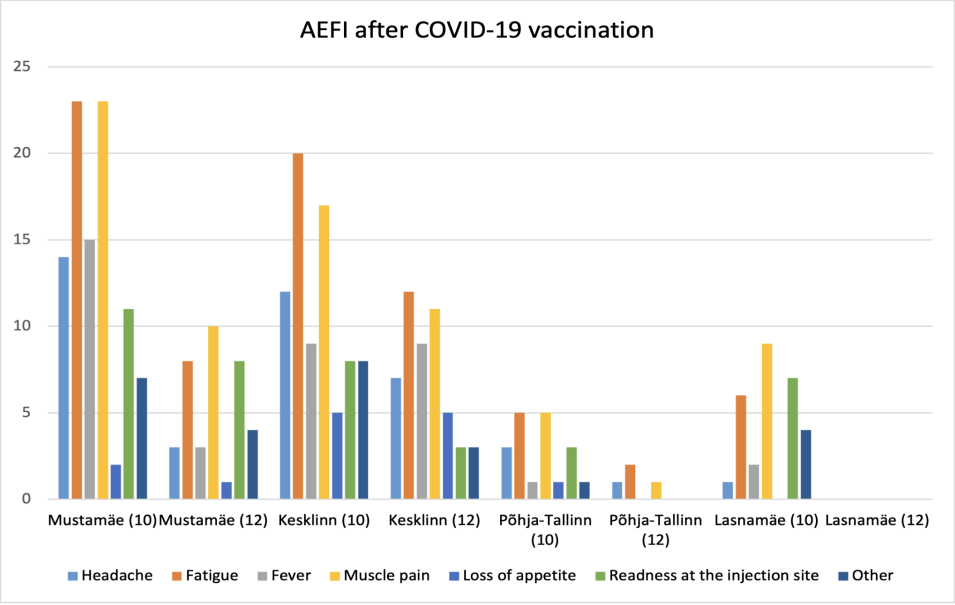
This question was designed with a scale, where each student selected a rating between 1 (I don't know at all) and 5 (I am fully informed). The scale included: 1 – I don't know at all, 2 – I know something, 3 – Some things are unclear, 4 – I am sufficiently informed, and 5 – I am fully informed.

The aim of this question was to either confirm or reject the hypothesis 3 (see Introduction). The majority of both 10th and 12th-grade students rated their knowledge in the mid-range, particularly at level 3 ("Some things are unclear"). For instance, in Mustamäe District, 37% of 10th-grade students and 56% of 12th-grade students selected rating 3. Similarly, in Kesklinn District, 45% of 10th-graders and 30% of 12th-graders rated themselves at level 3, though the 12th-graders also had significant percentages at levels 1 and 2. In Põhja-Tallinn District, 50% of 10th-grade students rated their knowledge as 4 ("I am sufficiently informed"), indicating higher confidence, while 12th-graders were evenly distributed among ratings 2, 3, and 4. Lasnamäe District's 10th-grade students predominantly rated their knowledge as 2 ("I know something") or 3, suggesting partial understanding with remaining uncertainties.



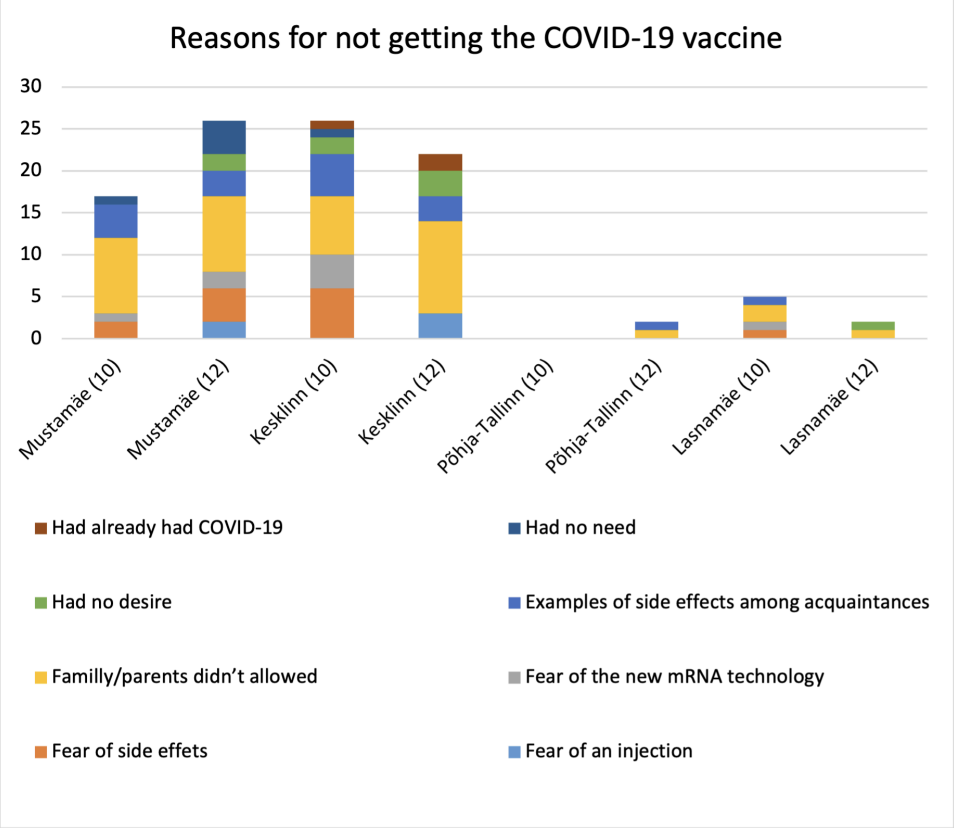
H. Figure 8: Vaccination rate

The aim of this question was to either confirm or reject the hypothesis. Across various districts, vaccination rates among 10th-grade students were consistently high, ranging from 77% to 90%. For instance, in Põhja-Tallinn District, 90% of 10th-graders had been vaccinated. In contrast, 12th-grade students exhibited lower vaccination rates, ranging from 47% to 67%, with Mustamäe District reporting only 47% of 12th-graders vaccinated. This trend suggests that younger students were more likely to be vaccinated than their older counterparts across all districts. These data are similar to the statistics across Estonia, as shown by the Health Board on their website "Coronavirus Statistics."



I. Figure 9: Causality assessment of an adverse event following immunization (AEFI)

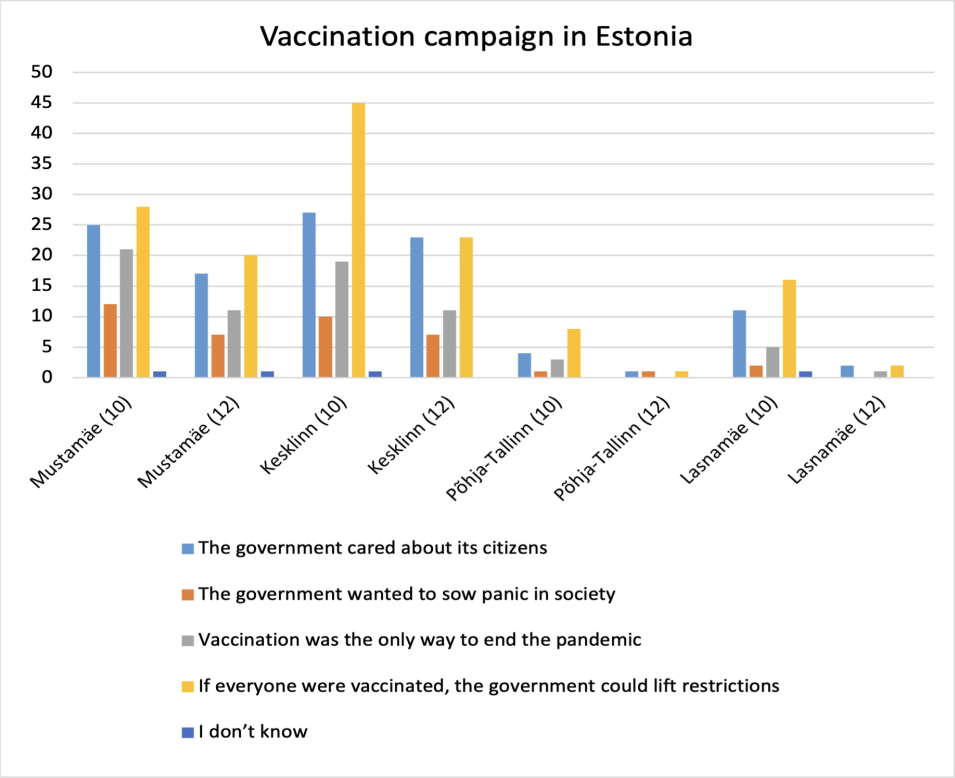
This question was directed to vaccinated students and was designed as a multiple-choice question where each student could select one or more of the six provided options: “Headache,” “Fatigue,” “Fever,” “Muscle pain,” “Loss of appetite,” and “Redness at the injection site,” plus the “Other” option. The author also analyzed the “Other” responses, which led to the following categories: “No side effects,” “I don’t know,” and “Special cases.” The aim of this question was to either confirm or reject the hypothesis 2 (see Introduction). Fatigue was reported by approximately 21% to 26% of 10th-grade students and up to 50% of 12th-grade students in some districts. Muscle pain was similarly prevalent, with reports ranging from 22% to 31% among 10th-graders and up to 27% among 12th-graders. Headaches and fevers were also noted, though less frequently, typically ranging from 3% to 16% among both grade levels. Redness at the injection site was reported by a notable percentage of students, varying between 10% and 24%. A smaller proportion of students experienced loss of appetite or reported no AEFI at all.



J. Figure 11. Reasons for Not Getting the COVID-19 Vaccine

Overall, the data indicate that the primary reason both 10th and 12th-grade

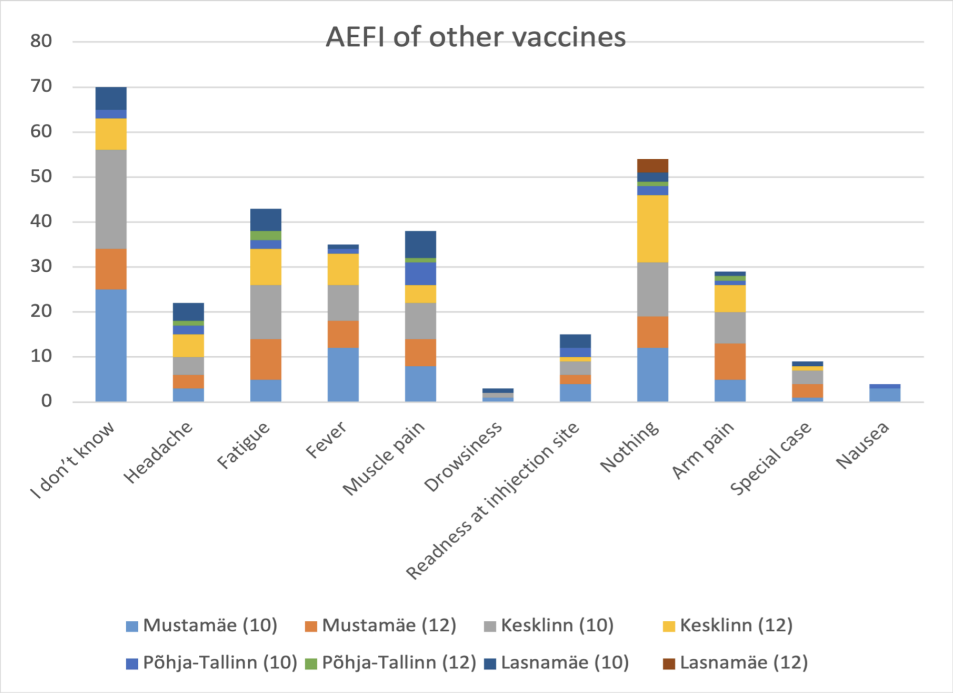
students chose not to be vaccinated was the disapproval of their family or parents. Among 10th-graders, nearly a third cited this as their main barrier (27%), followed by fear of side effects (18%), and learning of side effects from acquaintances (15%). Fear-based reasons, such as fear of injections (15%) and concern about the new mRNA technology (12%), were also present, though less prominent. Only small minorities simply did not want the vaccine (6%), felt they did not need it (1%), or had already recovered from the illness (1%). Among 12th-graders, parental disallowance was even more influential (32%), and while fear of side effects remained a significant concern (14%), other factors such as not needing the vaccine and concerns about technology or acquaintances' experiences were also noted, albeit at lower percentages. Overall, the findings suggest that family influence and apprehension about potential AEFI are key factors shaping students' vaccination decisions.



K. Figure 12. Evaluation of Government Actions

Among 10th graders, the most common belief was that widespread vaccination would enable the government to lift restrictions, followed by the sentiment that the government cared about its citizens. They were also somewhat likely to consider vaccination the only way to end the pandemic. Fewer students suspected the government's intention was to sow panic, and a very small number did not know what to think. Among 12th graders, opinions were more evenly split between believing that if

everyone were vaccinated, restrictions could be lifted and trusting that the government genuinely cared about its citizens. They were less inclined than 10th graders to see vaccination as the sole path to ending the pandemic or to think that the government wanted to stir up panic.



L. Figure 13. AEFI of Other Vaccines

Finally, students were asked to describe AEFI from other common vaccines. Their open-ended answers were grouped into categories such as general uncertainty ("Don't know"), common mild responses (headaches, fatigue, fever, muscle pain, drowsiness, redness at the injection site, arm pain, and nausea), as well as "nothing," "not vaccinated," and "special cases." This categorization will help in comparing students' reported experiences with the new COVID-19 mRNA vaccines to their broader vaccination history, offering insights into whether their perceptions of risks and AEFI are unique to COVID-19 vaccinations or consistent with their past experiences with other immunizations. Among 10th graders, uncertainty was common (26%), although many also indicated they had experienced no side effects (14%), fatigue (12%), or fever (12%). For 12th graders, an even larger share (22%) reported no side effects, with fewer expressing uncertainty (13%). When AEFI did occur, fatigue and fever were most frequently noted by 10th graders, while 12th graders often mentioned fatigue and arm pain. These patterns echo the findings of studies conducted by the Health Board on COVID-19 vaccines, suggesting that students' experiences with and perceptions of occurrences following immunization may be broadly consistent across different types of immunizations.

VI. Summary

The survey results from students in different areas of the city were as follows: in Mustamäe, 84% of 10th-grade students and 93% of 12th-grade students had COVID-19. In the city center (Kesklinn), 93% of 10th-graders and 85% of 12th-graders had COVID-19. In Põhja-Tallinn, 90% of 10th-graders and 33% of 12th-graders had COVID-19. In Lasnamäe, 91% of 10th-graders and 100% of 12th-graders had COVID-19. Based on these data, the highest percentage of 10th-grade students who had COVID-19 was in Kesklinn, while for 12th-grade students, this was the highest in Lasnamäe.

Regarding students' knowledge of mRNA in the 10th and 12th grades, the following results were found: in Mustamäe, 92% of 10th-graders and 77% of 12th-graders did not know what mRNA is; in Kesklinn, 82% of 10th-graders and 57% of 12th-graders did not know; in Põhja-Tallinn, 90% of 10th-graders and 100% of 12th-graders did not know; in Lasnamäe, 96% of 10th-graders and 50% of 12th-graders did not know. From this, we can see that most 10th-grade students in Kesklinn knew what mRNA is, whereas Lasnamäe had the lowest figure.

Data on students vaccinated against COVID-19 showed the following: in Mustamäe, 79% of 10th-grade students and 47% of 12th-grade students were vaccinated. In Kesklinn, 82% of 10th-graders and 50% of 12th-graders were vaccinated. In Põhja-Tallinn, 90% of 10th-graders and 67% of 12th-graders were vaccinated. In Lasnamäe, 77% of 10th-graders and 50% of 12th-graders were vaccinated. Thus, the vaccination rate was higher among 10th-grade students than among 12th-graders. Among vaccinated students, the most frequently reported side effects were as follows: in Mustamäe, the most common were fatigue (24%) and muscle pain (24%); in Kesklinn, fatigue (25%) and muscle pain (22%); in Põhja-Tallinn, fatigue (26%) and muscle pain (26%); and in Lasnamäe, muscle pain (31%) and fatigue (21%).

The results of the research showed that Tallinn students' awareness of mRNA vaccines was low, and the AEFI of vaccination were mainly fatigue and muscle pain. Parental refusal was the main reason why students were not vaccinated, and the information was primarily obtained from social media. The author believes that the research clearly shows how high school students are learning biology in school, as by the end of high school, biological knowledge increases fivefold compared to the 10th grade.

A. Hypothesis 1: "Over 60% of 10th and 12th-grade students in Tallinn are vaccinated"

10th grade: The hypothesis is confirmed, as in all districts, more than 60% of 10th-grade students were vaccinated (Mustamäe – 79%, Kesklinn – 82%, Põhja-Tallinn – 100%, Lasnamäe – 77%).

12th grade: The hypothesis is not confirmed, as the average percentage of vaccinated students across all districts was 53.5% (Mustamäe – 47%, Kesklinn – 50%, Põhja-Tallinn – 67%, Lasnamäe – 50%).

B. Hypothesis 2: "Under 40% of Tallinn students have experienced AEFI from vaccination according to their own assessment"

10th grade: The hypothesis is confirmed, as 93.5% of students reported AEFI.

12th grade: The hypothesis is confirmed, as 94% of students reported AEFI.

C. Hypothesis 3: "Under 40% of Tallinn 10th and 12th-grade students are aware of the use of mRNA technology in vaccines, and under 20% of Tallinn 10th and 12th-grade students understand what mRNA technology is"

10th grade: The hypothesis is confirmed, as 30% of 10th-grade students knew about the use of mRNA technology in vaccines, and 10% understood what mRNA technology is.

12th grade: The hypothesis is partially confirmed, as 36.05% of 12th-grade students knew about the use of mRNA technology in vaccines, and 54% understood what mRNA technology is.

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