



Evaluation of the effects of MERCK, MODERNA, PFIZER/BioNTech, and JANSSEN COVID-19 vaccines on vaccinated people: A metadata analysis[☆]

Nadia Al-Rousan^{a,*}, Hazem Al-Najjar^b

^a SEEIT, Computer Engineering Department, German Jordanian University, Amman, Jordan

^b Faculty of Information Systems, University of Petra, Amman, Jordan

ARTICLE INFO

Keywords:
Epidemiology
Symptoms
COVID-19
Vaccination
Data analysis

ABSTRACT

Purpose: This research investigates the impact of four specific vaccines on the health of people who have been vaccinated. The vaccines under scrutiny are MERCK, MODERNA, PFIZER BioNTech, and JANSSEN.

Methods: The analysis considers a range of variables, including symptoms, mortality status, gender, age, number of vaccine doses, hospitalization status, and the number of days following vaccination. The methodology involves cross-tabulation analysis to establish connections between vaccinated individuals and the variables under examination. The dataset was compiled from the Centers for Disease Control and Prevention, encompassing roughly 65,000 cases and documenting over 40 distinct symptoms.

Results: The overall mortality rate among the vaccinated population is noteworthy. Notably, 40 different mild to severe symptoms were reported among vaccinated individuals. The research highlights the 10 most common symptoms experienced after vaccination. Females under 60 years of age constitute the majority of the dataset.

Conclusions: The vaccination-related mortality rate stands at approximately 3 % of those who received the vaccine, with the majority of cases occurring among individuals under the age of 60, who were not hospitalized and had received their initial vaccine dose.

1. Introduction

Coronavirus disease (COVID-19) broke out in China towards the end of 2019 and was swiftly disseminated to various nations [1]. By December 31, 2019, the recorded count of confirmed cases stood at 27 [2], and it exponentially increased to more than 775 million cases globally by the end of May 2024, as shown in Fig. 1 [3]. The number of reported death cases is around 7 million [3,4].

Several symptoms experienced by COVID-19-infected patients have been reported. Flulike symptoms, a high fever, coughing, difficulty breathing, sore throat, fatigue, headaches, muscle aches, and runny noses are common symptoms of COVID-19 [5]. Several symptoms appeared only in COVID-19 patients, namely, nausea/vomiting, loss of taste/smell, diarrhea, hair loss, nose bleeds, trouble breathing, tiredness, and bluish face. All these symptoms were reported by the Centers for Disease Control and Prevention (CDC) [3,5].

Quarantines and vaccinations are the most effective ways to protect

people against COVID-19 [6,7]. Vaccinations help the body's immune system recognize and fight off COVID-19 [8]. Moreover, vaccines help the body develop defenses against COVID-19 [8,9]. More than 13 billion COVID-19 vaccine doses have been administered globally [3,4]. As shown in Fig. 2, 72 % of these cases have received at least one dose of a COVID-19 vaccine, while 66 % have been fully vaccinated against the disease [4].

Several companies have competed to develop and assess COVID-19 vaccines in preclinical trials and studies (Table 1) [9]. The procedures followed to develop COVID-19 vaccines can be classified into RNA-based, DNA-based, inactivated virus, non-replicating viral vector, protein subunit, and Virus-like particle (VLP) [10,11]. RNA-based vaccines (i.e., PFIZER/BioNTech, Moderna, and Curevac) directly deliver a messenger RNA (mRNA) to the body [12]. This mRNA can encode information in the body to produce an antigen, which is a protein from a pathogen [13]. This antigen stimulates the immune system to protect the body against COVID-19. Meanwhile, DNA-based vaccines (i.e., Cadila

[☆] Dr. Nadia and Dr. Hazem specialize in data analysis, artificial intelligence, and smart real-time applications. Dr. Nadia is classified as one of the top 10 women working in artificial intelligence in the world. She is an assistant professor in the Computer Engineering Department of German Jordanian University, Jordan. Dr. Hazem is an assistant professor in the Computer Science Department of the University of Petra, Jordan.

* Corresponding author.

E-mail address: nadia.rousan@yahoo.com (N. Al-Rousan).

<https://doi.org/10.1016/j.imu.2024.101564>

Received 11 June 2024; Received in revised form 26 July 2024; Accepted 26 July 2024

Available online 30 July 2024

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Healthcare and Osaka University/Takara Bio) directly inject plasmids containing the antigen-encoding DNA sequence into the appropriate tissues [14].

One of the most popular procedures for developing vaccines is to inject the body with an inactivated virus (i.e., Sinovac, Sinopharm, Biotech, Chinese Academy of Medical Sciences, and the Research Institute for Biological Safety Problems) [12]. In contrast, some vaccines have been developed by injecting only the antigenic parts of the pathogen (protein subunit) (i.e., Novavax, Anhui Zhifei Longcom Biopharmaceutical, and Clover Biopharmaceuticals Inc./GSK/Dynavax) [12, 15]. Some companies used live attenuated viruses derived from COVID-19 that had been weakened in the laboratory [14]. The non-replicating viral vector is another common method used to develop COVID-19 vaccines (i.e., Gamaleya Research Institute, Beijing Institute of Biotechnology, AstraZeneca, and J&J Pharmaceutical Companies) [15,16].

Some vaccines were approved and licensed by the CDC (i.e., PFIZER/BioNTech, MODERNA, MERCK, AstraZeneca, and J&J) [13,17] due to their level of safety and efficiency in preventing COVID-19 and protection people against it [8,18,19]. Moreover, several studies have shown that vaccination could reduce the severity of illnesses caused by COVID-19 [18].

However, COVID-19 vaccination may cause side effects [20] as the body protects itself against the injected pathogen [21]. Some people have rare allergic reactions and, thus, do not show any symptoms, whereas some symptoms may continue for a few days or longer in some cases [22]. Moreover, several local reactions have been reported (i.e., redness, pain, and swelling at the injection site), and various systemic reactions have been recorded, such as fever, fatigue, joint pain, and muscle pain [23]. These results were presented in a study conducted among 622 participants aged 17 and older in Italy to assess various side effects of Pfizer/BioNTech and Moderna vaccines. This study revealed that reactions are generally mild, with moderate and severe reactions being less common. The study also revealed an increase in lymphadenopathy following the booster in the primary vaccination series while other reactions like malaise, fatigue, and headache were reported less frequently.

However, factors such as prior SARS-CoV-2 infection and seasonal influenza vaccination influence the occurrence of adverse events, with reporting higher frequencies of side effects. These findings suggest that

the booster doses of these mRNA vaccines predominantly cause transient symptoms aligning with existing safety data and providing reassurance regarding the lack of serious or unexpected adverse events [23]. Therefore, the United States Food and Drug Administration (FDA) has collected data on each of the authorized COVID-19 vaccines to continue monitoring the safety of COVID-19 vaccines [22]. According to the CDC and FDA, several symptoms were recorded globally (i.e., headache, chills, fatigue, nausea, dizziness, injection site reactions, erythema, myalgia, rash, and arthralgia) [13,24]. Some cases of very rare side effects (i.e., colitis, gout, eye inflammation, and paralysis) have been reported [25,26].

The Pfizer/BioNTech, Moderna, and J&J vaccines were approved for use in the United States [27], and the CDC has highly recommended the Pfizer/BioNTech and Moderna vaccines to all other countries [28]. The Pfizer/BioNTech vaccine received full approval from the FDA in August 2021, and its marketing name is Comirnaty [29]. Table 2 shows a comparison between the symptoms of Pfizer/BioNTech, Moderna, MERCK, and J&J vaccines.

As shown in the table, the number of doses that should be given for each vaccine varies from one dose for the J&J vaccine to two doses for the Pfizer/BioNTech, Moderna, and MERCK vaccines [27]. Symptoms' locations differed from one vaccine to another. The Pfizer/BioNTech vaccine caused fatigue, headache, chills, and muscle pain, especially after the second dose [30], while Moderna caused fever, muscle aches, and headaches lasting a few days (also especially after the second dose) [31]. The Merck vaccine caused nausea, vomiting, constipation, and injection site pain and reactions [32], while the J&J vaccine caused injection site pain, headache, fatigue, and muscle pain [33]. The percentage of people protected against any infection caused by the vaccines are 95 %, 94.1 %, 84 %, and 66.1 % for Pfizer/BioNTech, Moderna, MERCK, and J&J, respectively [34].

Some significant side effects were recorded globally. Both Pfizer/BioNTech and Moderna were associated with extremely rare cases of anaphylaxis and Bell's palsy, which is a type of temporary facial paralysis [35]. The J&J vaccine caused blood clots with low platelets and thrombocytopenia [35,36]. Moreover, several claims ensured that the Pfizer/BioNTech, Moderna, and Merck vaccines could integrate themselves into the DNA of the patient and alter it [37]. Therefore, the FDA has issued a warning about heart inflammation for both the Pfizer/BioNTech and Moderna vaccines, as more than 1000 reports of

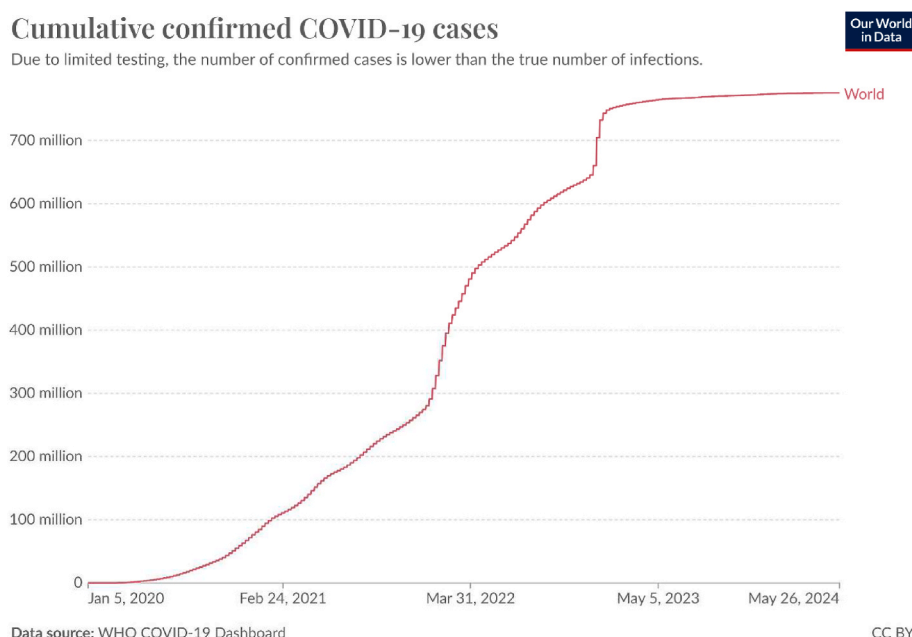


Fig. 1. Number of confirmed COVID-19 cases globally [4].

myocarditis and pericarditis have been reported in both vaccines [38, 39]. The FDA has also issued a serious warning about an increased risk of developing Guillain-Barre syndrome associated with the J&J and AstraZeneca vaccines, as well as risks associated with receiving the Merck vaccine during pregnancy [40–43].

The main aim of the present study is to confirm the validity of various claims about COVID-19 vaccinations by assessing the effects and symptoms of the Pfizer/BioNTech, Moderna, MERCK, and J&J vaccines on vaccinated people according to their metadata (i.e. sex and age, etc.). Crosstabulation analysis was used to connect vaccinated people and the variables of interest: namely, symptoms, death, sex, age, number of doses, hospitalization status, and number of days after the vaccination.

To the best of our knowledge, there is a lack of understanding of the relationship between the metadata of the vaccinated people and the symptoms that occurred after the vaccination, and no studies have used crosstabulation analysis to assess these relationships. Given that the investigation into this topic is still new and needs further attention, the present study will aid the current understanding of different developed vaccines and help people make decisions about the vaccination procedure.

2. Methods

The dataset was collected from the World Health Organization (WHO) and preprocessed to remove unnecessary data. The preprocessing method retained only five types of COVID-19 vaccines: MERCK, MODERNA, PFIZER_BioNTech, J&J, and one produced by an unknown manufacturer. For each patient in the dataset, a unique ID was used to differentiate between different patients. In addition, each patient was associated with one or more symptoms (independent variables). The collected symptoms included age, sex, headache, chills, fatigue, nausea, dizziness, injection site erythema, myalgia, rash, arthralgia, pruritus, vomiting, hypoaesthesia, lymphadenopathy, urticaria, diarrhea, asthenia, malaise, hyperhidrosis, cough, heart rate increased, tremor, blood pressure, tachycardia, musculoskeletal, migraine, anxiety, stiffness, syncope, dysgeusia, vision blurred, insomnia, eye pain, nasopharyngitis, seizure, eye pruritus, Bell's palsy, dyspepsia, deafness, myocardial infarction, colitis, gout, eye infection, and palsy. Moreover, test positive after the vaccination process (test positive) variable, incorrect dose administration, poor-quality product administered

(PQPA), vaccine lot, vaccine site, and vaccine dose are important variables in the collected data. Moreover, different notes are provided for each patient to show the patient-specific updates including death status, stay in a hospital, and historical data.

All the variables mentioned above are used to identify the side effects of various vaccines and the most common symptoms occurring after the vaccination process. The data contains 63,727 samples from 11 vaccine sites in the US. The dataset contains other vaccines that were excluded from the test. Before the dataset was analyzed, a filtering process was used to remove outliers from the dataset. Statistical analysis and cross-tabulation were used to analyze the vaccine dataset and understand the effect of each vaccine on various symptoms, patients' metadata, and other metrics. Statistical analysis was used to show the complexity of the dataset and the variation within it. Cross-tabulation was used to study the relationship between one independent variable and one dependent variable to determine the movement of the dependent variable based on the independent variables. The following tests were considered to explore the impacts of the vaccinations on patients' bodies:

1. **The common symptoms test:** This test determines the symptoms that are relevant to each patient after vaccination. Only the most common symptoms are selected after all patients are analyzed. The test is intended to find the most important symptoms of each vaccine and extract the most effects on the patient's body. Finally, the test identifies the noteworthy side effects of each vaccine and the safest vaccine based on the symptoms.
2. **Gender and age test:** This test determines which gender and age group most often received each vaccine.
3. **Death test:** This test determines the death rate associated with each vaccine and identifies the vaccine with the highest death rate.
4. **Death rate and age test:** This test determines the death rate based on two age categories (60 and older than 60, and younger than 60). This test will clarify each vaccine's benefits to older people.
5. **Death rate and on set date:** The test shows the death rate using the first nine days from the date of the vaccine. The test takes zero to nine days and calculates the death rate among vaccinated people.
6. **Death rate and hospital admission:** This test shows the relationship between the death rate and hospital admission. The test clarifies whether hospital treatment decreases the COVID-19 death rate.

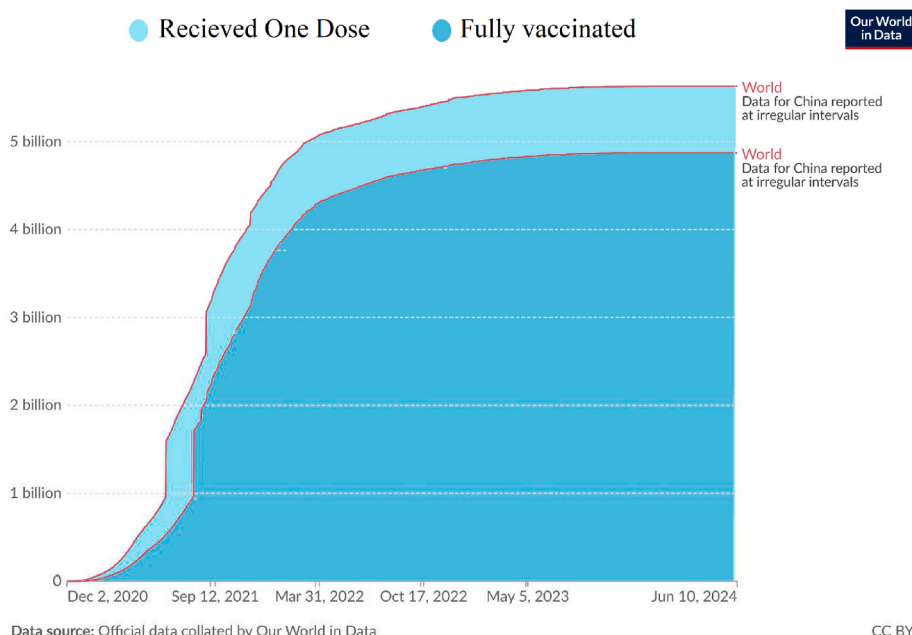


Fig. 2. Number of vaccinated COVID-19 cases globally.

7. Death rate and number of vaccine doses: This test shows the number of doses taken before death to elucidate the effects of the first and second doses.

Overall, the tests are intended to explore the effects of different vaccines on vaccinated people. This study attempts to determine the most appropriate vaccine based on various analytical experiments.

3. Results

This section explains the analytical experiments that were conducted to study the effects of four COVID-19 vaccines on vaccinated people. The study considers vaccines developed by MERCK, MODERNA, PFIZER_BioNTech, J&J, and an unknown manufacturer.

4. Dataset statistical analysis

The first step in understanding the dataset is to study the statistical analysis. For brevity, only the overall analysis for all the vaccines is presented. The results in Table 3 show variation in the vaccines' symptoms. The top 10 symptoms are headache, chills, fatigue, nausea, dizziness, injection site, erythema, myalgia, rash, and arthralgia. Meanwhile, colitis, gout, eye inflammation, and paralysis were rarely noticed after the vaccination process. One or more symptoms may appear after vaccination, depending on the vaccinated person and the vaccine. Moreover, many people either exhibited no symptoms or their symptoms were not recorded. There were 581 deceased cases after the vaccine across all the vaccines in the dataset, which represents less than 1 % of all vaccinated people. The percentage of positive test cases (2.12 %) was low compared to the total number of vaccinated cases.

The studied vaccines (J&J, MERCK, MODERNA, PFIZER_BioNTech, and UNKNOWN MANUFACTURER) are shown in Table 4. The total numbers of vaccinated people using the studied vaccines are 2964, 84, 33,056, 27,448, and 175, respectively. The analysis showed that Moderna and Pfizer/BioNTech are the dominant vaccines on the list; MERCK & CO. INC is rare in the dataset. The results indicate that many people experience different mild to severe post-vaccination symptoms from symptoms based on the vaccine and the vaccinated people.

5. The common symptoms test

Vaccinated people need to understand the expected symptoms of vaccinations so that they can decide how to treat them. In this test, all the symptoms of the vaccines were compared to find the most important symptoms. A cross-tabulation analysis was used to find the relationship between vaccines and symptoms (Table 5). For brevity, Table 5 only shows symptoms that affected more than 1 % of the vaccinated people. The symptoms that are not included are migraine, anxiety, stiffness, syncope, dysgeusia, vision blurred, insomnia, eye pain, incorrect dose administered, nasopharyngitis, seizure, eye pruritus, Bell's palsy, dyspepsia, deafness, myocardial infarction, colitis, gout, eye infection,

and palsy.

The most common symptoms in people vaccinated with the J&J vaccine are headache, chills, nausea, fatigue, dizziness, vomiting, rash, blood pressure, migraine, cough, fainting, and anxiety (40.6 %, 39.8 %, 19.1 %, 19.0 %, 7.7 %, 5.1 %, 4.8 %, 2.5 %, 2.3 %, 2.0 %, 1.1 %, and 1.0 %, respectively). The most common symptoms in people vaccinated with the MERCK vaccine are rash, deafness, and headache (8.3 %, 6.0 %, and 3.6 %, respectively). Chills, fatigue, dizziness, vomiting, syncope, malaise, seizure, tremor, injection site erythema, hypoesthesia, nausea, anxiety, insomnia, pruritus, asthenia, and hyperhidrosis were observed in 1.2 % of cases.

The most common symptoms in people vaccinated with the Moderna vaccine were headache, chills, injection site erythema, fatigue, nausea, dizziness, rash, myalgia, pruritus, arthralgia, vomiting, urticaria, and PQPA (17.0 %, 12.9 %, 12.7 %, 12.4 %, 10.0 %, 8.3 %, 7.0 %, 6.2 %, 5.9 %, 4.8 %, 3.8 %, 3.6 %, and 3.4 %, respectively). The most common symptoms in people vaccinated with the Pfizer/BioNTech vaccine were headache, chills, fatigue, nausea, dizziness, myalgia, arthralgia, rash, test positive, pruritus, hypoesthesia, malaise, lymphadenopathy, vomiting, asthenia, and diarrhea (21.4 %, 16.5 %, 15.2 %, 10.9 %, 9.1 %, 7.9 %, 6.0 %, 4.9 %, 4.0 %, 4.0 %, 3.8 %, 3.8 %, 3.7 %, 3.5 %, 3.1 %, and 3.1 %, respectively).

Finally, the most common symptoms for the vaccine produced by the unknown manufacturer were headache, chills, nausea, fatigue, arthralgia, vomiting, myalgia, rash, and coughing (10.2 %, 9.7 %, 8.0 %, 7.4 %, 6.3 %, 5.1 %, 4.5 %, 4.0 %, and 3.4 %, respectively). The results show that the 10 most common symptoms, when considering all vaccines (from most to least common) are headache, chills, fatigue, nausea, dizziness, injection site erythema, myalgia, rash, arthralgia, and pruritus.

The results indicate that not all vaccinated people had symptoms. The J&J, Merck, Moderna, Pfizer/BioNTech, and unknown vaccines resulted in no symptoms in 25.9 %, 75.0 %, 34.7 %, 37.2 %, and 59.1 % of the vaccinated people, respectively. Furthermore, the results revealed that 35 % of all vaccinated people had no symptoms. This indicates that side effects may differ based on human records and history.

6. Gender and age test

The analysis of the gender data showed three categories: undefined, male, and female (Table 6). The percentages of the vaccination process for J&J, MERCK, MODERNA, PFIZER_BioNTech, UNKNOWN MANUFACTURER are 0.6 %, 42.9 %, 5.6 %, 2.9 %, and 7.4 % for undefined cases; 28.5 %, 27.4 %, 20.8 %, 22.7 %, and 34.1 % for males; and 70.9 %, 29.8 %, 73.6 %, 74.4 % and 58.5 % for females, respectively. More than 70 % of the subjects vaccinated with J&J, MODERNA, and PFIZER_BioNTech were female. The overall results indicate that the majority of the vaccinated people were female.

In addition, the age of the vaccinated varied, and the study divided people based on their age into three groups: younger than 60 years, older than 60 years, and unknown (Table 7). The results for the J&J,

Table 1
Types of COVID-19 vaccines.

Vaccine Type					
Developed by/ researcher	RNA-Based	DNA-Based	Inactivated Virus	Non-Replicating Viral Vector	Protein Subunit
	BioNTech/Fosun	Cadila Healthcare Ltd.	Sinovac	Gamaleya Research Institute/ Health Ministry Russia	Novavax
	Pharma/Pfizer	Osaka University/ AnGes/Takara Bio	Beijing Institute of Biological Products/Sinopharm	CanSino Biological Inc./Beijing Institute of Biotechnology	Anhui Zhifei Longcom Biopharmaceutical
	Moderna/NIAID		Wuhan Institute of Biological Products/Sinopharm	University of Oxford/ AstraZeneca	Clover Biopharmaceuticals Inc./GSK/Dynavax
	Curevac		Bharat Biotech Chinese Academy of Medical Sciences Research Institute for Biological Safety Problems, Rep. of Kazakhstan	J&J Pharmaceutical Companies	

Table 2
Comparison of the Side Effects of the Pfizer/BioNTech, Moderna, MERCK, and J&J vaccines.

Vaccine developer	Pfizer/BioNTech	Moderna	MERCK	J&J
Number of Doses	Two doses, three weeks apart	Two doses, 4 weeks apart	Two doses, 2–4 weeks apart	One dose
Symptoms after vaccination	Fatigue, headache, chills, and muscle pain, especially after the second dose	Fever, muscle aches, headaches lasting a few days. Effects are worse after the second dose.	Nausea, vomiting, and constipation. Injection site pain and injection site reactions.	Pain at the injection site, headache, fatigue, and muscle pain.
Warnings	The FDA issued a warning about heart inflammation. Since April 2021, there have been more than 1000 reports of myocarditis and pericarditis.	The FDA issued a warning about heart inflammation. Since April 2021, there have been more than 1000 reports of myocarditis and pericarditis.	The FDA issued a warning about risks during pregnancy.	The FDA issued a warning about an increased risk of developing Guillain-Barre syndrome and thrombocytopenia
Percentage of people protected from getting infected in clinical studies	95 %	94.1 %	84 %	66.1 % globally; 72 % in the U.S.; 86 % effective against severe disease
Significant side effects	Extremely rare cases of anaphylaxis and Bell’s palsy, a type of temporary facial paralysis.	Extremely rare cases of anaphylaxis and Bell’s palsy, a type of temporary facial paralysis.	The drug could integrate itself into patients’ DNA and alter it.	Blood clots with low platelets may occur.

Table 3
Symptoms and data analysis for the collected dataset.

Symptom	Sum	Symptom	Sum	Symptom	Sum
Headache	11,577	Malaise	1702	Vision blurred	337
Chills	8865	Hyperhidrosis	1417	Insomnia	324
Fatigue	8349	Test positive	1354	Eye pain	200
Nausea	6340	Cough	1296	Incorrect dose administered	198
Dizziness	5252	PQPA	1136	Nasopharyngitis	179
Injection site Erythema	4710	Heart rate increased	1129	Seizure	167
Myalgia	4234	Tremor	912	Eye pruritus	142
Rash	3689	Blood pressure	875	Bell’s palsy	131
Arthralgia	3265	Tachycardia	859	Dyspepsia	98
Pruritus	3078	Musculoskeletal	630	Deafness	80
Vomiting	2258	Death	581	Myocardial infarction	42
Hypoaesthesia	1985	Migraine	580	Colitis	12
Lymphadenopathy	1982	Anxiety	558	Gout	8
Urticaria	1977	Stiffness	509	Eye infection	5
Diarrhea	1758	Syncope	466	Palsy	3
Asthenia	1719	Dysgeusia	398		

Table 4
The studied vaccine types.

Vaccine Type	Frequency	Percent	Valid Percent	Cumulative Percent
J&J	2964	4.7	4.7	4.7
MERCK	84	0.1	0.1	4.8
MODERNA	33,056	51.9	51.9	56.7
PFIZER_BioNTech	27,448	43.1	43.1	99.7
UNKNOWN MANUFACTURER	175	0.3	0.3	100.0
Total	63,727	100.0	100.0	

MERCK & CO. INC, MODERNA and PFIZER_BioNTech vaccines show that no more than 25 % of vaccinated people are over 60 years old, as the percentage of people under 60 years of age differs from the same vaccines. The proportions of people under 60 years of age who received the J&J, MERCK, MODERNA, and PFIZER_BioNTech vaccines are 76 %, 11 %, 65 %, and 64 %, respectively. Less than 11 % of the people who received each vaccine were of an unknown age, except for the MERCK vaccine (72.6 %). The unknown vaccine results show that the percentages for people older than 60, younger than 60, and of an unknown age are 39 %, 32 %, and 29 %, respectively. The overall results show that the percentages of people younger than 60 years, older than 60 years, and of an undefined age are 26 %, 65 %, and 8.9 %, respectively. The results

indicated that the percentage of vaccinated people younger than 60 years is very high compared to those older than 60 years.

7. Death rate test

After the vaccination process, the medical protocol requires vaccinated people to remain in the vaccinated area for a few minutes so that can receive assistance in case of an emergency. The current protocol attempts to record the status of vaccinated persons only at the vaccination site without looking at their condition afterward. Unfortunately, many cases were recorded as deceased after the vaccination process.

In the death rate test, the effect of vaccines on the death of vaccinated people was studied to determine the relationship between the vaccine received and other metadata of vaccinated people (i.e., age and gender). Table 8 shows the percentages of deaths for different vaccines. The results show that the death rates for J&J, MERCK, MODERNA, PFIZER_BioNTech, and UNKNOWN MANUFACTURER are 0.3 %, 6.0 %, 2.8 %, 3.1 %, and 21.0 %, respectively. The results indicate that the J&J vaccine had the lowest death rate, whereas the unknown manufacturer’s vaccine had the largest death rate. MERCK showed a higher death rate than the MODERNA and PFIZER_BioNTech vaccines. The overall results show that the overall death rate for all the vaccines is less than 3 %.

In addition, the death rate is correlated with the age of the vaccinated people. Therefore, the study divided people into three groups based on their age: younger than 60 years, older than 60 years, and unknown (Table 9). The death rate ranges for those older than 60, younger than 60, and of an unknown age are 14–31 %, 13%–77 %, and 1%–32 %, respectively.

The unknown vaccine was associated with the highest percentage (31 %) of death cases for people older than 60 years, whereas MERCK showed the lowest percentage (13 %). For patients younger than 60 years, J&J was associated with the highest percentage of death cases (77 %), whereas MERCK showed the lowest percentage (13 %). MODERNA and PFIZER_BioNTech were associated with a very high percentage of deaths (i.e., 66 %) for people younger than 60 years. For the unknown age category, MERCK and J&J were associated with the highest (73 %) and the lowest (1 %) percentages of deaths, respectively. For MODERNA, PFIZER_BioNTech, and unknown vaccines, the death rates were 8 %, 11 %, and 32 %, respectively.

The overall results show that the death rate for vaccinated people younger than 60 years is very high compared with those older than 60 years (97.4 % of the total number of deaths), whereas unknown vaccines showed a death rate below 0.2 %. The results indicate that people under the age of 60 who are vaccinated have a higher risk of death than people over the age of 60.

After the vaccination process, people who have been vaccinated may

Table 5
The most common symptoms observed after COVID-19 vaccination.

Symptoms	JANSSEN	MERCK & CO. INC.	MODERNA	PFIZER_BioNTech	UNKNOWN MANUFACTURER	Total
Headache	40.6 %	3.6 %	17.0 %	21.4 %	10.2 %	20.1 %
Chills	39.8 %	2.4 %	12.9 %	16.5 %	9.7 %	15.8 %
Fatigue	19.0 %	2.4 %	12.4 %	15.2 %	7.4 %	13.9 %
Nausea	19.1 %	1.2 %	10.0 %	10.9 %	8.0 %	10.8 %
Dizziness	7.7 %	2.4 %	8.3 %	9.1 %	2.3 %	8.5 %
Injection Site erythema	0.0 %	2.4 %	12.7 %	1.8 %	1.1 %	7.3 %
Myalgia	0.3 %	0.0 %	6.2 %	7.9 %	4.5 %	6.6 %
Rash	4.8 %	8.3 %	7.0 %	4.9 %	4.0 %	6.0 %
Arthralgia	0.0 %	0.0 %	4.8 %	6.0 %	6.3 %	5.1 %
Pruritus	0.0 %	1.2 %	5.9 %	4.0 %	2.8 %	4.8 %
Vomiting	5.1 %	2.4 %	3.8 %	3.5 %	5.1 %	3.8 %
Hypoesthesia	0.0 %	2.4 %	2.8 %	3.8 %	1.7 %	3.1 %
Lymphadenopathy	0.0 %	0.0 %	2.8 %	3.7 %	2.3 %	3.1 %
Urticaria	0.2 %	0.0 %	3.6 %	2.9 %	1.1 %	3.1 %
DIED	0.3 %	6.0 %	2.8 %	3.1 %	21.0 %	2.9 %
Diarrhea	0.0 %	0.0 %	2.7 %	3.1 %	2.3 %	2.7 %
Asthenia	0.0 %	1.2 %	2.6 %	3.1 %	1.7 %	2.7 %
Malaise	0.9 %	2.4 %	2.0 %	3.8 %	2.3 %	2.7 %
Hyperhidrosis	0.0 %	1.2 %	2.2 %	2.5 %	1.7 %	2.2 %
Test positive	0.0 %	0.0 %	0.7 %	4.0 %	0.6 %	2.1 %
Cough	2.0 %	0.0 %	1.8 %	2.5 %	3.4 %	2.1 %
PQPA	0.0 %	0.0 %	3.4 %	0.0 %	0.0 %	1.8 %
Heart rate increased	0.0 %	0.0 %	1.7 %	2.1 %		1.8 %
Tremor	2.5 %	0.0 %	1.2 %	1.7 %	1.7 %	1.5 %
Blood pressure	0.4 %	2.4 %	1.4 %	1.6 %	1.1 %	1.4 %
Tachycardia	0.6 %	0.0 %	1.2 %	1.7 %	0.0 %	1.4 %
Musculoskeletal	2.3 %	0.0 %	0.9 %	1.0 %	0.6 %	1.0 %

Table 6
The genders of vaccinated people who received different vaccines.

	JANSSEN	MERCK & CO. INC.	MODERNA	PFIZER_BioNTech	UNKNOWN MANUFACTURER	Total
Undefined	0.60 %	42.90 %	5.60 %	2.90 %	7.40 %	4.20 %
Male	28.5 %	27.4 %	20.8 %	22.7 %	34.1 %	22.1 %
Female	70.9 %	29.8 %	73.6 %	74.4 %	58.5 %	73.7 %

Table 7
Number of Vaccinated People Older than and Younger than 60 years.

	JANSSEN	MERCK & CO. INC.	MODERNA	PFIZER_BioNTech	UNKNOWN MANUFACTURER	Overall
Older than 60	23 %	17 %	28 %	25 %	39 %	26 %
younger than 60	76 %	11 %	65 %	64 %	32 %	65 %
Unkown	1 %	73 %	8 %	11 %	29 %	8.9 %

Table 8
Death rate of people who received different vaccines.

Vaccine	JANSSEN	MERCK & CO. INC.	MODERNA	PFIZER_BioNTech	UNKNOWN MANUFACTURER	Overall
Death Rate	0.30 %	6.00 %	2.80 %	3.10 %	21.0 %	2.90 %

Table 9
Death rates of vaccinated people based on age.

	JANSSEN	MERCK & CO. INC.	MODERNA	PFIZER_BioNTech	Unknown	Overall
Older than 60	22 %	14 %	26 %	23 %	31 %	2.4 %
Younger than 60	77 %	13 %	66 %	66 %	37 %	97.4 %
Unknown	1 %	73 %	8 %	11 %	32 %	0.2 %

or may not have some symptoms, while other people may die on the same day as the vaccination or several days later. This study focused on the first nine days after the vaccination to identify the most critical period. For the J&J vaccine, the majority of deaths occurred one day after the vaccination process, and the death rate was 55.6 %. The rest of the deaths occurred between two and six days after vaccination. For the MERCK vaccine, only 20 % of deaths occurred after the first day, with

the remaining cases occurring nine days after vaccination. For the MODERNA, PFIZER_BioNTech, and UNKNOWN MANUFACTURER vaccines, the majority of deaths (71 %, 66 %, and 54 %, respectively) occurred between zero and nine days. Finally, 80 % of deaths occurred between zero and nine days from the date of vaccination. As shown in [Table 10](#), the majority of deaths for all the vaccines occurred nine days after the vaccination, which can encourage vaccinated people to follow

Table 10
The relationship between death cases and number of days after vaccination.

Vaccination		NUMDAYS									
		0	1	2	3	4	5	6	7	8	9
JANSSEN	% DIED	0 %	55.6 %	0 %	22.2 %	11.1 %	0 %	11.1 %	0 %	0 %	0 %
MERCK & CO. INC.	% DIED	0 %	20.0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
MODERNA	% DIED	15.0 %	21.7 %	9.9 %	5.70 %	4.20 %	4.10 %	1.90 %	4.30 %	1.50 %	2.90 %
PFIZER_BioNTech	% DIED	15.9 %	17.0 %	7.80 %	6.00 %	5.70 %	3.50 %	3.10 %	2.60 %	2.30 %	2.40 %
UNKNOWN MANUFACTURER	% DIED	13.5 %	16.2 %	13.5 %	5.40 %	2.70 %	0 %	0 %	0 %	2.70 %	0 %

up at this time.

Hospitalization is an important factor in understanding the severity of the condition of vaccinated people after the vaccination process. The results show that the death rates among subjects vaccinated with J&J, MERCK, MODERNA, PFIZER_BioNTech, UNKNOWN MANUFACTURER vaccines are 4.3 %, 0 %, 6 %, 7 %, and 12 %, respectively (Table 11). For unvaccinated people, these percentages are 96 %, 100 %, 94 %, 93 %, and 88 %, respectively. The results show that the majority of deaths among vaccinated individuals occurred without prior hospitalization. This finding indicates that these vaccinated people did not present severe symptoms or complications that necessitated hospital admission. This suggests that the progression to a fatal outcome was rapid or that the symptoms were not recognized as severe enough to warrant immediate medical intervention. This highlights a potential gap in the early detection and management of adverse reactions in vaccinated people, underscoring the need for post-vaccination monitoring in addition to medical responses to symptoms that may initially appear mild but could escalate quickly.

The World Health Organization has suggested that one dose is not enough to protect against COVID-19. This test examines the death rate by considering the number of doses (Table 12). This test aims to determine the effect of the number of doses on the death rate. For the J&J and MODERNA vaccines, the death rates were very high after the first dose (about 78 % and 75 % respectively). Moreover, the other vaccines were associated with lower death rates with both the second and unknown doses (22 % and 23 %, respectively). For the PFIZER_BioNTech vaccine, the death rates after the first, second, and unknown doses are 54 %, 32 %, and 15 %, respectively. The unknown vaccine presented a different pattern than PFIZER_BioNTech, with death rates of 24 %, 14 %, and 62 %, respectively. Meanwhile, no information about the number of MERCK doses was provided. Finally, for the J&J, MODERNA, and PFIZER_BioNTech vaccines, the death rate is higher than 50 % after the first dose; the percentage becomes lower after subsequent doses.

8. Discussion

The COVID-19 pandemic has spread across the globe, causing damage to various sectors. To stop the spread and fight the virus, the World Health Organization has proposed the use of different vaccines after the required permissions have been obtained. A preliminary analysis of COVID-19 symptoms, gender, and age showed variance among vaccinated people. The majority of vaccinated people showed different symptoms, and the majority of vaccinated subjects were females under 60 years of age. The three most common symptoms were headache, chill, and fatigue. Moreover, many people took different numbers of doses.

After the vaccination process, vaccinated people suffered from different side effects, and less than 3 % of the vaccinated people died

Table 11
The relationship between death cases and hospitalization.

	JANSSEN	MERCK & CO. INC.	MODERNA	PFIZER_BioNTech	UNKNOWN MANUFACTURER
Admitted	4.3 %	0 %	6 %	7 %	12 %
Not Admitted	96 %	100 %	94 %	93 %	88 %

Table 12
The relationship between death cases and the number of vaccine doses.

	VAX_DOSE_SERIES		
	1	2	UNK
JANSSEN	77.8 %	0 %	22.20 %
MERCK & CO. INC.	0.00 %	0.00 %	100.00 %
MODERNA	74.8 %	11.2 %	14.0 %
PFIZER_BioNTech	53.7 %	31.3 %	15.0 %
UNKNOWN MANUFACTURER	24.3 %	13.5 %	62.2 %

after the first or second dose. The results indicated that the majority of deaths occurred after the first dose. In addition, minor deaths cases needed to be admitted to the hospital, and the majority of them died without being hospitalized. Those who died because of the vaccine were younger than 60 years old, which indicates that younger people are at risk because of the vaccine. Moreover, the results show that the first three days after the vaccination are very important in determining the status of vaccinated people.

Recent findings also extend to pediatric populations, among which vaccination strategies have been pivotal in safeguarding children and adolescents against COVID-19. Emerging data shows varying immune responses and potential side effects among younger age groups, necessitating tailored vaccination approaches. While adverse effects are rare, ongoing surveillance is crucial to comprehensively evaluate the long-term safety and efficacy of pediatric vaccination campaigns [44].

Incorporating these pediatric insights enhances the general understanding of vaccine impacts across diverse demographics, reinforcing the need for continued vigilance and research to optimize COVID-19 vaccination strategies globally.

9. Conclusion

This research explored the effect of five different COVID-19 vaccines on vaccinated people. The five vaccines include J&J, MERCK, MODERNA, PFIZER_BioNTech, and UNKNOWN MANUFACTURER. Various analyses were conducted on the collected data to uncover the relationship between vaccinated people (as well as their age and gender) and the most common symptoms. The results revealed that headache, chills, and fatigue were the most common symptoms reported across all vaccines. The majority of vaccinated people were females under 60 years old.

Moreover, various tests were conducted to determine the incidence of death. Deaths were analyzed using five variables to comprehend the vaccine’s effect on the human body. The findings show that the total death rate was less than 3 % among all vaccinated individuals, most of whom were not hospitalized and were under 60 years old. Furthermore, the analysis revealed that the death rate was higher after the first dose than after the second dose, with the majority of cases occurring within

three days after vaccination. The results provide evidence that some vaccines are safer than others. Additionally, individuals under 60 years of age had a higher probability of death than those over 60. This information is crucial in encouraging younger populations not to underestimate the severity of the COVID-19 virus's side effects.

Future research will employ machine-learning models to better explain the impact of the studied variables on recovery and death rates. These models could identify patterns and predict outcomes, thereby contributing to vaccination strategies and health interventions.

Ethical Statement

- 1) This material is the authors' own original work, which has not been previously published elsewhere.
- 2) The paper is not currently being considered for publication elsewhere.
- 3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
- 4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
- 5) The results are appropriately placed in the context of prior and existing research.
- 6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
- 7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

I agree with the above statements and declare that this submission follows the policies of Solid State Ionics as outlined in the Guide for Authors and in the Ethical Statement.

Funding

No funding was received for this study.

Availability of data and materials

Unstructured supplementary data is available online on the World Health Organization's website, where structured supplementary data is available upon request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

CRedit authorship contribution statement

Nadia Al-Rousan: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Data curation. **Hazem Al-Najjar:** Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

All authors equally contributed to this research.

Abbreviations

J&J	Johnson & Johnson
CDC	Centers for Disease Control and Prevention
FDA	Food and Drug Administration
mRNA	messenger RNA
WHO	World Health Organization
PQPA	poor-quality product administered

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