

The COVID-19 Vaccines: A Description of Adverse Events of Reactions Reported in Kansas

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ABSTRACT

Introduction. Coronavirus disease 2019 (COVID-19) is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and has spread rapidly throughout the world since its discovery in 2019. Three vaccines (Pfizer-BioNTech, Moderna/NIAID/BARDA, and Johnson & Johnson's Janssen) have been developed for use in the U.S. to aid in the fight against this virus, but have been scrutinized intensely for their efficacy and safety. It is important to understand and interpret the adverse events or reactions (AERs) associated with these vaccines in an objective and analytical manner. The goal of this descriptive study was to provide a resource outlining AERs associated with the three available vaccines in Kansas.

Methods. Reports were obtained from the Vaccine Adverse Event Reporting System (VAERS), representing AERs observed in Kansas from December 11, 2020 to May 13, 2021. All data were screened and coded, and descriptive statistics were used to describe AERs based on vaccine manufacturer, patient age and biological sex, and reported deaths.

Results. Only 0.00068% of COVID-19 vaccine doses given in Kansas were associated with an AER (1,445/2,120,350). There were 4,297 individual AERs reported, and the most common were fatigue/tiredness (266; 6.2%), tingling/itching (251; 5.9%), fever (226; 5.3%), hives (223; 5.2%), and muscle/joint pain (209; 4.9%). Only 0.002% of COVID-19 vaccine doses in Kansas were associated with a death (38/2,120,350). The majority of VAERS reports were by females (1,139; 78.8%) and those aged 30 to 39 years (297; 20.6%).

Conclusions. No reported AERs were unexpected compared to national data, and no VAERS report provided a causal relationship between vaccine administration and death. Vaccines are, and will continue to be, essential tools to fight COVID-19 in the quest to reach herd immunity. Providing a resource of potential AERs could aid in individual decisions to receive a vaccine and may help in the control of COVID-19. Future studies may include describing reported AERs for children under age 12 as the vaccines become available for those age groups, as well as reporting AERs for those who have received the vaccine after our study time period. *Kans J Med* 2022;15:39-47

INTRODUCTION

On December 31, 2019, a respiratory virus of unknown etiology was detected in Wuhan City, Hubei Province of China and reported to the

World Health Organization.¹ The virus, called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), was linked to the development of the 2019 novel coronavirus (2019-nCoV), more commonly referred to as the “coronavirus” or “COVID-19.” This novel coronavirus spread rapidly in the first months of 2020, with the first reported case in the U.S. on January 21, 2020. By March 20, 2020 there were a total of 250,000 confirmed cases of COVID-19 worldwide. As of August 31, 2021, the confirmed global case count of COVID-19 was more than 217.3 million people infected, with over 4.5 million deaths. In the U.S., there have been approximately 39.1 million confirmed cases and over 639,000 deaths.² Due to the morbidity and mortality rates associated with the proliferation of the virus, the U.S. Department of Health and Human Services (DHHS) launched a program called “Operation Warp Speed” to collaborate with the private sector to develop and distribute a vaccine to be used against COVID-19 quickly and effectively on March 30, 2020.³

On December 11, 2020, the U.S. Food and Drug Administration (FDA) announced an emergency use authorization (EUA) for the first COVID-19 vaccine approved for use in the U.S., manufactured by Pfizer-BioNTech.⁴ An EUA is awarded by the FDA when the public health benefit of a medical product, such as a vaccine, outweighs the known and potential harm.⁵ Officially named “Comirnaty” with the international non-proprietary name (INN) “tozinameran”, the Pfizer-BioNTech COVID-19 vaccine is colloquially known as the “Pfizer vaccine”.⁴ With an efficacy rate of up to 95%, the Pfizer vaccine was approved conditionally for use in persons aged 16 and older in the U.S. and requires two doses given three weeks apart.⁶⁻⁸ Recently, the U.S. Centers for Disease Control and Prevention (CDC) has been monitoring reports of myocarditis and pericarditis following vaccination, however, no suspension or pause in the use of the Pfizer vaccine has been issued.⁹

On December 18, 2020, just a week after the authorization of the Pfizer vaccine, a second COVID-19 vaccine from Moderna Therapeutics, the National Institute of Allergy and Infectious Diseases (NIAID), and Biomedical Advanced Research and Development Authority (BARDA) also received an EUA. The Moderna/NIAID/BARDA vaccine has the brand name “SpikeVax”, INN “elasomeran”, and is colloquially known as the “Moderna vaccine”. This vaccine requires two doses to achieve a vaccine efficacy of 94.1%; however, the Moderna vaccine only was authorized for use in individuals 18 years of age and older.⁷ On June 25, 2021, the FDA revised fact sheets related to the Moderna vaccine and disclosed that there may be an increased risk of myocarditis and pericarditis following vaccination, but this issue did not halt the FDA's EUA.¹⁰

On February 27, 2021, the FDA released the EUA for Johnson & Johnson's Janssen single dose COVID-19 vaccine (INN Ad26.COV2.S) colloquially known as the “J&J vaccine”.¹¹ This marked the third vaccine approved for use in the U.S.¹² Following use for more than a month, the CDC and FDA recommended a temporary suspension for the use of the J&J vaccine on April 13, 2021, due to reports of cerebral venous sinus thrombosis (CVST) in vaccinated individuals, particularly women under age 50.^{13,14} After a thorough safety review of the vaccine and the rare cases of CVST, the FDA and CDC lifted the pause on April 23, 2021.¹⁵ Although shown to be effective in combatting COVID-19, the

J&J vaccine has a slightly lower efficacy than the Pfizer or Moderna vaccines at 66.3%.¹⁶

Under the FDA's EUAs for the three vaccines, vaccine manufacturers and health care providers (such as local health departments, physicians, nurses, and pharmacists) who are administering the COVID-19 vaccines were mandated to report serious adverse events or reactions (AERs) that occur from any of the three vaccines through the DHHS's "Vaccine Adverse Event Reporting System" (VAERS), which is co-managed by the FDA and CDC, and accessible through the public resource, WONDER (Wide-ranging ONline Data for Epidemiologic Research).¹⁷ Serious AERs are defined by VAERS as:

*Death; a life-threatening adverse event; inpatient hospitalization or prolongation of existing hospitalization; a persistent or significant incapacity or substantial disruption of the ability to conduct normal life functions; a congenital anomaly/birth defect; an important medical event that based on appropriate medical judgement may jeopardize the individual and may require medical or surgical intervention to prevent one of the outcomes listed above; cases of multisystem inflammatory syndrome; cases of COVID-19 that result in hospitalization or death.*¹⁷

Health care providers are also encouraged to report any other AERs they observe in patients that they can reasonably conclude are due to the vaccine administered.

Individuals from the general public can report their AERs directly to the vaccination manufacturer or their health care provider, who are mandated to report the AERs to VAERS, or the person can report their vaccine side effects directly to VAERS by logging into the system and creating a report themselves.¹⁷ Due to the fact that the general public can report unverifiable AERs to the VAERS system, these reports alone cannot be used to determine if a vaccine caused or contributed to the reported AERs and the threat of conviction under Federal law for submitting a fabricated report may not deter people from submitting false reports. The strengths of the VAERS system are that it can be used to detect unusual or unexpected patterns ("safety signals") that can be followed in a strategic manner, and VAERS staff regularly can monitor and remove entries made by the general public that cannot be verified.

This project was of interest due to the concerns regarding the potential side effects of the three COVID-19 vaccines authorized for use in the U.S. Data obtained for this study from the VAERS database provides the information needed to describe reported AERs, and specifically, this study was intended to provide a resource regarding potential AERs associated with the Pfizer-BioNTech (Pfizer), Moderna/NIAID/BARDA (Moderna), and Johnson & Johnson's Janssen (J&J) COVID-19 vaccines in the State of Kansas.

METHODS

The VAERS database was searched from vaccine inception on December 11, 2020 to May 13, 2021 for AERs related to the three COVID-19 vaccines. The study team chose this ending date as it was the day prior to the Pfizer vaccine receiving FDA EUA approval for use in adolescents 12 to 15 years old.¹⁸ Results were grouped by vaccine manufacturer, whether the impacted patient resided in Kansas, patient age and gender, and included information on AER description, as well as any relevant or available data regarding labs, current illnesses, AERs

after prior vaccinations, medications at time of vaccination, and medical history and/or allergies. The full description of the search strategy is available from the authors upon request. This study was approved by the University of Kansas School of Medicine Institutional Review Board as non-humans subject research.

Data Screening. The search identified 1,705 separate patient entries in VAERS. The initial data file was screened by two of the authors (AT and KN) for entries that needed to be removed. KN initially removed 270 entries and AT initially removed 239 entries, with an agreement rate of 96.3%. After discussion, a consensus was reached to remove 222 entries (Cohen's $\kappa = 0.85$, $p = 0.16$, 95% CI -0.7% to 4.1%). Entries were removed for four reasons, "unknown" vaccine manufacturer (four removed), report of unapproved underage administration (23 removed), duplicate entries (15 removed), and those entries that were not COVID-19 vaccine related AERs (180 removed). The break-down of the screening criteria by vaccine manufacturer is shown in Table 1.

Table 1. VAERS COVID-19 vaccine entry data screening procedure.

	Pfizer	Moderna	J&J	Total
Removed "unknown" vaccines	---	---	---	4
Start	676	818	207	1,701
Removed - underage administration	1	9	13	23
Removed - duplicate report	8	5	2	15
Removed - not COVID vaccine AER	102	58	20	180
Total after non-AER entries removed	565	746	172	1,483
Removed if death was indicated	16	18	4	38

Of the 180 entries related to the COVID-19 vaccines that did not indicate an AER occurred: 68 reported a patient had a positive COVID-19 diagnosis but no vaccine AER; 60 reported an unauthorized use of the vaccine (e.g., incorrect dose, incorrect vaccine given for second dose); 21 had another diagnosis after vaccination that accounted for the report (e.g., ruptured appendix, strep throat); 19 were unclear as to the specific AER experienced (e.g., "seen at ER", "just didn't feel right"); 11 were unremarkable clinic progress notes of follow-up calls to patients who had received a vaccination; and one was removed because the submitter indicated it was a report based on a friend's social media post. This left a total of 1,483 separate patient entries. Thirty-eight entries that reported the patient's death were removed and discussed separately below. This left a total of 1,445 VAERS entries to be coded by the research team.

Data Coding. Each VAERS entry was screened by one of the three authors, coded by another, and reviewed by the third, with a rotating list of entries for each author, ensuring that each entry was seen and checked by all three members of the authorship team. Any entries that were unclear were resolved by discussion. Each identified AER that appeared two or more times was coded into a separate category, for a

total of 58 identified categories of AERs related to the COVID-19 vaccines. Twenty-eight category names utilized wording obtained from the side effects listed on the information sheets provided by the manufacturer for each vaccine.¹⁹⁻²¹ The additional 30 categories were named based on medical and lay terms for the AER identified (i.e., arrhythmia/abnormal heart rhythm). Additionally, there was a category named “other” for 16 individual entries that did not fall into the identified AER categories. Within all 59 categories there were a total of 4,287 separate AERs reported. Table 2 shows the AER categories identified with the breakdown of number of coded entries in each.

Data Analysis. Descriptive statistics were used to describe AERs reported by vaccine manufacturer (Pfizer, Moderna, and J&J), age category (29 and younger, 30 to 39, 40 to 49, 50 to 59, 60 to 64, and 65 and older), and gender (male and female), as well as any reported deaths in the data file. Traditional statistical analyses were not performed beyond calculating the inter-rater reliability as this is a purely descriptive study of reported AERs and causal inferences are unable to be performed due to the nature of the VAERS system.

Table 2. COVID-19 vaccine reported adverse events or reactions categories identified from 1,445 patient entries.

	Total	Pfizer	Moderna	J&J
Fatigue/tiredness	266	84	144	38
Tingling/itching	251	80	153	18
Fever	226	12	163	51
Hives	223	18	199	6
Muscle/joint pain	209	136	6	67
Nausea	189	79	88	22
Headache	187	126	6	55
Chills/shaking	175	101	26	48
Confusion	175	8	165	2
Seizure	174	8	163	3
Rash	146	50	90	6
Numbness	142	21	112	9
Dizziness	136	107	3	26
Bruising at injection site	133	4	124	5
Redness at injection site	131	25	101	5
Dyspnea/hypoxia (<i>Shortness of breath</i>)	118	17	101	0
Pain at injection site	98	57	30	11
Eye pain	88	82	1	5
Arrhythmia (<i>abnormal heart rhythm</i>)	81	31	34	16
Weakness	76	29	36	11
Blood clot	75	1	71	3
Syncope (<i>lightheadedness/fainting</i>)	75	28	34	13
Diaphoresis (<i>sweating</i>)	70	24	34	12
Vomiting	69	19	36	14
Sore throat	65	51	8	6
Diarrhea	60	20	34	6
Cough/congestion	56	34	16	6
Lymphadenopathy (<i>swollen lymph nodes</i>)	56	23	29	4
Arm pain	54	32	6	16
Xerostomia (<i>dry mouth</i>)	52	39	3	10

	Total	Pfizer	Moderna	J&J
Insomnia	51	8	37	6
Allergic reaction	47	24	15	8
Chest pain	46	35	2	9
Sensory issue/loss	36	10	20	6
Difficultly walking	30	2	25	3
Anxiety/panic/depression	27	11	16	0
Stroke	25	3	21	1
Abdominal pain	24	11	3	10
Ear pain/tinnitus (<i>ringing in ears</i>)	22	3	12	7
Metallic taste	20	6	10	4
Loss of appetite	11	3	4	4
Shingles	11	3	6	2
Epistaxis (<i>nosebleed</i>)	10	7	0	3
Bell's palsy	9	3	6	0
Hyperglycemia (<i>high blood sugar</i>)	6	1	4	1
Herpes labialis (<i>cold sores</i>)	5	2	3	0
Edema	5	2	3	0
Hematuria (<i>blood in urine</i>)	4	1	3	0
Vivid dreams	4	3	1	0
Gastrointestinal bleed	3	0	3	0
Myocardial infarction (<i>heart attack</i>)	3	0	3	0
Paralysis	3	2	1	0
Pneumonia	3	2	1	0
Asthma attack	2	1	1	0
Hallucinations/delusions	2	1	0	1
Hypoglycemia (<i>low blood sugar</i>)	2	1	1	0
Thrombocytopenia (<i>low blood platelets</i>)	2	2	0	0
Unexpected vaginal bleeding	2	1	1	0
Other	16	6	4	6
Total	4,287	1,500	2,222	565

RESULTS

Information from the Kansas Department of Health and Environment (KDHE) was obtained to determine how many people in Kansas had received at least one dose of the available COVID-19 vaccines (Andrea May, MPH, email communication, June 2021). From December 11, 2020 to May 13, 2021, the KDHE indicated that a total of 1,191,204 initial vaccine doses had been given, which translated to approximately 41% of the total population receiving at least one dose (1,191,204/2,911,641). VAERS did not indicate if someone submitted multiple reports, but this roughly indicated that for each vaccine dose given in Kansas, one in every 1,467 led to a report in VAERS (2,120,350/1,445), and one AER occurred per every 495 doses given in Kansas (2,120,350/4,287; Table 3). Of the 1,445 VAERS entries, 215 (14.9%) concerned patients younger than 29 years, 297 (20.6%) were age 30 to 39 years, 277 (19.2%) were between 40 and 49 years, 230 (15.9%) were age 50 to 59 years, 118 (8.2%) were age 60 to 64 years, and 263 (18.2%) were 65 years and older. Twenty-five entries had no age noted. In terms of gender, 296 (20.5%) entries reported male patients, 1,139 (78.8%) female patients, and 10 were unknown gender (0.7%).

Table 3. COVID-19 vaccines given in Kansas (December 11, 2020 to May 13, 2021).

	Pfizer	Moderna	J&J	Total
Total doses	1,130,089	922,728	67,308	2,120,350
Dose 1	624,528	499,808	67,308	1,191,056
Dose 2	505,561	422,920	---	929,069
<i>Unknown vaccine received</i>	---	---	---	225
Prevalence				
VAERS entry (<i>one per every</i>)	2,058 doses	1,267 doses	401 doses	1,467 doses
AER (<i>one per every</i>)	753 doses	415 doses	119 doses	495 doses

Adverse Events or Reactions Reported. Overall, there were a total of 4,287 AERs reported, with an average of 3.0 (\pm 1.9) AERs reported per VAERS entry, with a median number of 3 (range 1 to 12). The Pfizer vaccine had a total of 1,500 AERs reported with an average of 2.7 (\pm 1.8) AERs per patient entry, with a median number of 2 (range 1 to 11). The Moderna vaccine had a total of 2,222 AERs reported with an average of 3.1 (\pm 1.9) AERs reported per patient entry, with a median number of 3 (range 1 to 10). The J&J vaccine had a total of 565 AERs reported, with an average of 3.4 (\pm 2.0) AERs per patient entry, with a median number of 3 (range 1 to 12). Table 2 shows the breakdown of each AER by vaccine manufacturer.

Pfizer-BioNTech Vaccine. The Pfizer vaccine had a total of 549 entries in the VAERS system as of May 13, 2021, and 1,500 separate AERs. Of these entries, 92 (16.8%) included patients younger than 29 years, 117 (21.3%) were age 30 to 39 years, 93 (16.9%) were between 40 and 49 years, 91 (16.6%) were age 50 to 59 years, 37 (6.7%) were age 60 to 64 years, and 92 (16.8%) entries were 65 years and older. Twenty-seven had no age noted. In terms of gender, 103 (18.8%) were male patients, 1,139 (80.3%) were female patients, and 5 (0.9%) were unknown gender. The highest AER count was in female patients aged 30 to 39 reporting muscle/joint pain. The top five AERs for age and

gender are shown in Tables 4 and 5.

Moderna/NIAID/BARDA Vaccine. The Moderna vaccine had a total of 728 entries in the VAERS system as of May 13, 2021, and 2,222 separate AERs. Of these entries, 91 (12.5%) concerned patients younger than 29 years, 141 (19.4%) were age 30 to 39 years, 155 (21.3%) were between 40 and 49 years, 115 (15.8%) were age 50 to 59 years, 66 (9.1%) were age 60 to 64 years, and 149 (20.5%) were 65 years and older. Eleven had no age noted. In terms of gender, 144 (19.8%) entries were for male patients, 580 (79.7%) female patients, and 4 (0.5%) were unknown gender. The highest AER count was for female patients aged 40 to 49 who reported hives (Tables 4 and 5).

Johnson & Johnson's Janssen Vaccine. The J&J vaccine had a total of 168 entries in the VAERS system as of May 13, 2021, and 565 separate AERs. Of the VAERS entries, 32 (19.0%) were reports for patients younger than 29 years, 39 (23.2%) were age 30 to 39, 29 (17.3%) were between 40 and 49 years, 24 (14.3%) were age 50 to 59 years, 15 (8.9%) were age 60 to 64 years, and 22 (13.1%) were 65 years and older. Seven had no age noted. In terms of gender, 49 (29.2%) entries concerned male patients, 118 (70.2%) female patients, and one (0.6%) had an unknown gender. The highest AER count was for female patients aged 30 to 39 reporting muscle/joint pain (Tables 4 and 5).

Other Adverse Events or Reactions Reported. Overall, there were 16 AERs that were outliers, meaning they were only reported in VAERS once and they did not fall into one of the 58 identified categories. There were six patients who received the Pfizer vaccine who reported "other" AERs: anemia, severe acid reflux, onychorrhexis (unexplained breaking of fingernails), flaring of Fothergill's disease (trigeminal neuralgia), Takotsubo cardiomyopathy (apical ballooning syndrome), and development of Willis-Ekbom disease (restless leg disease). There were four patients who received the Moderna vaccine who reported either the development of pyelonephritis (kidney infection), hemorrhoids, constipation, or a report of a pulmonary embolism (blood clot in lung). There were six patient entries related to the J&J vaccine: the worsening of multiple sclerosis symptoms, polyuria (excessive urination), hormonal changes, neuralgia (burning nerve pain), an acute adrenal (Addisonian) crisis, and priapism (prolonged painful erection).

Deaths. There were 38 patient deaths identified in the VAERS system from December 20, 2020 to May 13, 2021 (38/1,483; 2.6%). Of these, 16 had received Pfizer, 18 received Moderna, and four received the J&J vaccine. No deaths were reported in patients under age 39, and the majority (11/38; 28.9%) were 65 years or older. Fifteen of these deaths were due to unknown causes at time of report, but were not suspected to be related to the vaccines; 17 deaths were related to other verifiable diagnoses, such as cancer or falls, and were also not suspected to be related to the vaccines; five deaths were related to COVID-19 complications in between vaccine doses; and one death is being reported by KDHE as related to an allergic reaction from the Pfizer vaccine. Figure 1 shows the breakdown of deaths by age group, gender, and vaccine manufacturer.

Table 4. Top five reported adverse events or reactions for each COVID-19 vaccine by age group.

	Pfizer Vaccine			Moderna Vaccine			J&J Vaccine		
	AER	n	%	AER	n	%	AER	n	%
29 years and younger	Muscle/joint pain	37	40.2%	Hives	24	26.4%	Fever, headache*	14	43.8%
	Headache	27	29.3%	Confusion	23	25.3%	Muscle/joint pain	13	40.6%
	Nausea	21	22.8%	Fever	22	24.2%	Chills/shaking	10	31.3%
	Fatigue, dizziness*	17	18.5%	Numbness	20	22.0%	Dizziness	6	18.8%
	Eye pain	15	16.3%	Fatigue, seizure*	18	19.8%	Chest pain, fatigue*	5	15.6%
30 to 39 years	Muscle/joint pain	46	39.3%	Hives	44	31.2%	Muscle/joint pain	22	56.4%
	Chills/shaking	28	23.9%	Confusion	40	28.4%	Headache	19	48.7%
	Headache	26	22.2%	Seizure	37	26.2%	Fever	12	30.8%
	Eye pain, fatigue*	23	19.7%	Tingling/itching	33	23.4%	Chills/shaking	11	28.2%
	Dizziness	22	18.8%	Fever	32	22.7%	Fatigue	9	23.1%
40 to 49 years	Muscle/joint pain	32	34.4%	Hives	46	29.7%	Muscle/joint pain	10	34.5%
	Headache	22	23.7%	Seizure	41	26.5%	Fatigue	9	31.0%
	Chills/shaking	21	22.6%	Tingling/itching	37	23.9%	Headache	7	24.1%
	Dizziness, eye pain*	17	18.3%	Fatigue	35	22.6%	Chills/shaking, fever, pain at injection site*	6	20.7%
	Tingling/itching	15	16.1%	Numbness	33	21.3%	Arm pain/syncope*	5	17.2%
50 to 59 years	Muscle/joint pain	41	45.1%	Hives	40	34.8%	Muscle/joint pain	8	33.3%
	Headache	25	27.5%	Confusion	31	27.0%	Chills/shaking, headache*	7	29.2%
	Tingling/itching	21	23.1%	Fatigue	30	26.1%	Fatigue, tingling/itching*	6	25.0%
	Dizziness	18	19.8%	Bruising at injection site	29	25.2%	Dizziness, fever*	5	20.8%
	Chills/shaking	13	14.3%	Fever	28	24.3%	Ear pain/tinnitus	4	16.7%
60 to 64 years	Muscle/joint pain	10	27.0%	Fever	18	27.3%	Fever	4	26.7%
	Nausea	6	16.2%	Hives	17	25.8%	Muscle/joint pain	4	26.7%
	Dizziness, headache, tingling/itching*	5	13.5%	Confusion	14	21.2%	Nausea	4	26.7%
	Diarrhea/fatigue/pain at injection site/rash*	4	10.8%	Fatigue, seizure, tingling/itching*	13	19.7%	Chills/shaking, headache*	3	20.0%
	Arm pain, cough/congestion, difficulty walking/weakness*	3	8.1%	Dyspnea/hypoxia, nausea	9	13.6%	Abdominal pain, dizziness, numbness/weakness*	2	13.3%
65 years and older	Dizziness	27	29.3%	Tingling/itching	38	25.5%	Muscle/joint pain	9	40.9%
	Muscle/joint pain	20	21.7%	Seizure	32	21.5%	Chills/shaking	8	36.4%
	Headache	14	15.2%	Fever	30	20.1%	Fatigue	7	31.8%
	Chills/shaking	13	14.1%	Hives	26	17.4%	Fever	6	27.3%
	Eye pain	12	13.0%	Confusion	24	16.1%	Headache	5	22.7%
Total	Muscle/joint pain	196	35.7%	Hives	197	27.1%	Muscle/joint pain	67	39.9%
	Headache	125	22.8%	Confusion	164	22.5%	Headache	55	32.7%
	Dizziness	107	19.5%	Fever	163	22.4%	Fever	51	30.4%
	Chills/shaking	100	18.2%	Seizure	161	22.1%	Chills/shaking	48	28.6%
	Fatigue	82	14.9%	Tingling/itching	152	20.9%	Fatigue	38	22.6%

*Tie between reported AER type.

Table 5. Top five reported adverse events or reactions for each COVID-19 vaccine by gender.

	Pfizer Vaccine			Moderna Vaccine			J&J Vaccine		
	AER	n	%	AER	n	%	AER	n	%
Male	Muscle/joint pain	34	33.0%	Fever	42	29.2%	Muscle/joint pain, headache*	16	32.7%
	Headache	20	19.4%	Confusion	39	27.1%	Chills/shaking	15	30.6%
	Dizziness	17	16.5%	Hives	38	26.4%	Fever	14	28.6%
	Eye pain, nausea*	14	13.6%	Fatigue	33	22.9%	Fatigue	11	22.4%
	Chills/shaking, fatigue*	13	12.6%	Bruising	29	20.1%	Dizziness	7	14.3%
Female	Muscle/joint pain	162	36.7%	Hives	159	27.4%	Muscle/joint pain	51	43.2%
	Headache	105	23.8%	Seizure	150	25.9%	Headache	39	33.1%
	Dizziness	90	20.4%	Tingling/itching	139	24.0%	Fever	37	31.4%
	Chills/shaking	87	19.7%	Confusion	125	21.6%	Chills/shaking	33	28.0%
	Tingling/itching	72	16.3%	Fever	121	20.9%	Fatigue	27	22.9%
Total	Muscle/joint pain	196	35.7%	Hives	197	27.1%	Muscle/joint pain	67	39.9%
	Headache	125	22.8%	Confusion	164	22.5%	Headache	55	32.7%
	Dizziness	107	19.5%	Fever	163	22.4%	Fever	51	30.4%
	Chills/shaking	100	18.2%	Seizure	161	22.1%	Chills/shaking	48	28.6%
	Fatigue	82	14.9%	Tingling/itching	152	20.9%	Fatigue	38	22.6%

*Tie between reported AER type.

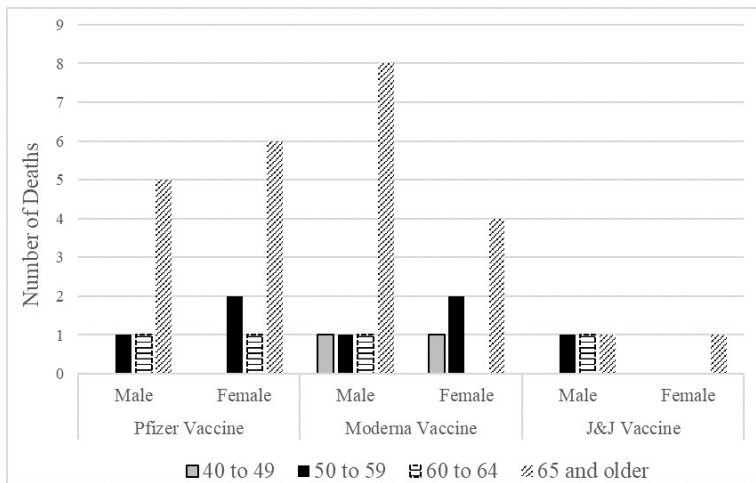


Figure 1. Number of deaths reported by age group, gender, and COVID-19 vaccine.

DISCUSSION

The information presented in this study can be used as a resource for those who are curious about the potential side effects of the three COVID-19 vaccines, especially those who may be hesitant for various reasons, such as fear of unknown risks, lack of trust in production, or personal safety. As of August 31, 2021, only 53.0% of the U.S. population and approximately 27.5% of the world population are fully vaccinated.² As of August 31, 2021, Kansas has had 369,890 confirmed cases of COVID-19 and 5,560 COVID-19 related deaths. Vaccine rates in Kansas were also slightly higher than previously reported on May 13, 2021, with 48.2% of the population being fully vaccinated. However, with more than 50% of the population of Kansas remaining unvaccinated, this indicated that many Kansans are either unable to get vaccinated (i.e., they are underage or have medical barriers) or they are unwilling. This hesitancy also may affect parental willingness to allow their chil-

dren to get vaccinated, as uncertainty regarding the adverse effects of vaccines has been cited as a major barrier to adolescent vaccination in Kansas.²²

Results from a June 2020 global survey of COVID-19 vaccine acceptance indicated that 71.5% of participants would be “very or somewhat likely” to receive a vaccine.²³ However, the survey results also indicated that the potential side effects and AERs related to the COVID-19 vaccines, as well as lack of trust in government and public health officials, have contributed to vaccine hesitancy. Despite the acceleration of the development of these three vaccines, the FDA has taken substantial and appropriate steps to ensure the validity and efficacy of these COVID-19 vaccines.²⁴

Highlighting the fact that mild and likely short term side effects were present most often may aid individuals in their decision to receive a vaccine. The Pfizer vaccine mainly saw reports of mild AERs, including high incidences of muscle/joint pain and headache were somewhat consistent with manufacturer reports, with 21 of the 41 identified AERs listed on the supplied FDA fact sheet.¹⁹ A prior study by Johnston and colleagues in 2021 reported allergic and neurologic reactions associated with the Moderna vaccine, with hives and seizure commonly reported.²⁵ Colloquially known as “COVID arm”, hives at the vaccine site frequently have been reported with the Moderna vaccine. Cases of seizure have been reported with other common vaccines, such as tetanus, pertussis, poliovirus, and influenza,²⁶ especially in children; however, these cases were extremely rare and the vast majority of which were short and did not cause any long-term damage.²⁷ Confusion/delirium in the Moderna vaccine, like many other AERs, may be related to the systemic inflammatory response associated with COVID-19 vaccines as this response may be associated with modification in brain physiology.²⁸ Overall, 18 of the AERs identified in this study were indicated on the provided patient

fact sheet for the Moderna vaccine, while 40 of the AERs identified were not.²⁰ The presence of additional AERs indicated that there may be additional side effects that will need to be monitored with two mRNA vaccines.

The Johnson & Johnson vaccine saw very similar AERs compared to the Pfizer vaccine. Of the AERs reported for the Johnson & Johnson vaccine, 19 of the AERs we identified are listed on the patient fact sheet, while 30 were not.^{21,29} Additionally, no reported cases of CVST were found through the VAERS system in Kansas for the study period.^{15,16} Reported blood clots of any kind after receiving the vaccine were limited to just three cases total with the J&J vaccine, and unfortunately no specification of what kind of blood clot was indicated in VAERS. Additionally, on July 13, 2021, the FDA announced revisions to the fact sheets of the J&J vaccine to include an observed risk of Guillain-Barre Syndrome (GBS) following vaccination.²¹ These cases are again exceedingly rare among J&J vaccine recipients as only 100 out of 12.5 million recipients reported cases of GBS after J&J vaccination, and no cases were noted in this study. Most people with GBS make a full recovery and as it stands there has been no definitive causal relationship established between the J&J vaccine and GBS.³⁰

One of the most important AERs that must be investigated rigorously was the prevalence of death among those who receive a COVID-19 vaccine. Our study reported that there were 38 deaths reported in the VAERS system from December 20, 2020 to May 13, 2021. This translated to 0.0002% (38/2,120,350) of persons in Kansas who had received a COVID-19 vaccine being associated with a death. None of these cases provided a causal relationship between vaccine administration and death, but there was one report that is being investigated. Given the nature of the VAERS system, it is difficult to determine relationships from the reports and data that were available; however, the FDA and CDC follow-up on any reported deaths in the VAERS system and make a further determination in conjunction with state health departments.¹⁷

When weighing the choice of receiving any sort of medication, vaccine, or health-related intervention, the benefits and the risks must be weighed in any case.³¹ All too often individuals suffer from omission bias, or the idea of favoring inaction over action when it comes to receiving a medical intervention, especially when it comes to vaccines. Additionally, the benefits and risks associated with other vaccines must also be considered. The flu vaccine, for instance, has common side effects including soreness, redness, and/or swelling from the shot, headache, fever, nausea, and muscle aches, which are very similar to the AERs reported with the COVID-19 vaccines.³²

Combatting vaccine hesitancy is not a new phenomenon. However, given themes related to the COVID-19 vaccine hesitancy, such as vaccine efficacy, safety, pace of development, and fear of side effects, it is important for health care providers and public health officials to have information available as these groups play a critical role in combating vaccine hesitancy.^{22,33-35} Of note, only 0.00068% (1,445/2,120,350) of

COVID-19 vaccine doses given from December 11, 2021 to May 13, 2021 were associated with a report in VAERS, showing a particularly low rate of reactions associated with these vaccines thus far. By providing a clear statistical overview of the AERs associated with these vaccines, this study may be utilized as a resource for individuals and their medical providers to make informed and educated decisions on whether to receive a COVID-19 vaccine.

CONCLUSIONS

On June 10, 2021, Moderna petitioned the FDA to approve its vaccine for adolescents aged 12 to 17; and as of August 23, 2021, the Pfizer/BioNTech COVID-19 was given full approval by the FDA for use in people ages 16 and older.³⁶ While Moderna has yet to be approved for adolescents, the EUA approval of the Pfizer/BioNTech vaccine for those aged 12 to 17 highlighted the confidence that the FDA has in the vaccine's efficacy and safety.¹⁸ In addition, beginning in March 2021, Pfizer/BioNTech began conducting randomized control trials in children aged 6 months to 11 years old, which hopefully will cement the "tolerability, immunogenicity, and safety" of this vaccine in virtually all age groups.³⁷ With the first COVID-19 vaccine receiving full FDA authorization, there is the expectation that some of those who are vaccine hesitant may cease to be so.

One way to combat a virus is through herd immunity.^{38,39} Herd immunity occurs when the majority of the population gets infected by a disease and, as a result, develops immunity and antibodies that makes the spread of the disease unlikely. Another way to reach herd immunity is through the use of vaccines. Prior to Spring 2021, when the global base reproduction number (R_0) of COVID-19 remained around 2.5, herd immunity was set at approximately 60%.⁴⁰ However, as the SARS-CoV-2 virus continues to mutate into variants of interest (VOIs), such as the Delta variant (B.1.617.2 lineage) and Lambda variant (C.37 lineage),³⁹ the global R_0 also has been increasing and was estimated at 4.1 (95% CI, 3.09-5.39), which pushed the need for global herd immunity close to 90%.⁴¹ To approach herd immunity in the U.S., it is crucial to provide accurate and credible information to educate and encourage those who can be vaccinated to do so. The more people who can achieve natural immunity through infection (less desirable) or through vaccination (more desirable), the greater chance there is to lower the emergence of new VOIs that current vaccines may be less effective against.

With the augmentation and distribution of safe and effective COVID-19 vaccines, along with other mitigation efforts, the societal effects of COVID-19 will diminish. It is important for public health experts, health care providers, and elected officials to provide consistent and reliable information to the public to increase vaccine uptake.^{35,42} Knowing that vaccine safety is an issue contributing to vaccine hesitancy, informing the public about the potential AERs of the COVID-19 vaccines is one step closer to fulfilling that gap.

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