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ABSTRACT

*From our study, all three covid-19 vaccines have a similar proportion of adverse reaction reports in which the patient had a history of allergies. However, the proportion of life-threatening outcomes were lower for those with the Janssen vaccine (0.62% hospitalization rate for Janssen versus 2.59% for Pfizer and 0.60% death for Janssen versus 5.15% for Moderna). In terms of specific allergies, patients with *cillin or sulfa allergies had the most adverse reactions to covid-19 vaccines, however, Janssen again had the lowest percentage of reported deaths (1.39% for *cillin-related allergy deaths for Janssen versus 6.10% for Pfizer). In terms of patient age and gender, females has 2.9x the number of adverse reactions than males and a lower average age for reactions for the Pfizer and Moderna vaccines. We feel this data could be used by individuals and medical professionals*

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to assist in choosing a vaccine to maximize patient safety based on their allergy history, age and gender.

Keywords: VAERS, SARS-COV2, Covid-19, Allergic Reactions

INTRODUCTION

According to the Centers for Disease Control and Prevention (CDC), "Any health problem that happens after vaccination is considered an adverse event following immunization. An adverse event can be a true adverse reaction, also known as a side effect, that is related to the vaccine, or a coincidental event that happened following vaccination." (Centers for Disease Control and Prevention, 2021). Experts will attest that no vaccine is completely without risk, but the adverse effects known to be caused by vaccines are usually short-lived and resolve on their own or are treatable/reversible.

Common adverse effects may be observed where the vaccine injection was delivered and may include pain, redness, and swelling. Systemic effects may include tiredness, headache, muscle pain, chills, fever, nausea, and malaise. Other serious effects such as swollen lymph nodes (lymphadenopathy), diarrhea and vomiting have also been reported (Mayo Clinic, 2021).

The purpose of this manuscript is to explore the relationship between patients with known allergies to reported adverse reactions with coronavirus vaccines.

In particular we examine the most common food, drug and environmental allergies co-occurring with coronavirus vaccine adverse reactions to determine if any relationship exists. We then investigate specific patient demographic information such as age and gender to determine any statistical connection to coronavirus vaccine adverse reactions.

The rest of this manuscript is organized as follows. Section 2 contains the literature review that focuses on allergies, covid-19 vaccines, the Vaccine Adverse Reporting System (VAERS) and known covid-19 vaccine allergies.

Section 3 is our research questions. Section 4 is the system design including VAERS data, ETL and data cleaning. Section 5 is the experimental design. Section 6 provides the experimental results and discussion. Finally, Section 7 delivers the conclusions, limitations and future directions.

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LITERATURE REVIEW

To address these challenges we investigate the relevant literature on allergies, covid-19 vaccines, a system for reporting vaccine adverse effects and known allergies to covid-19vaccines. We then present the research gaps that have motivated this investigation.

Allergies

The term allergy is used to refer to an organism's immune response to a certain substance that is generally harmless for other individuals, that can cause a series of symptoms in said organism. An allergy tends to manifest itself as a temporary allergic reaction that is visible as a series of highly varied symptoms which manifest as skin problems, (eczema, erythema, pruritus, etc.) bronchial problems (bronchospasm), problems of the nasal mucus, eyes (conjunctivitis), the digestive tract (diarrhea or vomiting) and even other organs of the body. It may also lead to allergic diseases such as asthma, rhinitis or urticaria, to mention a few. In the most severe cases, it may produce anaphylactic shock, a severe and generalised allergic reaction that may even cause the patient's death (Brown & Turner, 2015).There are different mechanisms for the diagnosis of allergies, ranging from skin tests, blood tests or genetic studies. With regard to treatment, current medical practice is based on four fundamental pillars, which are patient education, allergen avoidance, pharmacological intervention, and immunotherapy (Levin, 2018). Allergies may be classified in multiple ways, although this work focuses more on the type of substance that causes the allergy. In this connection, it is worth highlighting three types of allergies: those caused by foods such as eggs or milk; those caused by medicines such as antibiotics or anaesthetics; or those caused by environmental agents such as dust mites or pollen. In general, the different studies conducted point to a slow increase in the prevalence of allergies among the world's population, mainly those caused by food and especially in Western nations (Tang & Mullins, 2017).

Covid-19 Vaccines

A vaccine is a drug product that stimulates the immune system offering protection from an infectious disease and vaccination is the act of introducing a vaccine into the body. An individual who is immune to a disease because they have been vaccinated cannot get that disease and cannot spread it to others. In other words, if

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an individual is immune to a disease, they can be exposed to it without becoming infected.

Covid-19 is known to be caused by a virus known as SARS-CoV-2 coronavirus (Veronin et al., 2021). Prior to the development of vaccines to prevent covid-19, the most effective way to prevent illness was to avoid exposure to the virus. To date, three covid-19 vaccines are authorized by the U.S. Food and Drug Administration (FDA) for emergency use: Pfizer/BioNtech, Moderna, and Janssen (produced by Johnson and Johnson). Additional vaccines may receive authorization in 2021.

An Emergency Use Authorization (EUA) allows the FDA to make medical products available immediately. The EUA process differs from an established FDA approval or clearance. Under an EUA the FDA makes a medical product, such as a vaccine, available to the public based on the best available evidence, forgoing all of the evidence necessary for official FDA approval or clearance. When evaluating an EUA, medical experts carefully balance the potential risks and benefits of the products based on the available data.

On December 11, 2020 the FDA issued an EUA for the Pfizer-BioNTech covid-19 vaccine for individuals 16 years of age and older. On May 10, 2021 the FDA expanded the EUA to include adolescents 12-15 years of age.

The Pfizer-BioNTech covid-19 vaccine is a messenger RNA (mRNA) type, which uses a relatively new innovative formulation technology. Unlike attenuated vaccines that introduce a weakened or inactivated virus into the body, the Pfizer-BioNTech mRNA vaccine delivers a tiny piece of genetic code from the SARS CoV-2 virus to host cells in the body, essentially giving those cells instructions, or blueprints, for making copies of the protein spikes protruding from the coronavirus. These proteins stimulate an immune response by producing antibodies and developing memory cells that provide protection if the body is infected with the actual virus.

On December 18, 2020 a second vaccine for prevention of covid-19, manufactured by ModernaTX, Inc, was authorized for emergency use by individuals 18 years of age and older. Moderna is also an mRNA vaccine using the same technology as Pfizer-BioNTech.

On February 27, 2021 the FDA issued an EUA for a third vaccine manufactured by Janssen Biotech Inc, a subsidiary of Johnson and Johnson, for individuals 18 years of age and older.

The Janssen covid-19 vaccine is known as a carrier vaccine, or viral vector vaccine which uses a different approach than mRNA vaccines. Viral vector vaccines use a modified version of a different virus, such as an adenovirus (the vector) to instruct human cells to make the SARS CoV-2 virus spike protein, stimulating an immune response that provides protection if the body is infected with the actual virus.

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In early April 2021 the CDC and FDA issued a joint recommendation for states to pause the use of the Janssen covid-19 vaccine due to a rare, potentially serious, blood clotting disorder among women ages 18 to 48, occurring 6-13 days after vaccination. On April 23, 2021, the FDA ended its recommended pause on the vaccine and added a warning label about the blood clotting disorder which cleared the way to resume vaccinations. On July 12, 2021 the FDA announced a warning of increased risk for GuillainBarré syndrome, a progressively damaging neurological disorder that can lead to paralysis or death for males 50 years of age or older that can occur within 14 days of vaccination (Rendall, 2021).
Given these specific age/gender combinations reacting adversely to coronavirus vaccines, having accurate records of vaccine adverse reactions can help medical professionals make informed vaccine-related decisions.

VAERS

The Vaccine Adverse Event Reporting System (VAERS) is one of the largest government databases and is comprised of adverse event reports following vaccination (Singleton et al., 1999). Established in 1990, VAERS functions as a warning system to detect potential safety issues associated with vaccines. Anyone can submit a report to VAERS and reports have come from a variety of sources: healthcare professionals, health departments, vaccine manufacturers, and vaccine recipients (patients and family members) if they experience any adverse events after receiving a vaccine.
VAERS is co-administered by two agencies within the U.S. Department of Health and Human Services (HHS); the Centers for Disease Control and Prevention (CDC) and the U.S. Food and Drug Administration (FDA). The CDC and the FDA analyze reports of adverse events that monitor health problems that may occur following vaccination (Varricchio et al., 2004).
While reports to VAERS are voluntary, healthcare providers are strongly encouraged to report any additional clinically significant adverse events following vaccination, even if they are not sure if vaccination caused the event. However, under certain conditions, healthcare providers are required by law to report to VAERS after vaccination. Conditions include: 1)
Vaccine administration errors, whether or not associated with an adverse event (AE), 2)
Serious AEs as defined by the FDA regardless of causality, which includes: death, life-threatening, inpatient hospitalization or prolongation of existing hospitalization, or any pre-specified event that occurs within a certain period after vaccination.
According to the CDC, the number of VAERS reports submitted varies each year. During 2011-2014, VAERS averaged around 30,000 reports annually, with 7%

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classified as serious (Shimabukuro et al., 2015). In 2019 VAERS received over 48,000 reports. About 85-90% of the reports described mild side effects such as fever, arm soreness, or mild irritability. The remaining reports are classified as serious, which means that the reported AE resulted in permanent disability, hospitalization, prolongation of an existing hospitalization, life-threatening illness, congenital deformity/birth defect or death. According to the CDC these events can happen after vaccination, but are rarely caused by the vaccine.

Known Covid-19 Vaccine Allergies

In addition to adverse effects in general, allergic reactions have been documented and may be categorized as non-severe or severe. Non-severe allergic reactions include by pale or reddened irregular, elevated patches and severe itching (urticaria or hives), swelling or wheezing within 4 hours of the vaccine. Severe allergic reactions to the vaccine are rare and may occur within 15 minutes of getting vaccinated. Most have occurred in people with a history of allergies and who had previously experienced a severe and potentially life-threatening allergic reaction known as anaphylaxis. Signs and symptoms of anaphylaxis include a sensation of tightness in the throat which may cause the throat to close, or trouble breathing.

Other rare occurrences reported after covid-19 vaccination include blood clots in younger women (thrombosis with thrombocytopenia syndrome (TTS)) after Janssen injections. In addition, researchers are investigating the link between cases of inflammation of the heart, known as myocarditis and pericarditis in adolescents and young adults, occurring after mRNA vaccination.

A vaccine component known as polyethylene glycol (PEG) has been associated with anaphylaxis. Currently, PEG is found in the mRNA vaccines from Pfizer and Moderna. The Janssen vaccine does not contain PEG, however, it contains polysorbate, which is known to cross-react with PEG. This means that if an individual is sensitive to PEG, they may also be sensitive to polysorbate.

Given the hundreds of millions of vaccine doses administered, reports of AEs following vaccination, including deaths, are considered rare and do not necessarily mean that the vaccine directly caused the problem. Since covid19 vaccines are relatively new, scientists and clinicians have more questions than answers about the occurrence of allergic reactions. Research is ongoing to determine which patients, particularly those with prior vaccine allergies, may be at greater risk of adverse reactions to covid-19 vaccines.

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Research Gaps

From this review, there are no studies that specifically examine patient allergies and their relationship to coronavirus vaccine adverse effects. Most studies have focused on specific disease states resulting from a vaccine. Using historical patient data, medical professionals can improve vaccine recommendations based on specific patient factors.

RESEARCH QUESTIONS

Which covid-19 vaccine is associated with the fewest reported adverse reactions? Adverse reactions can occur with just about any vaccine. Analyzing the impacts of covid-19 vaccines can help the public make informed decisions. *Which allergens are most associated with patient deaths for the covid-19 vaccines?*

For patients with certain allergies, which allergens are observed most often and which vaccines are associated with these adverse effects. Answering this question can help guide patients to selecting vaccines least likely to cause significant adverse effects.

Are there patient demographic differences w.r.t. to the covid-19 vaccines and allergic reactions?

How does age and gender affect vaccine adverse effects? We analyze the three vaccines according to patient age and gender for life-threatening reactions. Answering this question can help providers to best recommend a vaccine to patients.

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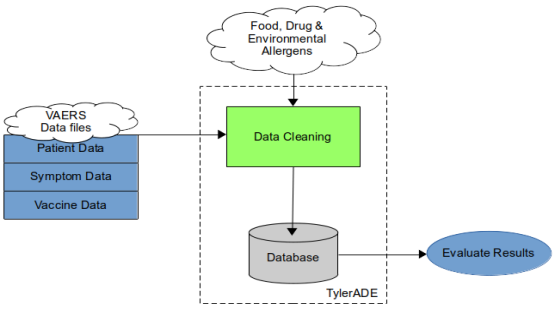
SYSTEM DESIGN

To answer these research questions we created the TylerADE System as shown in Figure 1.

Figure 1 - The TylerADE System



This system collects VAERS data: patient, symptom and vaccine data, before cleaning it by removing excess whitespace and performing a spellcheck. The most common food, drug and environmental allergies are then collected and used to filter VAERS data and store it in a database. The database is then queried to look for statistical relationships in the data.

EXPERIMENTAL DESIGN

For our study we used the Vaccine Adverse Event Reporting System (VAERS) [4] data from January 1 to March 30, 2021. VAERS data is stored in three tables of Data, Symptoms and Vaccine. For our study there were 46,163 records for Data, 64,356 for Symptoms and 46,824 for Vaccine. Between the three tables there were 45,800 covid-19 vaccine records in common. Table 1 shows the breakdown of VAERS records for each of the three covid-19 vaccines and the number of records in which allergens were reported.

[4] https://vaers.hhs.gov/index.html

Vaccine	Total Records	Allergen Records
Moderna	20,296	13,683
Pfizer	20,180	9,422
Janssen	5,324	4,227

Table 1: Covid-19 VAERS Records by Vaccine

For allergens we selected the most common food, drug and environmental allergens (HealthLine, 2020; The Daily Meal, 2012; WebMD, 2021). For food allergens we used egg, milk, peanut, soy, wheat, tree nuts, shellfish, fish, raw fruits/vegetables and sesame (The Daily Meal, 2012). For drug allergies we used *cillin (family of antibiotics, e.g.; penicillin, amoxicillin, etc.), tetracycline, ibuprofen, naproxen, aspirin, sulfa drugs, chemotherapy drugs, cetuximab, rituximab, abacavir, nevirapine, insulin, carbamazepine, lamotrigine, phenytoin, atracurium, succinylcholine and vecuronium (WebMD, 2021). For environmental allergies we used dustmites, pollen, pet dander, mold and smoke (HealthLine, 2020).

RESULTS AND DISCUSSION

To answer our research questions, we investigated the VAERS data for each of the three covid-19 vaccines.

Which covid-19 vaccine is associated with the fewest reported adverse reactions?

To answer this research question we analyze the proportion of VAERS records in which allergens were reported versus their totals for each of the three vaccines as shown in Table 2.

From this data, Janssen had the highest proportion of adverse event reports where an allergy co-occurred with 79.40%, followed by Moderna with 67.42% and Pfizer with 46.69%.

Vaccine	Records	Allergen Pct	Hospitalized Pct	Death Pct
Moderna	20,296	67.42%	2.38%	5.15%
Pfizer	20,180	46.69%	2.59%	2.70%
Janssen	5,324	79.40%	0.62%	0.60%

Table 2: Covid-19 Vaccine Record Counts and Reaction Severity

However, the presence of adverse reports does not address the reaction severity such as mild versus life-threatening interactions. Looking at the life-threatening reactions, 2.38% of adverse reactions for Moderna required hospitalization and 5.15% died whereas for Janssen 0.62% required hospitalization and 0.60% died. Janssen had a larger percentage of adverse reaction reports, but many of the reactions were not life-threatening.

There are a few unique circumstances that make these vaccines different and can impact the distribution of adverse reactions. First and foremost is that all vaccines are dosed in multidose vials. Therefore this forces a batch system type distribution, limiting vaccinations to small groups of 5 or 10 individuals depending on the multi-dose vial. As such, vaccine distribution for such a limited resource make distribution a group effort, and not an individual process. It is unclear how this may, or may not, affect the reported adverse events.

Another confounding factor is the temperature at which the vaccine needs to be stored. As the pandemic was unfolding, the Pfizer vaccine needed to be stored at a temperature of -112 to -67 degree F. This limited the distribution of the Pfizer vaccine to facilities that had the proper equipment. Some vaccine locations could not properly store the vaccine, therefore introducing a selection bias into the process, as many small and/or rural facilities elected not to distribute the Pfizer vaccine. It is unclear how this affected the reported adverse events.

With the process of vaccination, or 2 vaccines for certain individuals, there is also a concern that those individuals receiving only 1 of the 2 injections may not have had sufficient vaccine to provide proper immunization.

To answer Research Question 1 of which vaccine is associated with the fewest number of reported adverse reactions, the Pfizer vaccine had the fewest with 46.69%, however, Janssen had the fewest life-threatening reactions.

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Which allergens are most associated with patient deaths for the covid-19 vaccines?

To answer this research question we investigated common food, drug and environmental allergens and their co-occurrence with the three vaccines. Table 3 lists the percentage of VAERS records in which a specific allergen was reported. For presentation clarity we excluded allergens where none of the vaccines exceeded 1.00% of adverse reports.

Vaccine	Egg	Tree Nut	Shellfish	*cillin	Aspirin	Sulfa	Pollen
Moderna	0.81%	0.93%	2.00%	11.49%	0.99%	9.66%	0.98%
Pfizer	0.74%	1.09%	2.06%	11.13%	1.21%	9.70%	0.99%
Janssen	1.02%	1.25%	1.77%	11.92%	0.95%	7.22%	1.54%

Table 3: lists the percentage of VAERS records with specific allergen reported

From this data both the *cillin and Sulfa family of drugs had the highest proportion of reported adverse reactions across all three vaccines. It was interesting to note the similarity of proportion across all three vaccines. These numbers indicate that for 11% and 9% of adverse reactions, *cillin and Sulfa drugs were present respectively. While we do not possess data for allergy patients that did not have an adverse reaction, the relative difference in reaction percentages is still a cause for concern for those patients with *cillin and Sulfa allergies.

If we were to look at the occurrence of patient adverse records containing both *cillin and Sulfa drugs, this combination accounted for 1.98% of Moderna reactions, 1.95% for Pfizer and 1.75% for Janssen; much smaller by comparison.

Analyzing allergens through the prism of patient death for food, drug and environment are Tables 4, 5 and 6 respectively. For presentation clarity we omitted any allergen that did not have 30 or more occurrences per vaccine.

From this data for adverse reaction to *cillin drugs, 6.10% of Pfizer patients died versus 1.39% for Janssen. Sulfa drugs showed a similar ordering with 4.70% of Pfizer patients dying versus 0.66% for Janssen. The other notable findings were for the antibiotic Tetracycline which shown a similar ordering with 6.56% of Pfizer patients dying and Aspirin where 8.89% of Moderna and 5.26% of Pfizer patients died. It does appear that Janssen is the safest of the three vaccines in contributing to the fewest patient deaths across all allergens investigated.

These results stand in contrast to prior work in which there has been no generally accepted research published of a link between drug allergies and vaccines adverse

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events (American College of Allergy, Asthma and Immunology, 2021; Blumenthal et al., 2021).

Vaccine	Egg	Milk	Peanut	Shellfish	Fish
Moderna	2.70%	0.00%	2.13%	2.92%	4.00%
Pfizer	1.43%	2.78%	1.37%	2.58%	0.00%
Janssen	0.00%	NA	0.00%	1.33%	NA

Table 4: Covid-19 Vaccine Patient Deaths and Food Allergies

Vaccine	*cillin	Tetracycline	Ibuprofen	Naproxen	Aspirin	Sulfa
Moderna	3.94%	4.71%	2.44%	2.78%	8.89%	2.50%
Pfizer	6.10%	6.56%	3.28%	3.23%	5.26%	4.70%
Janssen	1.39%	NA	NA	NA	0.00%	0.66%

Table 5: Covid-19 Vaccine Patient Deaths and Drug Allergies

Vaccine	Dustmites	Pollen	Mold
Moderna	2.22%	2.24%	0.00%
Pfizer	NA	2.15%	3.51%
Janssen	NA	0.00%	0.00%

Table 6: Covid-19 Vaccine Patient Deaths and Environmental Allergies

Are there patient demographic differences w.r.t. to the covid-19 vaccines and allergic reactions?

To answer this research question we analyze the three vaccines according to patient age and gender for life-threatening reactions as shown in Table 7.
From this data the average age of patient adverse reactions for both Moderna and Pfizer was 51.0 years versus 46.1 years for Janssen. The average age for adverse reactions is a bit misleading. During the period of study, covid-19 vaccines were eligible for patients 75 years or older, or had a compromised immune system, or

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had a substantial risk factor or were frontline healthcare workers. Because of the skewness of data we cannot make patient age generalizations in the absolute sense. Instead we can use the age-related data comparatively. This is to say patients of 51.0 years are not in more danger, rather that Janssen appears to affect younger patients more than other vaccines.

Also within the data females had 2.9x more reported adverse reactions than males. This is a similarly unexpected result and could also be the result of skewed data where more female healthcare workers were receiving the vaccine than male counterparts. We do not have access to such data to know this definitively so we will also use gender for comparative analysis.

If we were to focus on just *cillin and Sulfa drugs and their patient demographics for adverse reactions, we would arrive at Tables 8 and 9 respectively.

Vaccine	Avg Age	Male	Female	Hospitalized	Died
Moderna	51.0	5,025	14,908	1,556	1,140
Pfizer	51.0	4,966	14,567	1,499	989
Janssen	46.1	1,540	3,740	110	54

Table 7: Covid-19 Vaccine Patient Demographics

Vaccine	Avg Age	Male	Female	Hospitalized	Died
Moderna	51.8	266	1,306	42	62
Pfizer	52.0	189	857	29	64
Janssen	49.9	111	392	2	7

Table 8: Covid-19 Vaccine Patient Demographics for *cillin Drugs

Vaccine	Avg Age	Male	Female	Hospitalized	Died
Moderna	52.6	127	1,189	37	33
Pfizer	52.5	100	809	28	43
Janssen	51.5	22	283	2	2

Table 9: Covid-19 Vaccine Patient Demographics for Sulfa Drugs

From this data patient age is roughly similar to that in Table 7. However vaccine adverse effects appear to be affecting females in greater numbers, 4.5x for *cillin and 9.2x for Sulfa drugs versus 2.9x for all allergens. This significant increase in adverse effects for females is certainly interesting and should be studied further. Patients with life-threatening reactions appear in a lower proportion.

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Looking deeper at age-related data, Tables 10 and 11 show the average patient ages for adverse reactions for *cillin and Sulfa drugs respectively.

Vaccine	Male	Female	Hospitalized	Died
Moderna	58.5	50.5	61.0	80.2
Pfizer	57.7	50.7	55.1	73.7
Janssen	48.3	50.4	72.5	73.3

Table 10: Covid-19 Vaccine Patient Demographics Average Age for *cillin Drugs

Vaccine	Male	Female	Hospitalized	Died
Moderna	59.6	51.9	61.4	75.7
Pfizer	55.1	52.2	57.4	79.1
Janssen	47.0	51.8	46.5	71.5

Table 11: Covid-19 Vaccine Patient Demographics Average Age for Sulfa Drugs

From this data it would appear that females have adverse reactions at a younger age for Moderna and Pfizer vaccines. However, for life-threatening reactions such as hospitalization and death, ages track higher with the exception of Pfizer hospitalization for *cillin, average age 55.1 years, and Janssen hospitalization for Sulfa, average age 46.5 years.

To investigate these outliers further, we dived deeper into patient ages for life-threatening reactions to *cillin and Sulfa drugs in Tables 12 and 13 respectively.

From this data we find that average ages for patient death are generally higher than for patient hospitalizations, with the most notable exception for males and Sulfa drugs where the average patient age with death as an outcome, occurs at younger ages for the Moderna and Pfizer vaccines. Interestingly no male patient death or hospitalization occurred with the Janssen vaccine for Sulfa drug allergies. Further, we noted large average age differences across genders for Sulfa drug hospitalizations for Moderna and Pfizer as well as *cillin drug hospitalizations for Moderna.

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Vaccine	Male	Female	Male	Female
Moderna	68.3	56.9	77.9	83.1
Pfizer	53.0	55.5	71.4	74.9
Janssen	NA	72.5	68.4	85.5

Table 12: Covid-19 Vaccine Patient Ages for Life-Threatening Reactions with *cillin Drugs

Vaccine	Male	Female	Male	Female
Moderna	81.4	58.3	68.9	77.6
Pfizer	77.0	56.7	76.2	80.4
Janssen	NA	46.5	NA	71.5

Table 13: Covid-19 Vaccine Patient Ages for Life-Threatening Reactions with Sulfa Drugs

CONCLUSIONS, LIMITATIONS AND FUTURE DIRECTIONS

Using this data from a patient safety perspective, it would appear that Janssen has the lowest proportion of life-threatening adverse reactions. In terms of specific allergies, patients with *cillin or sulfa allergies had the most adverse reactions to covid-19 vaccines, however, Janssen again had the lowest number of reported deaths. In terms of patient age and gender, females has 2.9x the number of adverse reactions than males and a lower average age for reactions for the Pfizer and Moderna vaccines.

While this study relied on reported adverse events and not the universe of data (i.e. patients receiving a vaccine without complication or all patients with an adverse reaction reporting it), the reported data has certainly led to some interesting conclusions.

We feel this data could be used by individuals and medical professionals to assist in choosing a vaccine to maximize patient safety based on their allergy history, age and gender.

This article presents an initial work that seeks to shed light on the appearance of adverse reactions caused by different covid-19 vaccines, analyzing co-occurrences between allergens and adverse reactions caused by these vaccines. For the next step, it would be interesting to apply advanced data mining techniques to predict

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the level of seriousness of a potential allergic reaction in a new patient to be vaccinated with a specific vaccine, thus helping to assess the suitability of a certain vaccine type for each patient in terms of minimizing the probability of the appearance of a severe allergic reaction.

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