

Analysis of Covid-19 Adverse Events Following Immunization (AEFI)

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Start →

INTRODUCTION



- The Ministry of Health has encouraged the COVID-19 vaccine to all citizens.
- Many countries have their own systems that allow the public and health-care professionals to report adverse reactions of the vaccines.
- Adverse events can lead to vaccine hesitancy.
- It is crucial not to rule out the possibility of common & serious side effects.
- An AEFI is considered serious if it causes death, is life-threatening, requires hospitalisation or causes significant disability. (World Health Organization, 2021)



PROBLEM STATEMENT



Risks of additional vaccine doses

- people are becoming increasingly concerned about additional potential risks, especially since vaccination will not phase out any time soon.



Little awareness regarding AEFI issues

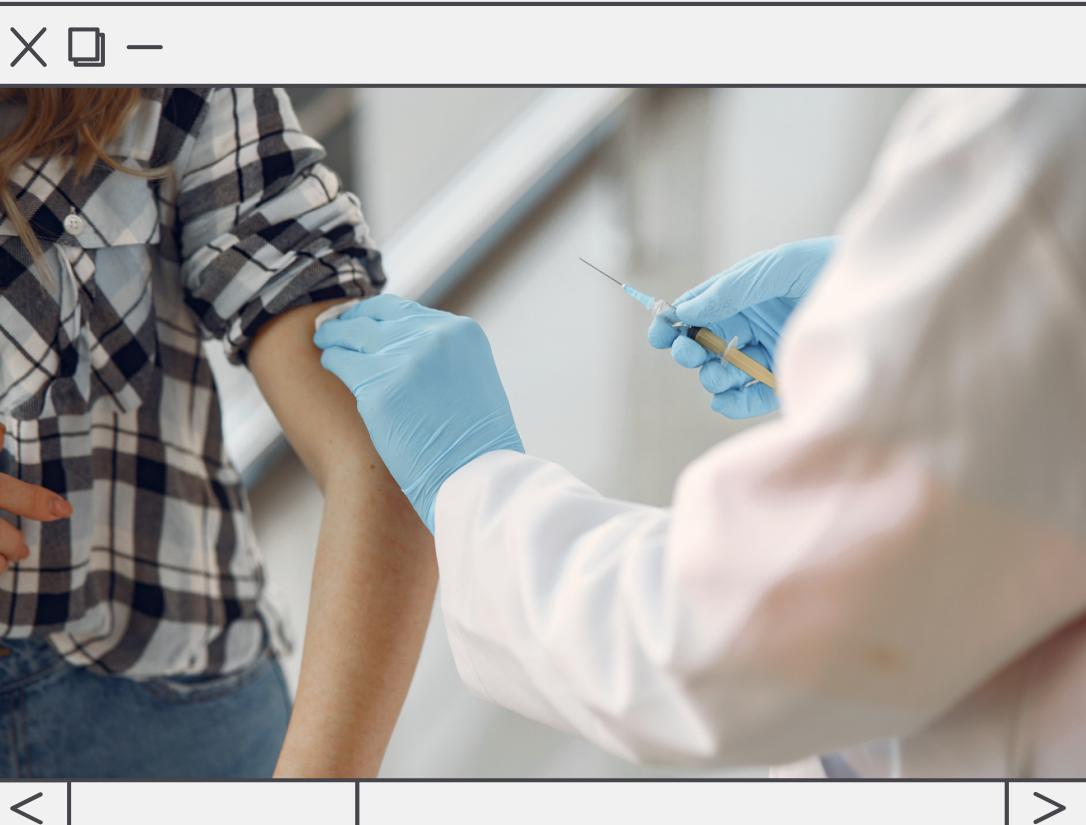
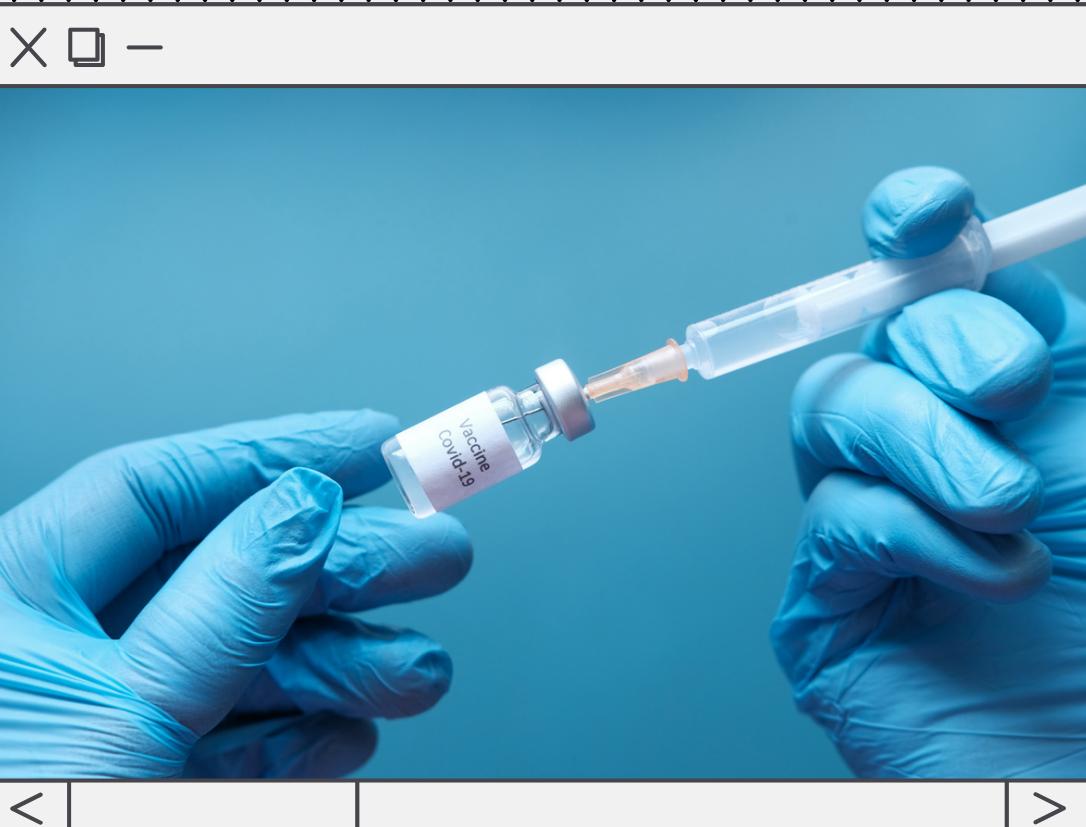


- The public are convinced that the vaccine's advantages outweigh any risks.
- no vaccine is completely risk-free, and adverse events can occur after an immunisation. (World Health Organization, 2021)

Death threats or medical complications in the future



- Further research is needed to figure out why there are adverse outcomes.



DATA SCIENCE QUESTIONS



1

Which Covid-19 vaccine had the most adverse events reported after immunisation?

2

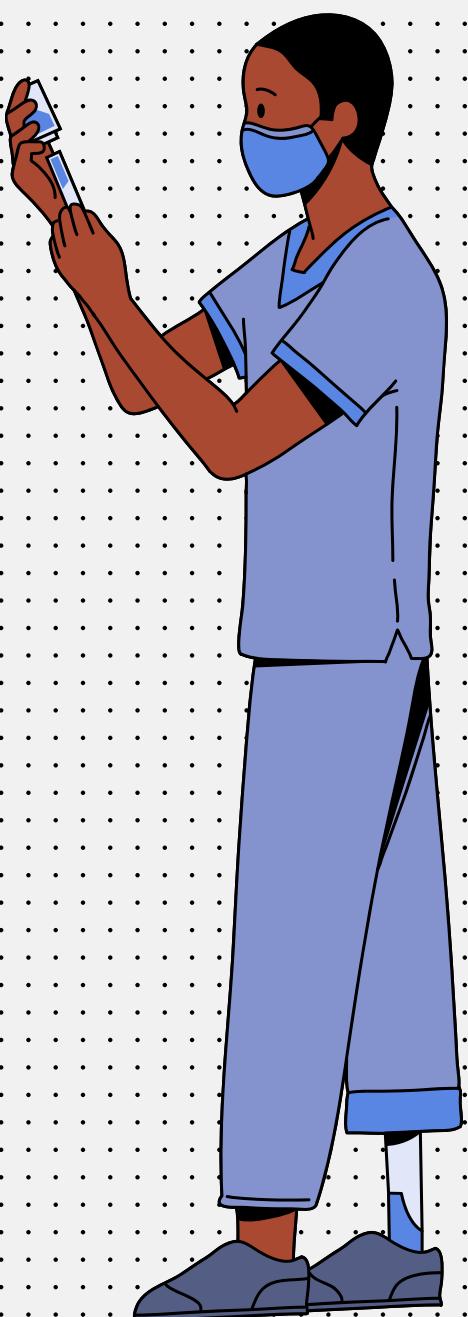
What are the health risks associated with administering a vaccine to a person?

3

How many people died after taking the Covid-19 vaccines?

4

Can we predict the health risks of vaccination for senior citizen?



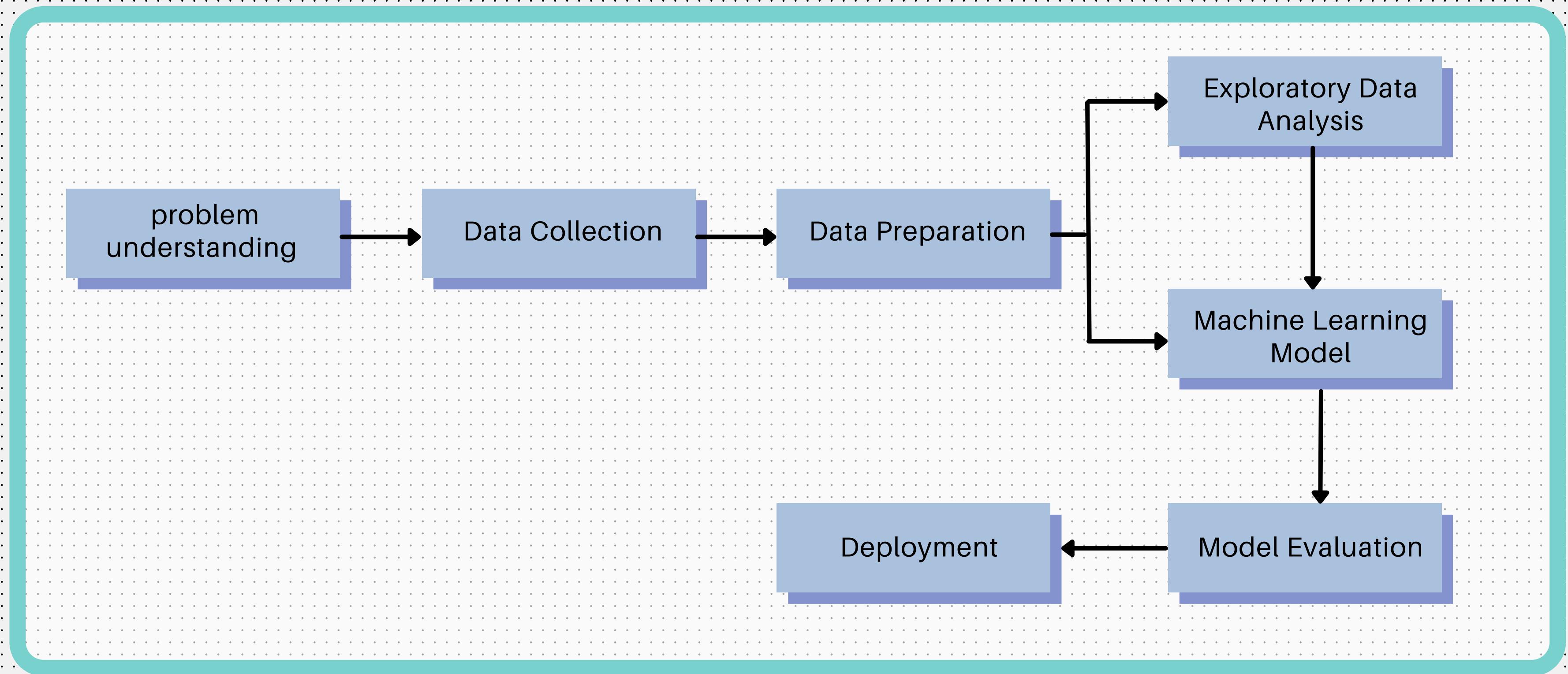
OBJECTIVES



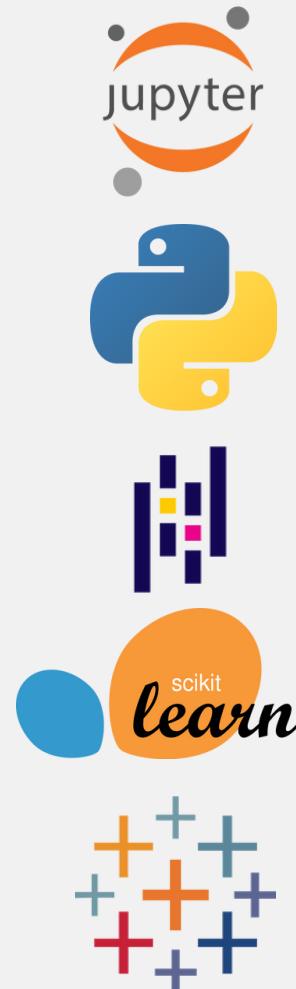
1. To identify the potential health risks of different vaccine types to people who have been vaccinated.
2. To predict the health risks of the vaccination for senior citizen using machine learning.
3. To develop a dashboard that visualizes the COVID-19 Adverse Events Following Immunization (AEFI).



DATA SCIENCE METHODOLOGY



TOOLS



Jupyter Notebook

Python

pandas

scikit-learn

Tableau

}

- Data preparation
- Machine Learning
- Exploratory Data Analysis

Data Collection

Kaggle

The screenshot shows a Kaggle dataset page. At the top, it says "Dataset" and "COVID-19 World Vaccine Adverse Reactions". Below that is the subtitle "COVID-19 Vaccine Adverse Event Reporting System". A profile picture of Ayush Garg and the text "Ayush Garg • updated 10 months ago (Version 4)" are displayed. Below this, there are tabs for "Data" (which is underlined), "Code (8)", "Discussion (6)", "Activity", and "Metadata". To the right of these tabs are buttons for "Download (34 MB)" and "New Notebook". There is also a "More" button represented by three dots. Below the tabs, there are sections for "Usability 10.0", "License CC0: Public Domain", and "Tags health, covid19, public safety, public health, demographics". A large text area at the bottom provides information about VAERS, mentioning its creation by FDA and CDC, its purpose to monitor adverse events, and the types of reports it receives. It also notes that healthcare providers are required to report certain adverse events following vaccination.

<https://www.kaggle.com/ayushggarg/covid19-vaccine-adverse-reactions>
<https://www.cdc.gov/vaccinesafety/ensuringsafety/monitoring/vaers/index.htm>

CDC VAERS website



Vaccine Safety

Vaccine Adverse Event Reporting System (VAERS)

As of October 2021, there are [three COVID-19 vaccines](#) approved or authorized for use in the United States to protect against COVID-19 disease. These vaccines are monitored by VAERS and several other vaccine safety monitoring systems as part of the most intensive vaccine safety monitoring effort in U.S. history. This continuous, robust safety monitoring helps keep COVID-19 vaccines safe and helps ensure the benefits of vaccination continue to outweigh any risks.

Learn more about [Ensuring COVID-19 Vaccine Safety in the U.S.](#)

Healthcare providers are required to report certain adverse events following COVID-19 vaccination to VAERS. Learn about [COVID-19 vaccine Emergency Use Authorization \(EUA\) reporting requirements for healthcare providers](#).

Dataset (total: 3 files)

2021VAERSDATA.csv

- VAERS_ID
- RECVDATE
- STATE
- AGE_YRS
- CAGE_YR
- CAGE_MO
- SEX
- RPT_DATE
- SYMPTOM_TEXT
- DIED
- DATEDIED
- L_THREAT
- ER_VISIT
- HOSPITAL
- HOSPDAYS
- X_STAY
- DISABLE
- RECOVID
- VAX_DATE
- ONSET_DATE
- NUMDAYS
- LAB_DATA
- V_ADMINBY
- V_FUNDBY
- OTHER_MEDS
- CUR_ILL
- HISTORY
- PRIOR_VAX
- SPLTTYPE
- FORM_VERS
- TODAYS_DATE
- BIRTH_DEFECT
- OFC_VISIT
- ER_ED_VISIT
- ALLERGIES



2021VAERSVAX.csv

- VAERS_ID
- VAX_TYPE
- VAX_MANU
- VAX_LOT
- VAX_DOSE_SERIES
- VAX_ROUTE
- VAX_SITE
- VAX_NAME



2021VAERSSYMPTOMS.csv

- VAERS_ID
- SYMPTOM1
- SYMPTOMVERSION1
- SYMPTOM2
- SYMPTOMVERSION2
- SYMPTOM3
- SYMPTOMVERSION3
- SYMPTOM4
- SYMPTOMVERSION4
- SYMPTOM5
- SYMPTOMVERSION5



Next →

Data Preparation

Data Cleaning

- filled in the categorical columns, e.g "DIED", "L_THREAT", "ER_VISIT" that has NULL values with "N".
- filled in "AGE" column NULL values with median value
- filled in "SYMPTOM" columns NULL values with '0'.
- created group for the "AGE" column to separate them according to their age groups.
- dropped unimportant columns
- dropped duplicates
- merged the datasets together

During Data Cleaning

- dropped unimportant columns

```
# remove Columns  
vaers_data_dropped = vaers_data.drop(columns =['CAGE_YR', 'CAGE_MO', 'RPT_DATE', 'ONSET_DATE','NUMDAYS', 'LAB_DATA',  
|'V_ADMINBY', 'DATEDIED', 'V_FUNDBY','SPLTTYPE', 'FORM_VERS'])
```

- filled in "SYMPTOM" columns NULL values with '0'.

```
new_vaers_symptoms_df = new_vaers_symptoms_df.fillna(0)  
new_vaers_symptoms_df
```

	VAERS_ID	SYMPTOM1	SYMPTOM2	SYMPTOM3	SYMPTOM4	SYMPTOM5
0	916600	Dysphagia	Epiglottitis	0	0	0
1	916601	Anxiety	Dyspnoea	0	0	0
2	916602	Chest discomfort	Dysphagia	Pain in extremity	Visual impairment	0
3	916603	Dizziness	Fatigue	Mobility decreased	0	0

- dropped duplicates

```
# Remove duplicates  
clean_vax_symp = vax_symp_join.drop_duplicates()  
clean_vax_symp
```

	VAX_TYPE	VAX_MANU	VAX_NAME	SYMPTOM1	SYMPTOM2	SYMPTOM3
VAERS_ID						
916600	COVID19	MODERNA	COVID19 (COVID19 (MODERNA))	Dysphagia	Epiglottitis	
916601	COVID19	MODERNA	COVID19 (COVID19 (MODERNA))	Anxiety	Dyspnoea	

- merged the datasets together

```
Merge_DATA_VAXSYMPTOM = csv1.merge(csv2,on=["VAERS_ID"])
```

Merge_DATA_VAXSYMPTOM

	VAERS_ID	AGE_YRS	SEX	DIED	L_THREAT	ER_VISIT	HOSPITAL	DISABLE	BIRTH_DEFECT
0	916600	33.0	F	N	N	N	N	N	N
1	916601	73.0	F	N	N	N	N	N	N

- created group for the "AGE" column to separate them according to their age groups.

```
#separate age group (into bins)  
bins = [0, 19.0, 41.0, 60.0, 110.0]  
labels = ["0-18", "19-40", "41-59", "60+"]
```

- filled in the categorical columns, e.g "DIED", "L_THREAT", "ER_VISIT" that has NULL values with "N".

```
vaers_data_cleaned.DIED.fillna(value = "N", inplace=True)
```

After Data Cleaning

VAERS_ID	AGE_YRS	SEX	DIED	L_THREAT	ER_VISIT	HOSPITAL	DISABLE	BIRTH_DEFECT	AGE_BIN
created age group									
916600	33.0	F	N	N	N	N	N	N	19-40
916601	73.0	F	N	N	N	N	N	N	60+
916602	23.0	F	N	<- filled NULL values with "N"				N	19-40
916603	58.0	F	N	N	N	N	N	N	41-59
916604	47.0	F	N	N	N	N	N	N	41-59
...
1113917	88.0	F	N	N	Y	N	N	N	60+
1113920	83.0	F	N	N	N	N	N	N	60+
1113963	59.0	F	Y	N	N	N	N	N	41-59
1115045	57.0	<- filled NULL values with median value				N	N	N	41-59
1115348	47.0	F	Y	N	N	N	N	N	41-59

SYMPTOM1	SYMPTOM2	SYMPTOM3	SYMPTOM4	SYMPTOM5
Dysphagia	Epiglottitis	0	0	0
Anxiety	Dyspnoea	0	0	0
Chest discomfort	Dysphagia	Pain in extremity	Visual impairment	0
Dizziness	Fatigue	Mobility decreased	0	0
Injection site erythema	Injection site pruritus	Injection site swelling	Injection site warmth	0
...
Nasal discomfort	Night sweats	Platelet count	Platelet count decreased	Pyrexia
Rash	SARS-CoV-2 test	0	0	0
Haemophagocytic lymphohistiocytosis	SARS-CoV-2 test	0	0	0
Death	0	<- filled in NULL values with '0'		
Death	0	0	0	0

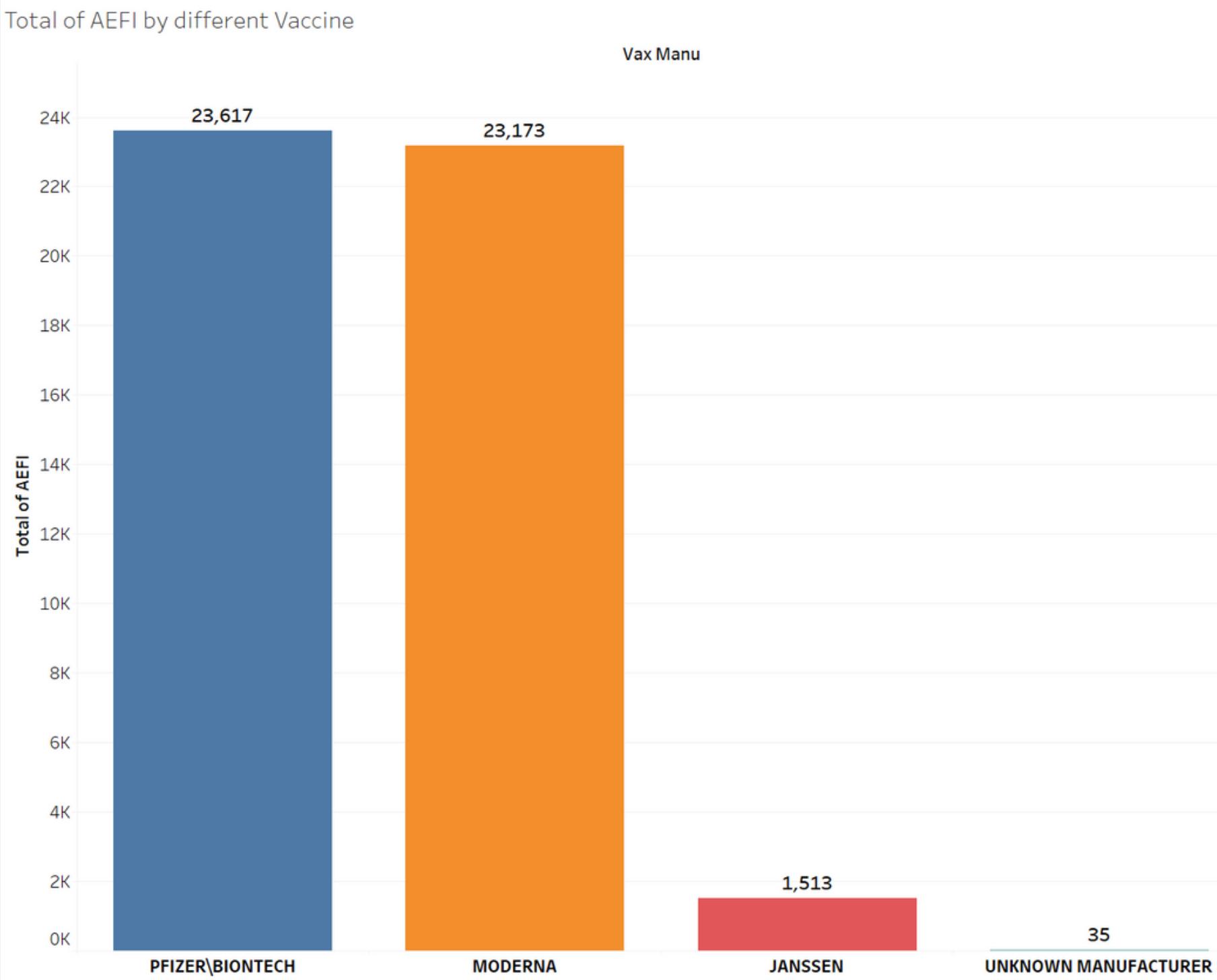
VAX_LOT	VAX_DOSE_SERIES	VAX_ROUTE	VAX_SITE	VAX_NAME
037K20A	1	IM	LA	COVID19 (COVID19 (MODERNA))
025L20A	1	IM	RA	COVID19 (COVID19 (MODERNA))
EL1284	1	IM	LA	COVID19 (COVID19 (PFIZER-BIONTECH))
unknown	UNK	NaN	NaN	COVID19 (COVID19 (MODERNA))
NaN	1	IM	LA	COVID19 (COVID19 (MODERNA))

VAERS_ID	SYMPTOM1	SYMPTOM2	SYMPTOM3	SYMPTOM4	SYMPTOM5	VAX_MANU	RECVDATE	STATE	AGE_YRS	SEX	...
916710	Appendicitis	Band neutrophil percentage increased	Surgery	White blood cell count increased	0	MODERNA	01/01/2021	MO	23.0	F	...
916890	Chest X-ray	Dyspnoea	Laboratory test	SARS-CoV-2 test	Throat tightness	PFIZER\BIONTECH	01/01/2021	TX	39.0	F	...
916890	Urticaria	Wheezing	0	0	0	PFIZER\BIONTECH	01/01/2021	TX	39.0	F	...

Exploratory Data Analysis



1. Which Covid-19 vaccine had the most adverse events reported after immunisation?



- **Pfizer** reported the highest count of AEFI (23,617 records)
- **Moderna** (23,173 records)
- **Janssen** (1,513 records)

Overall: 48,338 records

Exploratory Data Analysis

2. What are the health risks associated with administering a vaccine to a person?

Pfizer

AEFI	=	PFIZER\b..
Chills		1,421
Arthralgia		957
Headache		726
Dizziness		724
Fatigue		660
Asthenia		582
Pyrexia		500
Death		449
Pain		373
Nausea		316

Moderna

AEFI	=	MODERNA
Chills		1,476
Injection site ery..		1,319
Arthralgia		904
Headache		694
Dizziness		661
Fatigue		650
Erythema		600
Death		522
Asthenia		500
Pyrexia		496

Janssen

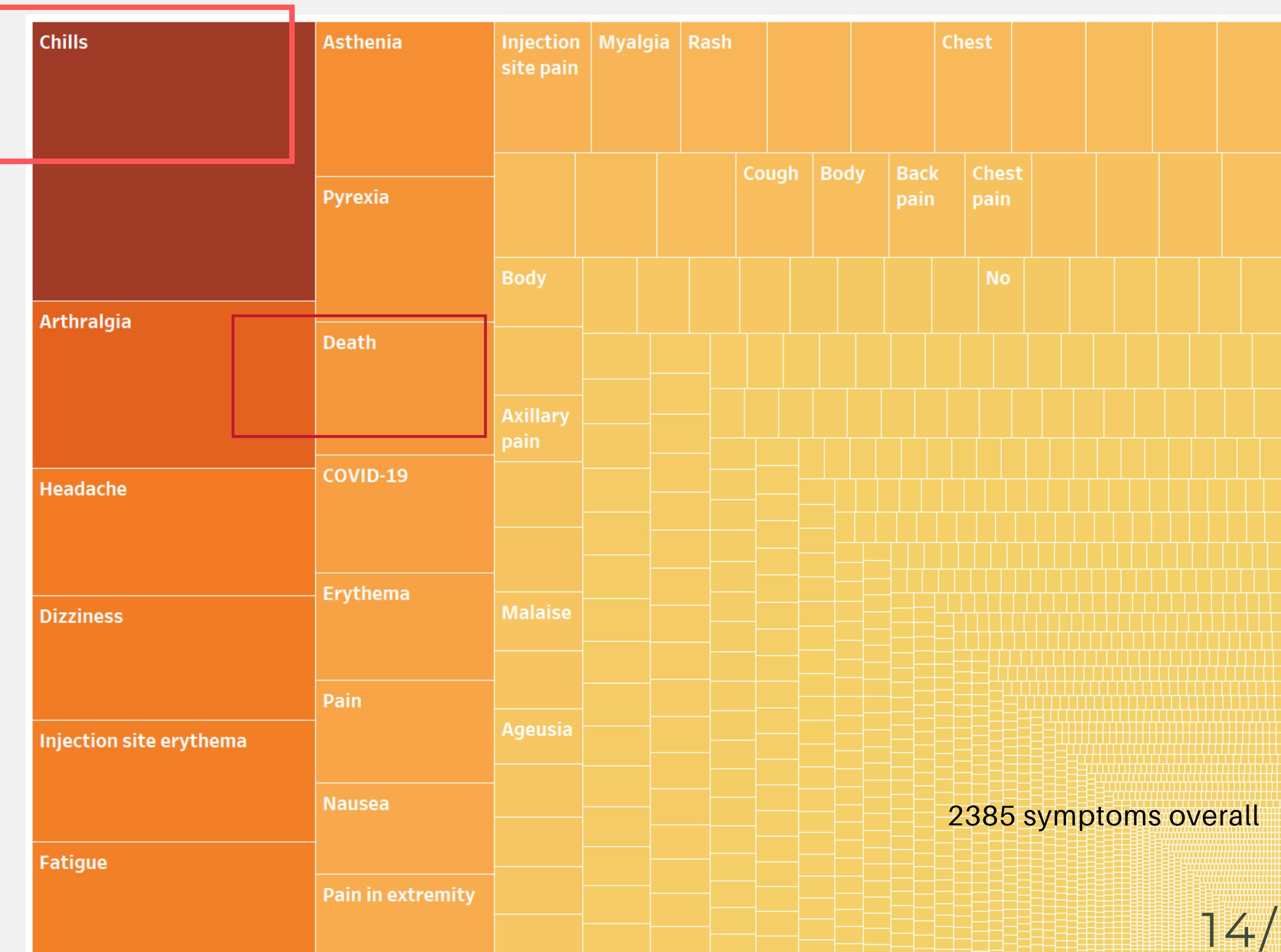
AEFI	=	JANSSEN
Chills		361
Arthralgia		85
Fatigue		77
Pyrexia		75
Headache		67
Dizziness		64
Asthenia		54
Pain		46
Nausea		34
Myalgia		21

Tree Map of AEFI symptoms

"chills" as the most reported symptom ➤

joint pain/stiffness ➤

swelling ➤



Top 10 most reported AEFI that directly/indirectly resulted to Death (serious AEFI)

AEFI	=
Cardiac arrest	3.169%
COVID-19	2.832%
Asthenia	2.259%
Unresponsive to stimuli	1.382%
Dyspnoea	1.214%
Sudden death	1.011%
Cerebrovascular accident	0.944%
SARS-CoV-2 test positive	0.775%
Cough	0.674%
Cardio-respiratory arrest	0.674%



Cardiac arrest is usually related to myocarditis (heart inflammation)

- In serious cases, it can cause abnormal heart rhythms.
- slightly less rare in children and young people.

AEFI	Age Group		
	19-40	41-59	60+
Cardiac arrest	4	10	80

- According to British Heart Foundation(2021), men are generally at higher risk of myocarditis than women, whether or not it is linked to the vaccine.

AEFI	Age Group / SEX	
	60+	Male
Cardiac arrest	30	50

Top 10 most reported AEFI that directly/indirectly resulted to Hospitalization (serious AEFI)

AEFI	=
Chills	6.744%
Arthralgia	4.030%
Headache	3.076%
Dizziness	2.998%
Injection site erythema	2.929%
Fatigue	2.869%
Asthenia	2.352%
Pyrexia	2.218%
COVID-19	1.785%
Erythema	1.636%

Chills/fever is the most common side effects of vaccine.



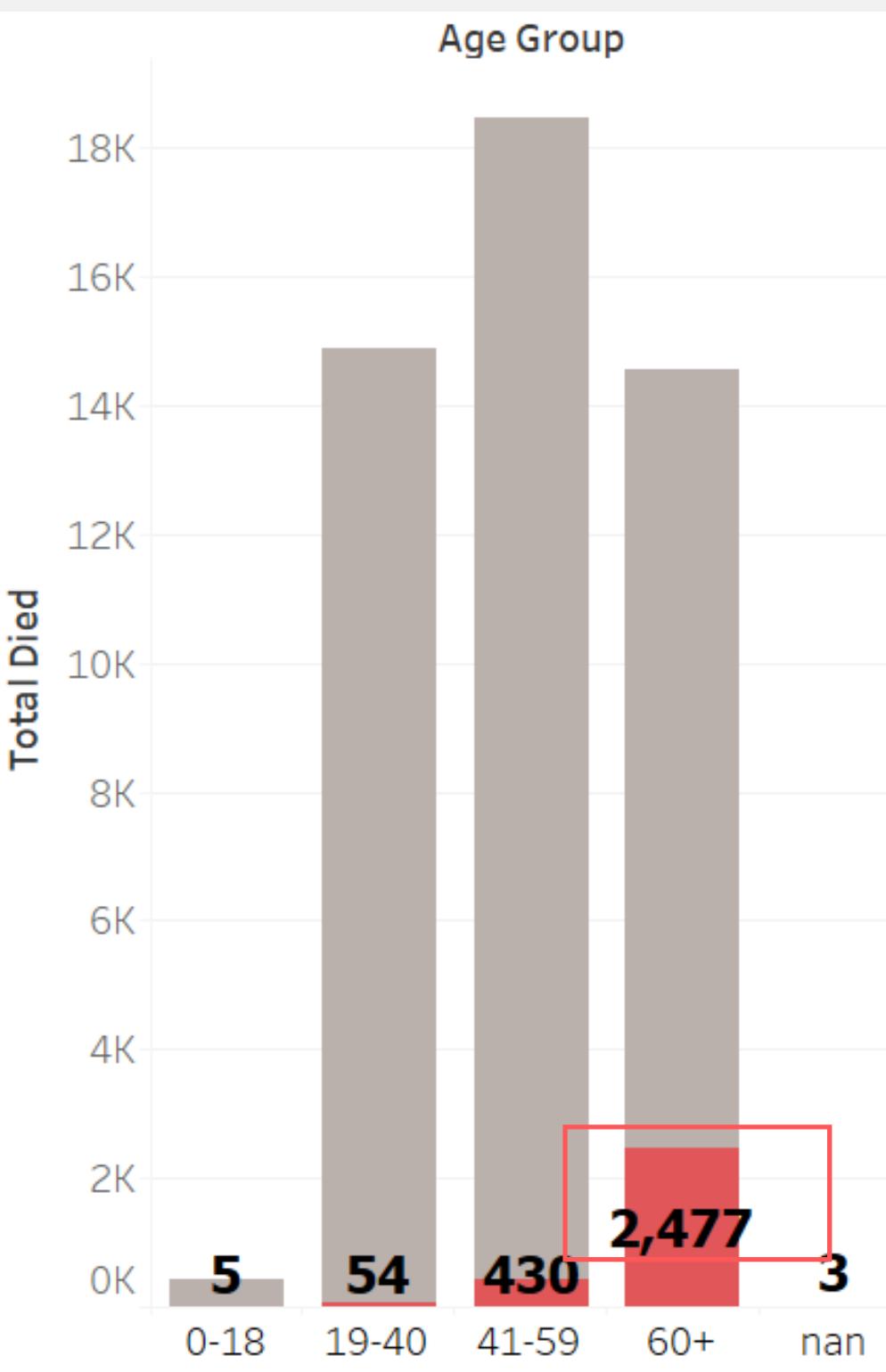
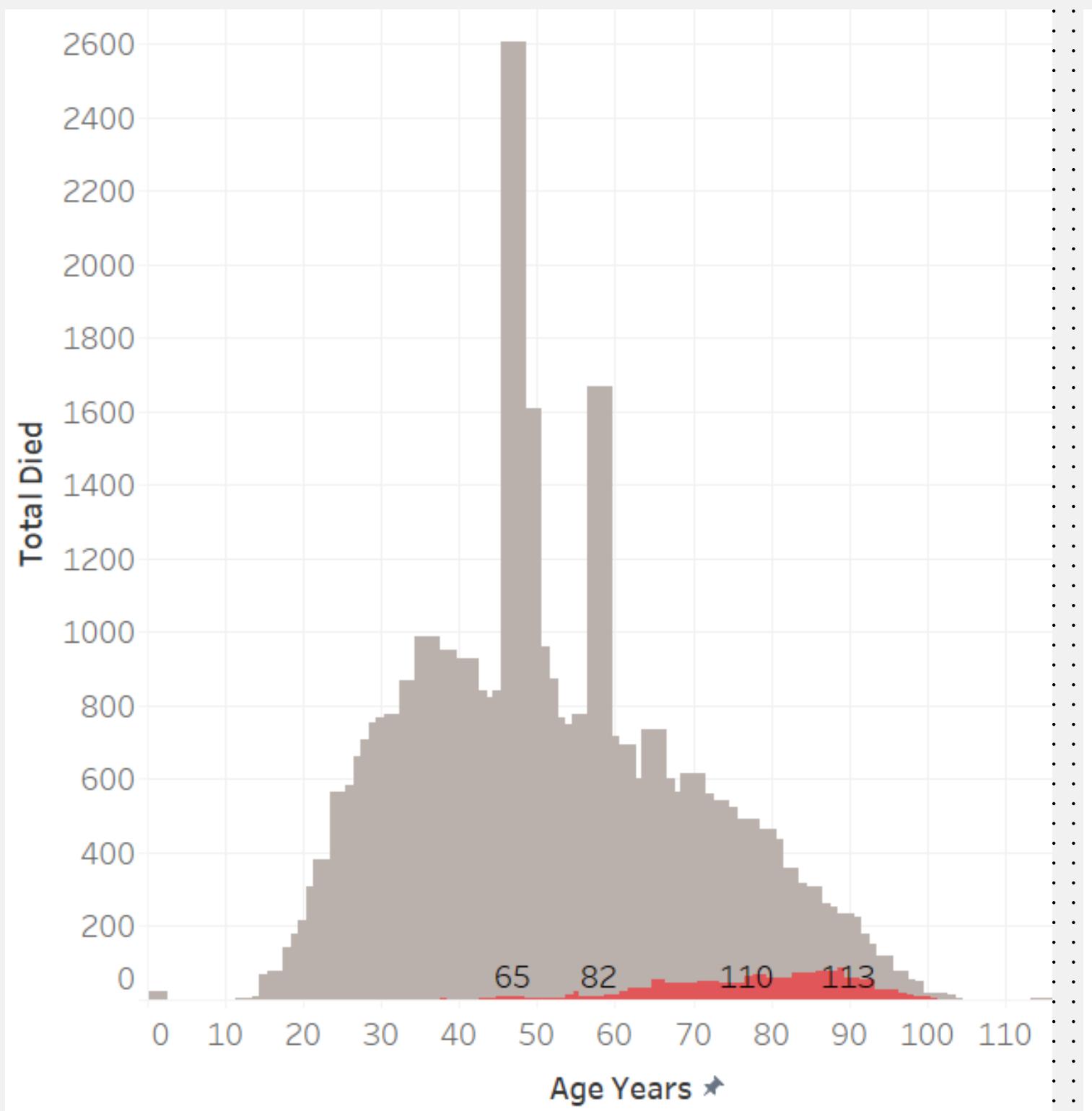
- usually is mild & relieved within 1 or 2 days
- According to CDC (2022), possible side effect of vaccine:
 - pain, swelling, tenderness, redness or itching at the injection site
 - tiredness
 - headache
 - muscle pain
 - nausea
 - fever and chills
 - feeling unwell
 - joint pain.
- but, 6.7% those who reported to have "chills", are hospitalized.
- it is advised to seek medical attention if the symptom do not recover as normal, or exceed certain temperature.

Top 10 most reported AEFI that directly/indirectly resulted to **Disability** (serious AEFI)

AEFI	F	
Arthralgia	4.912%	• joint stiffness/pain/arthritis
Asthenia	2.486%	
Cerebrovascular accident	1.455%	• stroke. usually related to blood clot.
Facial paralysis	1.395%	• According to a research by Sato (2021), the analysis revealed that the AEFI of facial nerve palsy , after administration of COVID-19 mRNA vaccines, was significantly highly reported
Headache	1.213%	
Chills	1.213%	
Pain in extremity	1.152%	
Pain	1.152%	
Back pain	1.152%	
Angiogram	1.092%	• x-ray imaging of heart's blood vessels

Exploratory Data Analysis

3. How many people died after taking the Covid-19 vaccines?



Age Gr..	N	Died
0-18	417	5
19-40	14,828	54
41-59	18,035	430
60+	12,089	2,477

- Senior Citizen (age 60+) reported the highest death counts
- They are the ones who took the vaccine first

Data Modelling - Predictive Analysis

4. Can we predict the health risks of vaccination for senior citizen (age 60 & above)?

Random Forest Model

```
# Create a random forest classifier.  
rf_model = RandomForestClassifier(n_estimators=128, random_state=42)  
  
# Fitting the model  
rf_model = rf_model.fit(X_train_scaled, y_train)  
  
# Evaluate the model  
y_pred = rf_model.predict(X_test_scaled)  
accuracy = accuracy_score(y_test,y_pred)  
  
print("Random forest predictive accuracy: %.2f%%" % (accuracy * 100.0))
```

Random forest predictive accuracy: 74.94%

XGBoost Model

```
from xgboost import XGBClassifier  
  
#create xg boost  
xg_model = XGBClassifier(random_state=42)  
  
# Fitting the model  
xg_model = xg_model.fit(X_train_scaled, y_train)  
  
# Evaluate the model  
y_pred = xg_model.predict(X_test_scaled)  
accuracy = accuracy_score(y_test,y_pred)  
print("XGBoost predictive accuracy:: %.2f%%" % (accuracy * 100.0))
```

XGBoost predictive accuracy:: 77.60%

Random Forest

```
print(classification_report(y_test, y_pred))
```

	precision	recall	f1-score	support
0.0	0.78	0.89	0.83	8451
1.0	0.62	0.42	0.50	3634
accuracy			0.75	12085
macro avg	0.70	0.66	0.67	12085
weighted avg	0.73	0.75	0.73	12085

Random forest predictive accuracy: 74.94%

XGBoost Model

```
print(classification_report(y_test, y_pred))
```

	precision	recall	f1-score	support
0.0	0.0	0.79	0.93	0.85
1.0	1.0	0.72	0.42	0.53
accuracy			0.78	12085
macro avg	0.75	0.67	0.69	12085
weighted avg	0.77	0.78	0.76	12085

XGBoost predictive accuracy:: 77.60%

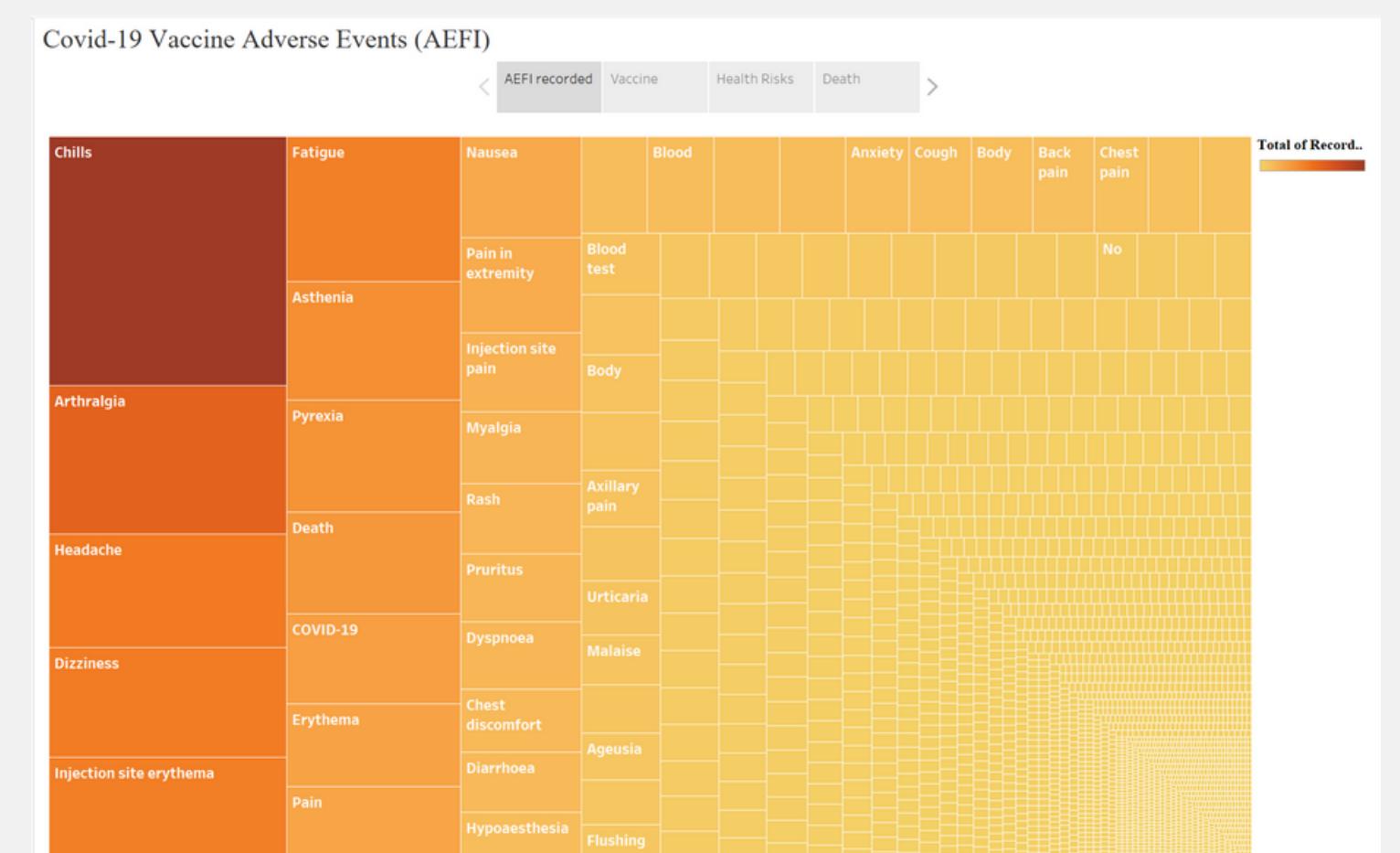
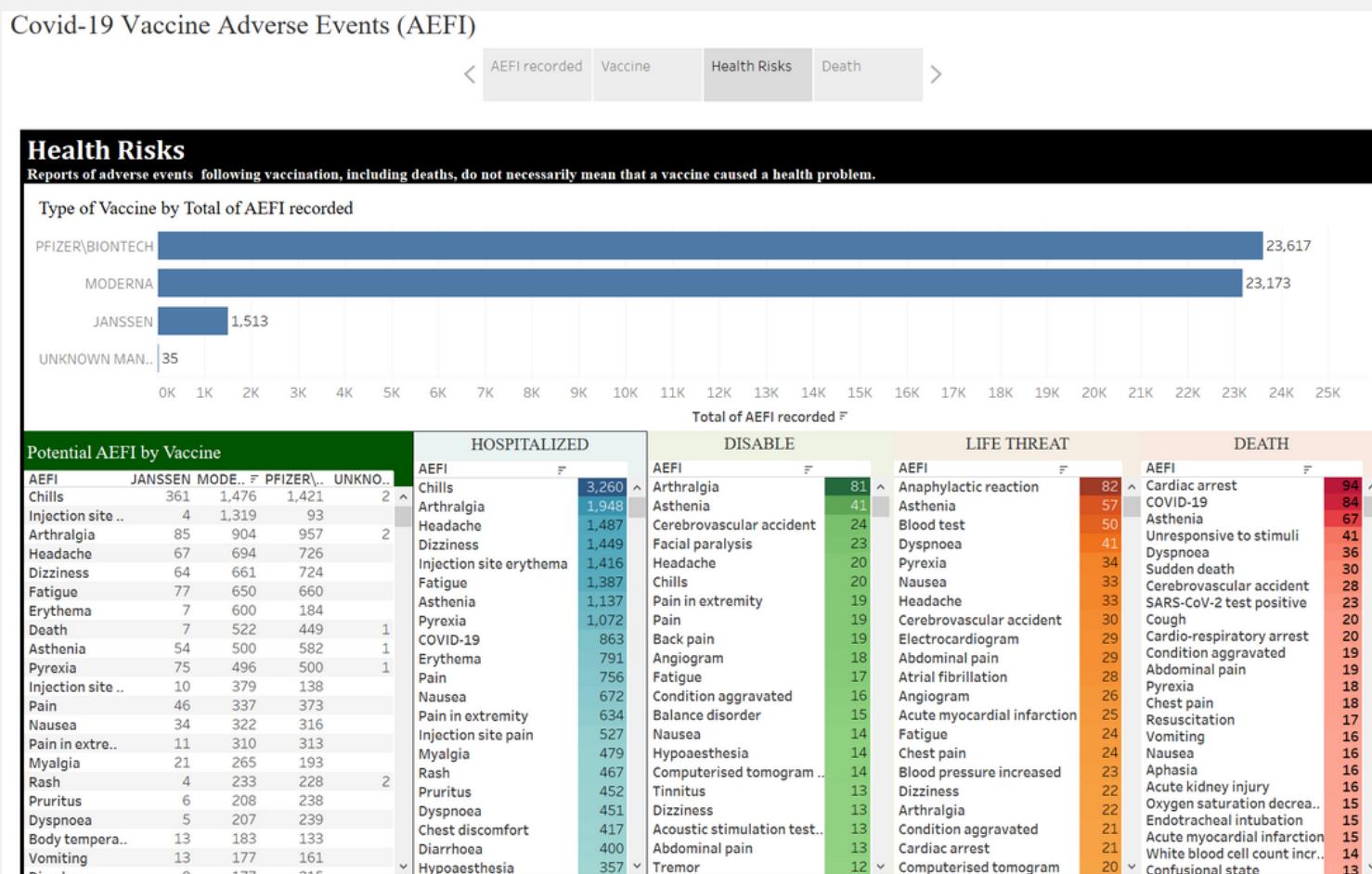
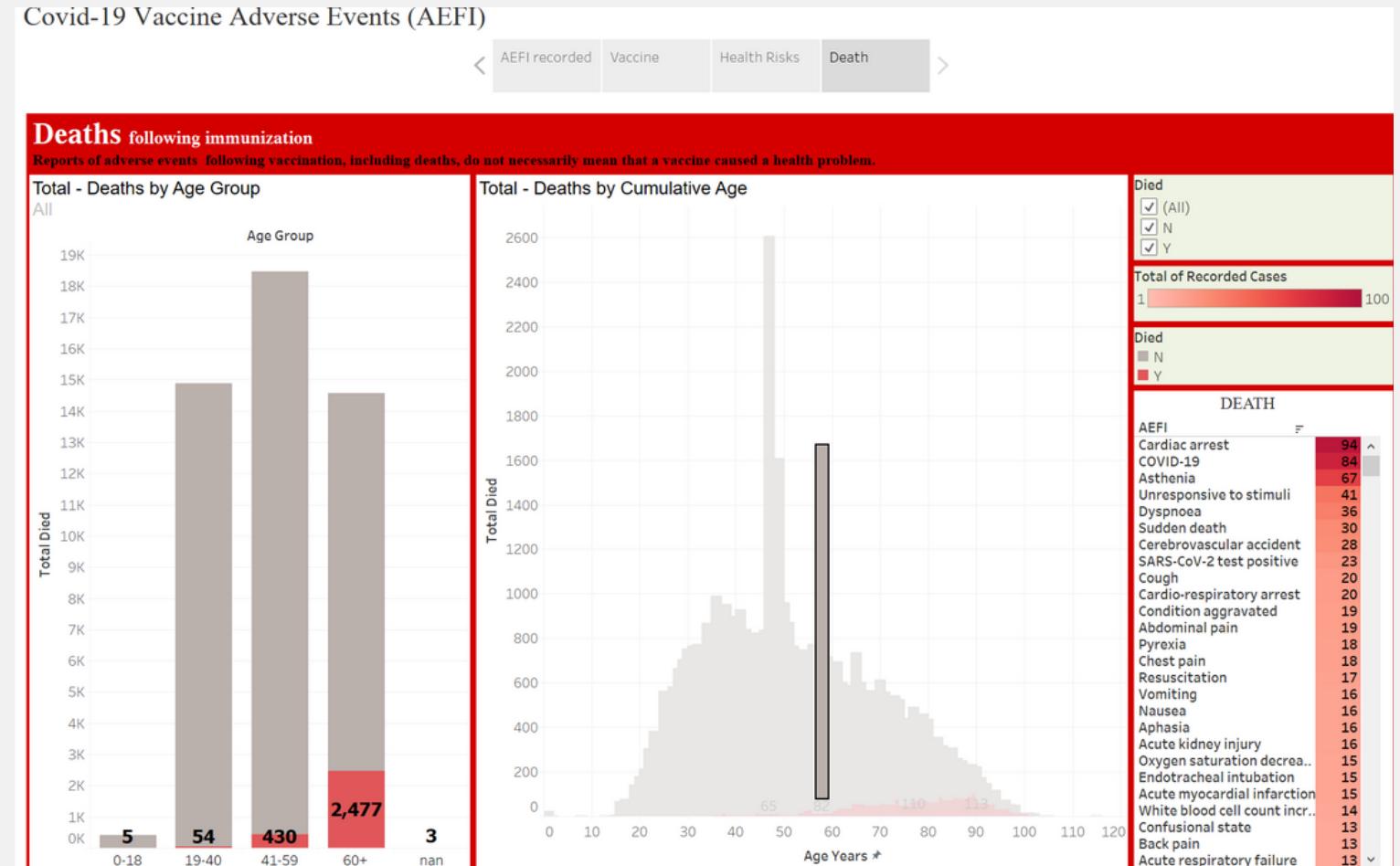
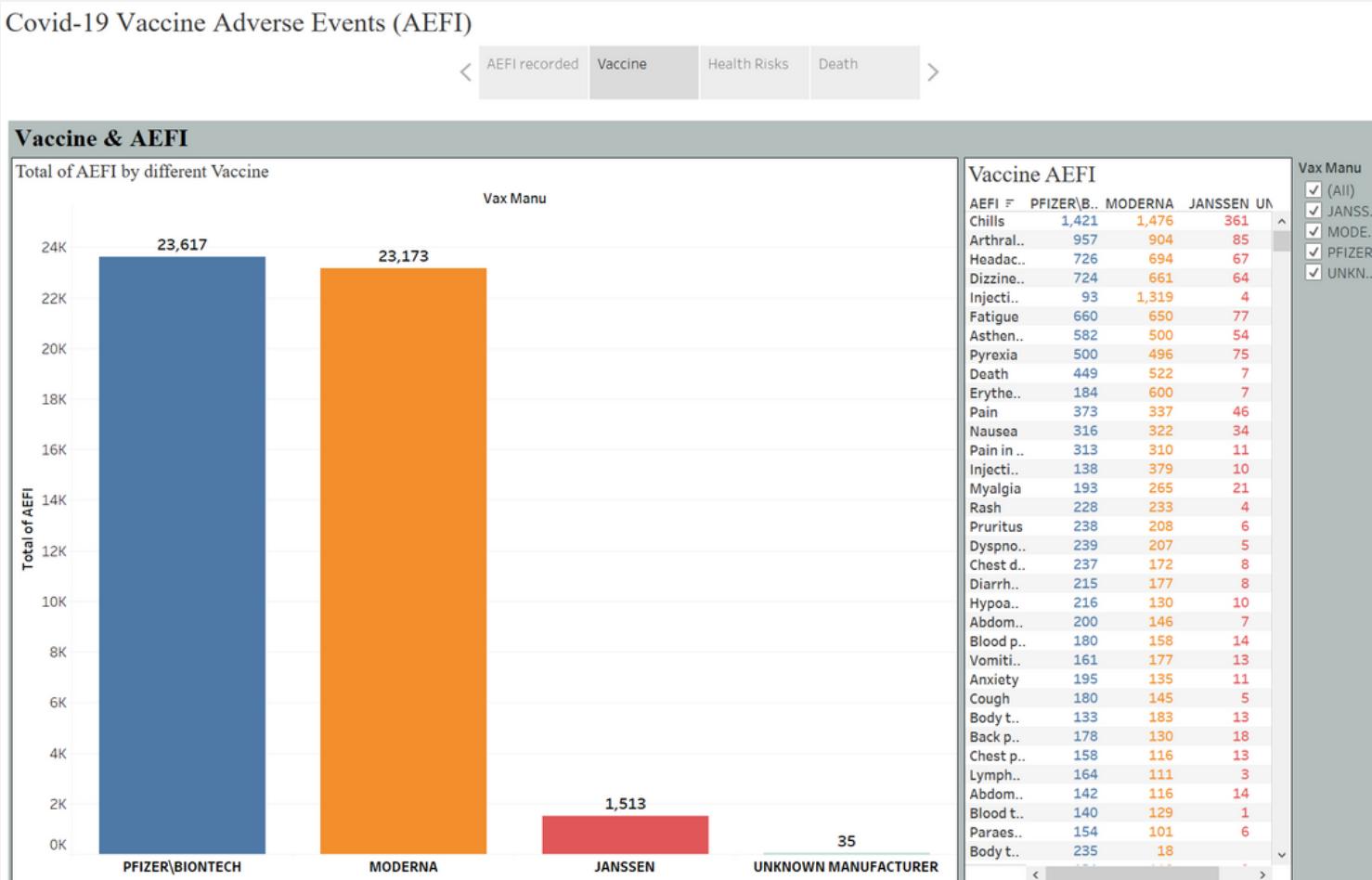


INSIGHTS & ACTION SUGGESTION



- Older people, and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness.
- These AEFI, if they happen at all, are temporary. (Johns Hopkins Medicine, 2021)
But, the possibilities for serious AEFI to occur, are there.
- Do research: questions are important, and getting the right answers from reliable sources can add to your peace of mind.

Data Product - Tableau Dashboard (public)



references

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Thank you!



Dr Salimah Mokhtar & me
- Meeting for Data Science Project