

Covid-19 Vaccination Campaign in Germany

The data used here were provided by [Robert Koch Institute](#) and the [German federal ministry of Health](#).

These institutions publish the datasets and some analysis on the page [impfdashboard.de](#).

Setup

Imports

```
In [1]: # standard library
import datetime
import math
```

```
In [2]: # third party
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import requests
import seaborn
```

Date this Notebook was run

```
In [3]: today = datetime.datetime.today().strftime('%Y-%m-%d')
today
```

```
Out[3]: '2021-05-27'
```

Set Defaults

```
In [4]: # style like ggplot in R
plt.style.use('ggplot')
```

```
In [5]: # Avoid cutting off part of the axis labels, see:
# https://stackoverflow.com/questions/6774086/why-is-my-xlabel-cut-off-in-my-matplotlib-plot
plt.rcParams.update({'figure.autolayout': True})
```

```
In [6]: population_germany = 83_200_000
```

Get and Transform Data

```
In [7]: vaccination_data_permalink = 'https://impfdashboard.de/static/data/germany_vaccinations_timeseries_v2.tsv'
vaccinations = pd.read_csv(
    vaccination_data_permalink,
    sep="\t")
```

Drop unnecessary / misleading columns

Columns with names starting with 'indikation_' will not be analyzed as the data providers stopped updating them.

```
In [8]: cols_to_drop = vaccinations.columns[vaccinations.columns.str.contains('indikation_')]
vaccinations.drop(columns=cols_to_drop, inplace=True)
```

Some more columns can be dropped, as there is no interest in analyzing differences on a vaccine level - especially since in some cases vaccines were mixed.

```
In [9]: more_cols_to_drop = ['dosen_biontech_erst_kumulativ', 'dosen_biontech_zweit_kumulativ',
                             'dosen_moderna_erst_kumulativ', 'dosen_moderna_zweit_kumulativ',
                             'dosen_astrazeneca_erst_kumulativ', 'dosen_astrazeneca_zweit_kumulativ']
vaccinations.drop(columns=more_cols_to_drop, inplace=True)
```

Some columns are labeled misleadingly. As stated by the data provider the columns `personen_erst_kumulativ` and `impf_quote_erst` contain people vaccinated with the Johnson & Johnson vaccine. As this requires only one shot. the same persons are included in `personen_voll_kumulativ`. Therefore more columns are dropped and recalculated later.

```
In [10]: vaccinations.drop(columns=['impf_quote_erst', 'impf_quote_voll'], inplace=True)
```

Convert datatype of date column

```
In [11]: vaccinations.iloc[:, [0]] = vaccinations.iloc[:, [0]].apply(pd.to_datetime)
```

Show Data

```
In [12]: vaccinations.info()

<class 'pandas.core.frame.DataFrame'>
```

RangeIndex: 151 entries, 0 to 150

Data columns (total 13 columns):

#	Column	Non-Null Count	Dtype
0	date	151 non-null	datetime64[ns]
1	dosen_kumulativ	151 non-null	int64
2	dosen_differenz_zum_vortag	151 non-null	int64
3	dosen_erst_differenz_zum_vortag	151 non-null	int64
4	dosen_zweit_differenz_zum_vortag	151 non-null	int64
5	dosen_biontech_kumulativ	151 non-null	int64
6	dosen_moderna_kumulativ	151 non-null	int64
7	dosen_astrazeneca_kumulativ	151 non-null	int64
8	personen_erst_kumulativ	151 non-null	int64
9	personen_voll_kumulativ	151 non-null	int64
10	dosen_dim_kumulativ	151 non-null	int64
11	dosen_kbv_kumulativ	151 non-null	int64
12	dosen_johnson_kumulativ	151 non-null	int64

dtypes: datetime64[ns](1), int64(12)

memory usage: 15.5 KB

In [13]: `vaccinations.tail(3)`

Out[13]:

	date	dosen_kumulativ	dosen_differenz_zum_vortag	dosen_erst_differenz_zum_vortag	dosen_zweit_differenz_zum_vortag	dosen_biontech_kumulativ
148	2021-05-24	45588467	322496	143172	179324	3338910
149	2021-05-25	46223183	634716	268926	365790	3382538
150	2021-05-26	47358842	1135659	456833	678826	3468345

Check Validity

In [14]: `# get the last row / the newest available data`
`last_row = vaccinations.tail(1)`

In [15]: `doses_used = last_row['dosen_kumulativ']`
`doses_used`

Out[15]: 150 47358842
 Name: dosen_kumulativ, dtype: int64

```
In [16]: # The number of person having been vaccinated at least once, includes those fully vaccinated
at_least_once = last_row['personen_erst_kumulativ']
fully_vaccinated_people = last_row['personen_voll_kumulativ']
partially_vaccinated_people = at_least_once - fully_vaccinated_people
# The johnson & Johnson vaccine is the only one used in Germany that only needs a single shot:
johnson_doses = last_row['dosen_johnson_kumulativ']
```

```
In [17]: # Must be exactly 0
doses_used - partially_vaccinated_people - (fully_vaccinated_people - johnson_doses) * 2 - johnson_doses == 0
```

```
Out[17]: 150    True
dtype: bool
```

Calculate columns

```
In [18]: vaccinations['partly vaccinated'] = round(
    (vaccinations['personen_erst_kumulativ'] - vaccinations['personen_voll_kumulativ']) * 100 / population_germany,
    2)
```

```
In [19]: vaccinations['fully vaccinated'] = round(
    vaccinations['personen_voll_kumulativ'] * 100 / population_germany,
    2)
```

```
In [20]: vaccinations.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 151 entries, 0 to 150
```

```
Data columns (total 15 columns):
```

#	Column	Non-Null Count	Dtype
0	date	151 non-null	datetime64[ns]
1	dosen_kumulativ	151 non-null	int64
2	dosen_differenz_zum_vortag	151 non-null	int64
3	dosen_erst_differenz_zum_vortag	151 non-null	int64
4	dosen_zweit_differenz_zum_vortag	151 non-null	int64
5	dosen_biontech_kumulativ	151 non-null	int64
6	dosen_moderna_kumulativ	151 non-null	int64
7	dosen_astrazeneca_kumulativ	151 non-null	int64
8	personen_erst_kumulativ	151 non-null	int64
9	personen_voll_kumulativ	151 non-null	int64
10	dosen_dim_kumulativ	151 non-null	int64
11	dosen_kbv_kumulativ	151 non-null	int64
12	dosen_johnson_kumulativ	151 non-null	int64
13	partly vaccinated	151 non-null	float64

```

14 fully vaccinated          151 non-null    float64
dtypes: datetime64[ns](1), float64(2), int64(12)
memory usage: 17.8 KB

```

```
In [21]: vaccinations.tail(3)
```

```
Out[21]:
```

	date	dosen_kumulativ	dosen_differenz_zum_vortag	dosen_erst_differenz_zum_vortag	dosen_zweit_differenz_zum_vortag	dosen_biontech_kumulati
148	2021-05-24	45588467	322496	143172	179324	3338910
149	2021-05-25	46223183	634716	268926	365790	3382538
150	2021-05-26	47358842	1135659	456833	678826	3468345

Last Update

Often the data is not updated on weekends, so get the highest date in the dataset.

```
In [22]: last_update = vaccinations.loc[vaccinations.index[-1], "date"].strftime('%Y-%m-%d')
last_update
```

```
Out[22]: '2021-05-26'
```

Doses Used

```
In [23]: doses = vaccinations.loc[:, ['date', 'dosen_differenz_zum_vortag']]
# Rename columns
doses.columns = ['date', 'doses used']
```

```
In [24]: # Scale number of doses as millions
doses['doses used'] = doses['doses used'] / 1_000_000
```

Doses Daily

```
In [25]: doses_daily = doses.set_index('date', inplace=False)
doses_daily.tail(1)
```

Out[25]:

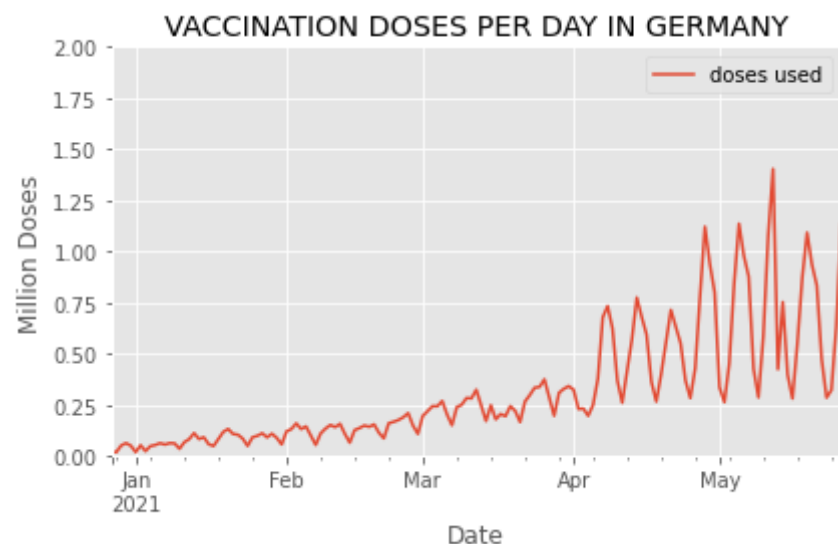
doses used	
date	
2021-05-26	1.135659

```
In [26]: # What is the highest number of doses used in a day?
max_doses_daily = max(doses_daily['doses used'])
max_doses_daily
```

Out[26]: 1.403751

```
In [27]: doses_daily.plot(
    ylim=(0,math.ceil(max_doses_daily)),
    xlabel='Date',
    ylabel='Million Doses',
    title='VACCINATION DOSES PER DAY IN GERMANY')
```

Out[27]: <AxesSubplot:title={'center':'VACCINATION DOSES PER DAY IN GERMANY'}, xlabel='Date', ylabel='Million Doses'>



Doses per Weekday (in the last 6 weeks)

```
In [28]: last_6_weeks = doses.tail(42)
```

```
In [29]: # Yields a warning, but exactly like the docs prescribe and it works
# https://pandas.pydata.org/docs/getting_started/intro_tutorials/05_add_columns.html
last_6_weeks['weekday'] = last_6_weeks['date'].dt.day_name()
```

```
<ipython-input-29-45013977109e>:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
last_6_weeks['weekday'] = last_6_weeks['date'].dt.day_name()
```

```
In [30]: # check:
last_6_weeks.tail(3)
```

```
Out[30]:
```

	date	doses used	weekday
148	2021-05-24	0.322496	Monday
149	2021-05-25	0.634716	Tuesday
150	2021-05-26	1.135659	Wednesday

```
In [31]: # drop the date column
last_6_weeks = last_6_weeks.drop(labels=['date'], axis=1)
```

```
In [32]: #last_6_weeks.set_index('weekday', inplace=True)
last_6_weeks.tail(3)
```

```
Out[32]:
```

	doses used	weekday
148	0.322496	Monday
149	0.634716	Tuesday
150	1.135659	Wednesday

```
In [33]: pivot_table = last_6_weeks.pivot(columns='weekday', values='doses used')
pivot_table.tail()
```

```
Out[33]:
```

	weekday	Friday	Monday	Saturday	Sunday	Thursday	Tuesday	Wednesday
146	NaN	NaN	0.472577	NaN	NaN	NaN	NaN	NaN
147	NaN	NaN	NaN	0.285324	NaN	NaN	NaN	NaN

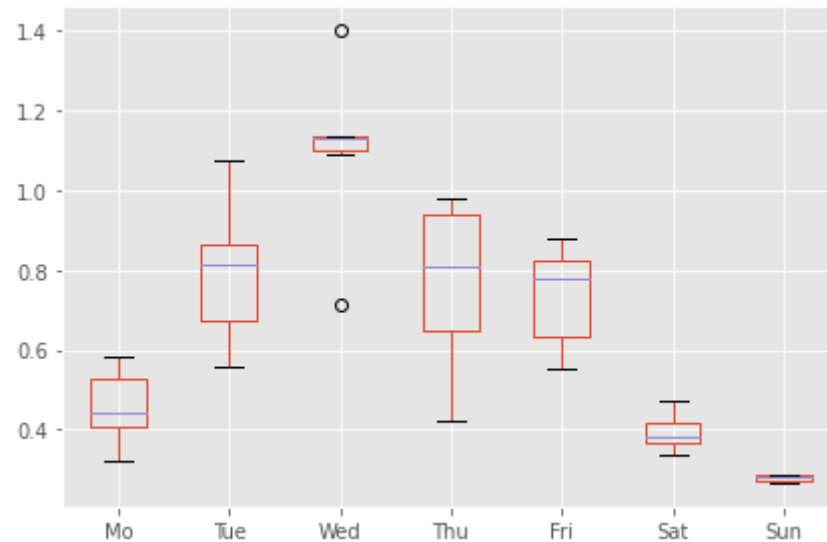
weekday	Friday	Monday	Saturday	Sunday	Thursday	Tuesday	Wednesday
148	NaN	0.322496	NaN	NaN	NaN	NaN	NaN
149	NaN	NaN	NaN	NaN	NaN	0.634716	NaN
150	NaN	NaN	NaN	NaN	NaN	NaN	1.135659

```
In [34]: # Reorder the columns
pivot_table = pivot_table[['Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday', 'Sunday']]
# Rename the columns
pivot_table.columns=['Mo', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'Sun']
pivot_table.tail()
```

```
Out[34]:
```

	Mo	Tue	Wed	Thu	Fri	Sat	Sun
146	NaN	NaN	NaN	NaN	NaN	0.472577	NaN
147	NaN	NaN	NaN	NaN	NaN	NaN	0.285324
148	0.322496	NaN	NaN	NaN	NaN	NaN	NaN
149	NaN	0.634716	NaN	NaN	NaN	NaN	NaN
150	NaN	NaN	1.135659	NaN	NaN	NaN	NaN

```
In [35]: weekday_boxplot = pivot_table.boxplot()
```

```
In [36]: fig = weekday_boxplot.get_figure()
fig.savefig('img/weekday_boxplot.png')
```

Doses per Week

```
In [37]: # W-Mon in order to start the week on a Monday, see:
# https://pandas.pydata.org/pandas-docs/stable/user_guide/timeseries.html#anchored-offsets
doses_weekly = doses.groupby(pd.Grouper(key='date', freq='W-Mon')).sum()
doses_weekly.columns = ['million doses used']
doses_weekly.tail()
```

Out[37]:

million doses used	
date	
2021-05-03	4.696559
2021-05-10	5.129997
2021-05-17	4.884954
2021-05-24	4.812848
2021-05-31	1.770375

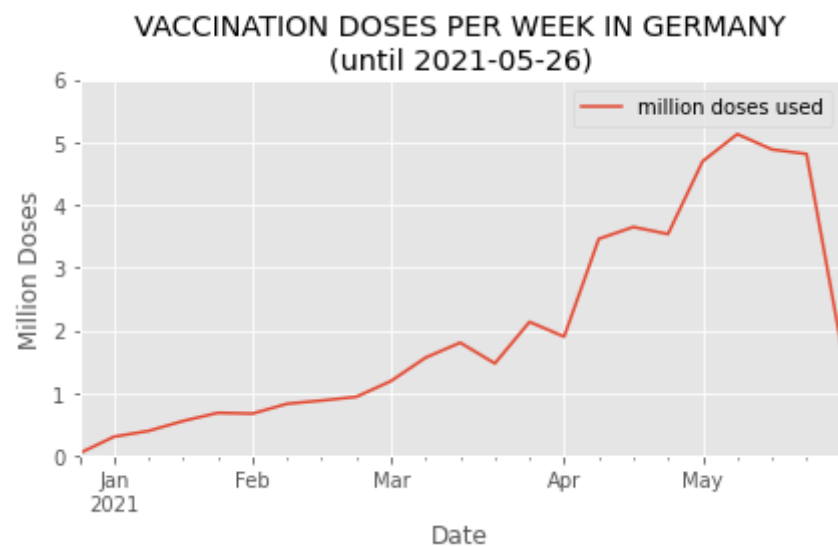
```
In [38]: # What is the highest number of doses used in a week?
```

```
max_million_doses_weekly = max(doses_weekly['million doses used'])
max_million_doses_weekly
```

Out[38]: 5.129997

```
In [39]: doses_weekly.plot(
    ylim=(0, math.ceil(max_million_doses_weekly)),
    xlabel='Date',
    ylabel='Million Doses',
    title=f"VACCINATION DOSES PER WEEK IN GERMANY\n(until {last_update})")
```

Out[39]: <AxesSubplot:title={'center': 'VACCINATION DOSES PER WEEK IN GERMANY\n(until 2021-05-26)'}, xlabel='Date', ylabel='Million Doses'>



Doses per Month

```
In [40]: # M = month end frequency
doses_monthly = doses.groupby(pd.Grouper(key='date', freq='M')).sum()
doses_monthly.tail()
```

Out[40]:

doses used	
date	
2021-01-31	2.345445

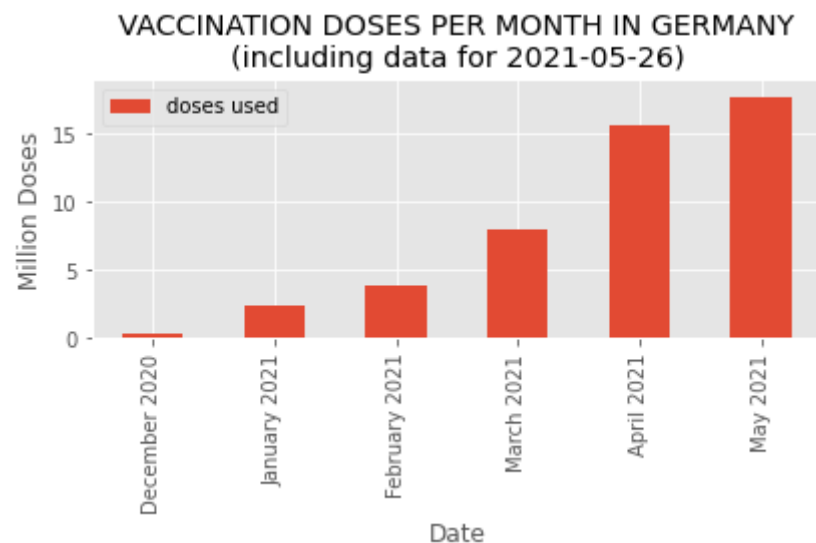
doses used	
date	
2021-02-28	3.780053
2021-03-31	7.853916
2021-04-30	15.525070
2021-05-31	17.647611

```
In [41]: max_doses_monthly = max(doses_monthly['doses used'])
max_doses_monthly
doses_monthly['month'] = doses_monthly.index.strftime('%B')
doses_monthly['year'] = doses_monthly.index.strftime('%Y')
doses_monthly['label'] = doses_monthly['month'] + ' ' + doses_monthly['year']
doses_monthly.drop(columns=['month', 'year'], inplace=True)
doses_monthly.set_index('label', inplace=True)
doses_monthly.tail(6)
```

Out[41]:

doses used	
label	
December 2020	0.206747
January 2021	2.345445
February 2021	3.780053
March 2021	7.853916
April 2021	15.525070
May 2021	17.647611

```
In [42]: monthly_plot = doses_monthly.plot.bar(
    ylim=(0, math.ceil(max_doses_monthly) + 1),
    xlabel='Date',
    ylabel='Million Doses',
    title=f"VACCINATION DOSES PER MONTH IN GERMANY\n(including data for {last_update})")
```



```
In [43]: fig = monthly_plot.get_figure()
fig.savefig('img/monthly_doses_germany.png')
```

Vaccination Campaign Progress

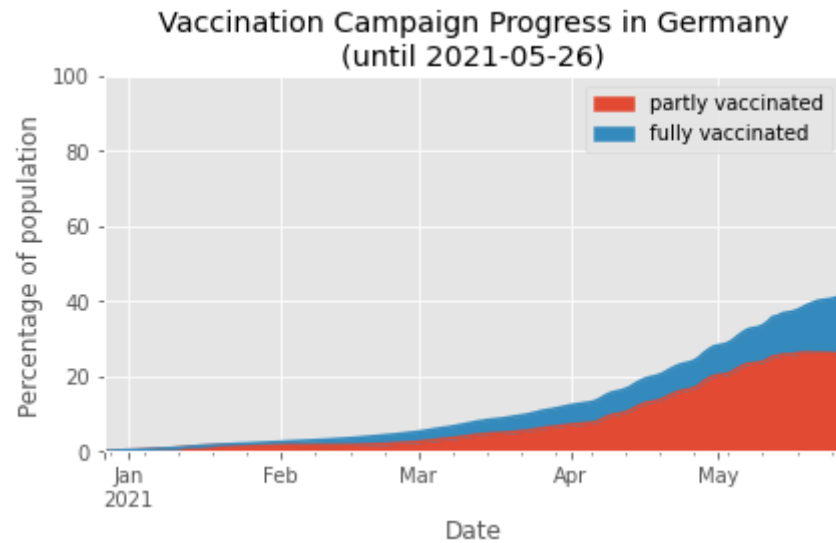
```
In [44]: doses_cumulative = vaccinations.loc[:, ['date', 'partly vaccinated', 'fully vaccinated']]
doses_cumulative.set_index('date', inplace=True)
doses_cumulative.tail(3)
```

```
Out[44]:
```

	partly vaccinated	fully vaccinated
date		

date		
2021-05-24	26.09	14.43
2021-05-25	26.00	14.87
2021-05-26	25.82	15.69

```
In [45]: doses_area_plot = doses_cumulative.plot.area(
    ylim=(0,100),
    xlabel='Date',
    ylabel='Percentage of population',
    title=f"Vaccination Campaign Progress in Germany\n(until {last_update})")
```



```
In [46]: fig = doses_area_plot.get_figure()
fig.savefig('img/vaccinations_germany_area_plot.png')
```

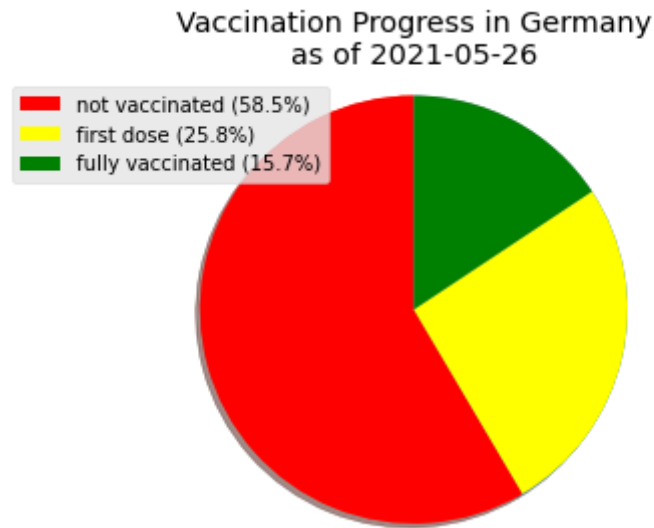
As of Today

```
In [47]: # get the last line of the data
current_state = doses_cumulative.iloc[-1]
current_state
```

```
Out[47]: partly vaccinated    25.82
fully vaccinated             15.69
Name: 2021-05-26 00:00:00, dtype: float64
```

```
In [48]: percentage_not_vacc = 100 - current_state['partly vaccinated'] - current_state['fully vaccinated']
labels = [f"not vaccinated ({round(percentage_not_vacc, 1)}%)",
          f"first dose ({round(current_state['partly vaccinated'], 1)}%)",
          f"fully vaccinated ({round(current_state['fully vaccinated'], 1)}%)"]
colors = ['red', 'yellow', 'green']
sizes = [percentage_not_vacc,
          current_state['partly vaccinated'],
          current_state['fully vaccinated']]
fig1, ax1 = plt.subplots()
ax1.pie(sizes, shadow=True, startangle=90)
ax1.axis('equal') # Equal aspect ratio ensures that pie is drawn as a circle.
patches, texts = plt.pie(sizes, colors=colors, startangle=90)
```

```
plt.legend(patches, labels, loc="best")
plt.title(f"Vaccination Progress in Germany\nas of {last_update}")
# plt.savefig must be before show()
# BEWARE plt.savefig must be in the same Jupyter code cell that creates the graph!
# See comment by ioseph here:
# https://stackoverflow.com/questions/9012487/matplotlib-pyplot-savefig-outputs-blank-image
plt.savefig('img/vaccination_in_germany_pie.png', bbox_inches='tight')
plt.show()
```



Vaccines in Use

```
In [49]: vaccine_use = vaccinations.loc[ : , ['date', 'dosen_biontech_kumulativ',
                                             'dosen_moderna_kumulativ',
                                             'dosen_astrazeneca_kumulativ',
                                             'dosen_johnson_kumulativ']]

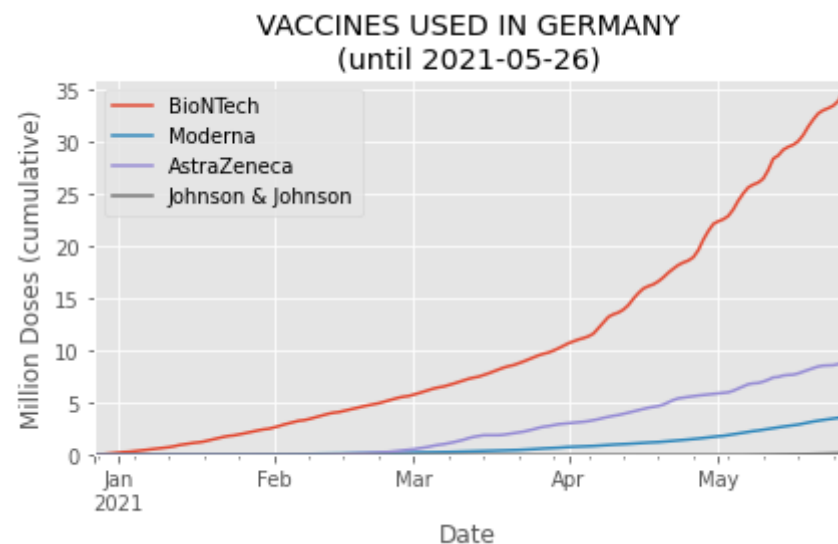
# Rename columns
vaccine_use.columns = ['date', 'BioNTech', 'Moderna', 'AstraZeneca', 'Johnson & Johnson']
# make 'date' an index
vaccine_use.set_index('date', inplace=True)
# divide columns by 1 million
vaccine_use["BioNTech"] = vaccine_use["BioNTech"] / 1_000_000
vaccine_use["Moderna"] = vaccine_use["Moderna"] / 1_000_000
vaccine_use["AstraZeneca"] = vaccine_use["AstraZeneca"] / 1_000_000
vaccine_use["Johnson & Johnson"] = vaccine_use["Johnson & Johnson"] / 1_000_000
vaccine_use.tail(3)
```

Out[49]:

	BioNTech	Moderna	AstraZeneca	Johnson & Johnson
date				
2021-05-24	33.389107	3.474912	8.588230	0.136218
2021-05-25	33.825384	3.550331	8.689245	0.158223
2021-05-26	34.683454	3.623044	8.817981	0.234363

In [50]:

```
vaccines_used = vaccine_use.plot(
    # as it is cumulative, the last row must contain the single highest number
    ylim=(0,math.ceil(max(vaccine_use.iloc[-1]))+1),
    xlabel='Date',
    ylabel='Million Doses (cumulative)',
    title=f"VACCINES USED IN GERMANY\n(until {last_update})")
```



In [51]:

```
fig = vaccines_used.get_figure()
fig.savefig('img/vaccines_used_in_germany.png')
```

Vaccination Centers versus Doctor's Practices

In [52]:

```
by_place = vaccinations.loc[ : , ['date', 'dosen_dim_kumulativ', 'dosen_kbv_kumulativ']]
```

```
by_place.columns = ['date', 'vaccination centers', 'practices']
```

```
In [53]: by_place['vaccination centers daily'] = by_place['vaccination centers'].diff()
by_place['practices daily'] = by_place['practices'].diff()
```

```
In [54]: by_place['percentage practices'] = round(
    by_place['practices daily'] * 100 /
    (by_place['vaccination centers daily'] + by_place['practices daily']), 2)

by_place['percentage centers'] = 100 - by_place['percentage practices']
```

```
In [55]: # make 'date' an index
by_place.set_index('date', inplace=True)
```

```
In [56]: by_place
```

```
Out[56]:
```

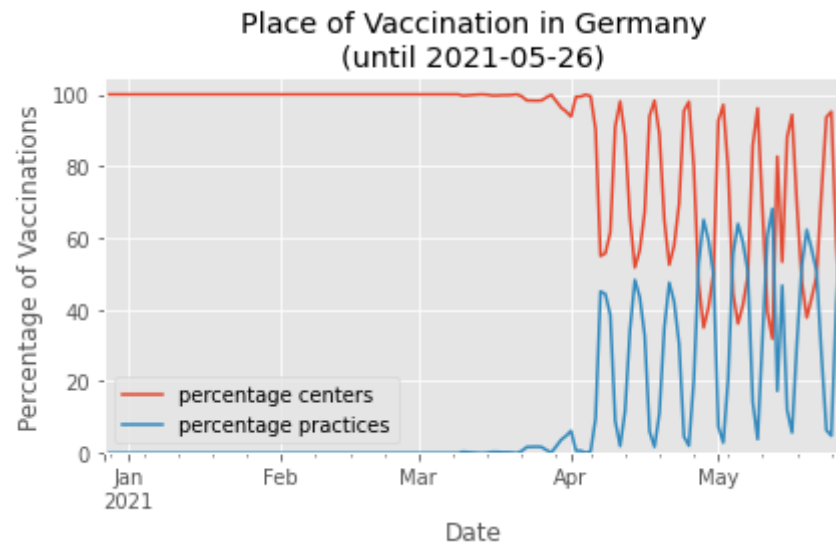
	vaccination centers	practices	vaccination centers daily	practices daily	percentage practices	percentage centers
date						
2020-12-27	24100	0	NaN	NaN	NaN	NaN
2020-12-28	42658	0	18558.0	0.0	0.00	100.00
2020-12-29	93514	0	50856.0	0.0	0.00	100.00
2020-12-30	156541	0	63027.0	0.0	0.00	100.00
2020-12-31	206747	0	50206.0	0.0	0.00	100.00
...
2021-05-22	32501483	12479164	343647.0	128930.0	27.28	72.72
2021-05-23	32768686	12497285	267203.0	18121.0	6.35	93.65
2021-05-24	33075657	12512810	306971.0	15525.0	4.81	95.19
2021-05-25	33451430	12771753	375773.0	258943.0	40.80	59.20
2021-05-26	33823674	13535168	372244.0	763415.0	67.22	32.78

151 rows × 6 columns

```
In [57]: share = by_place.loc[:, ['percentage centers', 'percentage practices']]
```



```
In [58]: vacc_shares = share.plot(
# as it is cumulative, the last row must contain the single highest number
ylim=(0, 105), # above 100 to see the line
xlabel='Date',
ylabel='Percentage of Vaccinations',
title=f"Place of Vaccination in Germany\n(until {last_update})")
```



```
In [59]: fig = vacc_shares.get_figure()
fig.savefig('img/vaccinations_germany_by_place.png')
```

Other units of Time

```
In [60]: by_place_daily = by_place.loc[ : , ['vaccination centers daily', 'practices daily']]
by_place_daily.columns = ['vaccination centers', 'practices']
by_place_daily.reset_index(inplace=True)
```

Monthly

```
In [61]: by_place_monthly = by_place_daily.groupby(pd.Grouper(key='date', freq='M')).sum()
by_place_monthly.tail()
```

```
Out[61]:
```

	vaccination centers	practices
date		

	vaccination centers	practices
date		
2021-01-31	2345445.0	0.0
2021-02-28	3780053.0	0.0
2021-03-31	7787682.0	66234.0
2021-04-30	10195930.0	5329140.0
2021-05-31	9507817.0	8139794.0

Scale:

```
In [62]: by_place_monthly['vaccination centers'] = by_place_monthly['vaccination centers'] / 1_000_000
by_place_monthly['practices'] = by_place_monthly['practices'] / 1_000_000
```

Rename the columns

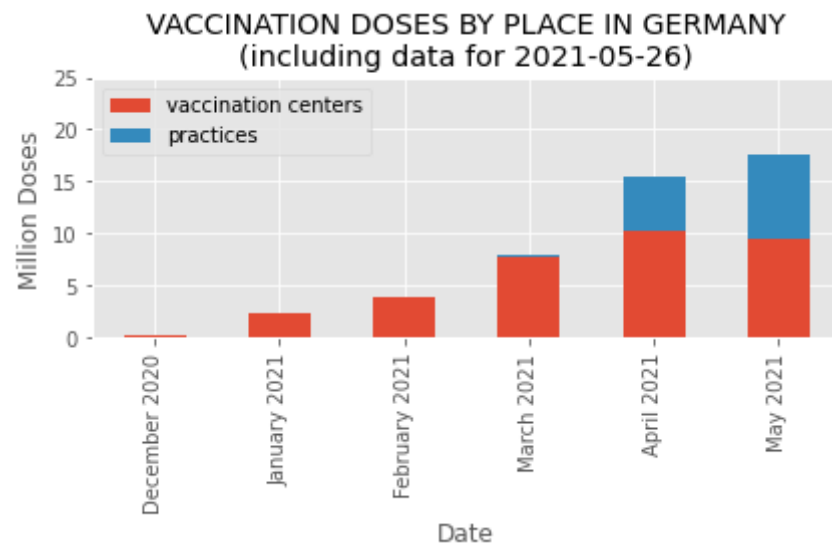
```
In [63]: by_place_monthly['month'] = by_place_monthly.index.strftime('%B')
by_place_monthly['year'] = by_place_monthly.index.strftime('%Y')
by_place_monthly['label'] = by_place_monthly['month'] + ' ' + by_place_monthly['year']
by_place_monthly.drop(columns=['month', 'year'], inplace=True)
by_place_monthly.set_index('label', inplace=True)
by_place_monthly.tail(6)
```

```
Out[63]:
```

	vaccination centers	practices
label		
December 2020	0.182647	0.000000
January 2021	2.345445	0.000000
February 2021	3.780053	0.000000
March 2021	7.787682	0.066234
April 2021	10.195930	5.329140
May 2021	9.507817	8.139794

```
In [64]: monthly_plot = by_place_monthly.plot.bar(
stacked=True,
```

```
ylim=(0, 25),  
xlabel='Date',  
ylabel='Million Doses',  
title=f"VACCINATION DOSES BY PLACE IN GERMANY\n(including data for {last_update})")
```



```
In [65]: fig = monthly_plot.get_figure()  
fig.savefig('img/monthly_doses_by_place_germany.png')
```