# 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]:
```
'2021-06-05'
```

### 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: 159 entries, 0 to 158
Data columns (total 13 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   date                            159 non-null    datetime64[ns]
 1   dosen_kumulativ                 159 non-null    int64
 2   dosen_differenz_zum_vortag      159 non-null    int64
 3   dosen_erst_differenz_zum_vortag 159 non-null    int64
 4   dosen_zweit_differenz_zum_vortag 159 non-null   int64
 5   dosen_biontech_kumulativ        159 non-null    int64
 6   dosen_moderna_kumulativ         159 non-null    int64
 7   dosen_astrazeneca_kumulativ     159 non-null    int64
 8   personen_erst_kumulativ         159 non-null    int64
 9   personen_voll_kumulativ         159 non-null    int64
 10  dosen_dim_kumulativ             159 non-null    int64
 11  dosen_kbv_kumulativ             159 non-null    int64
 12  dosen_johnson_kumulativ         159 non-null    int64
dtypes: datetime64[ns](1), int64(12)
memory usage: 16.3 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_kumulati |
|---|---|---|---|---|---|---|
| **156** | 2021-06-01 | 51592108 | 962074 | 398165 | 563909 | 3763537 |
| **157** | 2021-06-02 | 52790687 | 1198579 | 513690 | 684889 | 3859683 |
| **158** | 2021-06-03 | 53404798 | 614111 | 229597 | 384514 | 3905261 |

# 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]:
```
158    53404798
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]:
```
158    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: 159 entries, 0 to 158
Data columns (total 15 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   date                            159 non-null    datetime64[ns]
 1   dosen_kumulativ                 159 non-null    int64
 2   dosen_differenz_zum_vortag      159 non-null    int64
 3   dosen_erst_differenz_zum_vortag 159 non-null    int64
 4   dosen_zweit_differenz_zum_vortag 159 non-null   int64
 5   dosen_biontech_kumulativ        159 non-null    int64
 6   dosen_moderna_kumulativ         159 non-null    int64
 7   dosen_astrazeneca_kumulativ     159 non-null    int64
 8   personen_erst_kumulativ         159 non-null    int64
 9   personen_voll_kumulativ         159 non-null    int64
 10  dosen_dim_kumulativ             159 non-null    int64
 11  dosen_kbv_kumulativ             159 non-null    int64
 12  dosen_johnson_kumulativ         159 non-null    int64
 13  partly vaccinated               159 non-null    float64
```

```
 14  fully vaccinated                  159 non-null    float64
dtypes: datetime64[ns](1), float64(2), int64(12)
memory usage: 18.8 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 |
|---|---|---|---|---|---|---|
| **156** | 2021-06-01 | 51592108 | 962074 | 398165 | 563909 | 3763537 |
| **157** | 2021-06-02 | 52790687 | 1198579 | 513690 | 684889 | 3859683 |
| **158** | 2021-06-03 | 53404798 | 614111 | 229597 | 384514 | 3905261 |

## 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]:
```
'2021-06-03'
```

# 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]:

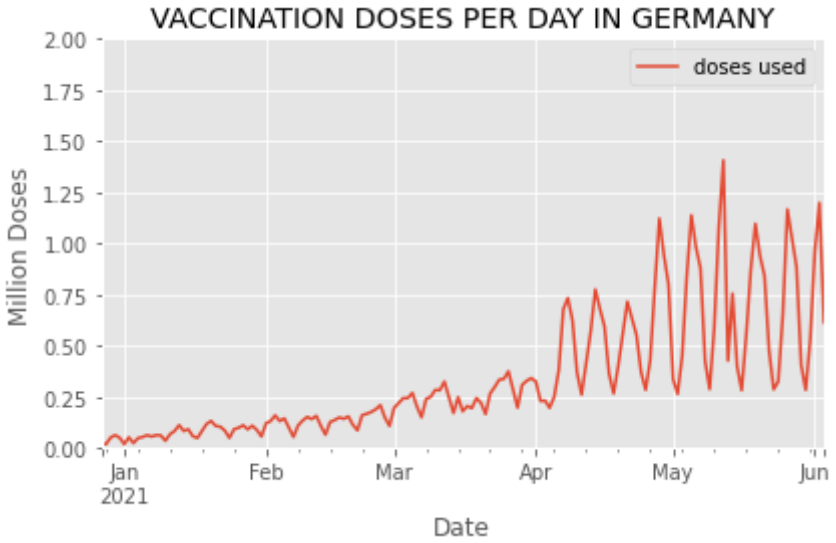
| date | doses used |
|---|---|
| **2021-06-03** | 0.614111 |

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]:
```
1.406945
```

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 |
|---|---|---|---|
| **156** | 2021-06-01 | 0.962074 | Tuesday |
| **157** | 2021-06-02 | 1.198579 | Wednesday |
| **158** | 2021-06-03 | 0.614111 | Thursday |

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 |
|---|---|---|
| **156** | 0.962074 | Tuesday |
| **157** | 1.198579 | Wednesday |
| **158** | 0.614111 | Thursday |

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 |
|---|---|---|---|---|---|---|---|
| **154** | NaN | NaN | NaN | 0.284056 | NaN | NaN | NaN |
| **155** | NaN | 0.532256 | NaN | NaN | NaN | NaN | NaN |

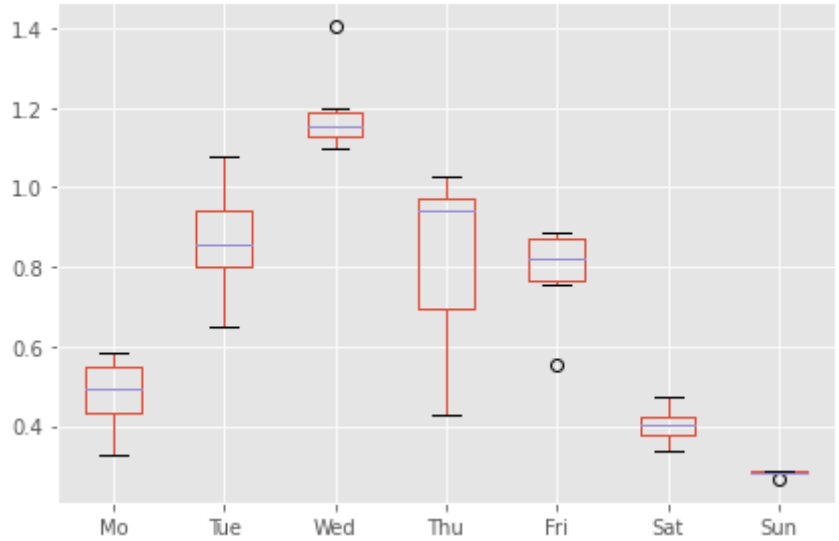
| weekday | Friday | Monday | Saturday | Sunday | Thursday | Tuesday | Wednesday |
|---|---|---|---|---|---|---|---|
| **156** | NaN | NaN | NaN | NaN | NaN | 0.962074 | NaN |
| **157** | NaN | NaN | NaN | NaN | NaN | NaN | 1.198579 |
| **158** | NaN | NaN | NaN | NaN | 0.614111 | NaN | NaN |

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 |
|---|---|---|---|---|---|---|---|
| **154** | NaN | NaN | NaN | NaN | NaN | NaN | 0.284056 |
| **155** | 0.532256 | NaN | NaN | NaN | NaN | NaN | NaN |
| **156** | NaN | 0.962074 | NaN | NaN | NaN | NaN | NaN |
| **157** | NaN | NaN | 1.198579 | NaN | NaN | NaN | NaN |
| **158** | NaN | NaN | NaN | 0.614111 | 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]:

| date | million doses used |
|---|---|
| **2021-05-10** | 5.142431 |
| **2021-05-17** | 4.902623 |
| **2021-05-24** | 4.840285 |
| **2021-05-31** | 4.952320 |
| **2021-06-07** | 2.774764 |

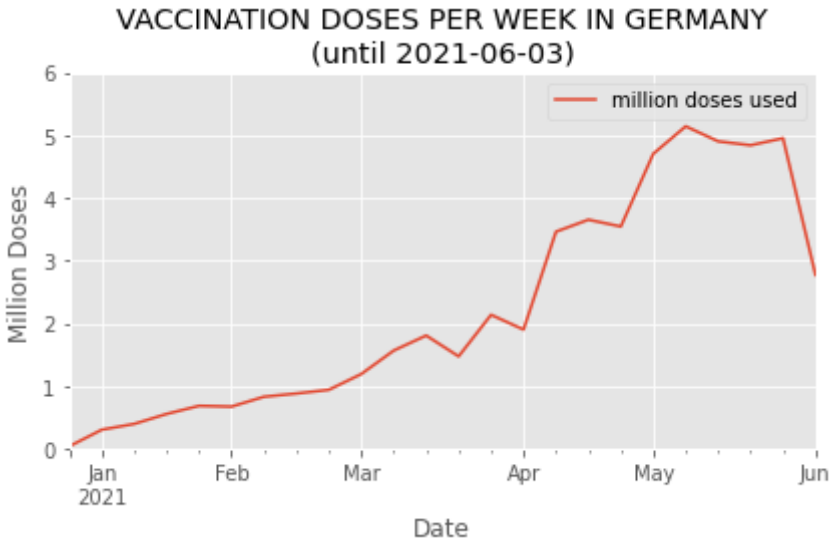
In [38]:
```
# What is the highest number of doses used in a week?
```

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

Out[38]: 5.142430999999999

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 2021-06-03)'}, 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** | |
| **2021-02-28** | 3.780776 |

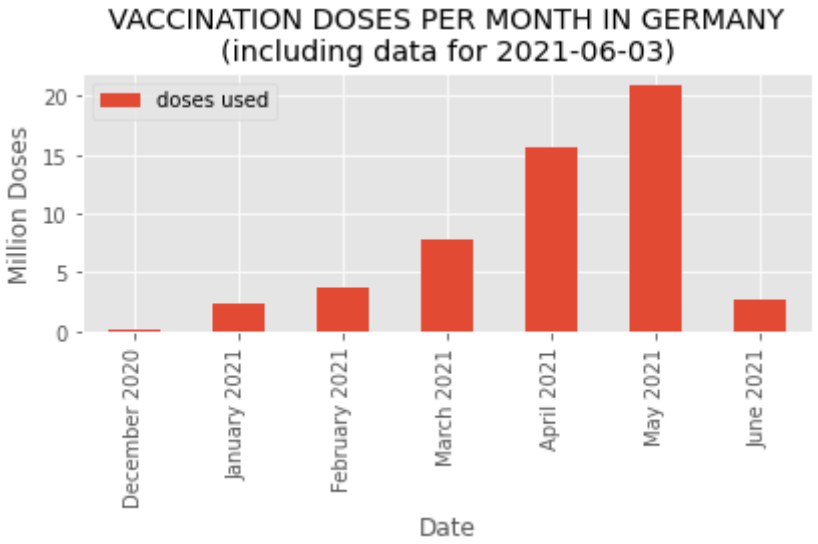
| date | doses used |
|---|---|
| **2021-03-31** | 7.859386 |
| **2021-04-30** | 15.547678 |
| **2021-05-31** | 20.889539 |
| **2021-06-30** | 2.774764 |

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]:

| label | doses used |
|---|---|
| **January 2021** | 2.345924 |
| **February 2021** | 3.780776 |
| **March 2021** | 7.859386 |
| **April 2021** | 15.547678 |
| **May 2021** | 20.889539 |
| **June 2021** | 2.774764 |

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')
```

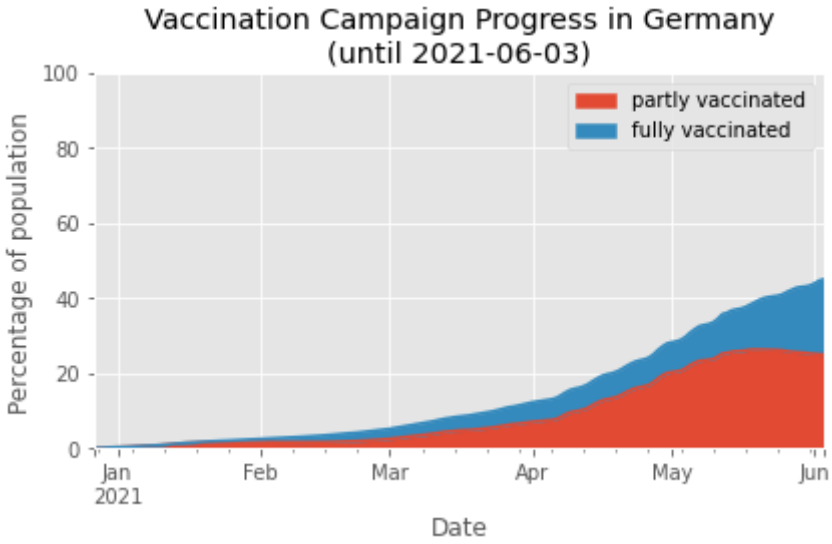
# Vaccination Campaign Progress

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

Out[44]:

| date | partly vaccinated | fully vaccinated |
|---|---|---|
| **2021-06-01** | 25.09 | 18.80 |
| **2021-06-02** | 25.01 | 19.62 |
| **2021-06-03** | 24.88 | 20.08 |

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')
```

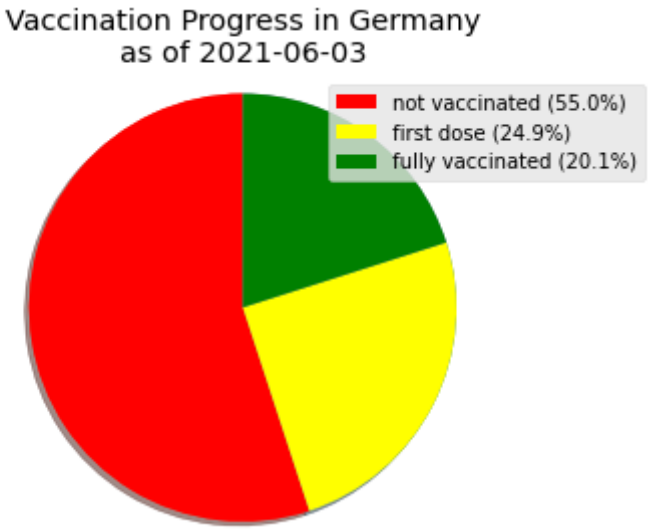
## As of Today

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

Out[47]:
```
partly vaccinated    24.88
fully vaccinated     20.08
Name: 2021-06-03 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 ijoseph 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

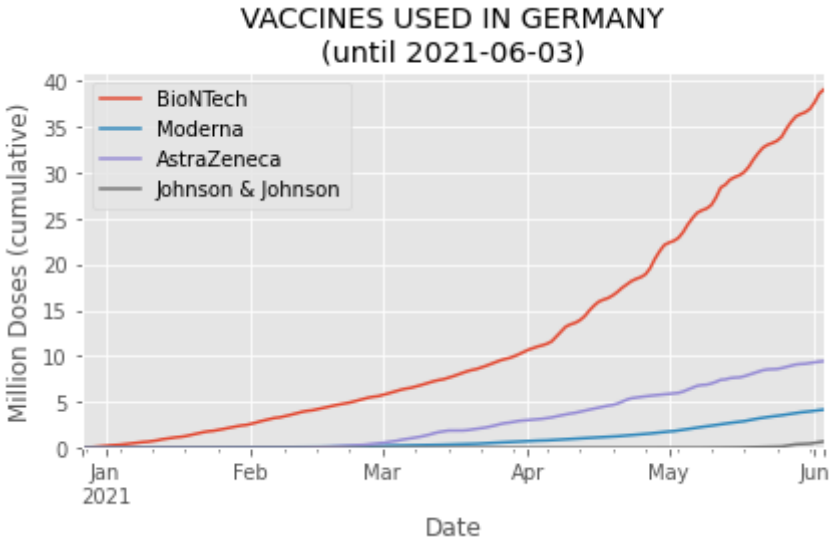
In [49]:

```
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]:

| date | BioNTech | Moderna | AstraZeneca | Johnson & Johnson |
|---|---|---|---|---|
| **2021-06-01** | 37.635371 | 4.064150 | 9.331011 | 0.561576 |
| **2021-06-02** | 38.596836 | 4.122936 | 9.407930 | 0.662985 |
| **2021-06-03** | 39.052619 | 4.182863 | 9.455800 | 0.713516 |

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
```

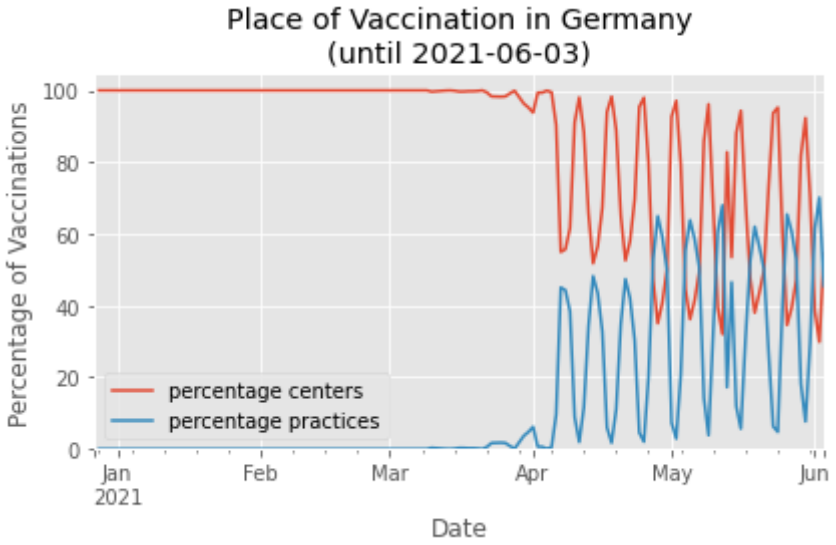
Out[56]:

| date | vaccination centers | practices | vaccination centers daily | practices daily | percentage practices | percentage centers |
|---|---|---|---|---|---|---|
| **2020-12-27** | 24099 | 0 | NaN | NaN | NaN | NaN |
| **2020-12-28** | 42656 | 0 | 18557.0 | 0.0 | 0.00 | 100.00 |
| **2020-12-29** | 93506 | 0 | 50850.0 | 0.0 | 0.00 | 100.00 |
| **2020-12-30** | 156531 | 0 | 63025.0 | 0.0 | 0.00 | 100.00 |
| **2020-12-31** | 206731 | 0 | 50200.0 | 0.0 | 0.00 | 100.00 |
| **...** | ... | ... | ... | ... | ... | ... |
| **2021-05-30** | 35376585 | 14721193 | 262238.0 | 21818.0 | 7.68 | 92.32 |
| **2021-05-31** | 35751072 | 14878962 | 374487.0 | 157769.0 | 29.64 | 70.36 |
| **2021-06-01** | 36122673 | 15469435 | 371601.0 | 590473.0 | 61.38 | 38.62 |
| **2021-06-02** | 36480974 | 16309713 | 358301.0 | 840278.0 | 70.11 | 29.89 |
| **2021-06-03** | 36815672 | 16589126 | 334698.0 | 279413.0 | 45.50 | 54.50 |

159 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]:

| date | vaccination centers | practices |
|---|---|---|

| date | vaccination centers | practices |
|---|---|---|
| **2021-02-28** | 3780776.0 | 0.0 |
| **2021-03-31** | 7793152.0 | 66234.0 |
| **2021-04-30** | 10218538.0 | 5329140.0 |
| **2021-05-31** | 11405951.0 | 9483588.0 |
| **2021-06-30** | 1064600.0 | 1710164.0 |

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

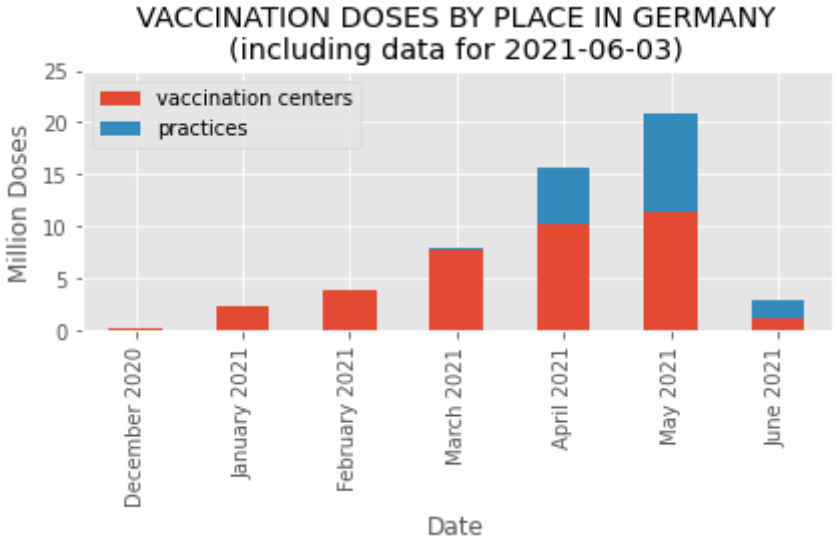
In [63]:
```
by_place_monthly['month'] = by_place_monthly.index.strftime('%B')
by_place_monthly['year'] =  by_place_monthly.index.strftime('%Y')
by_place_monthly['label'] = by_place_monthly['month'] + ' ' + by_place_monthly['year']
by_place_monthly.drop(columns=['month', 'year'], inplace=True)
by_place_monthly.set_index('label',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

Out[63]:

| label | vaccination centers | practices |
|---|---|---|
| **January 2021** | 2.345924 | 0.000000 |
| **February 2021** | 3.780776 | 0.000000 |
| **March 2021** | 7.793152 | 0.066234 |
| **April 2021** | 10.218538 | 5.329140 |
| **May 2021** | 11.405951 | 9.483588 |
| **June 2021** | 1.064600 | 1.710164 |

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')
```