Covid-19_UK

September 26, 2020

#

Coronavirus Pandemic (COVID-19)

##

Country Profile: United Kingdom

###

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0.1 Table of Contents

0.2 Introduction

This document explores the development of an infectious disease caused by a type of coronavirus, known as SARS-CoV-2.

The dataset is a collection of the COVID-19 data maintained by Our World in Data. It is updated daily and includes metrics on confirmed cases, deaths, and testing, as well as other variables of potential interest. A description of each variable is made available within the same repository in the csv labelled 'codebook.csv', along with the data source for each variable.

[1]:
```
#import necessary modules
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from urllib.request import urlretrieve
```

[2]:
```
#plot withinin notebook environment
%matplotlib inline
```

[3]:
```
#prepare visualisations in notebook by setting global theme, a default plot␣
 ↪size, font and color
sns.set_style('darkgrid')
plt.rcParams['font.size'] = 14
plt.rcParams['figure.figsize'] = (9,5)
plt.rcParams['figure.facecolor'] = '#00000000'
```

0.3 Gather Data

[4]:
```
#download data from owid and save file locally
urlretrieve('https://covid.ourworldindata.org/data/owid-covid-data.csv',
            'covid-daywise.csv')
```

[4]:
```
('covid-daywise.csv', <http.client.HTTPMessage at 0x22e32487988>)
```

[5]:
```
#read in locally saved csv into dataframe
covid_df = pd.read_csv('covid-daywise.csv', index_col='date')
```

0.4 Assess & Clean

[6]:
```
#visually inspect first five rows
covid_df.head()
```

[6]:

date	iso_code	continent	location	total_cases	new_cases	new_cases_smoothed	total_deaths	new_deaths	new_deaths_smoothed	total_cases_per_million	…	gdp_per_capita	extreme_poverty
2019-12-31	AFG	Asia	Afghanistan	0.0	0.0	NaN	0.0	0.0	NaN	0.0	…	1803.987	NaN
2020-01-01	AFG	Asia	Afghanistan	0.0	0.0	NaN	0.0	0.0	NaN	0.0	…	1803.987	NaN
2020-01-02	AFG	Asia	Afghanistan	0.0	0.0	NaN	0.0	0.0	NaN				
2020-01-03	AFG	Asia	Afghanistan	0.0	0.0	NaN	0.0	0.0	NaN				
2020-01-04	AFG	Asia	Afghanistan	0.0	0.0	NaN	0.0	0.0	NaN				

```
2020-01-02                    0.0  …        1803.987              NaN
2020-01-03                    0.0  …        1803.987              NaN
2020-01-04                    0.0  …        1803.987              NaN

            cardiovasc_death_rate  diabetes_prevalence  female_smokers  \
date
2019-12-31                597.029                 9.59             NaN
2020-01-01                597.029                 9.59             NaN
2020-01-02                597.029                 9.59             NaN
2020-01-03                597.029                 9.59             NaN
2020-01-04                597.029                 9.59             NaN

            male_smokers  handwashing_facilities  hospital_beds_per_thousand  \
date
2019-12-31           NaN                  37.746                         0.5
2020-01-01           NaN                  37.746                         0.5
2020-01-02           NaN                  37.746                         0.5
2020-01-03           NaN                  37.746                         0.5
2020-01-04           NaN                  37.746                         0.5

            life_expectancy  human_development_index
date
2019-12-31            64.83                    0.498
2020-01-01            64.83                    0.498
2020-01-02            64.83                    0.498
2020-01-03            64.83                    0.498
2020-01-04            64.83                    0.498

[5 rows x 40 columns]
```

[7]:
```
#number of columns and rows
covid_df.shape
print('This dataset contains {} rows and {} columns.'.format(covid_df.shape[0],␣
 ↪covid_df.shape[1]))
```

```
This dataset contains 46273 rows and 40 columns.
```

[8]:
```
#column names and data types
covid_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 46273 entries, 2019-12-31 to 2020-09-26
Data columns (total 40 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   iso_code                        46002 non-null  object
 1   continent                       45731 non-null  object
 2   location                        46273 non-null  object
```

```
 3   total_cases                       45659 non-null  float64
 4   new_cases                         45452 non-null  float64
 5   new_cases_smoothed                44670 non-null  float64
 6   total_deaths                      45659 non-null  float64
 7   new_deaths                        45452 non-null  float64
 8   new_deaths_smoothed               44670 non-null  float64
 9   total_cases_per_million           45388 non-null  float64
 10  new_cases_per_million             45388 non-null  float64
 11  new_cases_smoothed_per_million    44605 non-null  float64
 12  total_deaths_per_million          45388 non-null  float64
 13  new_deaths_per_million            45388 non-null  float64
 14  new_deaths_smoothed_per_million   44605 non-null  float64
 15  new_tests                         16450 non-null  float64
 16  total_tests                       16850 non-null  float64
 17  total_tests_per_thousand          16850 non-null  float64
 18  new_tests_per_thousand            16450 non-null  float64
 19  new_tests_smoothed                18541 non-null  float64
 20  new_tests_smoothed_per_thousand   18541 non-null  float64
 21  tests_per_case                    17029 non-null  float64
 22  positive_rate                     17457 non-null  float64
 23  tests_units                       19374 non-null  object
 24  stringency_index                  38373 non-null  float64
 25  population                        46002 non-null  float64
 26  population_density                43906 non-null  float64
 27  median_age                        41265 non-null  float64
 28  aged_65_older                     40652 non-null  float64
 29  aged_70_older                     41051 non-null  float64
 30  gdp_per_capita                    40734 non-null  float64
 31  extreme_poverty                   27180 non-null  float64
 32  cardiovasc_death_rate             41273 non-null  float64
 33  diabetes_prevalence               42728 non-null  float64
 34  female_smokers                    32349 non-null  float64
 35  male_smokers                      31940 non-null  float64
 36  handwashing_facilities            19306 non-null  float64
 37  hospital_beds_per_thousand        37295 non-null  float64
 38  life_expectancy                   45423 non-null  float64
 39  human_development_index           39822 non-null  float64
dtypes: float64(36), object(4)
memory usage: 14.5+ MB
```

Observations:

The entire dataset contains approximately 46,000 recorded observations (this number will continue to increase as data is added daily) and 40 features (variables). The focus for this analysis will be a subset of this data, namely the headline figures cases, deaths and tests for the UK.

[9]:
```
#subset data for UK
```

```
covid_uk_df = covid_df.loc[covid_df['location'] == 'United Kingdom',␣
↪['new_cases','new_cases_smoothed', 'total_cases', 'new_tests',␣
↪'new_deaths','new_deaths_smoothed', 'total_deaths',
                                                                  ␣
↪'new_tests_smoothed', 'total_tests', 'positive_rate']].copy()
covid_uk_df.head()
```

[9]:

date	new_cases	new_cases_smoothed	total_cases	new_tests	new_deaths
2019-12-31	0.0	NaN	0.0	NaN	0.0
2020-01-01	0.0	NaN	0.0	NaN	0.0
2020-01-02	0.0	NaN	0.0	NaN	0.0
2020-01-03	0.0	NaN	0.0	NaN	0.0
2020-01-04	0.0	NaN	0.0	NaN	0.0

date	new_deaths_smoothed	total_deaths	new_tests_smoothed
2019-12-31	NaN	0.0	NaN
2020-01-01	NaN	0.0	NaN
2020-01-02	NaN	0.0	NaN
2020-01-03	NaN	0.0	NaN
2020-01-04	NaN	0.0	NaN

date	total_tests	positive_rate
2019-12-31	NaN	NaN
2020-01-01	NaN	NaN
2020-01-02	NaN	NaN
2020-01-03	NaN	NaN
2020-01-04	NaN	NaN

Observations:

Data is recorded from the 31/12/2019 onwards.

[10]:
```
#user defined function to calculate missing values
def missing_values_table(df):
        mis_val = df.isnull().sum()
        mis_val_percent = 100 * (df.isnull().sum() / len(df))
        mis_val_table = pd.concat([mis_val, mis_val_percent], axis=1)
        mis_val_table_ren_columns = mis_val_table.rename(
        columns = {0 : 'Missing Values', 1 : '% of Total Values'})
        mis_val_table_ren_columns = mis_val_table_ren_columns[
            mis_val_table_ren_columns.iloc[:,1] != 0].sort_values(
        '% of Total Values', ascending=False).round(1)
        print ("Your selected dataframe has " + str(df.shape[1]) + " columns.\n"
            "There are " + str(mis_val_table_ren_columns.shape[0]) +
              " columns that have missing values.")
```

```
        return mis_val_table_ren_columns
```

[11]:
```
#apply user defined function over subset of data
missing_values_table(covid_uk_df)
```

```
Your selected dataframe has 10 columns.
There are 6 columns that have missing values.
```

[11]:

	Missing Values	% of Total Values
new_tests_smoothed	101	37.3
positive_rate	101	37.3
new_tests	94	34.7
total_tests	94	34.7
new_cases_smoothed	6	2.2
new_deaths_smoothed	6	2.2

Observations:

There is less data available for the number of new tests recorded (contains more null values) than the other variables.

The distinction between 0 and null values is subtle but important. In this dataset, it represents daily test numbers that were not reported on specific dates.

[12]:
```
#first reported day of testing
covid_uk_df.new_tests.first_valid_index()
```

[12]:
```
'2020-04-01'
```

Observations:

The UK only started publishing daily tests numbers on the 01/04/2020.

0.5 Exploratory Data Analysis

0.5.1 Univariate Exploration

[13]:
```
#summary statistics of numerical variables
covid_uk_df.describe().T
```

[13]:

	count	mean	std	min	\
new_cases	271.0	1.561756e+03	1.677671e+03	0.000	
new_cases_smoothed	265.0	1.528905e+03	1.574768e+03	0.000	
total_cases	271.0	1.724799e+05	1.413439e+05	0.000	
new_tests	177.0	1.065185e+05	6.006894e+04	11896.000	
new_deaths	271.0	1.547454e+02	2.762689e+02	0.000	
new_deaths_smoothed	265.0	1.578701e+02	2.618248e+02	0.000	
total_deaths	271.0	2.313314e+04	1.852765e+04	0.000	
new_tests_smoothed	170.0	1.086324e+05	5.629843e+04	15713.000	
total_tests	177.0	6.895317e+06	5.564955e+06	155174.000	

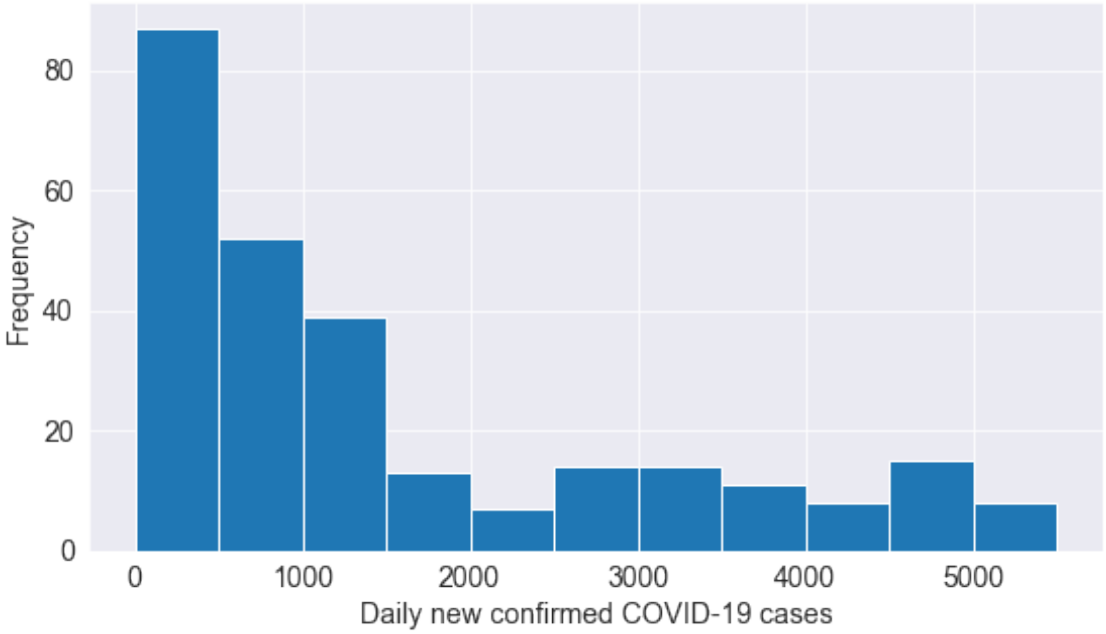
```
positive_rate        170.0  4.490000e-02  7.610151e-02       0.004
```

	25%	50%	75%	max
new_cases	56.500	950.000	2.643500e+03	6.873000e+03
new_cases_smoothed	101.714	983.286	2.574143e+03	5.328571e+03
total_cases	311.500	217708.000	2.959085e+05	4.232360e+05
new_tests	67116.000	93392.000	1.532250e+05	2.525090e+05
new_deaths	0.000	18.000	1.510000e+02	1.224000e+03
new_deaths_smoothed	1.000	17.429	1.982860e+02	9.424290e+02
total_deaths	1.500	32640.000	4.100000e+04	4.193600e+04
new_tests_smoothed	77472.500	94527.500	1.525295e+05	2.312570e+05
total_tests	1946011.000	5694990.000	1.099355e+07	1.932520e+07
positive_rate	0.006	0.012	3.300000e-02	3.020000e-01

Observations:

The standard deviation for the number of new cases, new deaths and new tests is proportionally large, suggesting the mean is not an accurate measure of central tendency. This chimes with the appreciation that the disease has progressed at different rates over the months.

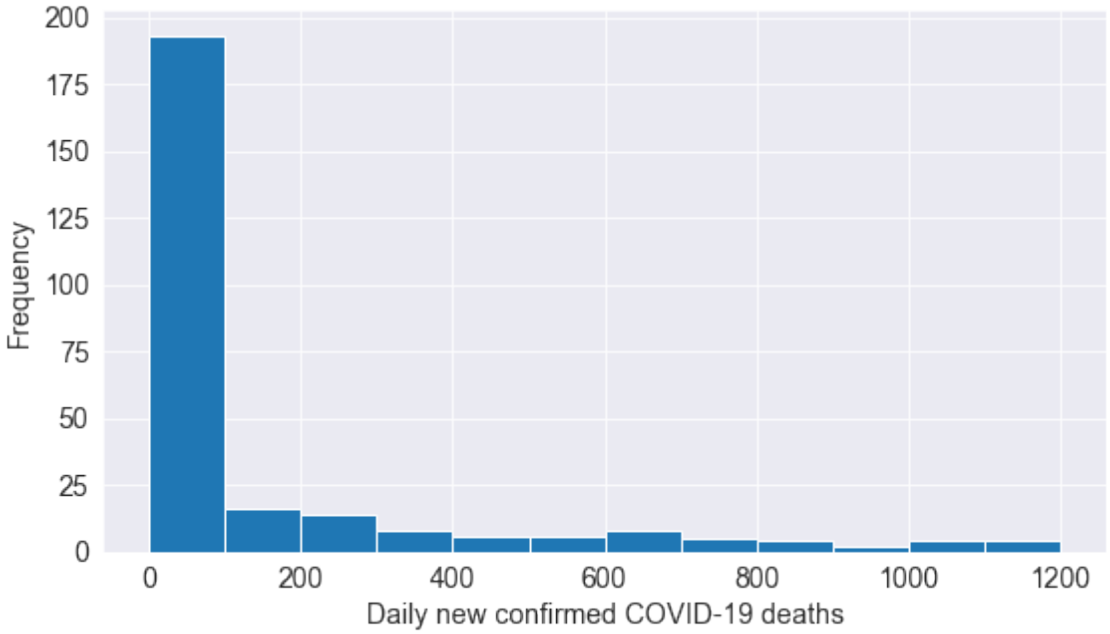
[14]:
```
#plot histogram of number of new reported cases per day
plt.hist(covid_uk_df.new_cases, bins=np.arange(0, 6000, 500))

#set axis labels
plt.xlabel('Daily new confirmed COVID-19 cases');
plt.ylabel('Frequency');
```



Observations:

-Right skew, with the majority of days reporting less than 1000 new cases per day.

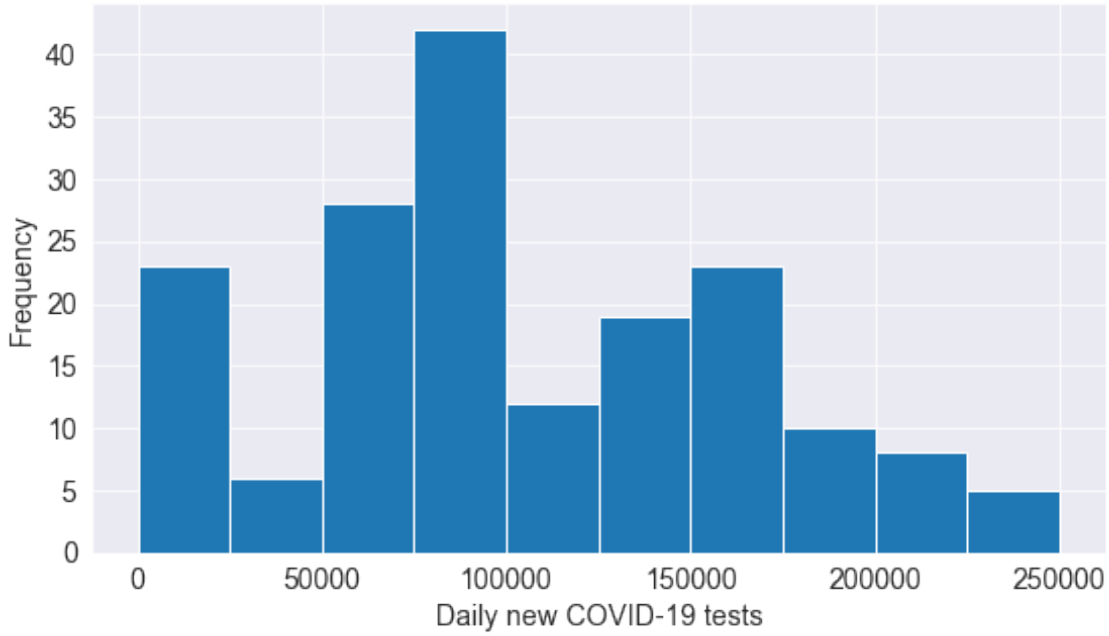
[15]:
```
#plot histgram with number of new deaths per day
plt.hist(covid_uk_df.new_deaths, bins=np.arange(0, 1300, 100))

#set axis labels
plt.xlabel('Daily new confirmed COVID-19 deaths');
plt.ylabel('Frequency');
```



Observations:

-Right skew, with the majority of days reporting less than 100 new deaths per day.

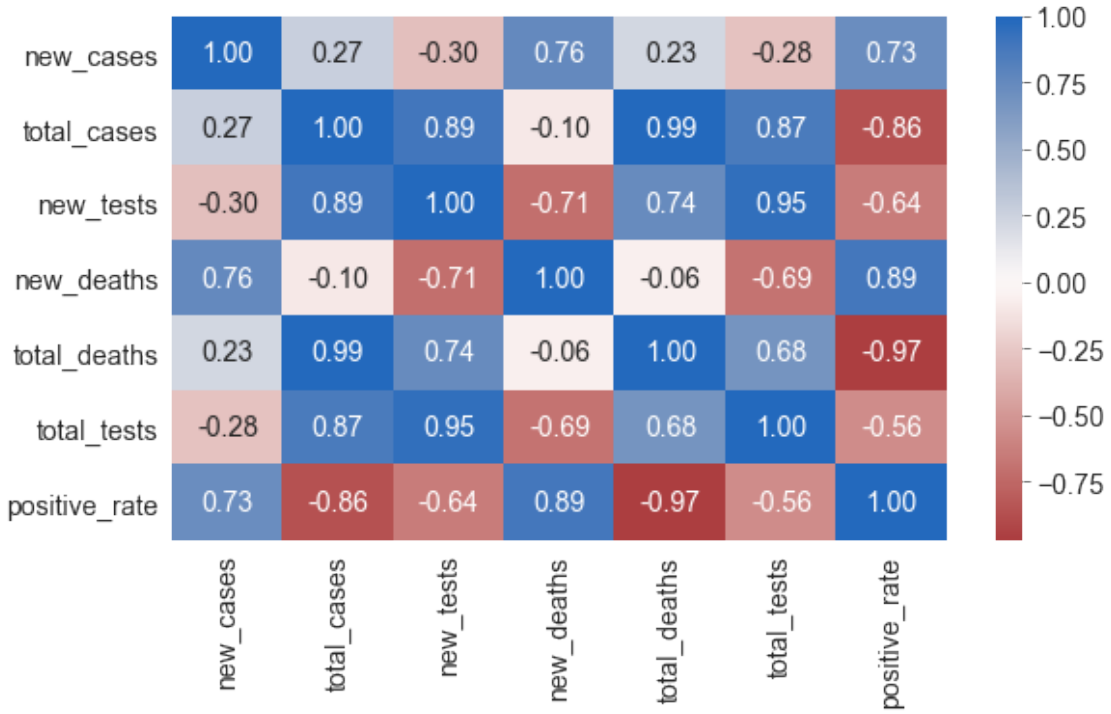
[16]:
```
#plot histgram with number of new tests per day
plt.hist(covid_uk_df.new_tests, bins=np.arange(0, 275000,25000))

#set axis labels
plt.xlabel('Daily new COVID-19 tests');
plt.ylabel('Frequency');
```



0.5.2 Bivariate Exploration

[17]:
```
#isolate for variables of interest
focus_vars = ['new_cases', 'total_cases', 'new_tests', 'new_deaths',␣
 ↪'total_deaths', 'total_tests', 'positive_rate']
```

[18]:
```
# correlation plot of numeric variables
sns.heatmap(covid_uk_df[focus_vars].corr(), annot = True, fmt = '.2f',
            cmap = 'vlag_r', center = 0);
```



Observations:

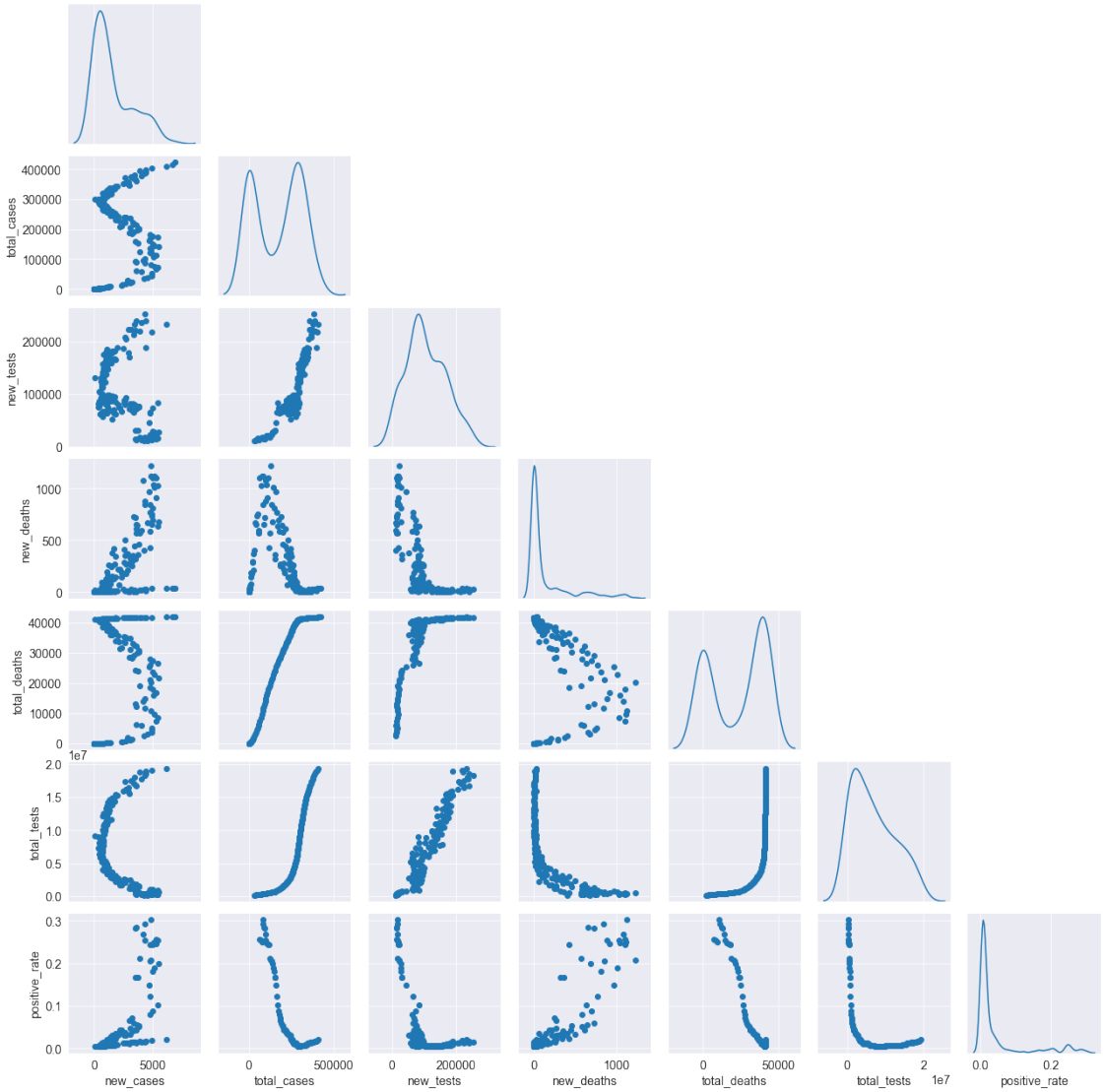
- The number of reported cases and the number of deaths attributed to Covid-19 are highly correlated.
- The number of tests and the positive rate are inversely correlated.

A word of caution:

1. Correlation does not imply causation. This means that although tests and deaths are inversely correlated, more testing does not necessarily lead to fewer fatalities.
2. Confounding variables are likely behind the correlations noted. For example, the positive rate is a composite measure of cases and tests, and therefore likely to influence the near perfect correlation between total deaths and the positive rate.

The heatmap above measures linear relationship. Scatter plots are drawn to understand the presence of non-linear relationships.

[19]:
```
#pairwise plots of variables
g = sns.PairGrid(data = covid_uk_df, vars = focus_vars, diag_sharey=False,␣
 ↪corner=True)
g.map_lower(plt.scatter)
g.map_diag(sns.kdeplot);
```



Observations:

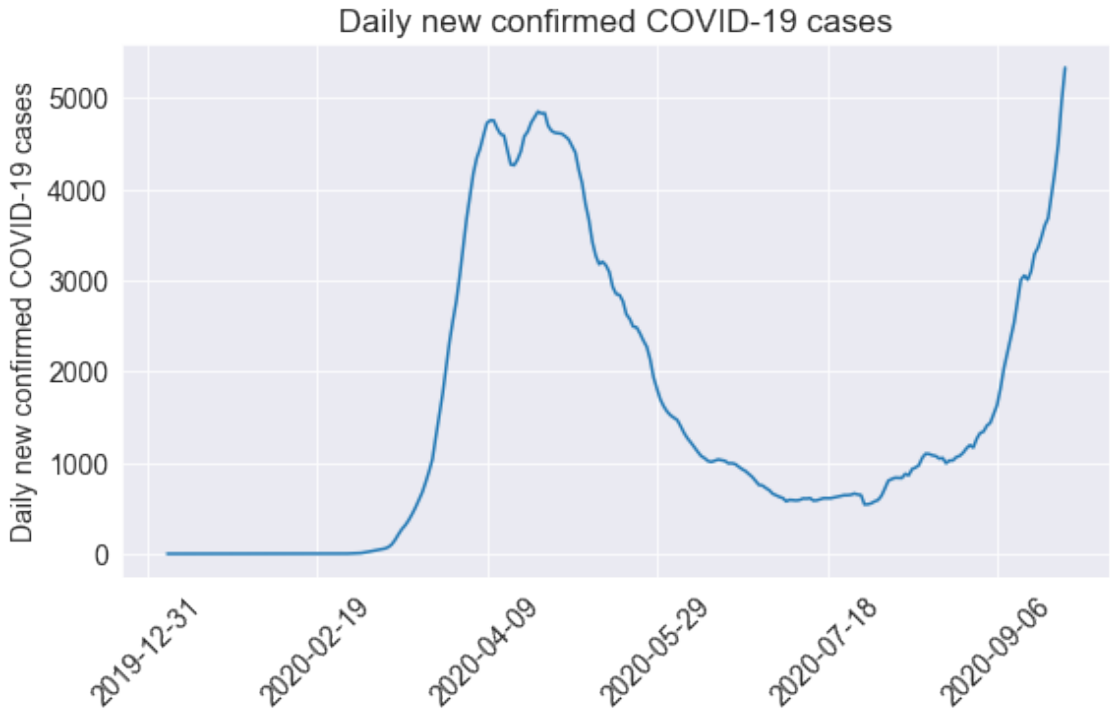
The presence of higher order correlations between most variables.

0.6 Q & A

For all data sources on the pandemic, daily data does not necessarily refer to the number of new confirmed cases on that day – but to the cases reported on that day. Since reporting can vary from day to day – irrespectively of any actual variation of cases – it is therefore helpful to look at a longer time span, which is less affected by the daily variation in reporting. This provides a clearer picture of where the pandemic is accelerating, staying the same, or reducing. A rolling average (7-day window) is therefore used to smooth short term variations.

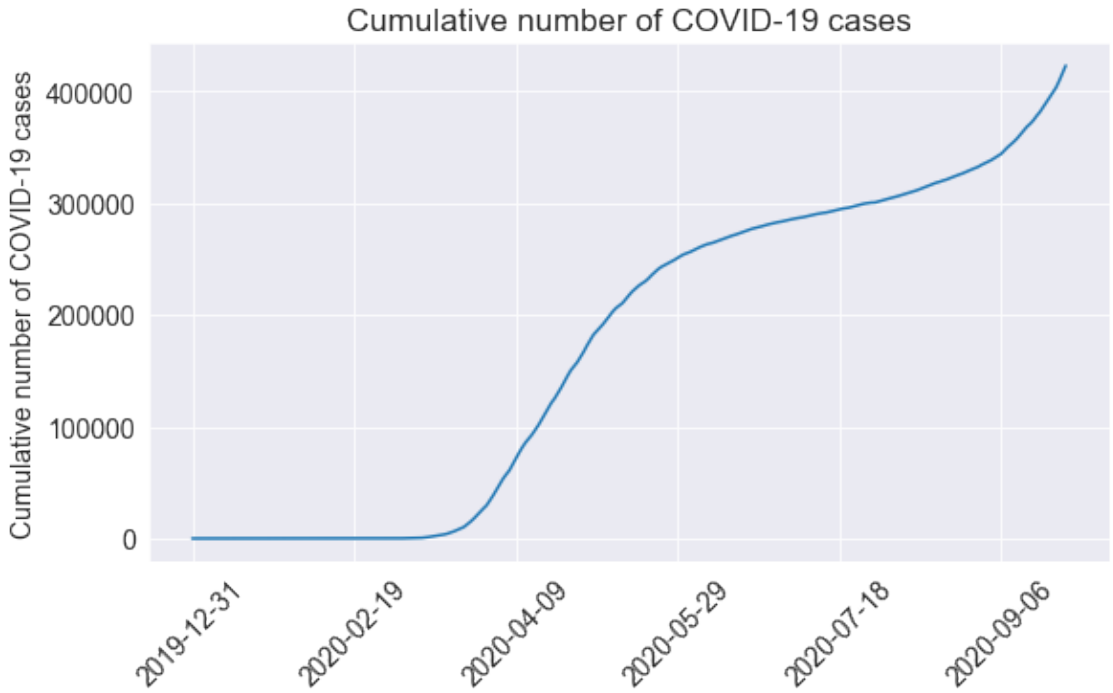
Q: What is the daily number of confirmed cases?

[20]:
```
#plot line chart of number of new reported cases per day
covid_uk_df.new_cases_smoothed.plot()

#set title and axis labels
plt.title('Daily new confirmed COVID-19 cases')
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Daily new confirmed COVID-19 cases');
```



Q: What is the cumulative number of reported cases?

[21]:
```
#plot line chart of cumulative cases
covid_uk_df.total_cases.plot()

#set title and axis labels
plt.title('Cumulative number of COVID-19 cases')
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Cumulative number of COVID-19 cases');
```

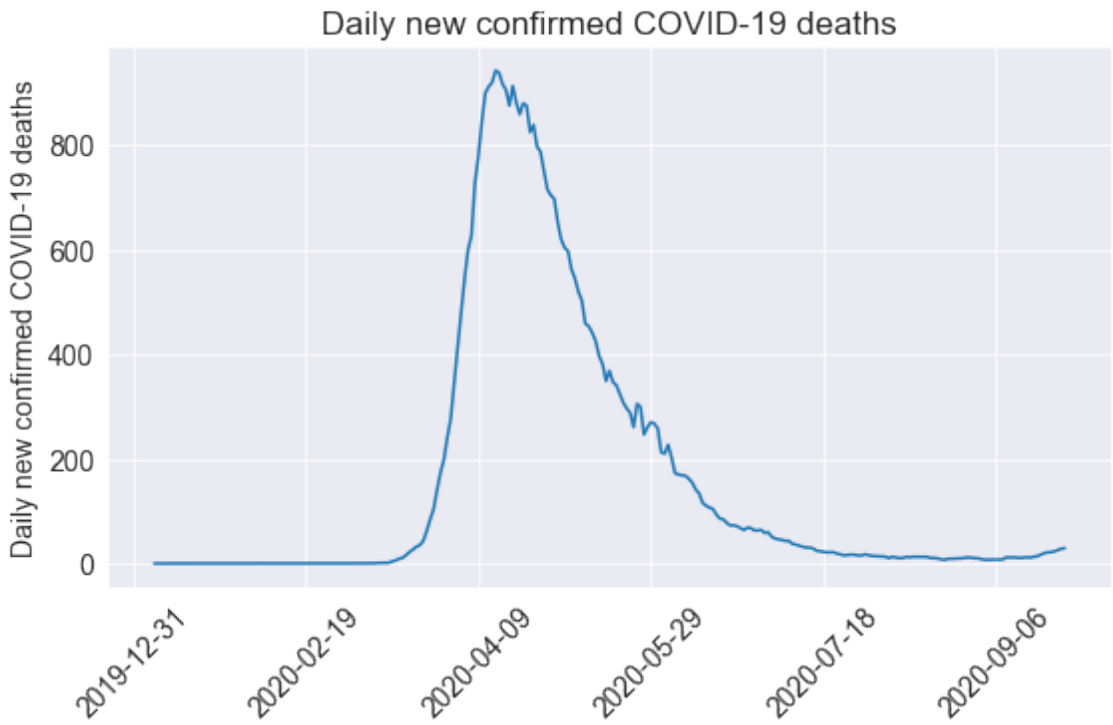


Observations:

- The number of reported cases peaked at approx 4,900 on the 10th of April 2020.
- Since the 18th of July the number of daily reported cases has once again begun to grow at an increasing rate.

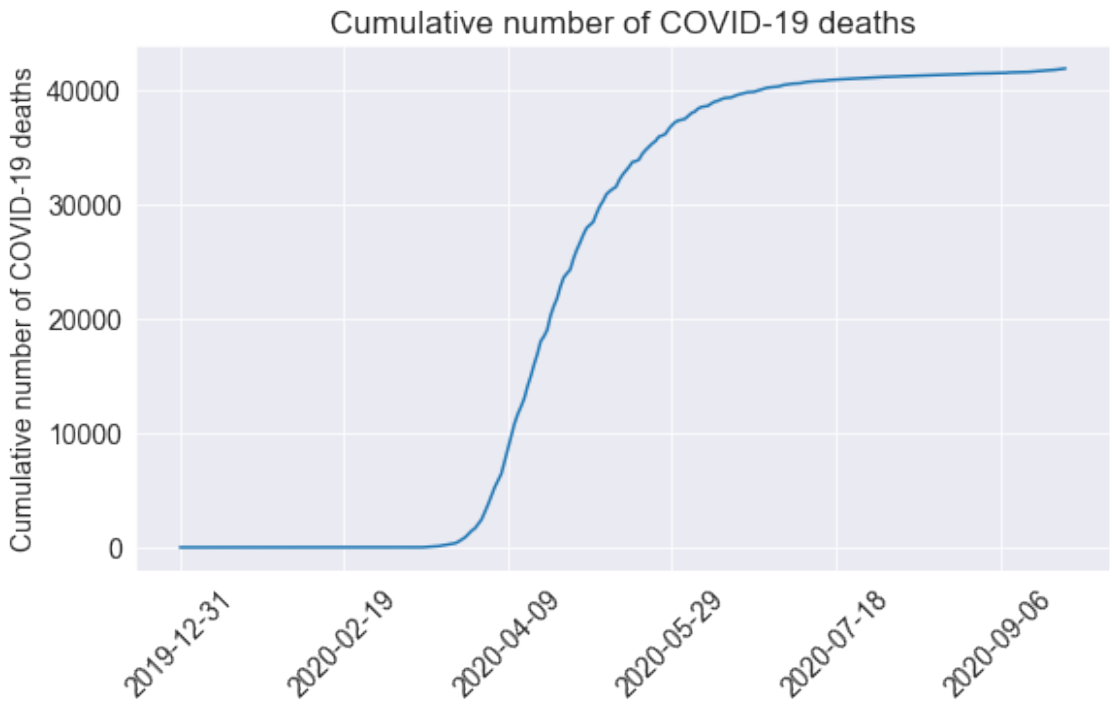
Q: What is the daily number of confirmed deaths?

[22]:
```
#plot line chart of new deaths per day
covid_uk_df.new_deaths_smoothed.plot()

#set title and axis labels
plt.title('Daily new confirmed COVID-19 deaths')
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Daily new confirmed COVID-19 deaths');
```



Q: What is the cumulative number of confirmed deaths?

[23]:
```
#plot line chart of cumulative deaths
covid_uk_df.total_deaths.plot()

#set title and axis labels
plt.title('Cumulative number of COVID-19 deaths')
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Cumulative number of COVID-19 deaths');
```



Observations:

- Similar to the number of reported cases, the number of deaths peaked around the 10th of April 2020. Domain knowledge indicates the number of deaths should lag the number of cases by around 14 days. This is not clear from the data, raising questions about data consistency. A closer look at the literature reveals a change in the methodology used to calculate the number of deaths attributed to covid-19 on the 20th May & 3rd of July. The change included a retrospective revision to past figures, which is why our understanding of the progression of the the disease does not align with the data.
- Given the rise in the number of reported daily cases, the number of daily confirmed deaths is expected to follow.

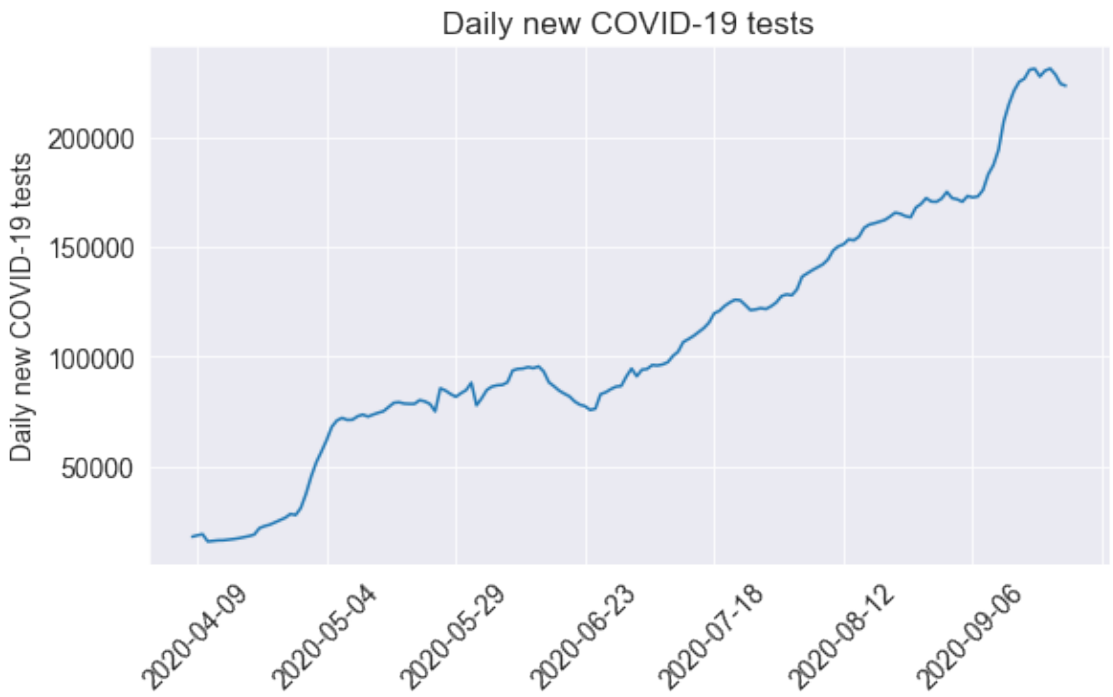
The widely available data on confirmed cases only becomes meaningful when it can be interpreted in light of how much a country is testing. Are countries testing enough to monitor the outbreak?

The figure for number of tests refers to the actual number of tests performed, rather than the number of people tested. This figure will thus be higher if the same person is tested more than once.

Q: What is the daily number of new tests?

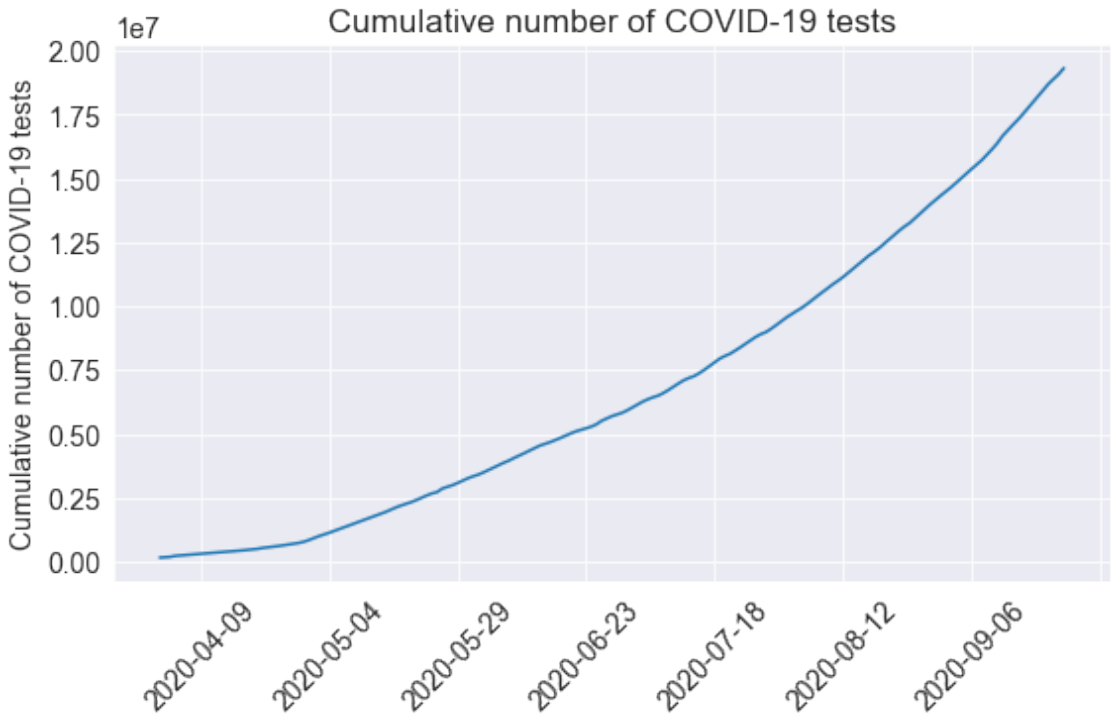
[24]:
```
#plot line chart of new tests per day
covid_uk_df.new_tests_smoothed.plot()

#set title, position of tick marks, and axis labels
plt.title('Daily new COVID-19 tests')
```

```
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Daily new COVID-19 tests');
```



Q: What is the cumulative number of tests?

[25]:
```
#plot line chart of cumulative tests
covid_uk_df.total_tests.plot()

#set title, position of tick marks, and axis labels
plt.title('Cumulative number of COVID-19 tests')
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Cumulative number of COVID-19 tests');
```



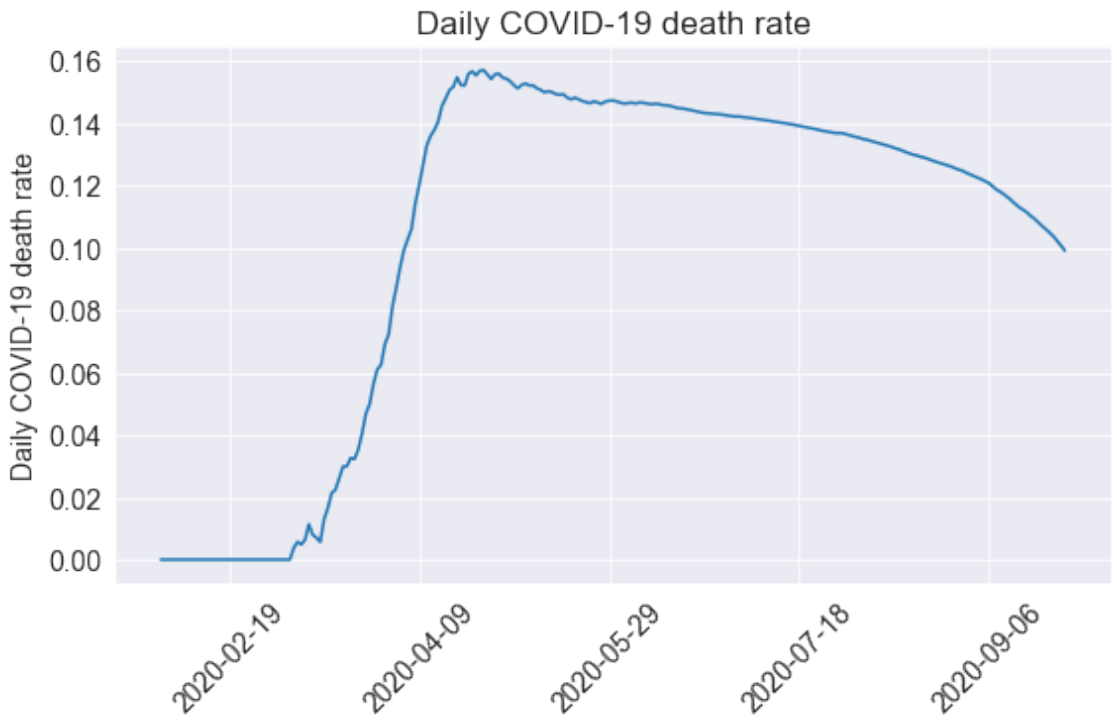
Observations:

As capacity is built the number of daily tests continues to rise.

Q: What is the death rate (ratio of confirmed deaths to reported cases)?

[26]:
```
#create new variable by dividing exisiting variables element wise
covid_uk_df['death_rate_t'] = covid_uk_df.total_deaths / covid_uk_df.total_cases
```

[27]:
```
#plot line chart of death rate
covid_uk_df.death_rate_t.plot()

#set title, position of tick marks, and axis labels
plt.title('Daily COVID-19 death rate')
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Daily COVID-19 death rate');
```



Observations:

At the height of the pandamic when testing was limited, the 'death' rate peaked at around 16%. This steadily decreased as the number of tests increased and is currently at around 10%.

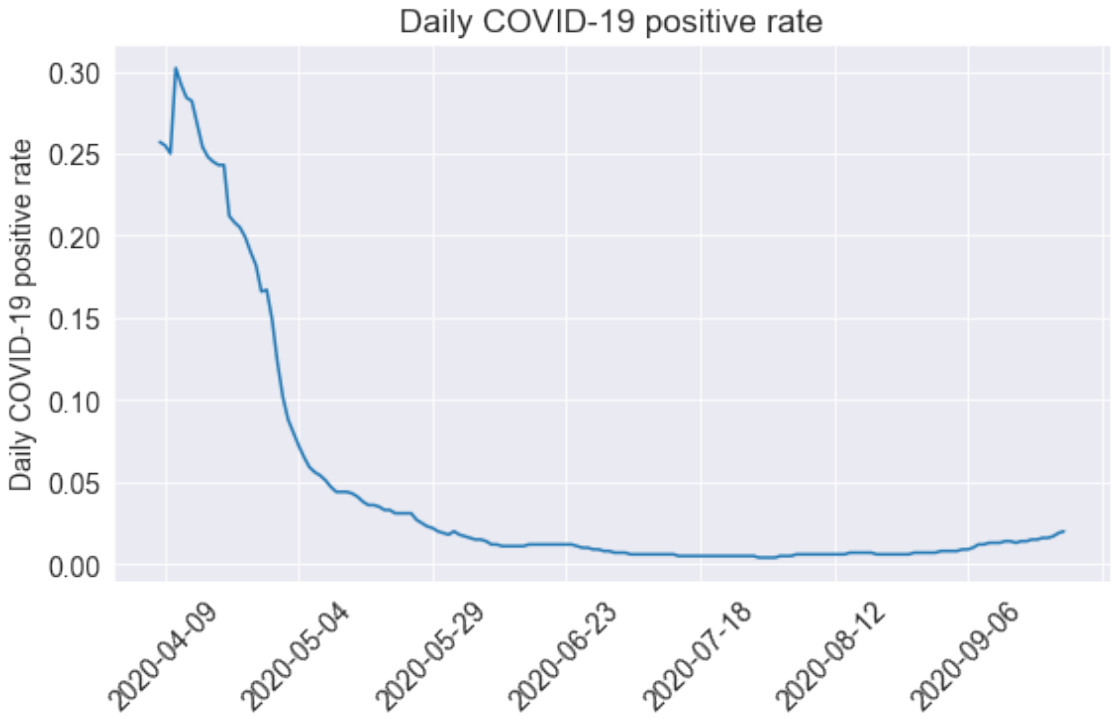
A word of caution:

This does not mean that around 10% of people who contract the virus will suffer a fatality. The true number is likely to lower given many cases are asymptomatic, and yet many more cases are never diagnosed.

One important way to understand if countries are testing sufficiently is to ask: What share of the tests confirm a case? What is the positive rate?

Q: What fraction of test returned a positive result?

[28]:
```
#plot line chart of positive rate
covid_uk_df.positive_rate.plot()

#set title, position of tick marks, and axis labels
plt.title('Daily COVID-19 positive rate')
plt.xticks(rotation=45)
plt.xlabel('')
plt.ylabel('Daily COVID-19 positive rate');
```



A country is not testing adequately when it is finding a case for every few tests they perform. Here it is likely that the true number of new cases is much higher than the number of cases that were confirmed by tests. The WHO has suggested a positive rate of between 3% and 10% as a general benchmark of adequate testing.

Q: How many cases, deaths and tests were recorded for each day of the month?

[29]:
```
#return date index to columns
covid_uk_df.reset_index(inplace=True)
```

[30]:
```
#convert data column to datetime object
covid_uk_df['date'] = pd.to_datetime(covid_uk_df.date)
```

[31]:
```
#extract year, month, day, and weekday from date variable and create new column␣
 ↪for each
covid_uk_df['year'] = pd.DatetimeIndex(covid_uk_df.date).year
covid_uk_df['month'] = pd.DatetimeIndex(covid_uk_df.date).month
covid_uk_df['day'] = pd.DatetimeIndex(covid_uk_df.date).day
covid_uk_df['weekday'] = pd.DatetimeIndex(covid_uk_df.date).weekday
covid_uk_df
```

[31]:

	date	new_cases	new_cases_smoothed	total_cases	new_tests	\
0	2019-12-31	0.0	NaN	0.0	NaN	
1	2020-01-01	0.0	NaN	0.0	NaN	

```
2   2020-01-02        0.0                NaN          0.0        NaN
3   2020-01-03        0.0                NaN          0.0        NaN
4   2020-01-04        0.0                NaN          0.0        NaN
..         …         …                  …           …        …
266 2020-09-22     4368.0           3928.571     398625.0   188865.0
267 2020-09-23     4926.0           4189.000     403551.0   218360.0
268 2020-09-24     6178.0           4501.429     409729.0   232268.0
269 2020-09-25     6634.0           4964.143     416363.0        NaN
270 2020-09-26     6873.0           5328.571     423236.0        NaN

     new_deaths  new_deaths_smoothed  total_deaths  new_tests_smoothed  \
0           0.0                  NaN           0.0                 NaN
1           0.0                  NaN           0.0                 NaN
2           0.0                  NaN           0.0                 NaN
3           0.0                  NaN           0.0                 NaN
4           0.0                  NaN           0.0                 NaN
..          …                    …             …                   …
266        11.0               21.571       41788.0            228564.0
267        37.0               23.000       41825.0            224325.0
268        37.0               25.429       41862.0            223455.0
269        40.0               28.143       41902.0                 NaN
270        34.0               29.143       41936.0                 NaN

     total_tests  positive_rate  death_rate_t  year  month  day  weekday
0            NaN            NaN           NaN  2019     12   31        1
1            NaN            NaN           NaN  2020      1    1        2
2            NaN            NaN           NaN  2020      1    2        3
3            NaN            NaN           NaN  2020      1    3        4
4            NaN            NaN           NaN  2020      1    4        5
..           …              …             …    …    …   …      …
266   18897349.0          0.017      0.104830  2020      9   22        1
267   19091955.0          0.019      0.103642  2020      9   23        2
268   19325203.0          0.020      0.102170  2020      9   24        3
269          NaN            NaN      0.100638  2020      9   25        4
270          NaN            NaN      0.099084  2020      9   26        5

[271 rows x 16 columns]
```

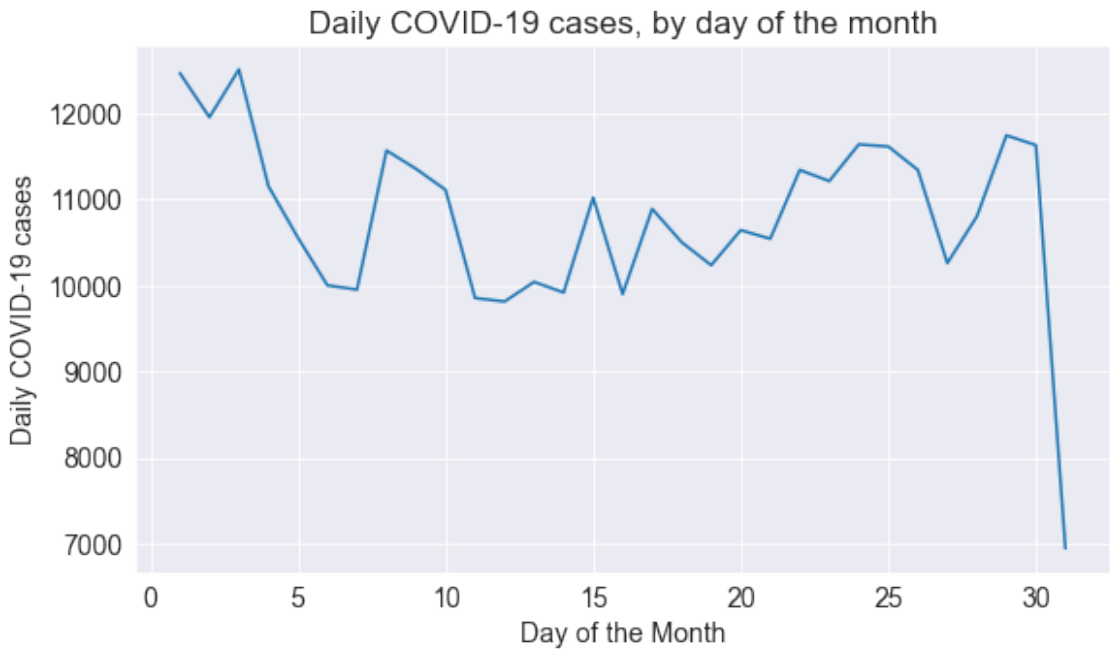
[32]:
```
#exclude incomplete months, i.e current month
covid_uk_exsep = covid_uk_df[covid_uk_df.month != 9].copy()
covid_uk_exsep
```

[32]:
```
          date  new_cases  new_cases_smoothed  total_cases  new_tests  \
0   2019-12-31        0.0                 NaN          0.0        NaN
1   2020-01-01        0.0                 NaN          0.0        NaN
2   2020-01-02        0.0                 NaN          0.0        NaN
3   2020-01-03        0.0                 NaN          0.0        NaN
```

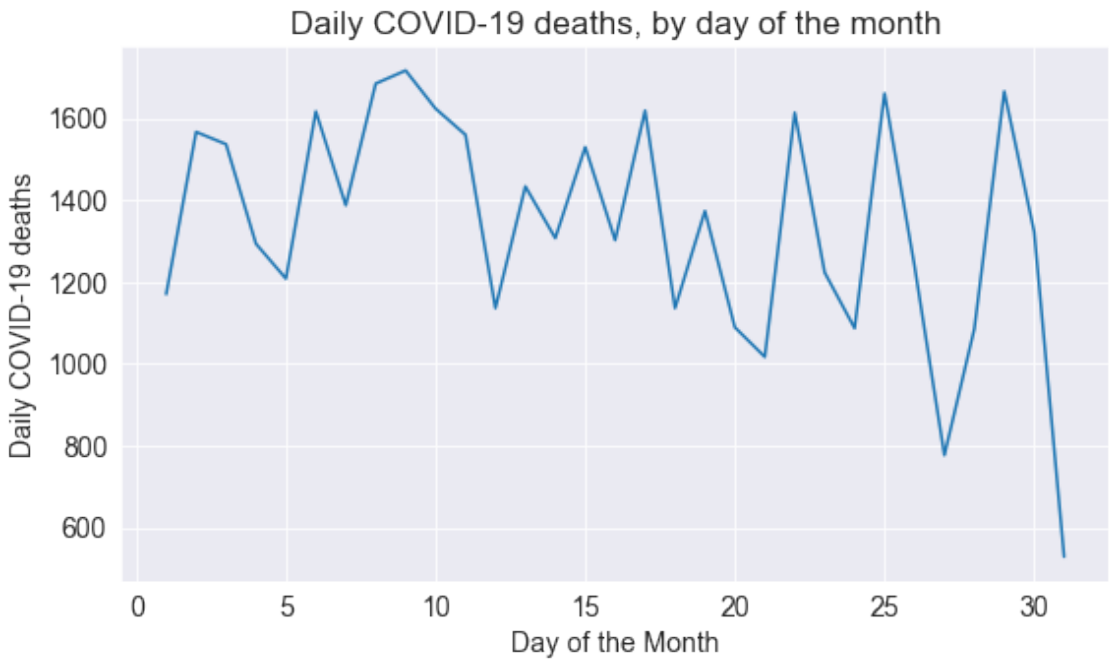
```
4   2020-01-04        0.0                 NaN          0.0        NaN
..         …        …                   …          …        …
240 2020-08-27     1048.0            1106.857     328846.0   184461.0
241 2020-08-28     1522.0            1155.429     330368.0   178203.0
242 2020-08-29     1276.0            1190.143     331644.0   168684.0
243 2020-08-30     1108.0            1164.429     332752.0   170574.0
244 2020-08-31     1715.0            1260.714     334467.0   166871.0

     new_deaths  new_deaths_smoothed  total_deaths  new_tests_smoothed  \
0           0.0                  NaN           0.0                 NaN
1           0.0                  NaN           0.0                 NaN
2           0.0                  NaN           0.0                 NaN
3           0.0                  NaN           0.0                 NaN
4           0.0                  NaN           0.0                 NaN
..          …                    …             …                   …
240        16.0                9.714       41465.0            169546.0
241        12.0               10.571       41477.0            172228.0
242         9.0               11.571       41486.0            170658.0
243        12.0               10.714       41498.0            170542.0
244         1.0               10.000       41499.0            172026.0

     total_tests  positive_rate  death_rate_t  year  month  day  weekday
0            NaN            NaN           NaN  2019     12   31        1
1            NaN            NaN           NaN  2020      1    1        2
2            NaN            NaN           NaN  2020      1    2        3
3            NaN            NaN           NaN  2020      1    3        4
4            NaN            NaN           NaN  2020      1    4        5
..           …              …             …    …    …    …  …       …
240   13633416.0          0.007      0.126092  2020      8   27        3
241   13823629.0          0.007      0.125548  2020      8   28        4
242   13992972.0          0.007      0.125092  2020      8   29        5
243   14163546.0          0.007      0.124711  2020      8   30        6
244   14330417.0          0.007      0.124075  2020      8   31        0

[245 rows x 16 columns]
```

[33]:
```
#sum cases, deaths and tests by day of the month
covid_uk_exsep = covid_uk_exsep.groupby('day')[['new_cases', 'new_deaths',␣
↪'new_tests']].sum()
```

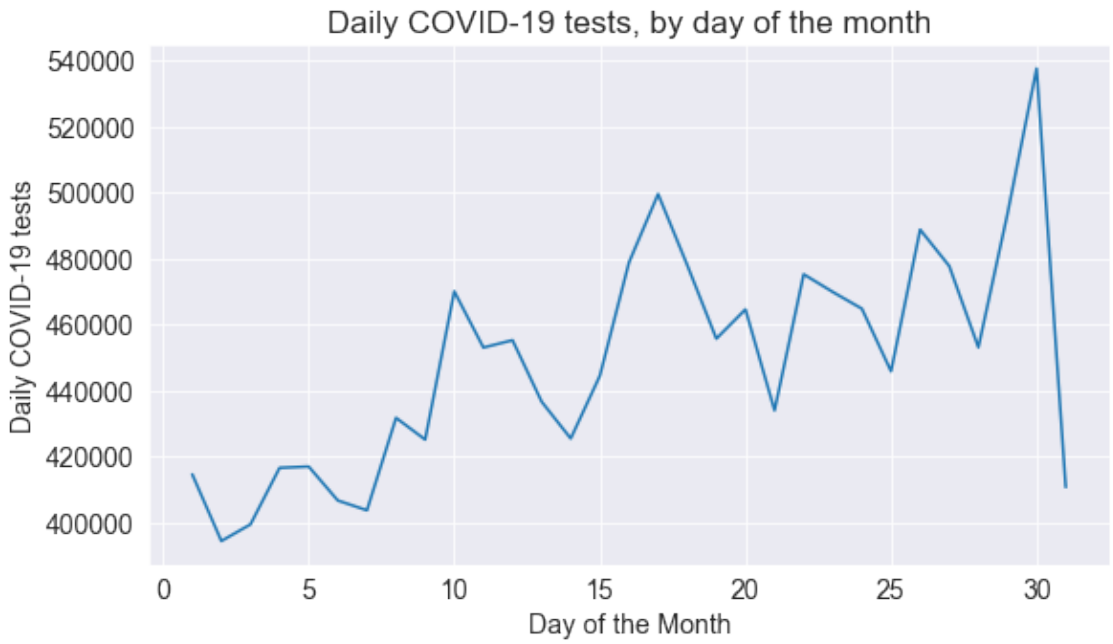
[34]:
```
#plot line chart of new cases by day of the month
covid_uk_exsep.new_cases.plot()

#set title, position of tick marks, and axis labels
plt.title('Daily COVID-19 cases, by day of the month')
plt.xlabel('Day of the Month')
plt.ylabel('Daily COVID-19 cases');
```



[35]:
```
#plot line chart of new cases by day of the month
covid_uk_exsep.new_deaths.plot()

#set title, position of tick marks, and axis labels
plt.title('Daily COVID-19 deaths, by day of the month')
plt.xlabel('Day of the Month')
plt.ylabel('Daily COVID-19 deaths');
```



[36]:
```
#plot line chart of new tests by day of the month
covid_uk_exsep.new_tests.plot()

#set title, position of tick marks, and axis labels
plt.title('Daily COVID-19 tests, by day of the month')
plt.xlabel('Day of the Month')
plt.ylabel('Daily COVID-19 tests');
```



Observations:

Variation in the number of deaths attributed to covid-19 increases in the last 10 days of each month. Perhaps, this is linked to the increased number of tests conducted during the same period. Whether these findings are statistically and/or practically significant would require further investigation.

Q: How many cases, deaths and tests were recorded for each day of the week?

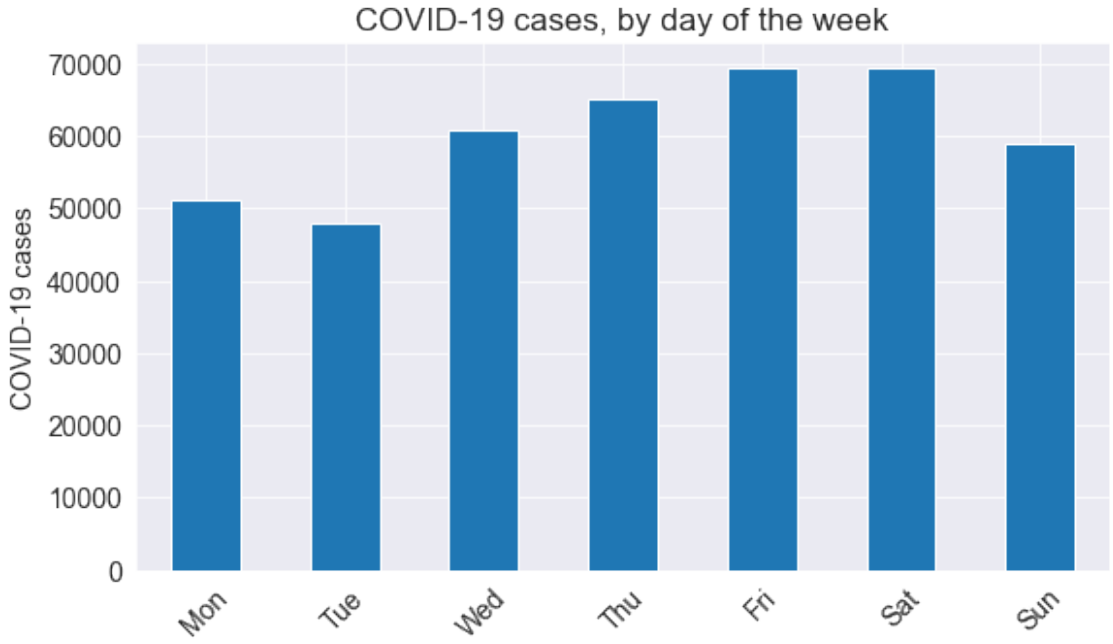
[37]:
```
# sum cases, deaths and tests by day of the month (monday is 0)
covid_weekday_df = covid_uk_df.groupby('weekday')[['new_cases', 'new_deaths',␣
↪'new_tests']].sum()
covid_weekday_df
```

[37]:

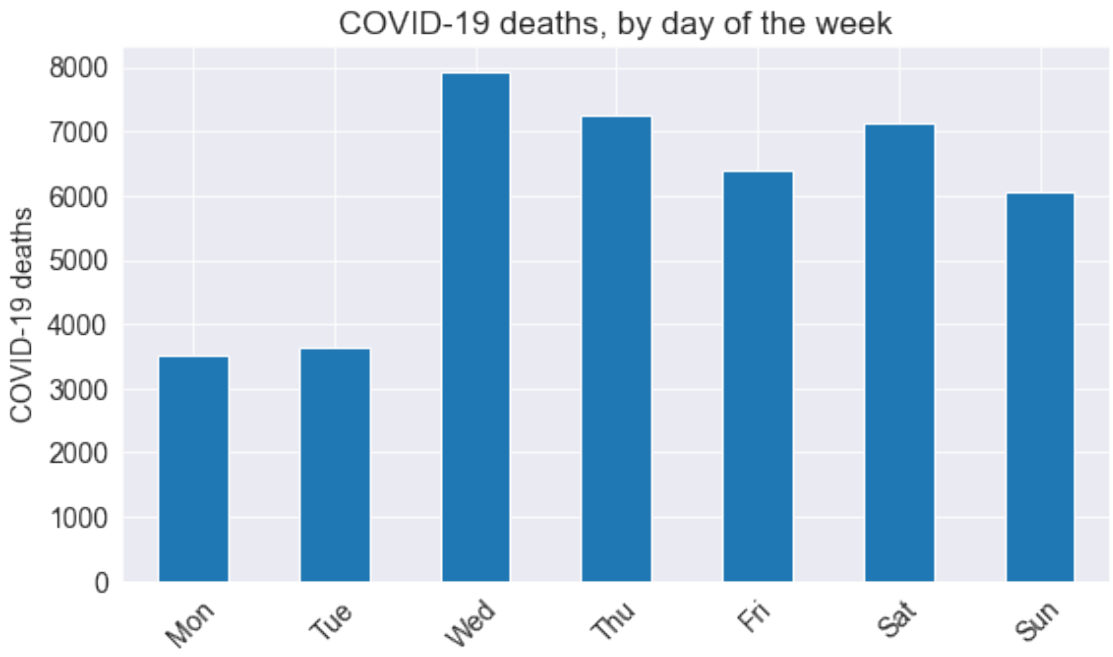
weekday	new_cases	new_deaths	new_tests
0	51237.0	3527.0	2430179.0
1	47857.0	3645.0	2245991.0
2	60998.0	7930.0	2675745.0
3	65190.0	7254.0	2981904.0
4	69430.0	6399.0	2864353.0
5	69492.0	7117.0	2912626.0
6	59032.0	6064.0	2742976.0

[38]:
```
#plot line chart of new cases by day of the week
covid_weekday_df.new_cases.plot(kind='bar')

#set title, position of tick marks, and axis labels
```

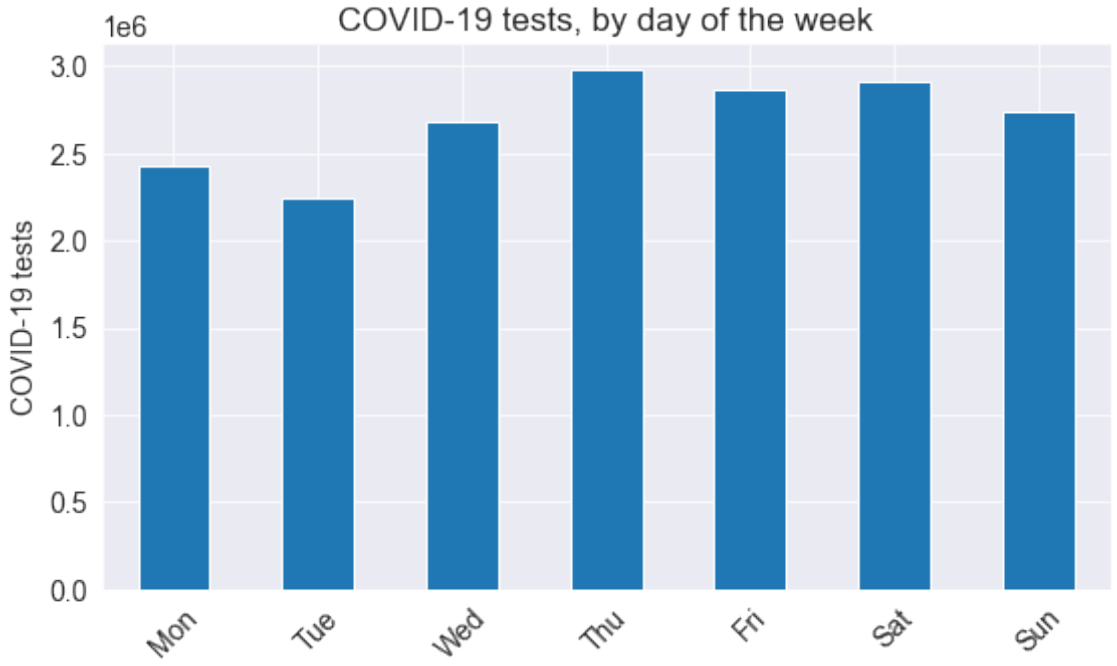
```
plt.title('COVID-19 cases, by day of the week')
day = ['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'Sun']
plt.xticks(np.arange(0, 7), day, rotation=45)
plt.xlabel('')
plt.ylabel('COVID-19 cases');
```



[39]:
```
#plot line chart of new deaths by day of the week
covid_weekday_df.new_deaths.plot(kind='bar')

#set title, position of tick marks, and axis labels
plt.title('COVID-19 deaths, by day of the week')
day = ['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'Sun']
plt.xticks(np.arange(0, 7), day, rotation=45)
plt.xlabel('')
plt.ylabel('COVID-19 deaths');
```



[40]:
```
#plot line chart of new tests by day of the week
covid_weekday_df.new_tests.plot(kind='bar')

#set title, position of tick marks, and axis labels
plt.title('COVID-19 tests, by day of the week')
day = ['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'Sun']
plt.xticks(np.arange(0, 7), day, rotation=45)
plt.xlabel('')
plt.ylabel('COVID-19 tests');
```



Observations:

The number of deaths attributed to Covid-19 reach a lull on Monday & Tuesday. This may be due to beauracratic idiosyncracies rather than an accurate model of reality.

[41]:
```
#save output to csv file
covid_uk_df.to_csv('results.csv', index=False)
```

0.7 Conclusion

0.7.1 Summary

1. The number of reported cases peaked at approx 4,900 on the 10th of April 2020.
2. Since the 18th of July the number of daily reported cases has once again begun to grow.
3. Given the rise in the number of reported daily cases, the number of daily confirmed deaths is expected to follow.
4. As capacity is built the number of daily tests continues to rise.
5. Variation in the number of deaths reported increases from the 20th day of each month.
6. The number of tests performed also increases toward the end of each month.
7. Signifacantly fewer deaths are confirmed on Monday & Tuesday.

The number of daily reported new cases has recently reached levels last witnessed during the height of the pandemic in early April. However, the number of daily covid-19 tests conducted in September is more than 4 times higher than what it was in early April. This suggests the number of cases that go undetected is far lower. So although the number of cases is increasing, the fatality rate (or how dangerous the virus is) is not expected to changed markedly. This is supported by the 'death' rate and the positive rate, both of which have remained steady.

0.7.2 Limitations:

What is important to note about these case figures? - The reported case figures on a given date does not necessarily show the number of new cases on that day: this is due to delays in reporting. - Keep in mind these are offically reported numbers, and the actual number of cases and deaths may be higher, as not all cases are diagnosed. - The actual number of cases is also likely to be much higher than the number of confirmed cases – this is due to limited testing. - Comorbidiy. Covid-19 may be a contributing factor but perhaps not the only cause of death.

0.7.3 Directions for Further Research

1. Statistical & Practical significance of day of the month/week differences