BDP_HW3

February 23, 2023

[1]:
```
from pyspark.sql import SparkSession
from pyspark.sql import functions as F
from pyspark.sql import types
from pyspark.sql.functions import unix_timestamp, from_unixtime
from pyspark.sql.window import Window

import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

[10]:
```
spark = SparkSession.builder.enableHiveSupport().appName('ReadWriteData').
↪getOrCreate()
```

[11]:
```
sc = spark.sparkContext
sc.defaultParallelism
```

[11]:
```
24
```

[20]:
```
sc
```

[20]:
```
<SparkContext master=local[*] appName=ReadData>
```

[21]:
```
import os
os.getcwd()
```

[21]:
```
'/home/jovyan'
```

[28]:
```
from pyspark.sql import HiveContext
hive_context = HiveContext(sc)
```

[209]:
```
%time df = spark.read.csv("Crimes_-_2001_to_Present (1).csv", inferSchema=True,␣
↪header=True)
```

```
CPU times: user 2.61 ms, sys: 0 ns, total: 2.61 ms
Wall time: 709 ms
```

[210]:
```
df.printSchema()
```

```
root
 |-- ID: integer (nullable = true)
 |-- Case Number: string (nullable = true)
 |-- Date: string (nullable = true)
 |-- Block: string (nullable = true)
 |-- IUCR: string (nullable = true)
 |-- Primary Type: string (nullable = true)
 |-- Description: string (nullable = true)
 |-- Location Description: string (nullable = true)
 |-- Arrest: boolean (nullable = true)
 |-- Domestic: boolean (nullable = true)
 |-- Beat: integer (nullable = true)
 |-- District: integer (nullable = true)
 |-- Ward: integer (nullable = true)
 |-- Community Area: integer (nullable = true)
 |-- FBI Code: string (nullable = true)
 |-- X Coordinate: integer (nullable = true)
 |-- Y Coordinate: integer (nullable = true)
 |-- Year: integer (nullable = true)
 |-- Updated On: string (nullable = true)
 |-- Latitude: double (nullable = true)
 |-- Longitude: double (nullable = true)
 |-- Location: string (nullable = true)
```

[49]:
```
hive_context.sql("show databases").show();
```

```
+--------------+
|     namespace|
+--------------+
|chicago_crimes|
|       default|
+--------------+
```

[211]:
```
df = df.withColumnRenamed("ID", "id")\
    .withColumnRenamed("Case Number","case_cumber")\
    .withColumnRenamed("Date","date")\
    .withColumnRenamed("Block", "block")\
    .withColumnRenamed("IUCR", "iucr")\
    .withColumnRenamed("Primary Type", "primary_type")\
    .withColumnRenamed("Description", "description")\
    .withColumnRenamed("Location Description","location_description")\
    .withColumnRenamed("Arrest","arrest")\
    .withColumnRenamed("Domestic", "domestic")\
    .withColumnRenamed("Beat", "beat")\
    .withColumnRenamed("District", "district")\
```

```
    .withColumnRenamed("Ward", "ward")\
    .withColumnRenamed("Community Area","community_area")\
    .withColumnRenamed("FBI Code","fbi_code")\
    .withColumnRenamed("X Coordinate", "x_coordinate")\
    .withColumnRenamed("Y Coordinate", "y_coordinate")\
    .withColumnRenamed("Year", "year")\
    .withColumnRenamed("Updated On", "updated_on")\
    .withColumnRenamed("Latitude","latitude")\
    .withColumnRenamed("Longitude","longitude")\
    .withColumnRenamed("Location", "location")
```

[51]:
```
hive_context.sql("show databases").show();
```

```
+--------------+
|     namespace|
+--------------+
|chicago_crimes|
|       default|
+--------------+
```

[55]:
```
hive_context.sql("create database chicago_crimes1");
```

[121]:
```
hive_context.sql("show tables").show();
```

```
+---------+---------------+-----------+
|namespace|      tableName|isTemporary|
+---------+---------------+-----------+
|  default|chicago_crimes1|      false|
|  default|foodinspections|      false|
+---------+---------------+-----------+
```

[57]:
```
hive_context.sql("drop table if exists chicago_crimes");
```

[212]:
```
df.write.mode('overwrite').saveAsTable('chicago_crimes2')
```

[213]:
```
df1 = hive_context.table("chicago_crimes2")
df1.show(5)
```

```
+--------+----------+-------------------+-------------------+----+----------
------+--------------+--------------------+------+--------+----+--------+----+--
------------+--------+------------+------------+----+-------------------+------
------+-------------+--------------------+
|      id|case_cumber|               date|              block|iucr|
primary_type|   description|location_description|arrest|domestic|beat|district|w
ard|community_area|fbi_code|x_coordinate|y_coordinate|year|          updated_on|
latitude|    longitude|            location|
```

```
+--------+----------+------------------+------------------+----+----------
------+-------------+------------------+------+--------+----+--------+----+--
-----------+--------+-----------+-----------+----+------------------+------
------+-------------+--------------------+
|10072869|   HY259916|05/13/2015 09:15:…|   031XX W CERMAK RD|031A|
ROBBERY|ARMED: HANDGUN|           SIDEWALK| false|   false|1022|      10|  24|
30|      03|     1155948|     1889214|2015|02/10/2018
03:50:…|41.851794306|-87.703117482|(41.851794306, -8…|
|10115148|   HY304078|06/16/2015 07:30:…|037XX W ROOSEVELT RD|1330|CRIMINAL
TRESPASS|       TO LAND|         GAS STATION|  true|   false|1011|      10|  24|
29|      26|     1151592|     1894452|2015|02/10/2018 03:50:…|
41.86625461|-87.718967674|(41.86625461, -87…|
| 1779162|    G597508|10/05/2001 11:50:…|044XX S COTTAGE G…|0820|
THEFT|$500 AND UNDER|  GROCERY FOOD STORE| false|   false|2123|       2|null|
null|      06|     1182380|     1875732|2001|08/17/2015
03:03:…|41.814225502|-87.606524776|(41.814225502, -8…|
| 1779163|    G599087|10/06/2001 12:01:…|  119XX S EMERALD AV|1320|  CRIMINAL
DAMAGE|    TO VEHICLE|              STREET| false|   false| 524|       5|null|
null|      14|     1173423|     1825917|2001|08/17/2015
03:03:…|41.677729912|-87.640850259|(41.677729912, -8…|
| 1779164|    G588865|09/27/2001 11:00:…|   057XX S CICERO AV|0810|
THEFT|     OVER $500|    AIRPORT/AIRCRAFT|  true|   false| 813|       8|null|
null|      06|     1145592|     1866396|2001|08/17/2015
03:03:…|41.789380622|-87.741703718|(41.789380622, -8…|
+--------+----------+------------------+------------------+----+----------
------+-------------+------------------+------+--------+----+--------+----+--
-----------+--------+-----------+-----------+----+------------------+------
------+-------------+--------------------+
only showing top 5 rows
```

0.1 Problem 1

a)

[214]:
```
df1.describe().toPandas()
```

[214]:

	summary	id	case_cumber	date	\
0	count	2086509	2086509	2086509	
1	mean	6584920.753162819	271044.0	None	
2	stddev	4511404.470700128	167805.04570482974	None	
3	min	1051	.JB299184	01/01/2001 01:00:00 AM	
4	max	12875442	ZZ591134	12/31/2019 09:00:00 AM	

	block	iucr	primary_type	description	\
0	2086509	2086509	2086509	2086509	
1	None	1125.3120223472015	None	None	
2	None	850.0328581260538	None	None	

```
3      0000X E 100 PL                0110              ARSON   $300 AND UNDER
4  137XX S LEYDEN AVE                9901  WEAPONS VIOLATION  WIREROOM/SPORTS

  location_description                beat  …                ward  \
0              2082636             2086509  …             1499802
1                 None  1181.7922712051566  …  22.965713474178592
2                 None   703.1902937143857  …  14.006137847185988
3   ABANDONED BUILDING                 111  …                   1
4                 YARD                2535  …                  50

       community_area            fbi_code       x_coordinate  \
0             1502149             2086509            2074557
1   36.95942280026815  11.974667034942778  1164681.962866289
2  21.454763891971435   7.340137505481005  16142.36652211198
3                   0                 01A                  0
4                  77                  26            1205119

        y_coordinate              year              updated_on  \
0            2074557           2086509                 2086509
1  1886582.3362655255  2009.473684513223                    None
2   31248.436053971905   7.72767840077094                    None
3                   0              2001  01/01/2016 03:54:40 PM
4             1951610              2022  12/31/2019 03:50:01 PM

             latitude           longitude                        location
0             2074557             2074557                         2074557
1    41.84437703545333  -87.67117746611007                            None
2  0.08593827566601325  0.05874516236726268                            None
3         36.619446395        -91.686565684  (36.619446395, -91.686565684)
4         42.022878225        -87.524529378  (42.022878225, -87.677335866)

[5 rows x 21 columns]
```

b)

[215]:
```
df1 = df1.drop("beat", "ward", "latitude", "longitude")
df1.columns
```

[215]:
```
['id',
 'case_cumber',
 'date',
 'block',
 'iucr',
 'primary_type',
 'description',
 'location_description',
 'arrest',
```

```
 'domestic',
 'district',
 'community_area',
 'fbi_code',
 'x_coordinate',
 'y_coordinate',
 'year',
 'updated_on',
 'location']
```

c)

[216]:
```
df1.printSchema()
```

```
root
 |-- id: integer (nullable = true)
 |-- case_cumber: string (nullable = true)
 |-- date: string (nullable = true)
 |-- block: string (nullable = true)
 |-- iucr: string (nullable = true)
 |-- primary_type: string (nullable = true)
 |-- description: string (nullable = true)
 |-- location_description: string (nullable = true)
 |-- arrest: boolean (nullable = true)
 |-- domestic: boolean (nullable = true)
 |-- district: integer (nullable = true)
 |-- community_area: integer (nullable = true)
 |-- fbi_code: string (nullable = true)
 |-- x_coordinate: integer (nullable = true)
 |-- y_coordinate: integer (nullable = true)
 |-- year: integer (nullable = true)
 |-- updated_on: string (nullable = true)
 |-- location: string (nullable = true)
```

[217]:
```
df2 = df1.withColumn("date", unix_timestamp("date", "MM/dd/yyyy hh:mm:ss aa"))
df2 = df2.withColumn("date", df2.date.cast(types.TimestampType()))
df2 = df2.withColumn("year_month", from_unixtime(unix_timestamp("date", "MM/dd/
 ↪yyyy hh:mm:ss aa"), "yyy-MM"))
df2 = df2.withColumn("updated_on", unix_timestamp("updated_on", "MM/dd/yyyy hh:
 ↪mm:ss aa"))
df2 = df2.withColumn("updated_on", df2.updated_on.cast(types.TimestampType()))
```

[218]:
```
df2.printSchema()
```

```
root
 |-- id: integer (nullable = true)
 |-- case_cumber: string (nullable = true)
```

```
 |-- date: timestamp (nullable = true)
 |-- block: string (nullable = true)
 |-- iucr: string (nullable = true)
 |-- primary_type: string (nullable = true)
 |-- description: string (nullable = true)
 |-- location_description: string (nullable = true)
 |-- arrest: boolean (nullable = true)
 |-- domestic: boolean (nullable = true)
 |-- district: integer (nullable = true)
 |-- community_area: integer (nullable = true)
 |-- fbi_code: string (nullable = true)
 |-- x_coordinate: integer (nullable = true)
 |-- y_coordinate: integer (nullable = true)
 |-- year: integer (nullable = true)
 |-- updated_on: timestamp (nullable = true)
 |-- location: string (nullable = true)
 |-- year_month: string (nullable = true)
```

[333]:
```
df2.show(5)
```

```
+--------+-----------+----------+--------------------+----+-----------------+---
-----------+--------------------+------+--------+--------+-------------+-------
-+------------+------------+----+------------------+--------------------+------
----+---+-----+
|      id|case_cumber|      date|               block|iucr|     primary_type|
description|location_description|arrest|domestic|district|community_area|fbi_cod
e|x_coordinate|y_coordinate|year|         updated_on|
location|year_month|dow|month|
+--------+-----------+----------+--------------------+----+-----------------+---
-----------+--------------------+------+--------+--------+-------------+-------
-+------------+------------+----+------------------+--------------------+------
----+---+-----+
|10072869|   HY259916|2015-05-13|   031XX W CERMAK RD|031A|
ROBBERY|ARMED: HANDGUN|            SIDEWALK| false|   false|      10|
30|      03|     1155948|     1889214|2015|2018-02-10 15:50:01|(41.851794306,
-8…|   2015-05|  4|    5|
|10115148|   HY304078|2015-06-16|037XX W ROOSEVELT RD|1330|CRIMINAL TRESPASS|
TO LAND|         GAS STATION|  true|   false|      10|            29|      26|
1151592|     1894452|2015|2018-02-10 15:50:01|(41.86625461, -87…|   2015-06|
3|    6|
| 1779162|    G597508|2001-10-05|044XX S COTTAGE G…|0820|
THEFT|$500 AND UNDER|  GROCERY FOOD STORE| false|   false|       2|
null|      06|     1182380|     1875732|2001|2015-08-17 15:03:40|(41.814225502,
-8…|   2001-10|  6|   10|
| 1779163|    G599087|2001-10-06|  119XX S EMERALD AV|1320|  CRIMINAL DAMAGE|
TO VEHICLE|              STREET| false|   false|       5|          null|
14|     1173423|     1825917|2001|2015-08-17 15:03:40|(41.677729912, -8…|
```

```
2001-10|  7|   10|
| 1779164|    G588865|2001-09-27|   057XX S CICERO AV|0810|            THEFT|
OVER $500|    AIRPORT/AIRCRAFT|  true|   false|       8|          null|      06|
1145592|     1866396|2001|2015-08-17 15:03:40|(41.789380622, -8…|   2001-09|
5|    9|
+--------+----------+---------+--------------------+----+-----------------+---
----------+--------------------+------+--------+--------+-------------+-------
-+-----------+-----------+----+------------------+--------------------+------
----+---+-----+
only showing top 5 rows
```

d)

[219]:
```
df2 = df2.withColumn("date", F.to_date("date"))
df2 = df2.withColumn("dow", F.dayofweek("date"))
df2 = df2.withColumn("month", F.month(F.to_date("date")))
df2 = df2.withColumn("year", F.year(F.to_date("date")))
df2.printSchema()
```

```
root
 |-- id: integer (nullable = true)
 |-- case_cumber: string (nullable = true)
 |-- date: date (nullable = true)
 |-- block: string (nullable = true)
 |-- iucr: string (nullable = true)
 |-- primary_type: string (nullable = true)
 |-- description: string (nullable = true)
 |-- location_description: string (nullable = true)
 |-- arrest: boolean (nullable = true)
 |-- domestic: boolean (nullable = true)
 |-- district: integer (nullable = true)
 |-- community_area: integer (nullable = true)
 |-- fbi_code: string (nullable = true)
 |-- x_coordinate: integer (nullable = true)
 |-- y_coordinate: integer (nullable = true)
 |-- year: integer (nullable = true)
 |-- updated_on: timestamp (nullable = true)
 |-- location: string (nullable = true)
 |-- year_month: string (nullable = true)
 |-- dow: integer (nullable = true)
 |-- month: integer (nullable = true)
```

[220]:
```
cn = spark.read.csv("chi_communities.csv", inferSchema=True, header=True)
cn.show(5)
```

```
+-------------+-------------------+
```

```
|community_area|community_area_name|
+--------------+-------------------+
|             0|            Missing|
|             1|        Rogers Park|
|             2|         West Ridge|
|             3|             Uptown|
|             4|     Lincoln Square|
+--------------+-------------------+
only showing top 5 rows
```

[221]:
```
df3 = df2.join(cn, on="community_area")
```

[222]:
```
df3.printSchema()
```

```
root
 |-- community_area: integer (nullable = true)
 |-- id: integer (nullable = true)
 |-- case_cumber: string (nullable = true)
 |-- date: date (nullable = true)
 |-- block: string (nullable = true)
 |-- iucr: string (nullable = true)
 |-- primary_type: string (nullable = true)
 |-- description: string (nullable = true)
 |-- location_description: string (nullable = true)
 |-- arrest: boolean (nullable = true)
 |-- domestic: boolean (nullable = true)
 |-- district: integer (nullable = true)
 |-- fbi_code: string (nullable = true)
 |-- x_coordinate: integer (nullable = true)
 |-- y_coordinate: integer (nullable = true)
 |-- year: integer (nullable = true)
 |-- updated_on: timestamp (nullable = true)
 |-- location: string (nullable = true)
 |-- year_month: string (nullable = true)
 |-- dow: integer (nullable = true)
 |-- month: integer (nullable = true)
 |-- community_area_name: string (nullable = true)
```

0.2 Problem 2

a)

[223]:
```
df3.filter(df3.description.like("%AGGRAVATED%"))\
    .groupby(df3.description)\
    .count()\
    .sort("count").orderBy(["count"], ascending=[0])\
```

```
    .show()
```

```
+--------------------+-----+
|         description|count|
+--------------------+-----+
| AGGRAVATED: HANDGUN|24445|
|AGGRAVATED: OTHER…|19639|
|AGGRAVATED:KNIFE/…|13770|
|      NON-AGGRAVATED| 4581|
|AGGRAVATED DOMEST…| 4469|
|          AGGRAVATED| 3551|
|AGGRAVATED DOMEST…| 2926|
|AGGRAVATED VEHICU…| 2642|
|AGGRAVATED DOMEST…| 1701|
|   AGGRAVATED: OTHER| 1018|
|AGGRAVATED DOMEST…|  969|
|AGGRAVATED - HANDGUN|  934|
|AGGRAVATED OF A S…|  920|
|AGGRAVATED: OTHER…|  822|
|AGGRAVATED PO: OT…|  604|
|AGGRAVATED FINANC…|  483|
|ATTEMPT NON-AGGRA…|  382|
|AGGRAVATED OF A C…|  298|
|AGGRAVATED PO: HA…|  271|
| ATTEMPT: AGGRAVATED|  270|
+--------------------+-----+
only showing top 20 rows
```

b)

[224]:
```
df3.filter(df3.location_description=="APARTMENT")\
    .groupby(df3.primary_type)\
    .count()\
    .sort("count").orderBy(["count"], ascending=[0])\
    .show(5)
```

```
+--------------+-----+
|   primary_type|count|
+--------------+-----+
|        BATTERY|61259|
|       BURGLARY|21604|
|CRIMINAL DAMAGE|19542|
|          THEFT|18857|
|  OTHER OFFENSE|15102|
+--------------+-----+
only showing top 5 rows
```

[225]:
```
df3.filter(((df3.location_description=="APARTMENT") & (df3.
 ↪primary_type=="BATTERY")))\
    .groupby(df3.community_area_name)\
    .count()\
    .sort("count").orderBy(["count"], ascending=[0])\
    .show(5)
```

```
+--------------------+-----+
| community_area_name|count|
+--------------------+-----+
|              Austin| 5108|
|         South Shore| 4798|
|      North Lawndale| 2883|
|Greater Grand Cro…| 2682|
|      Auburn Gresham| 2325|
+--------------------+-----+
only showing top 5 rows
```

Battery is the most prevalent crime and it occurs most often in Austin.

[226]:
```
spark.sql("set spark.sql.legacy.timeParserPolicy=LEGACY")
```

[226]:
```
DataFrame[key: string, value: string]
```

c)

[227]:
```
wp2020 = df3.filter(((df3.year==2020) & (df3.primary_type=="WEAPONS␣
 ↪VIOLATION")))\
            .groupby(df3.month)\
            .count()\
            .sort("count")\
            .orderBy(["count"], ascending=[0])\
            .show(5)
```

```
+-----+-----+
|month|count|
+-----+-----+
|    8|  285|
|    3|  177|
|    4|  131|
|   12|  128|
|    7|    2|
+-----+-----+
only showing top 5 rows
```

d)

[228]:
```
df3.filter(df3.domestic==True).groupby(df3.arrest).count().show()
```

```
+------+------+
|arrest| count|
+------+------+
|  true| 42141|
| false|186368|
+------+------+
```

[229]:
```
df3.filter(df3.domestic==True)\
    .withColumn('arrest', df3.arrest.cast(types.IntegerType()))\
    .agg({'arrest': 'mean'}).collect()
```

[229]:
```
[Row(avg(arrest)=0.1844172439597565)]
```

0.3 Problem 3

a)

[230]:
```
df3.filter(df3.year < 2024)\
    .groupby(df3.year, df3.month)\
    .count()\
    .groupby(df3.month)\
    .agg(F.avg('count').alias('avg_crimes'))\
    .sort("avg_crimes").orderBy(["avg_crimes"], ascending=[0])\
    .show()
```

```
+-----+------------------+
|month|        avg_crimes|
+-----+------------------+
|    8| 6583.590909090909|
|   10| 6508.181818181818|
|    7| 6347.761904761905|
|    3| 6173.380952380952|
|    5| 5986.272727272727|
|    9| 5938.545454545455|
|   11| 5853.047619047619|
|   12|5748.9047619047615|
|    6| 5677.619047619048|
|    4| 5254.761904761905|
|    1| 5168.954545454545|
|    2| 4631.909090909091|
+-----+------------------+
```

[231]:
```
df3.filter(df3.year < 2024)\
    .groupby(df3.date, df3.dow)\
    .count()\
    .groupby(df3.dow)\
    .agg(F.avg('count').alias('avg_crimes'))\
    .sort("avg_crimes").orderBy(["avg_crimes"], ascending=[0])\
    .show()
```

```
+---+------------------+
|dow|        avg_crimes|
+---+------------------+
|  7|351.37277147487845|
|  1|344.98172757475083|
|  6| 343.5679389312977|
|  5|334.56043956043953|
|  4| 334.3375196232339|
|  2| 330.1111111111111|
|  3| 326.6298003072197|
+---+------------------+
```

b)

[232]:
```
tmp3b = df3\
    .filter(df3.primary_type == "HOMICIDE")\
    .groupby(df3.date)\
    .count()\
    .sort("count").orderBy(["count"], ascending=[0])
```

[233]:
```
tmp3b.show(5)
```

```
+----------+-----+
|      date|count|
+----------+-----+
|2022-10-22|    2|
|2022-09-23|    2|
|2022-10-20|    1|
|2022-08-27|    1|
|2018-03-11|    1|
+----------+-----+
only showing top 5 rows
```

[234]:
```
days = tmp3b.select("date").head(2)
days[1][0] - days[0][0]
```

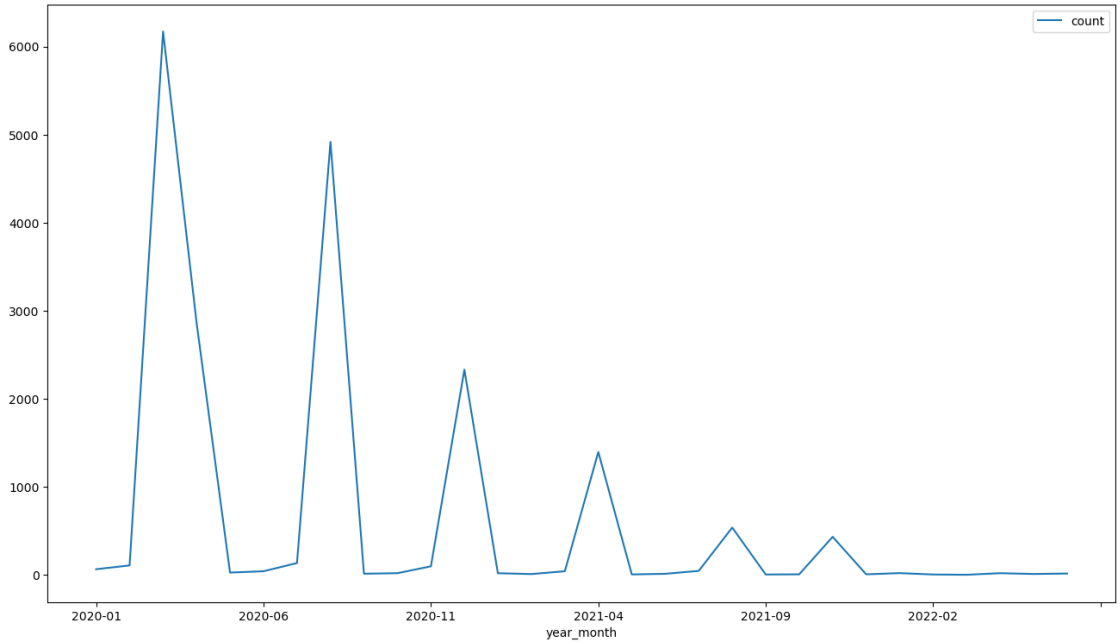
[234]:
```
datetime.timedelta(days=29)
```

c)

[235]:
```
tmp3c = df3.filter((df3.year < 2024) & (df3.year > 2019)).groupby(df3.
↪year_month).count().toPandas()
tmp3c = tmp3c.sort_values(['year_month']).reset_index().drop('index', axis=1)
tmp3c = tmp3c[~tmp3c.year_month.isna()]
```

[236]:
```
tmp3c.plot(x='year_month', y='count', figsize=(16,9))
```

[236]:
```
<Axes: xlabel='year_month'>
```



d)

[237]:
```
tmp3d = df3.filter(df3.year < 2024)\
    .groupby(df3.year, df3.primary_type)\
    .count()\
    .sort("count").orderBy(["count"], ascending=[0])

window = Window.partitionBy(tmp3d['year']).orderBy(tmp3d['count'].desc())

tmp3d = tmp3d\
    .select('*', F.rank().over(window).alias('rank'))\
    .filter(F.col('rank') <= 5)\
    .sort("year").orderBy(["year"], ascending=[0])\
    .toPandas()
```

[238]:
```
tmp3d
```

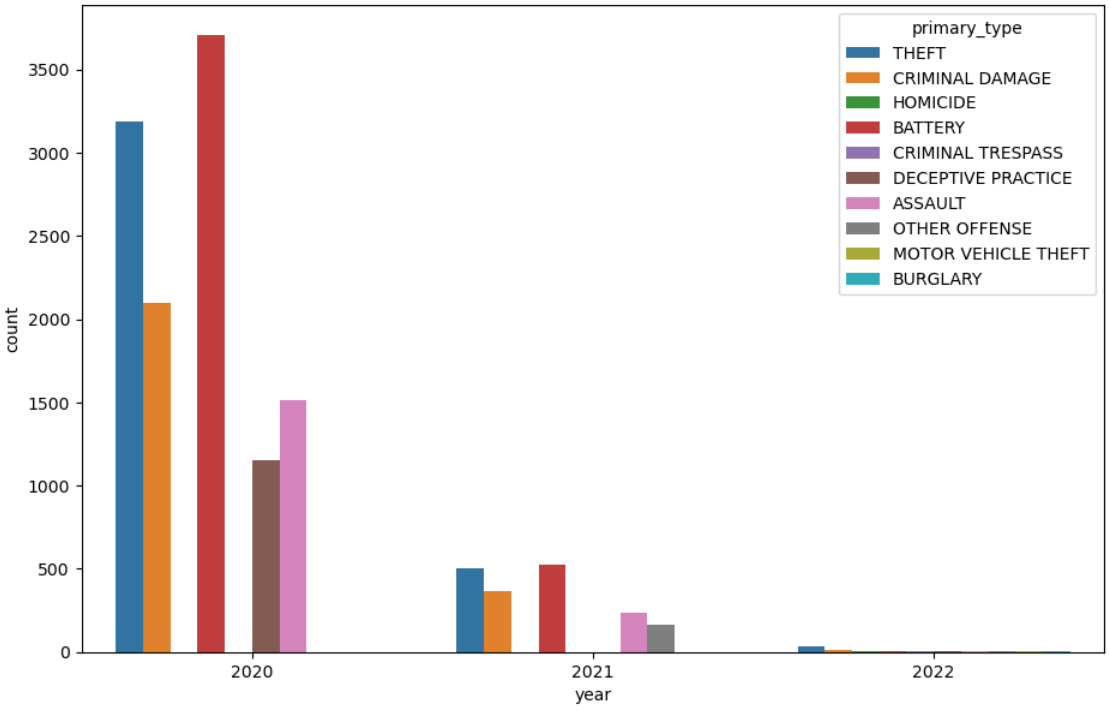
[238]:

	year	primary_type	count	rank
0	2022	THEFT	31	1
1	2022	CRIMINAL DAMAGE	11	2
2	2022	HOMICIDE	8	3
3	2022	BATTERY	7	4
4	2022	CRIMINAL TRESPASS	2	5
..	…	…	…	…
112	2001	THEFT	1282	1
113	2001	MOTOR VEHICLE THEFT	759	2
114	2001	DECEPTIVE PRACTICE	555	3
115	2001	BATTERY	277	4
116	2001	CRIMINAL DAMAGE	226	5

[117 rows x 4 columns]

[239]:
```
fig, ax = plt.subplots(figsize=(11,7))
sns.barplot(x='year', y='count', hue='primary_type', data=tmp3d[tmp3d.year >=␣
↪2020], ax=ax)
```

[239]: <Axes: xlabel='year', ylabel='count'>



0.4 Problem 4

a)

[345]:
```
from pyspark.sql.window import Window
from pyspark.sql.functions import col, row_number, udf
from pyspark.sql.functions import rank
import pyspark.sql.functions as psf
```

[278]:
```
crimesSpec = df3.groupby(df3.community_area_name)\
    .count()
```

[284]:
```
partition=Window.orderBy(col("count").desc())
```

[285]:
```
crimesSpec.withColumn("rank",psf.dense_rank().over(partition)).show()
```

```
+--------------------+-----+----+
| community_area_name|count|rank|
+--------------------+-----+----+
|              Austin|89118|   1|
|     Near North Side|61106|   2|
|      Near West Side|49683|   3|
|                Loop|48748|   4|
|         South Shore|48061|   5|
|      North Lawndale|46856|   6|
|       Humboldt Park|45951|   7|
|           West Town|45582|   8|
|      Auburn Gresham|41344|   9|
|      West Englewood|40398|  10|
|            Roseland|38136|  11|
|           Englewood|36653|  12|
|Greater Grand Cro…|36220|  13|
|             Chatham|34121|  14|
|        Chicago Lawn|33131|  15|
|            Lakeview|31141|  16|
|        Logan Square|31078|  17|
|  West Garfield Park|29785|  18|
|            New City|28038|  19|
|  East Garfield Park|27589|  20|
+--------------------+-----+----+
only showing top 20 rows
```

b)

[290]:
```
crimesSpec1 = df3.groupby(df3.date, df3.community_area_name)\
    .count().orderBy("date")
```

[291]:
```
crimesSpec1.show()
```

```
+----------+--------------------+-----+
|      date| community_area_name|count|
```

```
+----------+--------------------+-----+
|2001-01-01|        Lincoln Park|    1|
|2001-01-01|            Roseland|    1|
|2001-01-01|     Washington Park|    2|
|2001-01-01|Greater Grand Cro…|    1|
|2001-01-01|             Pullman|    1|
|2001-01-01|  East Garfield Park|    1|
|2001-01-01|      North Lawndale|    1|
|2001-01-01|         South Shore|    3|
|2001-01-01|            New City|    1|
|2001-01-01|       Brighton Park|    2|
|2001-01-01|       Humboldt Park|    2|
|2001-01-01|            Lakeview|    1|
|2001-01-01|       South Chicago|    1|
|2001-01-01|         Avalon Park|    1|
|2001-01-01|             Hermosa|    1|
|2001-01-01|         Rogers Park|    2|
|2001-01-01|      Garfield Ridge|    3|
|2001-01-01|        Norwood Park|    1|
|2001-01-01|             Chatham|    1|
|2001-01-01|             Beverly|    1|
+----------+--------------------+-----+
only showing top 20 rows
```

[299]:
```
crimesSpec1 = crimesSpec1.withColumn('unix_time', F.unix_timestamp('date',␣
 ↪'yyyy-MM-dd'))

winSpec = Window.partitionBy('community_area_name').orderBy('unix_time').
 ↪rangeBetween(-7*86400, 0)

crimesSpec1 = crimesSpec1.withColumn('rolling_sum', F.sum('count').
 ↪over(winSpec))

crimesSpec1.orderBy('community_area_name', 'date').show(20, False)
```

```
+-------------------+------------------+-----+----------+-----------+
|date               |community_area_name|count|unix_time |rolling_sum|
+-------------------+------------------+-----+----------+-----------+
|2001-02-05 00:00:00|Albany Park       |1    |981331200 |1          |
|2001-02-13 00:00:00|Albany Park       |1    |982022400 |1          |
|2001-02-28 00:00:00|Albany Park       |1    |983318400 |1          |
|2001-03-05 00:00:00|Albany Park       |1    |983750400 |2          |
|2001-05-07 00:00:00|Albany Park       |1    |989193600 |1          |
|2001-08-07 00:00:00|Albany Park       |1    |997142400 |1          |
|2001-08-18 00:00:00|Albany Park       |1    |998092800 |1          |
|2001-09-26 00:00:00|Albany Park       |1    |1001462400|1          |
```

```
|2001-11-01 00:00:00|Albany Park        |1    |1004572800|1          |
|2001-11-05 00:00:00|Albany Park        |1    |1004918400|2          |
|2001-11-14 00:00:00|Albany Park        |1    |1005696000|1          |
|2001-11-26 00:00:00|Albany Park        |1    |1006732800|1          |
|2001-12-01 00:00:00|Albany Park        |1    |1007164800|2          |
|2001-12-04 00:00:00|Albany Park        |1    |1007424000|2          |
|2001-12-10 00:00:00|Albany Park        |1    |1007942400|2          |
|2001-12-14 00:00:00|Albany Park        |1    |1008288000|2          |
|2001-12-27 00:00:00|Albany Park        |1    |1009411200|1          |
|2001-12-30 00:00:00|Albany Park        |2    |1009670400|3          |
|2002-01-01 00:00:00|Albany Park        |2    |1009843200|5          |
|2002-01-06 00:00:00|Albany Park        |1    |1010275200|5          |
+-------------------+-------------------+-----+----------+-----------+
only showing top 20 rows
```

c)

[301]:
```
crimesSpec2 = df3.groupby(df3.date, df3.community_area_name)\
    .count().orderBy("date")
```

[302]:
```
crimesSpec2 = crimesSpec2.withColumn('unix_time', F.unix_timestamp('date',␣
 ↪'yyyy-MM-dd'))
winSpec = Window.partitionBy('community_area_name').orderBy('unix_time').
 ↪rangeBetween(-7*86400, 0)
crimesSpec2 = crimesSpec2.withColumn('rolling_sum', F.sum('count').
 ↪over(winSpec))
crimesSpec2 = crimesSpec2.withColumn('rolling_avg', F.avg('count').
 ↪over(winSpec))
crimesSpec2.orderBy('community_area_name', 'date').show(20, False)
```

```
+----------+-------------------+-----+----------+-----------+------------------+
|date      |community_area_name|count|unix_time |rolling_sum|rolling_avg       |
+----------+-------------------+-----+----------+-----------+------------------+
|2001-02-05|Albany Park        |1    |981331200 |1          |1.0               |
|2001-02-13|Albany Park        |1    |982022400 |1          |1.0               |
|2001-02-28|Albany Park        |1    |983318400 |1          |1.0               |
|2001-03-05|Albany Park        |1    |983750400 |2          |1.0               |
|2001-05-07|Albany Park        |1    |989193600 |1          |1.0               |
|2001-08-07|Albany Park        |1    |997142400 |1          |1.0               |
|2001-08-18|Albany Park        |1    |998092800 |1          |1.0               |
|2001-09-26|Albany Park        |1    |1001462400|1          |1.0               |
|2001-11-01|Albany Park        |1    |1004572800|1          |1.0               |
|2001-11-05|Albany Park        |1    |1004918400|2          |1.0               |
|2001-11-14|Albany Park        |1    |1005696000|1          |1.0               |
|2001-11-26|Albany Park        |1    |1006732800|1          |1.0               |
|2001-12-01|Albany Park        |1    |1007164800|2          |1.0               |
|2001-12-04|Albany Park        |1    |1007424000|2          |1.0               |
```

```
|2001-12-10|Albany Park        |1    |1007942400|2          |1.0                |
|2001-12-14|Albany Park        |1    |1008288000|2          |1.0                |
|2001-12-27|Albany Park        |1    |1009411200|1          |1.0                |
|2001-12-30|Albany Park        |2    |1009670400|3          |1.5                |
|2002-01-01|Albany Park        |2    |1009843200|5          |1.6666666666666667|
|2002-01-06|Albany Park        |1    |1010275200|5          |1.6666666666666667|
+----------+-------------------+-----+----------+-----------+------------------+
only showing top 20 rows
```

d)

[303]:
```
tmp4d = df3.crosstab('primary_type', 'location_description').toPandas()
tmp4d.head()
```

[303]:

	primary_type_location_description	ABANDONED BUILDING	AIRCRAFT	AIRPORT BUILDING NON-TERMINAL - NON-SECURE AREA	AIRPORT BUILDING NON-TERMINAL - SECURE AREA	AIRPORT EXTERIOR - NON-SECURE AREA	AIRPORT EXTERIOR - SECURE AREA	AIRPORT PARKING LOT	AIRPORT TERMINAL LOWER LEVEL - NON-SECURE AREA
0	CRIMINAL TRESPASS	210	2	23	1	14	9	13	302
1	OFFENSE INVOLVING CHILDREN	6	0	0	0	2	0	0	1
2	NARCOTICS	514	3	2	7	4	3	1	6
3	RITUALISM	0	0	0	0	0	0	0	0
4	CRIMINAL SEXUAL ASSAULT	1	0	0	0	0	0	0	0

```
4                    0                                                  0

   AIRPORT TERMINAL LOWER LEVEL - SECURE AREA  …  \
0                                           4  …
1                                           2  …
2                                          14  …
3                                           0  …
4                                           0  …

   VEHICLE - OTHER RIDE SERVICE  \
0                             0
1                             0
2                             2
3                             0
4                             0

   VEHICLE - OTHER RIDE SHARE SERVICE (E.G., UBER, LYFT)  \
0                                                     1
1                                                     0
2                                                     5
3                                                     0
4                                                     0

   VEHICLE - OTHER RIDE SHARE SERVICE (LYFT, UBER, ETC.)  \
0                                                     0
1                                                     0
2                                                     0
3                                                     0
4                                                     1

   VEHICLE NON-COMMERCIAL  VEHICLE-COMMERCIAL  \
0                     385                  12
1                      76                   1
2                    3217                  28
3                       0                   0
4                       5                   0

   VEHICLE-COMMERCIAL - ENTERTAINMENT/PARTY BUS  \
0                                             0
1                                             0
2                                             0
3                                             0
4                                             0

   VEHICLE-COMMERCIAL - TROLLEY BUS  WAREHOUSE  YARD  null
0                                 0         72     0     0
1                                 2          1     0     0
```

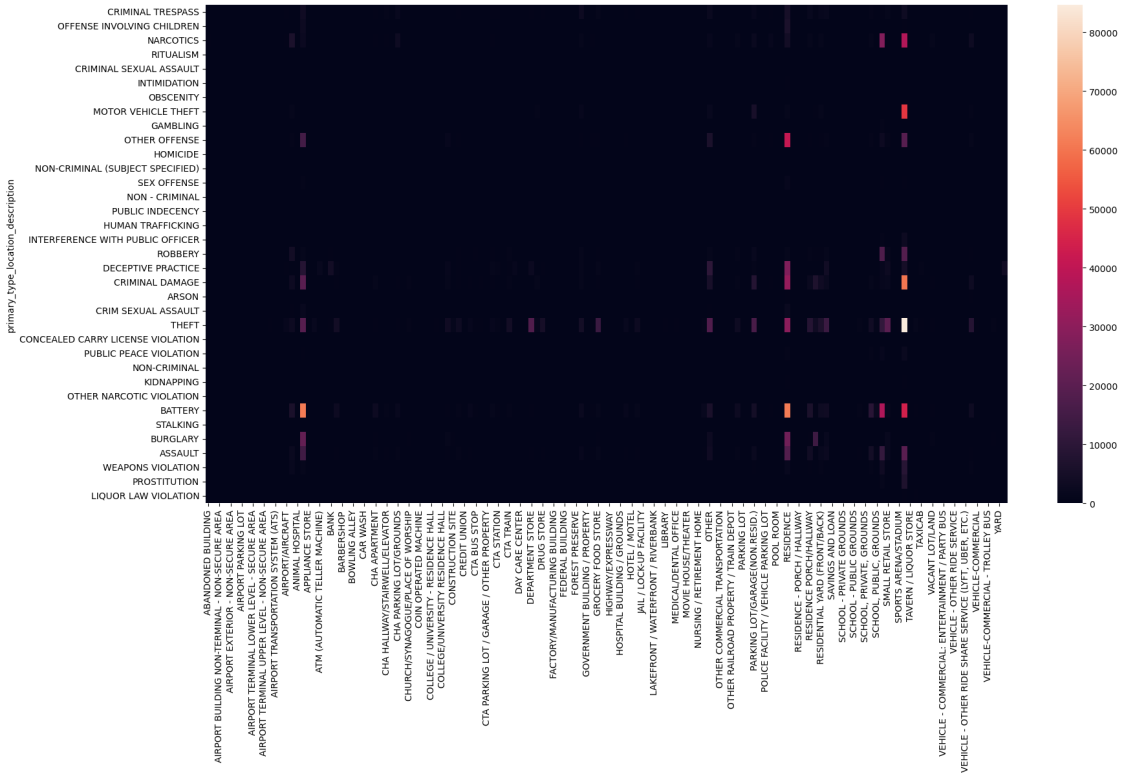
2	0	13	0	0
3	0	0	0	0
4	0	0	0	0

[5 rows x 145 columns]

[304]:
```
tmp4d = tmp4d.fillna(0)
tmp4d = tmp4d.set_index('primary_type_location_description')
```

[305]:
```
fig, ax = plt.subplots(figsize=(20,10))
sns.heatmap(tmp4d, ax=ax)
```

[305]: <Axes: ylabel='primary_type_location_description'>



0.5 Problem 5

a)

[306]:
```
%time df_covid = spark.read.
↪csv("COVID-19_Daily_Cases__Deaths__and_Hospitalizations.csv",␣
↪inferSchema=True, header=True)
```

```
CPU times: user 1.7 ms, sys: 983 µs, total: 2.68 ms
Wall time: 78.5 ms
```

[307]:
```
df_covid.printSchema()
```

```
root
 |-- Date: string (nullable = true)
 |-- Cases - Total: integer (nullable = true)
 |-- Deaths - Total: integer (nullable = true)
 |-- Hospitalizations - Total: integer (nullable = true)
 |-- Cases - Age 0-17: integer (nullable = true)
 |-- Cases - Age 18-29: integer (nullable = true)
 |-- Cases - Age 30-39: integer (nullable = true)
 |-- Cases - Age 40-49: integer (nullable = true)
 |-- Cases - Age 50-59: integer (nullable = true)
 |-- Cases - Age 60-69: integer (nullable = true)
 |-- Cases - Age 70-79: integer (nullable = true)
 |-- Cases -  Age 80+: integer (nullable = true)
 |-- Cases - Age Unknown: integer (nullable = true)
 |-- Cases - Female: integer (nullable = true)
 |-- Cases - Male: integer (nullable = true)
 |-- Cases - Unknown Gender: integer (nullable = true)
 |-- Cases - Latinx: integer (nullable = true)
 |-- Cases - Asian Non-Latinx: integer (nullable = true)
 |-- Cases - Black Non-Latinx: integer (nullable = true)
 |-- Cases - White Non-Latinx: integer (nullable = true)
 |-- Cases - Other Race Non-Latinx: integer (nullable = true)
 |-- Cases - Unknown Race/Ethnicity: integer (nullable = true)
 |-- Deaths - Age 0-17: integer (nullable = true)
 |-- Deaths - Age 18-29: integer (nullable = true)
 |-- Deaths - Age 30-39: integer (nullable = true)
 |-- Deaths - Age 40-49: integer (nullable = true)
 |-- Deaths - Age 50-59: integer (nullable = true)
 |-- Deaths - Age 60-69: integer (nullable = true)
 |-- Deaths - Age 70-79: integer (nullable = true)
 |-- Deaths - Age 80+: integer (nullable = true)
 |-- Deaths - Age Unknown: integer (nullable = true)
 |-- Deaths - Female: integer (nullable = true)
 |-- Deaths - Male: integer (nullable = true)
 |-- Deaths - Unknown Gender: integer (nullable = true)
 |-- Deaths - Latinx: integer (nullable = true)
 |-- Deaths - Asian Non-Latinx: integer (nullable = true)
 |-- Deaths - Black Non-Latinx: integer (nullable = true)
 |-- Deaths - White Non-Latinx: integer (nullable = true)
 |-- Deaths - Other Race Non-Latinx: integer (nullable = true)
 |-- Deaths - Unknown Race/Ethnicity: integer (nullable = true)
 |-- Hospitalizations - Age 0-17: integer (nullable = true)
 |-- Hospitalizations - Age 18-29: integer (nullable = true)
```

```
|-- Hospitalizations - Age 30-39: integer (nullable = true)
|-- Hospitalizations - Age 40-49: integer (nullable = true)
|-- Hospitalizations - Age 50-59: integer (nullable = true)
|-- Hospitalizations - Age 60-69: integer (nullable = true)
|-- Hospitalizations - Age 70-79: integer (nullable = true)
|-- Hospitalizations - Age 80+: integer (nullable = true)
|-- Hospitalizations - Age Unknown: integer (nullable = true)
|-- Hospitalizations - Female: integer (nullable = true)
|-- Hospitalizations - Male: integer (nullable = true)
|-- Hospitalizations - Unknown Gender: integer (nullable = true)
|-- Hospitalizations - Latinx: integer (nullable = true)
|-- Hospitalizations - Asian Non-Latinx: integer (nullable = true)
|-- Hospitalizations - Black Non-Latinx: integer (nullable = true)
|-- Hospitalizations - White Non-Latinx: integer (nullable = true)
|-- Hospitalizations - Other Race Non-Latinx: integer (nullable = true)
|-- Hospitalizations - Unknown Race/Ethnicity: integer (nullable = true)
```

[309]:
```
df_covid = df_covid.withColumnRenamed("Date", "date")\
    .withColumnRenamed("Cases - Total", "cases-total")\
    .withColumnRenamed("Deaths - Total", "deaths-total")\
    .withColumnRenamed("Hospitalizations - Total", "hospitalizations-total")\
    .withColumnRenamed("Cases - Age 0-17", "cases-age_0-17")\
    .withColumnRenamed("Cases - Age 18-29", "cases-age_18-29")\
    .withColumnRenamed("Cases - Age 30-39", "cases-age_30-39")\
    .withColumnRenamed("Cases - Age 40-49", "cases-age_40-49")\
    .withColumnRenamed("Cases - Age 50-59", "cases-age_50-59")\
    .withColumnRenamed("Cases - Age 60-69", "cases-age_60-69")\
    .withColumnRenamed("Cases - Age 70-79", "cases-age_70-79")\
    .withColumnRenamed("Cases -  Age 80+", "cases-age_80+")\
    .withColumnRenamed("Cases - Age Unknown", "cases-age_unknown")\
    .withColumnRenamed("Cases - Female", "cases-female")\
    .withColumnRenamed("Cases - Male", "cases-male")\
    .withColumnRenamed("Cases - Unknown Gender", "cases-unknown_gender")\
    .withColumnRenamed("Cases - Latinx", "cases-latinx")\
    .withColumnRenamed("Cases - Asian Non-Latinx", "cases-asian_non-latinx")\
    .withColumnRenamed("Cases - Black Non-Latinx", "cases-black_non-latinx")\
    .withColumnRenamed("Cases - White Non-Latinx", "cases-white_non-latinx")\
    .withColumnRenamed("Cases - Other Race Non-Latinx",␣
↪"cases-other_race_non-latinx")\
    .withColumnRenamed("Cases - Unknown Race/Ethnicity", "cases-unknown_race/
↪ethnicity")\
    .withColumnRenamed("Deaths - Age 0-17",  "deaths-age_0-17")\
    .withColumnRenamed("Deaths - Age 18-29", "deaths-age_18-29")\
    .withColumnRenamed("Deaths - Age 30-39", "deaths-age_30-39")\
    .withColumnRenamed("Deaths - Age 40-49", "deaths-age_40-49")\
    .withColumnRenamed("Deaths - Age 50-59", "deaths-age_50-59")\
```

```
   .withColumnRenamed("Deaths - Age 60-69", "deaths-age_60-69")\
   .withColumnRenamed("Deaths - Age 70-79", "deaths-age_70-79")\
   .withColumnRenamed("Deaths - Age 80+", "deaths-age_80+")\
   .withColumnRenamed("Deaths - Age Unknown", "deaths-age_unknown")\
   .withColumnRenamed("Deaths - Female", "deaths-female")\
   .withColumnRenamed("Deaths - Male", "deaths-male")\
   .withColumnRenamed("Deaths - Unknown Gender", "deaths-unknown_gender")\
   .withColumnRenamed("Deaths - Latinx", "deaths-latinx")\
   .withColumnRenamed("Deaths - Asian Non-Latinx", "deaths-asian_non-latinx")\
   .withColumnRenamed("Deaths - Black Non-Latinx", "deaths-black_non-latinx")\
   .withColumnRenamed("Deaths - White Non-Latinx", "deaths-white_non-latinx")\
   .withColumnRenamed("Deaths - Other Race Non-Latinx",␣
↪"deaths-other_race_non-latinx")\
   .withColumnRenamed("Deaths - Unknown Race/Ethnicity", "deaths-unknown_race/
↪ethnicity")\
   .withColumnRenamed("Hospitalizations - Age 0-17", ␣
↪"hospitalizations-age_0-17")\
   .withColumnRenamed("Hospitalizations - Age 18-29",␣
↪"hospitalizations-age_18-29")\
   .withColumnRenamed("Hospitalizations - Age 30-39",␣
↪"hospitalizations-age_30-39")\
   .withColumnRenamed("Hospitalizations - Age 40-49",␣
↪"hospitalizations-age_40-49")\
   .withColumnRenamed("Hospitalizations - Age 50-59",␣
↪"hospitalizations-age_50-59")\
   .withColumnRenamed("Hospitalizations - Age 60-69",␣
↪"hospitalizations-age_60-69")\
   .withColumnRenamed("Hospitalizations - Age 70-79",␣
↪"hospitalizations-age_70-79")\
   .withColumnRenamed("Hospitalizations - Age 80+",␣
↪"hospitalizations-age_80+")\
   .withColumnRenamed("Hospitalizations - Age Unknown",␣
↪"hospitalizations-age_unknown")\
   .withColumnRenamed("Hospitalizations - Female", "hospitalizations-female")\
   .withColumnRenamed("Hospitalizations - Male", "hospitalizations-male")\
   .withColumnRenamed("Hospitalizations - Unknown Gender",␣
↪"hospitalizations-unknown_gender")\
   .withColumnRenamed("Hospitalizations - Latinx", "hospitalizations-latinx")\
   .withColumnRenamed("Hospitalizations - Asian Non-Latinx",␣
↪"hospitalizations-asian_non-latinx")\
   .withColumnRenamed("Hospitalizations - Black Non-Latinx",␣
↪"hospitalizations-black_non-latinx")\
   .withColumnRenamed("Hospitalizations - White Non-Latinx",␣
↪"hospitalizations-white_non-latinx")\
   .withColumnRenamed("Hospitalizations - Other Race Non-Latinx", ␣
↪"hospitalizations-other_race_non-latinx")\
```

```
    .withColumnRenamed("Hospitalizations - Unknown Race/Ethnicity",␣
↪"hospitalizations-unknown_race/ethnicity")
```

[310]:
```
df_covid.write.mode('overwrite').saveAsTable('covid_cases')
```

[311]:
```
df_covid1 = hive_context.table("covid_cases")
df_covid1.show(5)
```

```
+----------+----------+-----------+---------------------+--------------+-----
----------+--------------+--------------+--------------+--------------+-----
----------+-------------+-----------------+------------+----------+-------------
-------+------------+---------------------+---------------------+-------------
---------+---------------------------+---------------------------+-------------
--+----------------+---------------+----------------+---------------+---------
-------+----------------+--------------+-----------------+-------------+-------
----+--------------------+-------------+---------------------+--------------
--------+----------------------+---------------------------+-----------------
-----------+--------------------------+--------------------------+--------------
-----------+--------------------------+--------------------------+-------------
------------+--------------------------+----------------------+---------------
-------------+----------------------+--------------------+--------------------
-----------+----------------------+-----------------------------------+----------
----------------------+-----------------------------------+----------------------
---------------+---------------------------------------+
|      date|cases-total|deaths-total|hospitalizations-total|cases-
age_0-17|cases-age_18-29|cases-age_30-39|cases-age_40-49|cases-age_50-59|cases-
age_60-69|cases-age_70-79|cases-age_80+|cases-age_unknown|cases-female|cases-
male|cases-unknown_gender|cases-latinx|cases-asian_non-latinx|cases-black_non-
latinx|cases-white_non-latinx|cases-other_race_non-latinx|cases-
unknown_race/ethnicity|deaths-age_0-17|deaths-age_18-29|deaths-age_30-39|deaths-
age_40-49|deaths-age_50-59|deaths-age_60-69|deaths-age_70-79|deaths-
age_80+|deaths-age_unknown|deaths-female|deaths-male|deaths-
unknown_gender|deaths-latinx|deaths-asian_non-latinx|deaths-black_non-
latinx|deaths-white_non-latinx|deaths-other_race_non-latinx|deaths-
unknown_race/ethnicity|hospitalizations-age_0-17|hospitalizations-
age_18-29|hospitalizations-age_30-39|hospitalizations-
age_40-49|hospitalizations-age_50-59|hospitalizations-
age_60-69|hospitalizations-age_70-79|hospitalizations-age_80+|hospitalizations-
age_unknown|hospitalizations-female|hospitalizations-male|hospitalizations-
unknown_gender|hospitalizations-latinx|hospitalizations-asian_non-
latinx|hospitalizations-black_non-latinx|hospitalizations-white_non-
latinx|hospitalizations-other_race_non-latinx|hospitalizations-
unknown_race/ethnicity|
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|10/15/2020|        907|           2|                  34|           86|
266|           213|           112|           115|           72|
28|          15|                0|         465|       442|                  0|
404|                  22|                  123|                  253|
25|                       80|             0|               0|
0|               0|               1|               1|               0|
0|                 0|            1|          1|                  0|
0|                     0|                     2|                     0|
0|                          0|                        1|
2|                        6|                       4|
4|                        8|                       4|
5|                          0|                     19|                  15|
0|                     6|                          0|
17|                                9|                                  2|
0|
|07/22/2022|        825|           1|                  37|           117|
152|           155|           113|           121|           85|
49|          32|                1|         482|       342|                  1|
191|                  39|                  229|                  223|
35|                      108|             0|               0|
0|               0|               0|               0|               1|
0|                 0|            1|          0|                  0|
0|                     0|                     0|                     1|
0|                          0|                        1|
5|                        2|                       4|
4|                        8|                       5|
8|                          0|                     18|                  19|
0|                     9|                          2|
16|                                7|                                  1|
2|
|02/02/2022|        367|          17|                  22|           70|
73|           73|           58|           44|           26|
14|           9|                0|         191|       174|                  2|
86|                  32|                  45|                  126|
25|                       53|             0|               0|
1|               1|               3|               4|               5|
```

```
3|                  0|            9|          8|                     0|
2|                       1|                       7|                       6|
1|                            0|                          1|
1|                          1|                            3|
3|                          5|                            1|
7|                            0|                        10|                    12|
0|                        7|                                 0|
4|                                 11|                                      0|
0|
|09/25/2021|         228|            3|                    26|            45|
50|              43|              31|              22|              23|
8|             6|                  0|          120|        108|                     0|
48|                       11|                       59|                     70|
18|                            22|                0|                 0|
1|                 0|                  1|                 0|                  0|
1|                   0|             2|           1|                       0|
0|                        0|                          2|                        0|
1|                             0|                             2|
6|                          3|                            3|
3|                          5|                            1|
3|                            0|                        18|                     8|
0|                        5|                                 2|
13|                                   4|                                      2|
0|
|10/26/2020|        1539|            8|                    76|           192|
403|             303|              257|             180|             117|
66|            21|                  0|          782|        754|                     3|
600|                        53|                       280|                     387|
55|                            164|                0|                 0|
0|                 0|                  0|                 0|                  2|
6|                   0|             4|           4|                       0|
4|                        0|                          0|                           4|
0|                             0|                             0|
5|                          5|                            5|
17|                          14|                           19|
11|                             0|                        30|                     46|
0|                       26|                                 2|
20|                                   23|                                      2|
3|
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only showing top 5 rows
```

[317]:
```
df_covid1.printSchema()
```

```
root
 |-- date: string (nullable = true)
 |-- cases-total: integer (nullable = true)
 |-- deaths-total: integer (nullable = true)
 |-- hospitalizations-total: integer (nullable = true)
 |-- cases-age_0-17: integer (nullable = true)
 |-- cases-age_18-29: integer (nullable = true)
 |-- cases-age_30-39: integer (nullable = true)
 |-- cases-age_40-49: integer (nullable = true)
 |-- cases-age_50-59: integer (nullable = true)
 |-- cases-age_60-69: integer (nullable = true)
 |-- cases-age_70-79: integer (nullable = true)
 |-- cases-age_80+: integer (nullable = true)
 |-- cases-age_unknown: integer (nullable = true)
 |-- cases-female: integer (nullable = true)
 |-- cases-male: integer (nullable = true)
 |-- cases-unknown_gender: integer (nullable = true)
 |-- cases-latinx: integer (nullable = true)
 |-- cases-asian_non-latinx: integer (nullable = true)
 |-- cases-black_non-latinx: integer (nullable = true)
 |-- cases-white_non-latinx: integer (nullable = true)
 |-- cases-other_race_non-latinx: integer (nullable = true)
 |-- cases-unknown_race/ethnicity: integer (nullable = true)
 |-- deaths-age_0-17: integer (nullable = true)
 |-- deaths-age_18-29: integer (nullable = true)
 |-- deaths-age_30-39: integer (nullable = true)
 |-- deaths-age_40-49: integer (nullable = true)
 |-- deaths-age_50-59: integer (nullable = true)
 |-- deaths-age_60-69: integer (nullable = true)
 |-- deaths-age_70-79: integer (nullable = true)
 |-- deaths-age_80+: integer (nullable = true)
 |-- deaths-age_unknown: integer (nullable = true)
 |-- deaths-female: integer (nullable = true)
 |-- deaths-male: integer (nullable = true)
 |-- deaths-unknown_gender: integer (nullable = true)
 |-- deaths-latinx: integer (nullable = true)
```

```
 |-- deaths-asian_non-latinx: integer (nullable = true)
 |-- deaths-black_non-latinx: integer (nullable = true)
 |-- deaths-white_non-latinx: integer (nullable = true)
 |-- deaths-other_race_non-latinx: integer (nullable = true)
 |-- deaths-unknown_race/ethnicity: integer (nullable = true)
 |-- hospitalizations-age_0-17: integer (nullable = true)
 |-- hospitalizations-age_18-29: integer (nullable = true)
 |-- hospitalizations-age_30-39: integer (nullable = true)
 |-- hospitalizations-age_40-49: integer (nullable = true)
 |-- hospitalizations-age_50-59: integer (nullable = true)
 |-- hospitalizations-age_60-69: integer (nullable = true)
 |-- hospitalizations-age_70-79: integer (nullable = true)
 |-- hospitalizations-age_80+: integer (nullable = true)
 |-- hospitalizations-age_unknown: integer (nullable = true)
 |-- hospitalizations-female: integer (nullable = true)
 |-- hospitalizations-male: integer (nullable = true)
 |-- hospitalizations-unknown_gender: integer (nullable = true)
 |-- hospitalizations-latinx: integer (nullable = true)
 |-- hospitalizations-asian_non-latinx: integer (nullable = true)
 |-- hospitalizations-black_non-latinx: integer (nullable = true)
 |-- hospitalizations-white_non-latinx: integer (nullable = true)
 |-- hospitalizations-other_race_non-latinx: integer (nullable = true)
 |-- hospitalizations-unknown_race/ethnicity: integer (nullable = true)
```

b)

[426]:
```
df3_cases = df3.groupby(df3.date, df3.primary_type)\
    .count()\
    .orderBy(["date"], ascending=[1])
df3_cases.show(5)
```

```
+----------+--------------------+-----+
|      date|        primary_type|count|
+----------+--------------------+-----+
|2001-01-01|         SEX OFFENSE|    3|
|2001-01-01|  DECEPTIVE PRACTICE|   14|
|2001-01-01| CRIM SEXUAL ASSAULT|    2|
|2001-01-01|               THEFT|   14|
|2001-01-01|OFFENSE INVOLVING…|   18|
+----------+--------------------+-----+
only showing top 5 rows
```

c)

[427]:
```
df3_crime_cases = df3_cases.filter(df3_cases.date >= "2020-01-01").
 ↪groupby(["date"]).sum().orderBy(["date"], ascending=[1])
df3_crime_cases.show(5)
```

```
+----------+----------+
|      date|sum(count)|
+----------+----------+
|2020-01-01|        13|
|2020-01-02|         2|
|2020-01-03|         6|
|2020-01-05|         1|
|2020-01-06|         3|
+----------+----------+
only showing top 5 rows
```

[467]:
```
df_cases = df_covid1.withColumn('date', F.to_date(F.col('date'), 'dd/MM/yyyy').
 ↪alias('date'))
```

[468]:
```
df_cases = df_cases.filter(df_cases.date >= "2020-01-01")\
    .orderBy(["date"], ascending=[1])
```

[396]:
```
from pyspark.sql.types import DateType
from datetime import datetime
from pyspark.sql.functions import date_format, to_timestamp, to_date
```

[470]:
```
df_cases.show(5)
```

```
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|      date|cases-total|deaths-total|hospitalizations-total|cases-
age_0-17|cases-age_18-29|cases-age_30-39|cases-age_40-49|cases-age_50-59|cases-
age_60-69|cases-age_70-79|cases-age_80+|cases-age_unknown|cases-female|cases-
male|cases-unknown_gender|cases-latinx|cases-asian_non-latinx|cases-black_non-
latinx|cases-white_non-latinx|cases-other_race_non-latinx|cases-
unknown_race/ethnicity|deaths-age_0-17|deaths-age_18-29|deaths-age_30-39|deaths-
age_40-49|deaths-age_50-59|deaths-age_60-69|deaths-age_70-79|deaths-
age_80+|deaths-age_unknown|deaths-female|deaths-male|deaths-
```

```
unknown_gender|deaths-latinx|deaths-asian_non-latinx|deaths-black_non-
latinx|deaths-white_non-latinx|deaths-other_race_non-latinx|deaths-
unknown_race/ethnicity|hospitalizations-age_0-17|hospitalizations-
age_18-29|hospitalizations-age_30-39|hospitalizations-
age_40-49|hospitalizations-age_50-59|hospitalizations-
age_60-69|hospitalizations-age_70-79|hospitalizations-age_80+|hospitalizations-
age_unknown|hospitalizations-female|hospitalizations-male|hospitalizations-
unknown_gender|hospitalizations-latinx|hospitalizations-asian_non-
latinx|hospitalizations-black_non-latinx|hospitalizations-white_non-
latinx|hospitalizations-other_race_non-latinx|hospitalizations-
unknown_race/ethnicity|
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|2020-01-03|          0|           0|                    2|             0|
0|              0|             0|              0|             0|
0|            0|               0|          0|         0|                   0|
0|                     0|                  0|                   0|
0|                          0|             0|               0|
0|               0|               0|               0|               0|
0|                  0|           0|          0|                   0|
0|                      0|                         0|                      0|
0|                           0|                        0|
0|                         1|                         0|
0|                         0|                         1|
0|                           0|                       1|                   1|
0|                      0|                              0|
0|                                2|                                   0|
0|
|2020-01-04|        461|          24|                  180|             3|
57|             68|             87|             85|             91|
41|           29|                0|         245|       216|                   0|
104|                    25|                   237|                   66|
14|                          15|             0|              0|
1|               1|               1|               7|               6|
```

8| 0| 12| 12| 0|
3| 1| 20| 0|
0| 0| 1|
4| 13| 26|
39| 42| 30|
25| 0| 77| 103|
0| 38| 5|
101| 26| 7|
3|
|2020-01-05| 1173| 39| 139| 59|
224| 221| 204| 195| 134|
68| 68| 0| 636| 537| 0|
636| 33| 225| 129|
34| 116| 0| 1|
0| 1| 4| 12| 8|
13| 0| 14| 25| 0|
12| 1| 15| 10|
0| 1| 0|
14| 13| 16|
23| 23| 30|
20| 0| 75| 64|
0| 48| 3|
62| 22| 3|
1|
|2020-01-06| 233| 21| 63| 21|
50| 35| 32| 35| 17|
17| 26| 0| 137| 95| 1|
97| 8| 56| 46|
8| 18| 0| 0|
0| 1| 2| 4| 4|
10| 0| 12| 9| 0|
6| 1| 10| 4|
0| 0| 2|
3| 11| 7|
9| 7| 11|
13| 0| 28| 35|
0| 20| 1|
29| 12| 0|
1|
|2020-01-07| 266| 13| 22| 17|
98| 51| 32| 27| 25|
6| 10| 0| 154| 111| 1|
96| 2| 71| 73|
3| 21| 0| 0|
0| 3| 2| 2| 2|
4| 0| 5| 8| 0|
6| 0| 4| 3|
0| 0| 1|

```
1|                         0|                         4|
5|                         4|                         3|
4|                           0|                       11|                        11|
0|                       5|                                 1|
11|                                 4|                                          0|
1|
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only showing top 5 rows
```

[471]:
```
df3_crime_cases.show(5)
```

```
+----------+----------+
|      date|sum(count)|
+----------+----------+
|2020-01-01|        13|
|2020-01-02|         2|
|2020-01-03|         6|
|2020-01-05|         1|
|2020-01-06|         3|
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only showing top 5 rows
```

[473]:
```
print((df3_crime_cases.count(), len(df3_crime_cases.columns)))
```

```
(412, 2)
```

[484]:
```
ddda = df3_crime_cases.join(df_cases, df3_crime_cases["date"]==␣
 ↪df_cases["date"], "left")
#dataframe.join(dataframe1, dataframe.ID == dataframe1.ID, "inner").show()
```

[485]:
```
ddda.show(5)
```

```
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+-------------------------------------+--------------------------------------+
|      date|sum(count)|      date|cases-total|deaths-total|hospitalizations-
total|cases-age_0-17|cases-age_18-29|cases-age_30-39|cases-age_40-49|cases-
age_50-59|cases-age_60-69|cases-age_70-79|cases-age_80+|cases-age_unknown|cases-
female|cases-male|cases-unknown_gender|cases-latinx|cases-asian_non-
latinx|cases-black_non-latinx|cases-white_non-latinx|cases-other_race_non-
latinx|cases-unknown_race/ethnicity|deaths-age_0-17|deaths-age_18-29|deaths-
age_30-39|deaths-age_40-49|deaths-age_50-59|deaths-age_60-69|deaths-
age_70-79|deaths-age_80+|deaths-age_unknown|deaths-female|deaths-male|deaths-
unknown_gender|deaths-latinx|deaths-asian_non-latinx|deaths-black_non-
latinx|deaths-white_non-latinx|deaths-other_race_non-latinx|deaths-
unknown_race/ethnicity|hospitalizations-age_0-17|hospitalizations-
age_18-29|hospitalizations-age_30-39|hospitalizations-
age_40-49|hospitalizations-age_50-59|hospitalizations-
age_60-69|hospitalizations-age_70-79|hospitalizations-age_80+|hospitalizations-
age_unknown|hospitalizations-female|hospitalizations-male|hospitalizations-
unknown_gender|hospitalizations-latinx|hospitalizations-asian_non-
latinx|hospitalizations-black_non-latinx|hospitalizations-white_non-
latinx|hospitalizations-other_race_non-latinx|hospitalizations-
unknown_race/ethnicity|
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|2020-01-01|        13|      null|       null|        null|
null|          null|           null|           null|           null|
null|           null|           null|          null|            null|
null|      null|               null|        null|                 null|
null|                  null|                       null|
null|           null|            null|           null|            null|
null|            null|            null|          null|              null|
null|       null|                 null|         null|                  null|
null|                   null|                       null|
null|                     null|                      null|
null|                      null|                     null|
null|                     null|                   null|
null|                   null|                null|
null|                   null|                            null|
null|                            null|                                  null|
null|
|2020-01-02|         2|      null|       null|        null|
null|          null|           null|           null|           null|
null|           null|           null|          null|            null|
null|      null|               null|        null|                 null|
null|                  null|                       null|
null|           null|            null|           null|            null|
null|            null|            null|          null|              null|
null|       null|                 null|         null|                  null|
null|                   null|                       null|
null|                     null|                      null|
null|                      null|                     null|
null|                     null|                   null|
null|                   null|                null|
null|                   null|                            null|
null|                            null|                                  null|
null|
|2020-01-03|         6|2020-01-03|          0|           0|
2|             0|             0|              0|             0|
0|              0|             0|            0|               0|           0|
0|                  0|           0|                      0|
0|                    0|                          0|
0|             0|              0|              0|              0|
0|               0|              0|             0|                0|
0|          0|                    0|            0|                    0|
0|                      0|                          0|
0|                       0|                         0|
1|                        0|                         0|
0|                        1|                       0|
0|                      1|                    1|                             0|
```

```
0|                                  0|                                  0|
2|                                       0|
0|
|2020-01-05|         1|2020-01-05|       1173|          39|
139|            59|            224|            221|            204|
195|            134|             68|            68|               0|
636|       537|                   0|         636|                  33|
225|                  129|                          34|
116|              0|               1|               0|               1|
4|               12|               8|            13|                  0|
14|         25|                     0|           12|                       1|
15|                      10|                           0|
1|                        0|                          14|
13|                         16|                         23|
23|                         30|                         20|
0|                      75|                    64|                                  0|
48|                                  3|                                  62|
22|                                       3|
1|
|2020-01-06|         3|2020-01-06|        233|          21|
63|            21|             50|             35|             32|
35|             17|             17|           26|                0|          137|
95|                   1|          97|                     8|
56|                    46|                          8|
18|              0|              0|              0|              1|
2|               4|               4|            10|                  0|
12|          9|                     0|            6|                       1|
10|                       4|                           0|
0|                        2|                          3|
11|                          7|                          9|
7|                         11|                        13|
0|                      28|                    35|                                  0|
20|                                  1|                                  29|
12|                                       0|
1|
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only showing top 5 rows
```
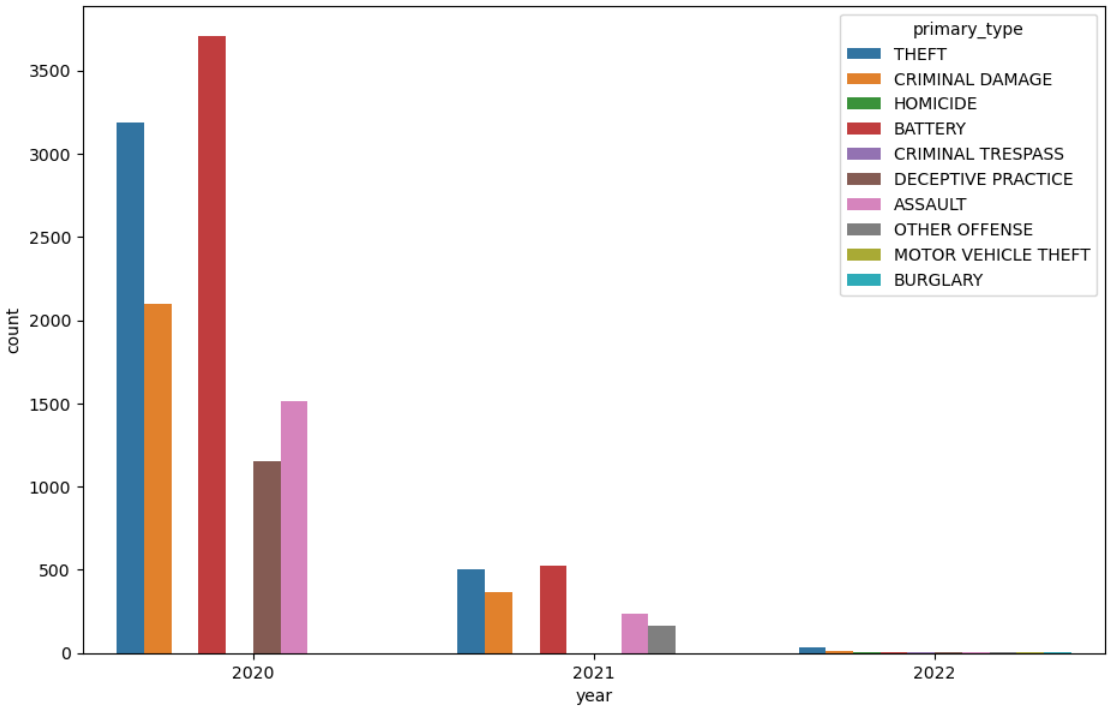

d)

[488]:
```
fig, ax = plt.subplots(figsize=(11,7))
sns.barplot(x='year', y='count', hue='primary_type', data=tmp3d[tmp3d.year >=␣
↪2020], ax=ax)
```

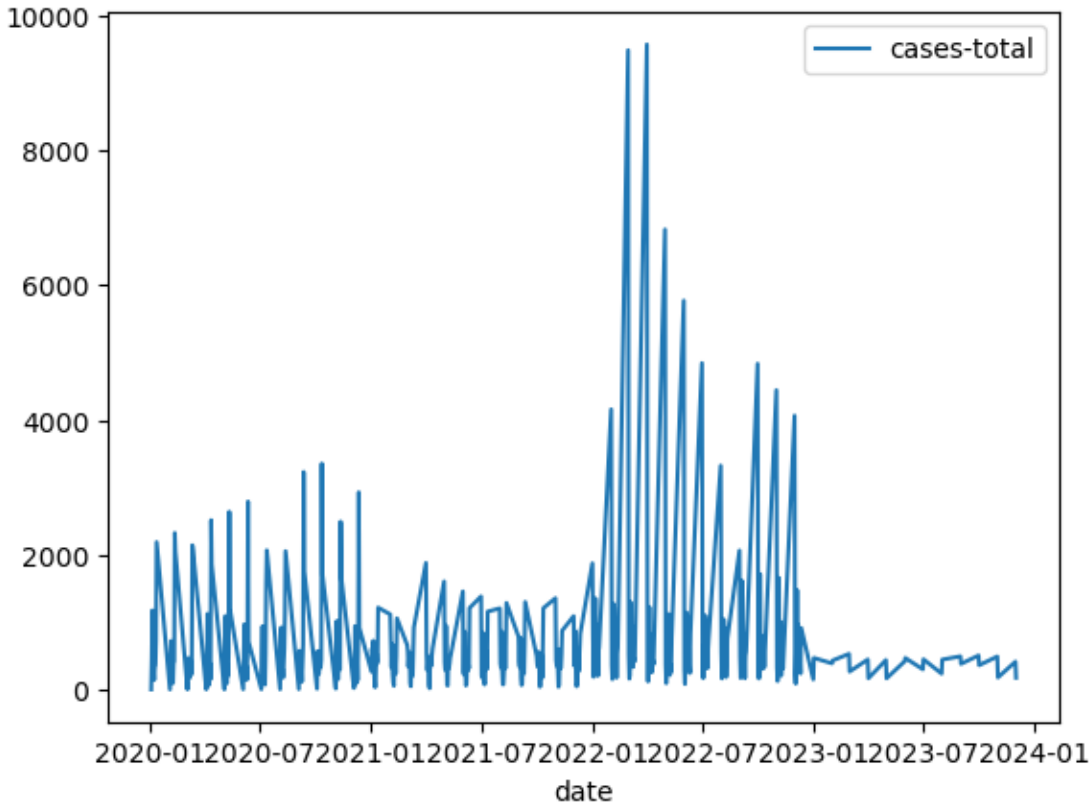
[488]:
```
<Axes: xlabel='year', ylabel='count'>
```



[490]:
```
df_cases1 = df_cases.toPandas()
```

[491]:
```
df_cases1.plot.line(x="date", y="cases-total")
```

[491]:
```
<Axes: xlabel='date'>
```



According to the plots, the covid to some extent makes the crimes decrease, probably because of the sickness and death.

[ ]: