

# Air Quality in Ukraine post Ukraine-Russia Dispute

Web address for GitHub repository

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# Contents

<b>1</b>	<b>Rationale and Research Questions</b>	<b>5</b>
<b>2</b>	<b>Dataset Information</b>	<b>6</b>
<b>3</b>	<b>Exploratory Analysis</b>	<b>7</b>
<b>4</b>	<b>Analysis</b>	<b>11</b>
4.1	Question 1: Are there significant differences in air quality levels between affected Ukrainian cities during the Russian invasion? . . . . .	11
4.2	Question 2: Are there significant differences in air quality levels in affected Ukrainian cities before and during the Russian attacks? . . . . .	13
<b>5</b>	<b>Summary and Conclusions</b>	<b>18</b>
5.1	Question 1: Are there significant differences in air quality levels between affected Ukrainian cities during the Russian invasion? . . . . .	18
5.2	Question 2: Are there significant differences in air quality levels in affected Ukrainian cities before and during the Russian attacks? . . . . .	18
<b>6</b>	<b>References</b>	<b>19</b>

## List of Tables

2	PM2.5 Levels by City . . . . .	7
3	PM10 Levels by City . . . . .	10

List of Figures

1	Air Pollution Heat Map . . . . .	7
2	Air Pollution Heat Map . . . . .	8
3	Air Pollution Heat Map . . . . .	9

# 1 Rationale and Research Questions

Rachel input written section

## 2 Dataset Information

Describe sources of data here (input Julia paragraph)

Explain data wrangling process here (shirley do this)

Data File Name	Description
UkraineData	(Raw) Ukraine air quality data
Ukraine_Processed	(Processed) Ukraine air quality data, w/o na's
Dnipro_2021	Dnipro PM2.5 + PM10, Mar 2021
Dnipro_2022	Dnipro PM2.5+ PM10, Mar 2022
Lviv_2021	Lviv PM 2.5 + PM10, Mar 2021
Lviv_2022	Lviv PM 2.5 + PM10, Mar 2022
FULL_DNIPRO	Lviv_2021 + Lviv_2022 combined
FULL_LVIV	Dnipro_2021 + Dnipro_2022 combined
FULL_Air_quality	
Full-air_quality_21_22	

### 3 Exploratory Analysis

INSERT COMMENTARY ABOUT EXPLORATORY ANALYSIS COMPONENTS

*#I'm confused if we need to upload a shapefile of ukraine so that we can make a map bu*  
*#https://simplemaps.com/data/ua-cities*  
*#we can download a csv of all the cities with lat and long from this link and we could*

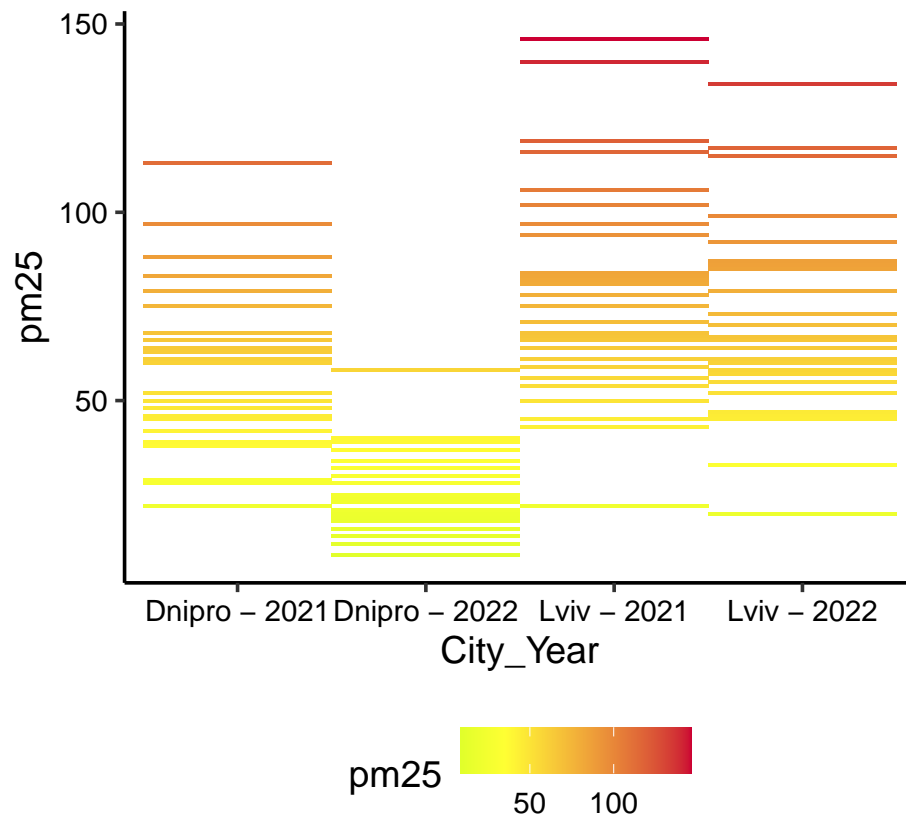


Figure 1: Air Pollution Heat Map

`## Bin width defaults to 1/30 of the range of the data. Pick better value with `binwidth``  
`## Bin width defaults to 1/30 of the range of the data. Pick better value with `binwidth``

Table 2: PM2.5 Levels by City

City	Mean	Min	Max	Std Dev
Dnipro	49.41546	4	160	25.91608
Lviv	60.51086	8	518	34.79405

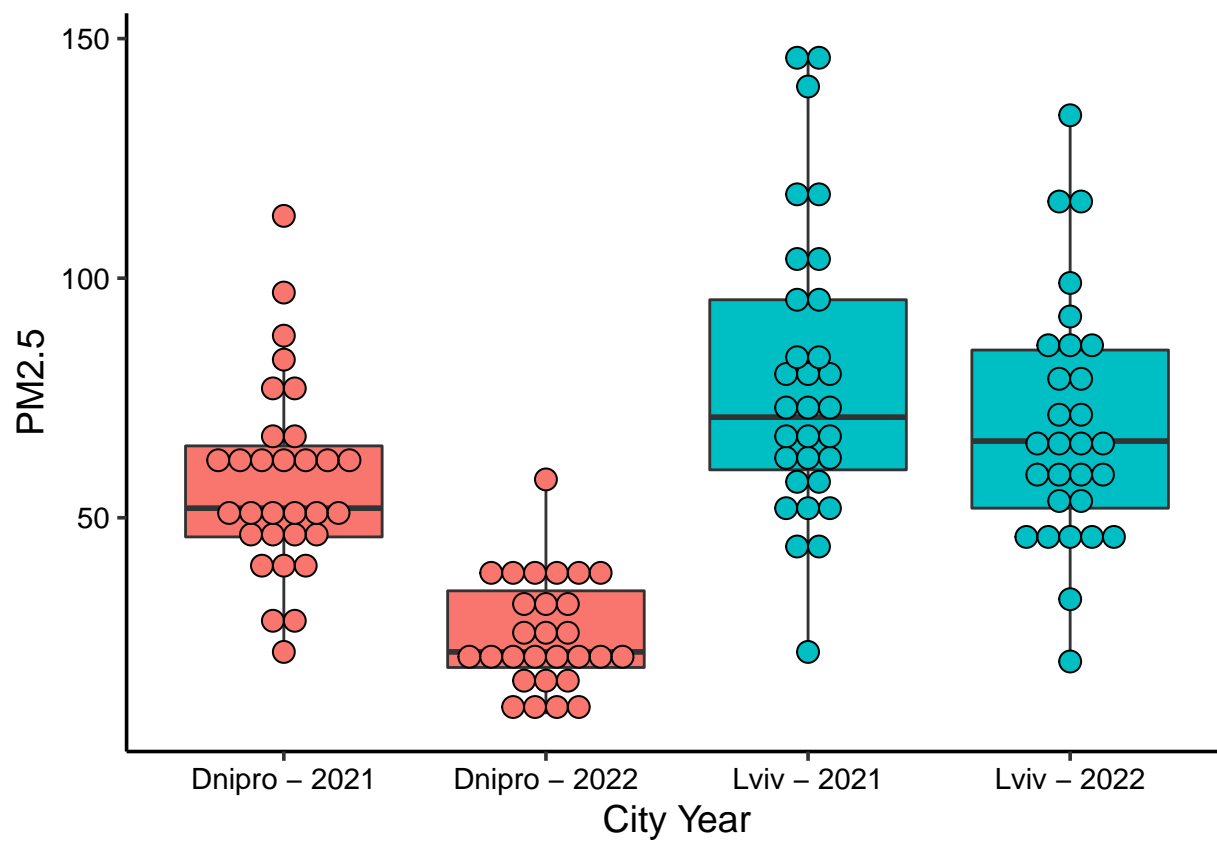


Figure 2: Air Pollution Heat Map



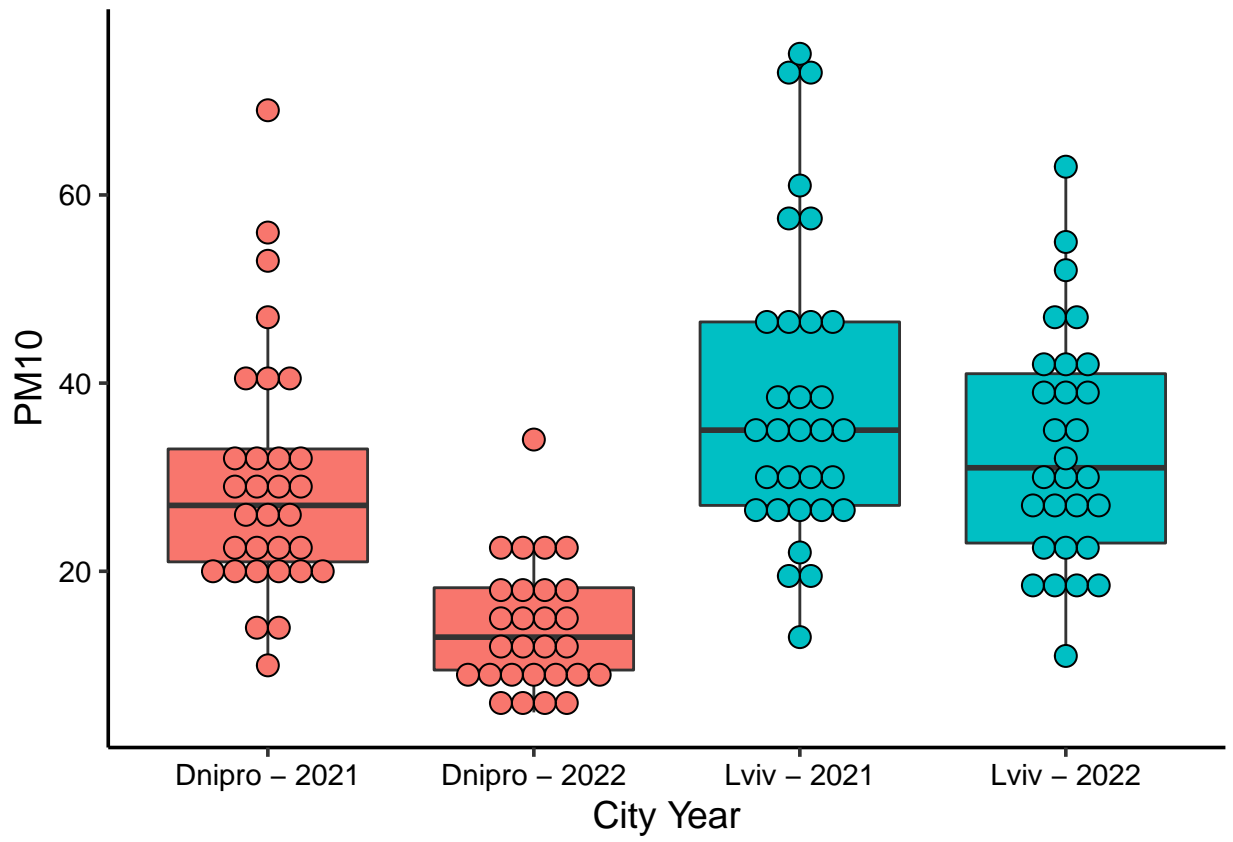


Figure 3: Air Pollution Heat Map

Table 3: PM10 Levels by City

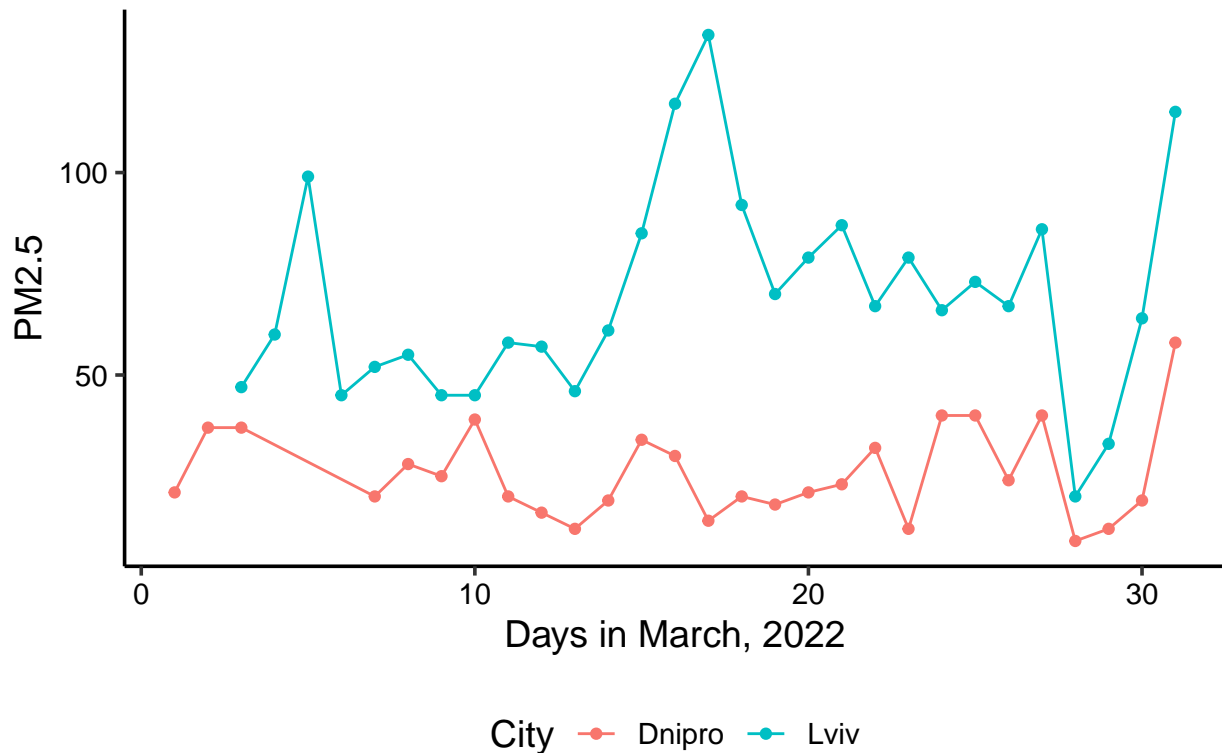
City	Mean	Min	Max	Std Dev
Dnipro	24.73309	2	120	15.82186
Lviv	30.29246	4	606	26.78330

## 4 Analysis

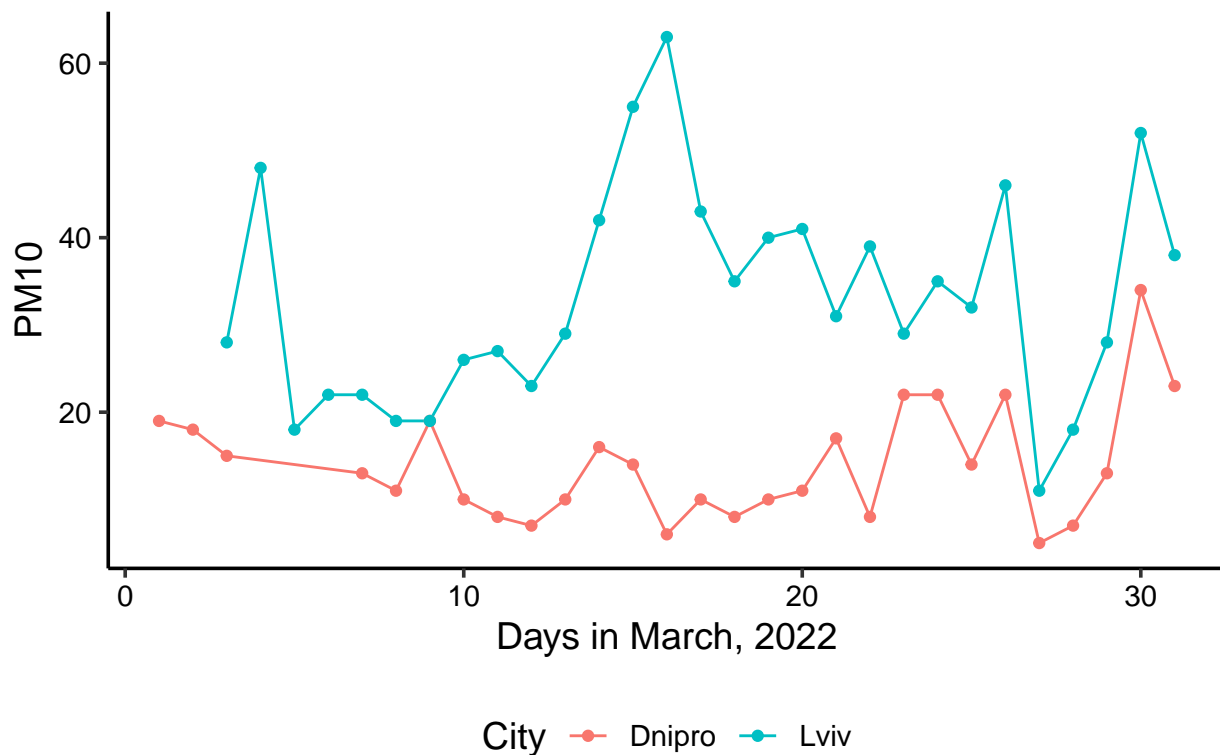
### 4.1 Question 1: Are there significant differences in air quality levels between affected Ukrainian cities during the Russian invasion?

[Shirley insert text about how we analyzed - visualizations and statistical tests]

#### Observing PM2.5 Values in Dnipro and Lviv, Ukrai



## Observing PM10 Values in Dnipro and Lviv, Ukraine



```
##
## Call:
## lm(formula = pm25 ~ City, data = FULL_Air_quality)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -49.103 -11.714  -3.103  11.286  64.897
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   25.714     3.791    6.783 8.54e-09 ***
## CityLviv      43.389     5.315    8.164 4.72e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 20.06 on 55 degrees of freedom
## Multiple R-squared:  0.5479, Adjusted R-squared:  0.5397
## F-statistic: 66.65 on 1 and 55 DF,  p-value: 4.715e-11
##
## Call:
## lm(formula = pm10 ~ City, data = FULL_Air_quality)
##
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -22.069  -6.000  -1.069   5.931  29.931
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    14.000      1.895   7.388 8.72e-10 ***
## CityLviv       19.069      2.657   7.178 1.93e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.03 on 55 degrees of freedom
## Multiple R-squared:  0.4837, Adjusted R-squared:  0.4743
## F-statistic: 51.52 on 1 and 55 DF,  p-value: 1.929e-09
```

## 4.2 Question 2: Are there significant differences in air quality levels in affected Ukrainian cities before and during the Russian attacks?

Similar to our first research question, we conducted a visual analysis of PM2.5 and PM10 levels within Dnipro and Lviv for years 2021 and 2022. For each of our visualizations, we created line plots that showed the air pollution levels within the city, comparing 2021 to 2022. As we needed to visualize the levels of both PM2.5 and PM10, we created four different plots - “Observing PM2.5 Values in Dnipro”, “Observing PM2.5 Values in Lviv”, “Observing PM10 Values in Dnipro”, and “Observing PM10 Values in Lviv”. Within each of these plots, we also created annotations to indicate the specific dates of the missile attacks within the cities to see if there were any PM2.5 or PM10 increases or decreases around those dates. Additionally, we conducted a linear regression analysis for each of these charts to understand if there is a significant difference in PM2.5 levels and PM10 levels within Dnipro and Lviv in March of 2021 compared to March of 2022.

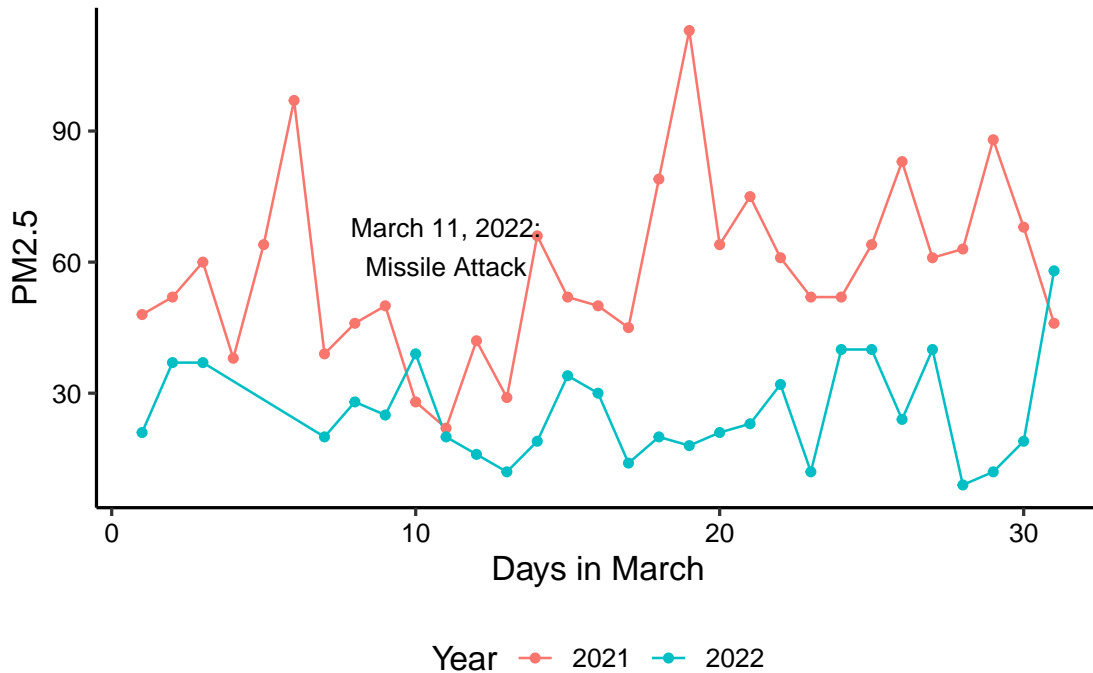
### PM2.5 in Dnipro

When plotting PM2.5 levels in Dnipro in 2021 compared to 2022, it is evident that overall, PM2.5 levels were higher in 2021 than 2022. It is also interesting to note that around March 11 in 2022, when the missile attack occurred, there appears to be an uptick in PM2.5 levels and then sharply decreases shortly after. Overall in both years, there seems to be a variety of fluctuation in PM2.5 levels and they are not consistent within each year. Additionally, within most of 2022, PM2.5 levels stayed within “good” to “moderate” levels, with an exception of reaching a level of “unhealthy for sensitive groups” at the end of March 2022. In March 2021, however, the PM2.5 levels were mainly in the “unhealthy for sensitive groups” or “unhealthy” category, with only a few days throughout that month in “moderate” levels.

For the statistical analysis, we ran a linear regression model of pm2.5 levels

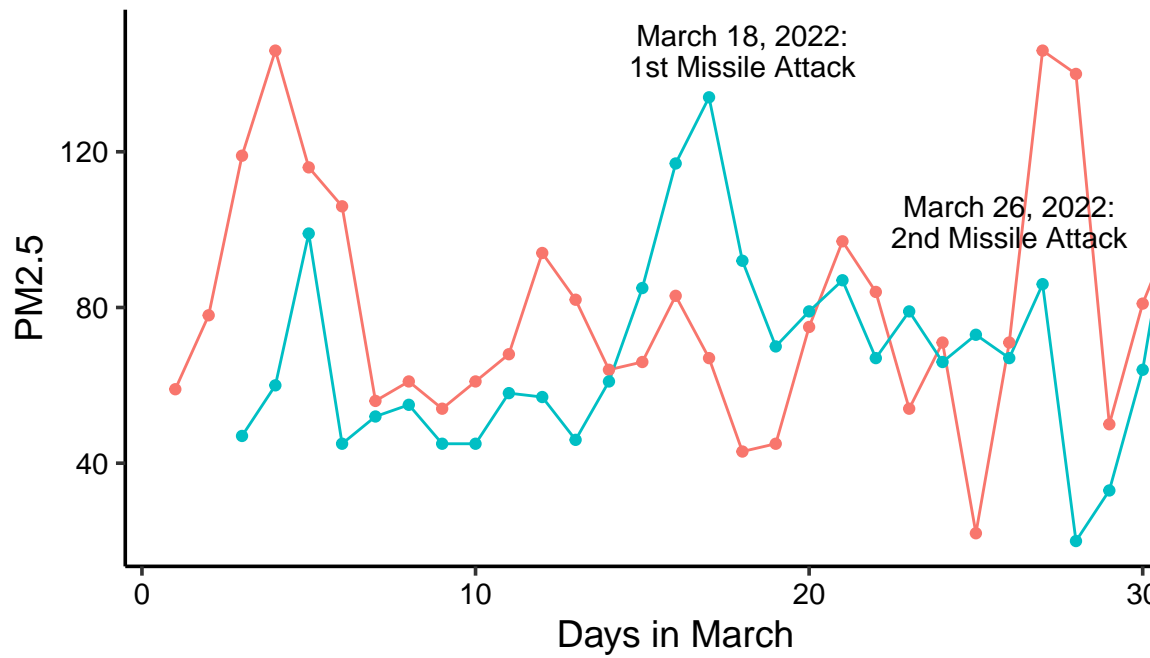
by year within Dnipro, to understand if there are significant differences in PM2.5 levels within the city in March 2021 compared to March 2022. The linear regression showed that the relationship between PM2.5 levels and year in Dnipro is significant ( $p = 5.074e-10$ ). Additionally, the slope (-32.253) is negative, meaning that PM2.5 levels decreased in 2022 compared to 2021.

### Observing PM2.5 Levels in Dnipro



```
##
## Call:
## lm(formula = pm25 ~ Year, data = FULL_DNIPRO)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -35.968  -9.841  -4.714   8.159  55.032
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    57.968     2.971  19.510 < 2e-16 ***
## Year2022      -32.253     4.313  -7.478 5.07e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.54 on 57 degrees of freedom
## Multiple R-squared:  0.4952, Adjusted R-squared:  0.4864
## F-statistic: 55.93 on 1 and 57 DF,  p-value: 5.074e-10
```

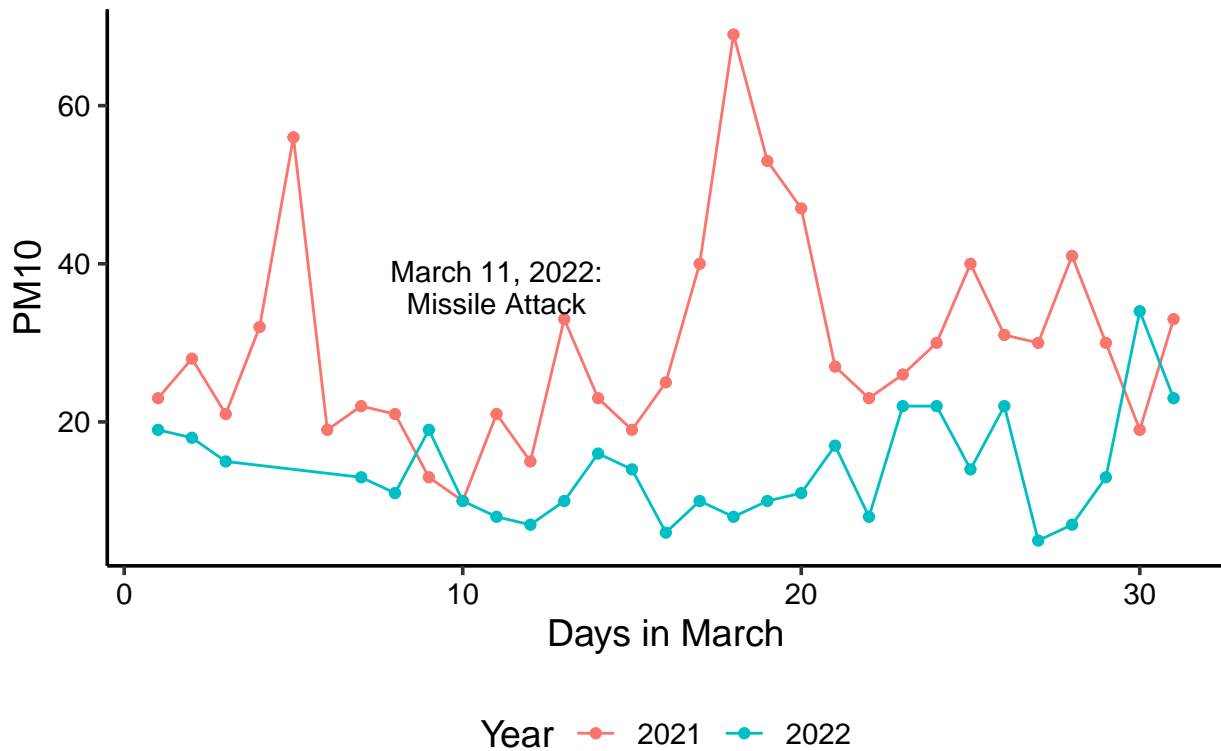
## Observing PM2.5 Levels in Lviv



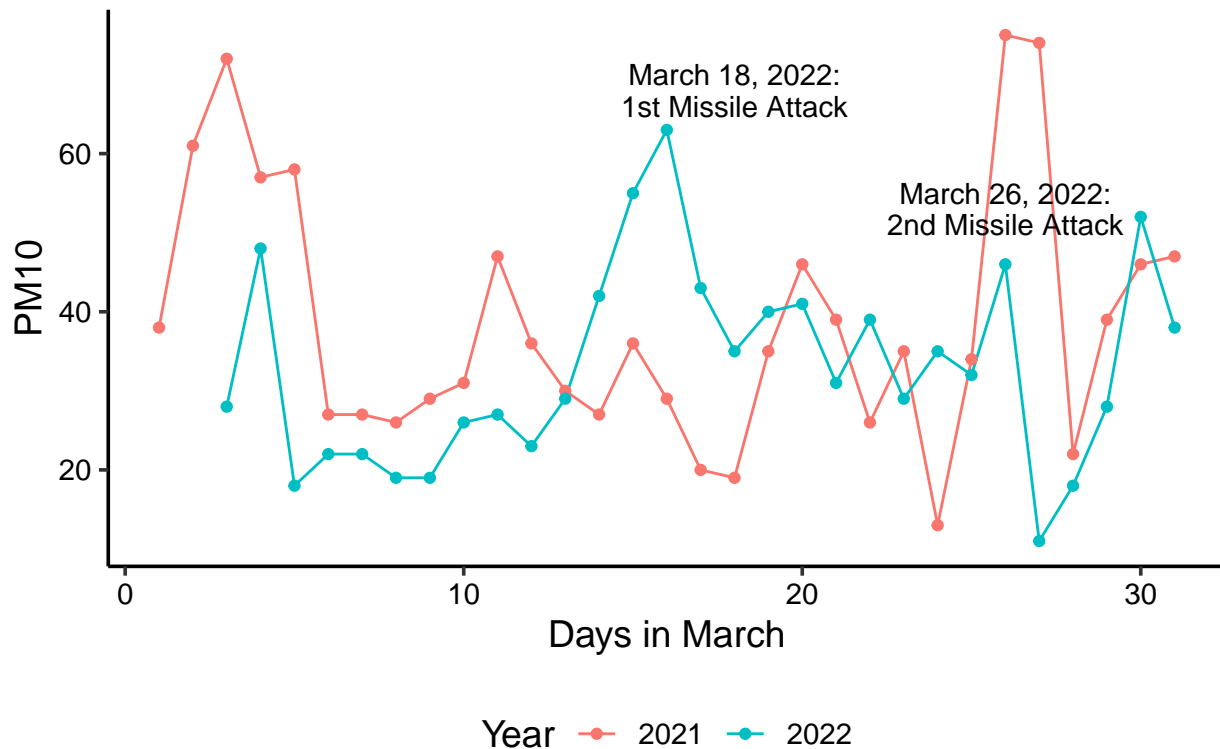
PM2.5 in Lviv >test

Year — 2021 — 2022

## Observing PM10 Levels in Dnipro, Ukraine



## Observing PM10 Levels in Lviv, Ukraine



```
##
## Call:
## lm(formula = pm25 ~ Year, data = FULL_LVIV)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -57.387 -18.887  -4.745  16.147  66.613
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   79.387     5.071   15.66  <2e-16 ***
## Year2022     -10.284     7.294   -1.41   0.164
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 28.23 on 58 degrees of freedom
## Multiple R-squared:  0.03314,    Adjusted R-squared:  0.01647
## F-statistic: 1.988 on 1 and 58 DF,  p-value: 0.1639
##
## Call:
## lm(formula = pm10 ~ Year, data = FULL_LVIV)
##
## Residuals:
```



```

##      Min      1Q  Median      3Q      Max
## -25.742 -11.069  -3.242   8.013  36.258
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   38.742      2.611   14.84  <2e-16 ***
## Year2022      -5.673      3.756   -1.51   0.136
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.54 on 58 degrees of freedom
## Multiple R-squared:  0.03784,    Adjusted R-squared:  0.02125
## F-statistic: 2.281 on 1 and 58 DF,  p-value: 0.1364
##
## Call:
## lm(formula = pm10 ~ Year, data = FULL_DNIPRO)
##
## Residuals:
##      Min      1Q  Median      3Q      Max
## -19.677  -6.677  -1.677   3.661  39.323
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   29.677      1.893  15.681  < 2e-16 ***
## Year2022      -15.677      2.747  -5.707 4.33e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.54 on 57 degrees of freedom
## Multiple R-squared:  0.3636, Adjusted R-squared:  0.3524
## F-statistic: 32.57 on 1 and 57 DF,  p-value: 4.325e-07

```

## 5 Summary and Conclusions

### 5.1 Question 1: Are there significant differences in air quality levels between affected Ukrainian cities during the Russian invasion?

[insert results from our analysis]

### 5.2 Question 2: Are there significant differences in air quality levels in affected Ukrainian cities before and during the Russian attacks?

[insert text about summary]

insert text about what may have affected our results, limitations of our data, and what we would do next if we could

## 6 References

<add references here if relevant, otherwise delete this section>