

Prevent Bicycle Thefts: Analyzing the time and location of the thefts*

Xuanle Zhou

September 21, 2024

This paper analyzes bicycle theft data in Toronto to identify patterns and contributing factors. Although fewer bicycle thefts have occurred, the recovery rate of stolen bicycles remains consistently low. Thefts are more likely to occur during the summer months, on Fridays, in the afternoon and evening, and in outdoor spaces. The analysis highlights the need to improve recovery strategies and implement effective theft prevention measures to address the ongoing issue of bicycle theft in Toronto.

1 Introduction

Cycling has emerged as a sustainable transportation mode, which offering environmental, social and economic benefit. It reduced reliance on non- renewable resources, promotes physical healthy, and provide a cost-effective alternative to driving. (Pucher & Buehler, 2008). Particularly for short and medium-length trips in urban areas, cycling present a viable and attractive choice for people (Tabascio et al., 2023). By recognizing these advantages, the City of Toronto has actively implemented various initiatives to create a safer and more welcoming cycling environment in the city.

However, bicycle theft remains a significant challenge in worldwide (Johnson et al., 2008). Around 20% of Montreal cyclist stated they are afraid of lack of appropriate parking facilities and fear of the theft (Bachand-Marleau et al., 2011). Studies have indicated that a substantial portion of cyclists reduce or cease their cycling activities following a theft (Cohen et al., 2024), highlighting the negative impact of this crime on the cycling community. Therefore, understanding the patterns of bicycle theft occurrences is crucial for riders to avoid theft and for governments to implement effective strategies to improve cycling safety. Specifically, investigating when and where bicycle theft is most likely to occur.

*Code and data are available at: https://github.com/Isazhou13/Bicycle_Thefts_Analysis.git

The remainder of this paper is structured as follows: Section 2 covers the data, and Section 3 presents the discussion. The Data section provides context and visualization for the dataset. Section 3 critically examines the results, discusses the limitations of the study, and proposes areas for future exploration.

2 Data

The dataset for this analysis on Bicycle Thefts in Toronto was obtained from OpenData-Toronto (Gelfand 2022). The data was cleaned and analyzed using R packages (R Core Team 2023), including libraries from tidyverse (Wickham et al. 2019), ggplot2(Wickham 2016), readr (Wickham, Hester, and Bryan 2024), dplyr (Wickham et al. 2023), here (2 2020), knitr(Xie 2023), and tidyr(Wickham, Vaughan, and Girlich 2023) .

This dataset on bicycle thefts includes incidents reported to the Toronto Police Service (Services 2024), which update annually. The raw data originally consisted of 32,000 observations across 28 variables. After removing missing values, selecting relevant variables, and improving readability through formatting and renaming, the final cleaned dataset contains 28,293 observations and focuses on the following six variables: Year Offence Occurred, Month Offence Occurred, Day of the Week Offence Occurred, Premises Type of Offence, Cost of Bicycle, and Status of Bicycle. The top five rows of the dataset are displayed in Table 1.

Table 1: Sample of Cleaned Data of Bicycle Thefts in Toronto

Year Offence Occurred	Month Offence Occurred	Day of the Week Offence Occurred	Hour Offence Occurred	Premises Type of Offence	Cost of Bicycle	Status of Bicycle	Day Part
2014	January	Wednesday	12	Apartment	1019	Stolen	Afternoon
2014	January	Friday	8	Other	560	Stolen	Morning
2014	January	Saturday	18	Apartment	200	Stolen	Evening
2014	January	Saturday	20	House	900	Stolen	Evening
2014	January	Sunday	23	Commercial	1800	Stolen	Evening

2.1 Offense Trends by Year

Figure 1 the status of bicycle offenses from 2014 to 2022. The data indicate increases in the total number of offenses from 2014 to 2020. Following 2020, it is noticeable that the occurrence of bicycle thefts declined, suggesting a potential improvement in public safety.

Even though there is a declining trend in the total number of offenses in recent years, the recovery of reported bicycle thefts remains concerningly low. As depicted in Figure 1, among the total number of occurrences, only a small portion of the bicycles are being recovered and

returned to their owners. Figure 2 provides a detailed examination of the bicycle recovery rate over the years, calculated by dividing the total number of recovered bicycles in a specific year by the total number of bicycle thefts in that year. In 2014, the recovery rate was approximately 1.33%, and in 2022, only 0.15% of bicycles were recovered (Appendix Table 2). This downtrend raises questions about the efficiency of bike recovery in Toronto.

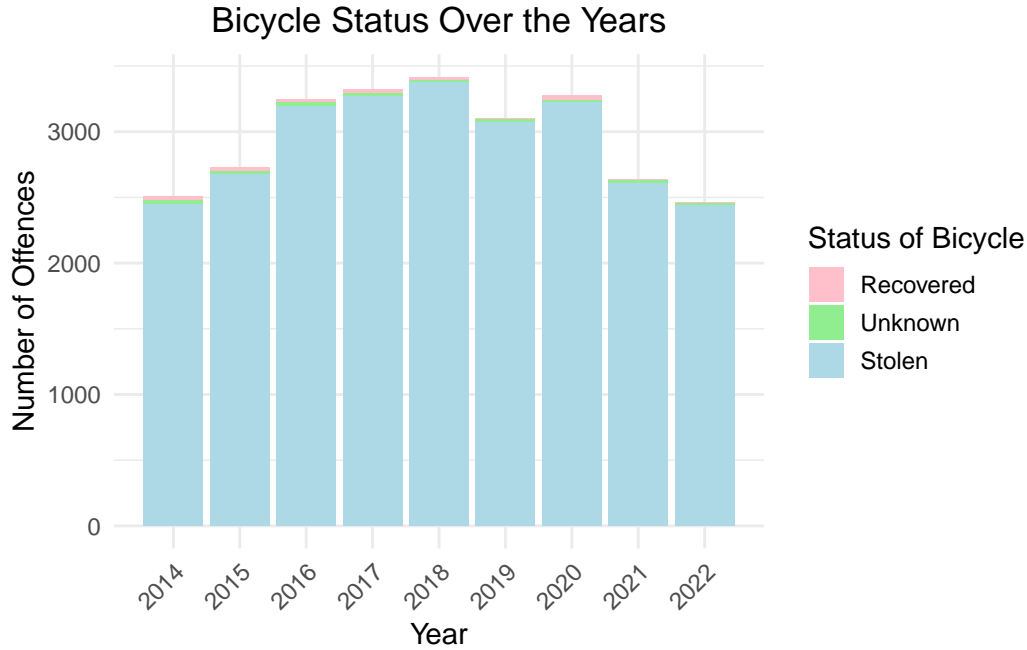


Figure 1: Bicycle Status Over the Years

2.2 Offense Trends by Month

Figure 3 shows the offenses of bicycle theft by month for each year from 2014 to 2022. The data reveals that the number of occurrences is lowest in February. It then steadily increases in the following months, reaching its peak around July, before showing a declining pattern again. This indicates a seasonal trend in bicycle thefts, where bicycle thefts tend to occur more frequently during the summer and are less likely to happen during the winter.

2.3 Offense Trends by Day of the Week

Figure 4 illustrates the number of bicycle thefts by day of the week. The data indicates a relatively consistent pattern of thefts throughout the week, with difference between weekdays

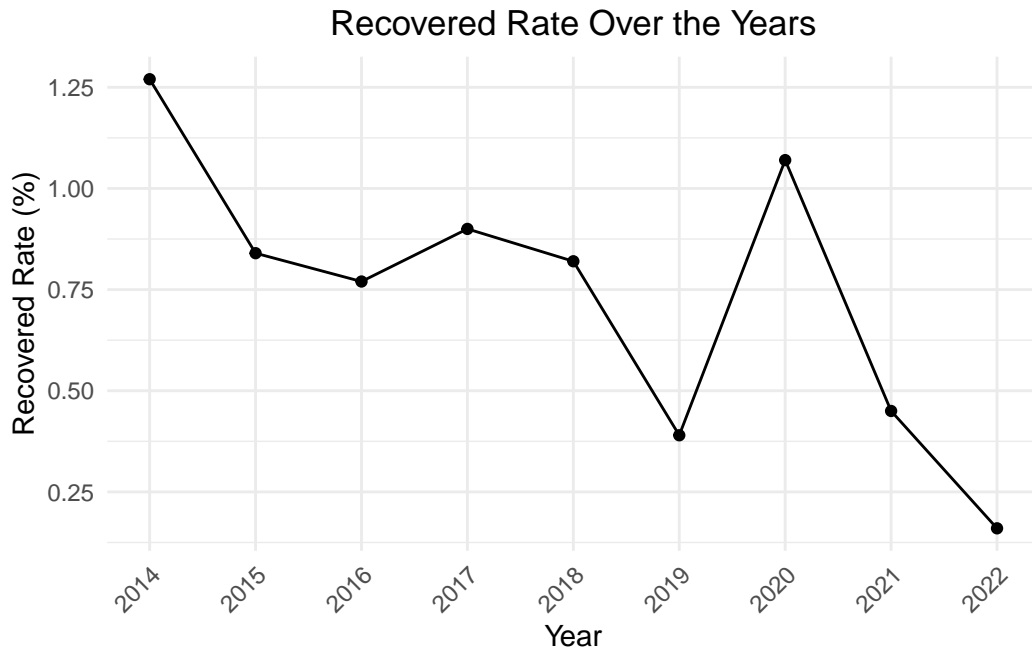


Figure 2: Recovered Rate Over the Years

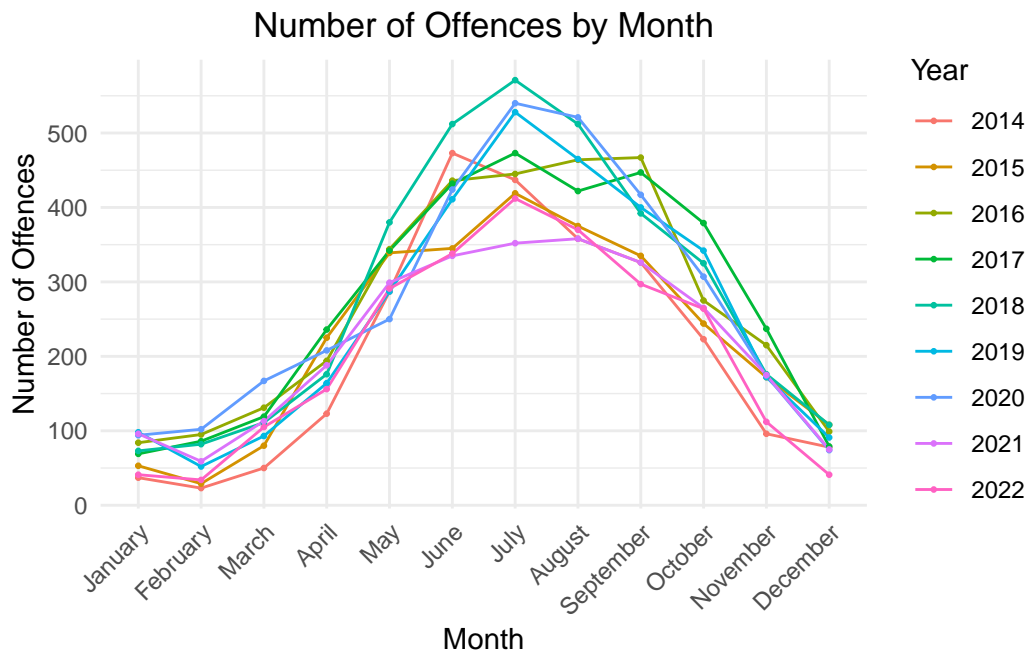


Figure 3: Number of Offences by Month

and weekends. Number of offences of bicycle thefts are generally lower on weekends compared to weekdays. Among the weekdays, Friday stands out as having the highest number of offences.

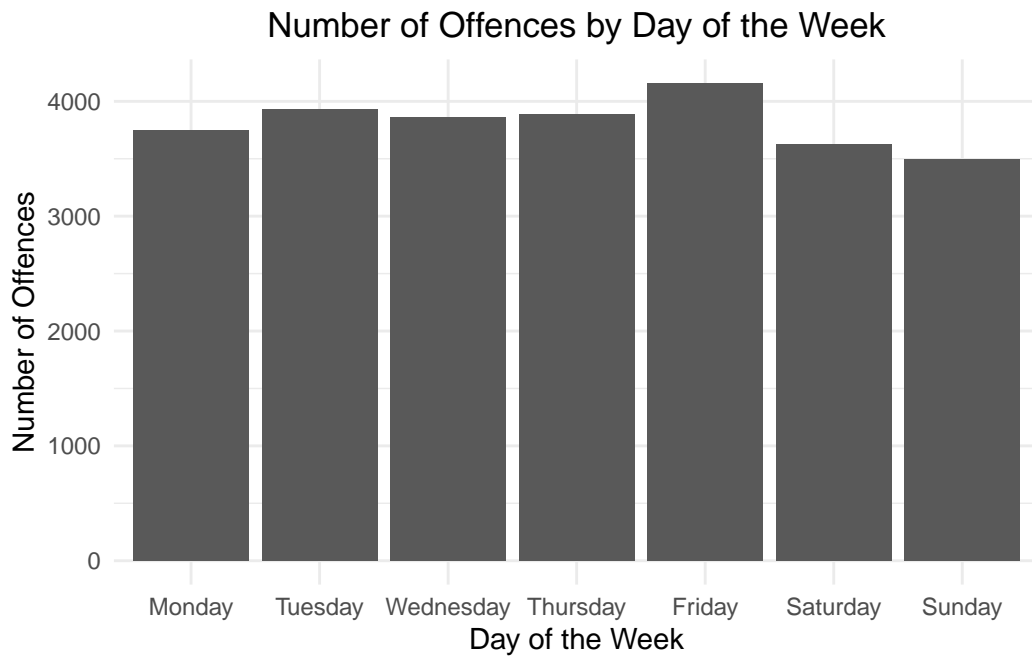


Figure 4: Number of Offences by Day of the Week

2.4 Offense by Hour

Figure 5 illustrates the distribution of bicycle thefts by hour. The data shows that the fewest thefts occurred around 5:00, while the peak occurred at 18:00. Categorizing the day into four periods—overnight (0:00-5:59), morning (6:00-11:59), afternoon (12:00-17:59), and evening (18:00-23:59). The graph shows that most thefts take place during the afternoon and evening, with the fewest incidents occurring overnight.

2.5 Offense by Premises Type

Figure 6 depicts bicycle thefts by premises type, revealing that top three locations where thefts are likely to occur are outside, in apartments, and in houses. This distribution suggests that outdoor areas, as well as residential environments, are key targets for theft.

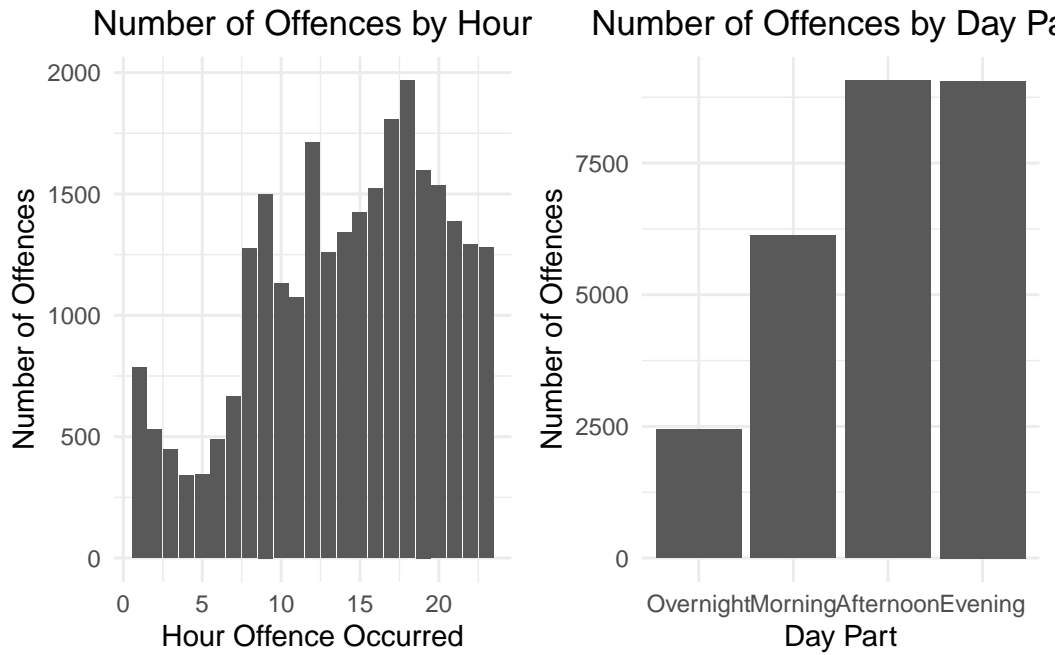


Figure 5: Number of Offences by Premises Type

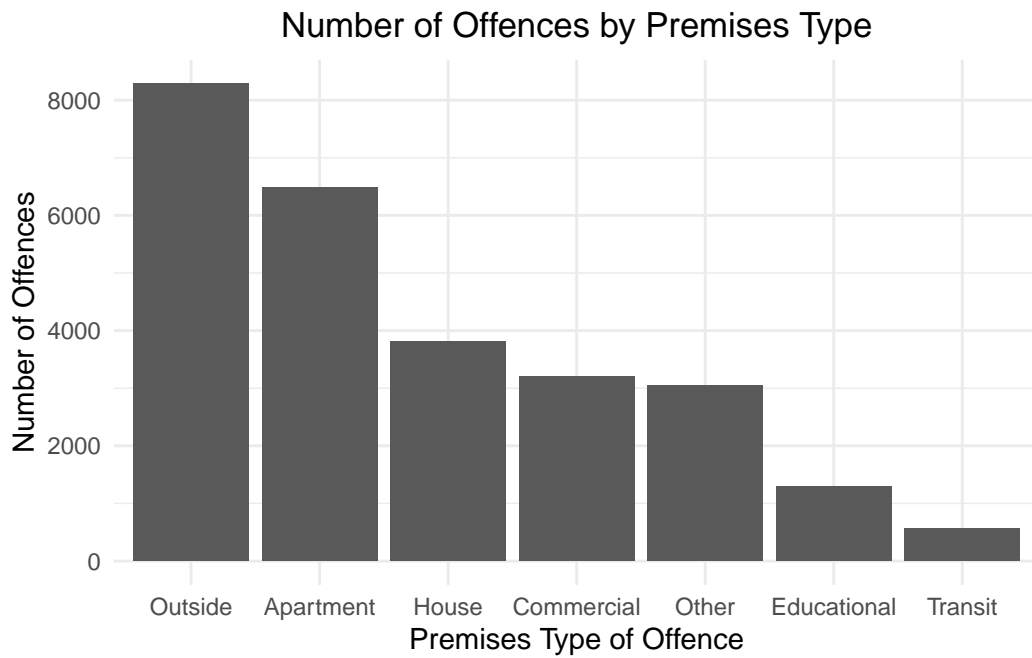


Figure 6: Number of Offences by Premises Type

3 Discussion

3.1 Summary of Findings

This study analyzed trends and patterns of bicycle theft occurrences in Toronto using a dataset from the Toronto Police Service covering 2014 to 2022. After data cleaning, the analysis focused on key variables such as bicycle status, offenses by year, month, day of the week, hour, and premises type. The research identifies when and where bicycles are more likely to be stolen. These findings not only can help Toronto residents and policymakers understand theft patterns and develop better prevention strategies, but also can be applied to similar issues in other regions to enhance preventive measures.

3.2 Essential to Prevent Bicycle Theft

Figure 1 shows an increase in bicycle thefts from 2014 to 2020, followed by a decline. This suggests that theft prevention measures may have improved. However, the decline also attributed to the widespread impact of COVID-19 pandemic, as individuals spent more time at home and used bicycles less frequently.

The recovery rates for stolen bicycles, as depicted in Figure 2, remain consistently low, dropping from 1.33% in 2014 to a mere 0.15% in 2022. These findings align with previous research, such as Van Lierop et al. (2015), which reported that only 2.5% of survey respondents recovered their stolen bicycles. The low recovery rate is lined with the proof of the ownership problem. Most cyclists cannot provide their bicycle series number, nor any legal evidence to proof the ownership of the bicycle, such as purchasing receipt. (Johnson et al., 2008).

To improve recovery rates, police departments could adopt strategies such as photographing and registering bicycles (Van Lierop et al., 2015). Despite the City of Toronto's efforts to provide guidelines for bicycle theft prevention, including advice on proper locking techniques, selecting safe parking spots, and encouraging bicycle registration, the recovery rate remains low. This raises concerns about the effectiveness of current police recovery strategies and the challenges of tracing and identifying stolen bicycles. It is therefore crucial for cyclists to be more vigilant and cautious when parking their bicycles to reduce theft risk.

3.3 Seasonal, Weekly, Daily, Premises Type Patterns

The findings support existing research that bicycle theft is more frequent in the summer, correlating with higher cycling activity during warmer months (Van Lierop et al.). Figure 3 demonstrates this seasonal trend, with thefts peaking in summer and declining in winter.

When examining weekly pattern, bicycle thefts are more common on weekdays, particularly on Fridays, compared to weekends. This is related to the increased presence of bicycles on the

streets during weekdays due to commuting, contributes to higher theft rates. Daily patterns shows that most bicycle thefts occur in the afternoon and evening, whereas overnight thefts are relatively rare. However, this finding contradicts other studies, such as Barbara’s research, which reported that 49% of thefts occur overnight.

The data indicates that the majority of bicycle thefts occur outdoors, making it the most frequent location for thefts. This suggests that public and outdoor spaces are key targets for bicycle thieves.

3.4 Weaknesses and next steps

Despite the valuable insights from this analysis, there are several limitations in the dataset.

Firstly, this dataset does not provide information on whether the stolen bicycles were locked, or if locked, what type of lock was used. This information could significantly influence the theft risk and duration required for theft, therefore influences bicycle theft occurrences count.

In addition, this dataset has reporting bias since the dataset is based on police reports, it excludes unreported bicycle thefts, potentially resulting in an incomplete picture of theft occurrences in Toronto.

Moreover, the dataset lacks information on the total number of bicycles in Toronto or yearly and monthly bicycle usage patterns. This makes the yearly and monthly bicycle theft analysis less precise, as more frequent bicycle use increases the likelihood of theft.

Future studies would benefit from finding related information and incorporating bicycle usage data to calculate a more accurate bicycle theft percentage relative to total usage bicycles.

Appendix

Table 2: Recovered Rate of Bicycle Theft Incidents by Year

Year Offence Occurred	Total_occurrences	Recovered	Recovered Rate(%)
2014	2511	32	1.27
2015	2724	23	0.84
2016	3249	25	0.77
2017	3321	30	0.90
2018	3418	28	0.82
2019	3103	12	0.39
2020	3278	35	1.07
2021	2641	12	0.45
2022	2461	4	0.16

““

References

- 2, Kirill. 2020. *Here: A Simpler Way to Find Your Files*. <https://CRAN.R-project.org/package=here>.
- Gelfand, Sharla. 2022. *Opendatatoronto: Access the City of Toronto Open Data Portal*. <https://CRAN.R-project.org/package=opendatatoronto>.
- R Core Team. 2023. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Services, Toronto Police. 2024. *Bicycle Thefts*. <https://open.toronto.ca/dataset/bicycle-thefts/>.
- Wickham, Hadley. 2016. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. <https://ggplot2.tidyverse.org>.
- Wickham, Hadley, Mara Averick, Jennifer Bryan, Winston Chang, Lucy D'Agostino McGowan, Romain François, Garrett Golemund, et al. 2019. "Welcome to the tidyverse." *Journal of Open Source Software* 4 (43): 1686. <https://doi.org/10.21105/joss.01686>.
- Wickham, Hadley, Romain François, Lionel Henry, Kirill Müller, and Davis Vaughan. 2023. *Dplyr: A Grammar of Data Manipulation*. <https://CRAN.R-project.org/package=dplyr>.
- Wickham, Hadley, Jim Hester, and Jennifer Bryan. 2024. *Readr: Read Rectangular Text Data*. <https://CRAN.R-project.org/package=readr>.
- Wickham, Hadley, Davis Vaughan, and Maximilian Girlich. 2023. *Tidyr: Tidy Messy Data*. <https://CRAN.R-project.org/package=tidyr>.
- Xie, Yihui. 2023. *Knitr: A General-Purpose Package for Dynamic Report Generation in r*. <https://yihui.org/knitr/>.