Assessing Bicycle Parking Safety in Toronto: The Multifaceted Nature of Theft Risk.*

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This study utilizes data on bicycle thefts sourced from the Toronto Open Data Portal. Preliminary findings indicate a increase propensity for bicycle thefts during summer months. While black mountain bicycles constitute a significant proportion of stolen bikes, it does not necessarily imply they are more susceptible to theft due to their overall prevalence. Moreover, the cost of a bicycle does not seem to influence its theft risk, thieves will not evaluate the price before they steal it. Future research should explore the role of neighborhoods as a potential factor influencing bicycle thefts.

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*Code and data from this analysis are available at: https://github.com/yiliuc/Bicycle_Thefts_2023.git

1 Introduction

In the 2022 annual rankings by PeopleForBikes (Silvestre 2022), Toronto has been named the 16th best cycling city in North America. Toronto has about 300 kilometers of on-street bike lanes and over 150 kilometers of off-street bike trails (Jen 2023). As traffic becomes heavier, cycling has become one of the primary transport modes for people living in Toronto. However, with more and more bicycles in the city, bicycle thefts have become a severe problem. That said, bicycle thefts in Toronto surged nearly 429 percent during the 2022 summer (Amanat 2023). According to the neighborhood crime app by TPS (Toronto Police Service Public Safety Data Portal, n.d.), bicycle theft is most likely to occur in downtown Toronto, especially the U of T campus, which is the hotspot of bicycle thefts.

Recovering a stolen bike is almost impossible (Rider 2021). Alarmingly, even though people lock their bikes, defeating a bike lock can be surprisingly simple. You can even break the U lock with only a pen (wikiHow 2022). Therefore, it will be necessary for cyclists to learn the factors increasing theft vulnerability and estimate the theft risk their bikes might have. In this paper, I will use the data on bicycle thefts in Toronto (Data 2023) to investigate the factors contributing to bicycle thefts, aiming to unearth the determinants of such thefts and guide riders about high-risk scenarios.

There will be four main parts: Data, Results, Discussion, and Conclusion. The Data section will introduce the data used in this paper and highlight the key variables. In addition, there will be figures to visualize the factors contributing to bicycle thefts. Moreover, in the Discussion session, I will interpret the main findings using the previous tables and figures to discuss the potential advice for cyclists in Toronto. Finally, there will be further conclusions and limitations in the conclusion session.

2 Data

The data used in this paper was obtained from Open Data Toronto Portal by the library `opendatatoronto` (Gelfand 2022). The name of the data file is `Bicycle Thefts` (Data 2023). The data contains more than 30,000 rows and about 30 columns. Data cleaning was executed using open-source statistical programming language `R` (R Core Team 2022) and R packages `tidyverse` (Wickham et al. 2019), `tidyr` (Wickham, Vaughan, and Girlich 2023),

and `janitor` (Firke 2023). The refined data set encompasses 11 distinct variables, which can be grouped into three primary categories.

2.1 The Time of Bicycle Thefts Occurrence

The cleaned data contains very detailed information regarding the occurrence time of each theft, detailing up to the specific hour of occurrence. The table below Table 1 summarize the occurrence year of bicycle thefts.

Table 1: Summary of Bicycle Thefts Occurrence Year (2014 to 2022)

Occurrence Year	Count
2022	2433
2021	2623
2020	3253
2019	3089
2018	3407
2017	3301
2016	3241
2015	2708
2014	2503

Table 1 shows the number of bicycle thefts from 2009 to 2022. Between 2014 and 2018, we can see that the number of bicycle thefts increased first, then the bicycle thefts dropped gradually since 2019. The reported number of bicycle thefts for last year was about 2400.

2.2 The Premises Place Where the Bike was stolen

The second main category in the cleaned data is the premises type of each bicycle thefts. The premises type here represents the places where the bicycle was stolen. In this data, there are six main premises types of bicycle theft: Commercial, Apartment, Other, House, Educational, Transit, and Other. Table 2 summarizes the number of thefts for each premises type.

Table 2: Summary of Bicycle Thefts In Terms of Premises Types

Premise Type	Count
Outside	8266
Apartment	6434
House	3809
Commercial	3195

Premise Type	Count
Other	3043
Educational	1288
Transit	564

From Table 2, we can observe that premises types "Outside" and "Apartment" have more bicycle thefts than the rest places, meaning that people need to pay more attention to their bicycles if they park them near the condo or on the street.

2.3 The Stolen Bicycles' Features

The last category of variables in the cleaned data is the features of each stolen bicycle. The features of each stolen bike in this data include its brand, type, color, and cost. In this paper, I will focus more on its type, color and cost.

Table 3: Summary of Stolen Bicycle Cost

Mean	SD	Min	Median	Max
1020.818	1654.558	1	700	120000

Table 3 shows the bicycle price of stolen bicycles. The mean cost of stolen bikes is around 1000 dollars. However, it is surprising that the most expensive stolen bicycles is worth 120,000 dollars.

3 Results

3.1 Compare the bicycle thefts in the recent six years

Figure 1 compares the monthly bicycle thefts from 2017 to 2022, with each line with different colors representing different years. The summer seems to have significantly higher bicycle thefts than winter each year. In addition, July is the most severe month of bicycle thefts each year, ranging from 350 to 550 from the previous years. At the beginning and end of each year, bicycle thefts were always stable, keeping constant around 100.

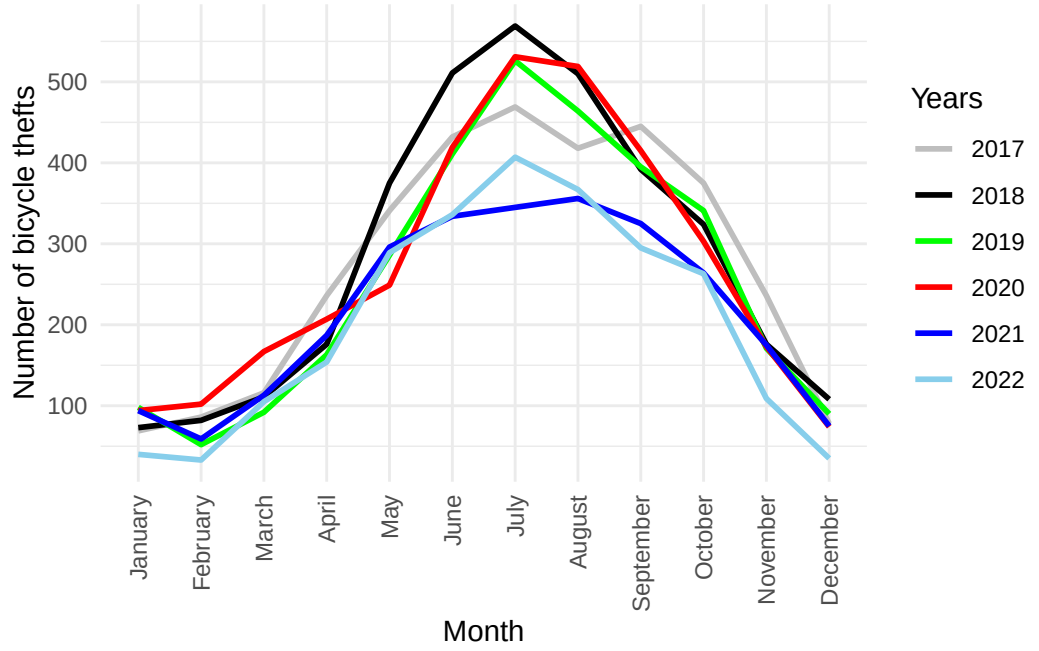

Figure 1: Number of bicycle thefts from 2017 to 2022 by month

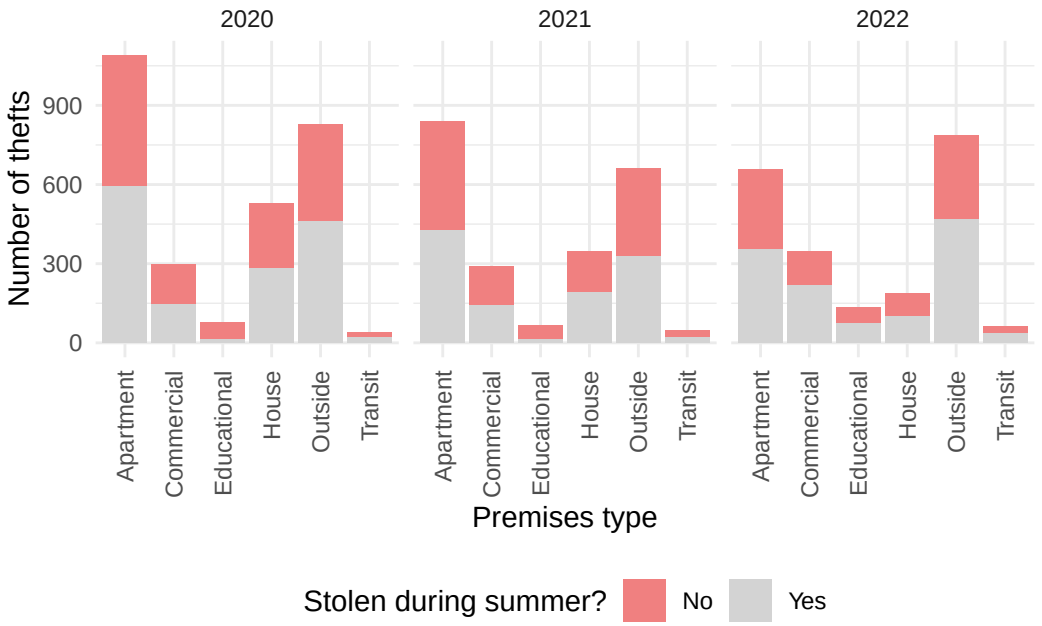

Figure 2: Distribution of Bicycle Thefts by Premises Type and Seasonal Trends in Toronto

3.2 Compare the premises types and probability to be stolen during summer.

Figure 2 compares the premises type of bicycle thefts in the recent three years and indicates the proportion of bicycles stolen during the summer. There are three facets marking three different years. Each bar in each facet represents the number of bicycle thefts of a premises type. The filled color in each bar shows the proportion of bicycles stolen during the summer, with light coral meaning NO and light grey meaning Yes.

3.3 Compare the top 4 colors and top 5 bicycle types from bicycle thefts

Figure 3: Distribution of bicycle thefts for the Top 4 Colours and Top 5 Bicycle Types

Figure 3 compares the number of bicycle thefts for the top 4 colors and top 5 bicycle types. Each bar represents the corresponding number of bicycles of a bike type under different colors. In addition, each bar is filled with two colors, orange and dark teal, representing the proportion of bicycles that have a price above the mean or below the mean price.

4 Discussion

4.1 Repeating patterns of bicycle thefts: expected to decrease in 2023.

As illustrated in Figure 1, bicycle thefts peak during the summer months and dip in the winter. This seasonal trend aligns with Amanat's observation (Amanat 2023) of a 429% surge

in thefts during summertime. A plausible explanation for this fluctuation is the increased cycling activity in summer due to favorable weather. Conversely, the cold winter months deter many from cycling, resulting in fewer theft opportunities.

For the summer month, we can observe a "pendulum movement" in bicycle thefts. The number of thefts oscillates annually, increasing one year and then decreasing the next. This trend repeats consistently from 2017 to 2022. In addition, comparing 2022 to 2021, we see that the number of bicycle thefts during summer of 2022 started to increase again comparing to 2021. We may expect that the number of bicycle thefts decrease during the past summer. Moreover, the most significant decrease is between 2020 and 2021, where there was about 200 decrease in the thefts during summer months. Although the COVID-19 pandemic might be a rationale for this substantial decline, it can not help us to predict the change of thefts for this year.

Throughout the six-year span, July consistently to be the highest number of thefts. Even if we project a downturn in thefts for summer 2023, the number of thefts in 2023 July are still anticipated to around 350 incidents, or nearly 10 thefts daily. For cyclists, this underscores the need for heightened vigilance in July.

4.2 Increasing number of bicycle thefts on the outside and educational areas.

Figure 2 provides insights into the distribution of bicycle thefts over the years, which remains relatively consistent. Notably, apartments emerged as the predominant location for such thefts. Yet, there's a discernible decline in apartment-related thefts from 2020 to 2023. In contrast, thefts in open spaces like streets, roads, or highways (categorized as "Outside") have seen a gradual increase, becoming most prevalent in 2022. Educational premises, such as schools or universities, also witnessed an increase in theft incidents, underscoring the need for students to rasie caution when parking their bicycles on campus.

For almost every premise type across all years, approximately half of the thefts occurred during summer. However, the number of bicycles stolen during summer increase gradually. This suggests that as the warmer months approach, bicycle owners should be particularly vigilant, regardless of where they park.

4.3 No evidence indicates that the cheaper/more expensive bicycles are less/more likely to be stolen.

Figure 3 reveals a distinct preference among thieves for black bicycles. In fact, the number of stolen black bikes equals to the combined total of the next three colors. In terms of bicycle types, mountain bicycles (MT) is the theives' primary target, closely followed by regular (RG) bicycles, which experience nearly identical theft rates.

When it comes to price of bicycles, with the exception of the EL type, the majority of stolen bikes across other categories are priced below the mean. Specifically, for the most sought-after

types by thieves, MT and RG. There were about eighty percent of the stolen bicycles are priced below the mean. This suggests that thieves don't necessarily factor in the bicycle's value during their selection. Instead, they likely act on opportunity, choosing any bicycle that presents a convenient theft chance.

5 Conclusion

This paper investigates the patterns of bicycle thefts in Toronto, discussing the annual trends, premises types, and characteristics of the stolen bicycles. The study found a resurgence in bicycle thefts in 2022, with forecasts suggesting a potential decline in 2023 based on historical data. A notable finding is the increased risk of bicycle thefts during summer months, which nearly half of all reported thefts happen during summer. Locations such as apartments and outdoor spaces like streets or highways are hotspots for these thefts. Alarmingly, educational institutions like schools and universities also see a rising trend in bicycle thefts, underscoring the need for heightened vigilance among student cyclists.

In terms of the characteristics of stolen bicycles, this paper found that while a third of all thefts involve black bicycles, this does not equivalent to that black are more likely to be stolen due to the overall prevalence of black bicycles. Importantly, the study suggests that the price of a bicycle doesn't significantly alter its theft risk. Whether inexpensive or costly, all bicycles seem to be stolen equally.

However, this paper has limitations. The data for this paper comes from `opendatatoronto` (Gelfand 2022)] which is not a up-to-date data. The data of bicycle thefts for 2023 is missing. This is crucial as we can verify the "pendulum movement" I discussed once we have the data of bicycle thefts in 2023. Secondly, the data set is lack of information of neighborhood for each bicycle theft which could have provided richer insights into high-risk areas, enabling more targeted preventive measures. Lastly, some people may not report the bicycle thefts to the police. Instead, they only report to the insurance company to get money from the coverage [citation]. If that situation exists a lot, then our analyse will seriously underestimate the bicycle thefts in Toronto.

For the future study, instead of using data from open data Toronto, using the data from Toronto police service open portal or the insurance companies regarding the bicycle thefts might be a better option. Once we can have the information of neighborhoods of bicycle thefts, our analyses will be more nuanced and help the cyclists to make more effective preventive strategies.

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