Analyzing Cigarette Butt Pollution in the City of Pacific Grove

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Overview

Tobacco cigarettes are addictive, toxic and non-biodegradable. A study conducted by Thomas E. Novotny indicates that at least 4.5 trillion cigarette butts are littered worldwide each year [2]. In particular, a recent city ordinance passed in Pacific Grove led capstone members to investigate the ordinances' effectiveness by estimating the expected count of littered cigarette butts in sampled commercial areas. To conduct the analysis, capstone members volunteered weekly to collect littered cigarette butts and applied a Poisson regression model and Bayesian analysis to examine the collected data. As a result, it was concluded that the amount of littered cigarette butts decreased due to the volunteer work done by capstone members, but littered cigarette butts will continue to pile up when the volunteer work is discontinued. However, the analysis of this study was halted by the global COVID-19 pandemic and its results were generalizable to the city of Pacific Grove. Nonetheless, this research signifies how cigarette butt pollution remains a global concern but with proper attention its impacts can be minimized.

Background

Cigarette butt pollution continues to be a global issue as the demand and consumption of tobacco cigarettes prospers. Because of a cigarettes addictive toxins, users are tempted to smoke a cigarette at any given moment and many avoid properly disposing of the remains. As a result, these littered cigarette butts along with their toxins can travel and make their way into a nearby water supply and cause harm within an entire ecosystem [3]. Nonetheless, advocates have taken several measures to reduce the amount of littered cigarette butts and prevent potential damage in populated areas.

Objectives

This project aims to estimate:

1. the expected count of littered cigarette butts in commercial areas of Pacific Grove
2. the overall reduction in the expected count of littered cigarette butts by our weekly volunteer activity
3. the expected count of littered cigarette butts collected on the 7th week of volunteering*
4. the expected count of littered cigarette butts in a street located within CSUMB (a smoke-free campus)

Meanwhile, this capstone project also intends to promote awareness amongst local residents and CSUMB students as to how cigarette butt pollution continues to be a global concern.

*The data collection was stopped at the 6th week due to the COVID-19 outbreak, so this estimation assumes the 7th week's expected count.

Method

Data Collection

- Each member was provided a glove, safety vest, and bag. The members were responsible for counting the cigarette butt as it was being picked up.
- Cigarette butts were collected once every week for a total of 6 weeks.
- Targeted areas: commercial area in Pacific Grove
  - A mall of a single big store (Location A)
  - A mall of multiple stores (Location B)
  - An intersection in the Downtown of Pacific Grove (Location C)

Statistical Method

- Poisson regression model was used to estimate the expected number of littered cigarette butts.
  - Quasipoisson model was used to account for overdispersion in the data.
  - Location A, B, and C were included in the model.
  - Each location was broken down into segments to cover all areas of interest.
  - Week variable was added into model, $\theta = e^{\beta_0 + \beta_1 B + \beta_2 A + \beta_3 week}$
- Bayesian analysis was used to illustrate and make statistical inferences

Results

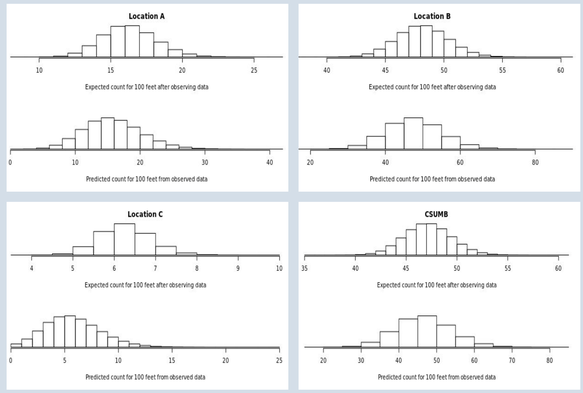

Figure 1: Histograms for each location which includes the expected count of littered cigarette butts without the data and with the data in the first week of data collection.

Figure 1 represents results from the Bayesian analysis. Per each location (locations A, B, C and CSUMB), there are two distributions presented by the first week data collection. The first is the posterior distribution of theta (for the expected count per 100 feet), and the second is the posterior predictive distribution (for the cigarette butts counts per 100 feet).

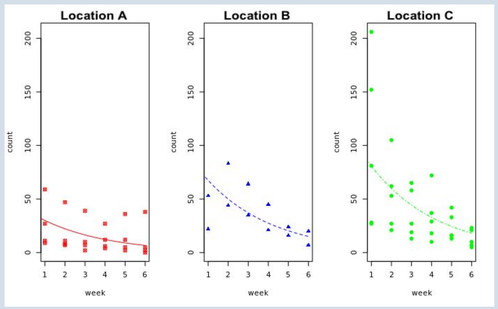

Figure 2: Regression graph for each location by week

Figure 2 illustrates the Poisson model that was utilized to estimate the expected count of cigarette butts (per 100 feet) with respect to week of volunteer work for each corresponding location. We can expect that as the weeks go by, the number of cigarette butts littered are reduced. Certain factors can affect this outcome, such as bringing awareness by making smokers conscious of their actions, and volunteer group reducing littered cigarette butts from volunteer work.

	Estimate	Std. Error	T value	Pr(>|t|)
β_0	2.2429	0.2941	7.627	1.76e-10
β_1	1.7236	0.2715	6.349	2.83e-08
β_2	1.4165	0.3275	4.325	5.65e-05
β_3	-0.2990	0.0645	-4.636	1.88e-05

Table 1: Estimated parameters from the Poisson model $\ln(\theta) = \beta_0 + \beta_1 L + \beta_2 S + \beta_3 week$

As shown in Table 1, the p-value for week and locations are significantly small which indicates that the variables are statistically significant. Given a location, when we compare a week to the previous week, the relative expected count of cigarette butts is $\exp(\beta_3) = \exp(-0.299) = 0.741$. That being said, we expect about a 26% reduction per week in the expected count, so we could predict count for the 7th week (which could not be observed due to the shelter-in-place order). As a result, we predicted 12, 14, and 5 cigarette butts per 100 feet in Locations A, B, and C, respectively.

Discussion

Findings

Location B (probably the most populated area, without any signages) has the most cigarette butt litter on average compared to Location A and Location C. In addition, Location C has the smallest slope of the two other locations because it has a low initial count. This can be contributed to the no-smoking rules enforced in the Downtown area [1].

Limitations

Unfortunately, there were several setbacks that caused difficulties in conducting an accurate analysis of littered cigarette butts in Pacific Grove. Primarily, the national COVID-19 pandemic that led to a shelter-in-place county order resulted in the inability to physically collect more littered cigarette butts. Additionally, cigarette butts hidden amongst foliage were difficult to account for. Meanwhile, smaller fragments of older cigarette butts were difficult to distinguish from regular plastic waste. Overall, these obstacles may have caused skewed results which would have resulted in underestimation of the expected count (but we still believe that the decreasing trend is still valid).

Conclusion

We can expect to see a continuing decline in cigarette butt pollution in all areas if volunteers would pick up cigarette butts every week. In addition, to help reduce the amount of littered cigarette butts in Location A, B, and C, we should put up non-smoking signs and replace the current smoking receptacles to one provided in Location C (see image of smoking receptacle in Method section). To conclude, this research demonstrates that the amounts of littered cigarette butts in public areas can be decreased when advocates clean up areas and influence cigarette users to properly dispose of the remains.

References

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