Modern city governance relies heavily on resident reports through ‘co-production systems’ – such as the 311 system deployed in more than one hundred North American cities – to identify problems such as downed trees and power-lines. Such reports are necessary, as they provide a real-time reflection on on-the-ground conditions that the city cannot hope to otherwise be aware of. These reports are used alongside internal data collection and automated sensor technology to make both immediate decisions—such as which dangerous, downed trees to inspect and fix—and longer-term planning decisions, such as which streets to resurface.

A major concern in these systems is that residents do not report problems at the same rates. In the setting of resident crowdsourcing systems, reporting disparities can lead to an inequitable allocation of government resources in downstream operations. However, because we do not observe ground-truth data about incidents, it is difficult to determine whether one neighborhood is under-reporting issues compared to other neighborhoods, or whether they truly experience fewer issues.

Previous work either does not attempt to distinguish these two cases by implicitly assuming that incident rates are similar across areas, or employs external data to construct proxies for ground truth incident rates. While accurate proxies can distinguish between incident rates and reporting rates, they may be difficult to construct or may not be precise enough to distinguish between types of incidents.

To the end of accurately auditing efficiency and equity of the reporting process, the contributions of this paper is two-fold.

**A method to identify reporting rates without ground truth data.** We propose a method to identify heterogeneous reporting rates, using just the reporting data itself. Our insight is that we can use information on **duplicate** reports about the same incident to identify reporting rates. This insight originates from the missing species estimation literature, where the number of duplicate observations provides evidence regarding the existence of unseen species. Using this idea, we show how to convert the reporting rate estimation task to a standard Poisson rate estimation problem, for which a large theoretical literature and empirical methods exist. In particular, one can use the number of reports between time of the first report (but excluding it) and an estimated death time (that may depend on the data, e.g., the reports or when the incident was inspected), to recover a Poisson likelihood with a corresponding rate function. We show the method is valid if the estimated death time is an under-estimate of the true resolution time, and is a stopping time.

**Applying our method to understand and enhance equity in 311 usage.** We apply our method to over 100,000 resident reports made to the forestry unit of the New York City Department of Parks and Recreation. Using a Bayesian Poisson regression framework, we estimate how the reporting rate varies as a function of incident characteristics, location, and socio-economic characteristics of the neighborhood in which the incident occurred. We illustrate that our method is indeed precise enough to find differences in reporting rates

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across incident types, and then turn to studying spatial and socio-economic heterogeneity. We find that there are substantial inter-location reporting differences, after controlling for the incident-level characteristics; even within each Borough, we find that factors like race/ethnicity and education levels are associated with reporting rates. These findings suggest that the allocation of government services, if reliant on incident reporting, may not be equitable.

We believe that our method is a general, powerful approach to understanding reporting behavior in such resident crowdsourcing systems, delivering precise reporting estimates without requiring ground truth data. It further opens up numerous possibilities for equitable design of resident crowdsourcing systems.

The full version of this paper can be found at https://arxiv.org/pdf/2204.08620.pdf.

CCS Concepts: • General and reference → Empirical studies; • Applied computing → Operations research.

Additional Key Words and Phrases: crowdsourcing systems, equity, Bayesian statistics

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