Using Publicly Available Data to Understand the Opioid Overdose Epidemic: Geospatial Distribution of Discarded Needles in Boston, Massachusetts

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Objectives. To use publicly available, crowdsourced data to understand geospatial trends in discarded needles.

Methods. We completed multiple geospatial analyses of discarded needles reported through the Boston, Massachusetts, 311 service request system.

Results. Between May 2015 and August 2017, 4763 discarded needles were reported. The highest concentration of needles were reported in census block groups in the South End and Roxbury neighborhoods. Cumulatively, 78.3% of the needles were reported within 1 kilometer of methadone clinics, safe needle deposit sites, homeless shelters, or hospitals.

Conclusions. Publicly reported data can help identify hot spots of discarded needles and examine indicators of spatial association. In Boston, the number of discarded needles being reported is rising, with the highest density of needles found in 2 central neighborhoods with several outlying hot spots. Most needles were found near areas associated with social stress and substance use disorder.

Public Health Implications. This analysis represents a novel way of leveraging publicly available information to target community responses to the opioid epidemic. Identifying hot spots of discarded needles may enable public health organizations to target future efforts to encourage safer needle disposal practices and reduce public injection drug use. (*Am J Public Health.* 2018;108:1355–1357. doi: 10.2105/AJPH.2018.304583)

The drug overdose epidemic in the United States continues to worsen. Approximately 64 000 overdose deaths occurred in 2016, a 400% increase since 2000, with a 15% rise in 2016 alone.[1] These trends are similarly reflected in Massachusetts, where a record 2155 deaths from opioids were reported in 2017, the last year for which complete data are available.[2]

An increasing proportion of these deaths are related to injection use of heroin or other more potent synthetic opioids—increasingly fentanyl and its analogs.[3] Although proper needle and syringe disposal facilities exist,[4] there are social and legal disincentives to safe disposal.[5,6] Furthermore, discarded used needles pose a public health infection risk and[7,8] stoke public anxieties.[9–12] In response to the proliferation of publicly discarded needles, Boston, Massachusetts, established a Mobile Sharps Collection Team in 2015 to pick up needles reported in the community. These services harness the existing Boston 311 infrastructure.

Globally, cities have developed nonemergency response services, like 311, to provide citizens a mechanism to report nonurgent community concerns.[13,14] Because 311 data necessarily include precise geographic information to guide city employees to the reported issue, they provide a high-resolution geospatial and temporal accounting of public concerns.[15]

We report a novel way to use these publicly available, crowdsourced data to understand geospatial trends in discarded needles.

METHODS

We performed a geospatial analysis on a data set from the city of Boston 311 service requests, made available through an Open Data Commons Public Domain Dedication and License.[16] Needle cleanup requests were submitted by calling 311, tweeting @BOS311, or using the Bos:311 mobile app or Web site. We identified those related to discarded needles by aggregating requests labeled as "Needle Pickup" or "GEN_Needle_Pickup." Each request included date opened, date closed, address, neighborhood, longitude, and latitude. We collected needle cleanup requests from the deployment of the Mobile Sharps Collection Team on May 15, 2015, through August 31, 2017.

We geocoded the addresses of reported needles with ArcGIS version 10.4.1 (ESRI, Redlands, CA). We converted street addresses to a latitude and longitude location for geospatial analysis. On initial review, we found that more than 22% (1086 of 4781) of the data set's latitude and longitude corresponded to a default location, although they had unique addresses recorded in the database.

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TABLE 1—Geospatial Approaches to Analyze Discarded Needle Data

	Choropleth Map	Cluster Analysis	Buffer Analysis
Description	Thematic map with shading proportional to a measure of needle density	Measure of spatial autocorrelation, can be global or local. Given a set of discarded needles, determines whether they are clustered (positive autocorrelation), dispersed (negative autocorrelation), or randomly distributed	Calculates number or proportion of discarded needles within a set distance from points of interest
Key findings	High needle densities in Roxbury and South End neighborhoods	36 census block group hot spots, 140 cold spots, 1 low-high outlier, 1 high-low outlier	78.3% of reported needles within 1 km of locations associated with high social stress
Advantages	Ease of visualization, identification of patterns, flexibility in defining data classification (e.g., breakpoints)	Easily identifies hot spots, cold spots, and spatial outliers; provides statistical rigor	Widely applicable and useful for basic analyses; easy to interpret
Disadvantages	Susceptible to ecological fallacy, obscures variation within boundaries, creates artificial or arbitrary boundaries (i.e., Modifiable Areal Unit Problem)	Requires expertise for implementation, difficulty in interpretation, geographic groupings can bias results	Variable results in rural vs urban areas given overlapping buffers, dependent on local road or infrastructure, nongeodesic distances can give misleading results with large study areas

We successfully geocoded more than 99.5% of all addresses after removing spurious portions of the address (e.g., "INTERSECTION" preceding the address itself). A total of 18 addresses were removed from this analysis as uninterpretable or unfindable, leaving 4763 geocoded needle pickups for our analysis.

We then spatially joined the needle locations to census block groups for the city of Boston (n = 559) to facilitate further exploratory analysis. Census block groups, which ideally contain 1500 residents, were chosen for their balance of geographic granularity and the availability of annually updated demographic, social, economic, and housing data.[17,18]

We performed cluster analysis with Anselin Local Moran's I[19,20] to determine statistically significant hot spots (clusters of high needle density), cold spots (clusters of low needle density), and outlier clusters. We adjusted for variability in census block group size by calculating the number of needles per square meter, setting the threshold for significant clusters at $P < .01$, and performing analyses both with and without the false discovery rate correction. False discovery rate correction is a method to account for multiple testing during spatial autocorrelation procedures.[21,22] In the final calculation, we excluded 20 census block groups for not having enough neighbors, a requirement for spatial autocorrelation.

The locations of hospitals, methadone clinics, homeless shelters, and safe needle and syringe disposal sites were geocoded with ArcGIS on the basis of address information. We then performed a buffer analysis to determine the total number and percentage of needles within 250, 500, and 1000 meters of these sites. We also performed descriptive statistical analysis with the R statistical package (Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Between May 2015 and August 2017, 4763 geocoded needle pickup requests were made in Boston. There were 624 requests in 2015 (May–December), 2001 in 2016 (January–December), and 2138 from January through August 2017. A mean of 170 needle pickup requests were made per month (SD = 90.8). Needle pickup requests were primarily made via the Bos:311 smartphone app (66%) and direct calls to 311 (33%).

A choropleth analysis identified a high concentration of needles in the census block group with LOGSF1 ID[17] 148139 and 148140, corresponding to the neighborhoods of the South End and Roxbury. Cluster analysis showed 36 census block groups clustered with a high density of needles (hot spots) and 140 with a low density of needles (cold spots). We also found 2 outlier clusters: a census block group with low needle density adjacent to a high density area (low-high outlier) in the Fenway neighborhood and a census block group with high needle density next to a low density area (high-low outlier) in the Allston-Brighton neighborhood. After applying the false discovery rate correction, the outlier clusters were not significant. Cumulative buffering analysis indicated that 78.3% of the needles were found within 1 kilometer of hospitals, methadone clinics, safe needle disposal sites, or homeless shelters, whereas the buffered areas accounted for only 37.2% of Boston's total land area.

Table 1 presents a summary of the results from the choropleth map, cluster analysis, and buffer analysis along with the advantages and disadvantages of each analytic approach. Complete maps and buffer analysis are available as a supplement to the online version of this article at http://www.ajph.org.

DISCUSSION

The Boston 311 data indicate that the reported number of discarded needles is increasing over time, with most needles concentrated geographically in the South End and Roxbury neighborhoods. We also identified 3 areas outside of this central high-density area: 1 hot spot in the North End, 1 hot spot on the South Boston–Dorchester border, and a high-low outlier in the Allston-Brighton neighborhood, providing areas for future research. Needles were reported near homeless shelters, perhaps representing areas of high social distress, an upstream factor thought to precede substance use disorder and its sequelae.[23,24]

The strengths of this study include the publicly available and crowdsourced nature of the data and the high resolution of the reported locations of discarded needles. Notable limitations are that this sample included only needles reported to the Boston 311 service and may not be representative of all discarded needles or syringes. Two thirds of needle pickup reports were from the Bos:311 smartphone app, which may have over-represented reports by a younger and wealthier population.[25]

We did not have access to the demographic information of individuals reporting found needles or the number of unique reporters. However, the number of discarded needles reported to Boston 311 is rising, and as more individuals report needles, the locations may become more representative of the distribution of discarded needles in Boston.

Although municipal 311 programs are ubiquitous in US cities, only Boston and Seattle, Washington, are currently using this approach to identify and collect publicly discarded needles. Seattle's program is a pilot, currently scheduled to run through December 2018.[26]

Our analysis represents a novel way of leveraging this publicly available information to target community responses to the opioid epidemic. We have focused on Boston for this article, but these techniques also could be applied to other cities with existing 311 systems that implement a discarded needle collection program. These data then could be used to direct the development of opioid use harm reduction programs, including accessible safe needle disposal sites, needle and syringe exchange programs, and supervised injection drug use facilities. AJPH

CONTRIBUTORS

B. Bearnot conceptualized and designed the study, analyzed and interpreted the data, drafted and critically revised the article, and approved the final version to be published. J. F. Pearson collected, cleaned, analyzed, and interpreted the data; drafted and critically revised the article; and approved the final version to be published. J. A. Rodriguez conceptualized and designed the study; collected, cleaned, analyzed, and interpreted the data; drafted and critically revised the article; and approved the final version to be published.

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HUMAN PARTICIPANT PROTECTION

These data were made available by the city of Boston, Massachusetts, through an Open Data Commons Public Domain Dedication and License and did not require institutional review board approval.

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