Why Not Here? An Examination Of Statewide Hospital Use Among Patients With Idu-Associated Diagnoses And Procedures In Lawrence And Lowell Ma, 2005-2019

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Why not here? An Examination of Statewide Hospital Use Among Patients with IDU-Associated Diagnoses and Procedures in Lawrence and Lowell MA, 2005-2019

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Abstract

This study sought to investigate the factors that led residents with IDU-associated diagnoses and procedures to seek care outside their home cities of Lawrence and Lowell, Massachusetts. Endocarditis diagnoses were found to be no different between hospitals in and out of Lawrence and Lowell, however, echocardiograms (CI = -0.19, -0.14; p-value = <0.001), skin and soft tissue infections (CI = 1.11, 1.23; p-value = <0.001), and irrigation and drainage procedures (CI = 0.15, 0.21; p-value = <0.001) were all found to be significantly different. These changes in hospital use highlight the need to account for patient-resident mobility during the creation of future similar studies.
Acknowledgements

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Introduction

HIV is a lifelong disease that is often associated with people that inject drugs. Between 2011 to 2016, the Northeast had reported 4136 new HIV infections that were associated with injection drug use (IDU), and Massachusetts (MA) is among the top ten states impacted with death as the primarily outcome\(^1\). A recent MA outbreak in June 2018 reported 129 new infections\(^2\) and by June 2020 that number has risen to 180.

The outbreak in MA primarily occurred in the counties of Lawrence and Lowell, and investigators have sought to identify variables that may have temporally preceded this spike in infections, as IDU is associated with a host of other infectious disease complications\(^3\). These complications can include, viral hepatitides, skin and soft tissue infections, and bacteremia from non-sterile injections that may lead to sepsis, endocarditis, and osteomyelitis\(^4,5\). Using a distributed lagged Poisson regression model in a Bayesian setting, several of the factors were identified to precede the spikes in HIV infections. Specifically, fatal overdoses were associated with “current month” HIV counts, 8 months prior, infective endocarditis, 10 months prior, and cases of skin and soft tissue infections and incision and drainage procedures, 12 months prior. These results may enable a better understanding for how and when healthcare providers should intervene when seeing people who inject drugs (PWID).

An analysis of the population resident zip codes revealed that a non-trivial number of people who resided in Lawrence and Lowell sought care outside of their home cities. Other studies have also sought to understand hospital bypass decisions made by local residents. These studies have primarily been grounded in standard utility theory, that the decision to bypass the nearest hospital to visit one that’s further is determined by both
characteristics of the hospital and patient. These characteristics can include patient employment status, type of procedure or care, expected wait time, teaching status of the hospital, patient age, and patient social status. However, increased travel time has often been negatively correlated with health outcomes, regardless of disease, geographical distances, and boundaries. Thus, it is imperative to better understand why patients with IDU diagnoses receive treatment at hospitals outside of their city of residence so that missing resources may be made available, especially in infectious diseases related outbreak scenarios.

This thesis aims to characterize factors that may have led Lawrence and Lowell residents to seek care elsewhere in Massachusetts for their IDU-associated diagnoses and procedures. To do this, we examined monthly hospital discharge data from the Massachusetts Department of Public Health (MDPH) for the period of 2005 to 2019. IDU-associated infections and their associated medical procedures were obtained from the MDPH Bureau of Infectious Diseases and Laboratory Sciences. Longitude and latitude coordinates for both residential and hospital zip codes were obtained from the US Census Bureau. Differences in use of hospitals by either diagnosis or procedure will provide insight toward the patient needs that may be missing in Lawrence and Lowell but present in other cities. Additionally, a better impression of hospital use by location will provide opportunities to assess other characteristics, whether intrinsic or extrinsic to the city, that may be translated to other places with similar needs. These findings can inform future studies through interrogating PWIDs needs at hospitals.
Methods

Data Collection

Monthly aggregate counts of International Classification of Diseases, Ninth and Tenth Editions (ICD-9 and ICD-10), diagnostic codes were obtained for infective endocarditis, echocardiograms, skin and soft tissue infections, and abscess incision drainage, irrigation, and joint wash-out procedures from hospital discharge data over 2005-2019 across all hospitals in Massachusetts among patients between 15-50 years of age. Among this dataset, patient zip codes were used restrict the data to include only diagnoses from patients that actually reside in Lawrence and Lowell in our study period, but still included all hospitals. This allows us to capture the travel and care use patterns associated with those that reside in the region of state where the 2018 HIV outbreak occurred but sought care elsewhere in MA. These 9 zip codes include 01840, 01841, 01842, 01843, 01850, 01851, 01852, 01853, 01854.

Patient data by hospital and zip code was obtained from the Massachusetts Center for Health Information and Analysis (CHIA). CHIA makes available researchers detailed health information that were submitted by hospitals, including: patient demographics, admission and discharge information, diagnostic and procedural coding, provider details, and detailed charge information. The use of these ICD-9 and ICD-10 codes as a corresponding measure for IDU-associated diagnoses have been used and substantiated in previous studies \(^3\),\(^4\). The age of patients in this study were restricted to include only those between 15-50 so as to reduce the likelihood of including cases that occurred outside of injection drug use\(^8\) and to mirror the age range of the PWID during the outbreak\(^9\). Echocardiograms and irrigation and drainage procedures were included upon the advice of
clinicians as additional proxies for IDU, in addition to the aforementioned diagnoses. To ensure consistent mapping of diagnoses and procedures upon the switch of ICD-9 to ICD-10 in 2017, we used The Centers for Medicare and Medicaid Services General Equivalence Mappings (GEM) with confirmation by clinician partners\textsuperscript{10}.

\textit{Data Cleaning and Analysis}

Addresses for hospitals were collected using Google Maps by entering the names of the 61 hospitals into the Maps search toolbar and manually saving the output. The United States Census Bureau Geocoder was then used to convert the physical addresses into geolocations with latitudes and longitudes\textsuperscript{11}. The central geolocations for residential zip codes were identified and mapped using the R software “zipcodeR” package. Distances between patients’ resident zip codes and their hospital were calculated by using the Haversine formula, a method to compute the distance between two points on the surface of a sphere using the latitude and longitudes\textsuperscript{12–14}. The straight-line distance has shown to be a good tool for studying distances in non-emergency purposes\textsuperscript{15}.

Frequencies and descriptive statistics were used to characterize the 4 diagnoses and procedures by counts and miles traveled from home to hospital. The simple t-test was used to examine differences between the use of hospitals in and outside of Lawrence and Lowell and significance was assessed at the $p \leq 0.05$ level. A time series decomposition plot consisting of trends and seasonality (STL) was created for each the four diagnoses and procedures over 2005 to 2019 using Loess\textsuperscript{16}. These plots were created with hospitals that were restricted to the top 8 hospitals which account for 90% of all diagnoses. This was done for ease of viewing as these plots allow easier visualization of patterns associated
with seeking care for various conditions. All analyses and management of data were conducted using R language version 4.0.3 and RStudio version 1.4.1103. Data was obtained from the MDPH using SAS Programming Language.

*Ethics and Human Subjects Protection*

Data collection occurred after ethical review of the study by the MDPH and Yale University Institutional Review Boards (IRB) and the Partners Human Research Committee. This study was declared exempt from IRB review by all review boards.

**Results**

**Description of Findings**

Between January 2005 and December 2019, 9065 residents from the cities of Lawrence and Lowell Massachusetts sought care for either one or a combination of diagnoses and procedures from hospitals throughout the state. These procedures and diagnoses include endocarditis, echocardiograms, skin and soft tissue infections, and irrigation and drainage procedures. 7309 residents sought care from hospitals in their cities of either Lawrence or Lowell, while 1756 sought care elsewhere in Massachusetts. **Table 1** describes the average number of diagnosis and/or procedure by resident, the total count of diagnosis and procedure, and a p-value for the simple t-test. These data show that there were comparable counts of patients diagnosed with endocarditis in hospitals both in and outside of Lawrence and Lowell (CI = -0.002, 0.029; p-value = 0.091). However, there were differences in the counts of echocardiograms (CI = -0.19, -0.14; p-value = <0.001), skin and soft tissue infections (CI = 1.11, 1.23; p-value = <0.001), and irrigation and
drainage procedures (CI = 0.15, 0.21; p-value = <0.001). Hospitals in Lawrence and Lowell saw significantly more skin and soft tissue infections, and irrigation and drainage procedures in its hospitals from local residents than hospitals outside these cities. A total of 1190 echocardiograms were conducted at the 61 hospitals for which we obtained counts. But, in a reverse fashion, echocardiograms occurred less frequently in Lawrence and Lowell hospitals, compared to hospitals elsewhere. Echocardiograms also brought Lawrence and Lowell residents the furthest from home, compared to the other 3 measures (Table 2). Residents traveled, on average, 14.38 miles from their zip code of residence to receive an echocardiogram. Meanwhile, endocarditis diagnoses, skin and soft tissue infections, and irrigation and drainage procedures, had residents drive, on average, 6-7.77 miles. Soft skin tissue infections were the most abundant measure assessed, followed by irrigation and drainage procedures, echocardiograms, and endocarditis.

Figure 1 maps the total counts for each one of the 4 measures over 2005-2019 at all hospitals in Massachusetts and provides a visualization for hospital use patterns. Outside of Lawrence and Lowell, these maps show that most care is provided in the cities of Boston and Cambridge. 1B shows that while ~175 echocardiograms were performed at Lawrence General Hospital while the second highest, ~120, were performed in MA at Tufts- New England Medical Center. Endocarditis and echocardiograms show less distribution in hospital access throughout the state than skin and soft tissue infections, and irrigation and drain procedures.

Time Series Trends and Seasonality
Between 2005-2019 there were fluctuations in all 4 diagnoses and procedures over time, and across the top 8 hospitals (Figure 2). The top 8 hospitals were measured by the total of all diagnoses and procedures and account for 90% of all diagnoses and procedures. These fluctuations are most notable in endocarditis diagnoses and echocardiograms. In 2014, endocarditis diagnoses begin to see an upward trend at Lawrence General Hospital, Lowell General Hospital – Main Campus, Lowell General Hospital – Saints Campus, and Tufts New England Medical Center. These trends reach a peak shortly before 2018, while Tufts New Medical Center sees a second wind at the end of 2019. Echocardiograms also show an interesting temporal trend. There is an uptick in the trend of echocardiograms between 2013-2016 at Lawrence General Hospital, and an upward trend at Tufts New England Medical Center following 2015 through the start of 2020. Both soft skin tissue infections and irrigation and drain procedures have relatively flat trendlines through the years, although there looks to be an uptick in the trend of irrigation and drain procedures at Massachusetts General Hospital at the start of 2020. There are no consistent patterns of seasonality in the counts of these diagnoses and procedures, amongst the top 8 hospitals assessed. However, it does appear that there may be seasonal upticks in endocarditis diagnoses and irrigation and drainage procedures near the end of each year.

**Discussion**

As of June 2020, 180 HIV cases have sprung out of the 2015-2018 HIV outbreak in the cities of Lawrence and Lowell. A previous study published by this group revealed temporal patterns in IDU-associated diagnoses and procedures that proceeded this
outbreak. However, it was revealed that a proportion of residents of Lawrence and Lowell sought care elsewhere. Thus, it became imperative for our group to understand some of the travel patterns associated with those seeking care for IDU-associated diagnoses and procedures. Figure 1 shows that a greater proportion of residents in Lawrence and Lowell have sought echocardiograms elsewhere, and they had traveled a mean distance of 14.38 miles. Numerous studies have drawn associations between travel times and health outcomes, and though some reports are mixed, the majority show that there is a negative association between the two. Thus, we posit that the residents of Lawrence and Lowell who leave to seek care, could expose themselves to worst health outcomes.

Patients who had contracted HIV during this outbreak were reported to have had high health insurance coverage, and Massachusetts is also reported to have very high insurance coverage. Despite this, many in the outbreak had not achieved full viral suppression, and 12% have not had a full viral load test in the past year, indicating that while PWIDs have access to insurance, it is underutilized and it is possible that they lack a primary care provider. Additionally, providers cited that homelessness and incarceration are frequent concerns for PWIDs and that mobility may lead them to a fragmented network of care. A search of prisons and correctional facilities in Massachusetts reveals that Lawrence and Lowell does not actually have its own correctional facility. The nearest correctional facility to Lawrence and Lowell is the Middlesex House of Correction and Jail. This correctional facility is 9 miles from Lahey Clinic – Burlington Facility, where in Figure 1 is shown to be a hospital frequently utilized for our 4 measured diagnoses and procedures, but especially so for echocardiograms. There are also two prisons in Boston, the Lemuel Shattuck Hospital Correctional Unit and the Boston Pre-Release Center that
may contribute to the increased use of diagnoses and procedures at Boston and Cambridge hospitals, following displacement of PWID through arrest and incarceration. Future studies need to be conducted to interrogate the relationship between incarceration dependent displacement and hospital use by PWIDs.

Residents could also have travelled outside their cities for reasons unrelated to incarceration or police activity. In October 2014, Lowell General Hospital and Tufts Medical Center of Boston finalized an agreement to form a new health system. Following finalization of this partnership, Figure 2a and 2b reveal a gradual increase in the trend of endocarditis diagnoses and echocardiograms at Tufts Medical Center. It is possible that the increase in these cases at Tufts Medical Center could be correlated with increased referrals from the Lowell Hospital Campuses. A search of echocardiograms at Tufts Medical Center reveals that Tufts has a dedicated cardiovascular imaging center with its own dedicated care team. Residents of Lawrence and Lowell (or just Lowell) may be referred to Tufts Medical Center due to more dedicated procedural expertise.

Limitations

As this was a secondary analysis of our group’s previous study, we did not have access to patient demographic data. Future studies may benefit from including information on a patient’s age, income, ethnicity, mobility, and incarceration status. Additionally, as we looked at only PWIDs from the cities of Lawrence and Lowell, the data may not be as generalizable to other regions in the US. Having a physician that worked at hospitals in Lawrence and Lowell, and elsewhere would have benefited the study as they could have
shared their experiences for why patients may seek care elsewhere, whether that is through referrals or displacement.

Conclusions

The patterns seen in this study are consistent with the patterns drug use in Lawrence and Lowell that proceeded the 2015-2018 outbreak of HIV. There are questions about why people travel which cannot be fully answered by this study. However, this study does show that, as our group embarks on a larger national project, there are compelling reasons for expanding the geography of studies and for exploring how residents seek healthcare. For future similar studies, it is critical that the region of interest is clearly defined, as the movement of people tells us that we cannot just rely on local data but also regional data.
Table 1. Description of the Diagnoses and Procedures, by Hospital Location\textsuperscript{a}

<table>
<thead>
<tr>
<th>Diagnoses &amp; Procedures</th>
<th>Yes (N = 7309)</th>
<th>No (N = 1756)</th>
<th>Total</th>
<th>P-value\textsuperscript{b}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endocarditis</td>
<td>0.09 ± 0.34</td>
<td>0.08 ± 0.29</td>
<td>780</td>
<td>0.091</td>
</tr>
<tr>
<td>Echocardiograms</td>
<td>0.10 ± 0.48</td>
<td>0.27 ± 0.31</td>
<td>1190</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Skin and Soft Tissue</td>
<td>2.17 ± 2.12</td>
<td>1.00 ± 0.82</td>
<td>17602</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Irrigation and Drainage</td>
<td>0.43 ± 0.71</td>
<td>0.25 ± 0.51</td>
<td>3569</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Table values are mean ± SD and include all hospitals 2005-2019

\textsuperscript{b} P-value is for \textit{t}-test test
Table 2. Description of the Diagnoses and Procedures, by Distance Traveled (miles)

<table>
<thead>
<tr>
<th>Diagnoses &amp; Procedures</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endocarditis</td>
<td>7.77 (10.18)</td>
<td>1.81</td>
<td>463</td>
</tr>
<tr>
<td>Echocardiograms</td>
<td>14.38 (11.16)</td>
<td>21.92</td>
<td>768</td>
</tr>
<tr>
<td>Skin and Soft Tissue</td>
<td>6.01 (9.41)</td>
<td>1.45</td>
<td>8445</td>
</tr>
<tr>
<td>Irrigation and Drainage</td>
<td>7.05 (10.46)</td>
<td>1.45</td>
<td>1742</td>
</tr>
<tr>
<td>All</td>
<td>6.80 (9.96)</td>
<td>1.45</td>
<td>11418</td>
</tr>
</tbody>
</table>
Figure 1. Bubble maps of hospitals in MA and counts of IDU-associated diagnoses and procedures where Lawrence and Lowell residents received care.

A.
Endocarditis Diagnoses from L&L Residents (2005-2019)

B.
Echocardiogram Tests from L&L Residents (2005-2019)
Figure 2. A seasonal and trend decomposition using Loess of endocarditis diagnoses in the top 10 diagnosed hospitals, by all diagnoses

A.

B.
References


