Medical practice office location analysis and operational metric assessment using spatial data visualisation tools

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Abstract In today's business environment leaders are often challenged with complex business decisions necessary to maintain profitable organisations and efficiently meet the needs of customers. Patient travel distance to healthcare service locations can affect utilisation and access. Organisations are turning to geographic information systems (GIS) and creating spatial data visualisation outputs using desktop data visualisation software packages to facilitate improved decision-making. These software tools can be useful when assessing current and future medical practice office locations. Investigators reviewed how data visualisation tools were used to examine a data set from a speciality medical care provider with multiple clinical locations across a major metropolitan area for better understanding and conceptualisation of key operating metrics and select future office locations.

KEYWORDS: data visualisation, geographic information systems, facility location, healthcare access

INTRODUCTION

Data visualisations have been demonstrated as efficient tools to assist in strategic decision-making on future clinic locations, operations and business policies.[1] It is important for medical practices to optimise the quality of capital investments, particularly when making major investments in real estate and medical office buildings. Facility location decisions are some of the most complex decisions for any business. Poorly located facilities or the use of too many or too few facilities can result in increased expenses and/or degraded customer service.[2] As noted by Owen and Daskin,[3] decision-makers must select sites that not only perform well according to the current system state, but that will continue to be profitable for the life of the structure, even as environmental factors change, populations shift and market trends evolve. Finding robust facility locations is indeed a difficult task, demanding that decision-makers account for uncertain future events. For these reasons, spatial data visualisation utilising geographic information systems (GIS) has been demonstrated as an effective tool to assist in facility location and siting.[4]

It is important to note that not only are GIS a special class of information systems that keep track of events, activities and things, but that these systems also denote where these events, activities or things occur or exist.[5] Today's GIS technology can store, access, retrieve, manipulate and synthesise data and create these spatial data visualisations to help managers better conceptualise and analyse complex issues, and share tacit elements that are hard to pass from one individual to another through verbal or written communications. Use of GIS to create spatial data visualisations is an evolving area for transfer of knowledge and shared decision-making between stakeholders involved in medical business assessment and planning. The current literature demonstrates that people are more likely to use health services conveniently located in relation to their activity spaces that encompass travel for work, shopping and childcare.[6] In the late 80s, Cromley and Shanon[7] reported on the concept of 'aggregate activity spaces' for the elderly as a basis for suggesting the location of ambulatory care facilities as part of clinic location planning. As McLafferty noted in her 2003 research,[8]

> GIS-based research on service performance and effectiveness is in its infancy. This is a challenging area because it involves relating geographic data on health care need, access, utilization, and outcomes with the characteristics of service delivery systems. Most studies provide only a partial analysis of these relationships.[9]

BACKGROUND

The focus of this article is a facility planning decision faced by a regional medical specialty physician practice located in a 14-county metropolitan area with a population in excess of 2.1 million people. Existing and future clinic locations were being evaluated as part of the organisation's strategic planning process.

The practice leadership team identified the need for assistance in assessment of practice office locations and operational metrics for each location as a component of their long-term (five to ten years) strategic planning initiative. The team had a particular interest in assessing patient travel distances and understanding how patient visit volumes were spread among the different office locations. The organisation's electronic health record (EHR) and financial systems did not have the capability to create reports that could be easily aggregated and understood for use in strategic decisions.

The organisation's leadership team commissioned external resources to create a practice location analysis utilising spatial data visualisation GIS software, creating data visualisations related to clinic volumes, patient travel distance modelling for clinic visits, bad debt rates and identification of potential clinic locations for expansion or closure. Determining access to healthcare services and improving access points within the metropolitan area was a challenging task for clinic managers and directors, and data visualisations were identified as important to developing a common, tacit knowledge of operations between leadership team members. The challenge was compounded by the task of translating the relevant data into a format that is clear and organised around geographic maps of the service area. GIS elements within data visualisation software packages, as previously noted, can help management analyse and transform complex data from various sources and incorporate the data into maps that illustrate problems and potential solutions with minimal effort for both experts and non-experts.[10] In addition to more traditional reporting of driving distances and travel time reporting via GIS and data visualisations, the management team was also interested in examining operational/financial metrics on a clinic-by-clinic basis.

METHODOLOGY

Patient encounter data was obtained from the medical specialty physician practice that provides outpatient and inpatient physician consultant services. The data set was created by the practice administrator, exporting information from the practice EHR, and was provided via a comma-separated values (CSV) format. Encounter elements in the extract included: visit office address, visit date and patient zip code for primary residence. The data set also contained information specific to the payment status of each payment, indicating whether the patient was responsible for uncollectible bad debt incurred by the practice. The data set was extracted from a time period of the prior 18 months and was received from the practice for analysis with over 21,000 patient encounters from January 2017 to June 2018. The data set had been de-identified of any specific patient identification by the clinic prior to dissemination for analysis, and a business associate agreement (BAA) was signed by the investigators to ensure data would be used only for the intended research analysis and publication of de-identified encounter data. Utilisation from all 16 office locations within the practice were included in the data set.

RESULTS AND ANALYSIS

Tableau Desktop software was used to prepare spatial and financial-operational data visualisations from the patient encounter data set. Using Tableau for the data visualisations, the engagement met certain important objectives, namely simplicity, timeliness, connectivity, visual competence, sharing and scale. In terms of these objectives, it was important for the visualisations to be easy for non-technical users to understand and replicate, have software connectable to a variety of data sources, provide appropriate graphics and visualisations by default, help the leadership team facilitate sharing of insight, and have software capable of handling large data sets. Simple, reproducible templates for the visualisations also allowed the medical practice to go beyond a single snapshot in time and produce ongoing visualisations tracking important metrics and performance across multiple time frames in the future, documenting results based on management long-term plans.

Appendices 1–7 are the key spatial and operational visualisations created for the medical practice based on the provided data set. Visualisations in the final report included the following:

A1. Location distribution with patient visit total by location

The location distribution simply provides a geoplot of clinic locations within the metropolitan area on a street map with the total number of visits for the 18-month period identified for each clinic location.

A2. Patient volume by zip code

The patient volume by zip code is designed to provide the leadership team with an assessment of volumes of patient visits based on patient home location within the metropolitan area. The bar graph provided superior insights as compared with a geoplot of volumes in each of the zip codes on a map background.

A3. Busiest time of day

The data set also provided the time of visits. This visualisation is beneficial in terms of assessing staffing, waiting room size, number of exam rooms and patient and staff parking.

A4. Top locations

The top location chart provides an analysis over time for growth or reduction in the number of overall clinic visits and was found to be beneficial in better understanding patient-to-staff ratios and determining performance on an operating cost per square foot basis.

A5. Bottom locations

The bottom location chart provides the same analysis over time for growth or reduction in the number of overall clinic visits and was also found to be beneficial in better understanding patient-to-staff ratios and determining performance on an operating cost per square foot basis. The chart was also found to be beneficial in raising questions about significant changes in overall patient volumes at one clinic site.

A6. Bad debt by location

Bad debt ratios by clinic location provided interesting and useful information about collection practices and support recommendations for further investigation related to household median incomes in zip codes where clinic patients reside, and analysis of clinic payer mix between Medicare, Medicaid, private insurance and self-pay patients

A7. Average driving distances

The driving distances chart provides traditional information based on geocoding of home locations for patients travelling to clinics. A more sophisticated analysis might also include travel times based on local traffic flows and time of day. Driving distance by location indicates that individuals living on the periphery of the metropolitan area are typically commuting longer distances and that information fits well with commuting distances for other services that individuals typically have when living in suburban areas within the metropolitan region.

DISCUSSION

Overall, the visualisations met the objectives identified in the scope of the engagement and facilitated the organisation's strategic planning process. The visualisations helped to confirm known information with facts, identify areas requiring further investigation for understanding of patterns, and provided information that would likely result in new dashboard metrics and investigations related to topics such as sharp increases or declines in clinic volumes and operating cost per square foot of clinics, as well as the need for improved scheduling processes to smooth the flow of patients into the clinic throughout the day and provide better utilisation of existing resources.

One area not included in the analysis and identified for further investigation was an overlay of competitor locations that would help ascertain opportunities and threats for future clinic volumes. It was also evident that previous location planning had not taken into consideration demographics of area residents in terms of median incomes or payer classification (Medicare, Medicaid, private insurance, self-pay). Another important consideration for future growth of the referral-based specialty was location of primary care physician offices and hospitals, geomapping these resources along with current clinic operations for a visualisation the management team identified as useful. An additional visualisation the management team requested was population counts over time to identify areas of the metropolitan region that were experiencing growth or decline for planning of future clinic locations. These additional items for study and creation of visualisations can be construed as limitations of the current study and items for future research on the topic.

CONCLUSION

This study demonstrates how GIS and spatial data visualisations, as well as operational metric visualisations can be used at the local level. The study also demonstrates how GIS can be utilised in healthcare services and health policy research at a regional or national level when performing needs assessments, at varying levels of sophistication and granularity. In the same manner that GIS was used to combine and visualise data elements related to healthcare access, other data sets of interest could also be adapted and incorporated into future research. Existing databases could be linked to visually identify areas that meet selected service standards or produce targeted financial and operational metrics. With the increased accessibility to clinical and population data, physicians and medical practices can use GIS for improved decision-making related to clinic operations, management of current and future patient populations, and facilitation of strategic planning processes.

It was evident during the analysis that addressed geocoding and use of local 'healthcare points of interest' databases are important potential tools that could be used to identify specific locations for future clinics at a postal code level area within a metropolitan region. By incorporating a systematic approach to embedding spatial data visualisation tools into the strategic planning process medical clinic operators can indeed make more informed decisions about optimal locations for clinics.

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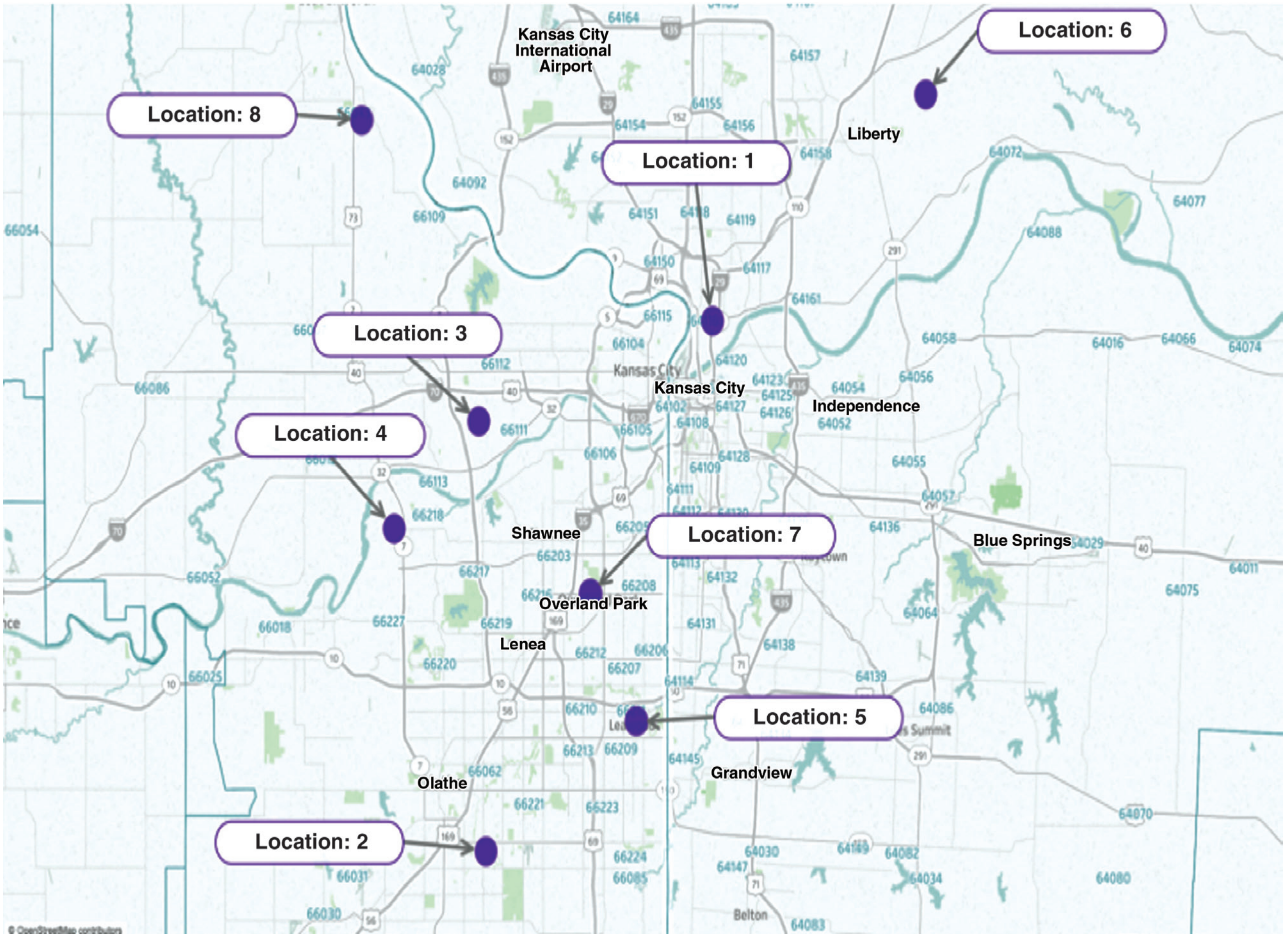
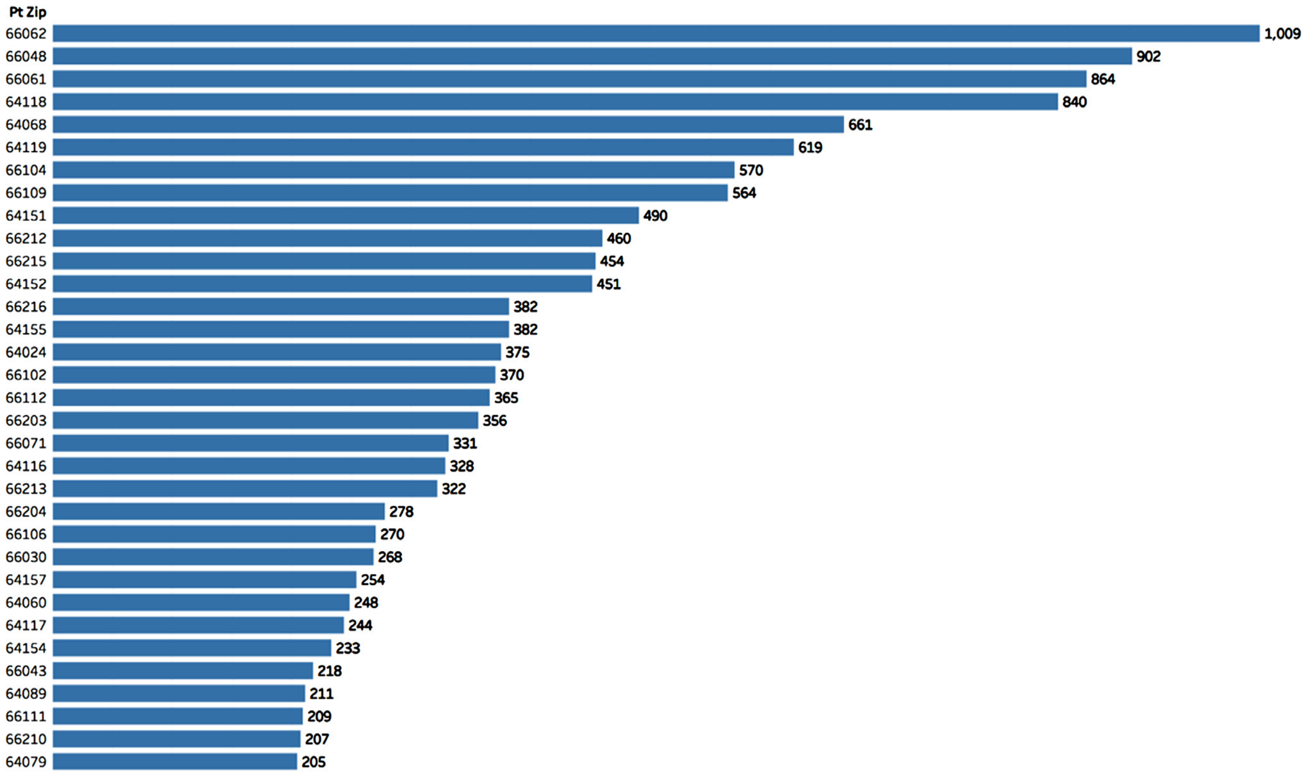
APPENDIX

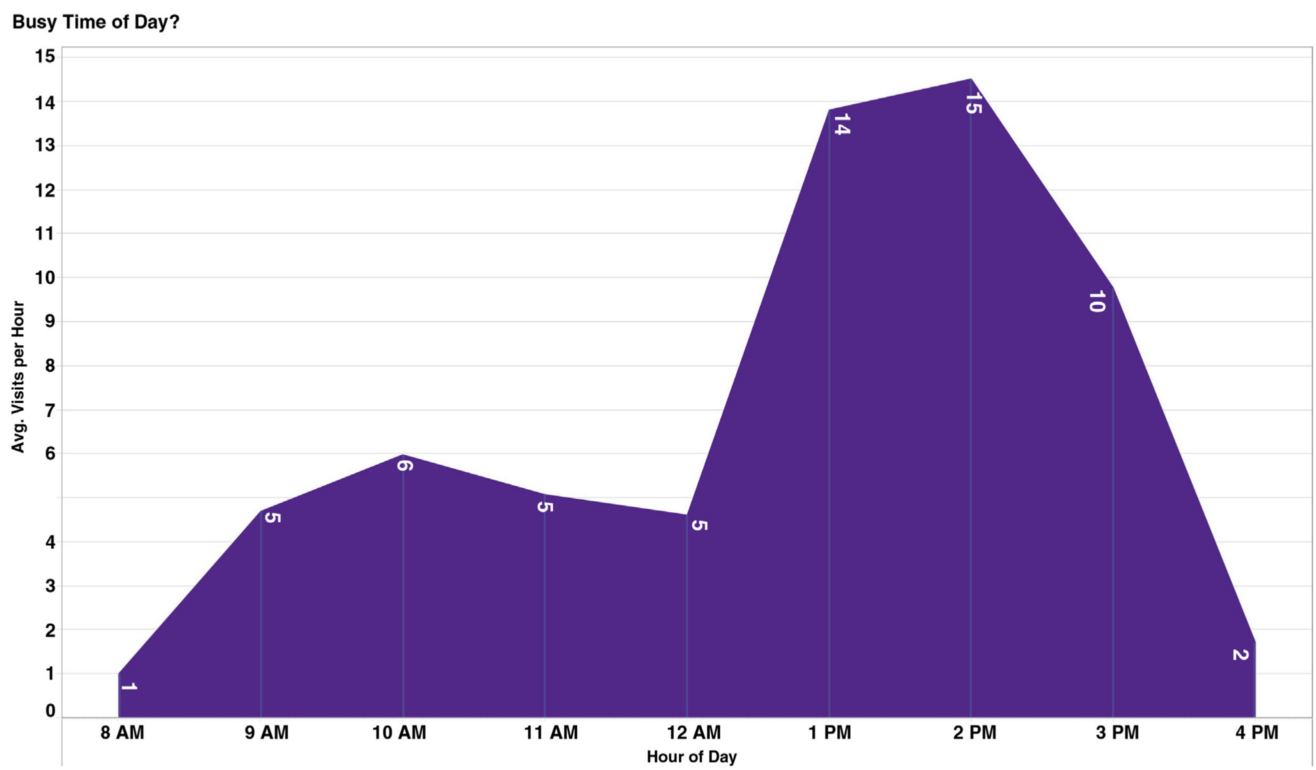
Appendix A1. Location distribution with patient visit total by location



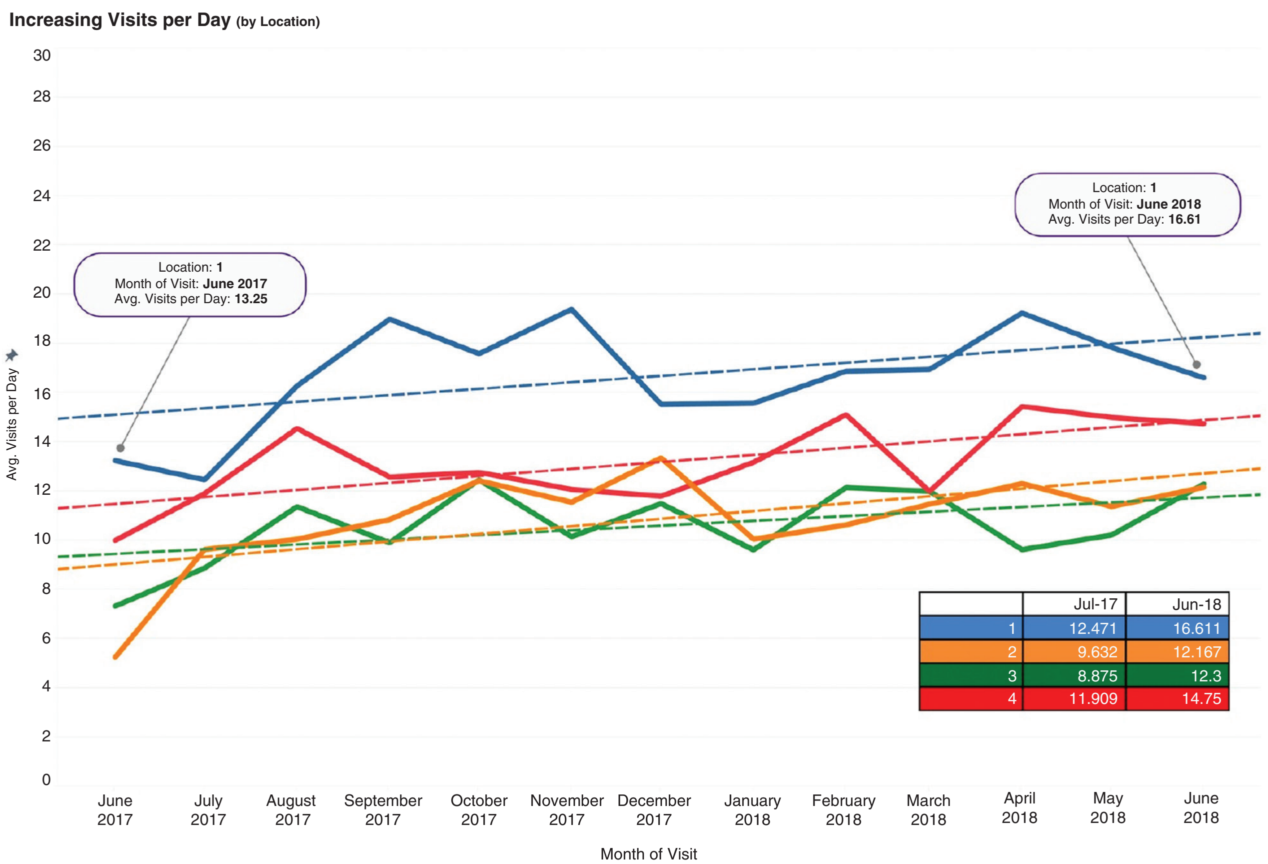
Appendix A2. Patient volume by zip code



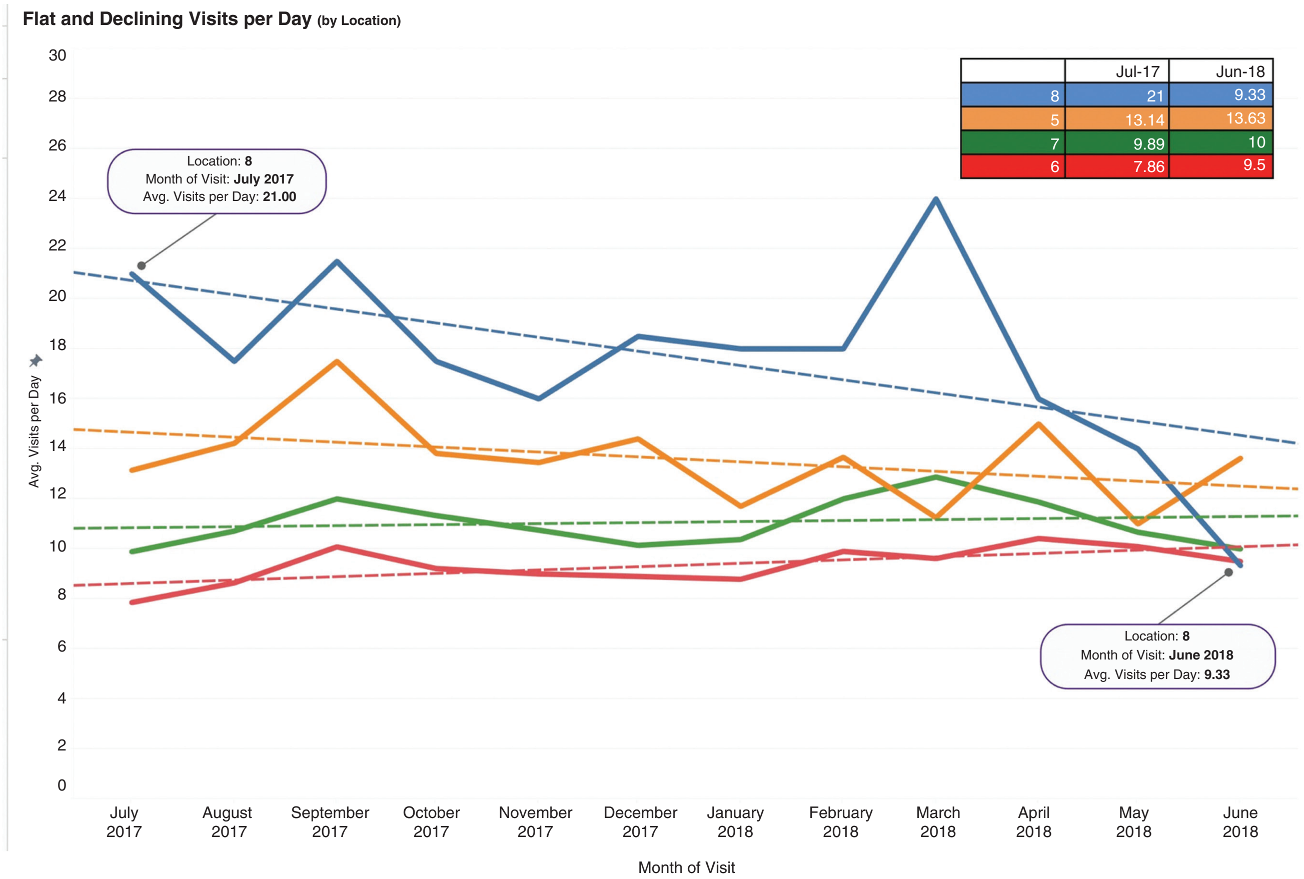
Appendix A3. Busiest time of day



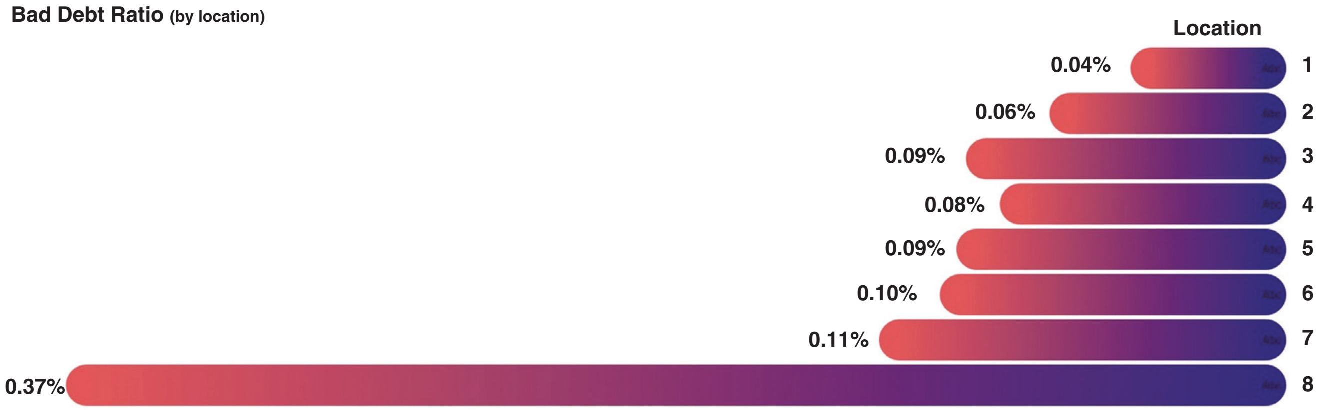
Appendix A4. Top locations

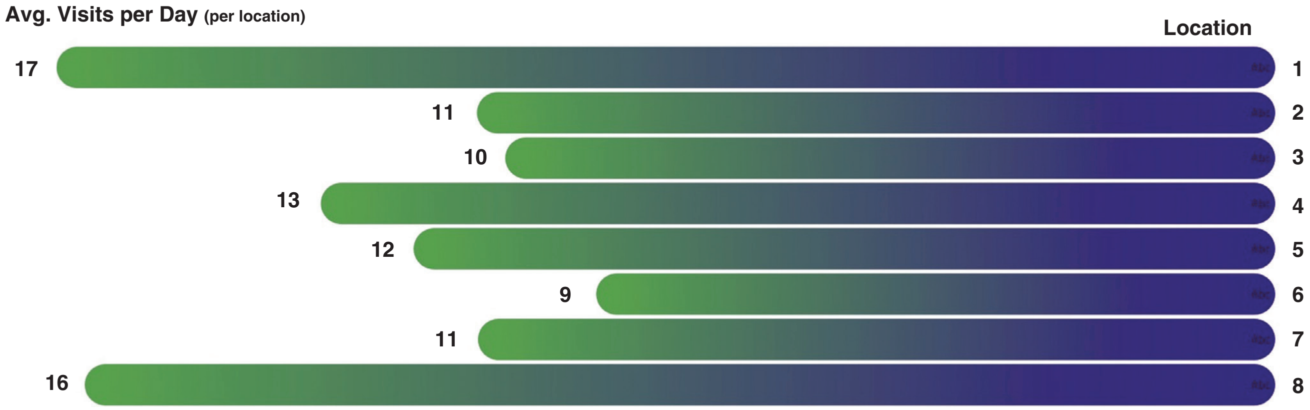


Appendix A5. Bottom locations



Appendix A6. Bad debt by location





Appendix A7. Average driving distances

Average Distance to Location

Location	Zip	
2	66062	13.8
6	64068	13.2
1	64116	13.1
4	66226	12.3
5	66211	11.2
3	66111	8.8
8	66043	7.4
7	66102	6.9