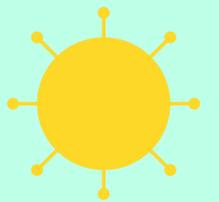


Custom script tool for vaccine center selection with age-based prioritization.

Claire Wright | Queen's University | 18-05-2021



Introduction

Geographic information science (GIS) has many applications in public health and is particularly effective for service allocation (McLafferty, 2003). It was used here to optimize immunization against the COVID-19 (SARS-CoV-2) virus in the Kingston, Frontenac, Lennox, and Addington (KFLA) region. The overall purpose of the project was to develop a custom GIS tool to determine which of set of candidate locations should be used for vaccine administration in the KFLA region and to allocate the dissemination areas within KFLA to the chosen locations. Research indicates that vaccine distribution should be tailored based on age-related patterns of transmission (Medlock & Galvani, 2009). Therefore, the tool also contains functionality for specifying age thresholds. The project is designed to facilitate efficient and equitable vaccination against COVID-19.

Date Sources

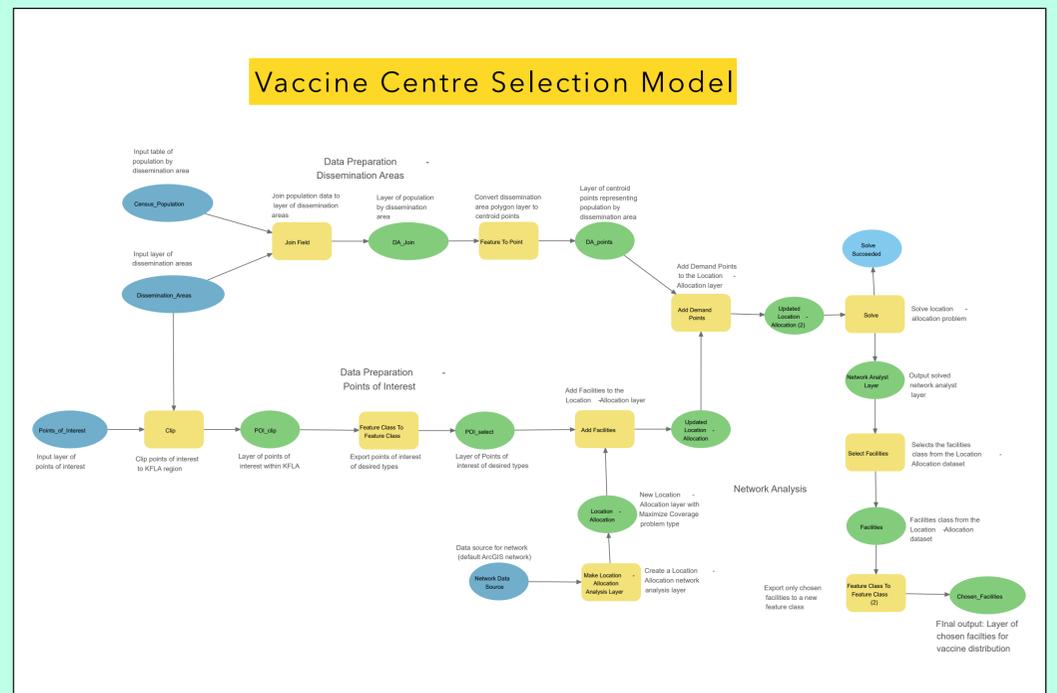
Three data sets were used for tool development:

- A layer of dissemination areas in the KFLA region available from the GPHY 348 course material at Queen's University, Kingston, ON
- A layer of points of interest in KFLA from the City of Kingston's open access data portal (City of Kingston, n.d.)
- Population data by dissemination area from the 2016 Canadian Census (Statistics Canada, 2020)

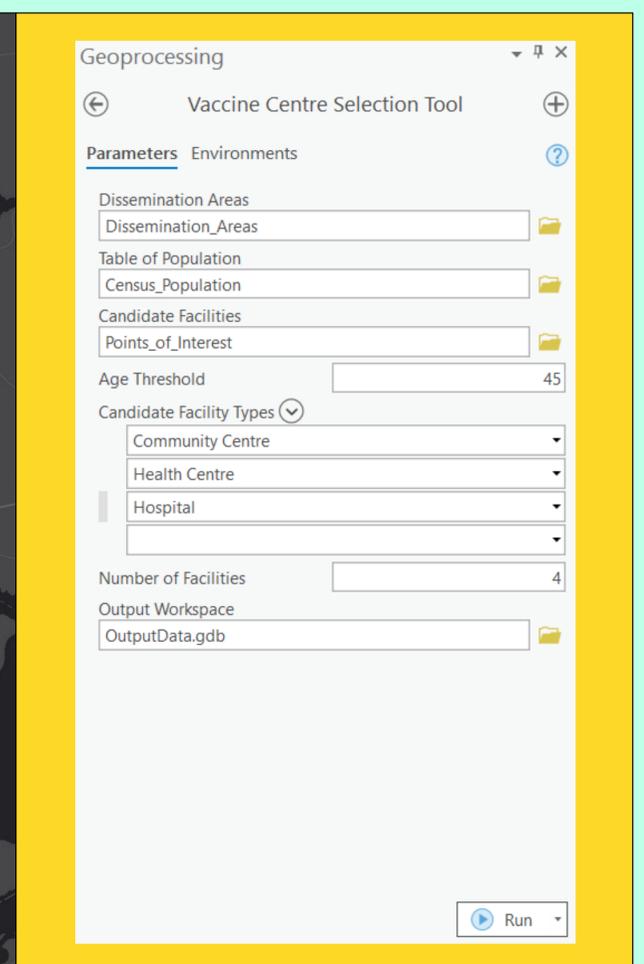
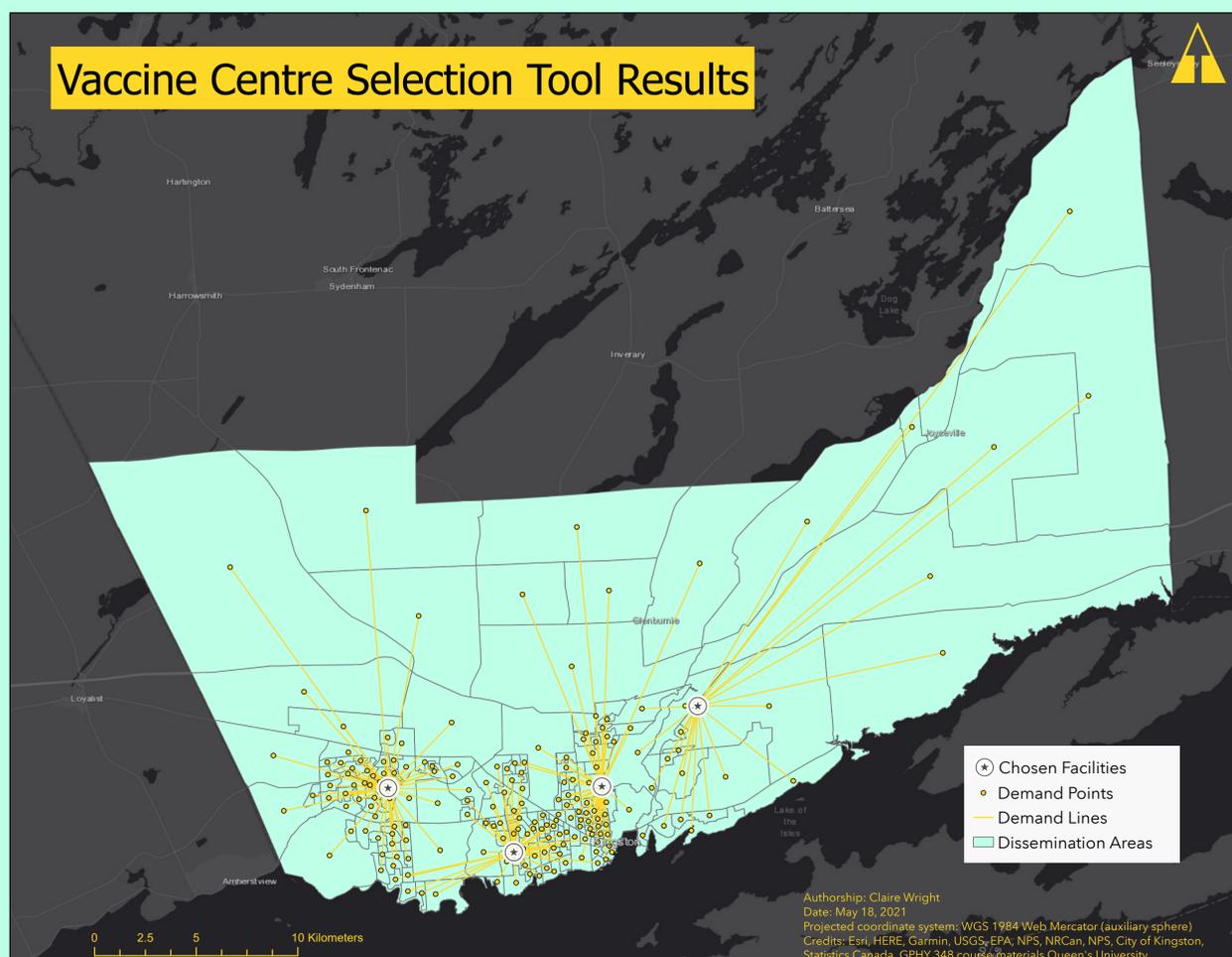
Tool Development and Description

The Vaccine Centre Selection custom script tool was created using Python and the GIS specific ArcPy site package. The tool takes user input for a layer of dissemination areas, a table of census information, and a layer of points of interest. The tool takes a user-input age threshold above which vaccines are being offered. The user is also able to select allowed facility types from a list of all types in the points of interest layer. Data preparation in the tool consists of a join operation between the layer of dissemination areas and a table of population by dissemination area. The centroids of the dissemination areas are exported to a new layer and a new field is added for eligible population according to the age threshold. As well, the points of interest layer is clipped to the extent of the dissemination area layer and facilities that are not of the user-specified types are deleted using a cursor.

To select vaccine centres, the tool creates a Location-Allocation network analysis problem that solves for maximum coverage. The user is able to specify a desired number of candidate facilities. The Location-Allocation problem takes the filtered points of interest as the candidate facilities and the dissemination area centroids as the demand points. The demand points are weighted by eligible population. A layer of chosen facilities, a layer of demand lines, and a layer of demand points are exported to an output workspace that the user specifies.



Vaccine Centre Selection Tool Results



Results

As the map above demonstrates, the Vaccine Centre Selection tool is able to determine which of a set of candidate locations should be used as immunization facilities. It allocates each dissemination area to a certain clinic based on the number of people living in the dissemination area that are aged above the user-specified threshold. The network analysis problem is location-allocation to maximize coverage, so the tool determines the best locations for facilities to serve the set of demand points while covering the most demand. This problem type is ideal in this scenario because it will maximize the accessibility of vaccines to the greatest number of people in the KFLA region.

There are several elements of the script underlying the tool implemented to catch user errors and to allow it to be easily adapted to other health units. The script determines which types of candidate facilities occur in the points of interest layer and presents them as a list in the tool interface. Additional checks are in place to ensure that the feature class of input layers is correct, that the age threshold is a numeric value and that it is not too high (based on the input age data in the census table), as well as to ensure that the number of desired facilities is less than the number of candidate facilities. There is also a statement in place to make sure that the output workspace is a geodatabase as this is required for network analysis.

Conclusion

There is a need for rapid and equitable vaccine delivery in order to combat the ongoing COVID-19 pandemic. This custom GIS tool will enable efficient selection of immunization facilities. The tool allows the user to select vaccine distribution centres from a set of candidate locations that will best serve the population based on a user specified age threshold. There are checks in place to make the tool usable by people who are not familiar with GIS concepts. The tool has the capacity to strongly benefit KFLA Public Health in their efforts to immunize the residents of the Kingston region. It could be easily adapted to serve other health authorities.

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