Automated Delineation of Cancer Service Areas

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Background

This poster reports preliminary results of an ongoing collaboration between the Geisel School of Medicine at Dartmouth College and Louisiana State University to develop an automated network-based community detection method in order to construct spatial units of Cancer Service Areas (CSA) in the Northeast Region of the U.S.

Methods

Data Source. Medicare enrollment and claims files from 1/1/2014 to 9/30/2015 from the Centers for Medicare and Medicaid Services (CMS).

Study Design and Method. A network is constructed for cancer service volumes between 5,969 zip code areas in the Northeast Region of the U.S. (Figure 1). Cancer services include cancer-directed surgeries, chemotherapy, and radiation therapy during the study period. The network optimization method, refined from Hu et al. (2018), defines CSAs by maximizing service volumes within each CSA while minimizing volumes between them. The algorithm is automated in a Geographic Information Systems (GIS) environment, and yields a maximum Localization Index (LI) for a given number of CSAs. LI reflects the proportion of measured utilization that occurs within the service area, and is a critical index of assessing "goodness" of the units. The method also accounts for user-defined constraints such as maximum travel time within each CSA and minimum CSA size (e.g., population).

Results

No. units	Modularity	Localization Index (LI)				Compactness				CSA Population (in 1,000)			
		Min	Max	S.D.	Mean	Min	Max	S.D.	Mean	Min	Max	S.D.	Mean
17 CSAs	0.7881	0.610	0.979	0.088	0.880	2.10	7.52	1.52	3.73	544.1	12123.7	2899.9	3213.1
43 CSAs	0.6082	0.410	0.976	0.149	0.744	1.56	7.39	1.07	3.03	145.7	4255.1	986.6	1270.3
43 HRRs	0.6983	0.185	0.967	0.178	0.676	1.54	7.83	1.53	3.14	199.5	4814.5	1212.7	1265.1
83 CSAs	0.4446	0.118	0.961	0.200	0.611	1.47	7.78	0.91	2.82	125.2	2417.4	451.4	658.1

Our preliminary study defines 17 CSAs in the study area (Figure 2). The 17 regions yield the global maximum modularity value for the network, a quality measure for network community detection.

In comparison to existing health service area units, such as the Hospital Service Areas (HSAs) of the Dartmouth Atlas, the derived CSAs enjoy several advantages:

(1) a significantly higher average LI value,
(2) more compact in geometric shape, and
(3) more balanced in service area size.

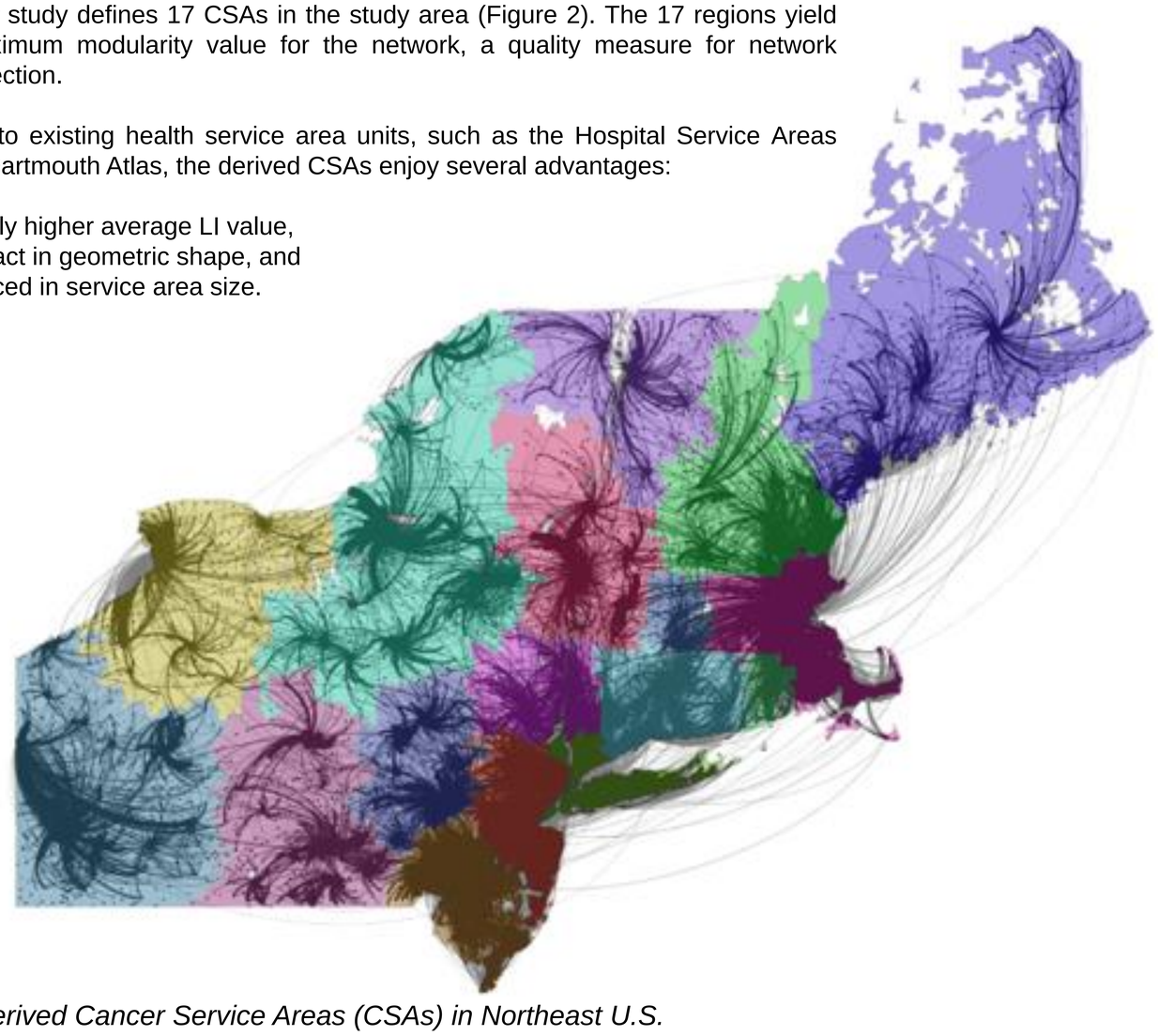

Figure 1: 17 Derived Cancer Service Areas (CSAs) in Northeast U.S. (CSAs in distinctive colors; service flow volumes superimposed)

Discussion

This research reports a pilot study on developing a spatially-constrained community detection method for delineating CSAs that is automated, scale flexible, and consistently generated. In short, the cancer care market is tangled in a complex patients-to-hospitals network, but mainly evolves around magnets that anchor distinctive local communities. The network-based community detection method is an effective approach to delineating the submarket structure of the system by maximizing service flows within communities and minimizing the flows between communities. This is evidenced in more favorable LI values and more balanced region size in the derived CSAs than comparable HRRs.

Limitations

There are a few limitations to the work. The transportation networks do not include analysis on multi-modal transportation networks. This could effect the results of the compactness and modularity. Additionally, there are computational limitations due to the size of the data requiring a stepped approach for the network analysis from primitive to full street centerline data.

Conclusion

The automated, data-driven, and scale-flexible method is an effective and efficient way for health professionals to define CSAs as the spatial unit of analysis of cancer-specific care delivery. The results will allow for assessment of geographic footprints, population characteristics, and per capita oncologist supply across CSAs.

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Selected References:
Hu, Y., F. Wang, and I. Xierali. 2018. Automated delineation of Hospital Service Areas and Hospital Referral Regions by modularity optimization. Health Services Research 53: 236-255.

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