Ambulance Deserts: Addressing Geographic Disparities and Ensuring Access While Minimizing Costs

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Background

- Ambulance services within many states are put together on an "ad hoc" basis, relying on volunteers to fill in the gaps in service areas.
- The result is a system that is in crisis, in that reliance on volunteers and community goodwill is not sufficient to ensure access to reliable quality services throughout the state/region.

Purpose

This paper addresses the need for reforming the current system of ambulance services and suggests a systematic methodology for doing so, with the goal of ensuring access to care while minimizing costs.

Methodology

The *overarching strategy* was to ensure access to care by locating services so that all persons living in the state were covered and living within 25 miles of an ambulance service.

- Both paved and gravel roads were considered in determining coverage.
- A location set covering problem was used to determine the most efficient means of providing coverage.
- EMS locations in all models were restricted to paved roads, while models differed based on the set of potential EMS locations such as:
  - towns with over 8000 people
  - towns that have a hospital
  - incorporated towns
  - on a paved road (if not located in towns)

- Based on the work performed by a national panel of EMS experts (see Jonk et al, "What Does it Cost to Maintain a Rural Ambulance Service?"), the financial resources required to run three ambulance service tiers based on population density were incorporated into the model(s).
- *Sensitivity analyses* within a GIS/economic framework conveyed the most cost-effective set of service locations for ambulance services based on population characteristics, hospital locations, road surfaces, distances traveled, and costs.

Decision Rules:

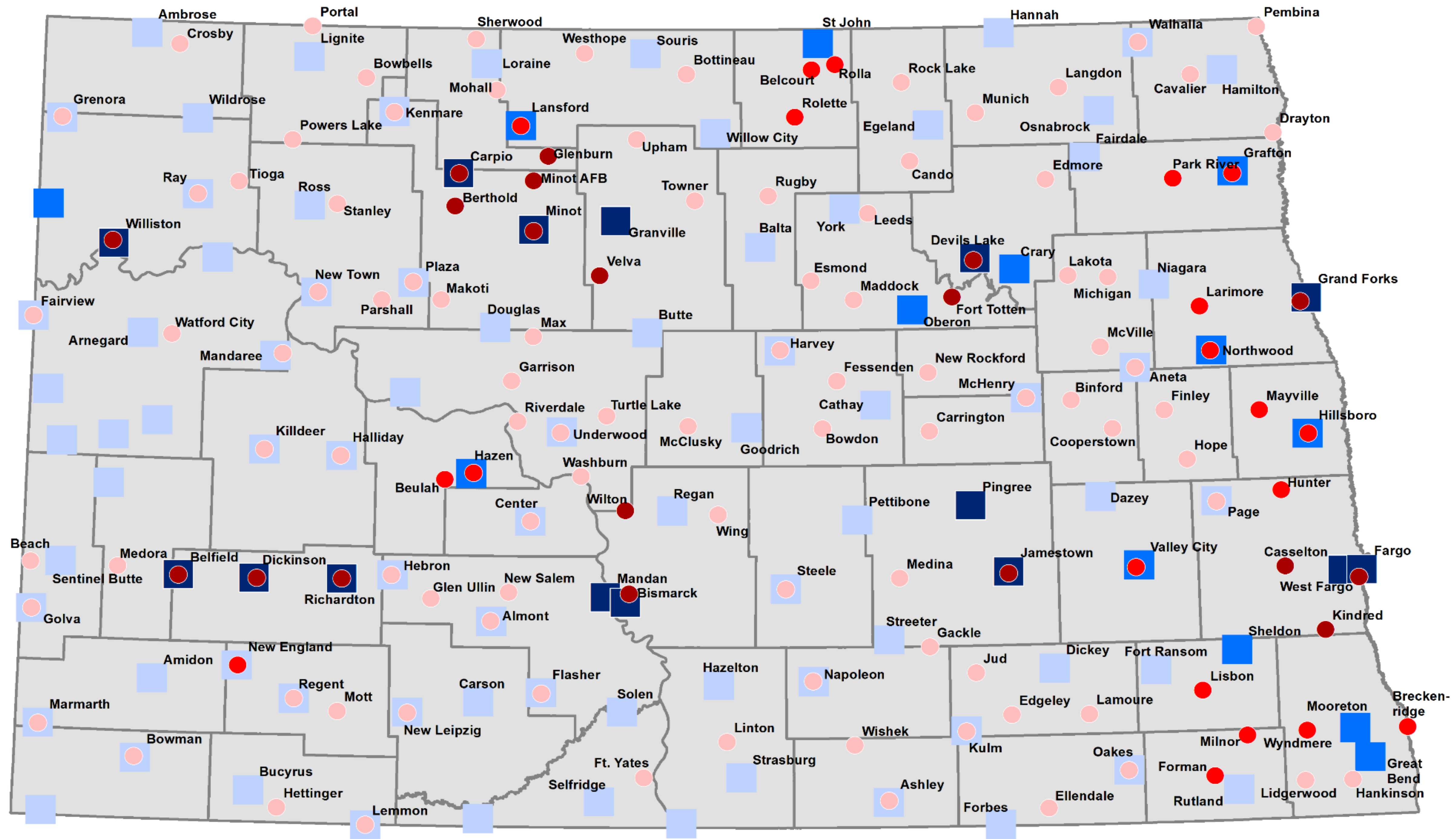
The following decision rules were used to obtain the most cost-effective solution for the state:

1. Does the current distribution of EMS locations provide full coverage?
   a. If yes, could the population be served with fewer services? Identify the optimal number of EMS sites for full coverage.
   b. If no, how many people are not covered and where do they live?
2. Locate additional EMS locations to ensure full coverage based on various scenarios:
   a. Identify optimal number of EMS for unserved areas in addition to the existing (or pared down) set of service.
   b. Ignore current EMS locations, and build system from scratch to identify optimal number and locations of EMS for full coverage.
3. Identify what tiers these ambulances are in based on their service area's population density.
4. Overlay existing and optimal EMS configurations to describe the level of resources needed for better coverage.

Data preparation, management, and visualization was performed in ArcGIS 10.4 (ESRI) while the optimization modeling was performed in CPLEX (IBM).

Results

Figure 1. Proposed New and Existing Ambulance Service Locations.



Current Location Tier
- 1
- 2
- 3

Existing 134 EMS locations serve 99.7% of North Dakota's population in 2010
- Number of Tier 1 EMS = 93
- Number of Tier 2 EMS = 20
- Number of Tier 3 EMS = 21

Optimal Location Tier
- 1
- 2
- 3

Optimal 105 EMS locations serve 100% of North Dakota's population in 2010
- Number of Tier 1 EMS = 77
- Number of Tier 2 EMS = 13
- Number of Tier 3 EMS = 15

Discussion

- Compared to 134 existing services, an optimal set of 105 services (46 existing, 59 new) covered the entire state's population within a 25-mile service area.
- Implementation costs include $132.4m in fixed costs and $56.9m in annual variable costs.
- An optimal solution could realize system savings of $67m in fixed costs and $33.5m in annual variable costs.

Conclusions

Addressing gaps and overlapping coverage areas demonstrates the potential for significant cost savings associated with efficiently locating ambulance services.

Implementing the approach within a Midwestern state demonstrates how other states can assess their "readiness" to respond to emergency situations, and the costs associated with addressing ambulance coverage gaps.

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