The adage “a picture is worth a thousand words” emphasizes the ability of an image to convert a complex data set into a more comprehensible format that may subsequently stimulate further innovation. For example, the advent of coronary angiography more than 50 years ago allowed physicians to visualize coronary anatomy, which subsequently led to the creation of modern-day percutaneous coronary interventions (PCIs). Similarly, geospatial information systems (GISs) can provide a “sky-view” that comprehensively defines the “anatomy” of all regional ST-elevation myocardial infarction (STEMI) systems within each state. Defining the anatomy of each network is the critical first step for implementing regional or statewide quality improvement (QI) “interventions.” Hence, the primary aims of this brief report include (1) a description of prior mapping efforts, (2) methods used for the current STEMI networks GIS mapping project, and (3) potential future directions.

The American Heart Association (AHA) Mission: Lifeline homepage (http://maps.heart.org/ml/) currently contains a first-generation (v1.0) interactive state-based map (with zoom features to the county-level) that simply displays PCI-capable versus non-PCI-capable hospitals. These v1.0 maps are based on 2010 data from the American Hospital Association, which unfortunately lack sufficient granularity to precisely classify the specific role of each hospital within a regional STEMI network. In addition, 2 prior GIS publications1,2 ignored the contribution of non-PCI hospitals to each state’s STEMI system, as both studies focused on the proportion of the nation’s population living within a 60-minute drive time to a PCI-capable hospital.

The overarching goals of this ongoing second-generation (v2.0) STEMI network map project are to accurately categorize every hospital within each state, document existing interhospital transfer relationships and associated transport strategies, and highlight remaining gaps in system coverage. The v2.0 mapping strategy starts with a comprehensive list of US hospitals from the Center for Medicare and Medicaid Services (CMS), followed by categorization of each hospital’s STEMI-care strategy by knowledgeable regional authorities. This approach is best described as “targeted crowd-sourcing” and uses a national database platform to synthesize the collective knowledge of local stakeholders across each state.

For the v2.0 GIS maps, the national CMS hospital list was chosen over the Hospital Association list. Although both allow geocoding via unique hospital identification numbers, the CMS Web site1 provides free public access downloads into Excel format, convenient filter options to easily sort hospitals by state and county, and searches that can be restricted to acute care hospitals. Minor issues with the CMS data set include the occasional existence of one CMS identification number for two “sister-hospitals” located on separate campuses, and rare omission of rural critical access hospitals when cross-checked against the Rural Assistance Center Web site.

Consistent with nomenclature in the Mission: Lifeline v1.0 maps and current Guidelines,3–5 the v2.0 maps start with two broad hospital category types (PCI-capable vs. non-PCI-capable), followed by further subcategorization to identify each hospital’s reperfusion strategy and exact role within a region as summarized in the Table 1. Any PCI-capable hospital should already be in compliance with applicable state laws regarding cardiac surgery on-site.

Key steps in GIS map development are detailed in chronological order below:

1. A comprehensive list of all CMS-registered hospitals within a chosen state (sorted alphabetically by county) was downloaded in Excel format. For simplicity, only key identifiers of each hospital were retained, including 6-digit CMS hospital number, official hospital name, city, state, zip code, and county (phone numbers and other general descriptors were deleted).

2. The Excel list was distributed by e-mail to knowledgeable stakeholders via each state’s leadership structure (eg, Department of Health or State EMS directors) or existing oversight committee (eg, local AHA STEMI task force or EMS authorities). An associated instruction sheet asked each stakeholder to perform 3 tasks on the Excel list:
   a. Verify hospital list accuracy in their county(s). Add hospital names (on a separate Excel row) if 2 sister-hospitals shared the same CMS number but had 2 different campus locations, or if a critical access hospital was missing.
   b. Accurately categorize each hospital into 1 of 7 designations as listed in Table 1.
   c. For Referral Hospitals, designate the associated STEMI Receiving Center(s) and principal mode of interhospital transfer (ground ambulance vs. air transport). If an air transport strategy was selected, ground transport was assumed to be the default option during periods of inclement weather.

3. Each PCI-capable hospital was subcategorized using the 3 choices given below.
   a. STEMI Receiving Center:* provides 24/7 primary PCI, formally designated by regional EMS authorities via destination policies, generally expected to participate in a regional and/or national QI registry(s), and accepts all STEMI patients identified by EMS in their catchment area regardless of insurance status, emergency department (ED) crowding level, or inpatient bed availability (only closes to internal disaster). STEMI centers can also provide PCI for associated Referral Hospitals via organized interhospital transfer protocols.
   b. Daytime primary PCI and after-hours transfer: These hospitals are located within a regional STEMI network, but generally do not receive any STEMI patients from EMS
TABLE 1. Hospital Categories

<table>
<thead>
<tr>
<th>PCI-capable Hospitals</th>
<th>Non-PCI-capable Hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEMI Receiving Centers</td>
<td>Referral (1)- Transfer for primary PCI</td>
</tr>
<tr>
<td>Daytime primary PCI and after-hours transfer for PCI</td>
<td>Referral (2)- Lytics and early transfer</td>
</tr>
<tr>
<td>Non-designated PCI hospital</td>
<td>Referral (3)- Reperfusion strategy varies</td>
</tr>
<tr>
<td></td>
<td>Non-transfer and non-PCI hospital</td>
</tr>
</tbody>
</table>

PCI indicates percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

Moving forward, this GIS map project provides the foundation for a broad portfolio of future initiatives. One obvious step involves integrating these maps with the recently released Mission: Lifeline Regional Reports, thus providing each regional STEMI network with nationally standardized tools to monitor their QI triad of structure-process-outcomes. Other opportunities for the GIS maps include interactive web-based capabilities, the mapping of reuscitation or stroke networks, EMS catchment areas, and overlays incorporating other data sets (eg, baseline comorbidity prevalence, population density, procedural volumes, 30-day risk standardized mortality rates, 30-day readmission rates, or average cost per care episode). Lastly, given the current focus of CMS on value-based purchasing, these GIS maps and data overlays may allow for the development of regional pay-for-performance incentives that promote maximal interhospital collaboration and complete integration with prehospital providers.

In conclusion, the Mission: Lifeline GIS v2.0 STEMI maps combine the strengths of a comprehensive national CMS list with detailed hospital capability categorization by knowledgeable local authorities. Moreover, these GIS maps provide the baseline "anatomic" picture needed for ongoing QI interventions that seek to optimize process-of-care, clinical outcomes, and value in STEMI networks across the 50 states.

ACKNOWLEDGEMENTS

We thank the many regional authorities who voluntarily replied to our queries about STEMI reperfusion strategies and interhospital connections in their jurisdiction.

DISCLOSURES

Drs. Rokos and Henry have received lecture honorariums as faculty for the AHA/Duke STEMI Accelerator Program.

REFERENCES