Surgery, Anesthesia and Obstetric Workforce Density and Surgical Mortality Among Hospital Referral Regions

Nate Hansen | Spring 2020 Poster Expo | PH-262: GIS for Public Health | Dr. Thomas Stopka

Background

- The surgical workforce plays a critical role ensuring access to high quality, affordable surgical care.
- Prior studies examined surgeons without considering anesthesiologists and obstetricians that constitute key components of the surgical workforce.
- The Lancet Commission on Global Surgery (LCoGS) identifies surgeon, anesthesiologist, and obstetrician workforce density as a core indicator of surgical capacity with a recommendation of 20-40 SAO/100,000 population as the minimum standard to ensure quality surgical coverage.[1]
- The United States, like many high-income countries, far exceeds the LCoGS minimum recommendation from a national standpoint, but a granular look at accessible SAO density for subsets of the population has not been measured.

HRRs

- Although studies have shown that up to 30% of all US counties have deficiencies in the number of surgeons,[2] it is not clear how these deficiencies impact surgical outcomes which are more closely related to referral systems larger than the county level.
- **Hospital Referral Regions** (**HRRs**), which are geographic units of analysis that were developed by the Dartmouth Atlas of Health Care to characterize referral patterns to tertiary care centers, more accurately represent the use of surgical services and the distribution of SAO providers.

Objective and Methods

Objective

- I sought to define the SAO density of US healthcare referral regions and the ratio of surgeons:anesthesiologists:obstetricians, determine the association between SAO density and mortality for common emergency general surgery and obstetric conditions among HRRs, and characterize the correlation between SAO density and Health Professional Shortage Areas (HPSAs).

Data Sources

- Counts of practicing surgeons, obstetricians, anesthesiologists, operating rooms, and total deaths were obtained from the Health Resources and Services Administration's 2018-2019 Area Health Resources Files (AHRF) by county.
- Surgical and obstetric emergency mortality was defined based on ICD9 codes identified by Shafi et al that represent emergent general surgical (EGS) conditions[3] and ICD10 codes defined by the World Health Organization that represent emergent obstetric conditions.[4] All codes were searched in the CDC WONDER database, which aggregates deaths by county based on cause of death by county.
- Population level demographic data by US Census block group was obtained from the US American Community Survey (ACS) estimates for 2017.
- Shapefiles for counties and block groups were obtained from the United States Census Bureau, and shapefiles for Hospital Referral Regions were obtained from the Dartmouth Institute for Health Policy and Clinical Practice.

Aggregation

- Counts of providers, operating rooms, and deaths were aggregated up to the HRR level using a county-to-HRR crosswalk. Counties were attributed in whole or in part to HRRs according to the amount of area bounded by each HRR.
- Surgeon, Anesthesiologist, and Obstetrician (SAO) density was defined as the number of practicing surgeons, anesthesiologists, obstetricians, and obstetric specialists per 100,000 population

Analysis

- The independent association between SAO density and surgical mortality was modeled using quantile regression in RStudio, adjusting for number of operating rooms, number of operations, percentage of population living in poverty, median household income, percent uninsured, and percent of population living in health professional shortage areas.
- The independent association between SAO density and the percentage of population living in medically underserved regions was determined using linear regression for HRRs.

Mapping

- Three maps were produced: a map illustrating SAO density across HRRs, a map illustrating mortality rate due to EGS and obstetric conditions across HRRs, and a map illustrating "medically underserved" regions among HRRs.
- GIS procedures used included data joins, choropleth map creation, and field calculation within attribute tables

Discussion

- Increased SAO density is associated with decreased surgical mortality.
- HPSA designation is not a good predictor of SAO density.
- Geographic analysis shows that US meets LCoGS targets at national level, but that disparities in SAO distribution can be seen upon regional analysis.
- Creation of a "surgically underserved" designation akin to HPSA should be explored in order to maximize reduction in surgically-amenable deaths.
- One important limitation of this work is that not all ICD9 codes outlined by Shafi et al were available from the CDC WONDER database, though the codes that were available seemed to span the breadth of general surgery practice
- A significant strength is that SAO density has never previously been studied at a regional level in a high-income country like the United States and the relationship between SAO density and surgical mortality has not been described

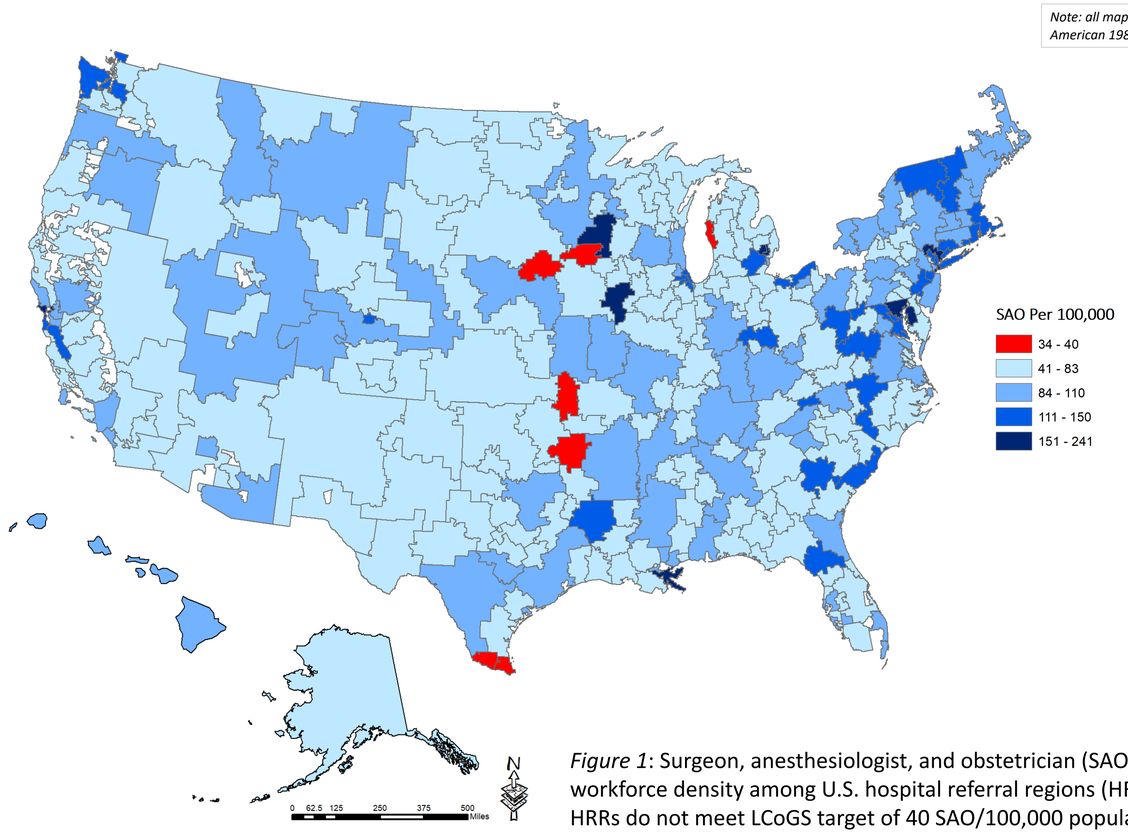

Figure 1: Surgeon, anesthesiologist, and obstetrician (SAO) workforce density among U.S. hospital referral regions (HRR). Red HRRs do not meet LCoGS target of 40 SAO/100,000 population.

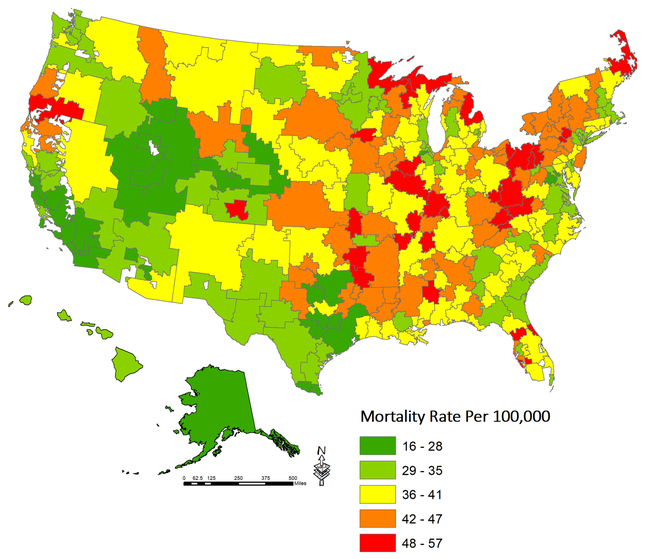

Figure 2: Mortality rate per 100,000 due to emergent general surgical (EGS) or ob-gyn conditions among HRRs

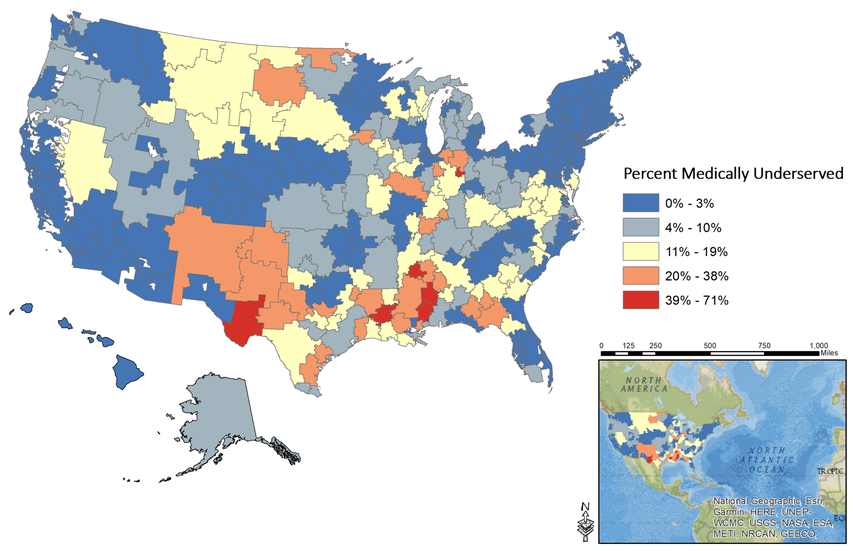

Figure 3: Percent HPSA designation ("medically underserved" status) among HRRs

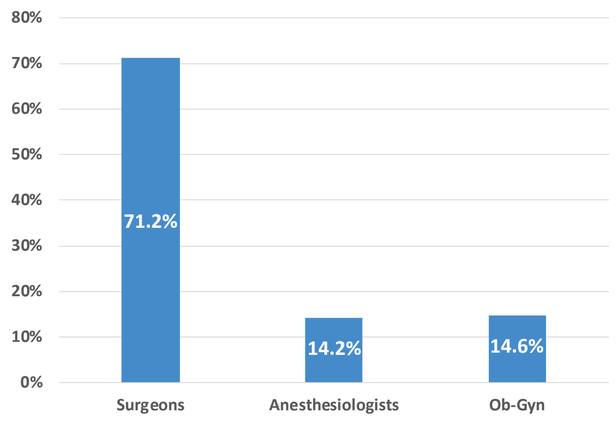

Figure 4: Drivers of SAO workforce density across HRRs

Figure 5: Summary statistics

91.2/100,000 National SAO Density	74.2 (33.3-241.0) Median (IQR) among HRRs
100% SAO > 20/100,000	97.7% SAO > 40/100,000

Figure 5 demonstrates that from a national perspective, the United States far exceeds the LCoGS targets. Furthermore, while all HRRs exceeded the minimum target of 20 SAO per 100,000 population, 2.3% of these surgical referral systems did not meet the recommended target of 40 SAO per 100,000.

Figure 6: SAO density, surgically-amenable deaths, and percent HPSA	10th Quantile	30th Quantile	50th Quantile	70th Quantile	90th Quantile
SAO Density	-0.648	**-0.747**	**-0.885**	**-0.936**	**-1.196**
Percent HPSA Shortage Area	-40.759	-33.862	-65.35	-71.459	-126.663

Figure 6 shows regression coefficients at various quantiles of surgical mortality (10^{th} – 90^{th}). Significant relationships ($p<0.05$) are highlighted in green.

Results

US Surgical Workforce

- The national SAO density was 91.1863 SAO/100,000 population (see Figure 1 for geospatial representation of SAO density by HRR). All HRRs met the Lancet Commission on Global Surgery SAO minimum density target of 20 SAO/100,000. 97.7% of HRRs exceeded the target of 20-40 SAO/100,000 (see Figure 5).

Surgical Delivery

- The mean mortality rate was 37.88 /100,000 (see Figure 2 for geospatial representation of death rate by HRR).
- Across all quantiles, the percent of medically underserved population (HPSA designation) was not significantly associated with SAO density (see Figure 6 – lack of statistical significance indicates no association).
- Surgeons constituted 71.2% of SAO density nationally (see Figure 4)

Relationship Between SAO Density and Surgical Mortality

- SAO density is associated with decreased surgical mortality among all quantiles of HRRs, except for HRRs with the lowest surgical mortality (10th quantile) for which the trend is consistent but not significant (see Figure 6).
- The association between SAO density and decreased surgical mortality increased in magnitude as underlying surgical mortality increased, with the strongest association in the 90th quantile (β=-1.196, $p<0.05$).

Works Cited

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