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Abstract

Background—The incidence and outcomes of out-of-hospital cardiac arrest vary widely across cities. It is unknown whether similar differences exist at the neighborhood level.

Objective—Determine the extent to which different neighborhoods experience persistently high rates of cardiac arrest, but low rates of bystander CPR.

Design & Setting—Multi-level Poisson regression of 1,018 cardiac arrests from 161 census tracts in Fulton County (Atlanta), Georgia, between October 1, 2005 to November 30, 2008, as captured by the Cardiac Arrest Registry to Enhance Survival (CARES).

Measurements—Incidence of cardiac arrest by census tract and year and bystander cardiopulmonary resuscitation (CPR) rates.

Results—Adjusted rates of cardiac arrests varied from across neighborhoods (IQR:0.57–0.73/1000 people; mean 0.64/1000 people, SD 0.10), but were stable from year to year, (ICC=0.36, 95% CI, 0.26–0.50, p value<0.001). Adjusted bystander CPR rates by census tract also varied (IQR: 19–29 percent; mean 0.25, SD 0.10).

Limitation—Analysis based on data from single city.

Conclusion—Surveillance data can identify neighborhoods with persistently high incidence of cardiac arrest and low bystander CPR rates. These represent promising targets for community-based interventions.

Out of hospital cardiac arrest survival rates have been stagnant for more than 30 years.(1) This fact has sparked a “back to the basics” approach that emphasizes early recognition, rapid provision of bystander cardiopulmonary resuscitation (CPR) and early defibrillation. Bystander CPR is clearly effective; one life will be saved for every 24 to 36 people who receive bystander CPR.(1) Boosting bystander CPR rates from the current national average of 27%(2) to 56%(3) could save an additional 1,500 lives per year in the United States.

It is widely known that survival rates vary tremendously by city,(4) but little is known about how the incidence of cardiac arrest and bystander CPR rates vary within particular cities. If the incidence of cardiac arrest at the level of a neighborhood is sufficiently stable, this could provide justification for targeting scarce public health resources, such as educational outreach and the placement of public access defibrillators, in specific neighborhoods. If certain neighborhoods have a high incidence of cardiac arrest but relatively low rates of bystander CPR, they may represent promising areas for targeted CPR training. To assess the feasibility of identifying candidate neighborhoods, we analyzed data from a cardiac arrest registry to determine: (a) if incidence rates of cardiac arrest are stable within census tracts, and (b) the extent of variability in rates of bystander CPR.

METHODS

The data were drawn from the Cardiac Arrest Registry to Enhance Survival (CARES) in Fulton County, Georgia, containing the city of Atlanta. In brief, CARES is an EMS-based registry for out-of-hospital cardiac arrest, where review of EMS logs is coupled with selected, anonymized extraction of hospital information. Detailed information is published elsewhere.(5, 6) From October 1, 2005 to November 30, 2008, CARES captured all 911-activated cardiac arrest events where resuscitation was attempted and the etiology was presumed to be cardiac. CARES analysts confirmed the capture of all cardiac arrests by each city's 911-center during the data review process.

All cases submitted to the registry during the study interval (n=2,028) were eligible for inclusion. A case was excluded if 1) prehospital resuscitation was not attempted based on local EMS protocols (e.g., obvious signs of death such as rigor mortis, decomposition, lividity; n=66); 2) EMS personnel determined that the arrest was due to a non-cardiac etiology (e.g., trauma, electrocution, drowning, or respiratory; n=283); or 3) the patient was not eligible for bystander CPR by a non-healthcare professional (i.e. patient's arrest occurred in a medical facility such as a nursing home or medical clinic) or the event was witnessed by EMS (n=468). We also excluded cases if: 4) data documenting the patient's clinical outcome was missing (n=24); 5) the patient's cardiac arrest location address could not be mapped (n=60); or 6) the event occurred in Atlanta's Hartsfield-Jackson International Airport, a public facility that is heavily monitored, has numerous trained rescuers and public access defibrillators (n=19 cases).

Because the CARES registry contains only de-identified data, our study was considered exempt research by the University of Michigan Institutional Review Board.

Data Collection and Processing

Fulton County's four EMS agencies prospectively submitted data in accordance with the CARES user agreement. The registry collects and links a limited standard set of data elements from three sources: 911 call centers, EMS providers, and receiving hospitals. A data analyst independently reviewed all submitted reports.

The CARES dataset was geocoded based upon the address of the cardiac arrest event using ArcGIS and Spatial Analyst Extension Software (Environmental Systems Research Institute (ESRI), Redlands, CA). We used census tracts as proxies for neighborhoods, as they tend to represent social and economically homogenous groups of approximately 4,000–7,000 people.(7) Census tract variables were linked using the 2000 US Census Summary files.(8) All statistical analyses were conducted using STATA version 10.0 (College Station, TX).

Data Analysis

To determine if certain census tracts produced more cardiac arrest events year by year, we first conducted a multilevel Poisson regression to assess the stability of the number of cardiac arrests by census tract and year. The year 2008 estimates were adjusted for only collecting data on eleven out of the twelve calendar months. We determined the intra-class correlation (ICC) to quantify the extent to which census tracts have stable rates of cardiac arrest by year. We then determined the incidence of cardiac arrest and rates of bystander CPR by census tract using Empirical Bayes methods to adjust the estimated rates for reliability, based on the number of cases observed.(9, 10) Based on these reliability-adjusted rates for incidence and CPR, we then identified census tracts that appear to have the highest and lowest potential for gains to be made. Those census tracts that appeared to have a higher incidence of cardiac arrest and lower rates of bystander CPR were considered to be possible higher-gain neighborhoods; as compared to those census tracts with a lower incidence rate of cardiac arrest and a higher bystander CPR rate, which were termed lower-gain neighborhoods.

RESULTS

1,108 cases met study criteria. Table 1 displays demographic, clinical and EMS statistics of study patients. 279 patients received bystander CPR. Forty-one patients (3.7%) survived to hospital discharge; 20 of the 41 received bystander CPR.

The average census tract had an adjusted incidence of 0.64 events/1000 people, SD 0.11, (IQR:0.57–0.73/1000 people), unadjusted rates varied widely from 0.04–2.11/1000 people. The mean number of cardiac arrests per year was 2.21 (SD 1.91, IQR 1–3.23). Twenty-five census tracts had more than twice that number in one or more of the three study years. Seven census tracts had at least 6 arrests in two of the three study years (Appendix Table 1). The ICC for between census tract variation was 0.36 (95% CI, 0.26–0.50, p value<0.001), indicating that neighborhoods that had high incidence of cardiac arrests in one year were more likely to have high rates the following year. Similar results were obtained when examining the absolute number of cardiac arrests, rather than a population-adjusted incidence (ICC 0.29 95% CI, 0.20–0.42). The census tracts from the highest and lowest gain areas are displayed in Figure 1, to highlight the stability of the occurrence of cardiac arrest across the three-year time period.

The mean rate of bystander CPR for the entire sample was 25% (SD 10%). However, bystander CPR rates varied widely across neighborhoods – unadjusted rates ranged from 0% to 100%. After adjustment for reliability**,** rates still varied from 10% to 57%. There was little association between the incidence of cardiac arrest events and reliability-adjusted bystander CPR-rates (correlation coefficient =0.13).

Fourteen census tracts appear in the lower right area of Figure 2, which has the highest reliability-adjusted incidence of cardiac arrests and the lowest reliability-adjusted bystander CPR rates. These census tracts could represent higher-gain areas that are potential targets for neighborhood-based CPR interventions. Of note, the triangles in Figure 2 correspond to the solid black lines in Figure 1, which represent the higher-gain census tracts; while the dots in the upper left corner in Figure 2 correspond to the dashed black lines in Figure 1, which represent the lower-gain census tracts. All fourteen higher-gain census tracts have mostly African-American residents (43.2% to 98.2%; Fulton County mean: 44.6%), lower median household incomes ($13,880 to $45,525; Fulton County median income: $47,321) and fewer high school graduates (46.7% to 86.1%; Fulton County mean: 84.0%) than is typical of Fulton County (Appendix Table 1).

DISCUSSION

This is the first study to demonstrate relative stability in the incidence of cardiac arrest within census tracts from year to year. It is also the first to show that it is possible to identify census tracts that are both higher-risk settings for cardiac arrest occurrence and relatively low bystander CPR rates. While the presence of cardiac arrest “hot spots” has been inferred, (11) it has not been previously shown that hot spots persist long enough to provide a useful target for intervention. Our data indicate that some census tracts experience 2–3 times higher incidence of cardiac arrest than others. We were also able to identify census tracts that have dramatically lower rates of bystander CPR than achieved in other parts of the same county. These census tracts may present promising settings for heart health promotion, CPR training, public access defibrillator placement, and other community-based interventions. If we were able to improve rates of bystander CPR in the full sample to the level achieved by the highest performing census tracts in Fulton County, an additional 355 people would receive CPR. This could save an additional 15 lives each year.

These findings have public health implications. Our analysis suggests that neighborhoods, as defined by census tracts, are an appropriate target for interventions to increase cardiac arrest survival by increasing bystander CPR. Offering CPR training to likely witnesses of cardiac arrest in selected neighborhoods—those most likely to benefit from higher rates of bystander CPR—may represent a more effective approach to CPR training than the current strategy, which tends to enlist young, healthy volunteers who are less likely to witness a cardiac arrest. Such neighborhood-based public health approach may produce the added benefit of building social capital,(12) and shows the utility of an EMS-based registry such as CARES, than can be used to target increasingly scarce public health dollars.

Our study is limited in certain respects. First, the data are derived from a cardiac arrest registry based on EMS and 911 reports that is capturing cardiac arrests of presumed cardiac etiology in which a resuscitation was attempted.(5) Intensive epidemiologic case-finding might identify additional cases that were not known to EMS or not “worked” as active resuscitations, and were therefore excluded from this database – although such arrests seem unlikely to have benefited from CPR. Second, our study is based on data from a single urban county. Replications will be needed to determine if other communities also have temporal stability. Finally, we used census tracts to approximate neighborhoods. Census tracts do not precisely match neighborhoods as perceived and described by residents, but they are a data structure routinely available for public health planning.

Despite extensive programs aimed at educating the public about CPR at the national and local level, wide variations in cardiac arrest incidence and bystander CPR provision exist within different census tracts in Fulton County, Georgia. Community-based surveillance data can be used to identify areas with high incidence of cardiac arrest and low rates of bystander CPR for targeted interventions. This may represent a fruitful avenue to focus community level interventions, and increase rates of cardiac arrest survival.(1)

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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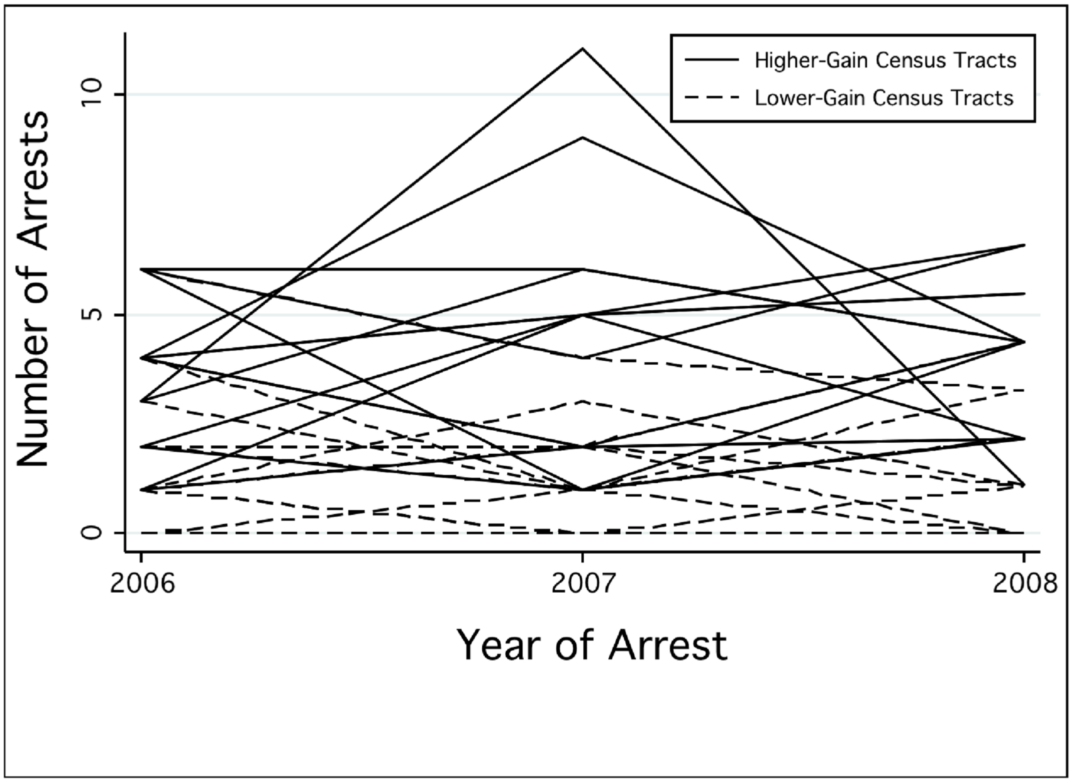
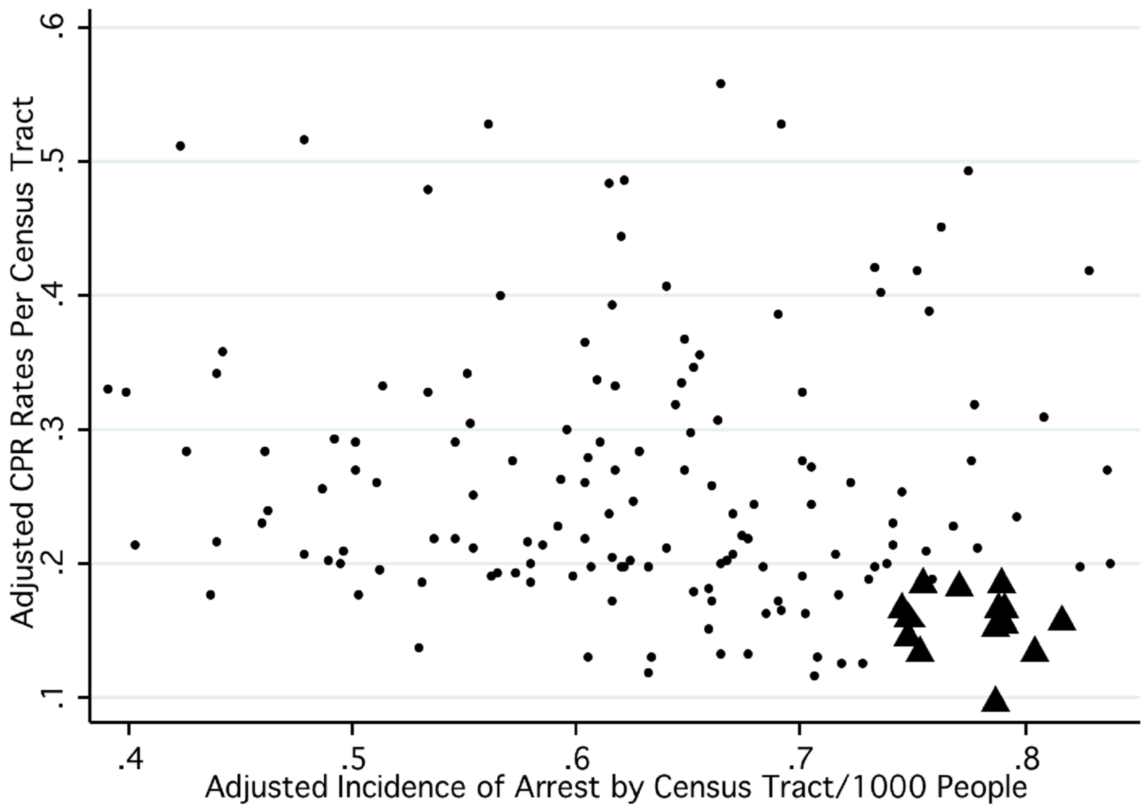


Figure 1.
Cardiac Arrest Events Across the Three-Year Time Period



*Higher-gain census tracts are represented by the triangles in the bottom righth corner, and correspond to the solid black lines in Figure
*Lower-gain census tracts are represented by the dots in the upper left corner, and correspond to the dashed black lines in Figure 1.

Figure 2.
Adjusted Incidence and CPR Rates by Census Tract in Fulton County, Georgia

Table 1

Patient Demographics & Cardiac arrest Characteristics

	Bystander CPR (n=279)	No bystander CPR (n=829)	P value
Age (SD) (n=1082)	60.8 years (18.2)	62.5 years (17.3)	0.171
Sex			
Female (n=466)	20.8%	79.2%	0.011
Male (n=640)	28.4%	71.6%	
Race			
White (n=209)	36.4%	63.6%	0.001
Black (n=396)	21.7%	78.3%	
Other (n=27)	25.9%	74.1%	
Unknown (n=476)	23.1%	76.9%	
Witnessed Arrest (n=489)	32.1%	67.9%	<0.001
Unwitnessed Arrest (n=615)	19.7%	80.3%	
Location of Arrest			
Private (n=847)	20.8%	79.2%	<0.001
Public Location (n=261)	39.5%	60.5%	
Presenting Rhythm			
VF/VT/Unknown Shockable (n=257)	35.8%	64.2%	<0.001
Unknown Unshockable (n=79)	20.2%	79.8%	
Asystole (n=564)	24.5%	75.5%	
Pulseless Electrical Activity (n=208)	15.9%	84.1%	
Who First Applied AED	96.5%	3.5%	<0.001
Bystander (n=29)			
First Responder (n=379)	22.2%	77.8%	
EMS (n=685)	23.9%	76.1%	
Overall Survival to Hospital Discharge (n=41)	7.2%	2.5%	