Published in final edited form as:

Ann Emerg Med. 2017 October ; 70(4): 533–543.e7. doi:10.1016/j.annemergmed.2017.03.029.

Geographic Variation in Use of Ambulance Transport to the Emergency Department

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Abstract

Context—Evidence on variability in emergency medical services (EMS) use is limited.

Objective—To obtain national evidence on geographic variation in the use of ambulance transport to the emergency department (ED) among Medicare enrollees, and assess the role of health status, socioeconomic status (SES) and provider availability.

Design, Setting, and Participants—We used 2010 Medicare claims data for a random sample of 999,999 enrollees aged 66 and older, and identified ambulance transport and ED use.

Main Outcomes Measures—Number of ambulance transports to ED per 100 person-years (*ambulance transport rate*) and proportion (%) of ED visits by ambulance transport by hospital referral regions (HRR).

Results—The national ambulance transport rate was 22.2 and the overall proportion of ED visits by ambulance was 36.7%. Relative to HRRs in the lowest rate quartile, HRRs in the highest quartile had a 75% higher ambulance transport rate (incidence rate ratio (IRR), 1.75; 95% confidence interval (CI) = [1.69, 1.81]) and a 15.5% higher proportion of ED visits by ambulance (IRR, 1.155; 95% CI = [1.146, 1.164]). Adjusting for health status, SES, and provider availability

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Author Contributions:

ADH and JF conceived the study and obtain research funding. ADH, MKP-O, KSD, WEB and JF supervised the study design and definition of study measures. ADH and CF performed the processing and analysis of data. All authors contributed to the interpretation of the findings and writing of the manuscript. ADH takes responsibility for the paper as a whole.

Disclosures: None of the authors have a conflict of interest.

Disclaimers: None.

reduced quartile 1 vs. quartile 4 difference in ambulance transport rate by 43% (IRR, 1.43; 95% CI = [1.38, 1.48]) and proportion of ED visits by ambulance by 7% (IRR, 1.145; 95% CI = [1.135, 1.155]). Among the three covariate domains, health status was associated with the largest variability in ambulance transport rate (30.1%), followed by SES (12.8%) and provider availability (2.9%).

Conclusion—Geographic variability in ambulance use is large, and associated with variation in patient health status and SES.

INTRODUCTION

Emergency medical services (EMS), ranging from 9-1-1 calls and medical dispatch to emergency and trauma care that take place prior to a patient's arrival to the hospital, are a vital component of the out-of-hospital healthcare system which covers virtually all ill and injured Americans. Despite its recent growth – most of the current infrastructure was developed in the last 60 years – there is “enormous variability in the design of EMS systems among states and local areas”, with half the systems relying on the local fire department.^{1,2}

To date there is little evidence on geographic variation in EMS use.¹ Data from the National Hospital Ambulatory Medical Care Survey (NHAMCS), an annual survey of ED patients, indicates that the number of ambulance transports to the ED was 20.4 million in 2012, amounting to 6.5 transports per 100 population.³ NHAMCS data are the basis for much of the current national evidence on ambulance transport to ED;^{4–6} however, due to limited sample size, geographic variation cannot be measured.⁷ Other cohort studies of hospitalized patients with acute conditions have examined use of ambulance transport in evaluating patient outcomes, but provide little information on geographic variability.^{8–11} Also, as much of the current evidence is based on data about ED patients and since propensity to seek ED care varies by geography, rates of use of ambulance transport at the community level may differ from that among ED patients.¹²

Our aim in this study was to evaluate geographic variability in the use of ambulance transport to the ED at the community level and among ED patients. Combining individual data on patient health status for a national sample of Medicare enrollees with area level socioeconomic and provider data, we also evaluated the relative role of three factor domains – health status, SES and provider availability – in accounting for the geographic variation in ambulance use.

MATERIALS AND METHODS

Study Design

We performed a retrospective cohort study of a random sample of Medicare enrollees aged 66 and older and their use of ambulance transport to ED.

Data Sources

Our primary data source was administrative claims data covering all inpatient and outpatient care received by Medicare enrollees. Among all Medicare enrollees, we identified 22.1

million enrollees aged 66 or older on 1/1/2010 and who were continuously enrolled in the Fee for Service plan (parts A and B) during 2009–2012. Treating these enrollees as the sampling universe, we obtained a random sample of 999,999 enrollees stratified by region, race/ethnicity and (zip code level) household income. We included those 66 and older to ensure availability of data on at least one year of prior healthcare utilization in Medicare. We used Dartmouth Institute's partitioning of the country into 306 hospital referral regions (HRR), derived from identification of contiguous areas wherein a majority of acute inpatient care of residents is provided;¹³ our sample has 1,140 to 11,470 enrollees from each HRR. We obtained person-level sampling weights to provide estimates for the universe of 22.1 million enrollees. We examined the use of ambulance transport and emergency department (ED) care during 2010, or till death for enrollees who died during 2010.

As factors that potentially mediate geographic variation in ambulance and ED use, we identified several area-level and hospital-level data from prior literature on geographic variation in healthcare utilization.^{12,14,15} We used Census data on zip code-level SES measures, including median household income, English language proficiency, and foreign birth.¹⁶ We characterized provider availability based on proximity to hospitals using data from the American Hospital Association survey (2010)¹⁷, area-level availability of physicians from the Dartmouth Institute¹⁴ and urban designation of enrollee county residence.¹⁸

Identification of ambulance transport and ED visits

In the Medicare data we identified individual ED visits not resulting in admission based on outpatient claims (revenue center codes 0450–0459 or 0981), and ED visits resulting in inpatient admission using inpatient claims (a positive value of emergency room charge amount).¹⁹ We identified emergent ambulance transport to a hospital ED from a non-hospital setting using claims arising from ambulance transport and ED visit. First, we identified ambulance service claims for emergent ground transport (*HCPCS code* A0427, A0429 or A0433 and a positive value in the mileage indicator field A0425) from any location other than a hospital (based on the *origin* field) to a hospital (based on the *destination* field).^{20,21} Second, to ascertain transport to an ED, we included ambulance transport claims for which the date of service was the same day or the day prior to the date of ED visit.

Outcomes

Our main outcomes were *ambulance transport rate*, defined as the number of ambulance transports to ED per 100 person-years and an indicator of community-level ambulance use, and *proportion of ED visits by ambulance*, defined as the proportion (%) of ED visits using ambulance transport, an indicator of ambulance use among ED patients. As a secondary outcome we also examined the number of ED visits per 100 person-years, the *ED rate*.

Covariates

We identified enrollee age at baseline, sex, and race/ethnicity (grouped as Hispanic, non-Hispanic black, non-Hispanic white, non-Hispanic Asian and Others); Others included 0.02% of enrollees with no race/ethnicity information. In identifying Hispanics, we used the

imputed Hispanic indicator field (included in the Medicare enrollee data), developed using name and location data.^{22–24}

We characterized enrollee health status by the prevalence status for 24 chronic conditions identified by CMS based on claims from prior healthcare claims.^{25,26} These conditions were developed by the Department of Health and Human Services to identify Medicare enrollees at risk of multiple chronic conditions and higher healthcare utilization.²⁷ Containing common chronic conditions among the elderly, including, heart disease, stroke, cancer, COPD, kidney disease and osteoporosis, there is considerable overlap with other commonly used comorbidity classifications (e.g., Elixhauser Comorbidity)²⁸. We characterized the reason for an ED visit using the admitting diagnosis code (for those hospitalized) or the principal discharge diagnosis code (for those not hospitalized); this ICD-9-CM code was categorized using Agency for Healthcare Research and Quality's Clinical Classification System.²⁹ The admitting diagnosis was used instead of the principal diagnosis as the former is a better indicator of the presumed reason for seeking ED care; this code is unavailable for ED visits not resulting in admission.³⁰

For enrollees who died during 2010 we used the number of days (in 2010) till death as the observation (exposure) period; all others were observed for the whole year (365 days). This measure is used to obtain ambulance transport and ED rates per 100 person-years of observation.

To characterize socioeconomic status we used several patient and zip code level indicators. Using enrollee data we identified those with dual Medicare-Medicaid coverage (as of January 2010) as an indicator of low income.³¹ We mapped enrollees, using their residence zip code, with Census measures on median household income, English language proficiency ("speak English less than well"), vehicle ownership, foreign birth, and rental housing (proportion of households in rental homes).¹⁶

We identified several measures of provider availability based on the location of all non-federal general and surgical hospitals with an ED.¹⁷ We identified if enrollee residence zip code was within 5 miles of an ED, number of EDs within 5 mile distance, and characteristics of the nearest ED hospital (teaching hospital status, critical access hospital status, ownership and bed size). As availability of healthcare resources and patterns of their use vary by regional population and density, we characterized enrollee's county location using the federal designations of *metropolitan statistical area*, *micropolitan statistical area*, and *other areas*.¹⁸ We also included a HRR-level measure of the number of all physicians per 1,000 population.¹⁴

Analysis

Our analysis had two objectives: first, to measure the extent of geographic differences in three measures – ambulance transport rate, ED rate and the proportion of ED visits by ambulance – and second, to evaluate the potential mediating factors associated with the geographic differences. All our results are based on appropriate adjustment for the sampling (stratification) design and weights so as to produce estimates representing the aforementioned national population of 22.1 million Medicare enrollees.

The overall ambulance transport rate was obtained as the observed number of ambulance transports per 100 person-years of observation. For comparability across regions, we obtained age-sex adjusted ambulance transport rate for each HRR using Poisson regression estimates with the number of ambulance transports for each enrollee as the outcome measure, and age, sex and HRR indicators as covariates.¹⁵ Using the number of ED visits for each enrollee as the outcome measure, we used a similar approach to obtain estimates of overall ED rate and age-sex adjusted ED rate for each HRR. To estimate the proportion of ED visits by ambulance, we aggregated all enrollees into cohorts by age, sex and HRR (N=1,836) and defined the proportion of ED visits by ambulance for each cohort as the outcome measure. The overall proportion of ED visits by ambulance was measured as the average across cohorts, adjusted for sampling stratification and weights. HRR-level age-sex adjusted proportion of ED visits by ambulance was obtained from estimates of a linear regression with cohort-specific proportion of ED visits by ambulance as the outcome and age, sex and HRR as covariates.

To examine potential mediators associated with geographic variation in outcome measures, we grouped the 306 HRRs into quartiles based on HRR-level age-sex adjusted value of each outcome measure. Treating the lowest quartile as the reference category, we measured the relative rate in the other quartiles two ways: without adjusting for any mediators (“base model”) and adjusting for all mediators (“full model”). The change in the relative rate, say, between the highest and the lowest quartile, between and base and full models was the basis for measuring geographic differences associated with mediators.³² Additional details about this approach are provided in the Appendix.

As noted in the previous section, we examined a range of potential mediators, relating to multiple domains (e.g., patient health status and SES). To further evaluate the independent contribution of the different mediators, we first grouped them by domain into three categories: patient health status, SES, and provider availability. We obtained the contribution of each domain by re-estimating the full models with the mediators from each domain included vs. excluded. Additional details about this approach are provided in the Appendix. Our choice of potential mediators and methodology was drawn from previous studies of variation in Medicare spending and patient outcomes.^{15,32}

We performed several secondary analyses. First, we compared rates of prevalence of chronic conditions across HRR quartiles using Poisson regression models adjusting for age and sex; we also tested for linear trend in prevalence rate by HRR quartile. Similar analyses were also performed for comparing across HRR quartiles the incidence of the common acute conditions associated with ED visit. Second, given prior evidence of geographic variation in overall Medicare spending, we examined the correlation between HRR-level ambulance use measures and total Medicare annual spending (age-sex adjusted).^{12,14,15}

We obtained heteroskedasticity-consistent robust standard error estimates adjusted for the stratified sampling design and weights.³³ Statistical significance was assessed at the level of $p < 0.05$. All estimation was performed using Stata Version 14.1.³⁴ The Boston University Medical Campus Institutional Review Board approved this study.

RESULTS

During 2010 our study sample of 999,999 enrollees had 627,993 ED visits, of which 230,221 were via ambulance transport. 53,690 enrollees (5.4%) died during 2010. Overall there were 22.2 ambulance transports to ED and 58.3 ED visits per 100 person-years, with proportion of ED visits by ambulance of 36.7% (Table 1 and Appendix AT1). Ambulance, ED and proportion of ED visits by ambulance were higher among enrollees who were older, women, had dual Medicare-Medicaid coverage and those with closest ED hospital characterized by larger bed size (>300 beds), non-critical access hospital and for-profit ownership. Ambulance and ED rates were higher among non-Hispanic blacks and in areas with low income, limited vehicle ownership, ED proximity and nearest ED in a teaching hospital.

Geographic variation in ambulance use

We found large geographic variation in ambulance and proportion of ED visits by ambulance: adjusted for age and sex, ambulance transport rate ranged from 16.3 (ambulance transports to ED per 100 person-years) in the lowest quartile HRRs to 28.4 in the highest quartile; the corresponding range for proportion of ED visits by ambulance was 27.6% to 43.1% (Table 2). Individual HRRs had sharply differing rates: ambulance transport rate ranged from 9.3 (Takoma Park, MD) to 37.8 (Charleston, WV), and proportion of ED visits by ambulance ranged from 15.1% (Baltimore, MD) to 57.6% (Wilkes-Barre, PA) (Table 2). HRRs with high ambulance transport rate are distributed across many states, and states with HRRs with high ambulance transport may have lower proportion of EDs by ambulance (Figure and Appendix AT2). However, Massachusetts, New York and Ohio had HRRs in the highest quartile on both measures; and lowest quartile HRRs on both measures were concentrated in the Midwest and Mountain regions.

Factors associated with geographic variation

Adjusting for health status, SES and provider availability, the difference in ambulance transport rate between the highest (quartile 4) and lowest (quartile 1) ambulance transport rate HRRs was reduced by 43% between the base model (1.75, 95% confidence interval (CI)=[1.69,1.81]) and the full model (1.43, 95% CI=[1.38, 1.48]) (selected estimates are in Table 3; complete regression estimates are in Appendix AT4). The corresponding difference decreased by 50% for quartile 2 vs. quartile 1 and by 45% for quartile 3 vs. quartile 1. Among the 3 domains, health status accounted for the largest proportion of variability (30.1%) between quartile 4 vs. quartile 1 HRRs, followed by SES (12.8%) and provider availability (2.9%). Alzheimer's disease and dementia (IRR=1.73), lung cancer (1.57), heart failure (1.53), COPD (1.51) and dual Medicare-Medicaid coverage (1.47) were associated with higher ambulance transport use. Compared to non-Hispanic whites, Hispanics (0.73) and Asians (0.61) had lower rates, while non-Hispanics blacks had a higher rate (1.09). Geographic variation in the proportion of ED visits by ambulance was relatively smaller; the age-sex adjusted rate in the highest quartile HRRs exceeded that in the lowest quartile HRRs by 15.5% (interquartile ratio=1.155) (selected estimates in Table 3; complete regression estimates are in Appendix AT5). Adjustment for all the covariates in the full model reduced this differences modestly (7%), to 14.5%.

Correlation between ambulance use and overall healthcare use

We found positive correlation between annual Medicare spending per person (\$) and both measures of ambulance use (R-squared: ambulance transport rate=27%, proportion of ED visits by ambulance=14%) (Figure 2).

LIMITATIONS

We recognize several limitations of this study. First, we recognize the limitations associated with the use of claims data in study of healthcare utilization in general and for ambulance and ED use in particular^{34,35}: accuracy and quality of clinical codes may be inconsistent; reported diagnosis codes do not capture patient severity and may understate patient comorbidity; and Medicare claims data only include services covered by CMS. We concede that our analysis to obtain risk-adjusted rates of ambulance and ED use by geography may be affected by inconsistency in coding by providers and regions. However, Medicare data have unique strengths compared to other claims and survey data. The Centers for Disease Control's National Hospital Ambulatory Medical Care Survey (NHAMCS) data are too small to be used for geographic comparison even at the state level. The Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project national databases (National Inpatient Sample and Nationwide Emergency Department Sample) do not contain information on ambulance use; further, information on ED use in the National Inpatient Sample and Nationwide Emergency Department Sample is based on a random sample of hospitals/patients from a subset of all states (N=33) and do not contain a patient identifier to capture repeated ED use. Medicare data do not have these limitations have been commonly used in the assessment of utilization and health outcomes associated with ambulance and ED services. [Sanghavi 2015; Doyle 2015; Nyweide 2016; Caines 2016; Gan 2016] In the present study, our primary focus is on utilization of ED and ambulance services; as Medicare covers both ambulance and ED use, our data are likely to comprehensively include all use of these services and suitable for examining geographic differences in utilization.

Second,, our data do not include Medicare enrollees on managed care plans; they comprised 23% of all Medicare enrollees in 2010.³⁶ Unfortunately, utilization data for such enrollees is not yet available; accordingly, our study findings may not be generalizable to this population. Also, while our estimates (for 2010) are not based on the most recent Medicare data, our supplementary analysis of ambulance and ED utilization rates for the cohort survivors in a later year (2014) indicated stability in the rates over time, overall and among age and sex subgroups. Third, limited patient-specific socioeconomic measures in the Medicare data may underestimate their relative role in geographic variability. We included a range of zip code-level indicators of SES; however, we recognize their limited sensitivity compared to patient-specific measures.³⁷

DISCUSSION

We highlight three findings on ambulance use to ED among Medicare enrollees. First, there is wide geographic variability: measured by the number of ambulance transports per 100 person-years, there was a four-fold difference between the lowest (9.3) and highest (37.8)

rates across hospital referral regions (HRR). Second, health status, accounted for the largest variation in ambulance transport rate (30.1%), followed by SES (12.8%) and provider availability (2.9%). Third, geographic variability in ambulance use measured at community level differs from that measured among ED users.

To our knowledge, this study provides the first estimates on geographic variability in ambulance use at the community level. Our estimates and those from previous studies (primarily based on NHAMCS data) are not directly comparable due to differences in time of data. While our study estimated 22.2 ambulance transports per 100 person-years in 2010, an earlier study estimated this rate to be 16.7 (1997–2000).⁵ Another previous study estimated an ambulance transport rate, by age group, of 10.9 (age 65–74) and 26.2 (age 75 and older) in 2003;⁴ the corresponding rates in our data were 11.5 and 31.2. To better understand the differences, further research needs to perform side-by-side comparison of the different sources of ambulance and ED use.

Health status accounted for 30.1% of the ambulance transport rate difference between the highest and lowest quartile regions. This pattern is consistent with studies of geographic variation in overall Medicare spending which found that health status accounted for up to 30% of the spending variation.^{15,38} We recognize that greater use of medical services is associated with identification or documentation of more health problems, which may overestimate the share of variation in ambulance use attributed to health status.¹⁵

Our findings indicate lower ambulance use among many subgroups: Hispanics, Asians, areas with limited English proficiency, and non-metropolitan statistical areas. This is consistent with evidence of access barriers in the use of ambulance and ED services in the form of limited transport alternatives, health literacy, and English proficiency.^{39–45} In assessing the implications of differential ambulance use, we note that there is “no expert consensus on what constitutes medical necessity for ambulance use” and perception of emergent need may vary.^{39,46} Evidence indicates that ambulance use is associated with improved patient outcomes, particularly for time-sensitive acute medical events, such as, stroke,⁸ myocardial infarction, cardiac arrest¹¹ and respiratory failure.¹⁰

An unexpected finding was the difference in patterns of ambulance use among the community population versus that among ED patients. Note that ambulance use among ED patients is measured by the proportion of ED visits by ambulance measures, and that among community population is measured by the ambulance transport rate. We found that health status, SES and provider availability were associated with 43% of the variability in ambulance use at the community level and 7% of the variability among ED patients. One plausible explanation is that access to ambulance services may itself be an important mediator in use of ED services; that is, those with access barriers for ambulance services may also have barriers to access ED care. Given that much of the current evidence on ambulance use is based on NHAMCS data, which is a survey of ED patients, our findings indicate that the patterns on ambulance use obtained from NHAMCS data may not be representative of population-level patterns in use of ambulance.^{5,7,39,44,47}

In light of the enormous variability in the ownership, organization and operation of EMS across local areas and regions, the Institute of Medicine cited “limited evidence base” as a key deficiency in the development of national performance standards. Addressing an evidence gap, this study provides the first broad-based national estimates on geographic variability in use of emergency ambulance transport among Medicare enrollees. Health status and SES were associated with substantial ambulance use variation at the community level; these findings suggest a need for further research to evaluate appropriateness of ambulance use, barriers in its use, and impact on patient care and outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Disclosure Statement: This research has been supported by NIH grants (1R01HL127212, A. Hanchate and J. Feldman, PI and 1R01MD007705, A. Hanchate, PI). Dr. Amresh Hanchate had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. The views expressed in this article are those of the authors and do not necessarily represent the views of the National Institutes of Health, Boston University, or Department of Veterans Affairs. The authors acknowledge receipt of Medicare data from the Centers of Medicare and Medicaid Services (CMS); CMS, their agents and staff, bear no responsibility or liability for the results of the analysis, which are solely the opinion of the authors.

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A. Quartile of age-sex adjusted ambulance transport rate, by hospital referral region

B. Quartile of age-sex adjusted % ED visits using ambulance, by hospital referral region

Figure 1. Geographic variation in ambulance transport rate and proportion of ED visits by ambulance by hospital referral region¹

Notes

1. In defining the four quartiles for each of the 3 outcome measures, we used the direct standardization method to estimate age-sex adjusted rate of each outcome measure by hospital referral region (HRR). We then grouped the 306 HRRs into quartiles by the HRR-level age-sex adjusted outcome rate (e.g., ambulance transport rate) and HRR-level enrollee population so that all quartiles have approximately similar enrollee population sizes. To enable adjustment of estimates (and standard errors) for stratified sampling design and weights we implemented direct standardization using Poisson regression models. For ambulance transport rate we estimated a person-level model (N=999,999), and for

proportion of ED visits by ambulance we estimated an HRR-cohort level model ($N=306*3*2=1,836$) where each HRR enrollee population was stratified by age (3 categories) and sex.

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Figure 2. Correlation between HRR-level ambulance use and Medicare spending

Notes:

1. For Figure 2a, a HRR-level (N=306) linear regression of age-sex adjusted ambulance transport rate on annual Medicare spending per person (2010 \$) was estimated. The R-squared was 0.27. For Figure 2b, a HRR-level (N=306) linear regression of age-sex proportion of ED visits by ambulance on age-sex adjusted annual Medicare spending per person (2010 \$) was estimated. The R-squared was 0.14.
2. Medicare spending figures, obtained from Dartmouth Institute were adjusted for age, sex, race and price differences by region.

Observed Rates of Emergent Ambulance Transport and Emergency Department Visits Study population: National random sample of 999,999 Medicare enrollees aged 66 and older

Table 1

	# sample enrollees	Frequency % (weighted)	Ambulance transport rate	ED rate	Proportion of ED visits by ambulance, %
All	999,999	21,635,416	22.2	58.3	36.7%
Sex					
Men	42%	42%	19.1	55.1	34.7%
Women	58%	58%	24.4	69.6	37.9%
Age					
66–74	49%	44%	11.5	41.4	28.2%
75–84	36%	38%	23.1	62.0	37.4%
85+	15%	18%	48.0	94.0	50.0%
Race/ethnicity					
White, non-Hispanic	31%	86%	21.8	56.8	38.5%
Black, non-Hispanic	31%	7%	32.0	82.6	38.7%
Hispanic	31%	4%	21.5	62.7	33.8%
Asian	4%	2%	13.5	37.0	36.6%
Others	3%	1%	16.6	51.1	32.4%
Socioeconomic status					
Low income zip code	50%	49%	24.1	62.6	36.7%
High income zip code	50%	51%	20.3	53.9	36.6%
Insurance					
Medicare only	75%	88%	18.9	52.8	33.3%
Dual Medicare + Medicaid	25%	12%	46.6	99.2	43.0%
Speak English less than well					
<=10% zip code population	71%	81%	22.0	58.7	36.5%
>10% zip code population	29%	19%	23.3	56.8	37.6%
Don't own vehicle					
<=10% zip code population	42%	47%	19.4	54.8	34.5%
>10% zip code population	58%	53%	24.7	61.5	38.2%
Closest ED within 5 miles					

	# sample enrollees	Frequency % (weighted)	Ambulance transport rate	ED rate	Proportion of ED visits by ambulance, %
No	61%	60%	23.2	59.5	37.2%
Yes	39%	40%	20.8	56.6	35.9%
Location					
Metropolitan Statistical Area	82%	78%	22.8	57.0	38.0%
Metropolitan Statistical Area	10%	12%	20.5	60.9	32.0%
Other areas	8%	10%	19.7	65.3	30.2%

Notes:

1. Selected characteristics are reported here; all other characteristics are included in Appendix Table AT1.
2. Ambulance transport rate = # ED visits using ambulance transport per 100 person-years; ED rate = # ED visits per 100 person-years. Note that the proportion of ED visits by ambulance is not a simple ratio of ambulance transport rate to ED rate; instead it is the sampling weight-adjusted average of the proportion of ED visits by ambulance defined at the cohort (age/sex/HRR) level, as noted in the Analysis section.
3. All rates are adjusted for the stratified sampling design and weights to represent the rates for the underlying sampling universe of 21.6 million Medicare enrollees aged 66 and older continuously enrolled in the Fee for Service plan from 2009 to 2012.
4. Income is measured in terms of median household income at zip code level. Other zip code level measures included – speak English less than well, don't won vehicle – are measured for zip code population aged 65 and older.
5. Metropolitan statistical area denotes county or counties with a core urban area with 50,000 or more population and micropolitan statistical area denotes with core urban area population between 10,000 and 50,000.

Table 2
Geographic variation in age-sex adjusted ambulance transport and proportion of ED visits by ambulance by hospital referral region (HRR)

Age-sex adjusted rate is reported with the corresponding 95% confidence interval

a. Rates by HRR Quartile		
	Ambulance transport rate	Proportion of ED visits by ambulance, %
Lowest Quartile	16.3 [15.8, 16.7]	27.6% [26.9%, 28.3%]
Second Quartile	21.6 [20.9, 22.2]	34.1% [33.7%, 34.5%]
Third Quartile	23.9 [23.2, 24.5]	37.6% [37.2%, 38.1%]
Highest Quartile	28.4 [27.7, 29.1]	43.1% [42.5%, 43.6%]

b. Top/Bottom 3 HRRs				
Highest/Lowest HRRs by Rate	Ambulance transport rate		Proportion of ED visits by ambulance	
	HRR Name	Rate [95% CI]	HRR Name	Rate [95% CI]
Lowest HRR				
1	Takoma Park, MD	9.3 [6.0, 10.6]	Baltimore, MD	15.1% [10.8%, 19.5%]
2	Provo, UT	10.3 [7.8, 12.8]	Takoma Park, MD	16.6% [11.7%, 21.5%]
3	Baltimore, MD	10.6 [8.2, 12.9]	Provo, UT	18.5% [15.2%, 21.8%]
Highest HRR				
1	Charleston, WV	37.8 [30.1, 44.9]	Wilkes-Barre, PA	57.6% [52.6%, 62.6%]
2	Worcester, MA	37.1 [31.3, 42.8]	Bronx, NY	52.6% [48.8%, 56.4%]
3	Kingsport, TN	36.4 [28.4, 44.4]	Springfield, MA	50.5% [47.9%, 53.4%]

Notes

1. As noted earlier (Figure 1), we identified the hospital referral regions (HRRs) that form the four quartiles for each of the 3 outcome measures based on age-sex adjusted rates of each outcome by HRR. Estimates for ambulance transport rate are age-sex adjusted rates for each quartile obtained from an enrollee-level Poisson regression model (N=999,999) of number of emergent ambulance transports on age, sex and indicators of quartiles of hospital referral regions, treating the number of days alive during 2010 as the exposure measure. The regression estimates (rates and standard errors) were adjusted for stratified sampling design and weights. Estimates for proportion of ED visits by ambulance (%) were obtained using HRR-cohort level data where HRR enrollee population was stratified by age (3 categories) and sex (N=306*3*2=1,836), a linear regression model with observed proportion of ED visits by ambulance as the outcome measure and indicators of age, sex and HRR quartiles as covariates, and stratified sampling weights.

2. Table 2B gives the age-sex adjusted rate based on direct standardization method; these HRRs estimates were also used in defining HRR quartiles identified in Figure 1.

Table 3

Factors associated with variation in ambulance transport rate and proportion of ED visits by ambulance

a. Interquartile difference in ambulance and proportion of ED visits by ambulance: Base and full models						
Hospital referral regions by ambulance use quartile	Ambulance transport rate			Proportion of ED visits by ambulance		
	Interquartile ratio (Reference=Quartile 1)		% reduction in interquartile difference in full model	Interquartile ratio (Reference=Quartile 1)		% reduction in interquartile difference in full model
	Base Model	Full Model		Base Model	Full Model	
Quartile 1 (low)	1.00	1.00		1.00	1.00	
Quartile 2	1.32 [1.28, 1.38]	1.16 [1.12, 1.21]	50%	1.066 [1.058, 1.073]	1.059 [1.052, 1.067]	9%
Quartile 3	1.47 [1.41, 1.53]	1.26 [1.21, 1.31]	45%	1.100 [1.092, 1.109]	1.093 [1.084, 1.102]	7%
Quartile 4 (high)	1.75 [1.69, 1.81]	1.43 [1.38, 1.48]	43%	1.155 [1.146, 1.164]	1.145 [1.135, 1.155]	7%

b. Contribution of each domain to differences in ambulance and proportion of ED visits by ambulance between quartile 1 and quartile 4 hospital referral regions (HRR)			
Domain	Factors included	Contribution of each domain factors to the difference in ambulance use measure between quartile 1 vs. quartile 4 HRRs	
		Ambulance transport rate	Proportion of ED visits by ambulance
Health status	Chronic conditions (N=24)	30.1%	2.4%
Socioeconomic status	Race/ethnicity, Medicaid, and zip code income, English language proficiency, rental home, vehicle ownership (N=10)	12.8%	2.9%
Provider availability	Metropolitan location and distance to nearest ED (N=3)	2.9%	2.0%

Notes:

1. The results reported here are selected estimates from the base and full model regressions. For the complete regression estimates corresponding to Table 3a see appendix Table AT4, and for the complete regression estimates corresponding to Table 3b see appendix Table AT5.
2. The focus here was on examining the extent to which factors from the 3 domains (health status, socioeconomic status and provider availability) account for the difference in ambulance and proportion of ED visits by ambulances between the first and the remaining quartiles. We took the age-sex adjusted differences (base model) as the baseline interquartile difference, and examined the changes in the interquartile differences in the full model after adding the factors from the 3 domains. All estimates from base and full models for ambulance transport rate are reported in Appendix table AT2 and that for proportion of ED visits by ambulance are reported in Appendix table AT3.
3. For analysis of ambulance transport rate, base and full models were Poisson regressions and interquartile differences were estimated as incidence rate ratios treating quartile 1 as the reference group. The % reduction in interquartile difference is measured between base and full models for each quartile. For instance, quartile 4 vs. quartile 1 difference lowered from 1.75 (base model) to 1.43(full model), reduction of 43%.
4. For analysis of proportion of ED visits by ambulance, base and full models are linear regression models. Interquartile difference between quartile 1 and each other quartile was estimated as the ratio in model adjusted rates for quartiles. For instance, the adjusted proportion of ED visits by ambulance ratio between quartile 4 and quartile 1 from the base model was 1.155.
5. In Table 3b, the focus was on the extent to which full model factor domains accounted for the difference interquartile differences in the base model (in Table 3a). Here we focused only on the difference between quartile 1 and quartile 4; that is, we assessed how much did each of the 3 domains contributed in the 43% reduction in quartile 4 vs. quartile 1 difference in ambulance transport rate. One approach is to sequentially add factors from each domain and assess the change in quartile 4 vs. quartile 1 difference; but this approach is sensitive to the ordering of the sequence of domains added. Instead, following Birkmeyer et al. (2003), we measured the percentage change in the interquartile difference (quartile 1 vs. quartile 4) from dropping all the covariates related to a domain from the full model. For instance, to assess the contribution of health status, we estimated the model with all covariates except health status and estimated the % change in the quartile 4 vs. quartile 1 difference. The sum of contributions from all domains do not add to 100% since contribution from each domain is obtained by comparison, not with the base model, but with a model with all other domains included; hence it is a conservative estimate of the exclusive contribution of each domain.