# Neighborhoods Matter: A Population-Based Study of Provision of Cardiopulmonary Resuscitation

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**Study objective:** Cardiorespiratory resuscitation (CPR) non-provision—the failure of bystanders to provide CPR to cardiac arrest victims—remains a well-documented public health problem associated with significant mortality. Multivariate data on failure to provide CPR are limited. Given the established independent contributions of neighborhoods to explaining many behaviors, we asked the following questions: Do neighborhood characteristics affect the likelihood of CPR non-provision? In particular, we sought to identify the characteristics of areas that have had the most success in providing CPR.

**Methods:** We performed multivariable logistic regression analysis of a prospectively collected cohort of 4,379 cardiac arrests linked at an individual level to neighborhood data from the US Census. These arrests represent all out-of-hospital cardiac arrests in the City of Chicago in 1987 and 1988.

**Results:** In multivariate analysis, patients who had cardiac arrests who lived in neighborhoods where cardiac arrests were more common were significantly more likely to receive CPR. Patients with arrests in racially integrated neighborhoods were most likely to be provided with CPR, followed by those in predominately white neighborhoods, with the lowest rates of CPR provision in predominately black neighborhoods. Neither the socioeconomic status, number of elderly, nor the occupational characteristics of the neighborhood appeared to influence CPR provision. At the individual level, in-home arrests and arrests among middle-aged black residents (relative to older black and all white residents) were less likely to receive CPR.

**Conclusion:** Substantial variation in rates of CPR nonprovision exists between neighborhoods; the variation is associated with neighborhood characteristics. Combining individual and neighborhood data allows identification of important factors associated with the failure to provide CPR.

## INTRODUCTION

Rapid cardiopulmonary resuscitation (CPR) provided by
bystanders has been shown to increase the odds of surviv-
ing an out-of-hospital cardiac arrest by 2 to 3 times.[1-5]
Unfortunately, a large majority of victims who need CPR
never receive it—that is, CPR nonprovision is common.[6]
This persistent failure to provide CPR during a crisis has
prompted organizations such as the International Liaison
Committee on Resuscitation to call for a "redoubling of
efforts" to teach the public CPR.[7] Indeed, more widespread
public CPR and an optimal emergency medical services
(EMS) system could potentially save 48,000 lives annu-
ally in the United States alone.[8]

Despite this evidence of effectiveness, surprisingly lit-
tle is known about who provides CPR in the community.
No studies have attempted to define the characteristics of
that majority of bystanders who do not provide CPR.
Previous reports on the provision of CPR have followed 1
of 3 analytic strategies: (1) describing characteristics of
actual providers of CPR,[9] (2) surveying general popula-
tions to determine rates of CPR training,[10-14] or (3)
describing the characteristics of victims who have higher
rates of receipt of CPR.[15-17] These approaches have limi-
tations. Studies describing those who provided CPR over-
look differences between those who actually performed
CPR and those who did not; typically no more than a
fourth of arrest victims receive CPR and therefore do not
provide information about the majority of bystanders
who are CPR nonproviders.[9,18] Studies that report rates
of CPR training in the general population provide no
detailed information about who actually provides CPR at
the moment of crisis[10-14]; moreover, there is reason to
suspect that significant numbers of untrained citizens
provide CPR.[18] Studies looking at the characteristics of
victims of cardiac arrest in order to understand CPR pro-
vision must assume that victims resemble the bystanders
at their arrest.[15-17]

This previous work, although informative, does not
address a core issue of CPR provision: who does *not* pro-
vide CPR. Those who fail to provide CPR are the natural
target for future efforts to realize the lifesaving potential
of CPR. To identify groups least likely to provide CPR, it is
necessary to have data describing both that minority who
provide CPR as well as the much larger population nearby
at the time of a cardiac arrest who did not provide CPR.
This is a difficult problem, because the people not provid-
ing CPR are precisely the people no longer there when
EMS personnel arrive with those who might collect data.
We propose to study neighborhood level effects on the
provision of CPR as one approach to this problem.
Although the precise identity of the people in any neigh-
borhood varies moment to moment, neighborhoods are
relatively stable and much less heterogeneous than the
city as a whole—neighborhoods define a measurable con-
text from which the CPR provider must emerge.

Neighborhoods have long been an important subject
of research[19,20] with applications to the study of health
behavior,[21] children's development,[22] and the exchange
of help between family members.[23] Features of neighbor-
hoods such as the income level, level of schooling, age
composition, and racial composition are often the focus
of this work. These results have reinforced the common-
sense notion that the social environment in which people
act may have effects independent of the individuals' char-
acteristics and experiences. Here we explicitly test the
hypothesis that neighborhoods matter for the provision
of CPR, although we recognize that other levels of social
organization may also have effects.

To test the effects of neighborhoods, we link previously
unexamined subsets of the CPR Chicago database[17] at the
individual level with data about the neighborhood in
which the arrest occurred (from the 1990 US Census).
That is, we use a population-based sample of all cardiac
arrests in the City of Chicago and evaluate the characteris-
tics of the few blocks around the location of a cardiac
arrest. Because the City of Chicago is large and heteroge-
neous, there exists a sufficient variety of situations to
allow us to disentangle the effects of 3 sorts of variables—
those associated with the arrest itself, those variables that
measure characteristics of the arrest victim, and those
that measure characteristics of the neighborhood in
which the arrest occurred. We always include certain con-
trol variables that have been shown important in other
populations—particularly location of the arrest,[24]
whether the arrest was witnessed,[24] and the age, race, and
sex of the victim.[15-17,24,25] We examine a set of variables
to formally test for independent effects of the following
hypotheses about the reasons CPR is provided: (1) that
neighborhoods in which more cardiac arrests occurred
are likely to be sensitized to the risks, and hence more
likely to provide CPR; (2) that higher socioeconomic sta-
tus of a neighborhood—measured as median income,
population density, employment, or education levels—is
associated with greater provision of CPR[26]; (3) that the

number of health care providers living in the neighborhood is positively associated with the provision of CPR; and (4) that the racial composition of the neighborhood is associated with the provision of CPR. Finally, we perform some exploratory data analyses to develop a richer understanding of the factors that lead to CPR provision. This includes tests as to whether racially integrated neighborhoods show the same distinctive patterns in regard to CPR provision that they show in other realms.[27] In this analysis, we focus exclusively on the provision of CPR, because the impact of CPR on survival has been well described in previous studies.[1-5,8]

## MATERIALS AND METHODS

The CPR Chicago project collected data on all out-of-hospital cardiac arrests whose victims were cared for by the EMS Services of the City of Chicago during 1987 and 1988; it has been described previously in detail.[2,17] Approval for this study was received from the institutional review boards of all 47 participating hospitals in the City of Chicago. The victim's age, sex, race, receipt of bystander CPR, whether the arrest was witnessed, time of call to paramedics, incident address, and home address of the victim were abstracted from Mobile Intensive Care Unit forms. To these data, we linked census tract information for each individual by incident address. The census tract containing each address was identified by the Bureau of the Census' TIGER census tract/street index. Data were extracted for each census tract from the Summary Tape File 3b of the 1990 Census.[28] The 1990 Census, although not quite precisely contemporaneous with the collection of the cardiac arrest data, provided the richest source of neighborhood data available.

According to the Bureau of the Census, a census tract is "a relatively homogenous area with respect to population characteristics, economic status, and living conditions with an average population of 4,000."[28] They are relatively small, consisting of about 9 square blocks; the median area of a tract in our study is 0.656 km² (0.25 sq mile). Tract boundaries do not overlap and are drawn to coincide with lived neighborhood boundaries. There are more than 800 census tracts within the City of Chicago. Characteristics of those tracts available from the census include age distribution, racial composition, educational levels, family income, and percent employed (Figure 1).

CPR Chicago collected data on 7,151 out-of-hospital arrests. These included all cardiac arrests in adults at least age 18 without obvious noncardiac etiology (eg, drowning, trauma). In the present analyses, we excluded

**Figure 1.**

*Characteristics of census tracts of the City of Chicago. A, Distribution of sizes of the census tracts in which there occurred at least 1 cardiac arrest included in this study. B, Histogram of the degree of racial homogeneity in each tract; the horizontal increment is 2% per bar. Census tracts in the City of Chicago have the following median (interquartile range) characteristics: population: 3,022 (1,738 to 4,096); percentage of the population living in households without an English speaker: 3.6% (0% to 11.9%); percentage of the tract's adult population that is working: 47% (44% to 50%); percentage of the tract's population with at least some college: 33% (24% to 49%); percentage working in the health care industry: 9.3% (5.9% to 12%); and, household income: $25,415 ($17,096 to $32,388).*
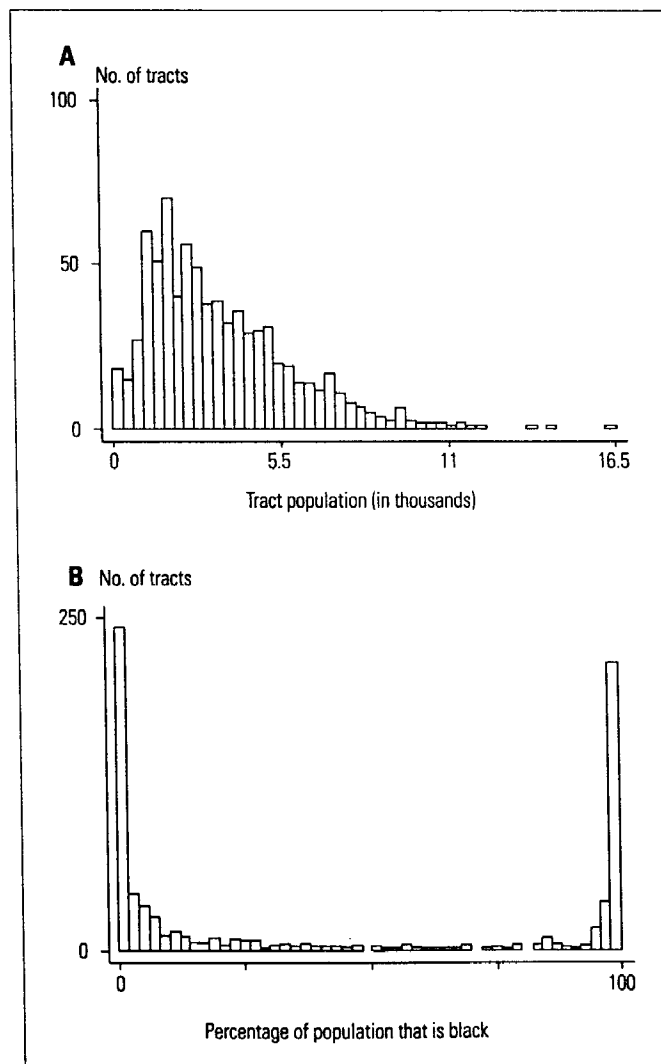
cardiac arrests occurring in nursing homes (780), arrests witnessed by paramedics (597), and arrests in jail (22); there were 5,752 possible cases.

We then excluded arrests missing information on whether CPR was received (1,114) or other crucial data (259), leaving 4,379 (76.1%) analyzable cases in our cohort. In the last excluded category were the 172 arrests that could not be unambiguously assigned to an inhabited census tract (eg, those whose cardiac arrest occurred at a park or airport) and 87 missing other important data, such as age or sex. The 1,373 (1,114+259) excluded cases were slightly younger (65.7±5.4 years versus 67.4±15.4 years), and less likely to be black (38.4% versus 44.7%), but did not differ statistically from the others with respect to sex or witness status. As described below, we conducted sensitivity analyses to test the degree to which the exclusion of these cases may have altered our findings.

In the cohort of 4,379, we included 566 cases that were missing data on whether the arrest was witnessed; these cases were dealt with by substituting the mean value for the population as a whole and including a dummy variable representing missing data among the explanatory variables in the regression model.[29] The coefficient for this dummy variable had no meaningful interpretation in this setting. The dummy variable allowed us to use the other information on cases where witness status was missing without biasing the coefficient estimates for the effect of witness status itself.

Race of the victim was coded by the paramedics at the scene of the arrest. The 118 (2.8%) victims whose race was coded as "Hispanic" and 58 (1.3%) victims coded as "other" were included with those whose race was coded as "white" in this sample because (1) most Hispanics self-identify their race as white in the census,[27] and (2) discussions with emergency medical technicians led us to believe most Hispanics were coded as "white." Our data therefore cannot support explorations beyond this black/white dichotomy. Home and incident addresses were compared to determine if they were the same. If the incident and home addresses occurred on the same block, they were coded as the same. For the 42 (0.7%) cases where an incident address was available but a home address was missing, these cases were assigned as if they had not occurred at home.

Several summary measures were constructed from the census data, including (1) employment (fraction of men and women age 16 and older who worked during 1989); (2) the fraction of those employed who worked in health care; (3) education (fraction of adults at least age 25 who attended some college); (4) linguistic isolation (fraction of households without a fluent English speaker, according to the Census definition); (5) population density (in units of thousands of people per square kilometer); (6) race (fraction of the census tract that reported their race as black, ranges from 0 to 1); and (7) median household income of the tract (in units of thousands of dollars). Regression results are reported in relative units for these census variables unless otherwise indicated; for example, a 1-unit increase in the fraction working represents an additional 10% of the tract's population employed. All neighborhood variables are included in the regressions as continuous variables, and results are presented for a 1-unit change in the units defined above. Thus, the odds ratio for employment measures the change in the rates of CPR provision associated with an increase of 10 percentage points in the rate of employment in the neighborhood (eg, it is the change in the rates of CPR provision between 2 otherwise identical neighborhoods where 1 neighborhood has a 40% employment rate but the second has a 50% employment rate).

The number of arrests occurring in each tract during the 2 years for which we had data was computed and converted to a per-capita rate using the population of the tract. This was entered in the regression as a logarithm to the base of 2; a 1-unit change in this variable is therefore interpretable as the result of doubling the per capita rate of arrests in the tract.

All analyses presented here were conducted at the individual level. The main dependent variable of interest was receipt of CPR from a bystander at the time of the arrest. Bivariate relationships were evaluated using Pearson $\chi^2$ tests for dichotomous variables and with logistic regression for continuous variables; 95% confidence intervals (CIs) were computed.[30] We simultaneously estimated the effects of individual and neighborhood characteristics on the dependent variable using multivariable logistic regression. Unless otherwise specified, odds ratios reported in the text are from the logistic regression, and are referred to as "adjusted." CIs on proportions receiving CPR were computed.[31] Preliminary analyses demonstrated a strong difference in the age profiles of CPR provision by race; therefore, a race and age interaction was tested. Other interactions with plausible rationales were tested; none were found significant and so were not included in the model presented here. (Results of these and all other alternative specifications of the model mentioned herein are available from the authors on request.) To control for the natural clustering of the arrests within tracts, we used

the method of White[32] as implemented by Allison.[33] This algorithm alters the standard errors of the coefficients to take into account pseudoreplication and produce accurate CIs and *P* values. This is one of the limitations of ecologic data of the type we used[34,35]; throughout we were careful to accommodate these limitations. Correlation matrices and outputs were inspected for the possibility of collinearity; there were no apparent symptoms. To ensure that subgroups were not driving the results, regressions stratifying on key variables were analyzed and inspected for substantial differences in patterns. Adequacy of fit of the multivariable model was assessed using the Hosmer-Lemeshow deciles of risk $\chi^2$ test; we also used standard techniques of graphical identification of outlier residuals and testing of our results for sensitivity.[36]

To evaluate the relative explanatory power of the variables, an approach that partitions the fitted variance between the sets of variables was used.[37] These estimates were based on the variance-covariance matrix obtained after correction for clustering. This method only explains the relative contributions of the variables to the explanatory power of the model; it does not assess the overall explanatory power of the model. No simple analog to the $R^2$ of linear regression is available for logistic regression; such measures are in general sensitive to the inclusion and scaling of the independent variables.[36]

Although the difference between the excluded cases and the study cohort was small, as described above, we performed the following tests to determine whether the excluded cases of the sample (for victims for whom only receipt of CPR was unknown) selectively influenced our results. The logistic regression analyses performed here was duplicated under 2 extreme assumptions: that all those cases missing data on CPR receipt in fact received CPR, or that none did. Although the magnitude of the coefficients changed, the sign and significance of the major variables described in this report were not altered from those reported under either of the 2 extreme assumptions.

Two adjustments were performed to assess the effects of the measurement error of the census as to the characteristics of bystanders of those victims whose arrests occurred in commercial areas. (The errors occur because the census is a survey of *households*.) In all analyses, those whose arrests occurred in parks or other completely nonresidential areas (<5% of all out-of-hospital arrest victims) were excluded, as previously described. The analyses here were also replicated sepa-

rately for those cases for which the incident arrest was more than a block from the victim's home address. The coefficients of these stratified regressions were very similar (data not shown).

## RESULTS

Of the 4,379 cases in the study population, 22.7% of cardiac arrest victims received CPR from a bystander. Most (84.7%) of the cardiac arrests in the cohort occurred at the victim's home; the rest occurred in other inhabited areas such as streets, neighbors' homes, local restaurants, and so on. There were witnesses to the actual moment of arrest for 47.4% of cases. Cardiac arrest victims had a mean age of 67.4 years (SD±15.4 years); 44.7% were black; 57.1% were men.

**Table.**
*Associations between receipt of bystander CPR and arrest, victim, and neighborhood characteristics.* *

| Did the Victim Receive Bystander CPR? | Odds Ratio (95% CI) | |
|---|---|---|
| | Unadjusted* | Adjusted* |
| **If the arrest was** | | |
| Witnessed† | 1.37 (1.17–1.60) | 1.41 (1.17–1.71) |
| At home | 0.64 (0.53–0.76) | 0.52 (0.41–0.66) |
| **If the victim was** | | |
| Male | 0.97 (0.84–1.12) | 1.04 (0.89–1.20) |
| Black | 0.62 (0.53–0.72) | 0.82 (0.56–1.21) |
| 10 years older (for whites) | 1.01 (1.00–1.01) | 1.02 (0.94–1.10) |
| 10 years older (for blacks) | 1.38 (1.32–1.43) | 1.23 (1.16–1.29) |
| **If the neighborhood** | | |
| Had twice as many arrests per capita | 1.71 (1.59–1.83) | 2.30 (1.84–2.88) |
| Was integrated (versus all white)‡ | 2.41 (2.03–2.86) | 1.43 (1.01–2.02) |
| Was all black (versus all white)‡ | 0.49 (0.41–0.59) | 0.38 (0.24–0.60) |
| Median income was $1,000 higher | 1.00 (1.00–1.01) | 0.99 (0.97–1.00) |
| Had 1,000 more people/km² | 1.03 (1.01–1.04) | 1.03 (1.00–1.05) |
| **If the neighborhood had an additional tenth of the population** | | |
| Linguistically isolated | 1.20 (1.11–1.30) | 1.11 (0.92–1.33) |
| Working | 1.53 (1.32–1.77) | 0.81 (0.63–1.05) |
| In health–related jobs | 1.08 (0.94–1.24) | 1.14 (0.85–1.54) |
| With some college education | 1.20 (1.15–1.24) | 1.10 (1.00–1.22) |
| Age >65 | 1.25 (1.17–1.33) | 1.03 (0.92–1.17) |
| **If witness status missing** | 1.28 (1.04–1.58) | 1.26 (1.00–1.59) |

*The bivariate odds ratios and CIs (computed with the Cornfield approximation[30]) are reported with the relationship between each predictor and the dependent variable, namely, whether the victim received CPR. Logistic regression estimates of the bivariate effect of a 1–unit change are presented for continuous variables. Information from all available cases is presented. The adjusted odds ratios and CIs are presented for the association between each of the arrest, victim and neighborhood characteristics, and whether the victim received CPR. These results were controlled for the effects of other variables shown here using logistic regression on the 4,379 cases in the study cohort.
†Unadjusted results are for the 3,855 cases for which witness status was available.
‡The unadjusted odds ratios for these 2 variables were computed simultaneously.

The Table lists the bivariate associations between the characteristics of the cardiac arrest, the victim, the neighborhood in which the arrest took place, and whether the victim received CPR from a bystander. Twenty-one percent of patients whose arrests occurred at home received CPR, whereas 29% of patients whose arrests occurred elsewhere received CPR. Nineteen percent of patients with unwitnessed cardiac arrests received CPR, whereas 25% of those with witnessed arrests received CPR. In the Table, all of the characteristics were simultaneously assessed using logistic regression. Cardiac arrest victims whose arrests were witnessed were 1.41 (95% CI 1.17 to 1.71) times more likely to have received CPR from a bystander than those whose arrests were not witnessed. Arrests at home were less likely to be witnessed; even when all the variables are taken into account, individuals whose arrests occurred in their own home were 0.52 (95% CI 0.41 to 0.66) times as likely to have received bystander CPR as those whose attack occurred outside the victim's own home.

Men and women were equally likely to receive CPR. From the bivariate associations, it appeared that younger people and black individuals were less likely to receive CPR. The logistic regression suggested a more complicated picture. The actual CPR experience of the races across ages is shown in Figure 2, where it is compared with that described by the regression analysis. White individuals had approximately the same probability of receiving CPR at any age. Black individuals, in contrast, were less likely to receive CPR the younger they were; an additional 10 years of age for a black individual yielded an

adjusted odds ratio of 1.23 (95% CI 1.16 to 1.29). Note that this age effect was not because older people had cardiac arrests after having called the paramedics for something else; those whose arrests were witnessed by paramedics (and would presumably immediately get CPR) were excluded from the cohort. As shown in Figure 2, at age 65, black individuals were 0.82 (95% CI 0.56 to 1.21) times as likely to receive CPR as white individuals.

Neighborhoods in which more cardiac arrests occur were more likely to provide CPR to any individual person having a cardiac arrest. A doubling of the annual number of cardiac arrests per capita was associated with a 130% increase in the odds of provision of CPR to each individual arresting (95% odds ratio CI 1.84 to 2.88). As the Table shows, socioeconomic status did not appear to have been associated with differences in the provision of CPR once arrest and individual characteristics were taken into account—none of the coefficients associated with income, density, education, or employment could be statistically distinguished from having no effect. Moreover, the point estimates of the coefficients were all almost exactly 1.0 and the standard errors were small (even after correction for clustering), suggesting that the true effects of these variables at the neighborhood level were adequately measured in our study but were negligible.

A close examination of the data revealed a complicated pattern when comparing integrated and segregated neighborhoods, as documented in Figure 3. Neighborhoods with different racial compositions provided CPR at different rates. Chicago, as most areas of the United States,[27] is segregated so that most neighborhoods are at least 90%

**Figure 2.**

*Variation in the receipt of CPR by age and race. The percentage of whites and blacks in each 5–year age group who received CPR is presented in the upper panel; scale is on the left axis. The regression lines are the aggregated results from the logistic regression presented in the Table; the observed percentage in each age/race group is provided for comparison. The lower panel shows the number of cardiac arrests by black (dark bar) and white patients (white bar) in each age group; scale is on the right axis.*
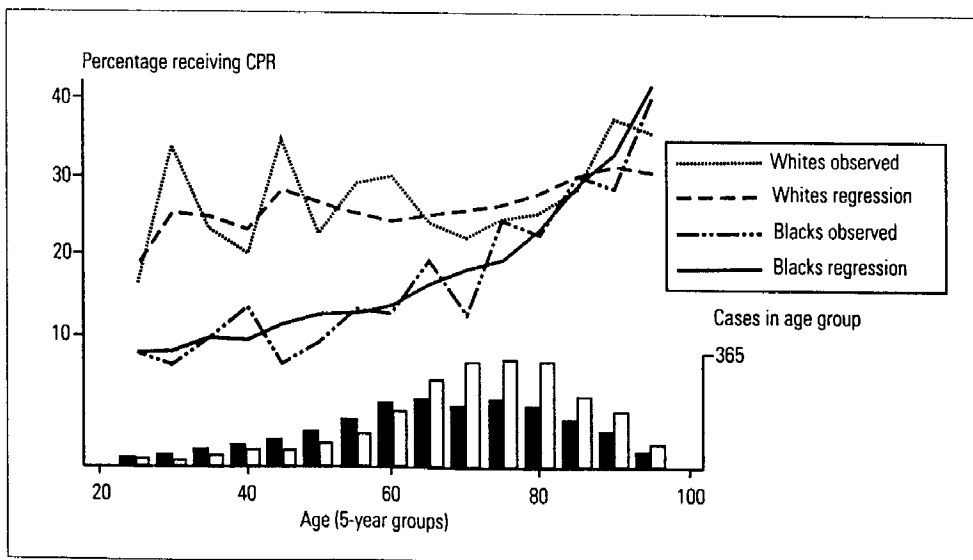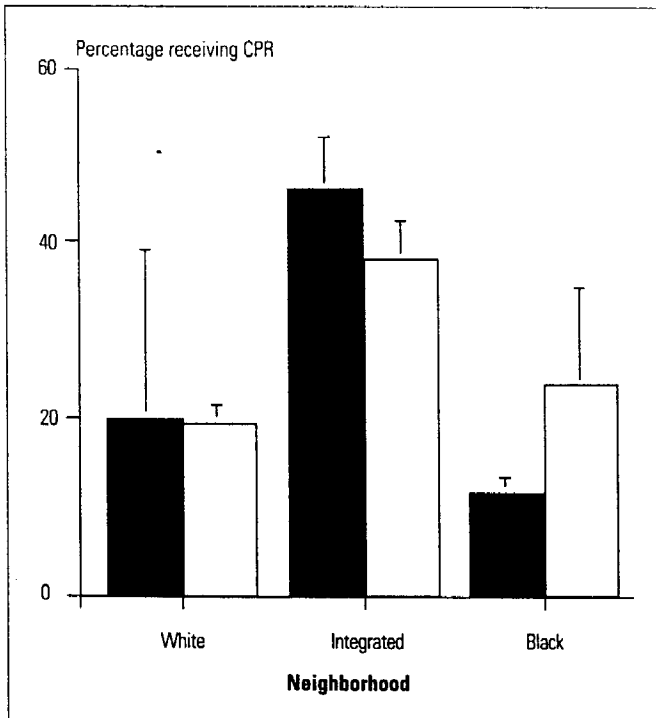
racially homogenous (Figures 1 and 4). Only 20% of the arrests occurred in "integrated" neighborhoods, defined as neighborhoods where more than 10% of the inhabitants were not of the majority race of that neighborhood (eg, an 80% black neighborhood is "integrated"). For arrests occurring in home, both blacks and whites who lived in integrated neighborhoods were substantially more likely to receive CPR—46% of the 286 blacks and 38% of the 486 whites whose arrests occurred at home in an integrated neighborhood were provided with CPR. Controlling for other effects (including the individual's own race), someone whose arrest occurred in an integrated neigh-

borhood was 1.43 (95% CI 1.01 to 2.02) times as likely to receive CPR as was someone whose arrest occurred in a segregated white neighborhood (Table). Someone whose arrest occurred in a segregated black neighborhood was significantly less likely to receive CPR than those in segregated white neighborhoods; holding all other variables constant, arrest victims in segregated black neighborhoods were 62% less likely to receive CPR than victims in white neighborhoods (95% CI 0.24 to 0.60). The patterns persisted in alternative definitions of segregation (eg, when segregation was defined as 95% racial homogeneity), as well as in models estimated separately by race (data not shown).

An assessment of the relative explanatory power of the 3 types of variables—arrest-, victim-, and neighborhood-level—partitions the variance that is explained by the model (*not* the total variance in the data) among the groups

**Figure 3.**

*Effects of neighborhood racial composition on the fraction of in–home arrests receiving CPR. The percentage of those who have a cardiac arrest in the home receiving CPR is shown as it varies across neighborhood type. The experience of black individuals is shown with the black bars, of white individuals with white bars. Integrated neighborhoods are defined as those with at least 10% of the population not of the majority race. Of those cardiac arrests that occur in the home and represented here, there were 1,742 white (54 black) patients with arrests in predominately white neighborhoods, 486 white (286 black) patients with arrests in integrated neighborhoods, and 80 white (1,371 black) patients with arrests in predominately black neighborhoods. Note that these graphs do not control for all the other factors listed in the Table.*

**Figure 4.**

*Geographic distribution of integrated neighborhoods in Chicago. Census tracts where at least 10% of the population was of the minority race—that is, which were less than 90% racially homogenous—were defined as integrated for the purposes of this study. They are highlighted in this map of the City of Chicago. The large area in the upper left is an artifact of the inclusion of O'Hare Airport within an otherwise small residential neighborhood's boundaries.*
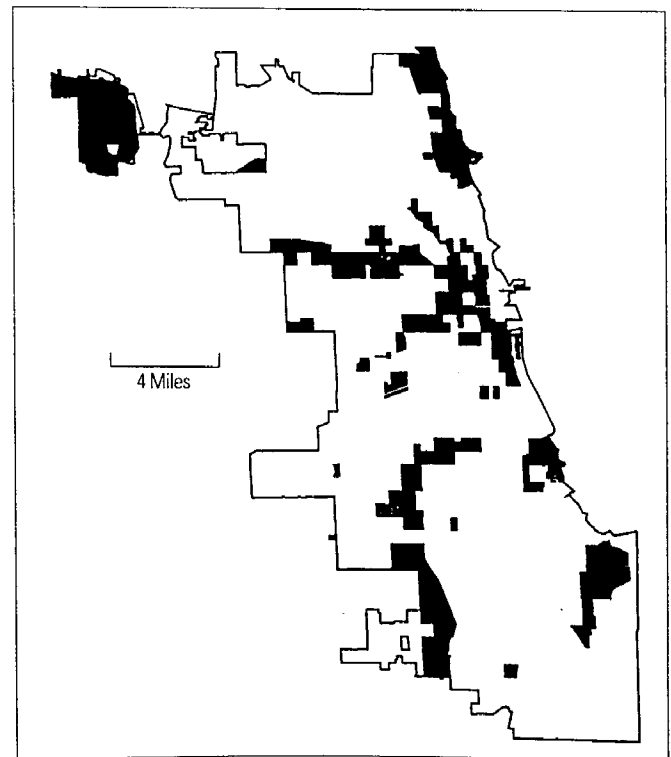
of variables. The characteristics of neighborhoods accounted for a majority of the explanatory power of the model of individuals' receipt of CPR. The 10 neighborhood-characteristic variables explained 82.8% of the *fitted* variation (95% CI 70.0% to 90.9%), whereas the 4 individual-level variables and the 3 arrest variables together accounted for the remaining 17.2%.

## DISCUSSION

Initial work on the provision of CPR demonstrated the substantial differences between arrests that occur in private and arrests in public.[24] The insight of those investigators—that the context within which a cardiac arrest occurs is crucial to understanding whether the victim will receive CPR—has largely been neglected. Most previous reports on the provision of CPR have not used methods that allow for an identification of the important characteristics of this context. By extension, they provide only limited insight into the key health issue: how to increase rates of CPR provision. Victims, after all, do not provide themselves with CPR; it is those around the victim who must act to save his or her life. To take into account one component of the potentially lifesaving context of cardiac arrest, we studied the effects of neighborhoods on arrest provision. The key finding of this article is that neighborhood characteristics in general are significantly more important to explaining receipt of CPR than are characteristics of the cardiac arrest victim.

The neighborhoods of Chicago (operationalized here as census tracts) are relatively homogenous geographic groupings of approximately 4,000 people, with well-described socioeconomic and demographic characteristics and stable boundaries. Neighborhoods provide information about those potentially available to respond to a cardiac emergency, allowing the study of rates of CPR provision by different types of bystanders. Our multivariate analysis used a complete listing of all out-of-hospital cardiac arrests for 2 full years to study the degree to which individual-level and neighborhood-level characteristics were associated with the provision of CPR.

There were striking differences in the rates of CPR provision across characteristics of the neighborhoods. Neighborhoods apparently could be "sensitized" to the risks of cardiac arrest. Having a neighbor who had a cardiac arrest was associated with an increased chance that an individual would be provided with CPR when he or she had a cardiac arrest. That is, people may have been responding to cardiac arrests in their neighborhood by

learning how to provide CPR. Cardiac arrests that occurred in nursing homes were excluded from the data and therefore are not the source of this result. However, it is conceivable that this effect could have been inflated as a result of neighborhoods with senior centers or outpatient facilities that both attract those more likely to have cardiac arrests and provide CPR through those centers; the current data do not support the examination of these potential confounders.

Our study also showed striking differences in provision of CPR as the racial composition of the neighborhood varied. As has been reported previously, victims whose arrests occurred in their own home were much less likely to receive CPR, regardless of other factors.[24] For the 84.7% of arrests that occurred in the home, both black and white victims were much more likely to receive CPR in integrated neighborhoods. (Small numbers prevented the reliable discernment of distinct patterns for arrests that did not occur in victims' homes.) This "protective effect" of integrated neighborhoods for in-home, bystander CPR has not been previously reported. It is consistent with previously reported deleterious effects of segregation on black individuals[38]; we are unaware of previous studies of the health effects of segregation on white individuals.

Although the causal mechanism that yielded higher rates of CPR in integrated neighborhoods is not clear, it seems unlikely to have been racial integration per se. However, the cause was clearly not socioeconomic differences if those differences are conceptualized in terms of median income, population density, education levels, employment levels, language barriers, or employment in the health care sector; all of these were measured and controlled in our analyses. Saltman[39,40] and others[27] have suggested that integrated neighborhoods only retain their racial diversity through the action of unusually strong local institutions. Possibly these same institutions served to increase individuals' readiness to perform CPR in the home; these institutions may have been used to provide CPR training. It is also possible that the type of people who chose to live in an integrated neighborhood were also more likely to train themselves in CPR provision and provided CPR when needed; they may have been more "socially conscious" or altruistic. However, the mechanism leading to such significantly higher rates of CPR provision in integrated neighborhoods remains a topic for future research that could have important implications for the targeting of future training efforts.

Beyond these neighborhood effects, our analysis revealed important individual-level patterns of age and

race effects on CPR provision not appreciated in prior studies. Contrary to what has been suggested by Swor et al,[41] older victims did not face lower rates of CPR. Although comparable studies of the effect of bystander age on CPR provision do not exist, these results do suggest caution when interpreting several previous surveys showing that older adults are significantly less likely to be formally trained in CPR.[10] However, the effects of age vary between white and black individuals. Although previous bivariate analyses of data from Chicago and elsewhere demonstrated that black indivudals do not receive bystander CPR as often as white individuals,[15-17] we found that rates of CPR receipt were substantially related to the victim's age for black individuals but not for white individuals. That is, on an individual level, middle-aged black individuals were least likely to be provided CPR. The possibility of a difference in the patterns of CPR across the ages between black and white individuals does not appear to have been previously explored.

Our analysis and the use of neighborhood data were not without limitations. There was no way to be sure that those actually around cardiac arrests were representative of those in the neighborhood as a whole—although the magnitude and significance of our estimates suggest that neighborhood data are informative. However, it is important to emphasize that 84.7% of arrests occurred in the individual's own home, about which the census provided high-quality data given the quite small size of the areas we used as "neighborhoods." The major technical limitation of using a neighborhood as the unit of analysis was its imprecision as a measurement tool for some variables, particularly access to financial resources (of which income is only one component) and actual nature of employment. This may explain our failure to detect an effect of socioeconomic status or the number of health professionals in a neighborhood; alternatively, such variables may have acted primarily at the household level rather than the neighborhood level. Other strategies might serve to detect such effects. For example, an alternative strategy for the collection of data on nonprovision of CPR would be the retrospective reconstruction of cohorts of bystanders present at arrests. If a sufficiently complete cohort could be developed, the characteristics of bystanders could be directly associated with their likelihood of providing CPR without the measurement error to which our study is subject. Beyond the substantial technical difficulties of executing such a study, however, such a design would not be able to detect the broader contextual effects that we have explicitly studied.

There were also the difficulties inherent in using race as a variable in any study.[42] For many applications, self-identification is the preferred method of racial coding; however, near-perfect agreement between observer-reported and self-reported race has been shown.[43] Therefore, although there was less danger from the data-imposed necessity of using a white/black dichotomy, we were clearly not able to capture or understand which facets of race were crucial for the failure to provide CPR. Future studies are required to understand the factors underlying these race-specific findings. More generally, we lack information about comorbid conditions, the physical appearance, and other characteristics of the victim that might affect the propensity of bystanders to provide CPR.[9] However, it is unclear to what degree such unmeasured variables would be correlated with our variables of interest; in the absence of such a correlation, our estimates should not be biased.[44] Clearly, more detailed collection of data about victims are a complement to rather than a substitute for the use of detailed information about neighborhoods.

Our study has both methodologic and policy implications for CPR training efforts. Methodologically, research strategies based on neighborhoods provide a number of benefits. Neighborhoods are relatively stable, and significant descriptive information is available. They are small enough to be fairly homogenous, yet large enough to provide stable statistical analyses. Neighborhoods can provide a useful population to act as the denominator to study rates of CPR provision that reflect both those who do and do not provide CPR. Without such a denominator, studies cannot draw inferences about tendencies toward CPR provision (and, in other studies, alternative health behaviors).

At a policy level, neighborhoods provide a natural unit at which programs can be implemented and evaluated. Translating research based on neighborhood characteristics into public health programs is straightforward, as the research directly identifies the neighborhood characteristics associated with greatest need. Moreover, the work presented here suggests that interventions that affect a neighborhood's view of cardiac arrest offer an alternative modality to interventions which target individuals; the analyses could be used to identify those neighborhoods that might be models for interventions. Thus, it holds the promise of meaningfully reducing the number of deaths from cardiac arrest.

Obviously, our study is not meant to suggest that physicians recommend that patients move to new neighbor-

hoods, any more than physicians could recommend that patients change their gender or age. Rather, our results seem to present an opportunity for policy interventions that transcend the individual patient/provider relationship. However, our data do suggest (although they do not prove) that familiarity with cardiac arrest increases rates of provision of CPR. Therefore, our data can be viewed as supporting an important role for individual physicians in making cardiac arrest salient for their patients, and encouraging them to develop the knowledge and skills necessary to provide CPR. Thus, research that takes into account neighborhoods can inform both broad policy and individual practice.

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