Socioeconomic factors and the incidence of hospitalized burn injuries in New England Counties, USA

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This study demonstrates that readily available socioeconomic data routinely collected by the US Census can be used to estimate the incidence of burn injuries within the 66 counties of the populous six-state New England region of the USA. The burn data were collected during the National Burn Demonstration Project and included New England residents admitted for hospital care of burns sustained between 1 July 1978 and 30 June 1979. Linear regression analysis revealed strong associations between calculated burn rates and a number of socioeconomic variables. Associations with five such variables are described, including per capita income, percentage of persons below poverty level, percentage of residences built prior to 1940, percentage of adults with 16 years or more of education, and percentage of persons moving since 1975 with previous residence in the same county. Estimates of burn incidence for counties, together with a previously reported study at the level of census tracts for a major Standard Metropolitan Statistical Area, can be used to reduce the time and cost of burn injury case reporting by health care providers or case-finding efforts for large population groups, and can be used to predict the effectiveness of social and economic programmes and policies that improve the overall well-being of county populations.

Introduction

Burn injuries account for nearly 6000 deaths per year in the USA, and result in the hospitalization of an estimated 100 000 persons (Baker et al., 1984). The treatment of hospitalized burns often requires a relatively long period of hospital stay, and a high proportion of patients sustain temporary or permanent disability resulting from their burns.

Socioeconomic status is a strong risk factor for burn injury together with extremes of age and male sex. How differences in socioeconomic status mediate burn rates, however, is not well understood nor adequately quantitated, nor have the actual causal attitudes and behaviours associated with socioeconomic status been identified. Several investigators have reported associations between high burn rates and low socioeconomic status in populations evaluated at the county level or for some other geographically defined area (Barancik and Shapiro, 1975; Feck et al., 1977; Clark and Lerner, 1978; Feck and Baptiste, 1979) and for occupational groups having different average incomes (Rossignol et al., 1989). In addition, surveys of persons hospitalized for the treatment of burn injuries at one or several hospitals or who died prior to hospitalization, support the existence of an association between high burn rates and low socioeconomic level, particularly among certain aetiological categories of burns, such as those which are housefire related. For example, housefire death rates are two times higher in areas of lower per capita income compared to areas with higher per capita incomes. In addition, Mierley and Baker (1983) found that the proportion of house fires which were ignited by faulty heating or electrical systems was greatest in areas with low income. Other surveys have documented a relationship between burn rates and other types of burn injuries. Barancik and Shapiro (1975) found a relationship between burn rates and per capita income which was strong for burns caused by clothing ignition from appliances and equipment, and Baker et al. (1984) reported that death rates from electrical current are twice as high in low-income counties compared with high-income counties. With respect to contact burns, Bull et al. (1964) documented the economic hindrances which kept people from having adequate guards on fireplaces and gas or electric space heaters.

The first report using socioeconomic Census data at the level of census tracts to quantify the effect of median family income on burn rates was published by MacKay et al. (1979). Locke et al. (1986) elaborated upon the approach used in that report by examining the variability of burn rates for more than 500 census tracts in the Boston Standard Metropolitan Statistical Area using 25 Census variables.

The present study applies an approach which is similar to the approaches used in the studies described in the preceding paragraph, to evaluate burn rates at the county level, and extends the catchment area to the entire six-state New England region. Specifically, the objectives of this study are to quantitate the effects of various socioeconomic factors on burn rates at the county level and to formulate models that might accurately predict burn rates in other geographical areas through the use of readily available Census information. In addition, the developed models can be used to estimate the overall effects of low socioeconomic status and

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its attitudinal and behavioural correlates on burn rates and to predict the expected decrease in burn rates from programmes and policies that increase the overall socioeconomic level of populations.

Methods

New England Regional Burn Program

The data for this study were developed during the National Burn Demonstration Project (NBDP), established under contractual agreements with the Division of Emergency Medical Services of the US Department of Health and Human Services (then the US Department of Health, Education and Welfare). The burn demonstration project provided an opportunity for the systematic enumeration of burns occurring to residents of geographical areas comprised of more than 10 per cent of the nation's population. The Project produced an extensive file of descriptive information on burn patients encountered at six demonstration sites during a 26-month period, May 1978 to June 1980.

The New England Regional Burn Program (NERBP) was the largest of the six participating sites, collecting burn data from 240 of the 256 acute care hospitals in the six-state New England region having a population of approximately twelve million persons (Burke and Locke, 1980). The primary objective of the NBDP was to collect data pertaining to the delivery of medical treatment to burned patients nationwide, with the goal of evaluating the adequacy of existing burn care facilities, providing estimates of the relative effectiveness of different modes of burn care, and identifying the cost of acute and long-term care of burned patients.

In addition to collecting data elements established by the NDPB and common to the six demonstration sites, the New England group followed expanded data collection procedures in which additional information was recorded, including the burn victim's place of residence. The county and city/town of residence was noted for all patients entering the study. In recording a residential address, suitable precautions were taken to assure patient confidentiality.

The cases on which the present study is based are a subset of the NERBP data taken from a summary tape delivered by the NBDP to the participating sites, and includes New England residents who received treatment as hospital inpatients for burn injuries sustained during the 12-month period from 1 July 1978 until 30 June 1979. Not included are New England residents treated in hospitals beyond New England or residents of other states treated in New England hospitals. Types of burns included in the study are scald, flame/flash, contact, electrical, chemical (ICDA codes 983.0, 983.1, 983.2, and phosphorus in code 983.9), and ultraviolet radiation burns. Overall, 77 per cent of the burns in the study were either flame/flash burns (36 per cent) or scald burns (41 per cent).

To assess the completeness of case ascertainment NERBP conducted two case-finding quality control studies among a representative sample of participating hospitals. These intensive reviews indicated the overall completeness of case-finding was at least 90 per cent.

While the data collected by the NERBP pertain to burn injuries that occurred in 1978 and 1979, these data still represent one of the largest information files on hospitalized burn injuries occurring to residents of a defined geographical area. In addition, while mortality from burns decreased and then increased over the period from 1978 to the present, there is little indication that the aetiological epidemiology of burns has changed substantially (Committee on Trauma Research, 1985; Waller, 1985).

Estimates of burn incidence

Incidence rates were calculated using the number of new hospitalized burn injuries as the numerator and person-years derived from population counts taken from published data collected during the US Census (Bureau of the Census, 1983) as the denominator. It should be noted that reported incidence rates are based on numerators which consist of burns occurring from mid-1978 to mid-1979, while the denominators are population counts reported in the 1980 Census. The unavailability of numerators and denominators for a common time interval and the expectation that the effect of this slight discontinuity is minimal, made this methodological approach acceptable for the purposes of this study.

The populations for two Massachusetts counties were adjusted by subtracting from the denominator the combined population of 14 communities served by hospitals which did not participate in the NERBP (seven in Essex County and seven in Middlesex County). The magnitude of this population adjustment was 369 126 or 6.4 per cent of the total population reported for Massachusetts in the 1980 Census. Similarly, nine cases occurring in these communities were subtracted from the numerator. The communities to be excluded were identified by a review of Hospital Patient Origin Data to determine communities for which 10 per cent, or more, of the residents hospitalized for medical/ surgical care were treated in one of the non-participating hospitals (Massachusetts Health Data Consortium, 1980, personal communication). In a similar adjustment, the entire population of Newport County, Rhode Island (81 383) was excluded, along with the five cases identified among its residents, since the hospital providing principal service to this county did not participate in the NERBP.

Demographic and socioeconomic data

Demographic and socioeconomic data for the 66 counties in New England were also taken from the 1980 US Census. The categories used in the analysis of variables were formed by combining counties having similar values for a variable of interest. By aggregating counties in this manner it was possible to obtain larger population totals as denominators, thus reducing the rate instability encountered in previous attempts to analyse burn rates within small population groupings. The midpoint of the variable for each grouping of counties was calculated as the weighted mean of values for the counties within the grouping, with the weights equal to the population count for each county.

Data analysis

Scatterplots were made with each socioeconomic variable and the county burn incidence rate. Where linearity was suggested by visual examination, linear regression was performed to determine the least squares equation of the line relating each socioeconomic variable to the county burn incidence rates. The degree of association between the variables was identified and reported here as the correlation coefficient (r value).

Results

During the 12-month period included with the data analysis, a total of 2759 hospitalized burns were identified. Nine cases for which the victim's county of residence was unknown

Table I. Burn injuries by state of residence. Inpatients; New England residents: 1 July 1978 to 30 June 1979

State of residence	Counties (no.)	Population	Burns (no.)	Burn incidence rate*
Connecticut	8	3107567	714	23.0
Maine	16	1124660	305	27.1
Massachusetts†	14	5367911	1226	22.8
New Hampshire	10	920610	214	23.2
Rhode Island‡	4	865771	174	20.1
Vermont	14	511456	117	23.1
Total	66	11897984	2750	23.1

*Number of burns per 100000 person-years.
†Excluding 14 communities with combined population of 369126.
‡Excluding Newport County (population 81 383).

were excluded. The overall incidence rate of hospitalized burns was 23.1 per 100 000 person-years.

Among the 66 counties for which burn patients were identified, incidence rates ranged from 8.8 to 45.4 burns per 100 000 person-years, with a median value of 22.5 burns per 100 000 person-years. For the county of Nantucket, Massachusetts, with a year-round population of only 5087 persons, no hospitalized burns were encountered. Among the New England states (*Table I*), Maine had the highest burn incidence rate (27.1 per 100 000 person-years) and Rhode Island the lowest rate (20.1 per 100 000 person-years).

A total of 30 variables measuring socioeconomic status were examined to determine the extent to which each was associated with the incidence of hospitalized burns. Seven of the variables were found to be highly and linearly associated with burn incidence. Four of these variables were found to have correlation coefficients (r values) in excess of 0.90 and three were in the range of 0.75–0.85. For the remaining 23 variables, little or no linearity was apparent when the variable was plotted against burn incidence

Since some of the variables that were highly correlated with burn incidence relate to similar socioeconomic factors (for example, percentage housing built pre-1940 and percentage housing built in 1970s), only five variables have been selected for discussion. The variables, which relate to population characteristics, economic factors and housing indicators are among the variables identified previously at the level of census tracts to be highly and linearly associated with burn incidence (Locke et al., 1986), with the exception of the percentage of housing built before 1940. These variables are given below, and a discussion of each is given in the sections that follow:

Variable:	r value:
1. Per capita income	−0.91
2. Percentage of families below poverty level	0.95
3. Percentage housing built pre-1940	0.84
4. Percentage of persons with 16 or more years of education	−0.91
5. Percentage movers within same county (persons who moved within the past 5 years from a previous residence in the same county)	0.96

Per capita income *(Figure 1)*

Per capita income is based on the aggregate money income in 1979 in a county, divided by the resident population of that county enumerated as of 1 April 1980. As such, this variable is an overall indicator of the level of economic well-being of county residents and provides a basis on which counties can be compared. As in previous studies (Barancik and Shapiro, 1975; MacKay et al., 1979; Locke et al., 1986), it is again evident that the incidence of burns varies inversely with income. The equation of the 'least squares' line of best fit is:

$$\text{Burn incidence rate} = -1.78\,(\text{per capita income}/1000) + 36.17 \qquad r = 0.91$$

Percentage of families below the poverty level *(Figure 2)*

This variable similarly reflects economic well-being as a risk factor in the occurrence of burn injuries. As described in the Census publication, families were classified as below the poverty level if their family income in 1979 was less than the poverty threshold for the applicable family size, age of householder, and number of children under age 18 years. The equation of the 'least squares' line of best fit is:

$$\text{Burn incidence rate} = 1.35\,(\text{percentage families below poverty}) + 12.71 \qquad r = 0.95$$

Percentage of housing built before 1940 *(Figure 3)*

This variable reflects the age of residential structures by reporting the percentage of year-round housing units which were constructed prior to 1940. The year in which a structure was built refers to the date when the building was first constructed, not when it was remodelled, added to, or converted. To the extent that lower income householders own or occupy older homes, this variable may be a surrogate for economic status or it may reflect more hazardous building designs, fixtures and appliances. The equation of the 'least squares' line of best fit is:

$$\text{Burn incidence rate} = 0.36\,(\text{percentage housing built before 1940}) + 8.75 \qquad r = 0.84$$

Percentage of persons with 16 or more years of education *(Figure 4)*

Educational status is described by the number of years of school completed for persons aged 25 years old and older. Sixteen years of schooling is roughly equivalent to the completion of a 4-year college education. This variable also reflects economic status since the level of a person's education frequently affects the ability to obtain higher-paying jobs. It may also reflect the acquisition of knowledge

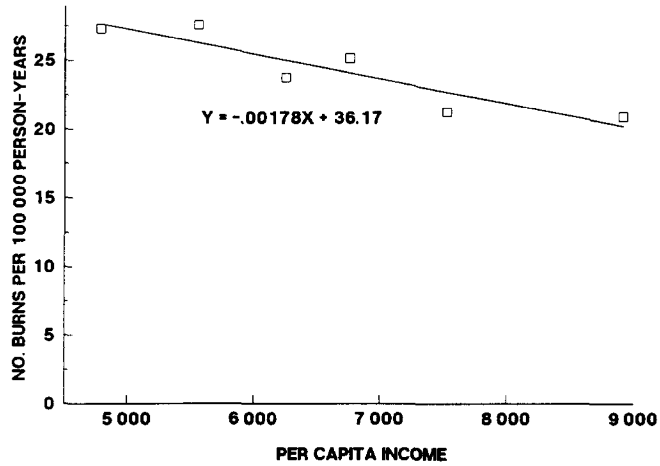

Figure 1. Burn incidence rates by per capita income, New England Counties (grouped), USA.

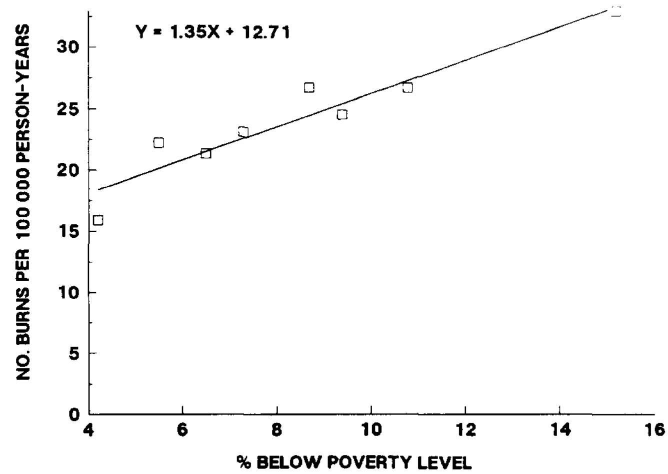

Figure 2. Burn incidence rates by percentage of families below the poverty level, New England Counties (grouped), USA.

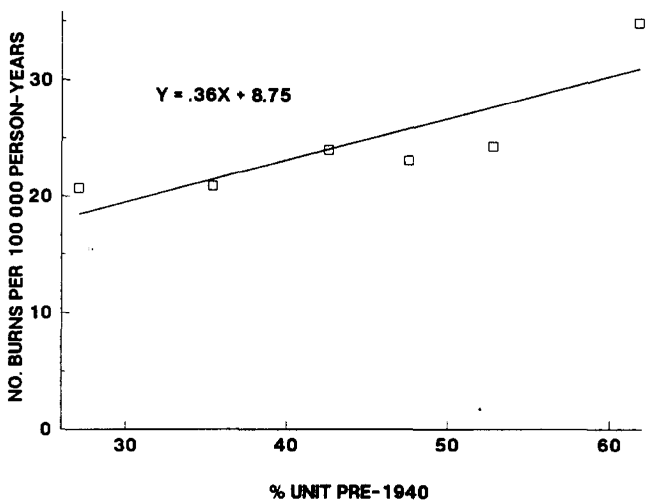

Figure 3. Burn incidence rates by percentage of housing built before 1940, New England Counties (grouped), USA.

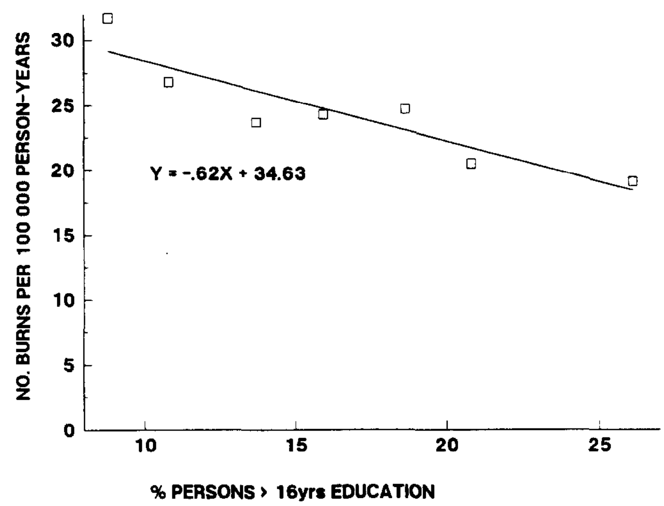

Figure 4. Burn incidence rates by percentage of persons with 16 or more years of education, New England Counties (grouped), USA.

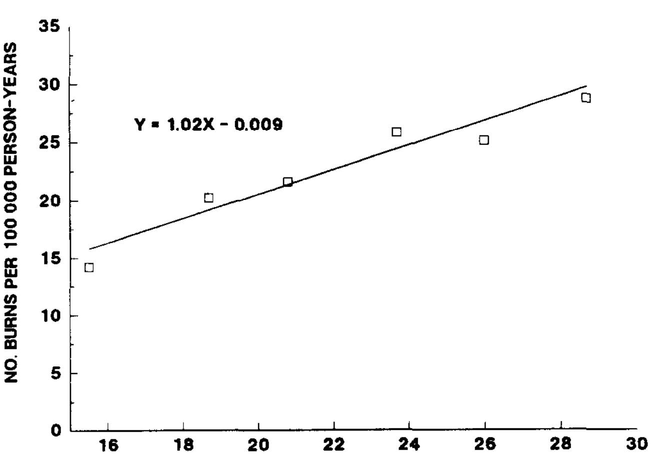

Figure 5. Burn incidence rates by percentage of persons moving within the same county since 1970, New England Counties (grouped), USA.

and attitudes that prevent burn injuries. The equation of the 'least squares' line of best fit is:

Burn incidence rate = − 0.62 (percentage persons 16 or more years of education) + 34.63
$r = -0.91$

Percentage of persons moving since 1970 whose previous residence was in the same county *(Figure 5)*
This variable reflects population mobility by reporting on a sample of persons age 5 years and over who, at the time of Census enumeration, were living in a residence different from that in 1975. Among those who had moved, this variable reports the percentage whose previous residence was in the same county. The equation of the 'least squares' line of best fit is:

Burn incidence rate = 1.02 (percentage movers/same county) − 0.009
$r = 0.96$

Discussion

Five demographic and socioeconomic variables have been identified which are highly associated with the incidence of hospitalized burn injuries in 66 counties in New England. The usefulness of identifying socioeconomic characteristics capable of accurately predicting burn incidence lies in the fact that these data appear in Census publications which are readily available in libraries, universities and city halls. In the past, knowledge of burn incidence in population groups was available only retrospectively, based on the maintenance of expensive burn injury reporting systems or through the costly review of medical records or hospital discharge data.

In circumstances where the identity of specific patients is not required, the alternative offered here provides a means of quantifying the burn injury problem and predicting the potential benefits from implementing programmes and policies that improve the socioeconomic well-being of county populations. For example, programme that decrease unemployment, thereby increasing per capita income and decreasing the proportion of families who live below the poverty level, would be predicted to result in a decreased incidence of hospitalized burn injuries even though the precise mediators are not known. The amount of the decrease would be predicted by the equations relating burn incidence to per capita income (adjusted for inflation from 1980 dollars) and to the proportion of families which live below the poverty level. Likewise, increasing the educational attainment of persons residing within a county should bring about a predicted lessening in the rate of burn injuries.

Another potential use of the developed models would be to help persons engaged in planning health care delivery systems, locating the need for specialized burn care facilities, or targeting high risk population groups for preventive housing inspections or educational interventions. Greater accuracy in predicting populations at increased risk of burn injury would strengthen the cost-effectiveness of such efforts.

One possible source of error in the present study warrants discussion. The models which were developed used information for groups of individuals (counties of persons) rather than for individual persons. For this reason, the analysis is considered an 'ecologic' analysis, and may be subject to an 'ecologic fallacy', as discussed by Morgenstern (1982). This fallacy generally is interpreted to mean that a causal inference about individual phenomena is made in error on the basis of data collected for groups of individuals. While this fallacy may apply to studies which seek to generate or evaluate aetiological hypotheses, the fallacy normally does not apply to analyses in which the main objective is to quantify or predict the effectiveness of a population intervention known to be beneficially related to the health outcome of interest. The latter objective applies to the present study because the relationship between socioeconomic level and burn rates has been firmly established (although poorly quantitated) previously. In addition, ecological analyses can be used advantageously to evaluate population interventions, such as interventions that affect socioeconomic well-being, in which the direct causal link between the risk factor and the health outcome is unknown. For example, in the present study, the exact nature of the factors which interact to increase the risk of burn injury among populations with low socioeconomic status is unknown. Despite this limitation, the effectiveness of an improvement in socioeconomic well-being on burn incidence can be measured by comparing burn rates among populations having different levels of socioeconomic indicators.

A potential limitation of the methodological approach described here is that the study is based on data from a single region of the country (although the six-state New England area displays considerable diversity with respect to sociodemographic and other variables). The general application of the observed associations to other populations and regions of the country has not been examined. Analysis of socioeconomic Census variables for other regions might allow the derivation of adjustment factors which could result in predictive equations for other areas of comparable accuracy to the equations reported here.

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