Statistical Models of the Demand for Emergency Medical Services in an Urban Area

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Abstract: First- and second-order statistical regression models are presented for the Emergency Medical Services (EMS) demand in an urban area as it relates to various socioeconomic, demographic, and other characteristics of the area. Individual models are formulated for different types of medical emergencies with the city of Atlanta, GA, serving as the data base. These models are generally shown to provide excellent fits to the empirical data. (Am. J. Public Health 69: 250-255, 1979.)

Introduction

The rising incidence of true medical emergencies (some 10 million disabling injuries and over 1.9 million deaths occurred in the United States in 1971)[1] and of emergency facilities deployment for a wide variety of nonurgent conditions[2] together with their attendant medical costs are recognized as important problems.

The Emergency Medical Services Systems Act of 1973 and its amended extension of 1976 as well as the National Health Planning and Resources Development Act of 1974 (Public Law 93-641) were important turning points in the development of meaningful emergency medical services. The legislation emphasizes regional EMS systems and a unified approach to the structuring of health care systems in general.

In the planning of any regional EMS system, (and to help evaluate existing services) some information about the nature of the demand for such services is essential. Specific quantitative data are needed pertaining to the demand for treatment of different types of medical emergencies. Predictions of such EMS demand may be based on statistical models using various socioeconomic, demographic, and other characteristics of a community as exogenous (independent) variables. This type of modeling approach has been used by Aldrich, Hisserich and Lave[3] for the EMS system of the city of Los Angeles, with similar models having been developed for the Chicago area,[4, 5] and for the nonurgency use of hospital emergency facilities of the Yale-New Haven Hospital Emergency Service.[6]

The present study was designed to try to develop similar types of multivariate linear statistical models for the total rate of EMS demand and for the rate of demand by individual categories of medical emergencies for the city of Atlanta, Georgia. In addition to formulating such first-order linear models, this study was also aimed at trying to develop and validate second-order models for the EMS demand.

The Data Base

The Atlanta EMS System

Until 1973, when the principal data collection for this investigation was carried out, no regionally coordinated EMS system existed for the Atlanta area. Furthermore, according to a 1972 survey,[7] over 65 different ambulance systems operated within the Atlanta Standard Metropolitan Statistical Area (SMSA), 41 of which claimed to provide emergency service (the remaining provided only convalescent transportation). Grady Memorial Hospital accounted for over 57 per cent of the total number of responses to medical emergency calls within the Atlanta SMSA during 1972.[7] This hospital, which was owned and operated by a public corporation, obtained back-up service from private ambulance firms should its own ambulance vehicles be committed; Grady would then reimburse the private firm a fixed amount for such back-up runs. Private ambulance firms receiving calls from very low income areas of the city would contact

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Grady hospital to obtain permission to respond to such calls and assurance that eventual payment would be received. The 1,350 such private back-up calls reported for 1969 accounted for 5.2 per cent of the total number of calls serviced by Grady hospital.[8]

This lack of coordination for the City's emergency medical services presented a number of data acquisition problems for this study as discussed elsewhere.[9] Due to such problems, the study had to be restricted to cover a 79 census tract area which represented 66.4 per cent of the City's total number of census tracts and a total population of 315,000 (63.4 per cent of the City's total population in 1970).*

Endogenous Variables

For the 79 census tract area selected for this study, the number of ambulance calls for each tract during one month was obtained as detailed elsewhere.[9] The month of March 1970 was used as the base period because: 1) the U.S. Census records, which served as the principal data source for the exogenous variables of the models, had an effective date of April 1, 1970; 2) it was determined from monthly time-series data derived for the period of January 1966 to March 1973 that the emergency call rate for the month of March 1970 approximated the average monthly call rate for this seven-year period; and 3) the data records for March 1970 were found to be relatively accurate and complete.

Both the total monthly number of ambulance calls and calls by seven categories or types of medical emergencies were obtained for each of the 79 census tracts and divided by the population of the tracts to yield the monthly EMS demand rate as the sample values of the eight endogenous variables used in this investigation. A brief definition and the sample statistics of these variables are given in Table 1 when scaled as indicated. These data are based on a total of 1,827 calls or an average of about 24 calls per census tract. This implies that for some of the types of medical emergencies considered, the number of calls per tract was very small and it may perhaps be argued that it would have been appropriate to group some tracts together as did Aldrich, et al.[3] However, such grouping, which in turn would reduce some of the large sampling variations indicated in Table 1, would have had the effect of reducing the degree of freedom of the regression models and was not done in the present study for this reason.

A number of observations are immediately discernible from the data in Table 1 and may provide some interesting comparisons with the Los Angeles public ambulance system studied by Aldrich, et al.,[3] and with some other studies. Thus, the total number of ambulance calls during a year (1970) was approximately 107 per 10^3 persons in Atlanta, which was nearly three times as high as the figure for Los Angeles and about 3.5 times that of Chicago.[4] Stevenson[10] reported annual number of ambulance runs per 10^3 persons ranging from 18 to 69 for six major cities in the U.S. As much as about 25 per cent of the relatively high total call rate for Atlanta was due to dry runs (see Table 1), the corresponding figure for Los Angeles[3] being 10 per cent. Automobile related trauma accounted for 9.3 per cent of the total EMS cases in Atlanta as compared to 26.4 per cent for Los Angeles. The EMS cases arising from all types of trauma, including those due to automobile accidents, constituted about 34 per cent, 47 per cent, and 34 per cent of the total EMS demand for Atlanta, Los Angeles, and New York (representing the average figure for four urban and suburban hospitals),[11] respectively. Emergency cases involving obstetrics or gynecology, which were the least frequent of all types of medical emergencies considered in the present study and which were not considered as a separate category by Aldrich, et al.,[3] accounted for 3.8 per cent of the total EMS demand for Atlanta and 3.5 per cent for New York.[11]

Exogenous Variables

Initially, a number of exploratory least squares regression runs were made for each endogenous variable using different sets of exogenous variables. Out of these sets of variables, a number of variables were found to be insignificant and 18 exogenous variables were retained as being those that generally contributed most to the demand for ambulance service for the different types of medical emergencies.** (Table 1). The primary data source for these variables was the 1970 Census. However, the values of some of the variables for the different census tracts had to be derived from other sources as outlined elsewhere.[9]

Results and Discussion

Models of Total EMS Demand

Based on a stepwise ordinary least squares regression of the total (rate of) EMS demand on the 18 exogenous variables defined in Table 1, the coefficient estimates associated with the different variables are those given in Table 2. The exogenous variables in this first-order model are presented in the order in which they entered into the regression. The model provides a highly significant fit to the empirical data with a coefficient of multiple determination $R^2 = 0.90$, implying that the model explains 90 per cent of the variation in EMS demand between census tracts.

As was also found by Aldrich, et al.,[3] each group of exogenous variables, i.e., those associated with the demographic, economic, housing and land-use, and traffic characteristics of an area, is clearly seen to contribute substantially to an area's total EMS demand. The variables that are by far the most important ones in terms of their effect on the total EMS demand for an area are the area's acreage per capita and the acreage itself. The coefficients of these two variables have opposite signs reflecting the multicollinearity or inter-

*The total City area included all of Fulton County and nine tracts within De Kalb County, while the City's total SMSA had a 1970 population of about 1.4 million.

**A number of additional exogenous variables that may have had potential effects on the endogenous variables were not included in the original sets of variables, such as the cost of EMS charged to the consumer and the supply of doctors and other medical facilities in an area.

TABLE 1—Summary Data for the Endogenous and Exogenous Variables in the 79 Census Tract Area

Variable Name	Mean	Standard Deviation	Variable Description
			Endogenous Variables (monthly call rate)
Total EMS demand	88.976	144.794	Total number of EMS cases per capita without regard to their nature (x10^4)
Drug intoxication	6.443	21.501	Number of EMS cases per capita arising from drug related incidents (including poisonings) (x10^4)
Obstetrics/ gynecology	3.338	4.988	Number of EMS cases per capita involving obstetrics or gynecology (x10^4)
Auto trauma	8.249	14.122	Number of EMS cases per capita arising from auto and auto-related accidents (x10^4)
Other trauma	21.824	42.033	Number of EMS cases per capita involving non-auto-related trauma (x10^4)
Cardiovascular	9.293	16.142	Number of EMS cases per capita involving cardio-vascular and pulmonary incidents (x10^4)
Other illness	18.710	24.805	Number of EMS cases per capita arising from medical reasons other than those covered by preceding categories (x10^4)
Dry runs	22.956	36.376	Number of EMS requests per capita involving false calls and cases when a patient was gone upon arrival of ambulance or patient refused treatment (x10^4)
			Exogenous Variables
% BLK	63.824	40.891	Percentage of population who are black
LT 15	27.400	9.621	Percentage of population younger than 15 yrs.
GT 65	10.797	6.499	Percentage of population older than 65 yrs.
UNEM M	4.465	3.239	Percentage of the male population who are unemployed
UNEM F	6.262	3.479	Percentage of the female population who are unemployed
TR POP	14.079	56.634	Average number of persons temporarily residing in hotels and motels (x10^{-1})
INC FA	63.317	22.998	Median income of all families during 1969 (x10^{-2})
VALOW	12.351	4.414	Median value of all owner occupied housing units (x10^{-3})
RENT	72.291	20.270	Median contract rent of all renter occupied housing units
ACRES	46.828	73.309	Total tract acreage (x10^{-1})
ACR PC	11.311	8.130	Total tract acreage divided by tract population (x10^2)
HSES	132.239	71.297	Total number of housing units (x10^{-1})
HSE PC	35.116	8.570	Total number of housing units divided by tract population (x10^2)
HS AGE	23.063	6.152	Average age of all housing units
% OWN	28.905	21.979	Percentage of housing units which are owner occupied
% COM	13.081	13.433	Percentage of tract acreage in commercial use
WRK COM	97.523	88.006	Number of workers who either drive or ride as a passenger in an auto to work (x10^{-1})
MLS TR	72.373	47.103	Mileage of traffic routes

correlation between the two variables, which was found to be as high as $r = 0.57$. The acreage of an area or tract is essentially a proxy for the location of the tract as the census tracts generally tend to become smaller the closer they are located toward the center of the City.

Among the other highly significant variables given in Table 2 are the economic status of families in an area, the rate of male unemployment in the area, and its racial composition. Thus, the data in Table 2 indicate that the demand for EMS increases with decreasing family income, increasing unemployment among males, increasing acreage per capita, and increasing percentage of the black population, assuming that the remaining exogenous variables remain fixed. These findings are in general agreement with those obtained by Aldrich, et al.,[3] and by some other investigators.[6, 12, 13]

The percentage of the population over 65 years of age is seen to explain a higher proportion of the variation in EMS demand than does the percentage of the population under 15 years. Any increase in the proportion of the aged results in nearly twice as large an increase in the total EMS demand as does the same increase in the proportion of children when all other variables remain fixed. The positive coefficients of these two exogenous variables imply that, stated in general and less precise terms, both children and the aged generate higher EMS demand than do those aged 15 to 65. Also, on the basis of some alternative model formulations by these authors,[9, 14] it was established that single males (unmarried, separated, widowed, or divorced) generate higher EMS demand than married males while the reverse situation applies for females, and, in general, there appears to be a tendency

TABLE 2—Models of Total EMS Demand

Variables	Parameter Estimates	*t* Value at Final Step	R^2
	First-Order Model		
% COM	2.288	2.83**	.36
INC FA	−3.350	−3.62***	.50
ACR PC	10.667	6.10***	.67
ACRES	−1.266	−5.47***	.76
WRK COM	1.019	3.32**	.81
TR POP	0.461	1.89	.83
HS AGE	5.479	2.99**	.84
% BLK	0.864	3.16**	.85
UNEM M	6.763	2.64*	.85
HSES	−0.805	−2.97**	.86
HSE PC	−0.768	−0.48	.87
MLS TR	0.681	1.67	.87
RENT	1.980	2.41*	.88
GT 65	6.375	2.81**	.88
LT 15	3.285	2.44*	.89
VALOW	4.038	1.62	.89
% OWN	−1.179	−1.58	.90
UNEM F	1.811	0.79	.90
Constant	−352.676		
	Second-Order Model		
(ACR PC) (% COM)	0.524	16.06***	.68
INC FA	−1.354	−5.70***	.81
(ACRES)(% COM)	−0.035	−7.75***	.87
(INC FA)(% COM)	−0.044	−6.10***	.91
(WRK COM)(TR POP)	0.006	3.70***	.92
$(\% \text{ COM})^2$	−0.031	−2.05*	.93
Constant	141.251		

*$p < 0.05$
**$p < 0.01$
***$p < 0.001$

for females to generate a higher demand than males. These results corroborate the findings from the Los Angeles study.[3]

In addition to the positive effect on the total EMS demand of the acreage per capita and the negative effect of the acreage itself, the percentage of an area's acreage in commercial use and the average age of its housing units both have a positive effect; the number of housing units per capita has a negative effect. These findings were found to apply to several of the individual categories of medical emergencies and were similar to those of the Los Angeles study.[3]

On the basis of the first six exogenous variables in Table 2, i.e., the six variables that first entered into the stepwise first-order least squares regression, a full second-order model was formulated incorporating first-order terms, quadratic terms, and interaction terms. The parameter estimates for this second-order model were obtained by a stepwise ordinary least squares regression procedure. The resulting estimates are given in Table 2 for the sixth regression step, after which the additional regressors produced only a minor increase in the proportion of the variation in EMS demand explained by the model. The coefficient of multiple determination of this model is seen to be as high as $R^2 = 0.93$.

The particular importance of an area's size, acreage per capita, and degree of commercialization as determinants of the EMS demand is again clearly borne out by this second-order model. The two interaction terms involving these three exogenous variables are seen to be the most highly significant ones among the six regressors. An area's median family income by itself and through its interaction with the extent of commercialization exerts a clear negative influence on the EMS demand. The interaction between the size of an area's transient population and the size of its labor force that commutes to work by automobile is also seen to have a substantial positive effect.

Models for Different Categories of Medical Emergencies

While the first-order models given in Table 3 do provide highly significant (at the 0.1 per cent level) fits to the empirical data for each of the seven types of medical emergencies (with R^2's ranging from 0.54 to 0.89), the second-order least squares regression models in Table 4 for five types of emergencies are clearly superior in terms of being capable of explaining more of the variation in the EMS demand while using substantially fewer regressors than in the first-order models. The second-order models for obstetrics/gynecology and auto trauma were found to require a relatively large number of regressors (at least 15) before R^2 reached a value of about 0.85.

TABLE 3—First-Order Models of EMS Demand for Different Categories of Medical Emergencies

Variables	Drug Intoxication	Obstetrics/ Gynecology	Auto Trauma	Other Trauma	Cardiovascular	Other Illness	Dry Runs
% BLK	0.030 (0.73;15)[a]	–[b]	0.156 (3.27;5)**	0.198 (2.10;12)*	0.068 (1.60;12)	0.166 (2.91;8)**	0.307 (3.88;8)***
LT 15	0.150 (0.73;14)	–	0.586 (2.49;9)*	0.849 (1.83;15)	0.400 (1.89;14)	0.692 (2.46;12)*	0.981 (2.51;12)*
GT 65	0.913 (2.63;11)*	−0.149 (1.11;10)	0.926 (2.34;8)*	1.742 (2.23;9)*	0.452 (1.27;16)	0.908 (1.92;13)	1.981 (3.01;7)**
UNEM M	0.807 (2.07;12)*	−0.162 (0.90;11)	0.756 (1.69;13)	2.723 (3.10;2)**	−0.267 (0.67;7)	1.258 (2.36;10)*	1.889 (2.55;2)*
UNEM F	0.154 (0.44;16)	0.284 (1.80;5)	0.047 (0.12;18)	1.403 (1.79;14)	−0.124 (0.35;8)	0.087 (0.18;18)	0.294 (0.44;18)
TR POP	0.122 (3.27;1)**	0.015 (0.92;7)	−0.023 (0.53;14)	0.032 (0.38;18)	0.113 (2.96;1)**	0.123 (2.43;1)*	0.089 (1.26;11)
INC FA	−0.721 (5.10;2)***	−0.227 (4.09;1)***	−0.033 (0.21;16)	−1.096 (3.44;4)**	−0.297 (2.05;2)*	−0.459 (2.38;2)*	−0.433 (1.62;5)
VALOW	0.633 (1.66;13)	0.095 (0.55;8)	0.107 (0.24;17)	1.734 (2.02;11)*	0.230 (0.59;18)	−0.504 (0.97;16)	1.695 (2.34;10)*
RENT	0.429 (3.43;8)**	0.040 (0.69;3)	0.290 (2.03;11)*	0.621 (2.20;7)*	0.155 (1.20;9)	0.344 (2.01;14)	0.188 (0.79;16)
ACRES	−0.146 (4.14;5)***	−0.008 (0.50;6)	−0.192 (4.75;2)***	−0.360 (4.51;5)***	−0.139 (3.83;4)***	−0.148 (3.07;4)**	−0.354 (5.27;4)***
ACR PC	1.143 (4.28;3)***	0.284 (2.32;2)*	1.204 (3.94;1)***	2.932 (4.87;3)***	1.027 (3.75;3)***	1.305 (3.58;3)***	3.160 (6.23;3)***
HSES	−0.139 (3.35;7)**	0.003 (0.17;14)	−0.091 (1.93;12)	−0.193 (2.07;10)*	−0.073 (1.71;10)	−0.161 (2.84;9)**	−0.178 (2.26;13)*
HSE PC	−0.719 (2.97;9)**	0.045 (0.41;12)	−0.080 (0.29;15)	−0.408 (0.75;17)	0.022 (0.09;11)	0.418 (1.27;7)	−0.237 (0.51;17)
HS AGE	0.633 (2.26;4)*	0.108 (1.03;9)	0.464 (1.45;10)	1.479 (2.35;13)*	0.452 (1.58;13)	1.073 (2.81;5)**	1.755 (3.30;9)**
% OWN	−0.036 (0.31;17)	0.091 (1.90;4)	−0.322 (2.47;3)*	−0.249 (0.97;16)	−0.199 (1.70;6)	−0.148 (0.95;17)	−0.443 (2.05;14)*
% COM	0.278 (2.25;10)*	0.012 (0.22;15)	0.295 (2.09;6)*	0.880 (3.17;1)**	0.090 (0.71;17)	0.209 (1.24;15)	0.637 (2.72;1)**
WRK COM	0.201 (4.29;6)***	0.003 (0.16;16)	0.138 (2.57;7)*	0.276 (2.61;6)*	0.066 (1.38;15)	0.135 (2.11;11)*	0.263 (2.96;6)**
MLS TR	0.019 (0.30;18)	−0.013 (0.45;13)	0.121 (1.71;4)	0.202 (1.44;8)	0.130 (2.04;5)*	0.140 (1.65;6)	0.139 (1.17;15)
Constant	−9.537	4.437	−68.520	−107.643	−23.751	−65.837	−122.523
R^2	0.89	0.54	0.67	0.85	0.80	0.85	0.86

[a]First number in each parenthesis is the absolute value of the *t* statistic; second number indicates the step in which the associated variable entered into the stepwise regression.
[b]Variables did not enter into the regression.
*$p < 0.05$
**$p < 0.01$
***$p < 0.001$

In general, it is apparent from the various significant interaction terms in the second-order models that the original exogenous variables defined in Table 1 tend to have their most significant impact on the EMS demand via mutual interactions. Such dependent effects are clearly seen to exist, for example, with regard to an area's median family income and population sparsity, which also exert significant independent effects on the majority of the endogenous variables as seen from the first-order models in Table 3. The joint effect of these two variables is highly significant (at the 0.1 per cent level) in the case of drug intoxication and dry runs, while a number of interaction terms involving one of these two variables are also seen to be significant. Thus, the median family income interacts with: 1) the size of the transient population to cause a negative and significant influence on the EMS demand for drug intoxications; 2) the degree of commercialization of an area as well as with its acreage to cause a significant negative effect on the EMS demand for other trauma; and 3) the average housing age to produce a significant negative effect on the EMS demand due to other illness.

The interaction between the acreage per capita for an area and the size of its transient population is a significant variable with a positive coefficient in the model for drug intoxication, cardiovascular and pulmonary incidents, as well as for other illness. The interaction involving acreage per capita and the degree of commercialization is seen to be the most highly significant variable both in the case of other trauma and dry runs. The square of an area's acreage per capita exerts a positive and significant influence on the rate of EMS attributable to drug intoxications and to dry runs.

The racial factor, which was found to be an important one in the studies by Aldrich, et al.,[3] and others[4,6] and in some of the first-order models of the present study, did not enter into the second-order models given in Table 4. However, the racial composition of an area did turn out to have a significant effect on the EMS demand related to automobile accidents through its interaction with the area's acreage by itself and on a per capita basis. Another demographic factor that is not incorporated into any of the second-order models, while it was found to be significant in some of the first-order models, is the age distribution of the population. Of other demographic variables, both the first- and the second-order models indicate that unemployed males tend to generate a significantly higher rate of EMS demand for some types of medical emergencies than do their employed counterparts, while this difference is not significant in the case of females. A similar finding with regard to unemployment was reported in the Los Angeles study[3] for the categories of dry runs and other illness.

On the basis of the second-order models in Table 4 as well as the first-order models in Table 3, it is possible to make much more precise quantitative inferences about the EMS demand. Thus, consider, for example, an average area within the city characterized by the mean values of the exogenous variables defined in Table 1. If, for instance, the median yearly family income in such an area is increased by 8 per cent, then it is easily found from the data in Tables 1 and 4 that the EMS demand in this area is predicted to decrease by about 18 per cent, 12 per cent, and 6 per cent for drug intoxications, other trauma, and dry runs, respectively.

The quantitative models developed in this study must necessarily be viewed as being unique to the particular EMS system of Atlanta, Georgia, although a number of their general characteristics are in agreement with those developed by some other investigators using data from different urban areas in the U.S. There exists a definite need to conduct additional studies of other EMS systems in order to gain better

TABLE 4—Second-Order Models of EMS Demand for Different Categories of Medical Emergencies

Variables	Parameter Estimates	t Value at Final Step	R^2
	Drug Intoxication		
(ACR PC) (TR POP)	0.011	9.40***	.59
(INC FA)(TR POP)	−0.002	−10.04***	.79
(ACR PC)(HS AGE)	0.035	7.84***	.86
(INC FA)(ACR PC)	−0.019	−9.43***	.93
$(ACR\ PC)^2$	0.025	7.32***	.95
$(INC\ FA)^2$	0.001	3.64***	.96
TR POP	0.105	3.63***	.97
Constant	−1.068		
	Other Trauma		
(ACR PC)(% COM)	0.100	14.75***	.61
(INC FA)(% COM)	−0.018	−9.48***	.77
(UNEM M)(% COM)	0.126	7.02***	.88
(INC FA)(ACRES)	−0.001	−4.61***	.91
INC FA	−0.145	−1.85	.92
Constant	23.451		
	Cardio-Vascular		
(ACR PC)(TR POP)	0.012	4.55***	.57
INC FA	−0.246	−4.39***	.69
ACR PC	0.937	4.62***	.73
ACRES	−0.118	−2.70**	.78
$(MLS\ TR)^2$	0.0003	1.30	.81
(ACR PC)(% OWN)	−0.010	−1.68	.82
$(TR\ POP)^2$	−0.001	−3.01**	.83
TR POP	0.247	2.75**	.84
(INC FA)(% OWN)	0.001	1.33	.85
Constant	15.630		
	Other Illness		
(ACR PC)(TR POP)	0.019	5.52***	.49
INC FA	0.119	0.48	.69
(ACR PC)(HS AGE)	0.033	2.24*	.81
(ACRES)(HS AGE)	−0.013	−3.50***	.83
(INC FA)(MLS TR)	−0.0001	−0.11	.84
$(TR\ POP)^2$	−0.002	−3.72***	.85
TR POP	0.367	3.06**	.86
(MLS TR)(HS AGE)	0.005	1.94	.87
ACR PC	0.007	0.86	.87
HS AGE	1.466	2.79**	.88
(INC FA)(HS AGE)	−0.021	−2.40*	.89
Constant	−1.601		
	Dry Runs		
(ACR PC)(% COM)	0.072	12.36***	.66
(UNEM M)(ACR PC)	0.063	2.67**	.77
(INC FA)(ACR PC)	−0.021	−5.78***	.85
(WRK COM)(% COM)	−0.004	−5.02***	.88
$(ACR\ PC)^2$	0.033	3.11**	.90
Constant	21.028		

*$p < 0.05$
**$p < 0.01$
***$p < 0.001$

insights into the basic characteristics of such systems in general. Such requirements are basic to the optimal design of regional emergency health care delivery systems. On an individual basis, a study such as the one reported in this paper ought to possess considerable utility as a quantitative tool for evaluating the existing operating characteristics of such a system and for formulating alternative plans for its structure and dynamics.

REFERENCES

1. National Safety Council, Accident Facts. Chicago, IL, 1971.
2. Sadler AM, Sadler BL, and Webb SB: Emergency Medical Care: The Neglected Public Service. Cambridge, MA: Ballinger Publishing Co., 1977, Chapters 1 and 6.
3. Aldrich CA, Hisserich JC, and Lave LB: An analysis of the demand for emergency ambulance service in an urban area. Am J Public Health 61:1156-1169, 1971.
4. Gibson G: An analysis of the demand for emergency ambulance service in an urban area. Am J Public Health 61:2158-2160, 1971.
5. Gibson G, Bugbee G, and Anderson OW: Emergency Medical Services in the Chicago Area. Center for Health Administration Studies, University of Chicago, 1971.
6. Weinerman ER, Ratner RS, Robbins A, and Lavenhar MA: Yale studies in ambulatory medical care: V. Determinants of use of hospital emergency services. Am J Public Heath 56:1037-1056, 1966.
7. Atlanta Regional Commission. Emergency Medical Services in the Metropolitan Atlanta Region, Vols. I and II. Atlanta, GA, 1973.
8. Grady Memorial Hospital, Summary of Monthly Ambulance Activities, January 1968-March 1973.
9. Deems JM: Prediction of Calls for Emergency Ambulance Service. Unpublished M.S. Thesis, Georgia Institute of Technology, 1973.
10. Stevenson KA: Operational Aspects of Emergency Ambulance Services. Technical Report No. 61 of the Operations Research Center, Massachusetts Institute of Technology, Cambridge, MA, May 1971.
11. Torrens PR, and Yedvab DG: Variations among Emergency Room Populations: A Comparison of Four Hospitals in New York City. Medical Care VIII, 60-75, 1970.
12. King BG, and Sox ED: An emergency medical service system—Analysis of workload. Publ. Hlth. Rep. 82:995-1008, 1967.
13. Lee SS, Solon JA, and Sheps CG: How new patterns of medical care affect the emergency unit. Mod. Hosp. 94:97-101, 1960.
14. Kvålseth TO, and Deems JM: A Demand Model for Emergency Ambulance Service in an Urban Area. Proc. 1973 Int'l. Cong. on Cybernetics and Society, Boston, MA, Nov. 5-7, 1973.

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