ORIGINAL ARTICLE

Missed Opportunities for Prevention of Sudden Death

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BACKGROUND We assessed patterns of health care utilization to further characterize chronic comorbidities prior to sudden death.

METHOD From March 1, 2013, through February 28, 2015, all out-of-hospital deaths aged 18-64 reported by emergency medical services in Wake County, North Carolina, were screened to adjudicate 399 sudden death victims. Retrospective analysis of clinical records on victims determined health care utilization. Health care utilization frequency was assessed by latent growth curve analysis.

RESULTS Medical records were available for 264 victims (aged 53.5 ± 9.2) who were predominantly male (65%) and white (64%). Of these, 210 (80%) victims had at least one visit within two years of death and 73 (28%) had a visit within one month of death. Over the two years prior to death, there was an increasing frequency of doctor visits ($P < .001$). Victims averaged 3.7 ± 4.6 yearly visits and were categorized into low (0.4 visits/year), medium (3.3 visits/year), and high (11.4 visits/year) tiers of visit frequency. The high visit tier had a greater prevalence of coronary artery disease (38%), hypertension (80%), diabetes (58%), depression (74%), anxiety (64%), and substance misuse (46%) ($P < .001$).

LIMITATIONS Those who were non-free-living, minors, without formal medical records, and adults aged 65 and older were excluded from the analysis.

CONCLUSIONS A majority of sudden death victims utilized health care within two years prior to death and had comorbidities that may have contributed to their unexpected death. The increasing frequency of visits prior to death provided an opportunity for health care providers to address potential victims' chronic medical conditions to potentially prevent death.

Sudden death is one of the leading causes of death in the United States [1-5]. Efforts to prevent sudden death are not often undertaken, as these deaths are often considered unexpected and the first manifestation of cardiovascular disease [1, 6, 7]. However, recent research from our group suggests that sudden death victims often have multiple medical conditions that may cause or contribute to their death [8, 9]. In order to assess possible opportunities for prevention of sudden death, we assessed health care utilization in the two years prior to sudden death within a population sample of sudden death victims.

Methods

Case Ascertainment

Emergency medical service (EMS) attended deaths were screened through electronic query of EMS patient care reporting software (ESO Solutions V 4.8, Austin, Texas) for presumed sudden death victims from March 1, 2013, through February 28, 2015, in Wake County, North Carolina. Two trained researchers screened electronic records to exclude participants if they were less than 18 or greater than 64 years old, were not residents of the county, were under hospice, had a do not resuscitate (DNR) order, were not free-living citizens (i.e., resident of nursing facility or incarcerated), or died due to a non-natural or violent cause. We excluded adults aged 65 and older in order to conduct a pilot study of premature sudden death and limit the complexity of adjudication for older adults (Figure 1). A secondary exclusion was performed by three cardiologists to adjudicate cases as sudden and unexpected. Cases were evaluated based on EMS data, medical records, and medical examiner documentation. In the case of disagreement between reviewers, majority decision determined adjudication.

Data Collection

Only subjects with available medical records were included in this study. Records within two years of a victim's death were examined for notes that were indicative of health care provider visits that were limited to encounters with a medical doctor, nurse practitioner, or a physician assistant. Visits included outpatient visits, hospitalizations, or emergency visits. Surgeries and procedure notes were excluded from the analysis. Demographic data and comorbidities including coronary artery disease, heart failure, hypertension, diabetes, dyslipidemia, chronic renal failure, chronic respiratory disease, depression, anxiety, schizophrenia, bipolar disorder, alcohol misuse, and substance misuse were also obtained from medical records, death certificates, and medical examiner reports. Trained abstractors fol-

Electronically published November 9, 2020.

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N C Med J. 2021;82(2):4-8.
0029-2559/2021/82201

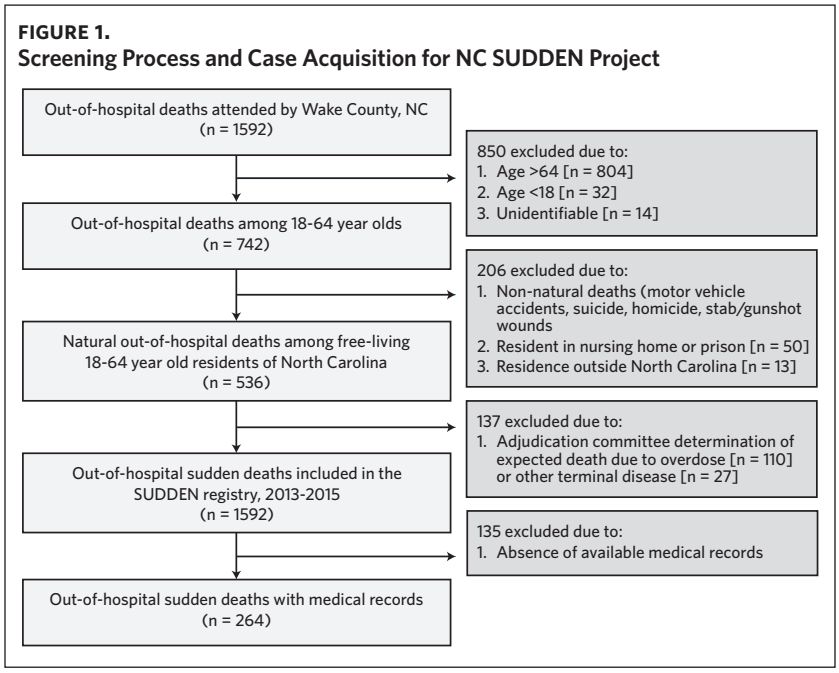


FIGURE 1.
Screening Process and Case Acquisition for NC SUDDEN Project

lowed written protocols and computer-generated screens in defined chart locations for all variables. Quality assurance of chart abstractions were performed with 15% resampling with retraining and resampling as appropriate to achieve concordance between reviewers.

Statistical Methods

To classify the victims into subgroups of health care visits, latent class growth curve analysis separated victims into three tiers of doctor visitation: low, medium, and high tiers. These three tiers represented statistically different degrees of visitation by the total number of provider visits over the two-year study period. These tiers were further stratified based on the degree of visitation in six-month intervals prior to death. SAS v.9.4 (Cary, NC) procedure PROC TRAJ was used to implement the analysis with zero-inflated Poisson regression as the model and Bayesian Information Criterion as the selection criterion for the order of the curve. The frequency of visits was compared between male and female and white and African American victims. Statistical significance between various characteristics was determined using χ^2 tests or two-sample t tests where appropriate. Logistic regression was used for covariates. P-values smaller than .05 were considered statistically significant.

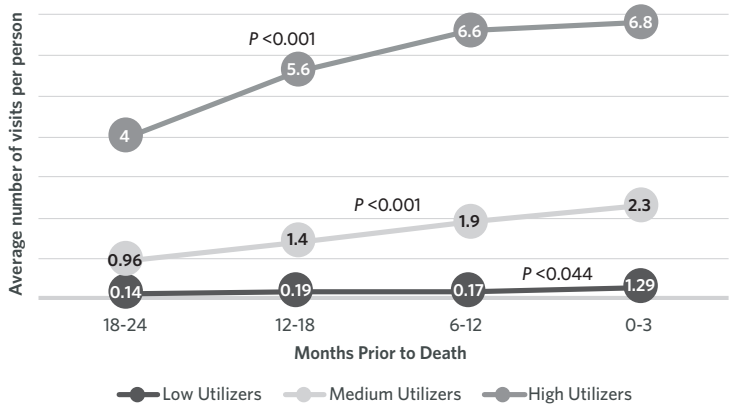
Results

From March 1, 2013, through February 28, 2015, there were 1,592 EMS referrals for presumed sudden death. Of these, 1,056 individuals were excluded from analysis by primary exclusion and 536 cases were then presented to the adjudication committee, which identified 399 sudden unexpected death victims. Medical records were available for 264 victims (66%), who were 53.5 ± 9.2 years old, predominantly male (65%), white (64%), and unmarried (62%). On average, there were 3.7 ± 4.6 visits per year. Of the total 1,921 visits over the two-year time period, 76% (1,460) were made to outpatient providers, 15% (285) to the emergency department, and 10% (176) were inpatient hospitalizations. There were no significant differences in the distribution of visits between men and women. Of the 264 victims, 73 (27.7%) had at least one visit within 30 days prior to sudden death. Low (n = 107), medium (n = 107), and high (n = 50) tiers of provider visits were identified through latent growth curve analysis; each group represented a statistically different degree of provider visitation.

The frequency of health care provider visits on average increased prior to a victim's death. This was most pronounced for the medium and high tiers ($P < .001$), although this relationship held true for the low group as well ($P < .04$) (Figure 2). There was also a linear increase in the total number of outpatient, inpatient, and emergency department visits in each six-month period prior to death. There were 316 total visits in the first period to 615 in the final period (Figure 3). In particular, inpatient and outpatient visits increased between each six-month period, but the linear relationship for emergency department visits was less pronounced, in which there were 97 and 98 visits in the final two six-month periods.

The three tiers of health care visits are shown in Table 1. On average, a victim from the low tier had 0.4 ± 0.5 visits per year, the medium tier had 3.3 ± 1.5, and the high tier had 11.6 ± 4.8 ($P < .001$). Those in the high tier were more likely to be smokers (70%, $P < .001$) and unmarried (72%, $P = .035$). There was no significant difference between years of attained education, BMI, sex, or ethnicity among the three groups. With respect to comorbidities, there was an increase in prevalence from the low to the high tier for

FIGURE 2.
Trend in Health Care Provider Visits for 264 Out-of-Hospital Sudden Death Victims Over Two years Stratified by Tier (utilizer)



Note. Each time point represents the average number of visits per person for a particular tier.

each comorbidity (Table 2). The high tier had a substantially greater burden of mental illness and substance misuse.

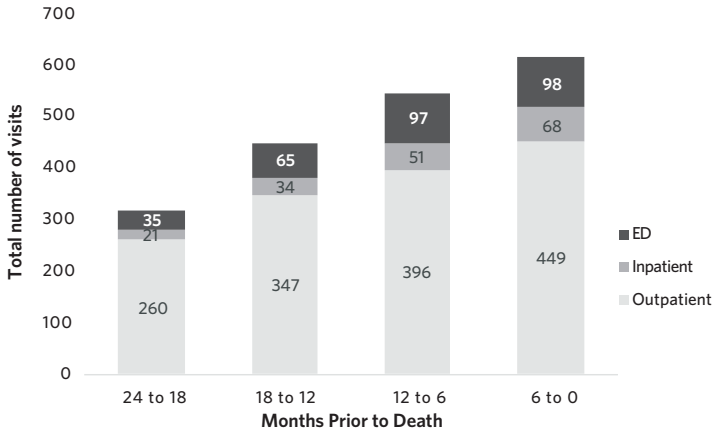
Discussion

Over 60% of sudden death victims saw a health care provider in the two years prior to their unexpected death. Many victims saw their health care providers at an exorbitantly high rate, exceeding 11 visits per year, and had a high burden of common comorbidities including diabetes, coronary artery disease, and respiratory disease with a disproportionately high percentage of mental illness and substance misuse. Most victims had an increased number of health care visits prior to death.

Our findings suggest most victims of sudden death have diagnosed, serious, chronic disease for which they seek medical care. Increasing medical visits closer to death suggest that victims experience an escalation of symptoms or disease progression prior to sudden death. Underuse of evidence-based care, particularly in relation to medication management for hypertension and coronary artery disease, may have worsened chronic disease and predisposed victims to death [10]. For example, in victims of sudden death with coronary artery disease, less than half were prescribed statins in contrast to the 59%-72% reported in other patient groups [10, 11]. Important drugs for diabetes such as metformin were also under-prescribed, with only 21% of diabetic patients receiving the drug in contrast to reports of overall prescription rates closer to 40% [10, 12]. Lack of goal-directed medical therapy may have predisposed victims to sudden death.

The predominance of mental illness and substance misuse in victims suggests a barrier to care as well. Almost half of the high visit tier was burdened by substance misuse and more than two thirds struggled with anxiety or depression. In the low and medium visit tiers, alcohol and substance misuse occurred in approximately 16%-27% of individuals with more than one third of them experiencing depression. Our findings support the previously found association between

FIGURE 3.
Total Numbers of Outpatient, Inpatient, and Emergency Department Visits in the Two Years Prior to Sudden Death



Note. ED = emergency department

TABLE 1.
Demographic Data for the 264 Sudden Death Victims Stratified by Tier (Low, Medium, High) in the Two Years Prior to Death

	Low (n = 107)	Medium (n = 107)	High (n = 50)	*P*-value	Total (N = 264)
Average number of total visits per person per year, mean (SD)	0.4 (0.5)	3.3 (1.5)	11.6 (4.8)	< .001	3.7 (4.6)
Age (years), mean (SD)	51.0 (10.1)	55.1 (7.0)	54.4 (10.6)	.002	53.3 (9.2)
Education (years), mean (SD)	13.5 (2.3)	13.5 (2.3)	13.1 (2.3)	.915	13.4 (2.3)
Body Mass Index, mean (SD)	30.4 (9.1)	30.9 (8.9)	30.1 (8.9)	.643	30.5 (9.0)
Male, n (%)	73 (68.2)	69 (64.5)	29 (58.0)	.266	171 (64.8)
Race, n (%)					
White	72 (67.3)	64 (59.8)	33 (66.0)	.380	169 (64.0)
African American	34 (31.8)	41 (38.3)	17 (34.0)		92 (34.9)
Married, n (%)	38 (35.5)	48 (44.9)	14 (28.0)	.035	100 (37.9)
Smoker, n (%)	47 (44.3)	70 (65.4)	35 (70.0)	< .001	152 (57.8)

Note. Numerical data is represented as an average (SD); categorical data is represented with n (horizontal %)

mental illness and sudden death [13]. Part of this association might be attributed to undetected overdose and the use of psychiatric medications, including benzodiazepines and various antipsychotics [14]. These results suggest that proactively addressing mental illness may present an opportunity for intervention in sudden death prevention. Regularly screening for signs of depression, anxiety, and substance misuse in general primary care clinics may represent a viable strategy, as these conditions may not be volunteered unless specifically asked for. If positive screens are identified, appropriate medical management and/or referrals can be placed at that time.

This study has limitations. We excluded those who were not free-living, minors, and adults aged 65 or older. As such, our results can only be interpreted with respect to the characteristics of younger adults. Our analysis is limited to victims for whom we were able to obtain medical records from health centers. Given that records were missing for a portion of the study population, visit rates may differ in relation to the general population. Despite these limitations, we feel our results should apply to a large segment of the adult US population with sudden death. We base this assertion on the diverse population studied and confirmatory evidence from another study we performed across other North Carolina counties. Specifically, we studied victims in Wake County, a county with population characteristics similar to that of the US population. In addition, we confirmed a high incidence of sudden death in other North Carolina counties and confirmed the association of poverty and rural status to sudden death [10, 15].

Conclusions

A majority of sudden death victims saw a health care provider within two years of death, often with increasing frequency prior to death. The frequency of these visits offers an opportunity for health care systems to provide evidence-based care that may potentially help prevent sudden death. NCMJ

TABLE 2.
Common Comorbidities for the 264 Sudden Death Victims Stratified by Tier (Low, Medium, High) in the Two Years Prior to Death for All Visit Types

	Low (n = 107)	Medium (n = 107)	High (n = 50)	Total (N = 264)	*P*-value
Heart Failure	5 (4.7)	24 (22.4)	15 (30.0)	44 (16.7)	< .001
Coronary Artery Disease by medical records	13 (12.2)	18 (16.8)	19 (38.0)	50 (18.9)	< .001
Hypertension	65 (61.3)	82 (76.6)	40 (80.0)	187 (71.1)	< .001
Diabetes	22 (20.8)	42 (39.3)	29 (58.0)	93 (35.4)	< .001
Dyslipidemia	28 (26.4)	74 (69.2)	34 (68.0)	136 (51.7)	< .001
Chronic Renal Failure	9 (8.5)	19 (17.8)	14 (28.0)	42 (16.0)	< .001
Chronic Respiratory Disease	25 (23.6)	50 (46.7)	33 (66.0)	108 (41.1)	< .001
Depression, n (%)	31 (29.0%)	42 (39.3%)	37 (74.0%)	110 (41.7%)	< .001
Anxiety, n (%)	25 (23.4%)	35 (32.7%)	32 (64%)	92 (34.8%)	< .001
Bipolar Disorder, n (%)	6 (5.6%)	12 (11.2%)	14 (26.9%)	32 (12.1%)	< .001
Alcohol misuse, n (%)	27 (25.2%)	29 (27.1%)	18 (36.0%)	74 (28.0%)	.180
Substance misuse, n (%)	26 (24.3%)	17 (15.9%)	23 (46.0%)	66 (25.0%)	< .001

Note. Each number represents numbers of subjects, n (%)

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Acknowledgments

The Wake County EMS Data System supports, maintains, and monitors EMS service delivery, patient care, and disaster preparedness for the Wake County, North Carolina, community at large. This manuscript has been reviewed by Wake County EMS Data System investigators for scientific content and consistency of data interpretation with previous Wake County EMS Data System publications.

We would like to thank the North Carolina Office of the Chief Medical Examiner, SUDDEN team of researchers, and the North Carolina Translational and Clinical Sciences Institute at University of North Carolina at Chapel Hill.

Financial support. The SUDDEN project is funded by individual and private donations, The Heart and Vascular Division of the University of North Carolina at Chapel Hill, and the McAllister Heart Institute. The project described was supported by the National Center for Advancing Translational Sciences (NCATS), National Institutes of Health, through Grant Award Number UL1TR002489. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

Potential conflicts of interest. All authors report no relevant conflicts of interest.

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