The vulnerabilities of age: burns in children and older adults

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Background. *Both children and older adults are thought to sustain burns serious enough to warrant hospitalization disproportionately more often than other age groups, but the incidence, injury characteristics, and outcome have not been precisely defined.*
Methods. *Patients hospitalized with a burn diagnosis were identified from hospital discharge data from California, Florida, New Jersey, and New York for the 5-year period 2000-2004.*
Results. *In those states, 60,024 residents were hospitalized with a diagnosis of burn and/or inhalation injury according to the* International Classification of Diseases, 9th Revision, Clinical Modification *diagnosis codes. Using population data from the United States Census 2000, we found that the average annual incidence of hospitalization with a burn diagnosis in these 4 states was 155 per million (per M) (95% confidence interval,153-158). There were 13,453 children under 15 years of age: incidence, 163 per M (range, 157-169). Of these 9508 (70%) were under 5 years of age: incidence, 363 per M (range, 347-379). In contrast, there were 10,686 patients 65 years of age or older: incidence, 214 per M (range, 205-224), of whom 2091 were at least 85 years old: incidence, 347 per M (range, 314-380). The incidence of hospitalization with a burn diagnosis for patients 15 to 64 years of age was 141 per M (range, 138-145). Compared with children younger than 15 years, patients aged 65 years and older more often had flame burns (odds ratio [OR], 2.12), burns of 20% or more of body surface area (OR, 2.41), inhalation injury (OR, 2.88), respiratory failure (OR, 4.48), and death (OR, 16.53), all $P < .0001$.*
Conclusions. *Older individuals are the most vulnerable to the morbidity and mortality of burn injury. Prevention strategies targeted to those older than 65 years should be developed. (Surgery 2006;140:705-17.)*

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Burns severe enough to require hospitalization are not common in developed countries, especially when compared with other types of injury. They are responsible, however, for a disproportionate share of injury death, disability, and resource utilization. Children and also older adults have been cited as segments of the population most at risk for sustaining a burn that will require hospital treatment.[1] A variety of strategies to prevent these injuries have been advocated. Some have been proposed to benefit all age groups, such as the introduction of fire-safe cigarettes[2] and smoke detectors, while others have targeted children specifically, such as fire-retardant sleepwear[3] and the regulation of hot water temperature to prevent tap water scalds.[4] In addition, burn prevention education has been offered to parents.[5] A recent Cochrane report, however, found that most of the available studies were inadequate to judge the effectiveness of these measures in preventing burns in children.[6] Other studies have identified factors more common in older adults that may predispose them to burn injury such as dementia or diabetes.[7,8] Although some prevention programs have been developed for older adults, their efficacy remains unknown.[9] Many of the available studies are limited to the experience of a specific institution or type of burn. Knowledge of the incidence of burns in a general population that result in hospitalization, however, could provide a basis for judging the impact of existing preventive measures and indicate where new ones might be beneficial. The purpose of this study, therefore, was to estimate the incidence of burn hospitalization, and to com-

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pare the injury characteristics and outcomes of children and older adults.

METHODS

Data sources. *New York.* Administratively releasable hospital discharge data of the Statewide Planning and Research Cooperative System (SPARCS) was obtained from the New York State Department of Health for the years 2000-2004 inclusive. The data for each year were in the form of text documents contained on 2 compact discs.

California. Hospital discharge data were obtained from the State of California Office of Statewide Health Planning and Development for 2000-2004. Data from all hospitals were combined for each year and written as a SAS Dataset (SAS Institute, Cary NC) on a single compact disk.

New Jersey. New Jersey UB-92 Data were obtained from Healthcare Systems Analysis, Research and Development, New Jersey Department of Health and Senior Services for the years 2000-2004. Data for 1 calendar year were written as a text document on a single compact disc.

Florida. Discharge data were obtained from the Agency for Health Care Administration, Florida Department of Health for the years 2000-2004. Data for each quarter were contained in a text document. Two quarters were included on a single compact disc.

Census data. Population data were taken from Summary File 1 (SF-1), 100-percent data from the *United States Census 2000* accessed through the Web site of the US Census Bureau.[10]

Study population. *New York.* On the basis of the layout scheme for the SPARCS data file, selected variables were extracted from each text file with the use of SAS 9.0 (SAS Institute). These included variables related to age, gender, county of residence, treating facility, admission type and source, diagnosis and procedure ICD-9-CM codes (*International Classification of Diseases, 9th Revision, Clinical Modification*), disposition, and length of stay. Additional categorical, dichotomous, and grouping variables were created from these. All records including these variables were contained in a SAS data set.

A study sample of patients hospitalized with a burn diagnosis was extracted from the total hospital discharges for each year. Each SPARCS record contains up to 15 ICD-9-CM diagnosis codes and 15 procedure codes. All records in which at least 1 of the diagnosis codes indicated a cutaneous burn or an inhalation injury (Table I) were extracted into another SAS data set.

Table I. Burn ICD-9-CM codes

Codes	*Description*
Anatomic sites burned	
941.00-941.59	Head and neck
942.00-942.59	Trunk
943.00-943.59	Upper extremity (not hand)
944.00-944.58	Hand and wrist
945.00-945.59	Lower extremity
946.0-946.5	Multiple specified sites
949.0-949.5	Site unspecified
Burn size	
948.00-948.99	Extent of body surface area burned
Inhalation injury	
947.0-947.1	Mouth, pharynx, larynx, trachea, lung
986	Carbon monoxide inhalation
987.9	Smoke inhalation

ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification.

Additional variables specific for patients with burns were assigned. The region of the body that had been burned was determined from the anatomic burn codes 941-945 and 947. The primary mechanism of injury was determined from the E-code in SPARCS, and the location where the burn occurred was determined from the Injury Location E-code. Procedures specific for the care of burn patients were identified by the procedure codes. Records in which the coded disposition indicated transfer to another acute care hospital were dropped from the data set in an attempt to avoid counting a given patient more than once.

Several additional dichotomous, categorical, and grouping variables were created. The presence of acute respiratory failure, for example, was identified from any one of the ICD-9-CM codes for acute respiratory failure (518.81, 518.82, and 518.84), respiratory failure after trauma (518.5), or the procedure code for mechanical ventilation for more than 96 hours (96.72). Similarly a dichotomous variable for inhalation injury was based on any diagnosis of a burn of the upper airway or lung (486.0 or 486.1), or inhalation of smoke (987.9) or carbon monoxide (CO; 986). Since carbon monoxide inhalation can occur in settings other than a fire, cases were excluded if the E-code indicated inhalation of fumes and if there were no codes that referred either to a burn in an anatomic region or to a burn size. The severity of burn injury, the extent of the body surface burned, was determined from the listed 948 series code (948.00-948.99). The fourth digit in the code indicates the total

percentage of the body surface (TBSA) that had at least a second-degree burn. To quantitate total burn size, we created a scale by assigning a number to each case with a burn size code. Thus, 948.00 (total body surface area burn of 0%-9% BSA) was assigned the value 0, 948.10 and 948.11 (TBSA, 10-19%) the value 10, and so forth. The fifth digit of the code indicates the percentage of the BSA that has full-thickness or third-degree burns. Since the fifth digit was not 0 in only a small number of cases, this analysis considered only the extent of total body burn. Hospitals listed by the American Burn Association Directory of US Burn Care Facilities were identified by the patient facility indicator.

The data sets containing all burn discharges from both New York City (NYC) and upstate hospitals for each year were combined into two 5-year data sets: one containing discharges from NYC hospitals and the other, upstate discharges. These data were then combined to create a single, NY state burn data set for 2000-2004. In addition each record was associated with variables reflecting the year in which the discharge occurred and whether it was at a hospital in NYC or outside of NYC.

California. A study data set of California burn discharges for each of 5 years was created in an analogous manner from the California data. These were combined to form a final data set, which contained a set of variables similar to those of the final New York data sets. Records in the California discharge data may contain up to 20 diagnosis and 20 procedure ICD-9-CM codes, but, similar to the selection procedure used for New York, a record was included in the study data set only if one of the first 15 diagnosis codes indicated a burn diagnosis. Similarly, only the first 15 procedure codes were included. California data include up to 4 E-codes, in contrast to New York, which includes 1 E-code for mechanism and 1 for injury location. All 4 codes were included and queried to determine a mechanism of injury and a location of injury for each record. Ten of the 58 counties in California have a population less than 30,000. These populations are combined in the releasable data set into 3 different county groupings such that the combined population of the counties in the group is greater than 30,000. Residents from these counties who are hospitalized have 1 of these county groupings listed as their county of residence.

Florida. Quarterly discharge data sets were combined to form 1 data set for each of the 5 years 2000-2004. A study data set was formed from each of these yearly data sets by following similar procedures to identify patients with a burn diagnosis. These data sets were then combined into a final data set for Florida, which included the same variables as those for the other states. Records in the Florida discharge data include up to 10 diagnosis and 10 procedure codes.

New Jersey. Study data sets for each of 5 years were created by similarly procedures from the New Jersey data and then combined to form a final data set.

Data analysis. SAS 9.0 and Microsoft Excel 2003 (Microsoft Corp, Redmond, WA) were used to perform data analysis. Since the discharge data from each of the 4 states included all discharges from all acute care hospitals in the state, the study data sets were used to estimate the number of state residents hospitalized for a burn diagnosis in a given year. All records were included that included an in-state county of residence and any disposition except transfer to another acute care hospital. Incidence rates of hospitalization with a burn diagnosis could then be determined as a proportion by dividing the average yearly number of discharges by the appropriate population value as listed in the *United States Census 2000*. The standard error and 95% confidence intervals of the proportions were calculated under the normal approximation of the binomial distribution. Incidence rates, standard errors, and confidence intervals are expressed as discharges per million residents in the population per year.

New York. Hospitalization rates for NYC and upstate residents were determined separately from the combined data set, so that they accounted for upstate residents treated in NYC hospitals and for city residents admitted to upstate facilities.

California. In the publicly releasable version of the California data, certain data elements are masked from records that contain a unique combination of demographic variables that might render them identifiable. These include age, gender, race, and ethnicity. The frequency of masking for those variables is reported annually and has been fairly constant over the years included in this study. Approximately 55% of the records include an age in years, but 87% of the records are assigned to a 5-year age category on the basis of the patient's true age. Counts of burn discharges based on gender or age group were then adjusted upward on the basis of the proportion of records in the study data set that had missing data as well as the relative differences in the frequency of masking reported for all California discharges. Incidence rates by county or residence, gender, and age group were calculated for the state as a whole on the basis of the annual average discharges during the 6 years 1999 through 2004.

Florida and New Jersey. Annual incidence rates by county of residence, gender, and age group were

determined for each state as a whole. The average annual number of discharges over the 5 years 2000-2004 was used to calculate the hospitalization rate for Florida, and the average over the 6 years 1999 through 2004 was used for the New Jersey data.

RESULTS

New York, 2000-2004. During this 5-year period there were 14,332,183 admissions to New York hospitals, 20,064 of which included a burn diagnosis (0.166%). Five hundred fifty-two patients were transferred to another acute care hospital and were not included in subsequent analysis. The resulting data set of 19,912 discharges included 18,872 with a New York county of residence. Of these, 608 had CO inhalation unrelated to a fire and were excluded. On the basis of US census data for 2000, these 18,264 cases reflected an average annual incidence of burn hospitalization of 193 per million (186-199).

There were substantial differences in incidence between NYC residents and those from other areas of the state. Patients living outside of the 5 boroughs of NYC included 7486 with a burn diagnosis for an average annual incidence of hospitalization of 137 per million (130-143). In contrast, there were 10,778 residents of NYC with a burn diagnosis for an average annual incidence of 269 per million (258-281). Table II includes estimates for the annual incidence of hospitalization as a function of gender and age group for both NYC residents and those from the rest of the state. Although the incidence is generally greater for all age groups in NYC than it is in the rest of the state, this observation is most apparent in the younger age groups. More than 1 of 1000 children younger than 5 years in NYC are hospitalized annually with a burn. Children younger than 10 years living in NYC are hospitalized more than 3 times as frequently as those in other communities in the state. Outside of NYC, however, the incidence for children was similar to that for those 75 years and older. This disparity has persisted for at least a decade.[11]

California, 2000-2004. During the 5-year period 2000-2004, there were 19,534,605 discharges from California hospitals. Of these, 26,969 (0.140%) were patients with at least 1 burn diagnosis. Eight hundred forty-three (3.1%) patients were transferred to an acute care hospital and were not counted in subsequent analyses. Of the remaining 26,156 discharges, 24,925 (95.3%) included a California county of residence. Of these, 804 had CO inhalation unrelated to a fire and were excluded. On the basis of the 2000 census, these 24,257 cases reflected an average annual incidence of hospitalization of California residents with a burn diagnosis of 143 per million (139-147) during the years 2000-2004 (Table II). This rate is similar to the 137 per million (130-143) in New York State outside of NYC.

Gender is a case descriptor that the Office of Statewide Health Planning masks in the publicly releasable version of the California hospital discharge data. This approach affected 20.9% of male discharges and 15.9% of female cases during the years included in this study. When the numbers of male and female burn discharges were adjusted upward by these proportions [number of cases / (1-proportion masked)], there were still 6785 (28%) records that were missing a value for gender. To estimate the incidence of cases for each gender, we further adjusted the cases to account for these missing data points under the assumption that the gender distribution among the masked cases was similar to that of the unmasked ones. The resulting estimates of hospitalization rate for both men and women (Table II) were similar to the values for upstate New York.

Similar procedures were followed to estimate the incidence of hospitalization with a burn diagnosis for each age group in California. There was a strong direct relationship between burn incidence and increasing age, except for a high incidence in children younger than 5 years. In California, the incidence in the oldest age group (≥85 years) was substantially greater than it was for the youngest.

Florida, 2000-2004. During the 5-year period 2000-2004, there were 11,905,948 discharges from Florida hospitals. Of these, 13,508 (0.113%) were patients with at least 1 burn diagnosis. Three hundred sixty-four (2.7%) patients were transferred to an acute care hospital and were not counted in subsequent analyses. The data set included 13,144 discharges, 12,445 (95%) of which included a Florida county of residence. Of these, 463 had CO inhalation unrelated to a fire and were excluded. On the basis of the 2000 census, these 11,982 cases reflected an average annual incidence of hospitalization of Florida residents with a burn diagnosis of 150 per million (144-156) during the years 2000-2004, similar to the rates for California and New York State outside of NYC. Except for the very young, there was a strong direct relationship between incidence of burn hospitalization and increasing age (Table II).

New Jersey, 2000-2004. There were 7,520,340 discharges from New Jersey hospitals in 2000-2004. Of these, 6,124 (0.083%) were patients with at least 1 burn diagnosis. One hundred seventy-nine (2.9%) patients were transferred to an acute care

Table II. Incidence of hospitalization for burns—2000-2004

	New York State				*New York City*				*Non-NYC New York*			
	Population	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*
Total	18,976,457	18,264	193	186-199	8,008,278	10,778	269	258-281	10,968,179	7,486	137	130-143
Women	9,829,709	7,403	151	143-158	4,214,074	4,503	214	200-228	5,615,635	2,900	103	95-112
Men	9,146,748	10,856	237	227-247	3,794,204	6,270	331	312-349	5,352,544	4,586	171	160-182
Age group (y)												
0-4	1,239,417	4,120	665	619-710	540,878	3,058	1,131	1,041-1,220	698,539	1,062	304	263-345
5-9	1,351,857	811	120	102-138	561,115	590	210	172-248	790,742	221	56	39-72
10-14	1,332,433	648	97	81-114	530,816	368	139	107-170	801,617	280	70	52-88
15-24	2,531,853	1,650	130	116-144	1,110,472	865	156	122-179	1,421,381	785	110	93-128
25-34	2,757,324	1,948	141	127-155	1,368,021	1,112	163	141-184	1,389,303	836	120	102-139
35-44	3,074,298	2,515	164	149-178	1,263,280	1,340	212	187-238	1,811,018	1,175	130	113-146
45-54	2,552,936	2,211	173	157-189	1,012,385	1,192	235	206-265	1,540,551	1,019	132	114-150
55-64	1,687,987	1,436	170	150-190	683,454	780	228	192-264	1,004,533	656	131	108-153
65-74	1,276,046	1,176	184	161-208	494,794	627	253	209-298	781,252	549	141	114-167
75-84	860,818	1,120	260	226-294	321,360	518	322	260-384	539,458	602	223	183-263
≥85	311,488	629	404	333-474	121,703	328	539	409-669	189,785	301	317	237-397

	California				*Florida*				*New Jersey*			
	Population	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*
Total	33,871,648	24,257	143	139-147	15,982,378	11,982	150	144-156	8,414,350	5,521	131	123-139
Women	16,996,756	9,298	109	104-114	8,184,663	4,344	106	99-113	4,331,537	2,313	107	97-117
Men	16,874,892	14,959	177	171-184	7,797,715	7,638	196	186-206	4,082,813	3,208	157	145-169
Age group (y)												
0-4	2,486,981	3,173	255	235-275	945,823	1,384	293	258-327	563,785	831	295	250-340
5-9	2,725,880	785	58	49-67	1,031,718	389	75	59-92	604,529	150	50	32-67
10-14	2,570,822	612	48	39-56	1,057,024	403	76	60-93	590,577	147	50	32-68
15-24	4,832,176	2,303	95	87-104	1,942,377	1,282	132	116-148	1,005,295	506	101	81-120
25-34	5,229,062	2,882	110	101-119	2,084,100	1,450	139	123-155	1,189,040	621	104	86-123
35-44	5,485,341	3,897	142	132-152	2,485,247	2,090	168	152-184	1,435,106	897	125	107-143
45-54	4,331,635	3,723	172	160-184	2,069,479	1,655	160	143-177	1,158,898	740	128	107-148
55-64	2,614,093	2,355	180	164-196	1,559,013	1,204	154	135-174	753,984	520	138	111-164
65-74	1,887,823	1,966	208	199-229	1,452,176	976	134	116-153	574,669	420	146	115-177
75-84	1,282,178	1,748	273	244-301	1,024,134	742	145	122-168	402,468	448	223	177-269
≥85	425,657	814	382	324-441	331,287	407	246	192-200	135,999	241	354	254-454

Population refers to data as recorded in the US Census 2000. *Cases* represents the total number of hospital discharges with a burn diagnosis during 2000-2004. *Incidence* represents the average annual incidence of hospital discharges with a burn diagnosis during 2000-2004 in cases per million population. *CI,* confidence interval.

Table III. Incidence of hospitalization for burns—2000-2004

	New York State				*New York City*				*Non-NYC New York*			
	Population	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*
Total	18,976,457	18,264	193	186-199	8,008,278	10,778	269	258-281	10,968,179	7,486	137	130-143
Women	9,829,709	7,403	151	143-158	4,214,074	4,503	214	200-228	5,615,635	2,900	103	95-112
Men	9,146,748	10,856	237	227-247	3,794,204	6,270	331	312-349	5,352,544	4,586	171	160-182
Age group (y)												
0-14	3,923,707	5,579	284	268-301	1,632,809	4,016	492	458-526	2,290,898	1,563	136	121-152
15-34	5,289,177	3,598	136	126-146	2,478,493	1,977	160	144-175	2,810,684	1,621	115	103-128
35-64	7,315,221	6,162	168	159-178	2,959,119	3,312	224	207-241	4,356,102	2,850	131	120-142
≥65	2,448,352	2,925	239	220-258	937,857	1,473	314	276-350	1,510,495	1,452	192	170-214
	California				*Florida*				*New Jersey*			
	Population	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*
Total	33,871,648	24,257	143	139-147	15,982,378	11,982	150	148-160	8,414,350	5,521	131	123-139
Women	16,996,756	9,298	109	104-114	8,184,663	4,344	106	102-116	4,331,537	2,313	107	97-117
Men	16,874,892	14,959	177	171-184	7,797,715	7,638	196	190-211	4,082,813	3,208	157	145-169
Age group (y)												
0-14	7,783,683	4,570	117	110-125	3,034,565	2,176	143	130-157	1,758,891	1,128	128	112-145
15-34	10,061,238	5,185	103	97-109	4,026,477	2,732	136	124-147	2,194,335	1,127	103	89-116
35-64	12,431,069	9,975	160	153-168	6,113,739	4,949	162	152-172	3,347,988	2,157	129	117-141
≥65	3,595,658	4,527	252	235-268	2,807,597	2,125	151	137-166	1,113,136	1,109	199	173-225

Population refers to data as recorded in the US Census 2000. *Cases* represents the total number of hospital discharges with a burn diagnosis during 2000-2004. *Incidence* represents the average annual incidence of hospital discharges with a burn diagnosis during 2000-2004 in cases per million population. *CI*, confidence interval.

Table IV. Relative risk of burn hospitalization

State/region	Age group (y)	Incidence	95% CI	Ages 0-14 vs ≥65		Ages ≥65 vs 0-14		P value
				Risk ratio	95% CI	Risk ratio	95% CI	
California	0-14	117	110-125	0.467	0.426-0.512	2.141	1.953-2.347	<.0001
	≥65	252	235-268					
Florida	0-14	143	130-157	0.947	0.829-1.082	1.056	0.942-1.206	.4243
	≥65	151	137-166					
New Jersey	0-14	128	112-145	0.644	0.535-0.775	1.506	1.290-1.869	<.0001
	≥65	199	173-225					
Non-NYC	0-14	136	121-152	0.712	0.607-0.834	1.404	1.199-1.647	<.0001
	≥65	192	170-214					
New York City	0-14	492	458-526	1.564	1.368-1.787	0.639	0.560-0.731	<.0001
	≥65	314	276-350					
Total w/o NYC	0-14	127	121-133	0.622	0.584-0.664	1.608	1.506-1.712	<.0001
	≥65	204	195-213					
Total w/NYC	0-14	163	157-169	0.76	0.719-0.804	1.316	1.244-1.391	<.0001
	≥65	214	205-224					

CI, Confidence interval; NYC, New York City.

hospital and were not counted in subsequent analyses. The data set included 5945 discharges, 5742 (97%) of which included a New Jersey county of residence. Of these, 264 had CO inhalation unrelated to a fire and were excluded. On the basis of the 2000 census, these 5521 cases reflected an average annual incidence of hospitalization of New Jersey residents with a burn diagnosis of 131 per million (123-139) during the years 2000-2004. This rate was similar to those for California, Florida, and New York State outside of NYC. There was a strong direct relationship between age and incidence of burn hospitalization after the age of 4 years, but the rates for the very young and those 75 years and older were similar.

To examine the relationship between age and incidence of burn hospitalization further, we combined the 5-year age categories were combined into 4 larger groups. A pediatric age group included those younger than 15 years, an older adult group included those 65 years and older, and 2 other adult groups were made up of those 15 to 34 years and those 35 to 64 years. In NYC the pediatric age group had the greatest incidence of burn hospitalization, but, outside of NYC and in California, Florida, and New Jersey, older adults were hospitalized with a burn as frequently as or more so than the pediatric population (Table III). Young adults had the lowest incidence of hospitalization for burn treatment.

The risk ratios and risk differences for children and older adults were determined in subset analyses (Table IV). Although the rate of hospitalization for children in New York City (NYC) was 56% greater than it was for older adults, the risk was substantially lower in the rest of New York and in California and New Jersey ($P < .0001$). In Florida, the risks in the 2 age groups were equivalent ($P = .4243$). When the data from all 4 states were combined, both excluding and including the NYC data, the risk of burn hospitalization was appreciably greater for older adults than it was for children: risk ratio 1.32 (range, 1.24-1.39) including NYC and 1.61 (range, 1.51-1.71) excluding NYC, $P < .0001$ (Table V).

There were 21,320 records for patients in the pediatric and older adult age groups combined. Data for these 2 groups of patients are displayed in Table VI. Males comprised 59.8% of children younger than 15 years but only 44.3% of the adults 65 years and older. Thus the older adults were predominantly women (odds ratio [OR], 1.87 [1.77-1.98], $P < .0001$).

A mechanism of injury E-code was included in 79% of these records. Scald burns were the most common burn mechanism for all patients, but they occurred less frequently in older adults than in children: 24.7% versus 54.3%; OR, 0.28 (range, 0.26-0.29), $P < .0001$. Burns due to flame or fire, however, were twice as frequent in older adults than in children: 21.7% versus 11.6%; OR, 2.12 (range, 1.97-2.2.29), $P < .0001$. The prevalence of contact burns was similar: 14.3% and 15.2% ($P = .07$). There was some variability in the distribution of the different burn types between states. Thus, burns from fire or flame varied from 16.4% of injuries in New York to 31.2% of cases in Florida, and scald burns varied from 45.1% in Florida to 57.9% in New York.

Table V. Incidence of hospitalization for burns—2000-2004

	Total				*Total without NYC*			
	Population	*Cases*	*Incidence*	*95% CI*	*Population*	*Cases*	*Incidence*	*95% CI*
Total	77,244,833	60,024	155	153-158	69,236,555	49,246	142	139-145
Women	37,521,234	26,733	142	139-146	33,307,160	22,230	133	130-137
Men	39,723,599	33,291	168	164-172	35,929,395	27,021	150	146-154
Age group (y)								
0-4	5,236,006	9,508	363	347-379	4,695,128	6,450	275	260-290
5-9	5,713,984	2,135	75	68-82	5,152,869	1,545	60	53-67
10-14	5,550,856	1,810	65	58-72	5,020,040	1,442	57	51-64
15-24	10,311,701	5,741	111	105-118	9,201,229	4,876	106	99-113
25-34	11,259,526	6,901	123	116-129	9,891,505	5,789	117	110-124
35-44	12,479,992	9,399	151	144-157	11,216,712	8,059	144	137-151
45-54	10,112,948	8,329	165	157-173	9,100,563	7,137	157	149-165
55-64	6,615,077	5,515	167	157-177	5,931,623	4,735	160	149-170
65-74	5,190,714	4,538	175	163-186	4,695,920	3,911	167	155-178
75-84	3,569,598	4,058	227	212-243	3,248,238	3,540	218	202-234
≥85	1,204,431	2,091	347	314-380	1,082,728	1,763	326	292-360
Age group (y)								
0-14	16,500,846	13,453	163	157-169	14,868,037	9,437	127	121-133
15-34	21,571,227	12,642	117	113-122	19,092,734	10,665	112	107-116
35-64	29,208,017	23,243	159	155-164	26,248,898	19,931	152	147-157
≥65	9,964,743	10,686	214	205-224	9,026,886	9,213	204	195-213

CI, Confidence interval; NYC, New York City.

Table VI. Burn injuries in older adults and children

	Ages ≥65 y (N = 9310)		*Ages 0-14 y (N = 12,010)*				
	Mean	*95% CI*	*Mean*	*95% CI*			P *value*
Age (y)*	77.2	77.1-77.4	3.4	3.4-3.5			<.0001
Length of stay (d)	10.2	9.8-10.7	6.8	6.6-7.0			<.0001
Hospital charges	$15.39 K	14.2-16.4	$13.1 K	12.4-13.7			<.0001
Total BSA burn*	5.90%	5.5-6.4	3.10%	2.9-3.3			
	Cases (%)	*95% CI*	*Cases (%)*	*95% CI*	*Odds ratio*	*95% CI*	
Female*	55.7	54.7-56.7	40.2	39.3-41.1	1.87	1.77-1.98	<.0001
Scald burn	24.7	23.8-25.6	54.3	53.4-55.3	0.276	0.260-0.293	<.0001
Flame/fire burn	21.7	20.9-22.6	11.6	11.0-12.1	2.12	1.97-2.29	<.0001
Inhalation injury	13.4	12.8-14.2	5.1	4.74-5.53	2.877	2.602-3.181	<.0001
Respiratory failure	9.5	8.9-10.1	2.3	2.02-2.56	4.482	3.905-5.147	<.0001
Death	8.3	7.7-8.8	0.5	0.4-0.7	16.53	12.80-21.32	<.0001

BSA, Body surface area; CI, confidence interval.
*Values do not include cases with missing data.

Children with flame burns were more likely to have been injured because of burning clothing (OR, 1.44 [range, 1.1.24-1.67], $P < .0001$) or flammable liquids (OR, 1.95 [range, 1.1.57-2.43], $P < .0001$) than older adults, and they were less likely to have been burned in a dwelling fire (OR, 0.50 [range, 0.43-0.59], $P < .0001$). In contrast, adults 65 years and older with scald injuries were slightly more likely than children younger than 15 years to have been burned by hot tap water (OR, 1.15 [range, 1.02-11.1.29], $P = .017$)

A code for burn size was included in 62% of the records for children and older adults. Most burns were small, less than 10% of the body surface (TBSA), and they occurred less frequently in older adults than in children: 73.1% versus 78.5%; OR, 0.74 [range, 0.68-0.81]; P < .0001. In contrast, burns of 20% TBSA or more were much more

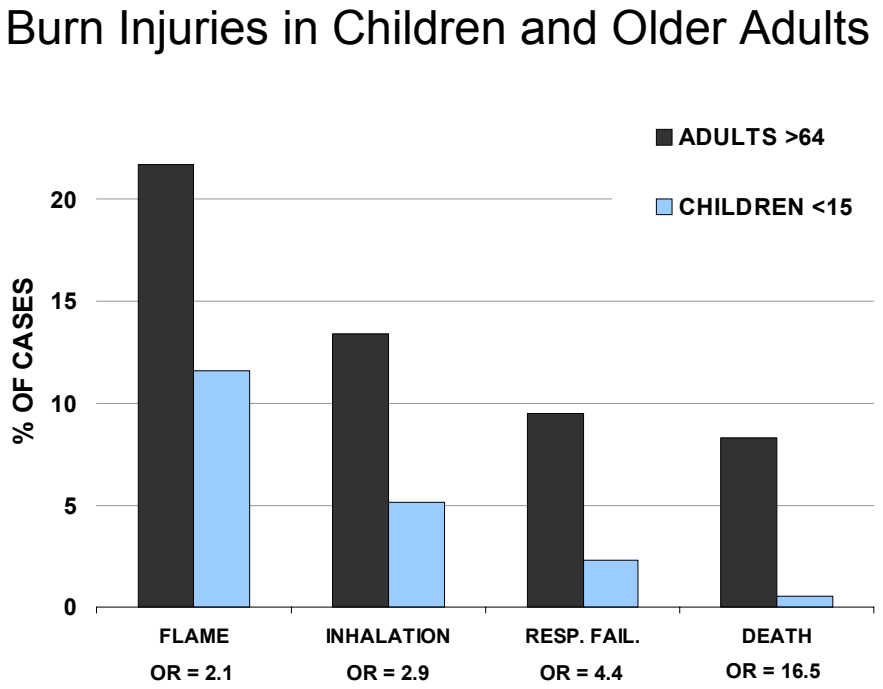

Figure. Differences between selected proportions for older adults and children hospitalized with a burn injury. Variables include burns due to fire or flame, inhalation injury, acute respiratory failure, and death. *OR,* Odds ratio. All are significantly different, $P < .0001$.

frequent in older adults than in children: 11.8% versus 5.3%; OR, 2.41 [range, 2.11-2.75], $P < .0001$. Burns involving 10%-19% TBSA occurred in similar proportions in both older adults and children: 15.2% versus 16.21%, $P = .126$. Burns of 20% TBSA or more were substantially more likely to be due to flame or fire than other mechanisms in both and older adults children (OR, 2.63 [range, 2.10-3.20] and 3.74 [range, 3.07-4.57] respectively, $P < .0001$ in both groups).

Older adults appeared to present with more complex medical situations than children. One of the primary burn ICD-9-CM codes (941.00-949.5) was listed as the principal diagnosis for more than 70% of children but for only 44% of the older adults. Other codes reflecting pneumonia, congestive heart failure, atrial fibrillation, syncope, cellulitis, and other cardiac, pulmonary, neurologic, or infectious problems were commonly used as the principal diagnosis. Although similar proportions of older adults and children had excisional procedures (20.4 and 19.5% respectively, $P = .1365$), older adults were substantially more likely than children to have had an inhalation injury, to develop respiratory failure, and to die (Table V, Fig 1). They also had a longer hospital stay than children (10.2 days [range, 9.8-10.7] vs 6.8 [range, 6.6-7.0], $P < .0001$) and incurred more charges ($15.4 thousand [range, 14.3-16.4] vs $13.1 [range, 12.4-13.7], $P = .0003$).

DISCUSSION

It is commonly thought that serious burn injury affects children disproportionately, but there have been no contemporary estimates of the incidence of these injuries. In this review, population-based estimates of the incidence of hospitalization with a burn diagnosis were determined from hospital discharge data from New York, California, Florida, and New Jersey for the 5-year period 2000-2004. The combined populations of those states in 2000 accounted for over 27% of the total population of the United States. Thus, the estimates in these 4 states combined, may approximate a national incidence. Since NYC may be atypical of other communities, estimates of hospitalization rates were calculated both with and without cases from NYC (Table V). On the basis of the hospitalization rates in these 4 states combined, it is estimated that between 40,000 and 43,600 patients with a burn-related injury are hospitalized annually in the United States. This finding is in general agreement with other estimates based on national hospital discharge data from the 1990s.[12,13]

In this review of 60,024 cases treated between 2000 and 2004 in which a burn-related diagnosis

was made, state residents who were 65 years and older were substantially more likely to be hospitalized with a burn than were children younger than 15 years as well as those in the intervening years. Burns in older adults were more likely to be large (20% TBSA or more) and to be caused by flame or fire than those in the pediatric age group. Older adults were more likely also to have an associated inhalation injury, to develop respiratory failure, and to die. Adults 65 years and older appear to be the segment of the population most vulnerable to burn injury.

Health department regulations in each of the 4 states require hospitals to submit discharge data on all cases treated as inpatients. Thus, these data served as the basis for this population-based analysis of burn hospitalization. The data are assembled at each hospital typically by medical records personnel on the basis of information in the medical record. If the medical record is complete and the coding accurate, administrative data can be a reliable source of information.[14] The validity of administrative data for burns, however, is not known.

Another limitation of this and any analysis is the effect of missing data. The state of California deliberately omits specific demographic data elements, such as age and gender, from its releasable data in an effort to prevent identification of specific individuals. The current analysis assumed that this process was random, but to the extent to which it was not truly random, some bias may have been introduced.[15] Specific burn-related data elements, such as an E-code for mechanism or the ICD-9-CM code for burn size, were also missing from several cases. Comparative analyses between groups of cases on specific variables were performed only on those cases that included the data element.

The National Trauma Data Bank (NTDB) is a database maintained by the American College of Surgeons and is a repository of data on patients who present to contributing hospitals for treatment of injury. The 2005 summary report included 857,428 patients with a known mechanism of injury admitted to reporting hospitals during 2000-2004.[16] Of these, only 5818 (0.68%) were injured as a result of fire or burns. Those injuries were associated, however, with the greatest hospital length of stay (6.81 days) of any injury mechanism and with a case fatality similar to that of motor vehicle traffic injuries (4.5% vs 4.9%).

The American Burn Association maintains a registry of burn patients cared for in burn centers, the National Burn Repository (NBR). The NBR report for 2006 includes almost 157,000 records of patients treated during the 11 years 1995-2005.[17] During 2000-2004, the length of stay of patients in the NBR was approximately 9 days, and the crude mortality was 5.5%. This compares with the length of stay in the burn centers in this review of 10 days and crude mortality of 4%.

A variety of preventive measures have been promoted to reduce the incidence of burns over the past several decades, including smoke detectors and reduced hot water temperature settings. Other efforts have been directed especially to the young, such as fire-retardant sleepwear and parental education. These initiatives may have been responsible, at least in part, for a reduction in the rate of burn hospitalization in children,[11] although that claim may not be well supported by empiric data.[6] What effect they may have had on burns in older adults, however, is not known. This review demonstrates that the risk of burn injury severe enough to require hospitalization in older adults is at least as great if not higher than it is for children. Thus, as the older age groups in the population grow, the number of older adults with burns admitted to hospitals will likely also increase. New burn prevention programs targeted to those older than 65 years, therefore, might be able to have a significant impact on the pain, misery, and morbidity attributable to burns in this age group. The vulnerability of older adults to burn injury only increases with age. Although children younger than 5 years and adults 85 years and older have almost the same likelihood of being hospitalized with a burn injury, the characteristics described for the 65 year and older group are even more pronounced in the elderly.

Specialized burn care centers began to be developed 30 to 35 years ago in an effort to improve outcome for burn victims. The American Burn Association Directory of Burn Care Facilities in the United States currently lists 29 burn centers in the 4 states considered here.[18] During the 5 years of this review, these burn centers discharged 54.5% of all 60,024 patients hospitalized with a burn diagnosis. They included 75.3% of children but only 24.7% of patients 65 years and older. Thus, burned children were almost 5 times more likely to be admitted to a burn center than older adults with burn injury ($P < .0001$). The older adults, however, were more likely to have comorbid conditions, more extensive burn injuries, and inhalation injury, and more often developed respiratory failure and died. The reasons for this disparity are not clear, but they might be related to staff inexperience and discomfort in caring for an injured child, inadequate resources to assess the potential for abuse or to deal with other social and family issues, and/or payer mix, given that hospital and profes-

sional charges would be covered by Medicare for a large proportion of older adults but not for most children. Although outcome after burn injury has multiple determinants, more frequent and expeditious transfer of older burn victims to specialized burn centers might offer them an additional chance for a good outcome.

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DISCUSSION

Dr Richard J. Kagan (Cincinnati, Ohio). Dr Bessey and his colleagues have compared discharge data on more than 60,000 patients admitted with primary diagnoses of acute burn and/or inhalation injuries over a 5-year period. Based upon US census data for that period, they have determined that children under 5 years age and adults over 65 years of age, especially those over 85 years of age, are at greatest risk for sustaining burn injuries that require hospitalization. They conclude that prevention strategies, which have generally targeted children, should be developed for adults over age 65. The data presented is consistent with that of the American Burn Association's National Burn Repository report from 2002, which was based on data from 46 burn centers throughout the United States and Canada. In that report, it was determined that more than 50% of the burn injuries occurred in the home and that, while 70% of the burns in children under 2 years of age were due to scalds, more than 70% of those in adults were due to flame.

The issue of burn care for the elderly has been a challenge as successful outcome can and should not be defined by survival alone. Care of the elderly patient consumes significant hospital and rehabilitative resources unless the patient is able to rapidly return to his or her preburn level of function. I therefore applaud Dr Bessey and his colleagues for their recommendations.

I have a number of comments and questions.

Were you able to determine how many of these patients were treated in verified or nonverified burn centers compared to hospitals without burn care expertise, and do you know how many of these patients met burn center admission criteria that have been established by the American Burn Association?

With respect to the etiology of injury, do you know how many of the burn injuries were related to smoking materials that caused ignition of clothing or home oxygen that may have been in use? This would be important in targeting specific prevention strategies.

Were any data available regarding the extent of full-thickness burn injury and surgical or nonsurgical treatment of the burn injuries in the elderly?

Do you have any length of stay and resource utilization data in the elderly patients to compare with data from children and young adults with burn injuries of similar etiologies?

Lastly, have you begun to develop any prevention programs targeting the elderly and how would you propose to measure the effectiveness of such programs?

Dr Sidney F. Miller (Columbus, Ohio). For scald injury in children, it appears that New York is an outlier compared to other states, and I wonder if you were able to dissect out the incidence of child abuse versus accidental scalding and whether there may be a higher incidence of child abuse in New York than in other areas of the country.

In regard to inhalation injury in the elderly, might this be related to the inability of the elderly to respond to the fire situation, being able to get out, leading to their higher incidence of inhalation?

Dr Gerard V. Aranha (Maywood, Ill). Could you tell whether burns were self-inflicted?

Dr. E. R. Zakaria (Louisville, KY). Do you have any data on the socioeconomic status of the population under study and the impact of that on your results?

My second comment is about the size of burns in children. It is well established that children may have a relatively large body surface area relative to their size. Was there any consideration for this in your analysis?

Dr. James R. DeBord (Peoria, Ill). Half the states that you chose in your review were states like Florida and California with a high elderly population. Did that skew your evaluation in any way?

Dr Palmer Q. Bessey. The question about burn centers is interesting. In this whole population, 53% of the patients were cared for in one of 29 burn centers that are listed in the ABA Resource Document for Burn Facilities in the United States in the 4 states studied. But when you look at the older group versus the children, the proportions are different. For children, 64% were in burn centers, whereas, in the older adults, only 27% were. So most of the older adults were not treated in burn center hospitals. They also had bigger burns, more inhalation injury, more respiratory failure, and a greater case fatality. A different pattern of triage of the older adults might have improved their outcome. We did not make a distinction between verified or nonverified burn centers.

Regarding admission, we had no way, unfortunately, of determining whether patients met ABA criteria or not. The largest proportion of patients by far in both burn centers and nonburn centers were those with small burns.

In regard to smoking and whether there were clothing fires and so forth, it is possible with this database to look at that level of detail based on the E-codes. I don't have that information right at hand today.

Nor do I have any information about full-thickness burns. The ICD-9-CM diagnosis code for burn size does indeed reflect both total burn size and the size of third-degree burn. Although it should be recorded for all patients as a secondary code in addition to codes for site of injury, less than 70% of all the records had one of these codes. Furthermore, from our own experience, it is not always easy to judge what is third-degree burn, especially on admission. Thus, we thought there would be too much uncertainty about the estimate of third-degree burn in this analysis.

About a third of the patients went to the OR for some sort of excisional procedure. In general, patients with bigger burns and older patients were in the hospital a little bit longer.

Dr Miller suggested that older patients were less able to respond to hazards, to avoid injury, particularly in regards to the issue of smoke inhalation. That also might occur in regards to scald burns. If the water suddenly became very hot while an older patient was bathing, they might not move out of the way or adjust the water mix as quickly or as agilely as a younger person. They might not be able to jump out of the way if something spills. So in fact that is a factor, I think, for a lot of the causes of burns.

One potential prevention measure has to do with control of the hot water temperatures in homes. Many older Americans have been in their homes for a long time, and they may have old hot water heaters or ones that are set too high. In New York City, there are apartment buildings that date back to the Civil War that do not have proper regulations. Another possibility is to mount an educational campaign with internists and geriatricians to encourage them to focus on injury prevention in their interactions with patients and their families. Although fall prevention may be an area of discussions, burn prevention has not. That has been a component of patient education for pediatricians, and sometimes for obstetricians, especially for new parents, and it has had an apparent marked effect.

I do not have information to distinguish between abuse, self-inflicted, and accidental injuries. There are E-codes reflecting intentionality, but they were used uncommonly in these patients and we did not analyze the data in that way. We consider the possibility of abuse in many of our pediatric admissions. Most often it is a matter of

neglect or ignorance and isn't intentional at all. This seems also to be related to socioeconomic factors. In another review done in collaboration with one of my associates at the Burn Center in New York, we looked at the incidence of burns in different health department regions within New York City. The incidence was related to the degree of poverty. Poorer people got burned more often.

Regarding the differences in body surface area between children and adults, burn centers usually use age-adjusted norms when determining body surface area burn. Most children were cared for in burn centers. The majority of records from non–burn center hospitals did not record a burn size code. Thus, if there was a bias in this regard, it would have had a small effect.

Dr DeBord asked about the influence of the relatively higher population of older adults in California and Florida. It is interesting that the older Floridians had the lowest incidence of burns for that age group in all 4 states.