The American Journal of Surgery (2013) 205, 29–34

The American Journal of Surgery®

Clinical Science

Predicting resource utilization of elderly burn patients in the baby boomer era

Winston T. Richards, M.D.[a,*], Winston A. Richards, Ph.D.[b], Makeesha Miggins, M.D.[c], Huazhi Liu, M.S.[c], David W. Mozingo, M.D.[c], Darwin N. Ang, M.D., Ph.D., M.P.H.[c]

[a]Department of Surgery, Division of Acute Care Surgery, PO Box 100286, Gainesville, FL 32610, USA; [b]Division of Science Engineering and Technology, Pennsylvania State University, Harrisburg, PA, USA; [c]Department of Surgery, Division of Acute Care Surgery, University of Florida, Gainesville, FL, USA

KEYWORDS:
Burn injury;
Baby boom;
Geriatric;
Resource;
Use;
Discharge disposition

Abstract

BACKGROUND: Census predictions for Florida suggest a 3-fold increase in the 65 and older population within 20 years. We predict resource utilization for burn patients in this age group.

METHODS: Using the Florida Agency for Healthcare Administration admission dataset, we evaluated the effect of age on length of stay, hospital charges, and discharge disposition while adjusting for clinical and demographic factors. Using US Census Bureau data and burn incidence rates from this dataset, we estimated future resource use.

RESULTS: Elderly patients were discharged to home less often and were discharged to short-term general hospitals, intermediate-care facilities, and skilled nursing facilities more often than the other age groups ($P < .05$). They also required home health care and intravenous medications significantly more often ($P < .05$). Their length of stay was longer, and total hospital charges were greater ($P < .05$) after adjusting for sex, race, Charleson comorbidity index, payer, total body surface area burned, and burn center treatment.

CONCLUSIONS: Our data show an age-dependent increase in the use of posthospitalization resources, the length of stay, and the total charges for elderly burn patients.

After World War II and extending into the 1960s, the United States observed a dramatic increase in its birth rates, often referred to as the "baby boom." This generation of Americans was the product of birth rates well over 3.5 million live births per year for a period of close to 20 years. This population wave is now approaching the 65 and over age group.[1] Burn injuries are among the top 20 causes of nonfatal injuries in the geriatric population.[2] The care of burn patients is a resource intensive team approach at burn centers across the United States. Combining the population age shift with frequent burn injury and resource intensive treatment suggests an increasing demand on these medical resources.

Medical resource usage is often measured by patient length of stay and total hospital charges. These measurements along with mortality figures account for the most common outcome measures in current research.[3–10] In 1980, Curreri et al[3] published an analysis of survival and hospitalization time that identified increasing mortality and length of stay with age. They also used these data to predict burn bed needs for a known or predicted population of

* Corresponding author: Tel.: +1-352-273-5670; fax: +1-352-273-5683.
E-mail address: winston.richards@surgery.ufl.edu
Manuscript received November 8, 2011; revised manuscript May 17, 2012

0002-9610/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.amjsurg.2012.05.002

regional burn victims. In 1990, Saffle et al[11] published a study on improvements in the survival of elderly burn patients, and in 2006 Pomahac et al[10] evaluated patients 80 years of age or older and found improved survival in this group of burn victims. Even with these improvements, elderly burn patients are reported to have higher mortality and worse outcomes despite advances in burn care.[11–14] Although the most expensive setting in medical care is acute hospitalization, there are additional factors that add to the costs of treating burn patients. A patient's discharge disposition highlights this. Patients may be sent home, to skilled nursing facilities, or to rehabilitation centers. Pham et al[12] described this as discharge to a nonindependent status. Other patients may require home health care and outpatient occupational and physical therapy. Data on the discharge disposition of patients are collected in the Agency for Health Care Administration admission dataset in the state of Florida. The goal of this study was to determine the potential required resource use of the elderly population in light of the aging "baby boom" generation in the state of Florida.

Materials and Methods

Study design

This is a retrospective cohort study using data from the Agency for Health Care Administration (AHCA) in Florida. With these data, we evaluated inpatient hospital admissions for patients with a diagnosis of burn injury. The Florida AHCA database was analyzed from 1997 through the third quarter of 2010 for outcomes after burn injury. The primary outcomes were hospital charges and length of stay, and the secondary outcome was discharge disposition

Database and study population

We identified 34,908 patients who were admitted with a diagnosis of burn injury using the *International Classification of Diseases, Ninth Revision* (*ICD-9*) diagnosis codes of 940 through 949 excluding 947 (internal burns secondary to ingestion of a caustic substance.) We further excluded those patients who died. Subsequently, we refined this group into those patients who had a 948 code for total body surface area (TBSA) burned. The Charlson comorbidity index was calculated for this dataset to adjust for comorbid conditions in these patients. This study was performed with institutional review board approval.

The Charlson comorbidity index was introduced in 1987 by Charlson et al. It is a weighted index that takes into account the number and seriousness of comorbid diseases.[15] This method of classifying comorbidity has been validated in several patient populations including intensive care unit admissions and several surgical procedures. It has been adapted for use with *ICD-9* databases.[16] It is one of the most extensively studied comorbidity indexes and has predictive validity with several outcome measures such as mortality, disability, readmissions, and length of stay.[17] This allows our age groups to be compared while adjusting for the effect of comorbid conditions on the outcome.

Statistical analysis

Differences between cohorts in length of stay and total hospital charges were evaluated by regression analysis. Multivariate regression was used to adjust and match for nonmodifiable factors that had the potential of confounding or biasing the outcome of interest. Confounding factors were considered in the multivariate analysis if it was reasonable to assume (gestalt) or if there were published data to show that these variables had an independent effect on the exposure (risk factor) and outcome of interest. Before regression analysis, multicollinearity was measured between the adjusted or confounding variables. Multicollinearity was evaluated before regression analysis by examining the correlation coefficient among confounders. If the correlation coefficient was greater than .8, only one of the confounders was used in the multivariate analysis.[18] None of the confounders in this study exhibited collinearity with each other. In the final multivariate regression, sex, race, payer, Charlson comorbidity index, TBSA burned, and burn center admission were treated as confounders. Analysis of variance was used to evaluate significant differences in demographics, burn center admission, and payer and discharge status between age groups. We used census predictions for the population of Florida and burn incidence rates from the AHCA hospital admission dataset to calculate future resource needs of our state. This incidence rate was calculated by the number of persons admitted to Florida burn centers per 1,000 person years. SAS version 9.2 of the SAS System for Windows (SAS Institute Inc, Cary, NC) was used during our statistical evaluation of the dataset.

Results

There were 34,908 records over 14 years with a diagnosis of burn injury on admission to a hospital in the state of Florida. Of those patients, 17,827 had an *ICD-9* 948 code describing burn size recorded and had survived through discharge from the hospital. We evaluated the following age groups: 0 to 17 years of age (pediatric), 18 to 64 years of age (adult), and ≥65 years of age (elderly). There were 4,982 patients in the pediatric group, 11,051 in the adult group, and 1,794 in the elderly group. The patients' sex and race are listed in Table 1. Analysis of variance was used to evaluate for differences in sex and race. Burn sizes for each age group are reported in Figure 1 they were separated by admission to burn centers and other hospitals. The mean burn size of elderly patients was lower than that for the adult and pediatric age groups, whereas the mean burn size admitted to burn units was larger than that admitted to other

Table 1 Demographic data of the 17,827 patients with 948 codes recorded who survived through discharge

	Child (0~17 y) (n = 4,982)	Adult (18~64 y) (n = 11,051)	Old (65+ y)	*P* value
Sex (%)				
Male	3,177 (63.8)	8,190 (74.1)	971 (54.1)	<.0001
Female	1,805 (36.2)	2,860 (25.9)	823 (45.9)	<.0001
Unknown	0	1 (.01)	0	
Race (%)				
American Indian	4 (.08)	23 (.2)	2 (.1)	.15
Asian	22 (.4)	64 (.6)	13 (.7)	.33
Black	1,534 (30.8)	2,155 (19.5)	277 (15.4)	<.0001
White	2,281 (45.8)	6,061 (54.9)	1,149 (64.1)	<.0001
White Hispanic	869 (17.4)	2,316 (21.0)	294 (16.4)	<.0001
Black Hispanic	29 (.6)	99 (.9)	12 (.7)	.10
Other	205 (4.1)	261 (2.4)	35 (2.0)	<.0001
No response	38 (.8)	72 (.7)	12 (.7)	.73

hospitals in all age groups. Burn center admission, payer category, length of stay, and total charges are reported in Table 2. Our elderly cohort (≥65 years of age) was less likely to be treated at a burn center compared with the adult and pediatric cohorts ($P < .05$). Approximately 43% of the elderly patients were treated in a burn center, whereas at least 71% of the adult and pediatric age groups were treated at burn centers. When reviewing the insurance coverage of this cohort of patients, we noted that approximately 83% of the elderly age group was covered by Medicare services. The adult age group had a wider spread of payer sources with 18.4% being covered by workers' compensation and 17% self-pay or uninsured.

The median length of stay and charges for each age group are recorded in Table 2. In addition, we compared length of stay and total hospital charges between groups using linear regression and adjusting for sex, race, Charlson comorbidity index, payer, TBSA burned, and burn center treatment. The crude linear regression of length of stay and age group was not significant. When adjusting for the parameters described previously, we found the elderly patients to have a longer length of stay ($P < .05$). We performed a

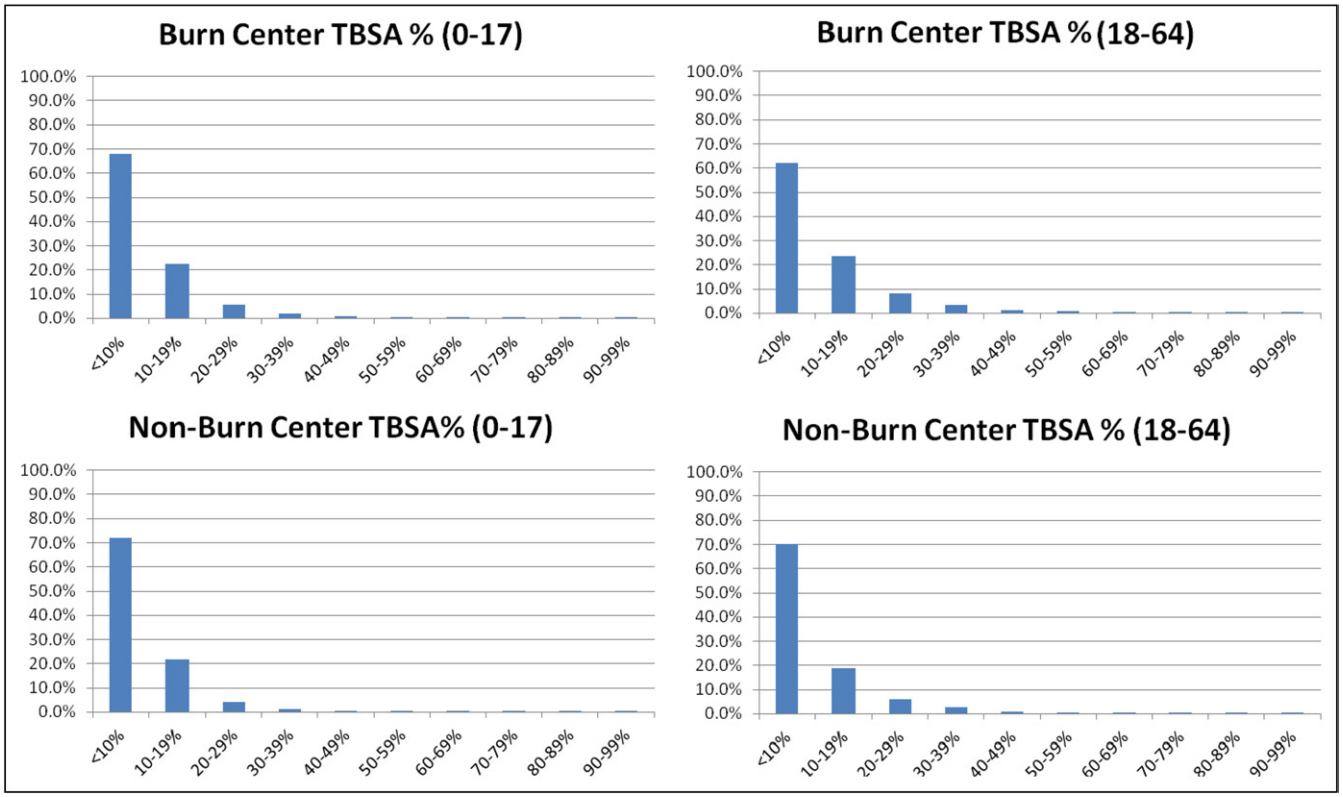

Figure 1 The frequency of burn sizes (TBSA) seen at burn centers and nonburn centers divided by age group.

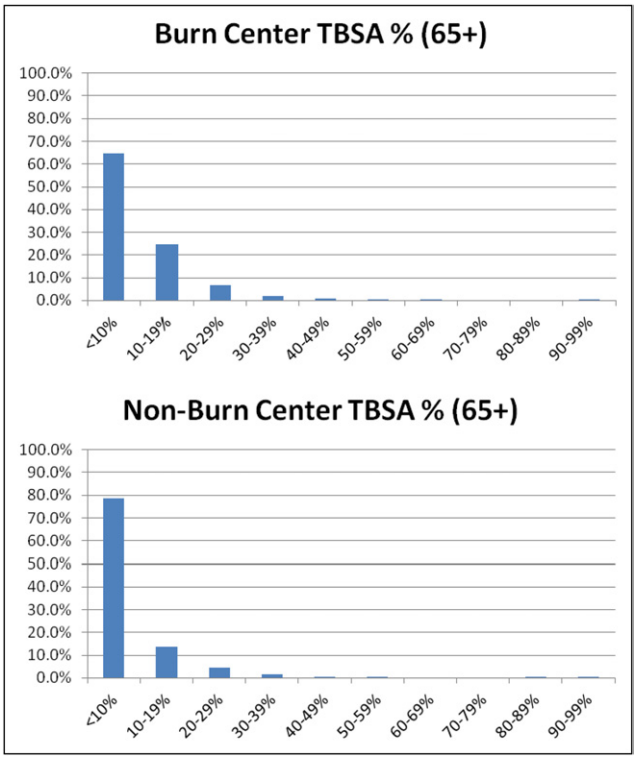

Figure 1 Continued.

similar comparison for total hospital charges and found that the crude regression was not statistically significant, whereas the adjusted regression showed that the elderly patients had higher charges than the other age groups ($P < .05$). For disposition, elderly patients were more likely to be discharged to short-term general hospitals, intermediate-care facilities, and skilled nursing facilities compared with the adult and pediatric age groups ($P < .05$) as shown in Table 3. We also noted that a larger percentage of the elderly population was discharged to inpatient rehabilitation facilities ($P < .05$). Elderly patients were also more likely to be sent home with home health care nursing and intravenous medications ($P < .05$). In addition to that, we noted that the elderly patients were more likely to be discharged into hospice care or a hospice medical facility ($P < .05$).

To extrapolate admission volume of age-specific burn injury for the future, we combined data from the state of Florida AHCA and the US Census Bureau. We calculated the incident rate of burn injury in the state of Florida using population data from the year 2000 as the reference data. Data from the US Census Bureau provided the projected population growth. This information is shown in Figure 2. By 2030, the total hospital admissions for burn patients 65 or older will surpass that of the patients in the 45- to 64-year-old age group. With the discharge disposition per-

Table 3 Discharge status of each age group compared using analysis of variance

Discharge status	Child (%)	Adult (%) (reference)	Old (%)
Home	87.2*	67.6	36.1*
Short-term general hospital	2.4	2.0	3.4*
Skilled nursing facility	.3	2.1	21.2*
Intermediate-care facility	.4	.5	1.7*
Other institution	2.1	3.1	4.9
Home health care	8.1*	22.1	28.4*
Left against medical advice	.3*	1.2	1.2
Discharged on intravenous medications	.2	.3	.9*
Hospice home	.3	.3	1.7*
Hospice medical facility	0	.2	1.2†
Inpatient rehabilitation facility	.8†	2.4	5.0*
Medicare long-term care facility	0	.6	2.0
Psychiatric hospital	0	.8	0

*Significantly different at $P = .01$.
†Significantly different at $P = .05$.

Table 2 Burn center admission, insurance status, length of stay, and total charges compared using analysis of variance

	Child (0~17 y) (n = 4,982)	Adult (18~64 y) (n = 11,051)	Old (65+ y) (n = 1,794)	*P* values
Burn center (%)				
Yes	3,576 (71.8)	7,851 (71.0)	781 (43.5)	<.0001
No	1,406 (28.2)	3,200 (29.0)	1,013 (56.5)	<.0001
Payer category (%)				
Medicare	9 (.2)	824 (7.5)	1,508 (84.1)	<.0001
Medicaid	2,824 (56.7)	1,449 (13.1)	43 (2.4)	<.0001
Commercial	1,522 (30.6)	3,110 (28.1)	146 (8.1)	<.0001
Workers' compensation	25 (.5)	1,812 (16.4)	41 (2.3)	<.0001
Government	103 (2.1)	713 (6.5)	146 (8.1)	<.0001
Self-pay	499 (10.0)	3,143 (28.4)	36 (2.0)	<.0001
Length of stay	6.3	9.4	9.3	<.0001
Total charges	$23,200	$54,071	$49,826	<.0001

A *P* value <.0001 suggests a significant difference between at least 2 of the age groups.

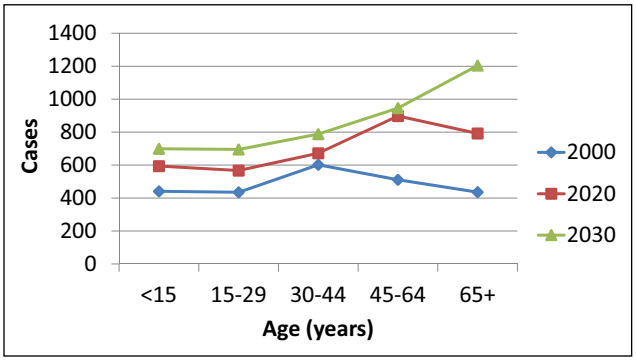

Figure 2 A graph showing the trend of increasing population in the state and the relative increase in the population of patients 65+. (Projected number of burn cases evaluated in Florida trauma centers by age based on the calculated 2000 incidence rate.)

centages from our 14-year cohort, we could expect to have on the order of 300 referrals for home health care services, 222 transfers to skilled nursing facilities, 43 transfers to short-term general hospitals, and 22 referrals to intermediate-care facilities in 2030 from the 65 and older age group. This compares with 100, 74, 14, and 7 in the year 2000. This represents close to 3 times as many patients requiring services in each of these areas per year.

Comments

A wave of elderly patients created by the baby boom is now approaching the 65 and over age group. This group of patients will likely suffer burn injuries at rates similar to the recent past. With population predictions provided by the Census Bureau, we are able to create a forecast of burn injuries, their dispositions, and their resource use. Using information gained from the AHCA dataset, we have identified a pattern that points to greater discharge needs for the elderly patients in comparison with the younger cohorts. Combining these sources, we noted a dramatic 3-fold increased need for home health care services, skilled nursing facilities, and short-term general hospitals for elderly burn patients on discharge after injury. Based on these findings, burn centers and other facilities in the state will need to plan for the increased volume of elderly patients in need of additional care at these facilities over the next 10 to 20 years.

Saffle et al[11,13] noted that the chances of survival after burn injury have steadily improved over the past 50 years. Wibbenmeyer et al[14] and others have reported that there have been limited improvements in survival for the elderly population despite the overall survival improvements.[15,19–22] This highlights geriatric burn injury as a specific area for improvement. Given the rapid approach of this increased demographic, there is an urgent need to address the resource requirements of this age group.

Many articles highlight length of stay, charges, and mortality rates in elderly patients as measures of outcome. Elderly patients stayed longer, cost more, and had higher mortality rates than their younger counterparts. Our research shows these differences in length of stay and charges while describing statistically significant differences in the discharge disposition of elderly patients. Discharge to home health care services, skilled nursing facilities, and short-term general hospitals represent continued losses in function and physical freedom and increased costs to society that may actually represent a potentially more important outcome measure than initial length of stay, charges, or mortality in terms of the total impact of burn injuries in the elderly population. In addition to the differences in discharge disposition between age groups, there are differences in the raw percent results in discharge disposition in the elderly population admitted to burn centers versus nonburn centers. These differences will be further evaluated using regression analysis techniques and may highlight the benefits of treatment at a burn center for elderly patients with burn injuries. With a set of well-accepted outcome measures for comparison, we can enhance our ability to be prepared for the treatment of our growing elderly population.

It is well accepted and documented that mortality rates for burn injury are higher in elderly patients. We would like to highlight the following: mortality from burn injury is highly dependent on TBSA involved, but the vast majority of burn injuries in this study (>90%) were less than 20% TBSA across all age groups. In addition, we limited this study to those patients who survived their burn injuries. Our findings highlight the morbidity associated with burn injury and its disproportionate effect on elderly burn patients and their discharge disposition. We think that increases in the elderly population combined with the small average size of burn injury will outweigh the effect of the mortality figures noted for the elderly in the current literature. However, we did not directly evaluate the resource use of those patients who died from their injuries. Given the higher mortality rate from burn injuries in the elderly population, this may represent an increased cost per TBSA percent burned. This highlights a limitation in the scope of this study.

Triage of burn patients to burn centers depends on multiple factors including TBSA burned, burn depth, patient age, comorbidities, and other clinical factors. During our analysis, we noted that elderly burn patients were seen or treated at burn centers 43% of the time, whereas pediatric and adult patients were seen at burn centers 73% and 71% of the time, respectively. This disparity was striking and deserves in-depth evaluation. Differences in triage and transfer patterns for patients with burn injuries are most certainly multifactorial. We intend to evaluate our data to identify factors associated with this difference including burn size and severity, insurance status, referral source, admission status, race, and sex. Demographic and financial factors may well account for this disparity, whereas patient requests and geographic location may add another layer to the analysis. Other factors such as physician referral patterns and emergency medical services transportation con-

tracts have all been forwarded as influences in the age disparity of burn patient treatment. With the available data points in this administrative dataset, we plan to systematically evaluate whether patients who met the American Burn Association (ABA) triage transfer criteria for burn center care were appropriately transferred regardless of age.

In this study, as with any study using administrative data, the results are highly dependent on the quality of data collected. We found that there were differences in the proportion of patients recorded with a TBSA ICD-9 code (948.00 through 948.99) in the nonburn and burn centers. This may represent familiarity with the coding and billing aspect of burn care that is limited in nonburn centers. There are also concerns that some coding does not accurately represent the severity of injury in patients seen at nonburn centers. These limitations are concerning but will improve with the continued use of the datasets and quality monitoring of the process for collecting the data.

In conclusion, a large number of baby boomers are reaching 65 years of age. We have identified increased resource use in their posthospital care from burn injury. Others have suggested that survival from burn injury is improving. Even though the elderly population has not seen the same survival benefits of our improved burn care, burn centers and other hospitals that treat the burned patient will need to prepare for increasing posthospital resource use from the growing elderly population.

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.amjsurg.2012.05.002.

References

1. Population Pyramids of Florida, U.S.Census Bureau, Population Division. Interim State Population Projections, 2005. Internet Release; 2005. Available from: http://www.census.gov/population/www/projections/statepyramid.html. Accessed September 14, 2012.
2. National Center for Injury Prevention and Control, CDC. NEISS all. Injury Program, Consumer Product Safety Commission. 20 Leading causes of nonfatal injury, United States 2010, all races, both Sexes, disposition: All Cases. Available from: http://www.cdc.gov/injury/wisqars/index.html. Accessed September 14, 2012.
3. Curreri PW, Luterman A, Braun DW, et al. Burn injury analysis of survival and hospitalization time for 937 patients. Ann Surg 1980;192:472–7.
4. Anous MM, Heimbach DM. Causes of death and predictors in Burned patients more than 60 years of age. J Trauma 1986;26:135–9.
5. Renz BM, Sherman R. Burn unit experience at Grady Memorial Hospital: 844 cases. J Burn Care Rehabil 1992;13:426–36.
6. Sarahadi S, Kincaid R, McGregor JC, et al. Burns in the elderly in the south east of Scotland: review of 176 patients treated in the Bangour Burns Unit (1982–91) and burn inpatients in the region 1975–91. Burns 1995;21:91–5.
7. O'Keefe GE, Hunt JL, Purdue GF. An evaluation of risk factors for mortality after burn trauma and the identification of gender-dependent differences in outcomes. J Am Coll Surg 2001;192:153–60.
8. Ho WS, Ying SY, Burd A. Outcome analysis of 286 severely burned patients: retrospective study. Hong Kong Med J 2002;8:235–9.
9. Rao K, Moiemen NS, Moiemen NS. Aetiology and outcome of Burns in the elderly. Burns 2006;32:802–5.
10. Pomahac B, Matros E, Semel M, et al. Predictors of survival and length of stay in burn patients older than 80 years of age: does age really matter? J Burn Care Res 2006;27:265–9.
11. Saffle JR. Predicting outcomes of burns. N Engl J Med 1998;338:387–8.
12. Pham TN, Kraner CB, Want J, et al. Epidemiology and outcomes of older adults with burn injury: an analysis of the National Burn Repository. J Burn Care Res 2009;30:30–6.
13. Saffle JR, Larson CM, Sullivan J, Shelby J. The continuing challenge of burn care in the elderly. Surgery 1990;108:534–43.
14. Wibbenmeyer LA, Amelon MJ, Morgan LJ, et al. Predicting survival in an elderly burn patient population. Burns 2001;27:583–90.
15. Charlson ME, Pompei P, Ales KL, Mackenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–83.
16. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 1992;45:613–9.
17. Groot V, Beckerman H, Lankhorst GJ, Bouter LM. How to measure comorbidity: a critical review of available methods. J Clin Epidemiol 2003;56:221–9.
18. Haque A, Jawad AF, Cnaan A, et al. Detecting multicollinearity in logistic regression models: An extension of bkw diagnostic. Joint Statistical Meetings, Annual Meeting of the American Statistical Association. New York, NY, August 11-15, 2002: 1356-8.
19. DeMeestre T, Feller I. Mortality in burned patients sixty-one years of age and older. Surg Gynecol Obstet 1968;126:1041–4.
20. Merrell SW, Saffle JR, Sullivan JJ, et al. Increased survival after major thermal injury. Am J Surg 1987;154:623–7.
21. McGwin G, Cross JM, Ford JW, Rue LW. Long-term trends in mortality according to age among adult burn patients. J Burn Care Rehabil 2003;24:21–5.
22. Latenser BA, Miller SF, Palmer B, et al. National Burn Repository 2006: a ten-year review. J Burn Care Res 2007;28:635–58.