Authors:

Robert M. Shavelle, PhD, MBA
David Strauss, PhD, FASA
John Whyte, MD, PhD
Steven M. Day, MS
Yuk Ling Yu, MD, FRCP

Affiliations:

From the Department of Statistics, University of California, Riverside, California (RMS, DS, SMD); Moss Rehabilitation Research Institute, Philadelphia, Pennsylvania (JW); and the Division of Neurology, Department of Medicine, Hong Kong University, Hong Kong (YLY).

Correspondence:

All correspondence and requests for reprints should be addressed to: Robert M. Shavelle, PhD, MBA, Life Expectancy Project, 1439 17th Avenue, San Francisco, CA 94122.

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Long-Term Causes of Death After Traumatic Brain Injury

ABSTRACT

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Objective: To determine which causes of death are more frequent in persons with traumatic brain injury (TBI), and by how much, compared with the general population. Our focus was the period beginning 1 yr after injury.

Design: Subjects were 2320 Californians with long-term mental disability after a TBI at age 10 yr or more, followed up between 1988 and 1997. The units of study were person-years, each linked to the subject's age, gender, level of ambulation, time since injury, and cause of death (if any) for the specific year. Observed numbers of cause-specific deaths were compared with numbers expected according to general population mortality rates.

Results: Mortality was higher between 1.0 and 5.0 yr postinjury than after 5.0 yr and was strongly related to reduced mobility. Death rates were elevated for circulatory diseases, respiratory diseases, choking/suffocation, and seizures, with seizure deaths being relatively frequent, even among the most ambulatory.

Conclusions: Death rates for several causes are elevated in persons with long-term sequelae of TBI. The increased risk of choking/suffocation should be of interest to caregivers. Life expectancy seems to be reduced, even for patients who are fully ambulatory.

Key Words: Cause of Death, Life Expectancy, Maladaptive Behavior, Mortality, Standardized Mortality Ratio

Traumatic brain injury (TBI) is a leading cause of premature mortality and of long-term disability. It has been estimated that 80,000–90,000 persons become permanently disabled after TBI each year in the United States.[1] Despite this, relatively little has been published on the long-term sequelae.

It is known that persons who have suffered a TBI have reduced life expectancy, even after the initial acute period has passed.[2–7] Which causes of death account for the elevated mortality is less clear, however. To date, the only published work seems to be the studies of Roberts[3] and Lewin et al.[4] who followed up a large group of patients injured in the United Kingdom between 1948 and 1961. Roberts[3] concluded that only the following causes of death had elevated risks: pneumococcal meningitis, epilepsy, suicide, accidents (especially drowning), and respiratory disease.

In the present study, we examined the long-term causes of death in a large California sample of persons who had suffered a TBI. As the results are likely to depend on age and gender, we adjusted for these factors in all cases. We also took account of the time since injury, as the risk is certainly greatest shortly after injury and may be expected to decrease with time thereafter. Finally, we adjusted for mobility, as diminished mobility is known to be a powerful predictor of increased mortality for patients with TBI, spinal cord injury, and many other conditions.[5,8–12] Our research questions, thus, were as follows: (1) which causes of death are elevated, and by how much? (2) how do the results depend on the patient's degree of mobility? (3) how are the results affected by the time since injury?

Objectives: Upon completion of this article, the reader should be able to (1) classify the causes of death that are elevated after traumatic brain injury; (2) discuss the factors that affect mortality after traumatic brain injury; (3) quantify the effect of the factors that affect mortality after traumatic brain injury.

Level: Advanced.

Accreditation: The Association of Academic Physiatrists is accredited by the Accreditation Council for Continuing Medical Education to sponsor continuing medical education for physicians.

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METHODS

Subjects were selected from a computerized data base of 168,461 persons who received any services from the California Department of Developmental Services between January 1988 and December 1997. Services include medical treatment, occupational or physical therapy, and board and care. To be eligible, individuals are mentally retarded or have "... a disabling condition found to be closely related to mental retardation or to require treatment similar to that required for mentally retarded individuals, but shall not include other handicapping conditions that are solely physical in nature."[13] The subjects, thus, had a long-term cognitive deficit, or at least the appearance of it as indicated by problems with communication (e.g., persons with locked-in syndrome).

All subjects are evaluated approximately annually, using the Client Development Evaluation Report (CDER).[14] This instrument contains some 200 psychological, medical, functional, behavioral, and cognitive items. The reliability of the functional items has been assessed previously and was judged to be satisfactory.[15–18] For descriptive purposes we also extracted CDER data on subjects' histories of suicide attempts, depression, violence, and other factors.

From this database, we selected the 2320 persons who met the following criteria: (a) origin of the disability was specified on the CDER as being either a motor vehicle accident or a cranial injury. The latter was identified by the International Classification of Diseases, Ninth Revision (ICD-9),[19] codes 800–804 or 850–854. These identifying codes have been used in earlier studies on persons with TBI[5,6,20]; (b) the injury occurred at the age of 10 yr or older; (c) the subject was alive 12 mo after the injury.

Condition (b) was imposed because children with TBI form a distinct group that deserves separate consideration. One reason is that these children are injured before they are fully grown, and this may influence the pattern of survival and recovery. Condition (c) reflects the study's focus on long-term mortality.

Because the above etiologic information began to be reported only in 1988, we chose the study period as the 10-yr interval from 1988 to 1997. Specifically, the beginning of the "exposure" period for a given subject was the later of (a) the first CDER after the first anniversary of the injury, and (b) January 1, 1988. The end of the subject's period at risk was the earliest of (a) the date of death, (b) the end of the study period (December 31, 1997), and (c) 3 yr after the date of the subject's last CDER evaluation. This last condition was included to minimize the potential bias attributable to subjects who may have left California. Deaths of such persons would not be in our records, but because of condition (c), these subjects would also not be counted as being at risk for more than a fairly short period. Migration from California is generally believed to be uncommon because California is the only U.S. state providing services to persons with mental disabilities as an entitlement.

Because all subjects suffered some long-term cognitive or communication disability, our sample represented a much more disabled group than would be obtained in most hospital series.

Mortality information was obtained from annual computer tapes from the State of California.[21] In California, it is required that death certificates be filed with the state, and the resulting computer tapes represent the state's official mortality record. Tapes were matched against the California disabilities data on the basis of name, date of birth, and social security number. We assessed questionable cases by direct inspection. Of the 2320 subjects in the study, we identified 119 subjects who died during the study interval.

Causes of Death

Because we lacked access to the subjects' medical records we worked with the causes of death given on the computer tapes. These were in the form of ICD-9 codes of three to four digits. In 37 cases, this cause was considered uninformative for our purposes. Examples were "homicide" and "late effects of accidental injury" or various codings for "unspecified." For these 37 cases, we requested death certificates from the State Department of Health Services, Office of Vital Records. This yielded 33 death certificates; in the remaining four cases, the certificates were apparently unavailable. In the 33 cases in which the cause was determined from death certificates, we attempted to identify the most informative causes. For example, "cardiac arrest due to seizure due to late effects of accidental injury" was coded as seizure. In all cases in which we were able to examine the certificate, both homicide and late effects of injury proved to refer to the original head injury, not a subsequent event, and the cause of death was reclassified.

Causes of death were grouped into nine categories: cancer (ICD-9 codes 140–239; $n = 8$); seizures (345,436,780.3; $n = 12$); circulatory (390–459; $n = 25$, primarily cardiovascular and cerebrovascular disease); respiratory (460–519; $n = 18$, primarily pneumonia and other infections); digestive (520–579; $n = 5$), kidney/urinary (580–599; $n = 6$); choking/suffocation (910–915; $n = 8$); other external causes (other codes 800+; $n = 11$, mostly accidents); and other ($n = 26$, including 11 unspecified). Individual cause information on all 119 deceased persons is available elsewhere.[22]

Comparison of death rates to the general population was carried out as follows: (1) for each combination of quinquennial age, gender, and cause of death group, we computed mortality rates in the general California population, using the California mortality tapes[21] and data on population over the time period 1988–1997[23]; (2) for the TBI subjects, we computed the *exposure time* as the total number of person-years at risk of death; this was done separately for every combination of age, gender, ambulation (classified into three levels), and time since injury (two levels: 1.0–5.0 yr and 5.0+ yr); (3) the mortality rates from step 1 were then applied to the exposure times to give an *expected number of deaths due to each cause* for each combination of the above factors, on the basis of the general population; (4) the actual number of deaths associated with each combination of factors was noted; (5) the ratio of the observed number of deaths to the expected number is a *standardized mortality ratio* (SMR)[24]; SMRs were computed for each combination of factors; also, by summing both observed and expected numbers appropriately, we computed SMRs for combined groups, such as "all causes, 5.0 yr or more postinjury"; (6) the unit of analysis is a person-year, not a person; thus, one person may contribute several person-years to the "1.0–5.0 yr since injury" category and several more to the "5.0 yr or more since injury" category; (7) confidence intervals for SMRs, based on the assumption that the observed number of deaths follows the Poisson distribution, were derived using the tables given in Singer.[25] By using the same source of mortality information when comparing the TBI group with the general California population, we attempted to minimize various sources of reporting bias.

RESULTS

Table 1 shows the breakdown of the 2320 subjects by age, gender, and other factors. As is common in groups of subjects with TBI, a majority (approximately two-thirds) was male. About half had at least some ambulatory disability. The ambulation variable may act as a marker for the degree of neurologic damage; for example, it is strongly correlated with speech deficits (32% of those who can climb stairs had some impairment, compared with 87% of those who did not walk). Four percent of the most ambulatory group had attempted suicide during the previous 5 yr, a rate much higher than in the general population. Strikingly high proportions of ambulatory persons had engaged in other maladaptive behaviors, such as drug or alcohol abuse or assault or were on probation for a criminal offense. Not surprisingly, maladaptive behavior was most frequent among the most ambulatory subjects, who presumably have the greatest freedom. Unfortunately, we lack information on which subjects had a history of such behavior before TBI.

TABLE 1
Characteristics of the 2320 subjects at first evaluation

	Ambulation (%)			
	None[a] (n = 342)	Some[b] (n = 871)	Stairs[c] (n = 1107)	All (n = 2320)
Died				
Yes	7	3	1	3
No	93	97	99	97
Tube fed				
No	68	98	100	94
Yes	32	2	0	6
Gender				
Male	64	64	71	68
Female	36	36	29	32
Decade of injury				
1960s	0	1	1	1
1970s	22	22	16	19
1980s	48	40	44	43
1990s	30	37	39	37
Age at injury (yr)				
10–19	71	51	49	53
20–29	16	24	28	35
30+	13	25	23	22
Clarity of speech				
No intelligible speech	55	10	4	14
Some difficulty to understand	32	45	28	35
Readily understood by strangers	13	45	68	51
Depression[d]				
Inhibits or affects all functions	10	19	16	16
Minimal effect	22	40	38	37
No evidence of depression	35	39	38	41
Too disabled to display	33	2	1	6
Attempted suicide in the past 5 yr[d]				
Yes	1	2	4	3
No	70	73	71	72
Unknown	29	25	25	25
Recent history of drug or alcohol abuse[d]				
Yes	2	5	8	6
No	70	71	68	69
Unknown	28	24	24	25
Assaultive behavior[d,e]				
Yes	4	10	16	12
No	76	71	65	69
Unknown	20	19	19	19
Medication for maladaptive behavior[d,f]				
Yes	10	17	17	16
Not within past 6 months	14	17	18	17
Never/unknown	77	66	65	67
On Probation[d]				
Yes	1	2	10	5
No	93	95	87	91
Unknown	6	3	3	4

[a]Does not walk.
[b]Walks with support or walks well alone at least 20 feet.
[c]Moves up and down stairs (or ramps) without the need for a handrail.
[d]History of this before traumatic brain injury is not available.
[e]The question on the Client Development Evaluation Report reads, "Has the client engaged in any assaultive behaviors that have or could have resulted in serious bodily injury or death?"
[f]Excludes sedatives for examinations only and medications for seizures or on an infrequent basis.

TABLE 2
Standardized mortality ratios (SMR): all causes combined

Time Since Injury (yr)	Level of Ambulation	No. of Deaths	SMR	95% Confidence Interval
	None[a]	16	16.4	(9.3, 26.7)
1.0–4.0	Some[b]	15	4.5	(2.5, 7.4)
	Stairs[c]	6	1.5	(0.6, 3.3)
	All	37	4.4	(3.1, 6.1)
	None[a]	35	6.4	(4.5, 8.9)
5.0+	Some[b]	31	2.4	(1.6, 3.4)
	Stairs[c]	16	1.3	(0.7, 2.1)
	All	82	2.7	(2.1, 3.4)
All	All	119	3.1	(2.5, 3.7)

[a]Does not walk.
[b]Walks with support or walks well alone at least 20 feet.
[c]Moves up and down stairs (or ramps) without the need for a handrail.

Table 2 shows the numbers of deaths and SMRs, classified by ambulation and time since injury. It is clear that long-term mortality is elevated in this TBI group as a whole. The increase is most marked in the early period, as may have been expected. Mortality is also strongly related to ambulation, the risk to nonambulatory subjects being several times larger than to ambulatory subjects. The strong association between mobility and mortality in TBI has been documented previously.[5,6]

Table 3 displays the cause-specific data. Perhaps not surprisingly, cancer mortality seems to be unaffected by TBI. By contrast, there were 12 deaths resulting from seizures, compared with an expected number of 0.5 according to the general population rates, an SMR of 24. Seizure deaths were relatively common even in the most ambulatory group. Elevated mortality resulting from seizures was also noted by Roberts.[3] The 25 deaths resulting from circulatory diseases were likewise more than would be expected in the general population (SMR = 3.3), especially among the nonambulatory subjects. Only 2 of the 25 were attributable to cerebrovascular accidents.

None of the subjects were coded as having died of meningitis, in contrast to the increased risk attributable to this disease reported by Roberts.[3] Our power to detect this is low, however, because the expected number of such deaths here was only 0.04.

The greatly increased risk of respiratory infections, especially among the nonambulatory, is as expected, but the marked increase in risk because of kidney and urinary disease is perhaps surprising. Finally, among the externally caused deaths (accidents, etc.), there was a substantially elevated risk of death by choking or suffocation (SMR = 29), but we did not find any clear increases for other external causes. In particular, in contrast to the study by Roberts[3], there were no deaths at all attributable to drowning in our group, and despite the large number of subjects who had attempted suicide, we found no increase in suicide deaths (two deaths; SMR = 1.0).

DISCUSSION

Subjects in this study had higher mortality than expected in the general population, after adjustment for age and gender. The markedly elevated mortality in those with reduced mobility is not surprising, as a sedentary life style is known to be associated with increased mortality risk, especially because of diseases of the circulatory system. For example, a relative risk of 1.34 for sedentary persons has been reported by Paffenbarger et al.[26–28] The findings here, however, suggest that even those who are ambulatory enough to climb stairs without the need of a handrail may have higher mortality rates than the general population. Such persons were, in particular, at much greater risk of seizure-related death.

In some cases, TBI results in maladaptive behavior that itself increases mortality risk. For example, schizophrenia is known to be associated with markedly elevated mortality.[29] Nevertheless, in contrast to anecdotal reports about persons with long-term TBI, we found relatively few deaths that seemed to result from reckless behavior. Of course, this may merely indicate that many of the subjects were restricted in their permitted activities. We do not know, for example, how many subjects were permitted to drive.

It should be noted that the cause-specific SMRs reported here are conservative, as in 9% of the cases we were unable to determine the cause.

TABLE 3
Cause-specific numbers of deaths,[a] expected numbers in the general population,[b] and standardized mortality ratios (SMR)

	Time Since Injury (yr)							
	1.0–5.0			5.0+				
	Ambulation			Ambulation				SMR
Cause of Death (ICD-9 Codes)	None[c]	Some[d]	Stairs[e]	None[c]	Some[d]	Stairs[e]	All	(95% c.i.)
Cancer (140–239)	0	2	1	1	3	1	8	1.1
	0.1	0.6	0.6	1.1	2.9	2.2	7.5	(0.5, 2.1)
Seizures (345, 436, 780.3)	2	1	0	2	1	6	12	24.3
	0.0	0.0	0.0	0.1	0.2	0.1	0.5	(12.4, 42.0)
Circulatory (390–459, except 436)	0	3	2	7	10	3	25	3.3
	0.1	0.7	0.6	1.2	2.9	2.1	7.5	(2.2, 4.9)
Respiratory (460–519)	3	1	0	8	6	0	18	9.7
	0.1	0.2	0.1	0.3	0.7	0.5	1.9	(5.6, 14.9)
Digestive (520–579)	0	0	0	2	2	1	5	2.9
	0.0	0.1	0.1	0.3	0.6	0.6	1.7	(0.9, 6.9)
Urinary/kidney (580–599)	3	0	0	2	1	0	6	15.2
	0.0	0.0	0.0	0.1	0.1	0.1	0.4	(5.5, 32.8)
Choking/suffocation (910–915)	0	2	1	2	2	1	8	29.4
	0.0	0.0	0.0	0.0	0.1	0.1	0.3	(11.7, 52.7)
Other external (800+, except 910–915)	2	3	2	2	1	1	11	1.1
	0.4	1.1	1.7	1.2	2.6	3.4	10.4	(0.5, 1.9)
Other/unknown[f]	6	3	0	9	5	3	26	NA

[a]The upper number of each pair.
[b]The lower number of each pair.
[c]Does not walk.
[d]Walks with support or walks well alone at least 20 feet.
[e]Moves up and down stairs (or ramps) without the need for a handrail.
[f]All others, including 11 in whom no cause of death information was available. Expected numbers are uninterpretable and are not shown.

Because medical records on cause of death were not available in this study, we worked with computer codes and death certificates. Although these sources are frequently used in large epidemiologic studies, their limitations are well known.[30] Any resulting bias may have been reduced, however, because the same source (California mortality computer tapes) was used for the causes of death of both the subjects with TBI and the reference California population.

As in the English study of Roberts[3] we found a substantial increase in the mortality risks because of seizures and accidents. The elevated mortality because of seizures in the most ambulatory group suggests that many subjects even in this group have suffered severe neurologic damage. The increased rate of accidental deaths was attributed primarily to choking on food or suffocation, which again suggests neurologic damage.

Unlike Roberts,[3] we did not find an increased risk of suicide. Given that 68 (3%) of the subjects had attempted suicide in the previous 5 yr, it seems surprising that there were only two suicides during our study period (neither of whom appeared to have made a previous attempt). We found no elevated mortality resulting from meningitis (although our power to detect increased meningitis rates was rather low). Roberts,[3] by contrast, observed four such deaths, all at least 1 yr after injury, and indicates that three were "unquestionably causally related to head injury."

Again, unlike Roberts, we found that death rates attributable to diseases of the circulatory system were elevated, being triple those in the general population. The reasons for the difference are unclear. Our finding, however, is consistent with the literature linking sedentary living and cardiovascular disease.[26–28] The excess mortality because of circulatory diseases was greatest in the nonambulatory group and least in the group who could climb stairs.

Finally, with regard to mobility, the distinction between ability and actual physical activity may be important. Some individuals capable of activity may still not engage in physical activity frequently; they may lack the initiative or be restricted by cognitive impairment. In future studies, it would be desirable to measure habitual physical activities, rather than just the ability to engage in them.

REFERENCES

1. Thurman DJ, Alverson C, Dunn KA, et al: Traumatic brain injury in the United States: A public health perspective. *J Head Trauma Rehabil* 1999;14:602–15

2. Walker AE, Leuchs HK, Lechtape-Gruter H, et al: Life expectancy of head-injured men with and without epilepsy. *Arch Neurol* 1971;24:95–110

3. Roberts AH: *Severe Accidental Head Injury: An Assessment of Long-Term Prognosis*. London, Macmillan Press, 1979

4. Lewin W, Marshall TFD, Roberts AH: Long-term outcome after severe head injury. *BMJ* 1979;2:1533–8

5. Strauss DJ, Shavelle RM, Anderson TW: Long-term survival of children and adolescents after traumatic brain injury. *Arch Phys Med Rehabil* 1998;79:1095–100

6. Strauss DJ, Shavelle RM, DeVivo MJ: Life tables for persons with traumatic brain injury. *J Insurance Med* 1999;31:104–5

7. Shavelle RM, Strauss DJ: Comparative mortality of adults with traumatic brain injury. *J Insurance Med* 1998;30:240–6

8. DeVivo DJ, Stover SL: Long-term survival and causes of death, in Stover SL, DeLisa JA, Whiteneck GG (eds): *Spinal Cord Injury: Clinical Outcomes from the Model Systems*. Gaithersburg, Aspen, 1995

9. Strauss DJ, DeVivo MJ, Shavelle RM: Long-term mortality risk after spinal cord injury. *J Insurance Med* 2000;32:11–6

10. Hutton JL, Cooke T, Pharoah POD: Life expectancy in children with cerebral palsy. *BMJ* 1994;309:431–5

11. Strauss DJ, Shavelle RM, Anderson TW: Life expectancy of children with cerebral palsy. *Pediatr Neurol* 1998;18:143–9

12. Strauss DJ, Shavelle RM: Life expectancy of adults with cerebral palsy. *Dev Med Child Neurol* 1998;40:369–75

13. *California Welfare and Institutions Code*, Section 4512.

14. California Department of Developmental Services: *Client Development Evaluation Report*. Sacramento, California Department of Developmental Services, 1978

15. Arias M, Ito E, Takagi N: Concurrent validity of the client development and evaluation report, in Silverstein AB, Fluharty AL (eds): *Pacific State Archives VIII*. Pomona, University of California at Los Angeles, Developmental Disabilities Immersion Program, 1983, pp 28–33

16. Harris CW, Eyman RK, Mayeda T: *An Interrater Reliability Study of the Client Development Evaluation Report: Final Report to the California Department of Developmental Disabilities*. Los Angeles, UCLA Mental Retardation Research Center, Lanterman State Hospital, 1982

17. Widaman KF, Stacy AW, Borthwick SA: *Multitrait-Multimethod of Evaluating Adaptive and Maladaptive Behavior of Mentally Retarded People*. Presented at the 109th Annual Meeting of the American Association on Mental Deficiency, Philadelphia, PA, 1985

18. Widaman KF: *Interrater Reliability of Adaptive Behavior Assessments: Item and Factor Levels*. Presented at the 92nd annual meeting of the American Psychological Association, Toronto, Ontario, 1984

19. Context Software Systems, Inc: *The International Classification of Diseases*, 9th Revision. Clinical Modification, ed 4. New York, McGraw-Hill, 1995

20. Mackenzie EJ, Edelstein SL, Flynn JP: Hospitalized head-injured patients in Maryland. *Md Med J* 1989;38:725–32

21. State of California, Department of Health Services, Center for Health Statistics, Office of Health Information and Research

22. Reference for the complete mortality records: www.LifeExpectancy.com/tbismr.html

23. State of California, Department of Finance: *Race/Ethnic Population with Age and Sex Detail, 1970–2040*. Sacramento, 1988

24. Kahn HA, Sempos CT: *Statistical Methods in Epidemiology*. Oxford, Oxford University Press, 1989

25. Singer RB: The application of life table methodology to risk appraisal, in Brackenridge RDC, Elder WJ (eds): *Medical Selection of Life Risks*, ed 4. New York, Stockton Press, 1992, p 58

26. Paffenbarger RS, et al: The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *N Engl J Med* 1993;328:538–45

27. Paffenbarger RS, Hyde RT, Wing AL, et al: Physical activity, all-cause mortality, and longevity of college alumni. *N Engl J Med* 1986;314:605–13

28. Paffenbarger RS Jr, Wing AL, Hyde RT: Physical activity as an index of heart attack risk in college alumni. *Am J Epidemiol* 1978;108:161–75

29. Newman SC, Bland RC: Mortality in a cohort of patients with schizophrenia: A record linkage study. *Can J Psychiatry* 1991;36:239–45

30. Lilienfeld AM, Lilienfeld DE: *Foundations of Epidemiology*, ed 2. New York, Oxford University Press, 1980

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