SCORING SYSTEMS FOR TRAUMA

D W Yates

Cost-benefit analysis of trauma care

Input
Anatomical injury
Physiological derangement

Treatment
Variations in the system of care
Variations in patient care

Output
Survival: alive or dead?
Disability: temporary or permanent?
- Neurological?
- Musculoskeletal?
- Visceral?

Previous articles in this series have emphasised the importance of an aggressive, integrated, interdisciplinary approach to trauma care by an experienced team that has immediate access to operating theatres and intensive care facilities. Many of the recommendations can be expected to incur appreciable additional costs. Will this money be well spent? Which changes are most effective in improving patient care and are there any which produce unexpected delays or complications?

To answer these questions about a system which has to respond to patients with an almost infinite constellation of injuries is a major challenge in clinical measurement and audit. Clearly, statistical analysis must replace anecdote and dogma, but the complexity of the task should not be underestimated.

The effects of injury may be defined in terms of input—an anatomical component and the physiological response—and output—mortality and morbidity. These must be coded numerically before we can comment with confidence on treatment. Elderly people and young children survive trauma less well than others, so age must be taken into account. The mechanism of injury is also important: the effect of a blunt impact from a fall or a car crash is quite different from that of a stab or gunshot wound. Most recent work has been concerned with the measurement of injury severity and its relation to mortality. The assessment of morbidity has been largely neglected, yet there are two seriously impaired survivors for every person who dies owing to trauma.

Input criteria

Examples of injuries scored by abbreviated injury scale

Injury	*Score*
Shoulder pain (no injury specified)	0
Wrist sprain	1 (Minor)
Closed undisplaced tibial fracture	2 (Moderate)
Head injury—unconscious on admission but for less than one hour thereafter, no neurological deficit	3 (Serious)
Major liver laceration, no loss of tissue	4 (Severe)
Incomplete transection of the thoracic aorta	5 (Critical)
Laceration of the brain stem	6 (Fatal)

Anatomical scoring system

The *abbreviated injury scale* (AIS) was first published in 1969. It scores from 1 (minor) to 6 (fatal) over 1200 injuries, which are listed in a booklet that is now in its fourth edition. (Copies of the booklet AIS90 may be obtained from the North Western Injury Research Centre—see footnote.) The intervals between the scores are not always consistent—for example, the difference between AIS3 and AIS4 is not necessarily the same as the difference between AIS1 and AIS2—but the higher the score the worse the injury.

Injury severity score

To obtain this:

(1) Use the AIS90 dictionary to score every injury

(2) Identify the highest abbreviated injury scale score in each of the following six areas: head and neck, abdomen and pelvic contents, bony pelvis and limbs, face, chest, and body surface

(3) Add together the squares of the three highest area scores

Patients with multiple injuries are scored by adding together the squares of the three highest abbreviated injury scale scores in predetermined regions of the body (see box). This is the *injury severity score* (ISS). The maximum score is 75 ($5^2+5^2+5^2$). By convention a patient with an AIS6 in one body region is given an injury severity score of 75. The injury severity score is non-linear: there is pronounced variation in the frequency of different scores—9 and 16 are common, 14 and 22 unusual, and 7 and 15 unattainable. The overall injury severity score of a group of patients should be identified by the median value and the range, not the mean value. Non-parametric statistics should be used for analyses.

Case study

A man is injured in a fall at work. He complains of pain in his neck, jaw, and left wrist and has difficulty breathing. There are abrasions around the left shoulder, left side of the chest, and left knee. Examination of the cervical spine (with radiography) suggests no abnormality. There are fractures of the body of the mandible, left wrist, and left ribs (5 to 9), with a flail segment.

ISS = $2^2+2^2+4^2=24$

Injury	Abbreviated injury scale
Fracture of body of mandible	2
Fracture of lower end of radius (not further specified*)	2
Fracture of ribs 5-9 with flail segment	4
Abrasions (all sites)	1
Neck pain†	0

*If fracture of radius was known to be displaced or open the AIS would be 3. If not specified the lower score is used.
†Symptoms are not scored if there is no demonstrable anatomical injury.

Glasgow coma scale

	Score
Eyes open:	
Spontaneously	4
To speech	3
To pain	2
Never	1
Best motor response:	
Obeys commands	6
Localises pain	5
Flexion withdrawal	4
Decerebrate flexion	3
Decerebrate extension	2
No response	1
Best verbal response:	
Orientated	5
Confused	4
Inappropriate words	3
Incomprehensible sounds	2
Silent	1

Physiological scoring systems

The *Glasgow coma scale* (GCS) is the accepted international standard for measuring neurological state. The score may be represented as a single figure (for example, GCS = 15) or as the response in each of the three sections (for example, eyes, motor response, and verbal response = 465). Coma is defined as a Glasgow coma scale of <8.

Various modifications of the scale have been suggested for use in small children. Some doctors reduce the maximum score to that which is consistent with neurological maturation. A more useful clinical device, which ensures more accurate communication and simplifies epidemiological research is to retain the maximum score of 15 but to redefine the descriptions.

Modification of Glasgow coma scale for children

	Score
Best verbal response:	
Appropriate words or social smiles, fixes on and follows objects	5
Cries but is consolable	4
Persistently irritable	3
Restless, agitated	2
Silent	1
Eye and motor responses are scored as in scale for adults	

Revised trauma score

	Coded value	×weight	=score
Respiratory rate (breaths/min):			
10-29	4		
>29	3		
6-9	2	0·2908	______
1-5	1		
0	0		
Systolic blood pressure (mm Hg):			
>89	4		
76-89	3		
50-75	2	0·7326	______
1-49	1		
0	0		
Glasgow coma scale:			
13-15	4		
9-12	3		
6-8	2	0·9368	______
4-5	1		
3	0		
Total = revised trauma score:			______

The *revised trauma score* combines coded measurements of respiratory rate, systolic blood pressure, and Glasgow coma scale to provide a general assessment of physiological derangement. It was derived from statistical analysis of a large North American database to determine the most predictive independent outcome variables. Selection of variables was also influenced by their ease of measurement and clinical opinion. The coded value is multiplied by a weighting factor derived from regression analysis of the database. This correction reflects the relative value of the measurement in determining survival.

The injury severity score is often underestimated when the patient first arrives at hospital, and the revised trauma score changes as resuscitation progresses. For the purposes of the analyses described below the injury severity score should be calculated only from operative findings, appropriate investigations, or necropsy reports. The revised trauma score is, by convention, taken as the score recorded when the patient first arrives in the accident and emergency department.

TRISS methodology

TRISS methodology

Probability of survival of individual patient (Ps)= $\frac{1}{1+e^{-b}}$

Where e=natural logarithm and $b=b_o+b_1$ (RTS)$+b_2$ (ISS)$+b_3$ (A)

b_{o-3}=Weighted coefficients based on major trauma outcome study (United States) data. These differ for blunt and penetrating injuries

RTS=revised trauma score

ISS=injury severity score

A=age (score 0 if <54, score 1 if ≥55)

Injury severity match ("M" statistic)

Compares the range of injury severity in the sample population with that of the main database (range 0·00-1·00). Z statistic is invalid if M <0·88

Population outcome comparison ("Z" statistic)

Measures difference between actual and predicted number of deaths or survivors (range −1·96 to +1·96)

The degree of physiological derangement and the extent of the anatomical injury are measures of the threat to life. Mortality will also be affected by the age of the patient and by the method of wounding. A blunt assault produces different injury characteristics and physiological abnormalities than does a penetrating object.

The "TRISS methodology" combines the four elements—revised trauma score, injury severity score, age of the patient, and whether the injury is blunt or penetrating—to provide a measure of the probability of survival (Ps). (The acronym is tortuously developed from **TR**auma score and **I**njury **S**everity **S**core.) It is important to appreciate that Ps is merely a mathematical calculation; it is not an absolute measure of mortality but only of the probability of death. If a patient with a Ps of 80% dies the outcome is unexpected in that four out of five patients with such a Ps could be expected to survive. But the fifth would be expected to die—and this could be the patient under study. The use of charts to identify patients whose Ps lies on the "wrong side" of a line that represents 50% mortality is widespread but may lead to inappropriate conclusions being drawn about the care of individual patients if this point is not recognised. Such charts are helpful in identifying patients for discussion at audit meetings but should not be used as the sole measure of performance.

Case study

A 65 year old pedestrian is knocked down, sustaining head, abdominal, and leg injuries. On arrival in the accident and emergency department he has a Glasgow coma score of 9, respiratory rate of 35 beats/min, and systolic blood pressure of 80 mm Hg. Computed tomography shows a small subdural haematoma with swelling of the left parietal lobe. There is a major laceration of the liver but no other intra-abdominal injury. Radiographs of the lower limbs show displaced fractures through both upper tibias.

Revised trauma score:

Glasgow coma score=9; coded value 3×weighting 0·9368=2·8104
Respiratory rate=35; coded value 3×weighting 0·2908=0·8724
Blood pressure=80; coded value 3×weighting 0·7326=2·1978

RTS=5·8806

Injury severity score

	Abbreviated injury score
Subdural haematoma (small)	4
[Parietal lobe swelling]	[3]
Liver laceration (major)	4
Upper tibial fracture (displaced)	3

ISS=$4^2+4^2+3^2$=41

Probability of survival

Coefficients from major trauma outcome study database for blunt injury:

$b_0=-1{\cdot}2470$
$b_1=\ 0{\cdot}9544$
$b_2=-0{\cdot}0768$
$b_3=-1{\cdot}9052$

$b=-1{\cdot}2470+(0{\cdot}9544)(5{\cdot}8806)+(-0{\cdot}0768)(41)+(-1{\cdot}9052)(1)$

$P_s=\frac{1}{1+e^{(0{\cdot}6886)}}=0{\cdot}3343$

Probability of survival=33%

Hospital review

Example

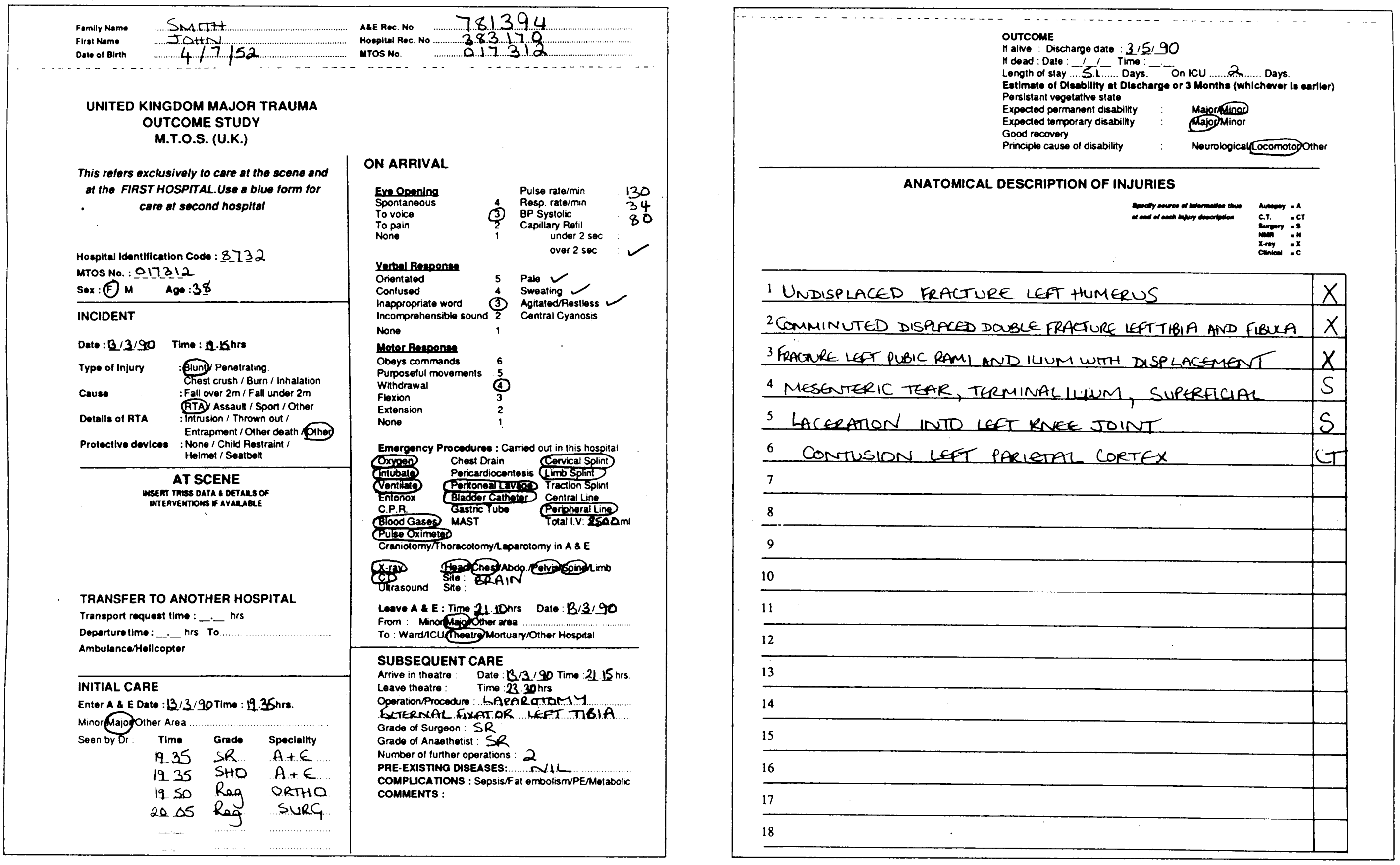
St Elsewhere District General Hospital treated 311 patients in one year who fulfilled the entry requirements for the major trauma outcome study. The distribution of probability of survival estimates in these patients was compared with those in the United States database of 80 000 patients to provide the M statistic. In this case M=0·94, signifying a patient population compatible with the main database. In all, 273 of the 311 patients survived. This compares with a prediction of 284 and gives a Z statistic of −4·81. A figure below −1·96 indicates an overall performance that is appreciably worse than expected.

Major trauma outcome study

The major trauma outcome study

—Measures overall severity of injury
—Records management and outcome
—Provides a database for audit in individual patients
—Allows comparison of performance over time and between hospitals

First developed in North America, the method employed in the major trauma outcome study is now also used in the United Kingdom and Australia to audit the effectiveness of systems of trauma care and the management of individual patients. The TRISS methodology is applied in all patients with trauma who are admitted to hospital for more than three days, managed in an intensive care area, referred for specialist care, or die in hospital. Additional information is sought about pre-hospital care, the seniority of doctors attending the patient on arrival at hospital, the initial management, and the timing of consultations and operations.



Family Name: SMITH
First Name: JOHN
Date of Birth: 4/7/52
A&E Rec. No: 781394
Hospital Rec. No: 383179
MTOS No.: 017312

UNITED KINGDOM MAJOR TRAUMA OUTCOME STUDY M.T.O.S. (U.K.)

This refers exclusively to care at the scene and at the FIRST HOSPITAL. Use a blue form for care at second hospital

Hospital Identification Code: 8732
MTOS No.: 017312
Sex: (F) M   Age: 38

INCIDENT

Date: 13/3/90   Time: 19.15 hrs
Type of Injury: (Blunt) / Penetrating. Chest crush / Burn / Inhalation
Cause: Fall over 2m / Fall under 2m (RTA) / Assault / Sport / Other
Details of RTA: Intrusion / Thrown out / Entrapment / Other death / (Other)
Protective devices: None / Child Restraint / Helmet / Seatbelt

AT SCENE

INSERT TRISS DATA & DETAILS OF INTERVENTIONS IF AVAILABLE

TRANSFER TO ANOTHER HOSPITAL

Transport request time: __.__ hrs
Departure time: __.__ hrs To ......
Ambulance/Helicopter

INITIAL CARE

Enter A & E Date: 13/3/90 Time: 19.35 hrs.
Minor/(Major)/Other Area ......
Seen by Dr:

Time	Grade	Speciality
19.35	SR	A+E
19.35	SHO	A+E
19.50	Reg	ORTHO
20.05	Reg	SURG

ON ARRIVAL

Eye Opening			
Spontaneous	4	Pulse rate/min	130
To voice	(3)	Resp. rate/min	34
To pain	2	BP Systolic	80
None	1	Capillary Refil	
		under 2 sec	
		over 2 sec	✓

Verbal Response			
Orientated	5	Pale	✓
Confused	4	Sweating	✓
Inappropriate word	(3)	Agitated/Restless	✓
Incomprehensible sound	2	Central Cyanosis	
None	1		

Motor Response	
Obeys commands	6
Purposeful movements	5
Withdrawal	(4)
Flexion	3
Extension	2
None	1

Emergency Procedures: Carried out in this hospital
(Oxygen) Chest Drain (Cervical Splint)
(Intubate) Pericardiocentesis (Limb Splint)
(Ventilate) (Peritoneal Lavage) Traction Splint
Entonox (Bladder Catheter) Central Line
C.P.R. Gastric Tube (Peripheral Line)
(Blood Gases) MAST Total I.V: 2500 ml
(Pulse Oximeter)
Craniotomy/Thoracotomy/Laparotomy in A & E

(X-ray) (Head)/(Chest)/Abdo./(Pelvis)/(Spine)/Limb
(CT) Site: BRAIN
Ultrasound Site:

Leave A & E: Time 21.10 hrs Date: 13/3/90
From: Minor/(Major)/Other area ......
To: Ward/ICU/(Theatre)/Mortuary/Other Hospital

SUBSEQUENT CARE

Arrive in theatre: Date: 13/3/90 Time: 21.15 hrs.
Leave theatre: Time: 23.30 hrs
Operation/Procedure: LAPAROTOMY EXTERNAL FIXATOR LEFT TIBIA
Grade of Surgeon: SR
Grade of Anaesthetist: SR
Number of further operations: 2
PRE-EXISTING DISEASES: NIL
COMPLICATIONS: Sepsis/Fat embolism/PE/Metabolic
COMMENTS:

OUTCOME

If alive: Discharge date: 3/5/90
If dead: Date: _/_/_ Time: __.__
Length of stay 51 Days. On ICU 2 Days.
Estimate of Disability at Discharge or 3 Months (whichever is earlier)
Persistant vegetative state
Expected permanent disability: Major/(Minor)
Expected temporary disability: (Major)/Minor
Good recovery
Principle cause of disability: Neurological/(Locomotor)/Other

ANATOMICAL DESCRIPTION OF INJURIES

Specify source of information thus at end of each injury description: Autopsy = A, C.T. = CT, Surgery = S, NMR = N, X-ray = X, Clinical = C

1	UNDISPLACED FRACTURE LEFT HUMERUS	X
2	COMMINUTED DISPLACED DOUBLE FRACTURE LEFT TIBIA AND FIBULA	X
3	FRACTURE LEFT PUBIC RAMI AND ILIUM WITH DISPLACEMENT	X
4	MESENTERIC TEAR, TERMINAL ILIUM, SUPERFICIAL	S
5	LACERATION INTO LEFT KNEE JOINT	S
6	CONTUSION LEFT PARIETAL CORTEX	CT
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		

Form for recording patient's details at the scene and at the first hospital and outcome.

Output variables

Scoring systems should be developed to measure the quality of life after major trauma

Measurement of the change in mortality that may occur in patients with a given combination of anatomical injury and physiological derangement is only one method of assessing the effects of modifications in the system of care. The quality of life of the survivors may vary considerably, but there is at present no adequate system of measuring this. The Glasgow outcome score is a recognised method for measuring the severity of permanent neurological impairment, but there is no universally accepted system for measuring disability resulting from injury to the musculoskeletal system. Most research has concentrated on the elderly and chronically infirm and has not addressed the issue of temporary disability that may be caused by injury to the locomotor system and incapacitate a young person for many months.

Future developments

Objectives of scoring systems

Short term objectives

- Better pre-hospital data
- Consistent hospital scoring
- Improved necropsy reports

Long term objectives

More sensitive scales to include:

- Biomechanical measurements
- More sensitive physiological assessment
- Biochemical analyses
- Assessment of temporary and permanent morbidity

There are wide variations in the provision of emergency medical services throughout the world, and the optimal system for the United Kingdom is still under debate. The major trauma outcome study provides an invaluable method for comparing the patterns of care in different parts of the country. This can be achieved only if data are carefully collected in a consistent format to allow collation and comparison of results. Deaths caused by trauma are too varied, too complicated, and too important to be discussed in isolation in individual hospitals, however sophisticated their software. The wide perspective of the major trauma outcome study is increasingly recognised as the only valid approach to trauma audit and is being taken up by regional and national bodies for this purpose. Identification of deficiencies is valuable, however, only if a mechanism exists to correct them. Local audit meetings and national comparisons must be used to stimulate appropriate changes in the systems of trauma care.

The development of the TRISS methodology has been a major advance in the measurement of injury severity. The detailed structure of the scales and the method of developing a single number to represent threat to life are, however, under constant review.

An alternative method of measuring anatomical injury has recently been described by using the root sum squares of the abbreviated injury scale scores of the head and trunk (anatomic profile). This has now been incorporated into a system for the characterisation of trauma (ASCOT), using different weightings for the revised trauma score and age.

These developments can be expected to lead to more accurate scoring systems, but for the present the TRISS methodology has a worldwide reputation for consistency and reasonable prediction of outcome. Immediate improvement in its usefulness could be made if, as is happening in some areas, ambulance crews measured the revised trauma score at the scene of the accident. This would allow a more scientific appraisal of the value of pre-hospital care. The accuracy of anatomical information could also be improved—particularly in necropsy reports: these are often inadequate for coding purposes and spinal cord injuries are rarely described in detail.

Measurement of outcome in terms of survival or death is, however, a crude yardstick. Further progress is required in measuring disability after non-cerebral injury. Most life threatening visceral injuries leave little disability. In contrast, musculoskeletal problems cause prolonged periods of disability and handicap. Some attempts have been made to measure permanent musculoskeletal sequelae, but the many more patients who sustain temporary incapacity are largely ignored in the statistics. Much more effort will be required to develop outcome measures based on disability; these are essential if the treatment of the multiply injured patient is to be based on sound scientific principles.

Definitions of impairment, disability, and handicap

Impairment has an anatomical or physiological basis and is usually a consequence of musculoskeletal or cerebral injury (for example, an amputated finger, anosmia). It is easy to measure but variably related to the patient's activity

Disability is a functional consequence of an impairment so that the patient cannot perform activities of daily life. Its measurement is relevant to the patient's needs but it is influenced by the environment

Handicap refers to disability within the patient's social and professional environment. It reflects a change in lifestyle, but it is difficult to relate it to specific injury and is very difficult to measure

The latest edition of the *Abbreviated Injury Scale Booklet* (AIS90) and information about the major trauma outcome study (UK) is available from the North Western Injury Research Centre, University of Manchester, Hope Hospital, Salford M6 8HD.

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The ABC of Major Trauma has been edited by Mr David Skinner, FRCS; Mr Peter Driscoll, FRCS; and Mr Richard Earlam, FRCS.

Letter from Chicago

Slippery slopes

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Br Med J 1990;301:1094-5

A retired pathologist from Michigan has recently invented a suicide machine. This he achieved by connecting two bottles hanging from a rack and installing a switch that sets off consecutive infusions of thiopental and potassium chloride. To obtain marketing approval, according to the law of the land, he would have to prove safety and efficacy in placebo controlled trials. So far no manufacturer has as yet added monitors and air conditioners to sell an improved model for $20 000. Nor is production of a device for multiple use under consideration. Leasing arrangements would become feasible only if the clients could be persuaded to return the machine after using it.

The inventor calls himself a bioethicist and obitiatrist, after his new specialty of the medical management of death, but he has also been referred to as Doctor Death. So far he has treated only one patient, quite likely his last. A strong willed woman, said to have lived life to its fullest but suffering from Alzheimer's disease for a year and no longer able to spell or play the piano, she was reportedly well enough to win at tennis and understand the consent forms. She travelled with her family from Oregon to Michigan, where the doctor inserted the intravenous needle and set up his device in a van, no hospital being willing to grant him obitiatric admitting privileges. The woman pressed the switch and all went as planned. The judge, however, did not concur and forbade him to use the machine again, in a van or for that matter anywhere else. Some thought that the doctor himself belonged in the van or at least behind bars. There were conflicting legal precedents in Michigan, one man having been sentenced to life imprisonment in 1920 for placing poison within the reach of his crippled wife; another having been acquitted in 1983 after helping his drunk, depressed friend to buy a gun.

The doctor said that he had not broken any law, "though you never know what happens in a highly emotional society." Some people acclaimed him as a hero who had brought the issue of suicide out of the woodwork; others thought that he was a lunatic. "A