U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

DOT HS 807 973

Final Report

December 1992

Rural Preventable Mortality Study

This document is available to the public from the National Technical Information Service, Springfield, Virginia 22161.

This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings and conclusions expressed in this publication are those of the author(s) and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its contents or use thereof. If trade or manufacturers' name or products are mentioned, it is because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 807 973		

4. Title and Subtitle	5. Report Date
Final Report Rural Preventable Mortality Study	December 7, 1992
	6. Performing Organization Code
7. Author(s) Esposito, T.J.; Reynolds, S.A.; Sanddal, N.D.; Hansen, J.D.; Rinker, C.F.; Dale, G.; Maningas, P.J.; O'Reilly, P.J.; Bleicher, J.; Petrashek, B.	8. Performing Organization Report No.
9. Performing Organization Name and Address Critical Illness and Trauma Foundation Box 1249 Big Timber MT 59011	10. Work Unit NO. (TRAIS)
	11. Contract or Grant No. DTNH22-90-C-05016
12. Sponsoring Agency Name and Address DOT/NHTSA 400 7th St. S.W. Washington DC 20590	13. Type of Report and Period Covered Final 06/04/90-04/01/92
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

All trauma deaths (n=154) from two rural (population density 6.08/sq. mi.) socio-demographically matched study areas, covering a one year time span, were analyzed to determine the rate of preventable death and inappropriate care.

The overall preventable mortality rate was 17%, with 10 preventable deaths in Area A (11.5%) and 16 preventable deaths in Area B (23.9%). Preventable deaths were identified by phase of care with 2 (7.7%) occurring as a result of deficiencies in the prehospital phase, 14 (53.8%) due to inadequacies of care in the emergency department and 10 (38.5%) occurring in the post emergency department.

The distribution of inappropriate care rendered for all deaths (preventable and non-preventable) in each phase of care was 15.7% in the prehospital phase, 62.8% in the emergency department and 21.6% post emergency department. Errors or omissions in care occurred in airway management (n=8), hemorrhage control (n=3), delay in treatment (n=11) and improper management of chest trauma (n=15).

The etiology of trauma showed a significant rate of motor vehicle related trauma, with 72 deaths as a result of vehicle crashes, 10 from auto-pedestrian incidents, 5 from motorcycles crashes and 4 involving motor vehicle/train collisions. Of the motor vehicle crashes, 45 (63%) involved single vehicle rollovers with (51%) of those involving the ejection of one or more of the fatalities.

Additional study of rural preventable trauma mortality and the continued refinement of this analytical process is recommended. Findings of this and other rural studies indicate a need to further develop and enhance trauma care systems, particularly in rural areas of the United States.

17. Key Words	18. Distribution Statement
Trauma, Preventable Trauma Mortality, ISS, TRISS, P_s, Prehospital, Rural	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
		27	$112,000

Form DOT F 1700.7 (8_72) Reproduction of this form and completed page is authorized.

ACKNOWLEDGEMENTS

This research was supported (in part) by the National Highway Traffic Safety Administration (NHTSA), U.S. Deparment of Transportation, under Contract No. DTNH22-90-C-05016. The opinions, findings and recommendations contained herein are those of the authors, and do not necessarily represent those of NHTSA.

The Critical Illness and Trauma Foundation, Inc., and the authors, gratefully acknowledge the support and cooperation of the following agencies and individuals in the completion of this study.

Montana Department of Justice

Division of Forensic Science
Gary Dale, M.D., State Medical Examiner

Highway Traffic Safety Division
Albert E. Goke, Administrator

Montana Department of Health and Environmental Sciences

Bureau of Records and Statistics
Sam H. Sperry, Chief

Emergency Medical Services Bureau
Drew E. Dawson, Chief

Montana-Wyoming Foundation for Medical Care

Janice Conners, Executive Director

Maureen Sheridan-McArdle, R.N.
San Diego County EMS, California

Connie Potter, R.N.
Las Cruces, New Mexico

Douglas R. Tuttle, M.D., FACEP
Chair, EMS Committee
Montana Medical Association

Nancy S. Rahm, R.N.
Rimrock Chapter ENA

TABLE OF CONTENTS

Technical Report Documentation Page (DOT F 1700.7) i

The Problem Identification Process 1
The Rationale for the Selection of This Process 2

Administrative Procedures and Tasks 3
Contract Administrative Procedures and Tasks 3
Individual Case Review Administrative Procedures 4

Research Design, Data Collection Process and Analytical Procedures 6
Discussion of the Analyses Conducted 13
Research Results and Findings 13
Discussion 20
Recommendations and Suggested Questions for Future Research 21
Footnoted References 23
Other References 24
Glossary of Terms 27

TABLE OF FIGURES

Table 1: Mechanism of Injury 14
Table 2: Preventability For All Cases 15
Table 3: Preventability for Deaths Occurring in the Hospital 15
Table 4: Preventability by Survival Time and Age 16
Table 5: Preventability and Cause of Death 16
Table 6: Preventability Judgment and Calculated Survival Probability (P_s) 17
Table 7: Preventability by Phases of Care When Care was Inappropriate 17
Table 8: Nature of Inappropriate Care by Phase of Care 18
Table 9: Nature of Inappropriate Care and Preventability Status 18
Table 10: Factors Potentially Affecting Reliability of Preventable Death Judgments 19

The Problem Identification Process

Montana, like many other rural states, does not have a standardized system of trauma care. The death rate from injury in Montana is significantly higher for all age groups (72/100,000)[1] than the national norm (62/100,000)[2] and dramatically higher in certain age groups and among Native Americans (200/100,000).[3] These figures have not caused undue alarm in either the general population or the medical community, since they tend to be dismissed as resulting from geographic or sociologic phenomena which make them "unpreventable." It is widely assumed that people die from injury in Montana because their injuries occur in remote locations and that the rate of death is substantially influenced by the lifestyles and occupations of the population. Little credibility is placed in the possibility that the increased death rate is directly attributable to deficiencies in the medical care system. Therefore, little emphasis has been placed on developing an organized system of trauma care.

Previous research has shown that prior to the implementation of a trauma care system, preventable trauma death rates have ranged from 21 to 30%.[4,5,6,7,8] However, these data have been gathered in predominately urban environments and are thought to have limited application in largely remote areas such as Montana. This is due to perceived differences in injury etiology, types and patterns, and the availability of resources. These studies also largely excluded those deaths occurring outside of the hospital which preclude the analysis of the prehospital phase of the trauma care system. Significant progress cannot be made in the development of a comprehensive trauma care system in Montana or other states until the extent and nature of preventable trauma deaths are thoroughly examined and brought to the attention of the medical, governmental, political and general communities.

The Critical Illness and Trauma Foundation, Inc., with the cooperation and support of numerous state and local agencies set out to replicate the aforementioned preventable death studies in Montana. However, an exact replication of the methods successfully employed in urban studies is neither feasible nor attainable in the rural environment. The data in many of the previous studies were physically available in one or two institutions and autopsies were routinely performed. In the rural environment, the sources of data are multiple and complete autopsies infrequent.

Blinded clinical chart review and autopsy review are the two general methods for determining the rate of preventability that have previously been reported in the literature.[9,10] Due to the problems unique to rural areas discussed above, a combination of the two processes was employed in the Montana study *which included for review any case in which preventability could be determined from any source of data.*

Other studies have largely excluded those deaths which occur outside of the hospital. To evaluate the total scope of the EMS system, issues of discovery, access and prehospital care also need to be examined. Therefore the final study population included *all deaths from mechanical trauma occurring during the period of time from October 1, 1990 — September 30, 1991, so long as sufficient data existed from any singular or collective source(s) so as to be able to determine preventability*. Exclusions were made for: non-mechanical trauma (ICD9-E 808-809, 845, 890-912, 924-954, 977-978, 990-999), insufficient data, and cases of successful suicide attempts which did not survive to the hospital. Deaths occurring prior to, or without, EMS system contact were judged non-preventable from an acute care aspect, however these cases were examined for potential problems in system access.

The Rationale for the Selection of this Process

This study design was chosen based on several considerations. The contract required a minimum of 60 cases in each of two study areas over a 12 month period of time. It also required a determination of the phase of care leading to untoward outcomes. It was, therefore, necessary to examine every possible case to ensure an adequate sample size and to examine all sources of information which might reveal the circumstances surrounding the demise of each patient.

Chart review requires both access to, and a consistency in the documentation of, each chart. These factors can largely be assured in confined settings involving a small number of hospitals with largely similar staffing patterns and capabilities. This study involved the potential for accessing and retrieving data from some 28 hospitals, most of which (89%) do not have full-time emergency department physician staffing. The other major limitation of the chart review process is that it would preclude examination of those cases which did not survive to the hospital. The issues surrounding inter-rater reliability and inherent biases in the review process are also heightened by the absence of autopsy information.

The autopsy method of determining preventability is described by its authors as an inexpensive alternative which does not reveal the range of information available in chart review. Obviously, it is also dependent upon both the availability of autopsy records and the quality of those records. There is no mandatory autopsy statute in Montana. The best estimate at the outset of the study (based upon gross review of a sample of the previous year's death certificates) was that the autopsy rate would be 60-65% (including both internal and external examinations). It was also suspected that those cases which were likely to have been autopsied would be those involving homicide or suicide. This had the potential to skew the outcome due to a preponderance of penetrating trauma which is not typical of rural patterns of injury. Likewise, since the autopsies which were conducted would be completed by a variety of personnel with varying degrees of training and interest, it was presumed that the quality of the autopsy data would vary dramatically.

These considerations served as the rationale for our selection of a multi-method process for determining the rate of preventable trauma death and the phase of care associated with untoward outcomes.

Administrative Procedures and Tasks

A. Contract administrative procedures and tasks

Work Plan:

The following task list describes in general the administrative accomplishments of the project.

Task 1. Review and analysis of relevant literature relating to preventable mortality, preventable mortality study methodologies, trauma care system problems unique to rural areas and injury scoring systems.

Task 2. Study analysis meeting with contract participants to analyze studies provided by the COTR.

Task 3. Develop a research plan. Identify a detailed methodology for research process, identify problems anticipated in data collection, review and analysis. State proposed methods to resolve said problems.

Task 4. Development of computer database software for data entry, manipulation and analysis of study cases.

Task 5. Implement data collection process.

Task 6. Conclude data collection.

Task 7. Case review process.

Task 8. Data analysis and statistical manipulation.

Task 9. Final Reporting Requirements.

Administrative Discussion:

In reviewing the previous literature associated with preventable trauma death studies, it was concluded that the methods were relatively well defined and rather straightforward. While we anticipated some delays in data acquisition, we simply did not have an appreciation for the overall complexity of the process starting with the development and refinement of the research design phase through the final data collection aspects of the project. This explains the need for two contract modifications with time extensions and one with an additional fiscal commitment. It is our hope that this final report will be of value to others who may wish to replicate this study in other rural areas of the U.S.

Overall, the project required 24 months for completion rather than the initial 18 which was proposed. The associated costs were $112,000 rather than the $68,827 initially budgeted. Out of the total contract amount $80,827 came from DOT/NHTSA while $31,173 was provided in tandem by the Montana EMS Bureau and the Montana Highway Traffic Safety Division. It is also of significant note that an intense effort to raise additional funds through private foundation sources within the State was totally unsuccessful. The primary costs associated with the project were related to personnel including both staff and consultants. Our review panel served gratis which saved an estimated $40,000 in project costs and represents a significant in-kind contribution to the project.

B. Individual case review administrative procedures and tasks

Initial case identification was through death certificate review. These are required to be filed with the Bureau of Records and Statistics within the Montana Department of Health and Environmental Sciences and should occur within thirty days of the date of death. However, it is more often 45-60 days following the date of occurrence. The death certificates were then flagged by county code and those deaths which occurred within the study areas and fell within the ICD-9-E code range of 800-999 were copied and forwarded to the Foundation for possible inclusion in the study. Since the death certificate often listed only the primary cause of death, the staff of the Bureau of Records prevented the inadvertent exclusion of a number of cases by conducting follow-up on those cases which had been signed out as natural or medical causes but which had a mention of an underlying etiology of trauma, e.g. a fall at home two weeks prior. This level of rigorous initial examination may be necessary in other rural areas attempting to replicate this study.

Once received by the Foundation, each case was entered into the data base and given a unique case identifier. Information contained on the death certificate most often determined the methods of obtaining additional information on the case. If the death certificate reported that the place of death had been a hospital then a request to that hospital was made for the chart. Similarly, if an autopsy had been recorded on the death certificate, the State Medical Examiner through the Division of Forensic Sciences was contacted. If the death was reported in a location other than the hospital, staff used knowledge of EMS response patterns to determine which EMS service was likely to have responded. Lastly, if the death certificate indicated that the cause of death had involved a motor vehicle or occurred on a highway, the Division of Highway Traffic Safety was contacted which provided Highway Patrol Investigative Summaries and other relevant information.

A contractual agreement was made with the Montana/Wyoming Foundation for Medical Care (MWFMC) to retrieve and abstract hospital charts. This was accomplished by written contract between MWFMC and each hospital. Charts were requested by mail, returned to MWFMC, abstracted and then forwarded to the CIT Foundation. It is our opinion that the level of hospital cooperation and data acquisition was substantially increased by using this arrangement. This is a result of the MWFMC, as the state peer review organization (PRO), having a long-standing relationship with these facilities. Of the 28 hospitals in the two study areas, only 3 refused to provide data for any reason. The process of receiving the hospital chart on any case often took up to ninety days from the initiation of the request. The range of hospital size for those hospitals which ultimately provided data was from 6 to 200+ beds. The level of detail of the charting varied dramatically (not always proportionately to the size of the facility).

In approximately 58% of the cases where a hospital chart was available, a prehospital record was attached to the record. Montana does not mandate an EMS run report and statute requires only a minimum set of data. Therefore, the quality of the EMS reports varied from highly detailed to those containing no information of use to the study. In those instances where EMS charts were not included with the hospital record, every attempt was made to follow-up with the probable responding agencies. These agencies, in the vast majority of the cases, were willing to share copies of their patient records for the study.

The selection and recruitment of case review personnel proved challenging. All personnel were to be from outside either study area. The study areas encompassed approximately 2/3 of the state, leaving only a small cadre of qualified personnel to choose from. In particular, we were unable to identify certified emergency physicians, orthopaedic or neurosurgeons from within the state to participate. Ultimately we completed the study with the following case review panel composition:

- 3 trauma surgeons (one from out of state who also served as an epidemiologist)
- 1 out of state emergency physician (who was largely unable to physically attend the panel meetings but who provided detailed case reviews as assigned)
- 1 anesthesiologist
- 1 forensic pathologist (state medical examiner)
- 2 registered nurses, both of whom work in a prehospital capacity as well (one as a flight nurse and the other as a ground EMT-Intermediate)

The absence of neurosurgical and orthopaedic representation on the panel was not a significant deficiency. Only four cases were subsequently sent outside of the panel for neurosurgical review and no cases necessitated a specific orthopaedic consult.

Four case review meetings were convened. At the first meeting a mere 6 cases were reviewed and at the final meeting some 84 cases were determined. The process went smoothly, although it is our recommendation that a more structured case review training process using demonstration cases be incorporated into subsequent studies. This would help to create a clearer understanding of the preventability criteria and case review techniques earlier in the process and promote consistency. Such pre-study training would also improve both inter-rater reliability and study validity.

Research Design, Data Collection Process and Analytical Procedures

GOAL: Organize and conduct a Rural Preventable Mortality Study in Montana.

OBJECTIVES:

A. Obtain detailed information on at least 60 deaths from trauma in each of two similar rural medical catchment areas in Montana.

B. Examine the effectiveness of the prehospital treatment and transport system and the ability of hospital medical personnel to identify and appropriately treat trauma patients in a rural setting.

C. Identify and order problems in rural EMS systems and contrast these with problems identified in previous studies conducted in urban EMS systems.

D. Develop and validate a research methodology and uniform data collection instrument which can be readily replicated and utilized in other rural areas of the U.S.

E. Identify EMS/Trauma care system problems in Montana which will provide data to support regional and state level policy changes to upgrade trauma care capabilities in prehospital, hospital and inter-hospital transport systems.

TYPES OF DEATHS: The following deaths by ICD-9-CM E-codes as determined from death certificate data were included in the study.

E-Code	Description
800-807	Railway incidents
810-819	Motor vehicle traffic incidents
820-825	Motor vehicle non traffic incidents
826-829	Other road vehicle incidents
830-838	Water transport incidents
840-844	Air transport incidents
846-849	Vehicle incident, not elsewhere classifiable
870-879	Misadventures to patients during surgical or medical care (only where initial injury occurs as a result of prehospital trauma)
880-888	Unintentional falls
913-915	Injuries caused by mechanical suffocation and foreign bodies
916-923	Other incidents
955-959	Suicide and self-inflicted injury (excluding gunshot wounds to the head)
960-969	Homicide and injury purposely inflicted by other persons (excluding assault by corrosive or caustic substance, poisoning, hanging or strangulation and drowning)
970-976	Legal intervention (excluding legal intervention by gas)
985-989	Injury undetermined whether unintentionally or purposely inflicted

STUDY AREAS: The study areas were two socio/demographically matched medical catchment areas characterized by a centrally populated area surrounded by remote counties which rely on the regional hospitals for critical trauma care. The following area descriptions indicate the similarities between the study sites and the rural nature of the selected locations.

The two areas have a medical catchment area of 28,155 and 31,822 square miles with a corresponding resident population of 175,778 and 188,653 respectively. This translates to a population density of 6.2 and 5.9 per square mile. Both areas have geographical descriptions which are common to the state including plains, mountains and major bodies of water. Their economic bases are also typical of those found throughout the state with agriculture, service industries, tourism, logging and gas/oil/minerals being dominant in both areas. Demographic analyses of age, sex and race showed no statistically significant differences in these characteristics of the population.

The prehospital systems were also similar with ALS provided in the major communities by ground ambulance and BLS throughout the remainder of the region. There was access to hospital-based rotor winged aircraft available in both areas. The major hospitals were similar with full-time, physician-staffed emergency departments, all sub-specialties and advanced diagnostics capabilities. There were 23 ambulance services in both areas and 11 and 13 hospital facilities respectively.

MAJOR DATA ELEMENTS: Experience in previous studies indicated that deficiencies in data sources were to be expected, particularly in areas of prehospital and hospital documentation. The following represent the major data sources and elements collected, where available, for each case included in the study.

> ***Death Certificate:*** Including patient identifier, socio-demographics, times and location of death, coroner/autopsy involvement, primary/contributory causes of death and manner of death. (100% availability)
>
> ***Ambulance Trip Report:*** Including prehospital times, protective devices employed, mechanism of injury, vital signs, assessment findings, treatments rendered, delays encountered and patient destination. (n= 83*)
>
> ***Hospital Medical Record:*** Including mode and time of arrival, emergency department assessment findings, vital signs, ED treatments rendered, duration of stay in ED, surgical consultation, transfer or disposition information, surgical intervention, complications, ICU stay, ICU complications, disposition or death information and discharge diagnoses. (n= 74)
>
> ***Autopsy Transcription:*** Including co-morbid factors, quantification of injuries, detailed description of injuries, factors identified which contributed to death, toxicology and blood alcohol levels. (n= 96)
>
> ***Investigative Report:*** Including a description of events leading up to incident, description of event, type of vehicle, weapon or other mechanism of injury and where patient was pronounced dead. This information was ascertained from uniform MVA fatality reports, coroners reports and law enforcement agency investigative summaries. (n=114, 100% of MVA)

*These numbers are total reports available for the study inclusion group. However, they do not attempt to qualify the records, e.g. autopsy transcription as used here includes both external and complete autopsies. Likewise, while 83 total prehospital charts were available, many were of no value to the eventual determination of preventability due to inadequate recording.

DATA COLLECTION PERIOD: Concurrent data were collected for a period of one year commencing October 1, 1990.

SAMPLE SIZE: The contract stipulated a minimum sample size of 120, 60 cases from each of the two study areas. 1989 data suggested that the minimum sample required could be obtained in a twelve month data collection period. A 60% autopsy rate was anticipated based on prior death certificate data. Since the sample size requirements could not be absolutely guaranteed, two contingency plans were entertained. These being: cases occurring prior to the beginning data collection date would be reviewed in order to achieve a statistically valid sample size, and alternatively, the concurrent data collection period would be extended beyond twelve months if funds were available. It was unnecessary to exercise either of these options.

DATA ENTRY/RETRIEVAL PROCESS: Trauma register software procured by the Montana Department of Health and Environmental Sciences (DHES) was utilized for the study database. The Critical Illness and Trauma Foundation had been authorized, by DHES, to utilize the software program titled *System Trauma Register*, written by Richard Cales, M.D., for the purpose of completing this study. The software data set was modified by Cales at the request of the DHES to specifically address all anticipated data needs of the project and is proprietary to DHES and Cales. The program is written in D-BASE 4.1, under license from Ashton-Tate Software. A Compaq Deskpro 80386/16 Mhz based microcomputer was utilized by Foundation staff for data entry and analysis during the study.

PREVENTABILITY CRITERIA: Preventability determination was based on the following criteria: Revised Trauma Score (RTS), Injury Severity Score (ISS) and the AIS-85 revision of the Abbreviated Injury Scale. These indices of injury severity were converted to TRISS probability of survival (P_S) values for each case where sufficient data existed to do so. The following preventability criteria were specified in the DOT/NHTSA grant/award.

Non-Preventable:

1. Anatomic injuries considered to be non-survivable under optimum care (recognized peer review standards will be utilized)

2. Physiologic state of patient at the time of arrival of first responder may be considered, but non-critical to judgment

3. Appropriate management using ATLS/ACLS/PHTLS guidelines (suspect care handled as error)

4. Patient's probability of survival falls below 0.25 or had an ISS above 50.

5. Patient had co-morbid factors which were major contributors causing death.

Potentially Preventable:

1. Anatomic injuries very severe but survivable under optimum care.

2. Patient generally considered unstable and responds minimally to treatment.

3. Generally appropriate ATLS/ACLS/PHTLS care, suspect care directly or indirectly implicated in patient demise.

4. Patient's probability of survival falls between 0.50 and 0.25 or had an ISS between 20 and 50.

Preventable:

1. Anatomic injuries considered survivable.

2. Patient generally stable, if unstable patient becomes stable with treatment.

3. Evaluation and management suspect in any way.

4. Patient's probability of survival falls above 0.50 or had an ISS below 20.

ADDITIONAL CRITERIA: The following criteria, representative of American College of Surgeons audit filters for quality of care, were used in conjunction with those listed above to indicate cases requiring closer scrutiny for preventability and to further determine appropriateness of care.

- Patient pronounced dead at scene
- Prehospital on scene time: 20 minutes — American College of Surgeons Committee on Trauma, Audit Filter #2 (ACSCOT 2)
- Prehospital transport time: 20 minutes
- Total prehospital time: 30 minutes
- Patient in Emergency Department (ED): 2 hours (ACSCOT 3)
- Patient died in ED
- Patient seen by initial physician after 15 minutes
- Patient experienced unplanned return to operating room (ACSCOT 8)
- Patient died within 24 hours of admission
- Patient in 1st hospital 90 minutes before transfer
- No Trauma Score documented except in intubated patients (ACSCOT 11)

CRITERIA FOR INAPPROPRIATE CARE: A determination of the appropriateness of care rendered was made irrespective of the preventability determination, i.e. the care rendered in cases judged non-preventable was evaluated for compliance with accepted standards of the ATLS and PHTLS courses as well as local trauma care protocols where such protocols were present.

CASE REVIEW PROCESS: Abstracts of each case, blinded for care giver and place of care, were prepared for distribution to the case review panel. Two panel members were then provided with an abstract for each case. One of those two panel members was designated as primary reviewer of the case. Upon request, a complete case file was provided to the primary reviewer. Each case was presented to the entire panel by the primary reviewer with added comments provided by the secondary reviewer. A single reviewer (the out of state trauma surgeon) reviewed all cases and served as arbiter and chairman of the panel. Where disagreement between two reviewers existed regarding preventability categorization or appropriateness of care a panel majority consensus agreement was reached in order to categorize the case. Unanimous consensus was reached in greater than 90% of the cases.

Reviewers also identified behavioral and environmental factors contributing to mortality.

Behavioral factors analyzed included, but were not limited to:

- Alcohol/drug use
- Utilization of automobile restraint systems
- Utilization of protective devices, e.g. motorcycle helmets
- Utilization of non-vehicle protective devices, e.g. ROPS devices on machinery

Environmental factors analyzed included:

- Weather/road conditions
- Road hazards
- Remote locations (wilderness areas, etc.)

Co-morbid factors analyzed included:

- Patient age

A Discussion of the Analyses Conducted

Statistical analyses of study data were conducted by project staff under the direction of the project epidemiologist. Statistical methods included: frequency distribution, cross tabulation and statistical tests as considered appropriate (significance level was set at .05). In addition, specific statistical methodologies related to mortality outcome studies, i.e. TRISS [11] and the calculation of P_s values were conducted. The majority of these analyses were completed by the resident reporting functions contained within the System Trauma Register and the underlying dBase IV language. A portion of the additional administrative data was entered into a separate free standing data base (MS Works) for analysis. Additional fields could have easily been added to the System Trauma Register at the outset which would have precluded the establishment of this administrative data base.

Research Results and Findings

There were 3085 deaths from all causes in the combined study areas during the study period. 286 (9.3%) of these were related to trauma. 132 of these trauma-related deaths were excluded from the study, 110 (83%) due to non-mechanical trauma being the cause of death and 22 (17%) as a result of insufficient information available to determine preventability. Therefore, 154 cases, representing 54% of all trauma related deaths were reviewed and judged for preventability. There were 87 cases (56%) of these were from study area A and 67 cases (44%) from study area B. Of all 154 study cases, 82 (53%) had no autopsy or an external autopsy only. These were included for review as other information sufficient to determine preventability and appropriateness of care was available.

There were 115 (75%) male and 39 (25%) female. Mean age was 40 (3-95), 78% were caucasian, 19% Native American and 3% other. Corresponding distribution of these races in the general population is 93%, 6% and 1% respectively. 81% of injuries were unintentional, 19% were intentional. Of the intentional injuries, 50% were homicides and 50% suicides. 81% of all fatalities sustained blunt injuries, 19% penetrating. Mechanism of injury included: 72 (46.8%) motor vehicle crashes, 26 (16.9%) gunshot wounds, 20 (13%) falls, 10 (6.9%) pedestrians struck, 5 (3.2%) motorcycle collisions, 5 (3.2%) industrial, 4 (2.6%) involved agricultural [including both livestock animals and machinery], 4 (2.6%) involved trains, 4 (2.6%) stab wounds and 4 (2.6%) involved aircraft (Table 1). (See following page.)

Table 1: Mechanism of Injury.

Mechanism	Area A #	Area A (%)	Area B #	Area B (%)	Total #	Total (%)
Motor Vehicle Crash	47	(54.0%)	25	(37.3%)	72	(46.8%)
Fall	9	(10.3%)	11	(16.4%)	20	(13.0%)
Motorcycle Crash	4	(4.6%)	1	(1.5%)	5	(3.2%)
Pedestrian Struck	1	(1.1%)	9	(13.4%)	10	(6.5%)
Gunshot Wound	16	(18.4%)	10	(14.9%)	26	(16.9%)
Stab Wound	2	(2.4%)	2	(3.0%)	4	(2.6%)
Agricultural	3	(3.4%)	1	(1.5%)	4	(2.6%)
Other	5	(5.7%)	8	(11.9%)	13	(8.4%)
Total	87		67		154	

Information was obtained on alcohol use in 79% of all cases. Of these, alcohol use was associated with 39% of all cases and 53.5% of motor vehicle related cases. 35% of all fatalities studied were legally intoxicated and 49% of those who were drivers of motor vehicles or pedestrians struck were legally intoxicated. For motor vehicle occupant fatalities where information on restraint use was obtained (36/72), 14% were restrained and 86% unrestrained. Of the motor vehicle fatalities, 63% involved one vehicle rollovers and 51% of the decedents were reportedly ejected from the vehicle.

Of the 154 cases studied, 5 (3.3%) were judged frankly preventable and 21 (13.6%) potentially preventable. This gives an overall preventability rate of 17% (26/154). Overall preventability was 12% in Area A and 24% in Area B (p =.07) (Table 2). Considering only hospital deaths (N=76), overall preventability was 32%; with 22% in Area A and 45% in Area B (p=.06) (Table 3).

Table 2: Preventability For All Cases (N = 154)

Preventability	Area A #	Area A (%)	Area B #	Area B (%)	Total #	Total (%)
Frankly Preventable	2	(2.3%)	3	(4.5%)	5	(3.3%)
Potentially Preventable	8	(9.2%)	13	(19.4%)	21	(13.6%)
Total Preventable	10	(11.5%)	16	(23.9%)	26	(17.0%)
Non-Preventable	77	(88.5%)	51	(76.1%)	128	(83.0%)

Table 3: Preventability for Deaths Occurring in the Hospital (N = 76)

Preventability	Area A #	Area A (%)	Area B #	Area B (%)	Total #	Total (%)
Frankly Preventable	2	(4%)	3	(10%)	5	(7%)
Potentially Preventable	8	(18%)	11	(35%)	19	(25%)
Total Preventable	10	(22%)	14	(45%)	24	(32%)
Non-Preventable	35	(78%)	17	(55%)	52	(68%)

Associated system access delay, either delay in discovery or excess response time was found in 46 (59%) of prehospital deaths. Excessive scene times (greater than 20 minutes) were found in 15 (23%) of the 64 cases where such data were available.

Preventability stratified by survival time, age and cause of death is presented in Tables 4 & 5. In the 77 cases where TRISS analysis was possible, 55.6% of deaths judged by the review panel to be preventable had a $P_s > .50$. For those cases judged non-preventable, 84.7% had a $P_s < .50$ (Table 6) (See next page).

Table 4: Preventability by Survival Time and Age.

Preventability	Time to Death				Age			
	<48 hr.		>48 hr.		<55 yr.		>55 yr.	
Frankly Preventable	1	(20%)	4	(80%)	1	(20%)	4	(80%)
Potentially Preventable	16	(76%)	5	(24%)	11	(52%)	10	(48%)
Total Preventable	17	(65%)	9	(35%)	12	(46%)	14	(54%)
Non-Preventable	118	(92%)	10	(8%)	100	(78%)	28	(22%)
Total	135	(88%)	19	(12%)	112	(73%)	42	(27%)

Table 5: Preventability and Cause of Death.

Preventability	CNS		Airway		Hemorrhage		Sepsis		Indeterminate	
	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)
Frankly Preventable	2	(40%)	2	(40%)	0	(0%)	1	(20%)	0	(0%)
Potentially Preventable	2	(09%)	8	(38%)	9	(43%)	1	(05%)	1	(05%)
Total Preventable	4	(15%)	10	(34%)	9	(38%)	2	(08%)	1	(04%)
Non-Preventable	81	(62%)	11	(09%)	32	(25%)	2	(02%)	2	(02%)
Total	85	(55%)	21	(14%)	41	(26%)	4	(03%)	3	(02%)

Table 6: Preventability Judgment and Calculated Survival Probability (P_s).

Preventability	All Deaths		P_s <50 #	(%)	P_s >50 #	(%)	P_s Not Calculable	
Frankly Preventable	4	(5.2%)	0	(00.0%)	4	(22.2%)	1	(1.3%)
Potentially Preventable	15	(19.5%)	9	(15.3%)	6	(33.3%)	6	(7.8%)
Total Preventable	19	(24.7%)	9	(15.3%)	10	(55.6%)	7	(9.1%)
Non-Preventable	58	(75.3%)	50	(84.7%)	8	(44.4%)	70	(90.9%)
Total	77	(100%)	59	(100%)	18	(100%)	77	(100%)

The rate of inappropriate care rendered for the entire sample was 33% (51/154). 64% of hospital deaths (49/76) received inappropriate care. The rate of inappropriate care for hospital deaths differed between study areas, 53% in A and 81% in B ($p = .03$). Inappropriate care data stratified by phase of care and preventability are outlined in Tables 7 & 8.

Table 7: Preventability by Phases of Care When Care was Inappropriate (N = 51)

Phase	Preventability: Preventable #	(%)	Non-Preventable #	(%)	Total #	(%)
Prehospital	2	(7.7%)	6	(24%)	8	(15.7%)
Emergency Department	14	(53.8%)	18	(72%)	32	(62.8%)
Post Emergency Dept.	10	(38.5%)	1	(4%)	11	(21.6%)

The most frequent kind of inappropriate care (45%) was related to respiratory problem management [including airway control and chest trauma management] and was most prevalent in the emergency department phase of care. 63% of cases with evidence of inappropriate care showed deficiencies occurring in the emergency department. This trend held true regardless of whether the death was judged preventable or non-preventable (Tables 8 & 9).

Table 8: Nature of Inappropriate Care by Phase of Care (N = 51)

Deficiency	Prehospital		Emergency Dept.		Post Emergency Dept.		Total	
Airway Control	3	(6%)	4	(8%)	1	(2%)	8	(16%)
Hemorrhage Control	1	(2%)	2	(4%)	0	(0%)	3	(6%)
Chest Decompression	0	(0%)	11	(21%)	4	(8%)	15	(29%)
Fluid Resuscitation	0	(0%)	0	(0%)	1	(2%)	1	(2%)
Delay in Treatment	2	(4%)	5	(10%)	4	(8%)	11	(22%)
Other	2	(4%)	10	(20%)	1	(2%)	13	(25%)
Total	8	(16%)	32	(63%)	11	(22%)	51	(100%)

Table 9: Nature of Inappropriate Care and Preventability Status (N = 51)

Deficiency	Preventable		Non-Preventable		Total	
Airway Control	6	(12%)	2	(4%)	8	(16%)
Hemorrhage Control	2	(4%)	1	(2%)	3	(6%)
Chest Decompression	7	(14%)	8	(16%)	15	(29%)
Fluid Resuscitation	0	(0%)	1	(2%)	1	(2%)
Delay in Treatment	7	(14%)	4	(7%)	11	(22%)
Other	4	(7%)	9	(18%)	13	(25%)
Total	26	(51%)	25	(49%)	51	(100%)

Table 10: Factors Potentially Affecting Reliability of Preventable Death Judgments

Area/ # patients	ISS mean	Age		Time		Cause of Death		*Complete Information
		<55 yr. # (%)	>55 yr # (%)	<48hr # (%)	>48hr # (%)	CNS # (%)	Other # (%)	
A/87	37	69 (79%)	18 (21%)	74 (85%)	13 (15%)	54 (62%)	33 (38%)	19 (22%)
B/67	41	43 (64%)	24 (36%)	59 (88%)	8 (12%)	31 (46%)	36 (54%)	11 (16%)
Total/ 154	39	112 (73%)	42 (27%)	133 (86%)	21 (14%)	85 (55%)	69 (45%)	30 (20%)

* Indicates cases where all information necessary for adequate determination of preventability was available from prehospital, hospital and complete autopsy records.

Discussion

The preventable trauma death rate in Montana does not seem to differ from those previously reported in areas without an organized system of trauma care. An overall preventability rate of 17% is low in comparison to other studies, however the previous studies considered only hospital deaths. When this variable is controlled for, the 32% preventability rate in Montana is similar to those reported in prior studies.

Prior to this study, it had been widely speculated that the preventability rate in rural areas would be significantly higher due to extended distances and time to care variables. This does not appear to be the case. It may be that extended time/distance factors serve as a natural triage system in which those with non-survivable injuries often die before any intervention (either prehospital or hospital). This factor may account for the lower preventability rate when all deaths (prehospital and hospital) are considered.

Issues surrounding delays in discovery, dispatch and extended response times are common in the rural environment. These were present in nearly 60% of prehospital deaths in this study. The delays which seemed to contribute most directly to untoward outcomes tended to be measured in hours rather than minutes. That is to say a motor vehicle would leave the roadway in the early morning hours (3:00 a.m.) and would not be found by another passing motorist until sunrise later that day. In these instances, access to telephones, other communication devices or EMS personnel seemed to be less of an issue than the fact that so few people travel various stretches of secondary highways late at night. From these rough data, it seems that automatic detection and signaling devices on the vehicle itself would be far more critical in the rural areas than routine installation of periodic call boxes on the highway or an increase in prehospital manpower.

It has also been widely conjectured that the prehospital phase of care may play a more important role in the outcome of trauma patients in rural areas due to extended transport times. Stratification of results by phase of care indicates that the problem is far more often the result of inadequate care once the patient reached the hospital rather than as a result of sub-standard care in the prehospital phase. Deficiencies noted in the prehospital phase included: absence of a clear and definitive protocol regarding field resuscitation of traumatic cardiac arrests occurring prior to the arrival of the prehospital personnel, failure to adhere to the loosely structured protocols which are in place, inadequate documentation of all aspects of care in the prehospital phase and increased scene time for ALS procedures. Preventable deaths in the prehospital phase were almost entirely due to inadequate airway management.

There were a number of deficiencies noted in the hospital phase of care. Predominately these occurred in the Emergency Department. This was the site where the greatest number of preventable deaths and cases of inappropriate care occurred for the entire study. As in the prehospital phase, these deficiencies were related to deviation from principles of airway management and respiratory problems. There was also a preponderance of treatment according to Advanced Cardiac Life Support (ACLS) protocol rather than Advanced Trauma Life Support (ATLS) protocol. This often resulted in administration of drugs which were of limited value or even detrimental to the trauma patient. Performance of invasive procedures taught in the ATLS course and surgical consultation and treatment were often delayed as a result. This was particularly true in cases of cardiac arrest.

While the decision to resuscitate patients with traumatic cardiac arrest was, in and of itself, not judged inappropriate care, the use of ACLS rather than ATLS principles was. It was noted that many prolonged efforts at resuscitation of blunt trauma patients in cardiac arrest represented an inappropriate use of resources. This was identified by the panel as a problem requiring rectification. This was also noted to be true in the prehospital phase, with a number of patients in traumatic cardiac arrest receiving aeromedical resources. These findings raise the issue of cost effective utilization of limited resources and strategies to accomplish this goal.

The errors or omissions in those cases listed as having inappropriate care were similar to those in previous studies and revolved around: inadequate airway control, failure to recognize and manage chest trauma, inadequate volume replacement coupled with poor hemorrhage control and timely surgical intervention. Errors or omissions were noted in all phases of hospital care including the emergency department, surgery and intensive care units. Clearly the development of an organized trauma care system is essential to overcoming these problems through appropriate staffing, initial and ongoing training, and the adoption of protocols which reflect current standards of care for the treatment of trauma patients.

The reliability of preventable death studies conducted using expert review panels has been questioned by several authors. [12,13.] Factors identified by these investigators which potentially affect reliability include older ages of the deceased, increased severity and non CNS nature of injury as well as lengthier survival time. Incomplete data from prehospital, hospital and autopsy sources has also been implicated as a factor decreasing reliability. These variables are presented for the entire sample and each study area in Table 10. The discrepancies in these variables noted between the two study areas are not statistically significant and therefore are not thought to account for the demonstrated differences in preventability and appropriateness of care rates between the two study areas.

Recommendations and Suggested Questions for Future Research

Based upon our experiences in this project, the authors would make the following recommendations:

- Additional studies of this nature should be conducted in other rural environments to validate these findings, to trend results, and to increase the overall sample size.
- Subsequent studies should explore an additional research question, that being, "Do the treatments and interventions provided to trauma patients (particularly cardiac arrest resulting from trauma) represent an appropriate utilization of resources?"
- Subsequent studies should be fully funded, with realistic time lines and without artificial constraints on geographic area or sample sizes, to ensure the smooth and timely completion of the research and reporting and to avoid sample bias. Funding agencies should recognize that the scope and duration of rural mortality studies will vary dramatically from those reported in urban studies due to the complexity of data retrieval from multiple sources and agencies which are unfamiliar with such processes.
- Review panels should be multi-disciplinary including prehospital providers and nursing staff as well as physicians.

- Specific orientation and training using previously determined cases should be provided to review panel members.

- Non-preventability does not excuse inappropriate or sub-standard care. Future studies should examine the incidence, nature and phase of occurrence of inappropriate care so that solutions can be formulated.

- Future studies should catalogue previously identified factors which potentially affect reliability of preventability judgments for the study population and any sub-populations. The degree of panel judgment concordance with the more objective classification criteria suggested by Shackford, et al, and the American College of Surgeons should also be noted. This will promote standardization of preventable death study reports, better characterize study populations and study reliability.

- Education of both prehospital and hospital providers in the basic principles of trauma management, with particular emphasis on airway and respiratory problems would address the majority of problems identified in this study.

- Funding should be identified to facilitate the retrospective study of the remaining areas of Montana which were not included in this study. This will provide a global picture of the current standard of trauma care throughout the entire state. It will further elucidate the differences in rates of preventable death and inappropriate care between the two study areas and would serve as a baseline for the development of a comprehensive statewide trauma system.

Footnoted References:

1. Bureau of Records and Statistics, Department of Health and Environmental Sciences, 1989-1990 Vital Statistics, Helena, MT, 1992.

2. National Research Council, Committee on Trauma Research. Injury in America: A Continuing Public Health Problem. Wasington, DC, National Academy Press, 1985.

3. Doney, T. Status of EMS Among the Indian Population of Montana: EMS Technical Assessment Report. Billings Area Indian Health Services, 1991.

4. Cales RH, and Trunkey DD. Preventable Trauma Death: A Review of Trauma Care Systems Development. JAMA. 254:1059-1063, 1987.

5. Certo TF, Rogers FB, and Pilcher DB. Review of Care of Fatally Injured Patients in a Rural State: 5-Year Followup. J Trauma. 23:559-565, 1983.

6. Houtchens BA. Major Trauma in the Rural Mountain West. JACEP. 6:343-350, 1977.

7. Smith N. The Incidence of Severe Trauma in Small Rural Hospitals. J Fam Pract. 25:595-600, 1987.

8. West JG, Trunkey DD, and Lim RC. Systems of Trauma Care: A Study of Two Counties. Arch Surg. 114:455-460, 1979.

9. Shackford SR, Hollingsworth-Fridlund P, and McArdle M. Assuring Quality in a Trauma System — The Medical Audit Committee: Composition, Cost and Results. J Trauma. 27:866-875, 1987.

10. West JG. An Autopsy Method for Evaluating Trauma Care. J Trauma. 21:32-34, 1981.

11. Boyd CR, Tolson MA, and Copes WS. Evaluating Trauma Care: The TRISS Method. J Trauma. 27:370-378, 1987.

12. MacKenzie, E.J., Steinwachs, D.M., Bone,L.R., Floccare, D.J., and Ramzy, A.I.. Inter-Rater Reliability of Preventable Death Judgments. J Trauma. 33:292-303, 1992.

13. Wilson, D.S., McElligott, J., and Fielding, P.L.. Identification of Preventable Trauma Deaths: Confounded Inquiries?, J Trauma 32:45-51, 1992.

Other references:

American College of Surgeons Committee on Trauma: Appendix G to Hospital Resource Documents: Quality Assurance in Trauma Care. In Hospital and Prehospital Resources for Optimal Care of the Injured Patient and Appendices A through J. Chicago, IL, 1987.

Association for the Advancement of Automotive Medicine: The Abbreviated Injury Scale: 1990 Revision, Des Plaines, IL. 1990.

Baker SP, O'Neill B, Haddon W Jr, et al. The Injury Severity Score: A Method for Describing Patients with Multiple Injury and Evaluating Emergency Care. J Trauma. 14:187-196, 1974.

Baker SP, Whitfield RA, and O'Neill B. Geographic Variations in Mortality From Motor Vehicle Crashes. N Engl J Med. 316:1384-7, 1987.

Baker SP, Whitfield RA, O'Neill B. County Mapping of Injury Mortality. J Trauma 28:741-745, 1988.

Baxt WJ, and Moody P. Differential Survival of Trauma Patients. J Trauma. 27:602-606, 1987.

Brodsky H and Hakkert S. Highway Fatal Accidents and Accesibility of Emergency Medical Services. Soc Sci Med. 17:731-740, 1983.

Cales RH. Medical Evaluation. In Trauma Care Systems: A Guide to Planning Implementation, Operation and Evaluation. Cales RH, and Heilig RW Jr (eds). Aspen Publishers, Rockville, MD. pp 201-222, 1986.

Cayten, G.C., Stahl, W.M., Agarwal, N., and Murphy, J.G.. Analysis of Preventable Daeths by Mechanism of Injury Among 13,500 Trauma Admissions. An. Surg. 214:510-521, 1991.

Champion HR, Sacco WJ, Copes WS, et al. A Revision of the Trauma Score. J Trauma. 29:623:629, 1989.

Champion, H.R., Copes, W.S., Sacco, W.J., et al. The Major Trauma Outcome Study: Establishing National Norms for Trauma Care. J Trauma. 30:1356-1365, 1990.

Champion HR, Copes WS, Sacco WJ, et al. A New Characterization of Injury Severity. J Trauma. 30:539-546, 1990.

Copes WS, Champion HR, Sacco WJ, et al. The Injury Severity Score Revisited. J Trauma. 28:69-77, 1988.

Copes WS, Lawnick M, Champion HR, and Sacco WJ. A Comparison of Abbreviated Injury Scale 1980 and 1985 Versions. J Trauma. 28:78:86, 1988.

Cox, W.J., Cooper, G.S., et al. 1990 Trauma System Report. County of San Diego, Department of Health Services, Division of Emergency Medical Services, 1991.

Davis, J.W., Hoyt, D.B., McArdle, M.S., et al. The Significance of Critical Care Errors in Causing Preventable Death in Trauma Patients in a Trauma System. J Trauma. 31:813-819, 1991.

Detmer DE, Moylan JA, Rose J, et al. Regional Categorization and Quality of Care in Major Trauma. J Trauma. 17:592-599, 1977.

Greenspan L, McLellan BA, and Grieg H. Abbreviated Injury Scale and Injury Severity Score: A Scoring Chart. J Trauma. 25:60-64, 1985.

Harviel JD, Landsman I, and Greenburg A. The Effect of Autopsy on Injury Severity and Survival Probability Calculations. J Trauma. 29:766-773, 1989.

Karmy-Jones, R., Copes, W.S., Champion, H.R., et al. Results of a Multi-Institutional Outcome Assessment: Results of a Structure Peer Review of TRISS-Designated Unexpeceted Outcomes. J Trauma. 32:196-203, 1992.

Kearney, P.A., Stallones, L., Swartz, C., Barker, D.E., and Johnson, S.B. Unintentional Injury Death Rates in Rural Appalachia. J Trauma. 30:1524-1532, 1990.

Krob MJ, Cram AE, Vargish T, et al. Rural Trauma Care: A Study of Trauma Care in a Rural Emergency Medical Services Region. Ann Emerg Med. 13:891-895, 1984.

Lowe DK, Gately HL, Goss JR, et al. Patterns of Death, Complication, and Error in the Management of Motor Vehicle Accident Victims: Implications for a Regional System of Trauma Care. J Trauma. 23:503-509, 1983.

Martin GD, Cogbill TH, Landercasper J, and Strutt PJ. Prospective Analysis of Rural Interhospital Transfer of Injured Patients to a Referral Trauma Center. J Trauma. 30:1014-1020, 1990.

Mayer JD. A Method for Geographical Evaluation of Emergency Medical Service Performance. AJPH. 71:841-844, 1981.

Neuman TS, Bockman MA, Moody P, et al. An Autopsy Study of Traumatic Deaths: San Diego County, 1979. Am Jur Surg. 144:722-727, 1979.

Report from the 1988 Trauma Registry Workshop, Including Reccommendations for Hospital-based Trauma Registries. J Trauma 29:827-834, 1989.

Rivara FP, Maier RV, Mueller BA, et al. Evaluation of Potentially Preventable Deaths Among Pedestrian and Bicyclist Fatalities. JAMA. 261:566-570, 1989.

Stothert JC Jr, Gbaanador GB, and Herndon DN. The Role of Autopsy in Death Resulting from Trauma. J Trauma. 30:1021-1026, 1990.

Waller JA, Curran R, and Noyes F. Traffic Deaths: A Preliminary Study of Urban and Rural Fatalities in California. Cal Med. 101:272-276, 1964.

Waller JA. Urban-Oriented Methods: Failure to Solve Rural Emergency Care Problems. JAMA. 226:1441-1446, 1973.

Waller JA. Rural Emergency Care—Problems and Prospects. AJPH. 63:631-634, 1973.

West JG. Validation of Autopsy Method for Evaluating Trauma Care. Arch Surg. 117:1033-1035, 1982.

West JG, Cales RH, and Gazzaniga AB. Impact of Regionalization: The Orange County Experience. Arch Surg. 118:740-744, 1983.