UM-HSRI-77-36-1

FIRE DATA METHODOLOGY: VOLUME I

National Estimates of Fire Injuries

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May, 1977

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UM-HSRI-77-36-1		

4. Title and Subtitle	5. Report Date
FIRE DATA METHODOLOGY: Vol. I National Estimates of Fire Injuries	May, 1977
	6. Performing Organization Code
7. Author(s) Jairus D. Flora, Jr.; Lily Huang; Larry D. Roi; Peter Cooley	8. Performing Organization Report No. UM-HSRI-77-36-1
9. Performing Organization Name and Address Highway Safety Research Institute The University of Michigan Ann Arbor, Michigan 48109	10. Work Unit No. (TRAIS) 014759
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Commerce National Fire Prevention & Control Admin. 2400 M Street, Washington, D.C. 20230	13. Type of Report and Period Covered Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Several sources of injury data are evaluated for usefulness in estimating the total number of fire injuries in the U.S. for 1975. The consistencies and inconsistencies of the data sources are noted. Methods for combining data from several sources and for extrapolating the data to the U.S. are discussed.

A combined estimate of the number of persons injured from fires is presented. For the U.S. in 1975 it is estimated that 7,300 persons died from fires, while an estimated 52,400 persons were hospitalized for injuries which resulted from fires. A range of from 225,000 to 400,000 persons received other injuries from fires, depending on the definition of what threshold is used to define non-hospitalized injuries.

Data from the State of Michigan and from a national sample of emergency room records are also analyzed to relate to the fire injuries such factors as age, time of day, type of injury, sex, and source of ignition.

17. Key Words	18. Distribution Statement
Fires Fire Injuries Data Analysis	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
none	none	75	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

* U. S. GOVERNMENT PRINTING OFFICE : 1973 725-504/328

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EXECUTIVE SUMMARY

The number of injuries caused by fires annually in the United States is quite uncertain. The purpose of this 1976-1977 study was to evaluate existing data sources relevant to this problem, develop and implement methods for combining these existing data, and recommend methods to improve the data for the future. In the process of doing this, concensus estimates of fire injuries in the U.S. were developed, together with some bounds on the errors associated with these estimates.

Existing data sources were reviewed and evaluated for their use in estimating the number of fire-caused injuries in the U.S. These data sources included national samples of hospital discharge records, national samples of hospital emergency room visits, death certificates, fire department records, burn registry information, and other specialized sources. Several aspects of the existing data made them somewhat unsuitable for making precise national estimates of the number of fire-caused injuries in the U.S. These difficulties are listed below:

1) None of the national representative samples contained sufficiently detailed information to identify injuries as caused by fires. Rather, injuries were classified by diagnosis.
2) The different data sources used different definitions of "injury." That is, some sources reported more minor injuries than others.
3) The different data sources were inconsistent in their reporting of severity of injury--if any severity was reported. For example, one source might report that a person was

"taken to a hospital," while another reported that a person was "hospitalized", i.e., admitted.

4) Data sources which had sufficient detail to determine the nature and extent of the injury and whether or not it was caused by fire were applicable only to special populations and would present a biased estimate of the nation as a whole.

As a result of these and other difficulties, indirect methods of estimation were used. A surrogate variable for "fire-caused" injury was found among the diagnoses. This was taken as the diagnosis of "burn" or "burn and anoxia." Then the proportion of such diagnoses which were caused by fires was estimated from the special studies where these data were available. Data sources which identified a set of fire-caused injuries and included the nature of injury were used to estimate the proportion of fire-caused injuries which were not burns or anoxia. Finally these estimated correction factors were applied to the national estimates of hospitalized burn injuries to obtain an estimate of the number of hospitalizations for fire-caused injuries.

To illustrate the process, consider the application to one particular set of data. The National Center for Health Statistics uses a national sample of hospitals to estimate the utilization of hospitals. One result of this study was the estimate that 93,000 hospital discharges (in 1972) had the primary diagnosis of burns. The sampling error associated with this figure is about $\pm$ 5000 discharges. In addition, some discharges also had secondary diagnoses of burns. The total estimated primary and secondary diagnoses was 117,000. However, this may include some double-counting if some persons had "burns" as both the primary and secondary diagnosis. These data can be compared to data from a sample of emergency room visits. Among patients treated for burns in hospital emergency rooms, and then admitted, 44% of the burns were caused by fires (as estimated from the data on emergency room visits from the National Electronic Injury Surveillance System). The combination would result in an estimate of 40,900

hospital discharges for fire-caused burns. Several data sources[1] indicated that about 85% of fire-injuries were burns. Thsu, applying a correction for the fact that not all fire-injuries are burns, an estimate of 48,100 fire-caused hospital discharges is obtained (48,100 = 40,900 ÷ 0.85). With the estimated errors in the percentages incorporated, an error of ± 5500 hospital discharges would be associated with this final estimate.

Combining the available data, a concensus estimate of the annual number of fatalities caused by fires in the U.S. is 7300 deaths. This is subject to an estimated sampling error of about 100 deaths. The number of hospital discharges (excluding deaths) from fire-caused injuries is estimated to be 52,400, with an associated error estimate of ± 5000. The number of fire-caused injuries not requiring in-patient hospitalization is much less certain. The data sources which contained information on non-hospitalized fire-caused injuries were quite inconsistent. A range of from 225,000 to 400,000 seems the most reasonable estimate. However, if very minor injuries were to be included, the upper limit might be low by at least a factor of two.

The number of hospitalizations caused by fires as estimated above was primarily derived from hospital discharge studies. The data currently being collected by fire departments in some states do not indicate hospitalization, but rather "taken to hospital". Presumably some of the persons taken to a hospital are treated and released, so the number taken to the hospital should be greater than the number of hospitalizations. However, extrapolating the data from Michigan, one obtains an estimate of only 30,300 persons taken to a hospital for fire-caused injuries. This is considerably lower than the estimate arrived at from other sources.

Several explanation are possible. The correction factors used with hospital discharge data may be wrong. The extrapolation from the limited fire departments data may be in error. Or the estimates from fire department data may be biased by non-inclusion of some injuries. Probably some combination of all three occurred. However, it seems likely that fire department data underestimate the number

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[1] See Table 1-2.

of fire injuries. They can only include injuries from fires to which they are called. Thus, an injury from clothing ignition from a stove or fireplace might result in a very severe injury, but not in a fire department call. Even at fires where the fire department is present, their immediate task is rescue of persons and extinguishing the fire. It is easily possible that they might not note all injuries.

Several steps could be taken to improve the data and the estimates of fire injuries in the U.S.

1) An injury severity scale or classification system appropriate to fire injuries needs to be developed and used. This would define "injury" and enable meaningful estimates of injuries by class to be made.
2) The cause of the injury should be added to existing studies of hospital discharges for accidental injuries. This would make it possible to identify fire-caused injuries. It would also be helpful if an injury scale could be incorporated.
3) The injury data collected by fire departments should be made compatible with other injury data. It could also use more detail, and needs at least an injury scale compatible with injury records from other sources.

One conclusion resulting from the study is that the injury information to be obtained from the National Fire Incident Reporting System (NFIRS) will need to be supplemented by other injury data sources to provide a check on its validity and to provide for coverage for all fire injuries. Unless interest is to be restricted to injuries which occur in fires to which fire departments are summoned, even if all states were fully participating in the NFIRS, the injury data from the NFIRS would be incomplete. A second conclusion is that an injury severity scale for fire-caused injuries needs to be developed and applied so that the number of injuries can be estimated by severity. Without such severity information, there is a risk that the consequences of a few carefully studied severe injuries will be extrapolated to a large number of more minor injuries. Finally, there is some need to define the term fire-caused.

Current data sources have been found inadequate to accurately estimate the number of fire-caused injuries annually in the U.S. Several improvements to existing data sources as well as development of new ones are suggested to provide meaningful estimates of the injuries caused by fires in the U.S. Existing data suggest that about 7,300 (± 100) persons are killed as a result of fires annually in the U.S., about 52,400 (± 5000) persons are hospitalized for fire injuries, and from 225,000 to 400,000 other persons are injured by fires but are not hospitalized.

The simplest and most cost-effective action which could be taken to improve the information available about fire-caused injuries in the United States would be to include two additional data items on the hospital record study conducted by the National Center for Health Statistics. For hospital discharges which resulted from injuries, the cause of the injury--e.g., fire, car accident, home accident--should be recorded. The second data element would be "Accidental injury reported to _____(police, fire department, etc.)" with a definite code for not reported. This would make it possible to obtain good information about fire-caused injuries requiring in-patient hospitalization and also to estimate the completeness of such injury data as reported from fire departments. A side benefit would be that such data would also be useful to accident investigators, or persons concerned with product or home safety.

1. INTRODUCTION

Estimating the number of injuries caused by fires in the United States is difficult. No data sources tabulate the number of injuries by the type of accident and cover all levels of injury from minor to fatal. Most current data sources tabulate injury data by the diagnosis or type of injury rather than the nature of the accident causing the injury. Further, no one data source addresses all levels of injury. Thus, for different severities of injury, and different treatment modalities, one is faced with data sets which are only partially compatible, which sometimes overlap and sometimes leave gaps, and which are subject to different types of sampling and bias errors.

This report evaluates a number of data sources for their usefulness in forming estimates of the number of fire injuries in the U.S. in 1975. It combines estimates from the most reliable data sources into a concensus and provides an evaluation of the errors of the resultant estimate.

Comparison of preliminary data from state fire incident reporting systems indicates that these consistently under-report the number of fire injuries of all severities, but particularly the minor injuries. Even the fire injuries requiring hospitalization are seriously under-reported. Improvement of the data collection system could improve the reporting of fire injuries requiring hospitalization from fire departments, but there will be a continued bias toward the low side caused by the fact that many fire injuries occur from a small or contained fire for which the fire department is not called. It seems unlikely that complete reporting of the minor injuries even from incidents for which the fire department is summoned can be obtained at a reasonable expenditure of effort from the fire departments.

Many data sources were evaluated and used in this report. Table 1-1 provides a glossary of the organizations and/or data source names, which are referred to in the text by abbreviations. Table 1-2 summarizes the major data sources used in forming national estimates of the number of different types of fire injuries in the U.S. in 1975. The table is annotated so that some of the particular features of methods used with each data source can be determined.

A brief summary of methods used may be helpful. Straight population expansion was used with the (MFIRS)* data. This appears to work well for the number of deaths. However, it does not work so well for the number of hospitalized injuries in the sense that the estimate so derived does not agree well with the estimates derived from CPHA, NCHS, or NEISS data. This may indicate that injuries which require hospitalization are under-reported in the fire department records, or that many of these injuries result from fires with no fire department call.

The following procedure was used to estimate the number of fire injuries requiring hospitalization from the hospital discharge records. First the percentage of persons hospitalized for treatment of burns who were injured in a fire was estimated. Several data sets provided estimates of this percentage. These individual estimates were combined using a weighted average. The weights were somewhat subjectively determined. The determination of the weights includes some objective criteria such as the number of cases on which the estimate was based, but also some rather subjective evaluations of the sampling methods, the populations sampled, the suspected bias from incomplete data, and other factors. This resulted in the estimate that 55% of hospitalized burns were the result of fires. The standard error estimated for this percentage is 6.8%. Other weightings of the estimates did not vary this much. They resulted in values ranging from 50% to 61%, even when very unreliable estimates (some as low as 13%) were included.

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*See Table 1-1.

Not all injuries from fires are burns. To adjust for this fact, the percentage of non-burn fire injuries (among injuries requiring hospitalization) was estimated from several sources. These estimates were combined in the manner described above. The percentage of non-burn fire injuries varied very little among the data sets, ranging from 83% to 86%. The percentage was estimated to be 85% with an associated estimated standard error of 0.7%.

This series of correction factors was applied to the hospital records data to obtain an estimate of the number of fire-injuries requiring hospitalization. For example, the NCHS hospital records study estimates 93,000 hospitalizations from burns. Assuming that 55% of these were caused from fires results in an estimated 51,150 fire-caused burns requiring hospitalization. Burns are assumed to represent only 85% of fire-caused injuries. Thus, dividing 51,150 by 0.85, the estimate of 60,176 is obtained for the number of fire-caused injuries requiring hospitalization. Some measure of the precision of this can be obtained by following the same procedure but varying the two correction factors. If a lower value for the first and then a higner value for the second is used, a lower bound will result, while using the higher value for the first correction followed by the lower value for the second factor will result in an upper bound. For example, a lower bound for the hospitalized fire injuries derived in this way for the NCHS data is 52,305 (93,000 x 0.482 ÷ 0.857 = 52,305). Similarly, the upper bound for the NCHS data is 68,178. Thus, the estimate of fire-caused injuries requiring hospitalization based on the NCHS hospital records study in round numbers is 60,200 $\pm$ 8000.

The same sorts of corrections were applied to the various data sources as appropriate to arrive at an estimate and an estimate error associated with it as above. These estimates were then averaged to arrive at an estimate of about 52,400 fire injuries resulting in hospitalization with an estimated standard error of about 5000.

Several data sources (NEISS, NBIE, & Guilfuy) provided estimates of the percentage of deaths among persons hospitalized for burns received in fires. These averaged 14.5% of the victims. Applying this percentage to the estimated number of hospitalizations results in an estimate of the

national number of fatalities. These are also reported in Table 1-2. These estimates were all rather consistent, ranging from 6,300 to 7,400.

The NEISS data are a sample of emergency room records, but only about 20% of such records--which deal with injuries which are product-associated--are sampled. If the estimates from the NEISS are magnified by a factor of five, then they agree closely with the other estimates for hospitalized injuries. If the same series of correction factors are applied to the estimate of hospitalized injuries from the NEISS to estimate the number of deaths as was done with the NCHS and CPHA data, then the number of deaths agrees reasonably well with the number from the vital statistics, which may be regarded as a standard.

The number of fire injuries which do not require hospitalization is an open question. It seems somewhat to depend on the definition of "injury." Even if a threshold of professional treatment is used, the estimates vary widely from the different sources. In the MFIRS, slightly fewer injuries were reported which did not result in hospitalization than did. This must clearly be a case of under-reporting, but the extent of the under-reporting is unknown. Among the NEISS data, approximately ten times as many burn injuries did not result in hospitalization as did, but among the injuries with fire recorded, slightly over five times as many did not result in hospitalization as did. The study by Guilfoy et al. reported that 58% of the flame burns (over 5% body surface so as to be reportable under Massachusetts law) resulted in hospitalization. Thus, the estimated number of non-hospitalized fire injuries runs from about 27,000 from extrapolation of MFIRS injury reports, to about 500,000 if a factor of ten times the number of hospitalized injuries is used. This suggests a figure in the 250,000 to 300,000 range as representing the non-trivial non-hospitalized fire injuries.

As a summary, an estimate about 7,300 deaths ($\pm$ 100), about 52,400 ($\pm$ 5000) hospitalized injuries, and from 225,000 to 400,000 non-hospitalized injuries from fires seems the best from the available data.

It seems evident that not all fire injuries will be included in data from fire department records, no matter how the system is improved. There are simply too many fire injuries which occur in instances when

the fire department is not called. As a consequence, the total picture of fire injuries can be obtained only with some auxiliary sampling method which will identify fire injuries not identified through fire departments. A sampling system based on hospital records, or hospital emergency room visits, seems most promising for the serious injuries. This might also be augmented by a survey of private physicians. In any event it will be necessary to carefully determine the nature of the incident which caused the injury and to determine whether the injury was also reported in the fire-department-based system.

TABLE 1-1

GLOSSARY OF ACRONYMS FOR DATA SOURCES AND ORGANIZATIONS

Acronym or Abbreviation	Full name
CPHA	Commission on Professional and Hospital Activities
CPSC	Consumer Product Safety Commission
FAA	Federal Aviation Administration
FRA	Federal Railroad Administration
H-ICDA	Hospital Adaptation of the International Classification of Diseases: A system of coding diseases and injuries used by the CPHA, the NCHS, and others
MAMCS	Michigan Ambulatory Care Survey
MFIRS	Michigan Fire Incident Reporting System
NAMCS	National Ambulatory Care Survey
NBIE	National Burn Information Exchange--a data registry on burned patients operated by the National Institute for Burn Medicine
NCHS	National Center for Health Statistics
NEISS	National Electronic Injury Surveillance System (Run by the Bureau of Epidemiology of the CPSC)
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NFPCA	National Fire Prevention and Control Administration
NTSB	National Transportation Safety Board
PAS	Professional Activity Study - (concluded by CPHA)

TABLE 1-2. MAJOR DATA SOURCES

Data Element	MFIRS[1]	NEISS[1]	NCHS	CPHA	NBIE	Guilfuy, et.al.	Branson, et.al.	Michigan Workman's Comp.
FATALITIES								
Fire (death certificate)	---	---	7,232	---	---	---	---	---
Fire (estimated)	7,390	1,360 NR[2]	7,400[1]	6,300[1]	---	---	---	---
% of hospitalized burns	---	(6,780)	---	---	15%	13%	---	---
HOSPITALIZED INJURIES	Civ Fire Sev (to hospital							
BURNS	--- ---	13,378-80,600[2]	93,000	79,000	---	12,930[1]NR	---	---
Burns from fire	14,960 2,460	5,700-27,800	51,150[2]	43,450[2]	67.5%	6,930NR	---	---
Total Fire	17,600 12,750 30,350	6,700-33,500 44% hosp'd. burns 75% hosp'd. thermal burns due to fire	60,200	51,000 13% of hosp'd. burns due to fire	of burns are from fire	54% of burns are from fire	---	---
Other Injuries	9,400 16,250 26,650	22,484 (fire) -225,000 105,000* thermal burns -145,000 fire injuries 23.5% of thermal burns due to fire	310,000[3]	263,300[3]	---	--- 27% of burns due to fire	---	--- 22% of burns due to fire
Miscellaneous information	85% of civilian fire injuries are burns. 19% of fire serious injuries are burns	86% of fire injuries are burns	---	---	---	---	83% of hosp'd. burns recorded in E.R. records	85% of fire injuries are burns
Notes	[1]Population factor of 23.23 used to extrapolate to U.S.	[1]Prescene of fire underreported by a factor of 2. [2]Only 20% of ERV's are coded. A factor of 5 used for expansion.	[1]Estimated deaths from data on hosp'd. burn injuries. [2]Fire-relation estimated as 55% of burns. [3]Non-hosp'd. fire injuries 5.1 times hosp'd. [4]Based on number of patients with E codes-severe underreporting.		Mortality rates & other consequences by severity of burn.	[1]Population factor of 35.72 for MASS used. Unreliable results based on only 611 cases in less than 1 year.	A notation of "NR" after an entry means that the entry is regarded as unreliable & that reasons for this have been identified.	

2. DATA SOURCE EVALUATION

One approach to the problem of estimating the number of fire injuries and fatalities in the United States is to investigate existing data sources which have compiled injuries and deaths by cause. Several of these data sources are evaluated in this section. Most of these sources suffer from some defect as a source for estimating the national total of fire injuries. The most common reason for this is that these data sources classify patients (or deaths) by the nature of the injury--e.g., burns--rather than by the underlying cause of the injury--e.g., fires. As a consequence, it is in general not possible to determine what proportion of the burn injuries were in fact due to fires. Neither is it possible to determine how many other injuries, such as fractures, were caused by fires. Each of these data sources is a valuable source for the purpose for which it was devised. However, none of them was designed to investigate the problem of fire injuries. As a consequence, each has drawbacks detailed below.

In addition to the evaluations summarized for each particular data source, there exists the problem of coverage and overlap. That is, each data source is particular to one type of patient as defined by type of medical care. Thus, the CPHA* and NCHS* hospital records studies deal with patients admitted to a hospital for treatment. The NBIE* considers patients admitted for treatment at specialized burn centers. The NCHS Ambulatory Care Survey deals with treatment in physician's offices. And the NEISS deals with care received in hospital emergency rooms. There are some connections. The NEISS notes when a patient was admitted to the hospital, as does the Ambulatory Care Study. However, a study in Rhode Island indicates that many burn patients do not pass through the emergency rooms.

*See Table 1-1 for abbreviations.

Of these sources, the NEISS is the most directly relatable to fires--although it would not include industrial or special property (grass or forest) fires. The NEISS data for January, 1975 through June, 1976 are analyzed in Section 3.

2.1 Use of a Surrogate Variable

Since most of the existing data sources do not classifiy patients by the cause of their injury, it is not possible to relate injuries directly to fires. Thus, while good samples of hospital records are available,* these do not indicate how an injured person was injured. As a result, some surrogate variable must be used in place of identification with fires, which is lacking.

A number of variables could possibly be combined to produce a useful surrogate for fire-association. The injury diagnosis is the most immediately obvious choice. That is, the diagnosis of burns is used as a surrogate for an injury due to fire. Another possibility would be asphyxiation. It is clear that no diagnosis will be a perfect surrogate for fire-associated injuries. Many burns--such as scalds from cooking--are not caused by fires. Similarly it is possible that many injuries which result from fires are neither burns nor asphyxiation. As an example, fractures or concussions could result from parts of a building collapsing during a fire.

In spite of the drawbacks, it appears that the diagnosis of burns, or thermal burns, is the best surrogate for fire-related injury to use in dealing with records which classify patients by diagnosis only. Data published by the NBIE indicate that about two-thirds of patients hospitalized for treatment of severe burns were burned as a result of fires. On the other hand, data from the

*"Inpatient Unilization of Short Stay Hospitals by Diagnosis," Vital and Health Statistics Series 13, No. 20, National Center for Health Statistics, U.S. Department of Health, Education and Welfare.

NEISS indicate that only about 25% of burns are related to fires--see Section 3. This latter data source is a sample of records of persons treated in hospital emergency rooms for product-associated injuries. This estimate is thought to be low because of incomplete reporting of fire association in the NEISS. However, the degree of this possible bias is unknown.

Data from a study of 611 burn injuries in the state of Massachusetts* indicate that 28% of those burns were caused by flame. Of the group of burns studied--which should include all burns of 5% body surface or more in Massachusetts for the six-month period October, 1975 through March, 1976--only 30% of the victims required hospitalization. Of those hospitalized, 54% of the cases were caused by flame, 36% by scalds, and the remaining 10% by a variety of causes such as electricity, radiation, contact, etc.

Data from the Workmen's Compensation Insurance claims in Michigan also indicate a figure of about 22% of burns being caused by fires. These data appear reliable, but deal with only a special class of injuries--those which are employment-related. Thus only persons whose jobs are covered under workmen's compensation are included and only injuries to those persons which occurred as a result of their jobs are included.

Thus, several sources of data indicate that among all burn injuries, only about 25% are directly caused by fires. However the proportion which are caused by fires are more severe. Among persons hospitalized for burns the proportion caused by fires appears to be between 54% and 67%. As a consequence, use of burns as a surrogate for fire injuries would over-estimate the number of injuries by a

*Guilfoy, V., et al., Burn Injuries: Causes, Consequences, and Behavior - Phase I of the Burn Injury Education Demonstration Project, Massachusetts General Hospital, Boston, June 1976.

factor of about two or four, depending on whether the injuries were hospitalized burns or all burns treated.

Other injuries may result from fires, however, which could offset the overestimation mentioned above. Data from the NEISS and from the Michigan Workmen's Compensation Insurance indicate that about 85% of the injuries caused by fires are burns. Data from the Michigan Fire Incident Reporting System show that 59% of civilian injuries resulting from fire incidents are burns. However, the MFIRS data also show that among persons injured seriously enough to be taken to a hospital or other medical facility for treatment (not necessarily hospitalized, however) the proportion of burn injuries is 82%. Among the fire service personnel injured in fire incidents, burns were only 17.8% of the total injuries. The remainder were strains, sprains, fracture, etc. (see Table 4-3 for details).

As a result of these comparisons, one can estimate that among persons hospitalized with burns as the diagnosis, probably about 60% had their injuries caused by fire. In addition, there would be patients hospitalized for non-burn injuries caused by fires. The number of these would be about 20% of the hospitalized persons with fire-caused burns.

Among all persons treated for burns it appears that a figure of about 25% of these were fire-related. However, in this case the number of non-burn injuries caused by fires is also larger. This number is quite uncertain. It might be as low as 15% as indicated by the NEISS, as much as 40% as estimated by Michigan fire incident injury data for civilians, or even as high as 80% to fire service personnel as estimated by Michigan fire incident injury data.

Thus, although the use of diagnosis of burns as a surrogate for fire injuries appears the best current surrogate, it is not particularly good. It is reasonably valid among hospitalized patients, but is quite unstable among all burn injuries. It is certainly clear that the severity of the injury--hospitalized or not--must also be reported.

Another point to consider is the precise definition of 'injury.' The frequency of injuries received in fires varies inversely with the severity of the injury. That is, the most serious injuries are relatively rare, while minor injuries such as cuts, bruises, or strains are quite frequent. This seems to be a general phenomenon associated with accidental injuries. It can result in some misleading estimates if it is not recognized. For example, injuries which have been investigated in detail are nearly always the most serious, with a resulting long hospitalization, high cost, loss of time, threat of disability or death, etc. The total number of all injuries, however minor, is extremely large. If the fact that the serious injuries are relatively rare is not recognized, one may erroneously combine the large number of minor injuries with the serious consequences of the severe injuries and obtain a quite misleading picture of the actual situation. Such combinations dramatize a problem, but do not provide a basis for attempting to remedy the problem on a rational basis.

The discussion in terms of fatalities, hospitalized injuries, and other injuries is a very crude scaling of injuries in terms of severity. What is needed is a definitive severity scale for injuries received from fires, together with estimates of the number of each injuries of each severity. However, no approrpriate injury scale currently exists. Within hospitalized burns, a severity scale based on probability of survival could be developed* in a straightforward manner. However, survival may not be the only appropriate measure--morbidity and threat of disfigurement or disability should also be considered. In addition, a substantial portion of fire burns do not require hospitalization, and an additional portion are not burns. These injuries should also be included in a severity scale.

Existing injury severity scales are not adequate for the problem of scaling fire injuries. To some extent this stems from the fact

*See for example, Feller, Flora, and Bawol, "Baseline Results of Therapy for Burned Patients," Journal of the American Medical Association 236: 17 pp. 1943-1947 (October 25, 1976).

that they were developed for sets of injuries which rarely included burns. As a result, burns are inadequately scaled. Since a large fraction of fire injuries are burns, any severity scale which deals with fire injuries must include burns as a major injury category. The severity scale used with the NEISS data* would essentially class all burns as either hospitalized or not, which would seem to be too crude a classification. Similarly, the abbreviated injury scale or even the comprehensive injury scale of the American Medical Association** deals mostly with trauma other than burns, and does not adequately scale burn injuries. The problem of developing an adequate severity scale for fire injuries is a difficult one which needs much additional effort. However, it is a problem which needs to be resolved if reasonable estimates of the national totals of the consequences of fire injuries are ever to be obtained.

*See for example, "The National Electronic Injury Surveillance System and Bicycle-Associated Accidents" by J.D. Flora, R.J. Kaplan, E. Margosches, and P.D. Ward. UM-HSRI-SA-75-18, October 1975, p 32ff. (Available from NTIS).

**See "Rating of Severity of Tissue Damage", Committee on Medical Aspects of Automotive Safety, J.A.M.A. 215:2 (January 11, 1971).

2.2 CPHA Hospital Discharge Data

The Commission on Professional and Hospital Activities (CPHA) collects and tabulates data on the discharges of approximately 40% of the short-term non-federal hospitals in the United States. A stratified random sample of these discharges is selected each quarter and used to make national estimates of the discharge diagnoses, the treatments, and the lengths of stay. Each quarter a new sample of 100,000 records is drawn. The estimates are reported as cumulative for the year to date. Thus, the estimates reported for the fourth quarter are for the entire year and are based on a stratified sample of 400,000 hospital discharge records.

These data are based on hospital discharges, using the United States adaptation of the H-ICDA (Hospital-International Classification of Diseases) codes. As a consequence of this, only injuries severe enough to result in admission to a hospital are included. In addition, using the H-ICDA codes alone, it is not possible to determine whether a burn injury resulted from a fire or from contact with a hot stove. It is also not possible to determine that other injuries--e.g., asphyxia from carbon monoxide--resulted from a fire.

The combined estimates are published quarterly by IMS America Ltd., Amblen, Pennsylvania. The publication, entitled "Hospital Record Study," also includes a brief description of the sampling methods and estimates of the sampling errors. For codes which have at least 30,000 discharges, separate estimates are presented for geographic regions, sex, age, and length of stay.

For 1975, estimates indicate that 79,120 hospital discharges were for burns as the primary diagnosis. A 95% confidence interval for this total is from 74,135 to 84,105. In addition, 66,260 discharges had burns listed as a secondary diagnosis. Since many victims of fires have several burns, it is likely that many of the secondary diagnoses of burns were also primary diagnoses of burns. However, the extent of the overlap is unknown. Thus the true number

of patients with burns is more than the 79,000 with burn as primary diagnosis, but is probably less than the total of the primary and secondary diagnoses.

As mentioned, there is also the difficulty of identifying injuries with fires. Data on burned patients treated in several burn centers indicate that only about 65% of such burns are due to flame. The remainder are due to scalds, contact with hot surfaces, or are electrical or chemical in nature. Only the flame burns would be likely to be associated with fires, and perhaps not all of them. Thus, the burn injuries due to fires might be only about two-thirds of the burn injuries.

There are codes in the H-ICDA coding system which indicate the cause of the injury--the external source. These are preceded by an "E." In the CPHA data, these are not used to any great extent. In the 1975 data, the code "E899"--accident caused by fire--is estimated to be a factor in only 14,000 of the discharges. This is so low due to serious under-reporting. That is, use of the "E-codes" is optional and many hospitals do not use them. The reported total is merely a sum of those reported. It seems inconceivable either that over 79,000 discharges could result from only 14,000 accidents, or that more than 65,000 burns did not involve fire. However, the CPHA could not provide any accurate estimate of the degree of under-reporting of the "E" codes without extensive computer work.

The present tabulations seem to be about the best that can be done with CPHA data in its present form. To identify the discharges with fires accurately would require introduction of consistent use of the "E-codes" or some other additional data collection by the CPHA. This would require a major effort and would be quite extensive. Conversations with CPHA indicated that estimates of the number of patients burned could be obtained from the annual sample for about $1,000. This would remove the question of how many of the

65,000 secondary diagnoses of burns represented patients who were not included in the primary diagnosis group. Identification of "burn" with fire as the cause would require data collection agreements with each hospital and does not seem feasible at this point.

2.3 NCHS Hospital Discharge Survey

The National Center for Health Statistics conducts the National Health Survey. As part of this survey, statistics are presented on the utilization of non-federal short-stay hospitals based on data abstracted from the Hospital Discharge Survey from a national sample of hospital records of discharged patients. The latest data published are for the year 1972 and were published in November of 1975.*

The sampling is based on approximately 225,000 discharges from 424 hospitals. The sample is stratified by hospital size and geographic region in a manner similar to the sample used by the CPHA. Two differences in the sampling technique should be noted. First, the CPHA stratifies by number of discharges in previous years as the measure of the size of the hospital, while NCHS stratifies by the number of beds as the measure of the size of the hospital. Secondly, the CPHA samples from the hospitals within its system, while the NCHS samples from the total population of the U.S. hospitals. The NCHS method is to be preferred, naturally, but they obtained participation of 424 out of the 497 hospitals in the sample for a missing rate of 14.7%. On the other hand, CPHA uses as the population the set of hospitals already supplying data, so it does not have any missing data from the sample selected. It does, however, have a noncoverage problem. The errors introduced by the two procedures are probably about the same order of magnitude. The number of records sampled by the CPHA in a year is nearly twice as large as the number in the NCHS sample. As a result, the sampling error bounds stated by

*"Inpatient Utilization of Short-Stay Hospitals by Diagnosis," Vital and Health Statistics Series 13, No. 20, National Center for Health Statistics, U.S. Department of Health, Education and Welfare.

the CPHA are somewhat smaller. The estimates arrived at by each source are reasonably consistent, so are presumably accurate.

The NCHS also uses the ICDS codes for diagnosis, excluding the "E-codes," which identify external cause of accident. Unfortunately, the "E-codes" are those which would identify fires as the cause of the injury. Consequently, the NCHS estimates suffer from the same deficiency that the CPHA estimates have --the inability to identify fire as the cause of the injury. This same defect will be found in any data source which uses ICDA codes unless there is strict adherence to use of the "E-codes" for all diagnoses.

There are probably some data available directly from the NCHS for later years than 1972, which are not yet published. It might also be possible to supplement the hospital discharge survey by adding the "E-codes" to the survey in the future. We would recommend the NCHS survey as the better vehicle for adding the information on accidental causes. There are two reasons for this. First, even with a few of the hospitals declining to participate, the representativeness of the sample seems to be on more solid ground than that of the CPHA. Secondly, it seems likely to be more efficient and less costly to work through the NCHS than the CPHA. On the other hand, there is generally a considerable delay in getting the data from the NCHS. The estimates based on the PAS study of the CPHA and published jointly by CPHA and IMS, America, are published more rapidly. This speed is obtained at the cost of less "cleaning" of the data, however.

2.4 NBIE Hospitalized Patients

The NBIE maintains patient and treatment data on burn admissions to burn treatment facilities in the U.S. and some foreign institutions. The total data set contains 32,000 cases from a total of 119 hospitals. The current collection rate is approximately 5,000 new cases per year.

One desirable use of these data would be to estimate the national incidence of burn injuries due to fire. The severity of the injury, survival rates, treatment, length of stay and other variables connected with these injuries and their treatment could also be investigated. Three major problems limit the feasibility of such national estimates:

1. Minor burns treated by private physicians and not requiring admission to a specialized burn care facility and catastrophic burns which result in death on the scene or on arrival at a medical facility would not be included in this data set.

2. The participation of an institution and submission of data is of a voluntary nature with the primary motivation being the information feedback from the NBIE to the institutions. This voluntary nature of the participation leads to doubtful data quality--particularly in terms of the completeness of reporting.

3. The institutions reporting to the NBIE constitute neither a complete census of institutions nor a representative sample of burn treatment facilities. In particular, one of the requirements for membership is that the institution must have treated at least 50 patients admitted for burns. As a result, the participants tend to be large institutions with specialized burn care units. There is no reason to believe that national projections from the participating hospitals would have approximate validity. Indeed, there is no clear method to make such national projections of the incidence of fire injuries.

The NBIE data could be used in investigation of subsidiary questions of importance, such as the relation of burn severity to mortality when good medical treatment is available, and for the medical costs and lengths of stay for severe burns. Also, the data prior to 1973--and for two institutions since then--contain extensive information on the etiology of the injury, which would allow the estimation of such quantities as the percentage of serious burn injuries which are fire related--even for various types of fires. This comprises about 16,000 cases, of which 67.5% were flame burns.

This may represent an approximate adjustment factor for other information on burn injuries. It is still approximate, since one could get a flame burn from a source which would not be classed as accidental fire or which would not be recorded as a fire incident.

In summary, the NBIE data are of little use in obtaining direct national estimates of fire injury incidence. They are of use in investigation of subsidiary burn injury questions. They could aid in compiling a complete fire problem picture for some geographic areas, such as the State of Michigan.

2.5 CPSC/NEISS Emergency Room Records

The U.S. Consumer Product Safety Commission operates the NEISS. This data system collects data on emergency room records from a probability sample of 119 hospitals throughout the U.S. The data are restricted to records of patients treated in hospital emergency rooms--patients admitted directly to a hospital without passing through the emergency room would be omitted. Also, the data are restricted to injuries resulting from accidents which are "product-associated." Excluded from this are products which are not in the purview of the CPSC, such as motor vehicles. Also excluded are industrial accidents. Informal conversations with CPSC officials indicated that the cases coded amounted to about 20% of the emergency room visits. The rest are not in-scope. That is, they are sudden illnesses, motor vehicle trauma, accidents without a consumer product involvement, or injuries for which no consumer product was noted.

In addition to the primary product codes, the variable "second product" has a special code value for "fire involvement." This should make it possible to identify those injuries resulting from fires. If so, then this source would provide nationally representative data on fire-related injuries which were treated in emergency rooms and related to a consumer product. This would not include all fire-related injuries. Some victims are admitted directly to the

hospital without passing through the emergency room. This is particularly true of severely injured patients in areas where there is an Emergency Medical Care System with a direct radio link to the hospital. It is also true in a number of burn centers. It would also miss the minor injuries which are treated by private physicians. It is not clear at this time to what extent residential fires would qualify as "in-scope"--i.e., consumer-product-related. They would appear to be in-scope from the coding manual, but that may not be the case in practice. It is clear that industrial fires or injuries to fire fighters would not be in-scope. The amount of non-coverage due to direct admission has been estimated at about 17% (Branson, Darling, and Branson).*

The NEISS would also fail to account for fatalities which occurred on the scene. The best source of data on fatalities still appears to be the death certificates. In this regard it should be noted that the CPSC has recently begun a study of death certificates which involve accidental deaths. This may be a more intensive study of accidental deaths than is currently available from the NCHS vital statistics.

National estimates based on the NEISS data are presented in Section 3. A discussion of a comparison of NEISS records and hospital admission records from the burn center at Buffalo Emergency Hospital is also presented. This provides additional information about the coverage of fire injuries from the NEISS and the patient records from a hospital.

2.6 Fatalities

The best current source of information on fire deaths seems to be the vital statistics summaries of death certificates provided by the National Center for Health Statistics. The main problem with

*"Methods of Estimating Incidence of Burn Injuries", D.M. Branson, P.H. Darling, and M.H. Branson. University of Rhode Island.

estimates from these death certificates is probably with the completion of the certificates at the local level. This is the basic source of all data quality or lack of it. To the extent that the causes of death and contributing circumstances are accurately reported, the death certificate data will be accurate. If the basic data are not adequately recorded on the death certificates, little can be done to improve the national estimates immediately. It is possible that not all the information relevant to estimating the number of fire deaths may be coded in computer format from the death certificates. In this case, the study of deaths due to accidental causes that the CPSC has begun may improve the estimates of fatalities.

2.7 NAMCS/MAMCS Physician Visits

Data have been collected by the Michigan Ambulatory Medical Care Survey (MAMCS) and the National Ambulatory Medical Care Survey (NAMCS) from May, 1973, to April, 1976. These data may be used to compute burn estimates for the U.S. and for Michigan. Inhalation injuries related to fire are classified the same as those of other origin and thus cannot be estimated separately from other inhalation injuries from these data. There are non-fire-related burns, such as scalds, which may be a significant portion of all burns. The ratio of fire-to non-fire-related burns would be estimated from NBIE data if the ratio is assumed the same for ambulatory care patients as for the least serious cases in NBIE files.

The NAMCS consists of a probability sample of primary statistical units (PSU's) with probability proportional to size. (PSU's are standard metropolitan statistical areas (SMSA's) or counties.) In Michigan additional PSU's were chosen in a manner consistent with the NAMCS and very large PSU's were selected with probability 1--Detroit SMSA, Grand Rapids SMSA, Flint SMSA, Washtenaw SMSA, and Lansing SMSA. Physicians were sampled from the selected PSU's with stratification

on four categories of specialties and proportional allocation among the strata. Each physician was randomly assigned a one-week period during which to collect data. If physicians expected to see more than 50 patients a week, a sample of 50 patients was sought.*

Those physicians who participated in the MAMCS did a thorough and conscientious job. There was very little missing data--less than 2% on each variable except color/race, which had 5% missing. However, of 265 physicians contacted, only 130 participated fully. There are three factors which indicate that the data may underrepresent the true totals:

1. The MAMCS/NAMCS was based on lists of physicians classified by the American Medical Association (AMA) and the American Osteopathic Association (AOA). There are some physicians not on these lists who met the criteria for classification at the time of the survey.

2. The non-participating physicians may be busier than the participants on the average.

3. A few patients may have been left off the Patient Logs, on which the physicians were to include every patient.**

Besides the burn diagnosis there are follow-up and referral variables. Patients who have been previously seen by a physician about a burn can be filtered out. One variable is "admit to hospital" so the overlap between these data and hospital data could be estimated. Other variables which may be relevant are age, sex, race, and seriousness of condition.

Data were coded according to a modification of the H-ICDA codes expanded for this project. Many reasons for visiting a physician

*Cornell, R.G. and T.J. Tomberlin, 1974. The sampling plan for the Michigan Ambulatory Medical Care Survey. Michigan Department of Public Health.

**Cornell, R.G., F.H. Ozgoren, and J.A. Rutherford, 1976. The 1973 Michigan Ambulatory Medical Care Survey. MCHIS Reports, Michigan Department of Public Health.

do not involve illness, so the ICDA codes were not inclusive enough. The coding system used is described in the National Ambulatory Medical Care Survey Sympton Classification.*

Formulas for Michigan estimates and their standard errors are given in the paper by Cornell and Tomberlin.** The NAMCS data for Michigan are part of the MAMCS data, which were collected in a manner consistent with the NAMCS. Thus the formulas for estimation and standard errors for the NAMCS would be similar to those for the MAMCS. Estimates are on a physician basis, rather than a population basis, corresponding to the collection of data as a sample of physicians. This is a different sampling basis than the NCHS (patient records) or the NEISS (hospital emergency rooms).

Since burns comprise only a small subgroup of the total data collected, burn estimates may have unacceptably large standard errors. Few if any ambulatory burn patients go directly to specialists of any kind. Hence it may be reasonable to restrict attention to general or family practitioners. This restriction might reduce the variance of the estimates. There is the general question of how useful burn data are for fire estimates. Burn patients in the MAMCS/NAMCS would be expected to come from fires in which only one person was injured, as victims of more serious fires would likely be taken to hospitals.

2.8 Workman's Compensation: State Data

The workman's compensation records for each state may provide data on the number of injuries from fires of an industrial or commercial nature to individuals in the work force. Efforts to

*The National Ambulatory Medical Care Survey Sympton Classification U.S. Vital and Health Statistics Series 2 No. 63, DHEW Publication No. (HRA) 74-1337. Health Researches Administration, Washington, D.C. U.S. Printing Office, May, 1974.

**Cornell, R.G. and T.J. Tomberlin, 1974. The sampling plan for the Michigan Ambulatory Medical Care Survey. Michigan Department of Public Health.

determine the accessibility of these data for Michigan are underway but have not been successful as yet. The utility of these data will largely be determined by whether the injuries are recorded by cause (i.e., fire) and by diagnosis. The usefulness of these data may be reduced if--as appears to be the case in Michigan, at least--the qualifying types of injuries have changed frequently. It is also likely that the definition of qualifying injuries will vary from state to state. If so, it would be necessary to try to define a common set of injuries for combination. It is probable that some states' data will not be usable or accessible.

The State of Michigan has computerized data on workmen's compensation which include type of injury and cause of injury. Preliminary contacts indicate that these data will be available for use if desired. Further detailed information on the variables recorded and the method of coding will be forthcoming. The data file has the capability of selecting a subgroup of injuries--e.g., those caused by fire--and then obtaining copies of the original reports. Thus it appears that these data may be more useful than originally thought. One drawback is that the data are not current. Data are available for the years 1970-1974 at the present time. No definite date for availability of the 1975 data would be obtained.

2.9 NCHS Health Interview Survey

The Health Interview Survey conducted by the NHCS is a national household interview survey. Respondents are asked about seeking medical aid for whatever reason. Accidental injuries are included. However, injuries resulting from fires have not appeared in published tabulations. These data are presumably available at the NCHS. However, it is likely that injuries resulting from fires are so rare as to not have appeared in the sample with sufficient frequency to give valid estimates.

2.10 Burn Data from the State of Florida

A series of papers presented recently report on data on burn injuries collected from records at 75 of the state's 220 hospitals.*-*** The analytical methods and the data reported in the papers leave much to be desired. However, the authors indicate that some potentially useful data have been collected. These data include both emergency room visits and admissions, facts about the hospitals, demographic variables about the patients, and burn history information--accident location, cause of burn, etc.--as well as medical treatment.

The data are from a retrospective, one-year study. Consequently, it is somewhat questionable how much missing data there is or how accurately some variables were recorded. There is also a prospective study ongoing collecting similar data. It may be useful to ask the authors for the use of their data.

2.11 State Data from NFIRS

The data to be obtained from the several states via the NFIRS will primarily be useful in estimating the incidence of fires. However, the injury reports will be a useful adjunct to the other injury information. In particular, they will be one of the few sources where the injury can be directly related to the fire incident. It is to be expected that not all fire injuries will result from fire

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*Linn, B.S.; Stephenson, S.E., Jr.; Smith, J. "The Assessment of Needs for Burn Care" Report from a Florida Medical Program, Inc. grant. (Contact B.S. Linn, M.D., Associate Chief of Staff for Education, Veterans Administration Hospital, Associate Professor of Survey, University of Miami, School of Medicine, Miami, Florida November, 1976.)

**Linn, B.S.; Stephenson, S.E., Jr; Bergstresser, P.R., and Smith, J. "Are Burn Units the Best Places to Treat Burn Patients?" Presented at Association for Academic Surgery, November 5, 1976, Key Biscayne, Florida.

*** _____ "Do Dollars Spent Relate to Outcomes in Burn Care." presented at Southern Medical Association Meeting, November 9, 1976. (Correspondence to B.S. Linn, M.D., Veterans Administration Hospital, 1201 Northwest 16th Street, Miami, Florida 33125.)

incidents which are reportable through the NFIRS. Further, there may be some under-reporting--particularly of minor injuries during the initial periods of reporting. Comparison of injuries reported through NFIRS with those from hospital or emergency room records will be important to identify the commonality of reporting as well as segments reported only through one source. These comparisons will be difficult, since the NEISS is only aimed at national totals, while the hospital record data from NCHS is national, and four geographical regions, while NFIRS will be for selected states. Comparisons may have to be restricted to certain cities.

The injury data from the NFIRS may be extrapolated to the U.S. in two ways. Each state's total may be expanded to the U.S. by simply using a population expansion factor:

$$\text{National extrapolation} = \text{Number for state} \times \frac{\text{US population}}{\text{States population}}$$

This would be done for each state and the results compared with those from other data and from other states. A second method is to use demographic variables by county or census tract in a model to predict the fire injuries. This estimated model would then be used with the national census data to obtain national estimates. These methods are discussed in more detail in Appendix A.

2.12 Published Estimates

These include the State Fire Marshall's reports and the estimates published by the NFPA. All estimates should be compared and inconsistencies noted. Attempts to resolve or explain inconsistencies in published reports should be made. Some suggested methods are discussed in Section 3.1.

2.13 Estimates of Fire Incidents

There appear to be two primary sources of information--NFIRS and the fire department survey that the NFPA conducts--and one secondary source--State Fire Marshall's reports.

The sample of fire departments utilized by the NFPA to form national estimates is potentially a very sound source. Assuming that a valid probability sample has been selected, there are only three factors which limit the precision and accuracy of the estimates derived from the survey data.

The first is sample size. This is reflected in the estimated standard errors of the estimates. The larger the sample size, the smaller the sampling error. However, since the standard error decreases by a factor of $(n^{-\frac{1}{2}})$, diminishing returns limit the sample size. That is, because of the square root of the sample size, there comes a point beyond which it becomes economically infeasible to increase the sample size. This factor is well known and controlled. The size of the standard error can be calculated.

The second factor is the percent of the fire departments in the sample which do not respond, or which do not supply adequate data. This non-response is always a problem in sample surveys. It introduces a bias into the results--a bias which is unknown. This bias adds to the root mean square error (RMS), which is generally the appropriate formulation of standard error or precision in sampling problems. The RMS is given by $(\text{Variance} + \text{Bias}^2)^{\frac{1}{2}}$. If a proportion, P, of the sample units (fire departments) do not supply data, and the difference on some variable, X, between those units surveyed and those not is Δ, then the bias is equal to P. Note that Δ is unknown, since Δ represents the difference between the values of X observed and the unknown values of X for units which were not observed. Thus the bias is generally unknown. Sometimes it is possible to find a reasonable upper bound for Δ so that the bias can be estimated. Sometimes follow-up efforts can obtain values for some of the units

originally missing, allowing Δ to be estimated. In any event, the smaller the proportion of missing data (p), the smaller the bias.

The third and most serious limitation on the NFPA survey data is the fact that it is a survey of records kept by the fire departments. Thus, it is subject to different record systems. For example, one department may have complete records on each incident, false alarm, fire or whatever, while another may only record fire runs. This also implies that desired detail may be lacking. Further, the survey designer has little control over the quality and accuracy of the original data collected. It may be difficult to assess the quality of data from any given fire department. Thus an additional source of bias is under-reporting or errors in the basic data at the sampled fire departments. It is probably not feasible, but the best interim national estimates would probably be obtained from a national sample of fire departments which were all using standard fire incident reporting forms, had been trained in their use, and which submitted the forms directly to the NFPCA on a regular basis (perhaps weekly). The NFIRS data should be used to validate the data obtained from the NFPA survey sample whenever possible.

The NFIRS data will have the most detail on fire incidents. They also appear to offer the best source of information about such questions as what proportion of fires result in injuries, what the distribution of type of property involved in fires is, what the distribution of type of injuries is. One difficulty is that the NFIRS data contain only incidents reported by fire departments. Thus, these data will not contain cases where an injury resulted from a fire which was not reported to the fire department. Many of the injuries reported through the NEISS may be of this type. Comparison of NEISS and NFIRS data in jointly covered communities will allow this to be estimated.

The NFIRS data are not a national sample. Some method of extrapolation to the nation must be used. (Suggested methods are

discussed in Appendix A.) For certain classes of fire incidents or injuries independent national estimates may be available. Examples of this are consumer product-associated fire injuries and automotive fire injuries. The degree of correspondence between the national extrapolation from the NFIRS for these cases and the other national estimates will provide a possible measure of the adequacy of the extrapolation. It may also suggest which method of extrapolating is preferred.

The State Fire Marshall's Reports provide summary statistics of varying accuracy for a subset of the states. To the extent that the modeling approach to extrapolation permits making state estimates, these can be cross-validated with the Fire Marshall's reports. The State Fire Marshall's reports can be cross-checked directly for the states from which NFIRS data are available. If the Fire Marshall's reports are done independently this would give some idea of the accuracy. If the Fire Marshall's reports use the NFIRS data, then comparison with previous year's reports--prior to NFIRS--will allow estimation of the effect of the introduction of NFIRS and consequently of the accuracy of the reports without NFIRS.

2.14 Transportation Fires

Fires involving people and goods in transit continue to be significant portion of the total problem of fire. Since transportation encompasses a vast array of transportation modes and transportation vehicles, it is most difficult to acquire these data relating to fires and fire injuries so that they are comparable, or meaningful when examined in total. Use of combustible fuels in transportation vehicles has contributed extensively to the potential for fire, as well as escalating the severity of fires when they do occur.

Flammable or hazardous materials in transit are also a major source of fire. The potential for creating "fire incidents" is

further compounded by modern, complex transit arrangements. Ship cargo may be transferred to motor carrier, which is then "piggybacked" by rail. This increases the handling of these materials which in turn increases the potential for an accident which could result in fire.

Marine accidents involving fire come within the domain of the U.S. Coast Guard. Large or catastrophic accidents with fire are reported in detail with accuracy. However, where such incidents do not involve any injury, or only minor injury, the data become sparse. This is particularly true where small commercial or pleasure boat accidents are involved. To acquire the necessary data to adequately describe the problem of marine fire, it is recommended that the NFPCA work directly with the U.S. Coast Guard so as to evolve a data system more representative of marine fires.

Data on fires involving railroads and rail-related fires are kept by the Federal Railroad Administration. In publications by the FRA, fire and its related effects are noted by codes 5863-5880. This information appears to be accurate and accessible. But it also seems to be somewhat limited. The latest report which includes such was published in 1972.*

The problem of railroad fires is intertwined with the problem of transporting hazardous materials. Here, the Department of Transportation's Office of Hazardous Materials is building a data system for receipt, storage, and convenient accessing of data concerning flammable and/or explosive materials in accidents. It is recommended that the NFPCA develop a system for accurate reporting and recording of fire incidents and fire injuries in conjunction with the FRA and Office of Hazardous Materials.

Aviation fires and fire-related injuries are available within publications of the FAA. These appear

*Accidents Bulletin No. 141, Federal Railroad Administration, Department of Transportation, Washington, D.C., 1972.

to be complete and accurate, and are perhaps the most reliable data available within the broad category of transportation fires. These data, however, may not include fires which occur within airports or in hangars, which would normally be reported through more conventional professional fire fighter organizations. While data relating fire incidents in aviation appear adequate, it is recommended that the NFPCA further assess the completeness of their data directly with the FAA.

Motor vehicle fires and fire-related injuries are perhaps the one area in transportation fires with sparse and seemingly inconsistent data. No planned or established data system exists which accurately represents this problem. Attention has been focussed on the problem of motor vehicle crash fires by the media and by consumer advocacy groups in recent years. This has resulted in a strengthening of the vehicle safety standard* dealing with fuel systems.

Fires in motor vehicle accidents are estimated to occur in about 17,000 accidents each year, which account for about 500 deaths resulting directly from the fire.** This represents from 1% to 1.5% of all vehicle traffic accident deaths. Deaths which occur in accidents which are accompanied by fire, or where fire may not be directly related to death, amount to about 1000 annually, and represent between 1.7% and 2.8% of our annual toll of vehicle crash deaths.

These totals are much smaller than were commonly accepted*** prior to the Cooley study. While the Cooley study did dimension the

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*Federal Motor Vehicle Safety Standard #301, "Fuel System Integrity", as amended by NHTSA published notice on April 16, 1975 to be effective September 1, 1975.

**"Fire in Motor Vehicle Accidents," Peter Cooley, University of Michigan, Highway Safety Research Institute, Report UM-HSRI-SA-74-3, April, 1974.

***Previous motor vehicle crash fatality experiences was believed to account for about 3500 deaths annually.

problem more accurately, it nevertheless is believed to represent conservative estimates of fire and fire deaths and injuries in motor vehicle crashes.

Some states have begun to include fire in their statewide accident reporting form so that estimates can be made based on mass accident reporting data. These have been initiated relatively recently and it will be some time before these data can be analyzed in terms of their appropriateness to national estimates.

Motor vehicle fires which are not the result of a crash represent a sizable portion of all motor vehicle fires. Data which include non-crash fires are difficult to obtain. Other than the conventional fire fighter system of responding to such fires and completing and filing fire incident reports,* little data are available. One area which appears to be most productive in assessing the problem of non-crash fires is through studying insurance claims data. One such study,** a study to determine vehicle defects from insurance claims data, has indicated that the problem of non-crash vehicle fires to be the largest vehicle defects category observed. Insurance claims data requires the cooperation of insurance corporations. Such cooperation is often difficult to obtain when there is a conflict, real or apparent, with their need to keep such data confidential for reasons of competition. Regardless of such obstacles, insurance claims data appear as the best source of non-crash vehicle fires and fire injuries.

The Bureau of Motor Carrier Safety requires that interstate commercial carriers report on accidents in which there is death or injury, or where total damage to all property involved in the accident amounts to an aggregate total of $2,000 or more. BMCS data are

*Which often contains little information other than that a fire occurred.

**Conducted by the American Automotive Association of Southern California and sponsored by the NHTSA Office of Vehicle Defects.

informative, but do not accurately portray the problem of commercial carrier vehicle fire and fire injury. Only interstate, or regulated, organizations are required to comply with the accident reporting requirement. They represent only a part of all commercial carrier organizations, and tend to be well-operated companies with consistent and established policies where safety is involved.

It seems likely that an effective statewide police reporting system for accidents involving all vehicles and specifically noting the presence or absence of fire in the accident will be the best method of acquiring data on fires and fire injuries associated with motor vehicle crashes. Non-crash car fires can only be identified through fire department records as in NFIRS. Some method of identifying whether a fire associated with a crash has been responded to by a fire department is necessary to avoid double counting of crash fires if both police and fire department records are to be used. A simple way to accomplish this would be to have a box on the accident reporting form to check if the fire department had been summoned.

The NTSB is one governmental organization which is concerned with all transportation accidents. NTSB has the responsibility of investigating causes of such accidents. But to investigate all such accidents is an impossible task. They have tended to concentrate their efforts on the more spectacular and catastrophic accidents with high public interest. The NTSB serves an important function in bringing attention to accidents where a study of their causal factors indicates needed changes to our transportation system. It cannot serve as a source of accurate and complete data regarding fire incidence experience in transportation.

In summary, data relating to fire incidents in transportation is spotty and spread among various organizations. These data are difficult to interpret and exist with varying degrees of confidence as

to their origin, accuracy, and completeness. Most organizations, such as FAA, FRA, NTSB, etc., tend to regard their accident data with fire included in varying degrees of completeness and importance.

Transportation fires is a most difficult area for the NFPCA, but one where better data can be obtained through working closely with the various organizations where such information resides, and working for changes in data reporting and handling within these organizations.

3. NATIONAL ESTIMATES BASED ON NEISS DATA

The NEISS data system is one source of national estimates of fire-related deaths and injuries. NEISS data are restricted to consumer-product-related emergency room visits. However, because "Home Structure" is considered to be a consumer product, the major types of emergency room fire injuries not included in the NEISS data apparently are industrial, fire fighter, and motor vehicle fire injuries.* Injuries with death occurring at the scene, or not treated in a hospital, or with direct admission to a hospital, would not be included in NEISS, since these persons are not treated in an emergency room. Thus when used for overall national estimates, NEISS will of course underestimate. As an example of this, consider that there were 46 deaths from accidents involving consumer products and fires during the period January, 1975, through June, 1976, reported in the NEISS data. Using the sampling weights for the hospitals in which these deaths occurred results in an estimated 865 fire-associated accidental deaths, of which an estimated 600 occurred during calendar 1975. This is clearly a gross underestimation of the number of fire-associated deaths. Further, a death estimate from NEISS appears to be unreliable, as examination of the data suggests reporting differences among the hospitals on deaths.

3.1 Fire-Related Deaths and Injuries

The national estimates for product-related emergency room visits with fire involvement is given in Table 3-1 for the period January,

*Analysis of the data makes it appear likely that most residence fires are not included in the NEISS. "Home Structure" is a general code used when no more specific product is available--not implying the intent to code all residential fires.

TABLE 3-1. NATIONAL ESTIMATES FROM NEISS FIRE RELATED EMERGENCY ROOM VISITS

	Fire Related	Thermal Burns
1975	28,425 (321.3)*	112,525 (1103.8)
First 6 months	13,010 (179.6)	53,538 (552.9)
Jan	1,789 (39.4)	6,090 (74.9)
Feb	2,118 (60.3)	7,031 (98.4)
Mar	1,728 (32.5)	9,157 (131.5)
Apr	2,101 (42.0)	8,165 (104.7)
May	2,343 (48.6)	9,561 (118.8)
Jun	2,931 (60.8)	13,534 (201.0)
Last 6 months	15,415 (172.6)	58,987 (603.7)
Jul	3,111 (63.8)	14,131 (214.5)
Aug	2,610 (44.2)	10,384 (133.1)
Sep	1,976 (34.6)	7,825 (86.3)
Oct	2,641 (41.4)	8,190 (103.8)
Nov	2,680 (53.4)	7,998 (105.0)
Dec	2,396 (44.7)	10,459 (175.0)
1976		
First 6 months	20,245 (251.7)	60,660 (601.7)
Jan	3,275 (52.6)	9,716 (125.2)
Feb	4,152 (108.4)	8,406 (129.8)
Mar	2,508 (38.0)	8,485 (103.1)
Apr	2,770 (58.0)	9,454 (128.2)
May	3,610 (56.8)	11,657 (130.3)
Jun	3,930 (74.9)	12,943 (169.3)

*The number in parentheses is in each case the standard error associated with the given estimate.

1975, to June, 1976. For comparison purposes a column for the diagnosis category thermal burn is also given. The two categories should have roughly comparable numbers, because thermal burn includes all flame and hot solid injuries, whereas fire-related should include all flame burns and fire-associated injuries. The fact that the estimates for fire-related injuries are one-fourth to one-third that of the estimates for thermal burn injuries suggests that the category fire involvement is under-reported in NEISS.

The data in Table 3-1 show an increase in the estimated number of fire-related injuries and thermal burns in the first six months of 1976 as compared to the first six months of 1975. The increase is particularly noticeable among the fire-related injuries, where 1.55 times as many were reported in the first six months of 1976 as in the first six months of 1975. Among thermal burns, 1.13 times as many were reported in the first six months of 1976 as in the first six months of 1975. This suggests that more attention is being paid to the determination of whether an injury was fire-related than previously. On the other hand, the increasing trend in thermal burns in the data does not have an apparent explanation. It may represent a national increase in this type of injury, or it may reflect changes in the reporting instructions and practices among the NEISS hospitals.

National estimates of the disposition of fire-related and thermal burns emergency room visits are given in Table 3-2. If thermal burn is used as a surrogate for fire-related injury, as seems to be the best interim procedure with currently existing data, Table 3-2 can give some information about the relation between injuries of two severities: "hospitalized" and "treated and released."

Among thermal burns, 91% of the cases were treated and released. That is, 10.1 times as many persons did not require hospitalization as did. Using this figure, one could estimate that about 10 times as many minor injuries occur as those requiring hospitalization. Among the cases with fire-related noted, 76% of the cases were released; thus the number released was about three times the number hospitalized.

TABLE 3-2. NATIONAL ESTIMATES FROM NEISS

Disposition of Fire-Related Emergency Room Visits

	1975		1976 First Six Months	
Disposition	Fire-Related	Thermal Burns	Fire-Related	Thermal Burns
Released	21,072 (222.8)*	103,239 (991.0)	15,700 (203.7)	55,149 (545.4)
Transferred	812 (28.7)	1,141 (31.8)	787 (29.7)	819 (31.4)
Died in E.R.	600 (34.8)	239 (15.6)	265 (12.3)	197 (11.8)
Total Not Admitted	22,484 (246.0)	104,619 (995.0)	16,752 (218.1)	56,165 (553.8)
Admitted	5,896 (133.9)	7,846 (179.6)	3,474 (73.0)	4,432 (92.7)
Disposition Unknown	45 (3.0)	61 (2.7)	20 (1.3)	63 (3.0)
Total	28,425 (321.3)	112,526 (1103.8)	20,246 (251.7)	60,660 (601.7)

*The number in parentheses is in each case the standard error associated with the given estimate.

3.2 Burn Injuries

Table 3-3 presents NEISS national estimates of the number of burn injuries resulting in emergency room visits and the number of burn hospital admissions entering through the hospital emergency room. For comparison purposes, CPHA and NCHS estimates of hospitalized burn injuries are also presented. The NEISS estimate of the number of burn admissions entering through the emergency room is about 17% of the CPHA estimate of the number of hospital admissions with burn injury as the primary diagnosis. Although no definitive national figures are available, the NEISS estimate of hospitalizations for burn appears to be too low by roughly a factor of five. A recent study in Rhode Island* reported that 83% of hospital admissions with the primary diagnosis of burn injury were admitted through the hospital emergency room. Even with this correction factor, the NEISS estimate is only about 20% of the CPHA or NCHS estimate of hospitalizations for burns.

A possible explanation for the discrepancy is that the NEISS codes only about 20% of hospital emergency room visits. The remaining 80% are not coded because they are not "in-scope." An emergency room visit is "in-scope" if the injury is associated with an accident involving a consumer product over which the CPSC has jurisdiction. Thus, even though the CPSC codebook for the NEISS includes various home structures, it seems likely that most of the fires are not directly associated with a consumer product and are, therefore, not coded.

Table 3-4 shows the NEISS estimates separately for diagnosis category among the fire-associated emergency room visits and also the separate diagnoses among all burns and anoxia. From this some

*Branson, D.M., P.H. Darling, M.H. Branson. "Methods of Estimating Incidence of Burn Injuries," presented at the American Statistical Association, August 25, 1976, Boston, Massachusetts.

TABLE 3-3. NATIONAL ESTIMATES OF BURN INJURIES*

	Source							
	CPHA (1975)		NCHS (1972)		NCHS (1971)			
Region	Total	Rate	Total	Rate	Total	Rate	NEISS (1975)	NEISS (1975)
Northeast	15,000	3.0	17,000	3.5	18,000	3.7	E.R. visits	E.R. Visits Resulting in Hospital Admission
North Central	22,000	3.9	26,000	4.6	23,000	4.0	---	---
South	29,000	4.7	37,000	5.8	31,000	4.9	---	---
West	13,000	3.7	12,000	3.5	15,000	4.2	---	---
Total	79,000	3.9	93,000	.5	86,000	4.3	267,082	13,378
	±2500		±6400		±6100		±4758	±454
Range**	79,000 to 144,000		93,000 to 117,000					

*Number of Patients by First Listed Diagnosis. Rates are number of discharges per 10,000 population.

Sources: Hospital Record Study CPHA and IMS, America Ltd.
Inpatient Utilization of Short-Stay Hospitals by Diagnosis National Center for Health Statistics

**The range is on the number of distinct patients. The upper limit is the estimates total number of burn diagnosis. Some of these may represent duplicate diagnoses for the same patients.

TABLE 3-4. NATIONAL ESTIMATES FROM NEISS

Fire Related Injuries by Diagnosis

	1975		1976-First Six Months	
Diagnosis	Fire Related	Burn & Anoxia	Fire Related	Burn & Anoxia
Unspecified Burn	461 (1.6%)	18,341 (6.7%)	404 (2.0%)	6,919 (5.1%)
Scald Burn	454 (1.6%)	94,778 (34.5)	119 (.6%)	47,198 (34.5%)
Chemical Burn	722 (2.5%)	41,438 (15.1%)	155 (.8%)	17,197 (12.6%)
Thermal Burn	22,498 (79.1%)	112,525 (41.0%)	17,263 (85.3%)	60,660 (44.4%)
All Burns	24,136 (84.9%)	267,082 (97.2%)	17,941 (88.6%)	131,974 (96.6%)
Anoxia	2,361 (8.3%)	7,694 (2.8%)	1,651 (8.2%)	4,675 (3.4%)
Amputation	239 (.8%)		0 (0.0%)	
Contusion/ Abrasion	202 (.7%)		141 (.7%)	
Fracture	128 (.5%)		65 (.3%)	
Laceration	805 (2.8%)		194 (1.0%)	
Strain or Sprain	92 (.3%)		25 (.1%)	
Poisoning	143 (.5%)		145 (.7%)	
Other	127 (.4%)		85 (.4%)	
All Non-Burns	4,106 (14.4%)		2,305 (11.4%)	
Diagnosis Unknown	184 (.6%)		0 (0.0%)	
Total	28,425 (100%)	274,776 (100%)	20,246 (100%)	136,649 (100%)

information about the use of burns or thermal burns as a surrogate for fire injury can be obtained. From the table, one can see that 82% of fire-related injuries are thermal burns, while 86% of those injuries are burns of some sort. On the other hand, thermal burns make up 43% of all burns. (These figures are from the combined data for 18 months.)

Many burns are not fire-related, at least according to the NEISS data. Only 10.5% of all burns were reported to be fire-related. Twenty-three percent of thermal burns were reported to be fire-related. The percentage of fire-related injuries among diagnosis of anoxia is even lower: 3.4%. From these data, the diagnosis of thermal burn is the best surrogate for fire-injury, but is subject to considerable error. It seems likely that the fire-related variable is under-reported in the data set, but there is no verification of this.

Table 3-5 gives a tabulation of the NEISS estimates of the number of burn, anoxia, and fire-related deaths. There is a severe underestimation of the number of such deaths, but the proportions of diagnosis may be reliable. The underestimation of deaths in the NEISS is easily understood, particularly for fire-related accidents. Many deaths occur at the scene and consequently would not reach the emergency room. Further, a seriously injured victim would be hospitalized. If he were to die, the NEISS data would not show his death unless it occurred in the emergency room. (It appears likely that one institution in the sample follows all patients and updates their record if they die, since this institution reported about a quarter of the deaths from the whole sample of 119 institutions.)

3.3 Discussion

Several questions have been raised regarding the extent that fire-related injuries, hospitalized burn or fire-related injuries, and fire-related deaths are represented in the NEISS. In the case of hospitalized burn injuries, one facet of this question has been investigated by comparing data from hospitals in both the NEISS and NBIE data bases.

TABLE 3-5. NATIONAL ESTIMATES OF DEATHS BY DIAGNOSIS (NEISS DATA)*

	1975				Jan-Jun, 1976			
	Fire-Related		Burns & Anoxia		Fire-Related		Burns & Anoxia	
Unspecified Burns	1.5%	9(0.8)	1.5%	9(0.8)	3.0%	8(0.7)	2.2%	8(0.7)
Scald Burns	0		0		0		0	
Chemical Burns	0		0		0		0	
Thermal Burns	38.2%	229(15.6)	40.7%	239(15.6)	70.9%	188(11.8)	53.1%	197(11.8)
All Burns	39.7%	238(15.6)	42.2%	248(15.6)	74.0%	196(11.9)	55.3%	205(11.9)
Anoxia	30.0%	180(7.7)	57.8%	339(14.7)	26.0%	69(3.6)	44.7%	166(8.8)
Diagnosis Unknown	30.3%	182(7.8)	---		0		---	
Total		600(34.8)		587(26.0)		265(12.3)		371(14.7)

*The figures in parentheses are the standard errors.

Three hospitals have an emergency room in NEISS and a burn unit in NBIE: Buffalo Emergency, Buffalo, N.Y.; Cook County, Chicago, ILL.; University of Texas, Parkland, TEX. For these three institutions over the years 1974 and 1975, hospitalized burn cases in the NEISS data were compared with NBIE cases to obtain matches.

Matching was done initially on age, sex, and month of burn. If duplicate matches then occurred, the competing cases were further matched on day of burn and severity of burn so that only one match resulted.

For Cook County in 1974 and 1975 and for Parkland in 1974 no NEISS burn cases were recorded as hospitalized, thus no matches were possible. For Parkland 1975 and Buffalo 1974, 1975, Table 3-6 gives the matches which resulted.

Although only one match was made for Parkland in 1975 this is probably due to the fact that only 31 of the actual 381 burn unit admissions are currently in NBIE records. (If we assume that all 17 NEISS cases actually went to the burn unit, the chance of one or fewer matches with the 31 NBIE cases is .60.) The number of matches for Buffalo is consistent with the hypothesis that all the NEISS cases were admitted in the burn unit. Altogether, we clearly have a wide variation in reporting practice among the three hospitals. A reasonable conclusion is that for Cook and Parkland, burn admissions are not recorded in NEISS even if initially treated in the emergency room, whereas for Buffalo all burn unit admissions pass through the emergency room and are recorded in NEISS.

An analysis of the uniformity of recording by NEISS hospitals of fire-related and hospitalized cases is presented in Tables 3-7 and 3-8. For the 119 NEISS hospitals, 25.2% of all thermal burn and anoxia cases were coded as fire-related. However, among the individual hospitals the proportion of thermal burn and anoxia cases coded as fire-related ranged from zero percent to 60%. The statistical test of the hypothesis that the fire-related proportion is the same among all the hospitals

TABLE 3-6. COMPARISON OF NEISS AND NBIE HOSPITALIZED BURN CASES

	Parkland	Buffalo Emergency	
	1975	1974	1975
NEISS	17	72	42
NBIE	31 (381*)	127 (142)	88 (129)
Matches	1	55	26

*The number in parenthesis is the actual number of admissions to the given burn ward for the year. For example, 31 cases had been received by the NBIE for Parkland 1975 out of 381 actual burn unit admissions at the time this study was done.

TABLE 3-7. NEISS HOSPITALS 1975

Percent of Thermal Burns and Anoxia Coded as Fire-Related

Range of Percents	Hospitals
0	17 (14.5%)
.1-10.0	18 (15.4%)
10.1-20.0	32 (27.4%)
20.1-30.0	25 (21.4%)
30.1-40.0	16 (13.7%)
40.1-60.0	9 (7.7%)
Total	117* (100%)

All hospitals - 25.2%

*This total excludes two hospitals that had no thermal burn or anoxia NEISS cases in 1975.

TABLE 3-8. NEISS HOSPITALS 1975

Percent of Burn and Anoxia Cases Admitted

Range of Percents	Hospitals
0	36 (30.3%)
.1-2.5	18 (15.1%)
2.6-5.0	26 (21.8%)
5.1-7.5	13 (10.9%)
7.6-10.0	14 (11.8%)
10.1-22.8	12 (10.1%)
Total	119 (100%)

All hospitals - 6.3%

rejects the hypothesis of uniformity, with P less than 0.0001 (X^2 = 510, 116 df.).

Similarly, overall, 6.3% of the NEISS burn and anoxia cases result in hospitalization, while the percent admitted varies among the individual hospitals from zero to 22.8%. This variation is significant; $P < 0.0001$, (X^2 = 817, 118 df.). It is clear that fire-related and hospitalized injuries are not uniformly and reliably reported in the NEISS.

In summary, the overall conclusion is that NEISS data seriously underestimate the number of deaths, fire-related injuries, and hospitalized cases. In part this is due to non-uniform reporting practices among the institutions in the sample. A larger reason, however, is probably that only about 20% of emergency room visits are reported to the system. The deaths will be seriously under-reported by any system keying on emergency room records, even if later deaths in a hospital are noted. The reason for this is that many deaths occur at the scene. Fire-involvement seems particularly inconsistently reported in the NEISS. Consequently, the surrogate thermal burn injury seems preferable.

4. INJURY DATA FROM MICHIGAN FIRE INCIDENTS

The State Fire Marshall for Michigan supplied HSRI with a data tape containing the fire incident and casuality reports for 18 months (January, 1975 to June, 1976) for the State of Michigan. These data are similar to data collected from other states as part of the NFIRS. The casuality information analyzed here represents data on injuries which occurred in connection with fire incidents for which the fire department was called. Thus, these data should include information on all injuries resulting from fire incidents--where the definition of a fire incident is that there was a fire and the fire department was notified. Injuries from fires which are not reported obviously are not covered. Injuries to fire service personnel are separated into fire and non-fire incidents. The number of fatalities was under-reported, since persons who are seriously injured in a fire and die as a result of these injuries sometime later are not coded as fatalities.

The quality of the data in the computerized file of Michigan fire incidents and casualties could be improved. It is perhaps typical of computer data from state files. About 10% of the cases seem to have some miscoded or missing data, although this varies considerably with the variable. Some variables, for example, "activity at time of injury" or "conditions preventing escape," were not coded during 1975. There are a number of miscodings apparently caused by the proximity on the form of "number of personnel used at scene" and "number of casualities." These are difficult to identify. Other types of miscodings which are apparent are the "property type" code being entered as the "number of civilian casualties." The data quality could be improved considerably with careful editing of the forms before keypunching and computerizing. Also, checking of the computer file to ensure that data from one line

of the form was not incorrectly punched on the succeeding line would eliminate some of the mistakes. With these sort of quality control procedures, the missing and incorrect data could be reduced to a few percent.

There are some discrepancies between the number of casualities listed on the fire incident reports and the number for which casuality reports have been submitted. The detailed information about the injury--e.g., age, type of injury, activity at time of injury--are only available from the casuälty reports. The type of property and source of ignition are available from the incident reports. Thus, Tables 4-1 through 4-6 are based on the data reported in the casualty reports, while Tables 4-7 and later are based on the fire incident reports.

Casualty reports are received for about 75% of the cases listed in the incident file. For fire service injuries, the proportion is about 72%. Approximately 80% of the civilian deaths reported in the incident file have casualty reports, while the number of civilian deaths in the fire incident file appears to be only about 70% of the actual number of deaths. In part this last discrepancy is caused by deaths which occur late not being updated in the computer file. The computer file for fire service deaths had more errors than actual deaths in it, so was of no use.

With these restrictions, the data may be used to estimate relationships among types of injury by type of treatment which can be used as adjustment factors to national data on hospitalization records or emergency room records. Unfortunately the data only specify whether an injured person was transported to a hospital or to some other medical facility. It is not possible to separate persons who were seen in the hospital emergency room and treated and released from those who were actually admitted to the hospital.

Among the 1,163 injuries (including deaths) to civilians in 1975, for which a casualty report was coded, 686 or 59.0% were burns. Thus, burns comprise about three-fifths of the fire injuries to civilians. Among persons taken to hospitals, burns accounted for 82% of the injuries, while burns were 65% of injuries given first aid on scene, or

TABLE 4-1. DISTRIBUTION OF CIVILIAN FIRE INJURIES PERCENT BY NATURE AND SOURCE OF TREATMENT (MICHIGAN 1975)

Source of Medical Treatment	Nature of Injuries						
	Burns	Asphxia	Laceration	Dislocation & Fracture	Strains, Sprains & Complaint of Pain	Other	Total
Taken to Hospital	43.8	18.6	6.7	0.7	1.4	4.1	75.3
First Aid on Scene	5.3	1.9	0.9	0	0	0.4	8.5
Other Medical Treatment	7.5	1.1	1.9	0.1	0.4	1.0	12.0
Refused	3.1	0.3	0.2	0	0	.1	3.7
Total	59.7	21.9	9.7	0.8	1.8	5.6	99.5
Missing Data							0.5

TABLE 4-2. FIRE DEATHS BY NATURE OF INJURY AND YEAR

	Nature of Injury								
	Burns & Asphyxia	Burns	Asphyxia	Laceration	Dislocation & Fracture	Shock	Other	Missing	Total
1975	54.0	6.9	23.6	0.6	0.6	0.0	8.6	5.7	173
Jan-June 1976	51.9	11.1	18.5	0	0	1.2	7.4	9.9	81
%	53.5	8.3	22.0	0.4	0.4	0.4	8.3	7.1	
N	136	21	56	1	1	1	21	18	255

TABLE 4-3. FIRE SERVICE INJURIES BY NATURE OF INJURIES

Nature of Injury	1975 N	1975 %	January-June 1976 N	January-June 1976 %	Total %
Burns & Asphyxia	37	3.1	10	1.4	2.4
Burns Only	207	17.4	95	13.4	15.4
Asphyxia Only	156	13.1	67	9.4	11.4
Lacerations	291	24.5	170	23.9	23.6
Dislocation & Fracture	24	2.0	15	2.1	2.0
Complaint of Pain	155	13.1	126	17.7	14.4
Shock	6	0.5	2	0.3	0.4
Strain or Sprain	157	13.2	135	14.0	14.9
Other	154	13.0	90	12.7	12.5
Total	1187	99.9	710	99.9	
Missing	37		21		3.0

seeking their own medical aid. Burns were less than half (48%) of the injuries which refused treatment or for which no treatment was recorded. Seventy-three percent of the persons receiving burn injuries from fires were taken to hospitals. Table 4-1 gives the distribution of injuries by type of medical treatment and type of injury.

There were 174 reported fatalities in Michigan in 1975 from fires, and 81 reported in the first six months of 1976. Of the total 255 fatalities, 53.5% were due to burns and asphyxia, an additional 8.3% were due to burns alone, and 22.0% were due to asphyxia alone. Table 4-2 gives the distribution of the deaths by year and nature of injury.

The injuries which occurred to fire service personnel tended to be of a somewhat different nature than those to civilians. A table of their distribution is given in Table 4-3. Burns (with or without asphyxia) accounted for only 18.4% of such injuries, combining the data for all 18 months. Lacerations accounted for nearly a quarter (24.3%) of the injuries, while strains and sprains accounted for 15.4%, and asphyxia accounted for 11.8%. The somewhat nebulous category "complaint of pain," accounted for 14.8% of the service injuries. Thus, burns and asphyxia combined accounted for only 30.2% of the injuries, compared to 53.5% among the civilian injuries.

Among the civilians, 69% of the persons injured were males, while among the service personnel, 98.4% of the injuries occurred to men. Table 4-4 gives the age and sex distribution of the civilian injuries and deaths for the two time periods. Males are consistently about two-thirds of the injuries and deaths. However, the age distribution is somewhat different for injuries than for deaths. Children under ten account for only about 10% of the injuries, but for about 20% of the deaths. Similarly, persons over 60 account for less than 5% of the injuries, but for more than 10% of the deaths. Persons aged 21 to 50 comprise a larger proportion of the injuries than they do of the deaths. Thus, fires and the resulting injuries are most dangerous to the young and the old.

Table 4-5 gives the distribution of the injuries and deaths for civilian casualties by condition of the individual prior to the injury.

About two-thirds of the persons injured were awake and unimpaired at the time of the injury, and a quarter were asleep. About 3% were reported to be impaired by drugs or (primarily) alcohol at the time of their injury. A quite different pattern is noted among the deaths. Forty-five percent of the persons killed were asleep, emphasizing the danger of fires which occur while persons are sleeping. Slightly over a quarter (27.8%) of the persons fatally injured in fires were awake and unimpaired. Relatively one-third as many (9.1%) were impaired by drugs or alcohol. Children too young to act (8.6% of the fatalities) and elderly persons (3.2% of fatalities) and persons with handicaps (4.8% of fatalities) were other classes notably higher among the fatalities than among the injuries in general. Again, this emphasizes the danger fires pose to persons with reduced capacity to act to escape.

Table 4-6 shows the time of day when the injuries happened. If injuries occurred uniformly, about 4.2% of them would happen during each of the 24 hours in a day. As can be seen in the table, injuries are faily uniformly distributed by time of day. However, fatalities occur much more frequently during the nighttime hours, when most people are asleep. For example, 55.3% of the fatalities occurred between 11 p.m. and 7 a.m., while only 29.3% of the injuries occurred during this time period.

Table 4-7 gives the distribution of civilian injuries by structure type and cause of fire. This table is based on 18 months of data from Michigan. Many of the cells are very small, so that the marginal percents may not always be obtained from the cell totals because of rounding errors. All entries are correct to one-tenth of a percent.

From Table 4.7 it is evident that nearly 60% of all civilian injuries occur in residential fires. The cause of ignition fires leading to civilian injuries is most often cooking, followed by smoking, and heating. A total 2,065 injuries to civilians were reported in the fire incident report, while the file contains only 1,547 civilian casuality reports. Thus, if the injury counts derived from the fire incident reports are accurate, casualty reports are completed on only 74.9% of the civilian injuries. There were some obvious coding errors in the

TABLE 4-4. AGE AND SEX DISTRIBUTION OF CIVILIAN FIRE INJURIES AND DEATHS IN MICHIGAN

Sex	Age 0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	Total
				Injuries in 1975					
Male	6.8	14.4	19.3	11.4	9.0	6.4	2.3	0.2	69.8%
Female	4.0	5.5	9.0	5.0	2.3	2.7	1.5	0.3	30.2
	10.8	19.9	28.3	16.4	11.2	9.1	3.8	0.5	
				Injuries, January-June, 1976					
Male	6.3	17.5	19.6	11.4	9.0	6.0	1.8	0.6	72.3
Female	1.8	5.7	5.4	5.1	4.2	3.3	1.5	0.6	27.7
	8.1	23.2	25.0	16.6	13.3	9.3	3.3	1.2	
				Deaths, 1975					
Male	9.8	13.9	15.6	8.2	5.7	6.6	5.7	2.5	68.0
Female	10.7	4.1	4.9	2.5	2.5	5.7	1.6	0	32.0
	20.5	18.0	20.5	10.7	8.2	12.3	7.4	2.5	
				Deaths, January-June, 1976					
Male	13.2	9.4	13.2	9.4	5.7	3.8	9.4	5.7	69.8
Female	9.4	7.5	1.9	3.8	1.9	0	5.7	0	30.2
	22.6	17.0	15.1	13.2	7.5	3.8	15.1	5.7	

TABLE 4-5. CONDITION BEFORE INJURY (CIVILIANS)

	Awake & Unimpaired	Asleep	Impaired by Drugs or Alcohol	Too Young to Act	Too Old to Act	Physical or Mental Handicap	Other	N
1975								
Injuries	66.5%	24.9%	2.6%	1.2%	0.4%	1.6%	2.8%	925
Deaths	26.0	42.7	9.2	10.7	4.6	4.6	2.2	131
Total	61.5%	27.1%	3.4%	2.4%	0.9%	1.9%	2.8%	1056
Injuries	66.7%	24.0%	3.9%	1.7%	0.6%	1.6%	1.5%	516
Deaths	32.1	50.0	8.9	3.6	0	5.4	0	56
Total	63.3%	26.6%	4.4%	1.9%	0.5%	2.1%	1.2%	572
All Injuries	66.6%	24.6%	3.1%	1.4%	0.5%	1.6%	2.2%	1441
All Deaths	27.8	44.9	9.1	8.6	3.2	4.8	1.6	187

TABLE 4-6. INJURIES BY TIME OF DAY (1975)

Time	Civilian Injuries (%)	Civilian Deaths (%)	Service Injuries (%)	Service Deaths (%)
Midnight to 1 am	6.2	9.8	6.2	23.8
1-2	3.0	5.2	4.6	0
2-3	2.3	8.0	5.5	0
3-4	3.3	8.6	4.7	4.8
4-5	4.3	4.6	5.6	0
5-6	2.6	5.2	3.5	0
6-7	2.0	2.3	2.0	9.5
7-8	3.5	5.7	2.1	0
8-9	3.1	4.0	2.8	9.5
9-10	4.9	3.4	3.1	4.8
10-11	3.7	7.5	3.0	4.8
11-12 noon	4.2	2.9	2.9	0
Noon-1 pm	3.9	1.7	2.9	4.8
1-2	4.1	1.1	5.1	0
2-3	6.5	3.4	4.2	0
3-4	6.1	1.1	3.0	0
4-5	5.9	2.3	4.0	4.8
5-6	4.4	2.9	4.2	0
6-7	6.2	4.0	4.2	0
7-8	3.5	1.7	5.0	0
8-9	4.0	1.1	4.5	4.8
9-10	4.0	1.1	4.3	4.8
10-11	3.5	0.6	5.0	14.3
11-Midnight	4.3	10.9	6.6	9.5
N	989	174	1224	21

civilian injury counts derived from the incident reports, which were corrected. However, there remains the likelihood that the count derived from the incident reports is slightly too high.

Of the injuries from residential fires, 845 or 68.4% were one- or two-family dwellings. Apartment fires accounted for 285 or 23.1% of the injuries, while mobile homes accounted for 60 or 4.9% of the injuries. Hotels, motels, dormitories, and other residences accounted for 21, 4, 4, and 16 injuries or 1.7%, 0.3%, 0.3%, and 1.3%, respectively. Among residential fire injuries, smoking was the primary cause of the fire, accounting for 20.8% of the fires. This was followed by cooking (15%) and heating (14%). The other causes accounted for only 2 to 6% each.

Table 4-8 gives the distribution of injuries to fire service personnel by property class and cause of fire. A total of 2,731 fire service injuries were recorded on the fire incident reports, while only 1,954 had casualty reports. Again, it is suspected that coding errors have somewhat inflated the count of service casualties. However, if that count is regarded as accurate, only 71.5% of the service injuries were accompanied by casualty reports.

Slightly over half (53.3%) of the service injuries occurred while fighting residential fires. Mercantile shops and office fires ranked second in frequency (9.1%) and warehouses and storage (8.7%) ranked third. Open flame or sparks was the most frequent source of ignition (12.7%), followed by heating (11.2%), electrical distribution (7.8%), other heat sources (7.7%), and smoking (7.0%).

There were 218 reports of civilian fire deaths in the computer file. The Michigan State Fire Marshall's office reported 312 civilian fire deaths for 1975, while the casualty file contained 174 reports of deaths. Thus, it appears that only about 80% of the deaths reported on the incident report are followed up with a casualty report. However, only about 70% of the deaths are listed in the incident reports. The remaining 30% of the five deaths are late deaths, for which there was no fire department cell (e.g., clothing ignition), or deaths which were

TABLE 4-7. DISTRIBUTION OF CIVILIAN INJURIES BY PROPERTY CLASS AND CAUSE (PERCENT)

Property Type	Exposure	Natural	Incendiary Suspcious	Explosives Fireworks	Smoking	Children	Heating	Cooking	Air Conditioning/Refrig.	Electrical Distribution	Appliances	Gas	Flammable Liquid	Open Flame, Sparks	Other Equipment	Other Heat	Unknown	Total
Public Assembly 000-199	---	---	---	0.0	0.0	---	0.2	0.8	---	0.1	---	0.0	0.0	0.0	0.0	---	0.2	1.6
Education 200-299	---	---	---	---	---	---	0.2	10.4	---	0.5	---	---	0.1	---	0.4	---	0.0	11.6
Institution 300-399	---	---	0.7	---	0.5	---	---	0.0	---	0.0	0.3	---	0.0	0.3	---	0.0	0.4	1.8
Residence 400-499	0.7	0.1	2.4	0.2	12.4	3.4	8.4	9.0	0.5	2.9	3.1	0.5	1.4	4.6	1.5	3.0	5.5	59.8
Mercantile Shops,Offices 500-599 + 888	---	---	0.0	---	0.5	---	1.2	0.0	---	0.5	0.1	0.1	0.2	---	0.6	0.1	---	3.4
Utilities 600-654/656-659/ 670-679	---	0.0	---	---	---	---	---	---	---	0.1	---	---	---	---	---	---	---	0.1
Industrial Manufacturer 700-799	0.0	0.4	0.2	---	---	0.1	0.0	---	0.1	0.2	0.2	0.0	---	---	1.2	0.0	1.1	3.6
Storage 800-850/852-855/ 857-899	0.3	0.2	---	---	0.3	0.0	0.2	0.1	0.1	0.4	0.0	0.3	0.4	0.1	0.8	0.3	0.0	3.6
Construction 910-919	---	---	0.0	---	0.0	---	---	---	---	---	---	---	---	0.0	---	0.0	0.1	0.3
Highways,etc. 920-929	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.1	---	---	0.1
Special 900-909/930-990	0.3	---	0.1	0.0	0.4	---	0.2	0.1	---	0.1	0.1	0.2	0.8	0.3	0.7	0.2	0.1	3.8
Others (outdoors)	0.2	---	0.1	0.1	0.5	0.1	0.9	0.5	---	0.3	0.1	0.6	0.9	0.2	1.0	0.6	4.0	10.2
Total	1.5	0.8	3.5	0.4	14.9	3.7	11.3	20.9	0.7	5.0	4.0	1.9	4.0	5.7	6.3	4.4	11.5	N=2065 Civilian Injuries

Notes " " includes no cases observed
"0.0" indicates a percent less than 0.5%.

TABLE 4-8. DISTRIBUTION OF FIRE SERVICE INJURIES BY PROPERTY CLASS AND CAUSE (PERCENT)

Property Type	Exposure	Natural	Incendiary Suspcious	Explosives Fireworks	Smoking	Children	Heating	Cooking	Air Conditioning/Refrig.	Electrical Distribution	Appliances	Gas	Flammable Liquid	Open Flame, Sparks	Other Equipment	Other Heat	Unknown	Total
Public Assembly 000-199	---	0.1	0.2	---	0.1	0.0	0.6	0.5	0.0	0.5	0.2	---	0.2	0.1	---	0.1	0.5	3.3
Education 200-299	---	---	---	0.0	0.1	0.1	0.1	---	---	0.1	0.1	0.2	---	0.4	---	0.4	0.3	1.7
Institution 300-399	---	---	---	---	0.2	---	0.3	---	---	0.0	0.1	---	---	0.1	---	0.1	---	0.7
Residence 400-499	2.9	0.7	1.7	0.5	5.2	3.0	7.5	2.2	0.6	5.2	1.8	0.8	1.7	6.9	1.1	4.0	7.5	53.3
Mercantile Shops,Offices 500-599 + 888	2.2	0.1	0.3	0.1	0.4	---	0.7	---	---	1.0	0.2	0.0	0.5	0.8	0.3	0.7	1.7	9.1
Utilities 600-654/656-659/670-679	---	0.1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.1	0.1
Industrial Manufacturer 700-799	0.1	0.5	0.1	0.0	0.3	---	0.3	0.1	0.1	0.1	0.2	---	---	0.6	1.2	0.2	0.3	4.1
Storage 800-850/852-855/857-899	0.7	0.3	0.2	0.2	0.3	0.5	1.5	---	---	0.3	0.3	0.3	0.3	1.1	0.8	0.7	1.3	8.7
Construction 910-919	0.0	---	0.5	0.1	---	0.1	---	0.1	---	---	---	---	0.1	0.4	---	---	0.5	1.9
Highways,etc. 920-929	---	0.0	---	---	---	---	---	---	---	---	---	---	---	0.0	0.0	---	---	0.1
Special 900-909/930-990	0.1	0.0	0.1	0.1	0.1	0.1	---	---	---	0.1	0.2	0.4	0.2	1.0	0.9	0.7	1.0	5.1
Others (outdoors)	0.4	0.3	0.1	0.2	0.3	0.1	0.2	0.1	0.0	0.5	0.0	0.1	0.6	1.2	0.3	0.8	6.4	11.6
Total	6.4	2.2	3.3	1.4	7.0	4.0	11.2	2.9	0.8	7.8	3.1	1.7	3.7	12.7	4.6	7.7	19.6	N=2731 Service Injuries

Note: " " indicates no cases. "0.0" indicates a percent less than 0.5%.

missed in the incident report. Generally these are found from death certificates. The difference in the total number of reported deaths in the computer file and the number finally reported for the state is due primarily to the fact that a number of persons injured in fires die of their injuries. These late deaths are counted in the fire marshall's report, but are not reflected in the computer file, which contains data collected at the time of the fire. Thus, only 70% of the deaths appear to make it into the computer file of fire incidents.

Of the deaths reported in the computer file, the majority occur in residential fires (77.5%). Most of the residential fire fatalities occur in one- and two-family dwellings (72.3%). Apartment fires claimed 17.4% of the residential fatalities, while mobile home fires claimed 7.0% of the residential fatalities. Among fatalities, smoking again was the principal cause (19.9% of the cases), followed by heating (17.0%), cooking (8.0%), electrical distribution and other heat sources (7.7% each), flammable liquids (7.1%), open flames and sparks (5.4%), and explosions and fireworks (5.1%).

There are too few fire fighter fatalities (6 in 1974, 4 in 1975, and 3 in 1976) to make any distribution by type of fire or source reasonable.

5. NATIONAL ESTIMATES OF FIRE INJURIES

The several sources of injury information mentioned in Section 2 provide estimates of various components of fire injuries. This section investigates the agreements and disagreements among the sources and attempts to combine these into a concensus estimate. The approach taken is to consider separate estimates for different levels of injury severity--as measured crudely by treatment. Three levels of injury are considered: fatalities, injuries requiring hospitalization, and injuries requiring medical treatment but not requiring admission to a hospital. Injuries which are minor in that they require only first aid or are self-treated are omitted. At present there seems no way to estimating these with any reliability. Further, these are of less importance than the more serious injuries.

5.1 Fatalities

As mentioned in Section 2, the best source of data on deaths is the NCHS Vital Statistics. Deaths in the United States are well recorded, and are tabulated by several variables in Vital Statistics* of the United States, which gives an estimate of 6,714 deaths due to accidents caused by fire and flames in 1972. This is based on a 50% sample of death certificates and includes those with deaths coded as E890-899 in the International Classification of Diseases, 1965, Adapted. The sampling error is estimated as less than 1%, so this estimate would be plus or minus perhaps 50 deaths. Later years are counts of data as given on death certificates.

*Vital Statistics of the United States 1872 Volume II Mortality Part A, United States Department of Health, Education, and Welfare, Public Health Service, Health Resources Administration, National Center for Health Statistics, Rockville, Maryland 1976, p.176.

There could be disagreement about whether the classification is broad enough to include all "fire deaths." For example, professional fire service personnel who are killed in a traffic accident enroute to a fire or who died of a heart attack while fighting a fire are often recorded as fire-related deaths by State Fire Marshall's offices and by 901, but not by NCHS.

An additional 518 deaths were reported as due to explosive material in industrial accidents in 1972, and additionally 218 deaths were due to steam, heat, etc., in industrial accidents. These might be added to the deaths due to fires, since most of the explosions probably resulted in fires. An additional 1,088 deaths were due to electrical causes. However, most of these would not have fire associated with them, and should not be included. If deaths due to fires, flame, and explosive materials are combined, the total becomes 7,232, while if the steam explosions are also added, the total becomes 7,514.

It is interesting to compare estimates of the number of deaths from other data sources with the figure from the Vital Statistics. As reported in Section 3, the NEISS data estimated a total of 600 deaths from product-associated injuries resulting in emergency room visits with fire noted. This is clearly too low, for several reasons. First, only product-associated emergency room visits are coded. Second, if an injured person is admitted to the hospital, and dies later, this would generally not be coded as a death. Third, deaths on scene or on arrival would be missed. Only about 20% of all emergency room visits are "in-scope," and thus coded in the NEISS. Even using an expansion factor of five, the estimated number of deaths becomes only 3,000. One might estimate that the non-coverage of deaths in emergency room records is thus about 50%. That is, that the true number of deaths is about twice the number estimated from emergency room records--after correction to include all emergency room records. Another attempt to adjust the NEISS estimates to be nationally representative is the following. There were an estimated 5,900 admissions for fire-related injuries in 1975 from the NEISS data. Ninety-three percent of these were for burns or anoxia. If the factor of five is used to attempt to make this representative of

of the total of emergency room visits, there would be an estimated 29,500 admissions. If on the average 13% of these persons die--as reported from the Massachusetts study of burn injuries* and which is consistent with the NBIE data--then one arrives at an estimated 3,835 fatalities--still unacceptably low. The conclusion seem inescapable that the recording of fire in relation to the injury in the NEISS is incomplete. If the NEISS estimate of admissions for burns (13,378) is used, and this is expanded by a factor of five to account for the non-reporting of 80% of emergency room visits, then one obtains 66,900 admissions. It has been estimated that 17% of burn admissions do not pass through the emergency room, so this figure could be further inflated to 80,600 (which agrees well with the estimate of 79,000 discharges for burns in 1975 by CPHA). With the assumption that about 60% of burns resulted from fires and of a mortality rate of 13%, one arrives as an estimate of about 6,300 deaths--reasonably close to that reported by the vital statistics.

There are several uncertain factors in the above argument, and it is not recommended that the NEISS estimates should be so used for estimating fatalities. However, the fact that a reasonable agreement can be obtained with the number of fatalities--which is known--lends credence to the estimates to be derived by similar methods for other types of injuries for which the total is not known.

The most uncertain factor is the correction for the 20% of emergency room records which are coded in the NEISS. Although the 20% figure may be fairly reliable, there is also an implicit assumption that the non-coded cases have similar characteristics in terms of injury and relation to fires that the reported cases do, and there is no justification for this assumption. The other factors--the proportion of burns resulting from fires, and the proportion of admissions which do not

*Guilfoy, V., et al., Burn Injuries: Causes, Consequences, and Behavior - Phase I of the Burn Injury Education Demonstration Project, Massachusetts General Hospital, Boston, June, 1976.

pass through the emergency rooms--can be documented to some extent at least, as can the 13% mortality.

According to the Michigan State Fire Marshall's Office, the numbers of deaths in Michigan caused by fires from 1971 to 1976 were 352 (1971), 304, 296, 334, 318, and 358 (in 1976). The ratio of the population of the United States to that of Michigan is 23.23. If one uses this ratio to obtain a national extrapolation, one obtains an estimate of 7,060 for 1972, which is in reasonably good agreement with the number reported in the Vital Statistics. The annual data from Michigan show an increasing trend (about 6.5 additional deaths per year from 1961 to 1976) and some random fluctuation about that trend. Based on the observed deaths in 1975 one would extrapolate a national total of 7,390. Based on a smoothed line, the national estimate for 1975 would be 7,800. An estimated standard error for this projection is 497 deaths. Note that this estimates only the error from the variability of the number of deaths in Michigan and the expansion factor. It does not include a bias factor. The bias is unknown and represents the fact that presumably there are regional differences in the U.S. which would make any expansion from a single state to a national total subject to bias error.

5.2 Injuries Requiring Hospitalization

The number of patients hospitalized for burn injuries in the U.S. was estimated in Table 3-3. For 1975 the estimate was 79,000 patients (primary diagnosis), based on data from the CPHA. The NCHS sample of hospitals in the U.S. estimated the number as 93,000 in 1972 and 86,000 in 1971. Using a weighted average with weights inversely proportional to the sampling variances results in the estimate of 81,000 hospitalizations for burns in 1975 with an estimated error of 2,500 hospitalizations. The weighting used seems reasonable, since, although the CPHA estimate is more recent, it is subject to larger potential bias errors from the selection of hospitals. The NCHS estimate has a sounder sampling base, but is for an earlier year. If the number of hospital

admissions for burns is estimated from the NEISS data for 1975, one arrives at 13,378. According to Branson, et al.,* only 83% of admissions for burns come through the emergency room, so this figure should be inflated to 16,118 to include direct admissions for burns. If one finally multiplies this result by five to adjust for the fact that the emergency room visits coded in the NEISS are only 20% of all emergency room visits, one obtains an estimate of 80,590 hospital admissions for 1975 in the U.S. for burns. The standard error would be about 2,300, after applying the two correction factors as if they were known constants. This agrees remarkably well with the estimate obtained from the CPHA and NCHS hospital record data.

Not all of these admissions for burns resulted from fires. Guilfoy, et al.,** estimated that 54% of the hospitalized burns resulted from fires. The NBIE--which has a bias toward more severe injuries--estimates that 67.5% of the admissions are the result of fires. Although the notation of fire-related injuries in the NEISS seems to be too low, it would indicate that the fires account for 44% of the admissions for all burns, and for 75% of the admissions for thermal burns. The use of the "E-codes" in CPHA data is too inconsistent to be regarded as a valid estimate--fires are listed only in 13% of the admissions. The Michigan workmen's compensation data indicates that 22% of burns result from fires, but these data are only for members of the work force with job-connected injuries, and are not restricted to hospitalized injuries. As a combined estimate, about 55% of the hospitalized burn injuries seem to be due to fires. This is close to the estimate based on data from Massachusetts, which is probably the most reliable estimate, although based on a small sample size. It is also the unweighted average of the three estimates; the other two being from the NBIE and the NEISS.

*Branson, et al., loc.cit.
**Guilfoy, et al., loc cit.

Thus a concensus estimate of the number of hospitalized burn injuries which are caused by fires in the U.S. is 44,550 in 1975.

If the data from the Michigan Fire Marshall's file are extrapolated to the national total, one arrives at an estimate of 30,300 persons taken to the hospital. It should be noted that this is not the same as hospitalized. Presumably not all of those persons taken to the hospital were admitted, but conceivably a large portion of them were. It should also be recalled that only about 75% of the injuries reported on the fire incident form also had casualty reports. The estimates of the number of persons taken to the hospital is based on the casualty reports, so is somewhat low.

If the completion of a casualty report is not related to the nature of the injury, then one might estimate a total of 40,400 persons taken to hospitals as a result of fires at which fire departments were present. It is plausible, however, that the cases without casualty reports were generally the more minor injuries, in which case the 30,300 might not be substantially increased by complete submission of casualty reports.

In addition to the data reporting problems, the number taken to hospitals estimated from the fire department reports is too low for another reason. Some fire injuries are caused by clothing ignition from a contained fire source; e.g., a barbeque grill. The injured person may be taken to a hospital by a private auto or by an ambulance without the injury's ever coming to the attention of the fire department. It is also possible that some injuries may be taken to the hospital before the fire department arrives. It would be difficult for these to be entered in the fire department record.

If one assumes that all the injuries would have been of the same general type had they all had casualty reports, then about 40,400 persons would have been taken to the hospital as a result of fires for which the fire department was called. If all these were indeed hospitalized, then approximately 20% of the hospitalizations for fire

injuries would appear to come from fires for which the fire department was not summoned. On the other hand, if only 90% of those taken to the hospital were admitted, then fire department records would appear to miss about 30% of the hospitalizations from fire injuries, with correspondingly larger proportions missed if fewer of those taken to the hospital are actually admitted.

Not all of the hospitalized injured from fires are burns. Of the injuries with fire noted in the NEISS, 86% were burns. Of the injuries from fire in the Michigan Workmen's Compensation, 85% were burns. Of the injuries reported from the Michigan fire data, 82% of the civilians transported to the hospital were burns. Thus, burns appear to represent about 85% of the hospitalized injuries from fires. Thus one would estimate that in addition to the 44,550 hospitalized burn injuries from fires in 1975 there were about 7,860 hospitalizations from fires for injuries other than burns. This results in a total of about 52,400 hospitalizations from fires in 1975.

5.3 Non-hospitalized Fire Injuries

It is particularly difficult to estimate the number of non-hospitalized fire injuries, since many of the available sources of data concentrate on hospitalizations as the threshold. Also, minor injuries are not as likely to be reported in any of the data collection systems. Among the civilians injured by fires in Michigan, only 24.6% were not taken to the hospital. However, the number actually hospitalized is unknown, since presumably some of those transported to the hospital could be treated and released rather than admitted. Among the fire service personnel injured, 54.1% were not taken to the hospital. Thus, for fire service personnel--whose minor injuries may be better reported than the civilians'--slightly more were reported as injured and not hospitalized than were injured and hospitalized.

In the NEISS data on persons injured from fires, 3.83 times as many persons were not admitted as were admitted. This is probably a more accurate estimate than that from the Michigan fire

reports. However, it does not include persons injured from fires who sought medical aid from sources other than hospital emergency rooms. Thus, a conservative estimate would be that there are about four times as many non-admission injuries from fires as admission injuries. Approximately 43% of injuries are thought to be first seen in hospital emergency rooms. Thus, the number actually could be nearly nine times as many non-hospitalized injuries as hospitalized injuries. The popularly quoted ratio of ten to one may be reasonable.

Based on the data available, plus the known fact that not all injuries are treated in hospitals, a minimum of 225,000 non-hospitalized fire injuries in 1975 seems a reasonable estimate. If in fact more than half of the persons injured in fires did not obtain treatment through hospitals, then the number of such injuries could be more in the neighborhood of 400,000. The number of fire injuries requiring some medical treatment but not calling for hospitalization is rather uncertain. It seems likely to be seriously underestimated from any sort of fire-department-based data system. The difficulty of identifying the individuals and determining their minor injuries, together with the fact that fire department personnel are not primarily data collectors, means that minor injuries will probably always be underestimated by NFIRS or any similar system.

In summary, the best estimates for fire injuries in the U.S. for 1975 seem to be:

7,300 deaths $\pm$ 100

52,400 injuries requiring hospitalization $\pm$ 5,000

225,000 to 400,000 other injuries requiring treatment

The number of deaths is nearly exact, except possibly for differences in the definition of fire-death. The number of hospitalizations has been reasonably consistently estimated from several sources. The quoted error of 5,000 seems an adequate estimate of the root mean square error. The number of other injuries is uncertain. The range reported seems reasonable. However, the threshold of a minor but

treated injury is somewhat uncertain. The lower the threshold is set, the larger the number of injuries would be. If one were to include all injuries, no matter how minor, then the quoted range is probably still too low.

APPENDIX

METHODS OF COMBINING DATA FROM DIFFERENT STUDIES

If several sources report the same estimates, there is generally no problem. The common estimate is taken as acceptable. This is generally true so long as the several estimates are within plus or minus one or two standard deviations of each other. That is, they agree to within the sampling precision of the estimates. In this case, it is sufficient to check that the estimates have been made in a valid manner. It may be that although several estimates agree satisfactorily, that the reported errors are unacceptably large. In this case more data--a larger sample--must be collected. Typically this would be done in the same manner as used to form the previous estimates.

It is unfortunately often the case that several reported estimates of a phenomena--number of deaths from fires, for example--differ by far more than could be due to sampling precision. In this situation it is difficult to determine the best estimate. Careful evaluation of each estimate is required before a concensus can be reached. This process is sometimes more art than science, but the following may serve as a guide or outline. The original estimates and their disparities should also be reported along with a warning that the concensus estimate may be unreliable.

Determine the exact definition of the population on which each estimate is based. It is frequently true that there are different thresholds defined. This is often the case if the phenomenon in question is an accident or an injury. Some sources may report all fires, some all fire departments calls, some only fire in the case of property damage in excess of $10,000, etc. If differences in threshold level

can be identified, then further comparisons would be within estimates based on the same threshold. Also, it may be possible to state the estimates separately by level--e.g., so many fires involving fatalities, so many involving injury, etc.

Check the sampling on data collection procedures to ensure that the population actually sampled is the same as the target population and that these populations are the same in the different studies. Thus, samples to estimate the number of household fires using exactly the same data elements and forms could reach quite different populations and quite different conclusions if they were based on a telephone interview survey, a household interview survey, and a mail survey.

If the same populations have been reached and the same variables and definitions used, but results still differ by more than can be explained by sampling errors and missing data rates, then look for unsuspected variables which may be different in the different studies. These could be intervening variables such as time or a public safety program, or they might be inherent variables such as type of construction, different prevalences of types of heating fuel, or different weather conditions during the period of the sampling. If candidate variables which may explain the differences can be identified, hypotheses about the relation of these new variables to the phenomenon would be formulated and tested. From the "pure" point of view, these new hypotheses should be tested with new data. From a more practical point of view, the observed relationships would be investigated to the extent possible with existing data. It should be pointed out that this has been done and that any such post hoc relationships need to be verified in future work, but they may be advanced as tentative explanations. It may turn out, of course, that the data required to develop explanatory relationships with the new variables are not present in the existing studies. In this case, its explanatory power can only be conjecture.

Once the differences in results have been determined and explained to the extent possible, there still remains the desire to combine the results into a common or consensus estimate. Some methods that have been used are:

(1) "Vote". Each of several experts who have reviewed the studies votes on the most appropriate estimate.

(2) "Count". The combined estimate is taken as the one most frequently reported. This is essentially taking each separate estimate as a data point and using the mode to represent the group.

(3) "Pick a Favorite". One estimate is selected as the best on the basis of data base quality, care of presentation, author's reputation, or other factors.

(4) "Pool". If the data on which the estimates are based are available, they may be pooled and re-analyzed to yield a pooled estimate.

(5) "Bayesian". The estimates themselves are each given a weight which reflects a judgment about their precision. The estimates are then combined, using a weight average.

Each of these methods can be appropriate under proper circumstances. Each also has potentially serious drawbacks. The first three represent selection of an estimate based on the judgments of several reviewers. The result will depend both on the quality of the original set of estimates and on the ability of the reviewers to select a good estimate. The fifth method depends on the ability of the reviewer to formulate appropriate weights based on the precision. To the extent possible the precision can be measured by the mean square error (variance plus bias^2). The subjectivity may come in in estimating the bias. The weight may also be adjusted to reflect recency of the data--that is, to give less weight to studies done some time ago and more weight to more current studies. The fourth method--pooling the data and reanalyzing--is fraught with pitfalls and is

generally best avoided. It requires not only the actual data from the several studies, but also assurance that sampling methods, data collection methods, and definition of variables were the same. Further, the resulting combined sample must represent the target population appropriately. This is unlikely to be the case. In general stronger influences can be drawn from comparisons of results of separate studies, including their discrepancies, than from lumping all the data together and ignoring differences.

Generally the most widely applicable method is the fourth listed. That is, combining the individual results with each weighted according to its precision. In the case of categorical data, particularly for rates on dichotomies, this is known as the Mantel-Haenzel procedure and may be found in Fleiss.*

With the current status of data relating to fire-injuries, the best means of forming national estimates at present seems to be the following.

1. Take as the number of fire-deaths the number reported by the NCHS in the Vital Statistics.

2. The number of fire injuries requiring hsopitalization seems best estimated from hospital record studies of hospital discharges. There is a slight preference for the study conducted by the NCHS. However, any such system must have adjustments to account for the fact that not all fire injuries are burns and that not all burns were due to fires. About 55% of hospitalized burns were caused by fires, and the number of fire burns (hospitalized) represents about 85% of the hospitalized fire injuries. Apply these correction factors to the estimated number of discharges caused by burns to estimate the number of fire-caused injuries requiring hospitalization. It is best to do this for several data sources and average the results to reduce the error.

*Fleiss, J. Statistical Methods for Rates and Proportions. Wiley, 1974.

3. The estimation of fire-caused injuries not requiring hospitalization is quite difficult. The best current method would appear to be to estimate these from the information on civilian injuries in the Fire Incident Reports. However, this is likely to result in a considerable amount of underestimation. Another approach would be to estimate that fire-injuries not requiring hospitalization are some factor times the number of hospitalized injuries and apply this factor to the number of hospitalized injuries. In the data sources used, this factor ranges from about 5 to over 10, thus this method is subject to large errors and does not appear to be sufficiently reliable.

The estimation of fire-injuries requiring hospitalization would be considerably better if the hospital record studies, such as those conducted by NCHS, would include a variable for the external cause of the injury rather than just the diagnosis. In addition, it would be very useful to note whether such injury was brought to the attention of a government agency--fire department, police, etc.

Estimation of the number of fire-injuries which do not require hospitalization remains difficult. Currently the best approach would seem to be through the casualty report of the fire incident reporting system. However, this should be supplemented with follow-up efforts to determine whether all injuries in a fire were reported and whether persons taken to a hospital were admitted or treated and released. A possible validation method could be the sample of emergency room records conducted by the CPSC in its NEISS. However, this would need to be augmented to cover all emergency room records, not just those with product-association.