

NBSIR 75-969 (R)

Accidents Involving Several Selected Appliances: Summary and Descriptive Analysis

Mary E. Stefl
P. Clare Goodman
Ann M. Ramey
Fran D. Bents

Human Factors Section
Product Systems Analysis Division
Center for Consumer Product Technology
Institute for Applied Technology
National Bureau of Standards
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Final Report

Prepared for
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EXECUTIVE SUMMARY

The Problem

In FY 74, the former Technical Analysis Division of the National Bureau of Standards (NBS) undertook a human factors analysis of appliance-related accidents for the Consumer Product Safety Commission (CPSC). Appliance products listed in the top 50 of the then-current CPSC Hazard Index were chosen for initial study. Thus, space heaters and heating stoves, kitchen ranges, wringer washers, hot water heaters, and irons were included.

Three data sources were available:

- a. In-Depth Investigative Reports (IDIR's),
- b. National Electronic Injury Surveillance System (NEISS), and
- c. Flammable Fabrics Accident Case and Testing System (FFACTS).

Methodology

All IDIR case histories were read and summarized. Categories were developed to describe the behavior sequences of victims just prior to accidental injury. A series of cross tabulations between victim's age, sex, injury type and severity, and antecedent activity were then constructed in an attempt to identify product hazards and uncover accident patterns common to all the appliances investigated. Product factors were also considered.

NEISS and FFACTS data were used to supplement and verify trends reported in the IDIR's.

Results

The original attempt to develop generic patterns of injury, product hazard, and victim activity was not successful. However, the following general trends were noted:

- a. Children were over-represented as accident victims in all data bases and for all appliance products.
- b. The elderly (66+ years) appeared to suffer injuries of the greatest severity.
- c. Thermal burns were by far the most common injury.

Other accident trends are presented individually by appliance type. Notable product-specific injuries, hazards, or antecedent activities are discussed.

Discussion

The difficulties encountered in the present approach to product-specific accident analysis are noted. A limited number of generic hazards, i.e., those hazards observed across appliance types, are identified.

Specific recommendations are made to:

- a. Expand the data bases to include information describing the interface between product and product user.
- b. Intensify research on product exposure patterns so that a perspective will exist on which to assess current trends in accident occurrence.
- c. Re-examine age based priorities. Future research and prevention programs might accrue the greatest societal gains by focusing on the elderly.

ACCIDENTS INVOLVING SEVERAL SELECTED APPLIANCES:
SUMMARY AND DESCRIPTIVE ANALYSIS

1.0 INTRODUCTION

Household appliances are used regularly by a majority of the consumer population and are involved in a great number of accidental injuries. During FY 1974, the former Technical Analysis Division of the National Bureau of Standards (NBS) was asked by the Consumer Product Safety Commission (CPSC) to analyze appliance-related accidents from a human factors point of view. Investigation was to focus on those accidents related to products listed among the top 50 of the then-current Hazard Index. The appliance products involved, together with their hazard ranking, are shown in Table 1.

Case history investigations of accidents related to these products were studied in an attempt to better understand the sequence of events leading to an appliance accident. This effort was aimed at developing a series of injury/hazard/activity cross tabulations or relationships which would characterize accident patterns common to all the appliances included. It was hoped that such patterns would reveal generic hazards which, combined with specified product-related human behaviors, produce a predictable type of accident and injury. Accident prevention could then focus on interrupting the accident sequence by removing the generic hazard or redesigning the product in ways which would inhibit the human activity identified in the cross-tabulations as hazardous.

Data for the present effort were derived from three sources: the National Electronic Injury Surveillance System (NEISS), In-Depth Investigative Reports (IDIR's), and the Flammable Fabrics Accident Case and Testing System (FFACTS). A brief description of each of these systems follows.

NEISS. Operated by the CPSC's Bureau of Epidemiology, NEISS is a telecommunication network connected to 119 hospital emergency rooms throughout the country. These hospitals represent approximately two percent of all U.S. hospitals having emergency rooms and were chosen as a statistically representative sample.

NEISS surveys only product-related accidents. The type of product involved, the age and sex of the victim, the type of injury, the body part involved, and the hospital disposition of the victim are among the data recorded and transmitted daily via computer terminals to CPSC headquarters.

NEISS includes only injuries treated in hospital emergency rooms. However, where and how an accident is treated may depend upon a number of factors (e.g., family income level, distance to nearest hospital, age of victim), all of which introduce a definite but unspecified bias into the NEISS data.

TABLE 1

Appliance Items Selected
for Study

<u>Product</u>	<u>FY74 Hazard Index Ranking</u>	<u>IDIR's Reviewed</u>
Space heaters & heating stoves	15	186
Kitchen ranges	17	401
Wringer washers	28	120
Hot water heaters	39	69
Irons	47	<u>37</u>
	Total	813

IDIR's. The National Injury Information Clearinghouse at CPSC maintains a system of In-Depth Investigative Reports dealing with product-related accidents. Essentially, IDIR's are the result of personal interviews conducted with accident victims or their families by local contractors scattered across the country. To insure most accurate recall, interviews are performed, whenever possible, within 10 days of the accident occurrence. Many IDIR's are drawn from cases reported in NEISS, but other sources, such as the news media, are also tapped.

No claim is made that IDIR's are representative of the population of accidents or the rated hazard of any given product. Bias is introduced in a number of ways.¹ IDIR's are often collected on a demand basis. That is, if a hazard is suspected for a particular product, a directive to collect IDIR's may be issued by CPSC irrespective of the total number of accidents associated with that product. The directive may be even more specific, aimed, for example, at a particular age group of accident victims. In addition, the use of the news media may introduce bias since only the most severe and/or unusual accidents are deemed newsworthy.

FFACTS. FFACTS data were maintained by NBS' former Fire Technology Division (FTD) and includes case histories similar to IDIR's. Limited in scope to flammable fabrics fire accidents, FFACTS reports pertain to only three of the appliance products studied: kitchen ranges, space heaters and heating stoves, and hot water heaters.

As with the IDIR system, no claims are made for the statistical validity of FFACTS. Indeed, the use of FFACTS case histories was not emphasized in the present study since an acknowledged but undefined overlap exists between FFACTS and both the NEISS surveillance and the IDIR data. Reservation must therefore be exercised in the interpretation of any results based on this set of data.

Bias is obviously inherent in all three of the data bases. Unfortunately, no other known sources contain either the broad range of product-related accident statistics or the behavioral activity information essential to a human factors analysis. However limited, these data bases supply the best information currently available.

2.0 METHODOLOGY

2.1 Procedure

Because they attempt to include the total sequence of events leading to an accident, IDIR's comprised the primary data source for this study. All available IDIR's dealing with the products involved were consequently obtained from the CPSC. The number of IDIR's provided, by appliance type, is shown in Table 1.

¹All comments here and below refer only to the IDIR's used in the preparation of this report, i.e., those available as of January 1974. The authors acknowledge that substantive changes and improvements have occurred in the data base since then.

NBS staff members read each case history and extracted the following information:

1. Age of injured
2. Sex of injured
3. Type of injury
4. Bodily location of injury
5. Hospital disposition of victim
6. Product or products involved
7. Location of accident in the home
8. Behavioral data (narrative of accident sequence).

An attempt was then made to categorize the behavioral data (Item 8) based on the victim's activity just prior to injury. For example, victims were often found to be "leaning over" a range top or "pulling the cord" of a hot iron. Unfortunately, the availability of these data was somewhat limited. Information was frequently incomplete and occasionally missing, and in other cases, impossible to procure. For example, a young child or the victim of a severe accident often cannot report or recall events just prior to injury. In addition, the quality and completeness of the accident narrative varied greatly from interviewer to interviewer.

Finally, a series of cross-tabulations or relationships among the various data listed above was developed for each product type. For example, the victim's age and sex was compared to the type of injury incurred, the severity of the injury (as judged by hospital disposition) and the victim's antecedent behavior. Special attention was directed towards those cross-tabulations including behavioral sequences (Item 8 above).

NEISS data served a secondary function in the present study. At the time the study was undertaken, NBS was just developing its ability to access the FY 73 NEISS data. Its use in the present analysis was therefore minimal, limited to distributions of accident victim's age and sex. For each appliance product, the age and sex trends observed in FY 73 NEISS were compared to those of the IDIR sample. A crude assessment of the representativeness of the sample IDIR data could thus be made. However, future accident analyses should make full utilization of the NEISS data, examining entrees for injury type and bodily location, hospital disposition, and injury severity as well as age and sex of the accident victims. The present effort was weakened by the unavailability of such information.

It was beyond the scope of the present study to read and review all relevant FFACTS studies. Since the NBS Human Factors Laboratory staff had performed a human factors analysis of FFACTS range-related accidents at an earlier date (Pezoldt, Persensky, and Peiser, 1973) those results, where appropriate, are noted in the present research. For both space heaters and heating stoves and water heaters, FTD made available summary data indicating the victim's age and sex, type and extent of injury, and hospital disposition. In many cases, a short behavioral description of the victim's activity at the time of the accident (e.g., "leaning over pilot light") was also included. Such information was utilized whenever possible.

2.2 Limitations and Qualifications

The limitations of the behavioral information found in the IDIR's have already been noted, yet a thorough human factors analysis of appliance-related accidents requires rather complete activity sequence information. Neither NEISS, which contains no behavioral data, nor FFACTS, which is limited in scope, could adequately supplement or substitute for the widespread "gaps" found in the IDIR's.

The development of comprehensive injury/hazard/activity cross-tabulations was also hampered by the broad nature of the products themselves. In the course of the study it became obvious that some products (irons, wringer washers) are "use" products, usually requiring continual human involvement. Others (space heaters and heating stoves and hot water heaters) are "functional" products operating in the absence of human interaction. Still other appliances (kitchen ranges) operate in both modes. The accidents and injury/hazard/activity relationships associated with such a wide range of man-machine interfaces necessarily differ greatly.

Thus the initial attempt to develop accident patterns generalizable to all appliance products was abandoned. Instead, each appliance product was "analyzed" separately and a series of relationships between product hazards, injury, and human behavior was generated for each product. Whenever possible, general relationships or trends were developed across all appliance types; in no case, however, was it possible to incorporate behavioral information in these general relationships. What has emerged is in descriptive terms, that is, general relationships and averages are reported but no statistical inferences are made. Percentage figures, which imply a certain degree of statistical authority, are limited to discussions of the NEISS data. Trends observed in both the IDIR's and FFACTS, where sampling bias is known to exist, are reported in only the most general terms.

Finally, a brief note on how to use this report is in order. The results are presented first in general terms. Accident trends and statistics are combined and reported for all products. Thereafter, a separate subsection of the results section is devoted to each appliance item studied. Thus, the reader interested in only one of the appliances reviewed should read first Section 3.1 (General Trends) and then consult that subsection dealing with the appliance of interest.

3.0 RESULTS

3.1 General Trends

While the majority of results apply to individual appliances, a few general observations can be made.

For example, the victim of an appliance accident was slightly more likely to be female. Table 2 illustrates that 56.2 percent of the FY 73 NEISS victims were female and only 43.8 percent were male when all appliances were combined.

TABLE 2

Distribution of All Accident
Victims (FY 73 NEISS) by Age and Sex

Age Group	Male	Female	Total	Percent of Total	Percent of Total U.S. Population**
0-12 mos.	158	102	260	9.6	
13-18 mos.	71	41	112	4.2	
19 mos.-2 yrs.	129	106	235	8.7	
3-5 yrs.	177	145	322	11.9	
<hr/>					
0-5 yrs.	535	394	929	34.4	(10.32)
6-10	124	119	243	9.0	(10.05)
11-15	58	91	149	5.5	(10.11)
16-20	83	150	233	8.6	(9.12)
21-26	102	196	298	11.1	(9.08)
27-35	77	160	237	8.8	(10.61)
36-45	73	105	178	6.6	(11.48)
46-55	58	115	173	6.4	(11.25)
56-65	38	73	111	4.1	(8.87)
66+	32	111	143	5.3	(9.12)
Unknown		1	1		
No victim			1		
<hr/>					
TOTAL	1180	1515	2696		
Percent of Total	43.8	56.2		100.0*	

* Due to rounding errors, percentages may not always sum to exactly 100.0.

** 1970 Census.

It should be noted that the data in Table 2 are divided into 10 major age-groups, each representing approximately 10 percent of the total U.S. population according to the 1970 census. The farthest column on the right of Table 2, "Percent of Total U.S. Population," gives the exact population percentages by age categories. This same breakdown by age will be used consistently throughout the report but the "Percent of Total U.S. Population" column will not be repeated. Due to the large percentage of accidents involving children under five years of age (34.4%), this group has been further divided into four subgroups. The same subgroups will also appear throughout the report. Finally, a category designated "No Victim" appears in the "Age Group" column. This apparent inconsistency includes those cases where an accident occurred but the product user escaped injury. Such cases were included in the data base when they provided descriptions of the events and behaviors preceding the accidents.

Closer examination of Table 2 suggests an age by sex interaction. Figure 1 presents these same data in histogram form. Here it is apparent that younger victims of appliance accidents tend to be male but older victims are more often female.

A similar age and sex interaction was observed when the IDIR victims for all types of appliance accidents were combined (see Table 3).

Accident age statistics are often bimodal, that is, the very young and very old members of the population are typically over-represented (Haddon, Suchman & Klein, 1964) as accident victims. The present data partially supports this model. While children are clearly frequent accident victims in both the NEISS and IDIR data bases, a similar trend is not evident for the elderly. The elderly may be construed, however, as over-represented in terms of accident severity, that is, the injuries they suffered were of greater apparent severity than any other age group. This point will be discussed below.

It was noted that the NEISS data available in the present study were limited to the age and sex distributions of accident victims. The hospital dispositions recorded in the IDIR's, therefore, were used as a rough gauge of accident severity. Table 4 presents the number of victims for each category of hospital disposition by appliance product. Note that the third column from the right, "Total Admissions and/or Deaths," represents a composite of all those cases where death or injury requiring hospital admission resulted. A crude means of assessing a product's relative accident severity results from comparing the number of "Total Admissions and/or Deaths" to the total number of victims for that product.

Table 4 also presents each product's ranking on CPSC's Hazard Index. The Hazard Index attempts to rate product hazard (not accident severity) by assigning a weighted function of accident frequency, injury severity and age of victim to each product. Little correspondence between accident severity (as judged by hospital disposition) and the

Figure 1. Accident occurrence by age and sex of victims for all appliances combined (FY 73 NEISS)

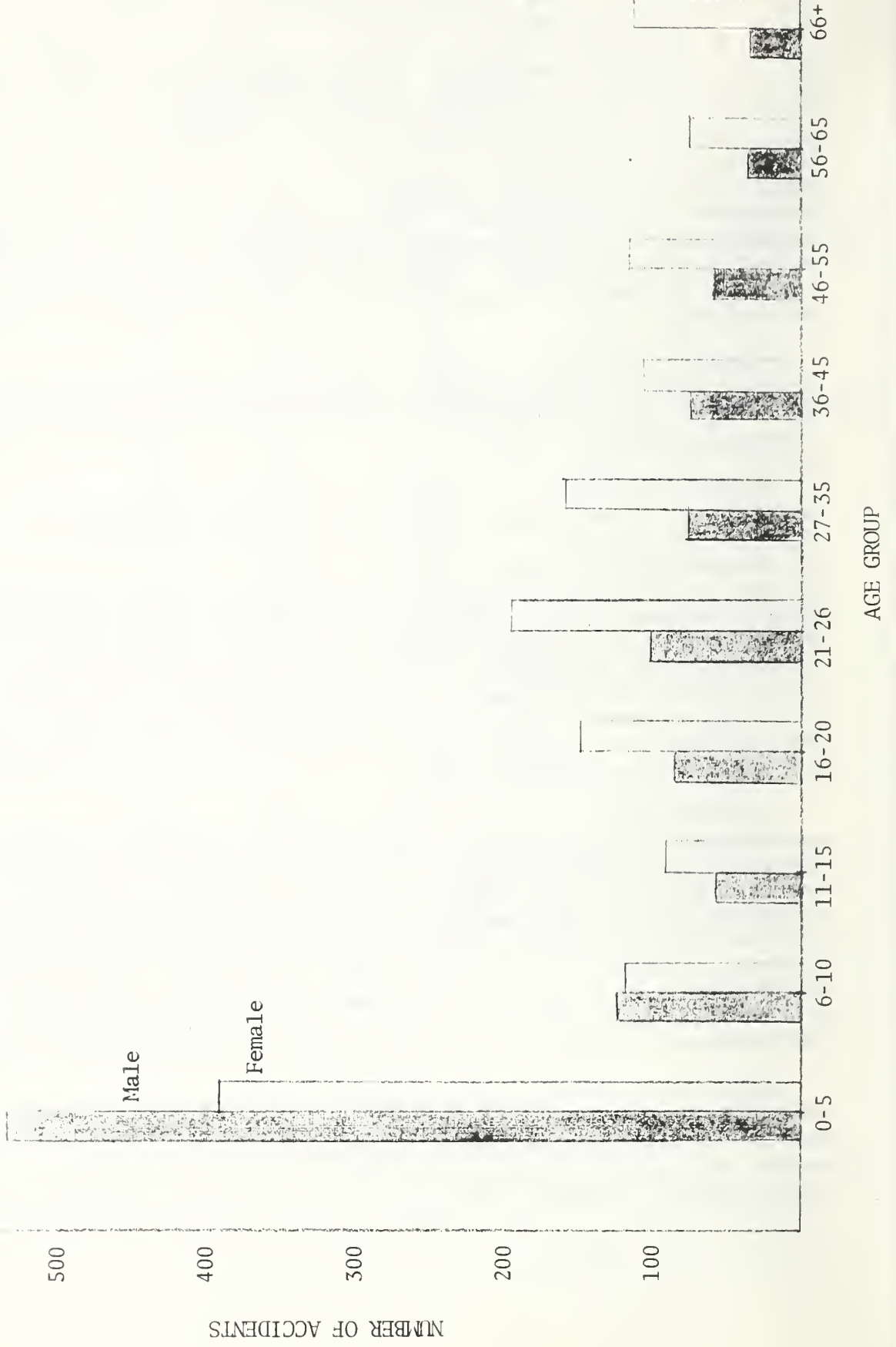


TABLE 3

Distribution of All IDIR Appliance
Accident Victims by Age and Sex

Age Group	Male	Female	Unknown	Total
0-12 mos.	29	13		42
13-18 mos.	19	20		39
19 mos.-2 yrs.	34	39	1	74
3-5 yrs.	81	43		124
<hr/>				
0-5 yrs.	163	115	1	279
6-10	42	51		93
11-15	25	35		60
16-20	23	35		58
21-26	15	52		67
27-35	26	39		65
36-45	22	23		45
46-55	14	18		32
56-65	15	22		37
66+	16	46		62
Unknown	4		3	7
No victim	4	2	2	8
<hr/>				
TOTAL	369	438	6	813

TABLE 4

Distribution of Accident Severity
As a Function of Appliance Product

Appliance	Treated & Released	Treated & Admitted	Treated & Transferred	Dead on Arrival	Later Died	Other/Unknown	Total Admissions and/or Deaths	Total Cases	Hazard Index Ranking
Space heaters/ heating stoves	116	36	13	2	9	10	60	186	15
Kitchen ranges	245	74	15	8	24	35	121	401	17
Wringer washers	73	43	--	--	--	4	43	120	28
Hot water heaters	30	22	--	3	2	12	27	69	39
Irons	31	1	3	--	--	2	4	37	47
TOTAL	495	176	31	13	35	63	255	813	

product's ranked hazard is evident in Table 4, with the possible exception of irons. This product ranks lowest of all the appliances on the Hazard Index, and appears to have a low accompanying severity (e.g., four "Admissions and/or Deaths" of a total of 37 victims) as well.

Table 5 compares hospital disposition to the age of the IDIR victim. Again, the relative severity of accidents in each age group may be crudely assessed by comparing the number in the "Total Admissions and/or Deaths" column to the total number of cases. Note the relatively high severity of accidents associated with the oldest age group, the group which also accrues the largest number of fatalities. The youngest age group, on the other hand, incurs the largest number of total accidents, but with what appears to be the lowest associated severity.

Finally, Table 6 shows the type of injury sustained as a function of appliance product. Burns were the most commonly observed injury, affecting the majority of victims. Burn injuries were not, however, uniformly distributed across all appliances sampled. For example, only one burn injury was associated with wringer washer accidents. No other single injury was common to all appliance types.

The results for individual appliances follow. Whenever possible, verbal descriptions of relationships and trends are minimized, and reference is made instead to data tables for detail. More attention, however, is devoted to the delineation of victim activity sequences and their implications. Because of the biases and limitations inherent in the data sample, caution must be exercised in the interpretation and application of all results.

3.2 Space Heaters and Heating Stoves

Ranking 15th on the Hazard Index, space heaters and heating stoves have long been recognized as hazardous products. The list of associated hazards includes open flames, high surface temperatures, and gas accumulation/explosion potential; the relationship and interaction between these factors and human behavior, however, has been relatively unexplored. A total of 186 IDIR's were available for this analysis.

3.2.1 Victim Characteristics

Sex was marginally related to space heater accidents; 45.5 percent of the FY 73 NEISS victims were female and 54.5 percent were male (see Table 7).

Children, however, were particularly prone to accidents with these appliances. Nearly one-half (46.6 percent) of the victims were five years of age or less, and another 9.8 percent were 6-10 years of age. Thus almost 60 percent of space heater accidents were incurred by the youngest 20 percent of the population.

Age and sex distributions for the IDIR sample are presented in Table 8. The relationships evidenced here are similar to those described for the NEISS data.

TABLE 5

Distribution of All Accident Victims (IDIR's)
by Age and Hospital Disposition

Age Group	Treated & Released	Treated & Admitted	Treated & Transferred	Dead on Arrival	Later Died	Other/ Unknown	Hospital Disposition		Total Cases
							Admissions and/or Deaths	Total Admissions and/or Deaths	
0-12 mos.	34	3	2	1		2		6	42
13-18 mos.	33	3		1	1	1		5	39
19 mos.-2 yts.	53	15	3	1		2		19	74
3-5 yts.	73	39	2		4	6		45	124
<hr/>									
0-5 yts.	193	60	7	3	5	11		75	279
6-10	50	23	9		4	7		36	93
11-15	42	12	2			4		14	60
16-20	40	10	1	1	1	5		13	58
21-26	46	11	3		3	4		17	67
27-35	35	22	3		1	4		26	65
36-45	30	6	2	1	1	5		10	45
46-55	17	7	2		1	5		10	32
56-65	18	6	1	3	7	2		17	37
66+	23	18		2	11	8		31	62
No victim/ unknown	1	1	1	3	1	8		6	15
TOTAL	495	176	31	13	35	63		255	813

TABLE 6

Distribution of Type of Injury Incurred
by Appliance Product

<u>Injury</u>	<u>Space Heaters/ Heating Stoves</u>	<u>Kitchen Ranges</u>	<u>Wringer Washers</u>	<u>Hot Water Heaters</u>	<u>Irons</u>	<u>Total</u>
Burn	163	373	1	54	36	627
Smoke Inhalation	16	7				23
CO Poisoning				14		14
Laceration	4	11	24			39
Contusion	1		53			54
Crush			14			14
Abrasion			13			13
Avulsion			3			3
Sprain			2			2
Fracture		4	3			7
Amputation			2			2
Concussion	1					1
Other/Unknown	1	6	5		1	13
No injury				1		1
TOTAL	186	401	120	69	37	813

TABLE 7

Distribution of Space Heater &
Heating Stove Accident Victims by Age and Sex
(FY 73 NEISS)

Age Group	Male	Female	Total	Percent of Total
0-12 mos.	23	12	35	13.2
13-18 mos.	11	6	17	6.4
19 mos.-2 yrs.	15	16	31	11.7
3-5 yrs.	20	21	41	15.4
<hr/>				
0-5 yrs.	69	55	124	46.6
6-10	13	13	26	9.8
11-15	8	4	12	4.5
16-20	4	8	12	4.5
21-26	12	6	18	6.8
27-35	12	9	21	7.9
36-45	10	12	22	8.3
46-55	6	9	15	5.6
56-65	2	3	5	1.9
66+	9	2	11	4.1
<hr/>				
Total	145	121	266	
Percent of total	54.5	45.5		100.0

TABLE 8

Distribution of Space Heater &
Heating Stove Accident Victims by Age and Sex
(IDIR's)

Age Group	Male	Female	Total
0-12 mos.	8	4	12
13-18 mos.	5	7	12
19 mos.-2 yrs.	7	18	25
3-5 yrs.	26	17	43
<hr/>			
0-5 yrs.	46	46	92
6-10	6	12	18
11-15	2	5	7
16-20	5	8	13
21-26	3	6	9
27-35	12	7	19
36-45	5	2	7
46-55	1	1	2
56-65	2	3	5
66+	6	7	13
No victim			1
<hr/>			
Total	88	97	186

Twenty-six IDIR victims of space heater accidents could be described as physically or emotionally handicapped. That is, their response capabilities were impaired due to alcohol consumption, drug use, fatigue, seizures, dizziness, or the like. While it may be inferred that such factors contributed to the sequence of events leading to the accident, complete information was usually missing from the case histories. These data are admittedly difficult to obtain; victims are often reluctant to reveal such factors for fear of public embarrassment, insurance cancellations, legal problems, etc. There is a need for skilled IDIR interviewers who can convince and reassure victims that anonymity will be maintained.

3.2.2 Injuries

Burns were the most frequently observed result of space heater accidents, involving 163 of the 186 IDIR victims. Another 16 victims suffered inhalation poisoning, and the remaining seven victims (all children five years of age or less) incurred lacerations, contusions, or concussions after "Falling into" a heating unit.

Eleven deaths resulted from space heater accidents and another 49 of the total 186 IDIR victims required hospitalization.

While the oldest group (66+ years) was not over-represented in accident occurrence, the injuries incurred by these victims were more severe than average. As Table 9 illustrates, five of the 13 victims in this age group were fatalities and another three were hospital admissions.

3.2.3 Behavioral Classification

Activities preceding space heater accidents were divided into four major categories. Table 10 lists these activities, along with the associated number of IDIR victims. The two most frequently observed categories of behavior, "Interacting with" and "Occupied near" were further classified into more explicit descriptions of the victim's antecedent behavior.

Only 59 of the 186 IDIR victims were injured while directly "Interacting with" the heater, that is, while engaged in activities related to the unit's heating function. Another 94 victims were injured while engaged in nearby unrelated activities, and seven victims were simply "Passing by" the unit. The implication is, of course, that space heater hazards do not relate only to the direct operation of the space heater.

The fourth category, "No causative activity," refers to those behaviors prior to the accident that could not be integrated into the accident sequence. Sleeping victims of carbon monoxide poisoning are an example.

Summaries of 122 FFACTS were classified according to the same behavioral categories. The results of this effort are also shown in Table 10.

TABLE 9

Distribution of Space Heater Accident Victims
(IDIR's) by Age and Hospital Disposition

Age Group	Hospital Disposition							Total
	Treated & Released	Treated & Admitted	Treated & Transferred	Dead on Arrival	Died Later	Other* Unknown		
0-12 mos.	9		2	1			12	
13-18 mos.	10	1		1			12	
19 mos.-2 yrs.	21	2	2				25	
3-5 yrs.	32	0	1			1	43	
<hr/>								
0-5 yrs.	72	12	5	2		1	92	
6-10	9	4	3		2		18	
11-15	5	2					7	
16-20	3	5	1		1	3	13	
21-26	5	3				1	9	
27-35	9	6	2		1	1	19	
36-45	6	1					7	
46-55	1					1	2	
56-65	3	1	1				5	
66+	3	2	1		5	2	13	
No victim						1	1	
<hr/>								
Total	116	36	13	2	9	10	186	

*"Other" category includes those who suffered from inhalation of fumes but received no treatment.

TABLE 10

Behavioral Classification of
Space Heater and Heating Stove Accidents

<u>Activity</u>	<u>Number IDIR's</u>	<u>Number FFACTS</u>
Interacting with	59	26
- lighting	6	6
- warming	40	18
- place object on	1	0
- sit on	2	1
- touch purposely	10	1
Occupied near	94	65
- standing	5	35
- playing	19	4
- working	3	4
- using flammables	14	16
- fell into	50	4
- lean over heater	3	2
Passing by	7	10
No causative activity	24	8
Other/unspecified	2	13
<hr/>		
TOTAL	186	122

Certain age-related activities were observed. All 10 IDIR victims whose behavior was described as "Using: touched purposely" were children five years of age or less. All but one victim injured while "Passing by" was 10 years old or less. These trends imply that some children are not cognizant of space heaters as a hazard and that the units are not (or cannot be) located outside a child's sphere of activity. Similarly, 36 of the 50 victims who were "Occupied near: fell into" were children.

3.2.4 Product Factors

Due to the large number of IDIR accidents that occurred without the victim actually using the heater, an effort was made to assess the condition of the unit itself. Heating units were judged to "Need repair" or be characterized by "Poor design" according to the guidelines listed in the Appendix. Even though insufficient data often made classification difficult, 118 of the units in the IDIR sample were judged in "Satisfactory" condition. Another 51 units showed "Poor design," 16 were shown to "Need repair," and no decision could be made in one instance.

Accidental injury seems to have occurred far more frequently with gas space heaters and heating stoves than any other type. Of the 186 sample IDIR's, 131 cases involved gas, 19 involved electric, 10 involved oil or kerosene, and the remaining 26 cases concerned heating units of an unspecified nature.

3.2.5 Injury/Hazard/Activity Sequences

Two commonly observed accident sequences were noted:

1. While using a space heater to warm themselves, individuals moved too close to the gas heater's exposed flame. Clothing ignition and burn injuries resulted.
2. While engaged in unrelated "play" activities nearby, children fell into the heating unit and incurred relatively minor contact burns.

Some of the hazards associated with space heaters and heating stoves have already been noted; these include an exposed flame, gas explosion/accumulation potential, and high surface temperatures. In addition, the present data suggest that the presence of the unit itself may be hazardous, for a relatively large number of victims (94) were injured while engaged in activities adjacent but unrelated to the heating unit. Whether or not these accidents can be linked to the portability of many of the units (which implies that the user can position it "hazardously") is a topic for further study.

3.3 Kitchen Ranges

Kitchen ranges rank 17th on the CPSC listing of hazardous products. A total of 401 IDIR's dealing with range-related accidents were available for NBS use. Both gas and electric ranges were included.

3.3.1 Victim Characteristics

According to the NEISS data, more females than males were injured in range-related accidents. As shown in Table 11, 59.2 percent of the victims were female and 40.8 percent were male.

This sex distribution is not consistent across all age groups, as Figure 2 illustrates. Notable exceptions occur:

- in the youngest age group (0-5 years) where the majority of the victims, 58.9 percent, were male.
- in the 21-26 year old age group. Here 71.8 percent of these victims were female, many of whom were probably young homemakers interacting extensively with a kitchen range for the first time.
- in the oldest age group (66+) where 72.4 percent of the victims were women. At this age level, however, the majority of the total population is female.

The age distribution for the victims of kitchen range accidents was similar to the age distribution for all appliance accidents combined. Again, a relatively large percent of the injured, (27.0 percent of the NEISS victims) were drawn from the youngest 10 percent of the population (see Table 11).

Table 12 presents the IDIR data for kitchen ranges. The age and sex trends correspond well to those reported in FY 73 NEISS, suggesting that the sample studied was representative, at least with respect to these factors, of the overall surveillance system data.

3.3.2 Product Factors

The data suggest that gas ranges are more hazardous than electric ranges. While the Gas Appliance Manufacturers Association, Inc. reports (NEISS News, April 1975) a nearly equal number of gas and electric ranges in residential use in 1974, gas range accidents outnumbered electric range accidents 2.6 to 1 in the IDIR's sampled. Even higher ratios between gas and electric range-related accidents were reported in FY 73 NEISS (3.0 to 1) and FY 74 NEISS (2.8 to 1).

3.3.3 Injuries

Burns were the most commonly observed injury associated with kitchen ranges, affecting 373 of the 401 IDIR victims.

TABLE 11

Distribution of Range Accident
Victims by Age and Sex
(FY 73 NEISS)

Age Group	Male	Female	Total	Percent of Total
0-12 mos.	92	60	152	11.7
13-18 mos.	22	16	38	2.9
19 mos.-2 yrs.	51	28	79	6.1
3-5 yrs.	41	40	81	6.3
<hr/>				
0-5 yrs.	206	144	350	27.0
6-10	45	28	73	5.6
11-15	27	50	77	5.9
16-20	52	103	155	12.0
21-26	53	135	188	14.5
27-35	35	97	132	10.2
36-45	33	58	91	7.0
46-55	35	70	105	8.1
56-65	27	38	65	5.0
66+	16	42	58	4.5
Unknown		1	1	0.1
No victim			1	0.1
<hr/>				
Total	529	766	1296	
Percent of total	40.8	59.2		100.0

Figure 2. Frequency of NEISS Range-related Accidents as a Function of Victims' Age and Sex

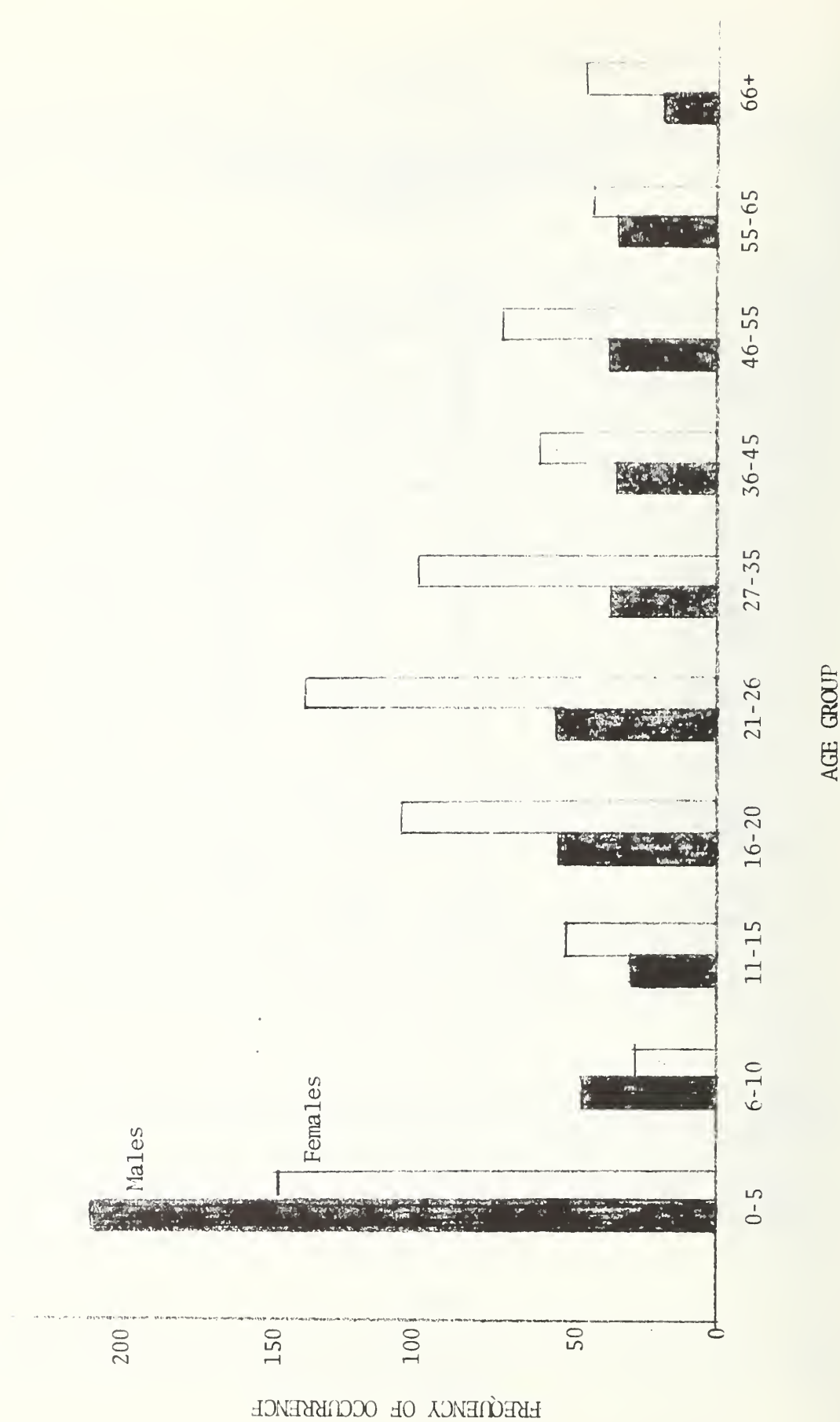


TABLE 12

Distribution of Range Accident Victims
by Age and Sex
(IDIR's)

Age Group	Male	Female	Total
0-12 mos.	13	3	16
13-18 mos.	8	9	17
19 mos.-2 yrs.	13	10	23
3-5 yrs.	18	13	31
<hr/>			
0-5 yrs.	52	35	87
6-10	12	23	35
11-15	18	21	39
16-20	13	22	35
21-26	12	36	48
27-35	9	18	27
36-45	13	17	30
46-55	10	16	26
56-65	12	16	28
66+	7	32	39
Unknown	1	0	1
No Victim	4	2	6
<hr/>			
Total	163	238	401

Burns were inflicted in three basically different ways. Many (170 of the cases) victims were burned by direct contact with flames, often following flammable fabric ignition. Others (108 victims) received contact burns from a hot surface or were burned by the heat from a gas range explosion (92 victims).

The type of injury incurred as a function of the IDIR victim's age is shown in Table 13. Since no relationship between age and range type was apparent, gas and electric ranges have been combined. Note that one-half of the victims of contact burns were children five years of age or younger.

Of the 401 victims of kitchen range accidents, 245 were treated and released from a hospital emergency room, and 89 required hospitalization but survived. A total of 32 fatalities (48 were observed in the overall IDIR sample) were associated with kitchen ranges.

No accident severity trends were observed by range type, age group, or sex.

3.3.4 Behavioral Classification

Classifying victim behavior just prior to an accident is one of the most crucial features of a human factors approach to accident research. At an earlier date NBS staff had performed a behavioral analysis of kitchen range accidents using FFACTS data (Pezoldt, Persensky, and Peiser, 1973). The activity sequences developed at that time were applied to all comparable IDIR's in the present study, that is, those 215 case studies involving flammable fabric related fires. New behavioral categories were developed for the remaining data.

The behavioral classification of flammable fabric range accidents is shown in Table 14. Five of the nine categories encompassed behavior broad enough to require further subdivision. Table 14 depicts the number of accidents associated with each activity sequence for both the flammable fabric related IDIR's and FFACTS case histories analyzed earlier.

Similar relationships were found in both data bases. For example, 33 of the 215 subsample IDIR victims and 44 of the 285 FFACTS victims were injured while "Leaning against the range." Similarly, 38 of the IDIR and 43 of the FFACTS victims were injured while "Occupied near the range." These similarities support the validity of the activity sequences identified. However, a notable discrepancy exists for the "Reaching across the range" category. Here, 103 of the 285 FFACTS victims, but only 42 of the 215 IDIR victims were injured in this manner.

Many range-related accidents do not occur during range use, as an examination of Table 14 reveals. None of the activities described in Categories IV or V ("Occupied near range" and "Climbing onto or around range") involved use of the range for cooking or meal preparation. Together these categories encompass a substantial number of cases in both data bases (50 IDIR's, 62 FFACTS).

TABLE 13

Distribution of Range Accident Victims
(IDIR's) by Age and Type of Injury

Age Group	Burns		Burns		Burns		Burns		Burns		Unknown/		Total
	Flames	Explosion	Contact	Unknown	Laceration	Inhalation	Fracture	None	None	None	None	None	
0-12 mos.		1	13		1	1							16
13-18 mos.	1	1	15										17
19 mos.-2 yrs.	7		17		1								25
3-5 yrs.	16	1	9		2	1							29
<hr/>													
0-5 yrs.	24	3	54		4	2							87
6-10	23	7	4				1						35
11-15	21	11	6		1	1							39
16-20	12	16	5		1								35
21-26	15	22	11		2	1	1						48
27-35	8	12	4							1			28
36-45	16	5	7							1			29
46-55	10	4	10		2	1							26
56-65	15	5	6	1	1								28
66+	26	6	1	2	1	1	2						39
Unknown		1						6					7
<hr/>													
Total	170	92	108	3	11	7	4	6					401

TABLE 14

Behavioral Classification of IDIR and FFACTS
Range Accidents
(Flammable fabric related accidents only)

	<u>Behavioral Category</u>	<u>Subsample IDIR's</u>	<u>Total FFACTS</u>
I.	Reaching Across Range	42	103
	A. To set controls	6	11
	B. To back burner, front burner energized	2	14
	C. To item on range surface	12	13
	D. Accidentally energizing burner	0	3
	E. While standing on chair	2	6
	F. Contact with pilot	0	4
	G. Other, cooking	17	52
	H. Unaware burner was on	3	0
II.	Reaching Above Range	14	21
	A. Into cupboard/shelf above	6	7
	B. Other than into cupboard	2	6
	C. Accidentally energizing burner	1	2
	D. While standing on chair	5	6
III.	Leaning Against Range	33	44
	A. Using range as support	11	13
	B. Unaware burner was activated	1	4
	C. Falling, fainting, tripping, etc.	12	6
	D. Using range as heater	9	21
IV.	Occupied Near Range	38	43
	A. Walking near range	8	6
	B. Standing in close vicinity	16	29
	C. Standing on chair near range	8	8
	D. Using range as heater	6	0
V.	Climbing Onto or Around Range	12	19
	A. Directly on range	9	12
	B. On adjacent counter	2	7
	C. To keep warm	1	0

TABLE 14 (Con't)

	<u>Behavioral Category</u>	<u>Subsample IDIR's</u>	<u>Total FFACTS</u>
VI.	Flammable Solvent Used Near Range	17	9
VII.	Physical or Emotional Problem	5	7
VIII.	Grease Related	17	19
IX.	Other	37	20
	A. Upset pan on range	3	
	B. Testing to verify if burner is on	2	
	C. Accidentally energized burner	3	
	D. Touching hot cooking surface	4	
	E. Misc/unknown	25	
<hr/>			
	TOTALS	215	285

The remaining 186 IDIR's (those not involving flammable fabric fires) are classified by activity sequence in Table 15. Nearly half (86) of the victims of these accidents were injured by gas range explosions. Another 49 victims, most of whom were children, received contact burns after touching a hot surface.

Items III and IV on Table 15 are "catch-all" categories, encompassing the rather small number of "Non-burn" injuries and "Others." In both Tables 14 and 15, "Others" refers either to those accidents which were in some way unique or for which little or no behavioral information was available.

Finally, the activity sequences identified for all 401 IDIR's are shown as a function of range type in Table 16. Categories VIII and IX, "Flammable solvent used near range" and "Explosion" are limited to gas ranges. The majority of the other behavioral categories involved more gas than electric ranges, a finding in consonance with the overall ratio of gas to electric range-related accidents reported above. The "Climbing onto or around range" and "Grease related" categories are exceptions, for they involve electric ranges more often than gas.

3.3.5 Injury/Hazard/Activity Sequences

Burns were the usual injury resulting from kitchen range accidents in the IDIR data; the overwhelming majority of victims (393) suffered some sort of burn injury. A variety of hazard/activity sequences, however, were noted.

Fabric ignition was the hazard most frequently encountered. More than half of the surveyed victims were injured after some part of their clothing ignited, usually following contact with an energized surface element. The activities related to this hazard usually involved reaching across or above the range while cooking. More often than not, a loose-fitting sleeve or shirt tail was involved.

The exposed pilot light on gas ranges was also identified as hazardous. In this case, the accident sequence often included attempts to light an oven or burner pilot. Other injuries resulted from the use of volatile liquids in the vicinity of an exposed pilot light.

Finally, hot surface temperatures on both types of ranges were found hazardous, especially to children. An activity sequence commonly associated with this hazard involved a young child, just learning to walk, using the fronts of kitchen cabinets and appliances for support. A child who encounters a hot oven door in this manner often does not possess the motor skills which would enable him or her to move quickly enough to avoid injury. It is noteworthy, however, that the injuries related to hot surfaces were not as severe as those associated with kitchen ranges in general.

TABLE 15

Behavioral Classification of IDIR Range Accidents
(Non-flammable fabric-related accidents)

	<u>Category</u>	<u>No. of Incidents</u>
I.	Explosions	86
	A. Lighting the oven, explosion occurs	66
	B. Lighting the burner, explosion occurs	14
	C. Range explosion, other/unknown pilot	5
	D. Microwave explosion	1
II.	Touching hot surface (e.g., oven door)	49
III.	Non-Burn	23
	A. Cleaning oven	3
	B. Lost balance, fell	5
	C. Bumping into range	2
	D. Closing oven or broiler door on hand	2
	E. Laceration on other range-part	3
	F. Smoke inhalation	1
	G. Gas leak (inhalation)	7
IV.	Other	28
	A. Climbing on oven or broiler	4
	B. Moving grease	4
	C. Camp stove related	6
	D. Unspecified	14
TOTAL		186

TABLE 16

Behavioral Classification by All IDIR
Range Accidents by Range Type

	<u>Activity Pattern</u>	<u>Range Type</u>			<u>Total</u>
		<u>Gas</u>	<u>Electric</u>	<u>Other/ Unspecified</u>	
I.	Reaching across range	23	17	2	42
II.	Reaching above range	11	3	0	14
III.	Leaning against range	20	12	1	33
IV.	Occupied near range	22	13	3	38
V.	Climbing onto or around range	4	7	1	12
VI.	Grease related	5	9	3	17
VII.	Physical or emotional problem	5	0	0	5
VIII.	Flammable solvent used near range	17	0	0	17
IX.	Explosions	85	0	1	86
X.	Touching hot surface	18	9	22	49
XI.	Non-burn injuries	18	3	2	23
XII.	Other	<u>29</u>	<u>23</u>	<u>13</u>	<u>65</u>
	TOTAL	257	96	48	401

Several measures may be taken to alleviate or reduce these hazards. For example, the surface temperatures on oven doors may be reduced. Backsplash controls can be placed high enough above the range top to reduce the probability that loose-fitting garments will touch an energized burner. Both measures have, in fact, been addressed by the latest revisions (effective September 30, 1975) to the Underwriters' Laboratory Standard (#858) for kitchen ranges.

Other safety measures might include shielding a gas burner pilot from any possible contact with the range user's clothing. Reminding parents of the dangers of storing substances attractive to children above, in, or nearby the range would be helpful and the designers of future kitchens should insure that cabinets or shelves are not built directly above the range. The relatively large number of gas explosions resulting in accidental injury are of particular concern. Unfortunately, whether these accidents may be attributed to product factors or human factors is generally unknown.

3.4 Wringer Washers

A total of 120 IDIR's were summarized concerning washing machines with wringers, the 28th most hazardous product according to the CPSC Hazard Index. FY 73 NEISS data was also available for this product.

3.4.1 Victim Characteristics

Tables 17 and 18 show the age and sex distributions of wringer washer accident victims for NEISS and the IDIR's, respectively. While no sex differences were observed for IDIR victims, nearly two-thirds (62.1 percent) of the victims reported by NEISS were female.

For age, however, both data bases show distinctive age biases. Fifty-seven of the 120 IDIR victims were children five years or less and another 31 victims were 6-10 years old. NEISS reports percentages of 38.5 percent and 20.0 percent, respectively, for these same age groups.

Once the high incidence of injuries to the two youngest age groups was noted, the case histories were reread to determine whether or not a supervising adult had been present when the accident occurred. For those 88 IDIR cases involving children ten years of age or less, 19 occurred in the presence and 46 in the absence of adult supervision. Even though no classification could be made for the remaining 23 cases, the data clearly suggest that wringer washers pose a greater hazard for an unsupervised child as for a supervised child.

Finally, an age by sex interaction was observed for the victims of wringer washer accidents. An examination of both Tables 17 and 18 reveals that younger wringer washer victims tended to be male but older victims were more often female. Societal sex roles suggest a possible

TABLE 17

Distribution of Wringer Washer
Accident Victims by Age and Sex
(FY 73 NEISS)

Age Group	Male	Female	Total	Percent of Total
0-12 mos.	2	1	3	0.7
13-18 mos.	4	2	6	1.3
19 mos.-2 yrs.	22	10	32	7.1
3-5 yrs.	78	54	132	29.4
<hr/>				
0-5 yrs.	106	67	173	38.5
6-10	41	49	90	20.0
11-15	8	13	21	4.7
16-20	2	9	11	2.4
21-26	2	18	20	4.5
27-35	1	18	19	4.2
36-45	5	11	16	3.6
46-55	1	19	20	4.5
56-65	1	17	18	4.0
66+	3	58	61	13.6
<hr/>				
Total	170	279	449	
Percent of total	37.9	62.1		100.0

TABLE 18

Distribution of Wringer Washer
Accident Victims by Age and Sex
(IDIR's)

Age Group	Male	Female	Total
0-12 mos.			
13-18 mos.			
19 mos. -2 yrs.	9	7	16
3-5 yrs.	29	12	41
<hr/>			
0-5 yrs.	38	19	57
6-10	18	13	31
11-15		5	5
16-20	2	2	4
21-26		1	1
27-35		8	8
36-45		3	3
46-55			
56-65		3	3
66+		7	7
Unknown	1		1
<hr/>			
Total	59	61	120
Percent of total	49.2	50.8	

explanation. Young boys are more likely than girls to be attracted by the "mechanical" nature of the washer's moving wringers and to be injured while exploring the machine's workings. Older victims, on the other hand, are most often housewives injured while using the machine.

3.4.2 Injuries

Almost all of the IDIR wringer washing machine accidents involved the machine's moving wringer. It is not surprising, then, that 53 of the 120 resultant injuries were contusions. Lacerations were also common (14 cases), as were crushes (14 cases) and abrasions (13 cases). Injury type was apparently not age-related.

3.4.3 Behavioral Classification

"Feeding clothes through the wringer" was the most common activity preceding a wringer washer accident in the IDIR data. As Table 19 indicates, a substantial number (50) of victims, including most of the adults, were injured in this manner, that is, while using the machine for its intended purpose.

Twenty-six children aged ten or under were also injured while "feeding clothes through the wringer," but many of these young victims were described as mimicking or attempting to help their mothers or caretakers.

Most other children were injured after "Touching the roller" or "Playing" with the machine. IDIR interviewers frequently attributed the former activity to the child's curiosity. Indeed, careful reading of the case studies suggests strongly that the moving wringers hold an inherent fascination for children. Those victims described as "Playing" were often trying to feed an object other than clothes (e.g., toys) through the wringer.

3.4.4 Injury/Hazard/Activity Sequences

A common injury/hazard/activity sequence to emerge from the wringer washer data involved a young child, usually a boy, who was fascinated by the movement of the wringer on the washing machine. When his or her caretaker was somehow distracted or absent, the child touched the wringer, or attempted to put some object through it. The child's arm was drawn into the wringer and the resulting injury involved a bruised, crushed, or lacerated arm.

The most hazardous aspect of a wringer washer appears to be the wringer itself. It is related to both product use and product abuse injuries. Some product use injuries might be prevented by added safety features. An emergency release button, already present on some models, is an example. Underwriters' Laboratory Standard #560 (Electric Home-laundry Equipment), already specifies that the roller system be designed such that it disengages whenever a force greater than 20 pounds is

TABLE 19

Behavioral Classification of IDIR
Wringer Washer Accidents by Age of Victim

Age Group	Feeding Clothes Through Wringer	Playing	Touching Roller	Resting Near Arm or Hand Resting Near Roller	Climbing Near	Pulling Clothes From Rollers	Knocked Over Washer	Slipped or Tripped	Other/ Unknown	Total
0-12 mos.										
13-18 mos.										
19 mos.-2 yrs.	2		10	1	2		1			16
3-5 yrs.	11	15	8	1	1				5	41
0-5 yrs.	13	15	18	2	3	0	1	0	5	57
6-10	13	9	1			1		1	6	31
11-15	3			1					1	5
16-20	3	1								4
21-26	1									1
27-35	8									8
36-45	2					1				3
46-55										0
56-65	2					1				3
66+	5			1					1	7
Unknown									1	1
TOTALS	50	25	19	4	3	3	1	1	14	120

applied in a direction other than that which feeds the roller. The adequacy of this 20 pound requirement should be examined in light of the relatively large number of injuries still occurring during proper product use.

Since abuse injuries with wringer washers seem to involve mostly children, the prevention of these injuries could focus on making the wringer's operation somehow less appealing. A possible but untested solution would involve designing a shield to obscure the moving rollers from young observers. Since a number of children were injured after activating the wringer themselves, the operation of the wringer could be made more complicated. For example, the continual depression of a foot pedal could be required for operation. Careful positioning of this pedal could ensure that the average child could not simultaneously depress it and still reach the wringer.

3.5 Hot Water Heaters

Water heaters rank 39th on the CPSC Hazard Index. While these appliances are fueled in a variety of ways, utility gas and electricity are, of course, the most common methods. The Census Bureau reports (July 1972) that approximately 35.0 million gas and 16.1 million electric water heaters are currently in use. However, only two of the 69 available IDIR's dealing with water heater accidents involved electrically fueled units. The remainder were powered by natural gas (43 cases), bottled gas or oil-fired fuel (16 cases), or by an unknown or unspecified agent (8 cases).

3.5.1 Victim Characteristics

Sex of the victim was a factor in hot water heater accidents. Table 20 shows that 66.8 percent of the FY 73 NEISS victims were male and 33.2 percent were female. The IDIR sample also reflects this sex trend. As shown in Table 21, 40 of the 69 hot water heater victims were male and only 24 were female (the sex of the remaining five victims was unspecified).

Children were again over-represented as accident victims. Here, 22.4 percent of the NEISS and 19 of the 69 total IDIR victims were five years of age or less.

It should be noted that the correspondence between the IDIR sample and the NEISS surveillance system data is not as high for hot water heaters as for the other appliances studied. The small sample size also suggests that all reported relationships be considered cautiously.

3.5.2 Injuries

Burns and carbon monoxide poisoning were the only two types of injuries reported in the IDIR's: 54 and 14 hot water heater victims, respectively, incurred these injuries. Type of injury was not related to the victim's age and sex in the IDIR sample.

TABLE 20

Distribution of Hot Water Heater
Accident Victims by Age and Sex
(FY 73 NEISS)

Age Group	Male	Female	Total	Percent of Total
0-12 mos.	6	5	11	4.9
13-18 mos.	5	4	9	4.0
19 mos.-2 yrs.	15	7	22	9.9
3-5 yrs.	6	2	8	3.6
<hr/>				
0-5 yrs.	32	18	50	22.4
6-10	14	7	21	9.4
11-15	9	2	11	4.9
16-20	16	5	21	9.4
21-26	21	8	29	13.0
27-35	17	17	34	15.2
36-45	18	7	25	11.2
46-55	13	4	17	7.6
56-65	7	4	11	4.9
66+	2	2	4	1.8
<hr/>				
Total	149	74	223	
Percent of total	66.8	33.2		100.0

TABLE 21

Distribution of Hot Water Heater
Accident Victims by Age and Sex
(IDIR's)

Age Group	Male	Female	Unknown	Total
0-12 mos.	4	2		6
13-18 mos.	1	1		2
19 mos.-2 yrs.	4	1	1	6
3-5 yrs.	4	1		5
<hr/>				
0-5 yrs.	13	5	1	19
6-10	2	3		5
11-15	5	2		7
16-20	3	2		5
21-26	-	5		5
27-35	5	6		11
36-45	4	1		5
46-55	3	-		3
56-65	1	-		1
66+	3	-		3
Unknown	1		3	4
No victim			1	1
<hr/>				
TOTAL	40	24	5	69

Five fatalities were reported and another 22 of the 69 IDIR victims were hospitalized. Note, however, that the hospital disposition of 12 victims, a relatively large proportion of the sample, was not known. None of the victims suffering from carbon monoxide poisoning required hospitalization.

3.5.3 Behavioral Classification

The precipitating activity sequences for hot water heater IDIR accidents are shown in Table 22. In 20 of the 69 cases the victim's activity was judged "Irrelevant to the accident" suggesting that product, rather than human, factors were involved in the causal chain of events precipitating the accident. Typical product factors could include design defects or malfunction.

Table 22 also shows that 17 victims were injured while "Using a flammable substance near a heater." The most typical flammable substance was gasoline being used as a cleansing agent. Another eight victims "Upset or spilled a flammable substance" in the vicinity of a heater. These data suggest a general lack of awareness of the presence of an exposed flame.

Still another seven victims encountered scald burns, an injury unique to this appliance judging by the IDIR's. Children who "Contacted hot water from the faucet" while being bathed were usually involved in these accidents. A malfunctioning or improperly adjusted thermostat was frequently implicated.

Because FFACTS deals only with flammable fabric-related accidents, the activity sequences developed for the IDIR sample were not applicable to the 75 hot water heater accidents reported in FFACTS. It should be noted, however, that 47 of the FFACTS cases involved using a flammable liquid near the heater and another 10 cases involved a spilled or upset flammable liquid.

3.5.4 Injury/Hazard/Activity Sequences

In the present study, the open flame of a gas pilot light emerged clearly as a water heater hazard. Burns were the most common and severe of the observed injuries. The most frequently related activity involved the use of a flammable solvent, usually gasoline. Thus, the most commonly encountered injury/hazard/activity sequence in the IDIR data involved the use of a flammable solvent near the hot water heater. Flames or an explosion resulted, and the victims suffered burn injuries.

It is apparent that many of the victims of hot water heater accidents were unaware of the potential hazards associated with this appliance. Because the operation of the appliance does not require constant or regular monitoring, the consumer may "forget" that an exposed flame is present when flammable substances are being used. Other victims reported not knowing that the fumes from a volatile

TABLE 22

Behavioral Classification of IDIR
Hot Water Heater Accidents

<u>Activity</u>	<u>Total</u>
Activity-irrelevant (gas or fume leak)	20
Using flammable substance near heater	17
Upset or spilled a flammable substance	8
Lighting pilot light	9
Contact with hot water from faucet	7
Bumped into hot water heater	3
Other (includes "no injury")	5
<hr/>	
TOTAL	69

substance could ignite, and thus perceived no danger in using flammable liquids in the same room as a gas hot water heater. Here certain accidents might be prevented by appropriately shielding the heater's open flame. In addition, highly conspicuous labels depicting the dangers of an exposed flame could be affixed to the appliance to "remind" the user of its inherent dangers.

A relatively large number of hot water heater accidents were unrelated to the behavior of the victim; as noted above, 20 of the 69 IDIR's could be attributed directly to faulty equipment or gas leaks. Besides educational programs which stress the importance of regular product maintenance and potential ignition hazards, little from a human factors approach can be applied towards water heater accident reduction.

3.6 Irons

Household irons rank 47th on CPSC's Hazard Index. Only 37 IDIR's dealing with iron-related accidents were available; any reported trends are therefore extremely tenuous.

3.6.1 Victim Characteristics

Table 23 shows the age and sex distributions for FY 73 NEISS iron accident victims. A disproportionately high rate (50.2 percent) of victims were children five years of age or less. Because of the small sample size, an age by sex distribution for iron IDIR's is not included but an over-representation of the youngest age group was again apparent. Twenty-four of the 37 victims were five years of age or less:

Within this youngest age group, no sex differences in relation to iron-related accident occurrence were observed in either data base. For all other age groups combined, however, the NEISS victims were 2.5 times more likely to be female than male, a finding in accord with traditional sex roles.

3.6.2 Injuries

Thirty-six of the 37 IDIR victims of iron accidents suffered burns. As judged by hospital disposition, these injuries were generally not severe. Only four victims required hospital admission. Thirty-one victims were treated and released and the disposition of the remaining two victims was not reported.

As use patterns would predict, a large proportion of the IDIR iron-related injuries (10 instances) were concentrated around the hands or wrist. Another eight injuries involved the feet or legs. No other isolated bodily part was consistently injured.

TABLE 23

Distribution of Iron Accident Victims
by Age and Sex
(FY 73 NEISS)

Age Group	Male	Female	Total	Percent of Total
0-12 mos.	35	24	59	12.8
13-18 mos.	29	13	42	9.1
19 mos. -2 yrs.	26	45	71	15.4
3-5 yrs.	32	28	60	13.0
<hr/>				
0-5 yrs.	122	110	232	50.2
6-10	11	22	33	7.1
11-15	6	22	28	6.1
16-20	9	25	34	7.4
21-26	14	29	43	9.3
27-35	12	19	31	6.7
36-45	7	17	24	5.2
46-55	3	13	16	3.5
56-65	1	11	12	2.6
66+	2	7	9	2.0
<hr/>				
Total	187	275	462	
Percent of total	40.5	59.5		100.1

3.6.3 Behavioral Classification

The behavioral categories developed for iron-related accidents are shown in Table 24 as a function of the victim's age. Note that age groups unrepresented in the IDIR sample have been omitted from this table.

"Pulling the cord" emerged as a frequent activity leading to an iron accident; 13 of the incidents could be characterized by this behavior. All victims in this category were children injured by a falling hot iron. Nearly half of these children were infants, 12 months of age or less.

Another five victims were injured after "Touching a hot iron"; again it should be emphasized that three of these victims were children.

Three accidents may be attributed to product failure and/or design defect. In these cases, adult victims were burned by emerging steam while "Examining the bottom of the iron".

Several other cases specified virtually nothing regarding the victim's specific actions just prior to the accident. The category "Playing" is an example. Since the varieties of children's play activities are innumerable, the designation of a behavioral sequence as "Playing" only occurred as a last resort, when no other activities were specified in the IDIR. This problem could be reduced by training future interviewers to be more explicit in their behavioral descriptions of the accident.

3.6.4 Injury/Hazard/Activity Sequences

An accident sequence commonly observed for iron-related accidents involved a young child (often an infant) pulling the cord of a hot iron and being injured as the hot iron fell on or next to him or her. With only one exception, the injured suffered burns; thus the IDIR data suggest little hazard associated with the mass of the iron itself. No simple design modifications are evident which would reduce or prevent the types of iron-related accidents found in the present data.

4.0 DISCUSSION

Certain relationships or trends have emerged from the data under study; thus a human factors descriptive analysis by individual appliance product has not been without merit. At times, hazards have been identified and possible, but untested, mechanisms to reduce accident occurrence and severity have been suggested. It is apparent, however, that the original intent, namely the identification of injury/hazard/activity patterns which would apply in a generic manner to all home appliances, has not met with success.

TABLE 24

Behavioral Classification of IDIR Iron
Accidents by Age of Victim

Age Group	Activity										Total
	Pulled Cord	Touched Hot Iron	Examining Bottom of Iron	Knock Iron Off Board	Bumped Against Iron	Playing	Tripped Over Cord	Dropped Iron	Other	Total	
0-12 mos.	6	1			1						8
13-18 mos.	4	1			1			2			8
19 mos.-2 yts.	1	1		1		1					4
3-5 yts.	1					1	1		1		4
0-5 yts.	12	3		1	2	2	1	2	1		24
6-10	1						1		2		4
11-15			1						1	2	2
16-20									1	1	1
21-26		1	2						1	4	4
46-55		1							1	1	1
Unknown				1						1	1
TOTALS	13	5	3	2	2	2	2	2	6		37

4.1 Problems

It is instructive to examine the factors working against a more satisfactory completion of this original task. In the first place, the limitations of the available data for a human factors analysis cannot be overemphasized. The inconsistencies, omissions, and dubious representativeness of the IDIR's have already been noted. These shortcomings render any trends described in the results section of questionable authenticity, though to a lesser degree if that same trend is also discernable in the available NEISS data.

Beyond these shortcomings, the IDIR's do not systematically record the right kind of information necessary for a complete human factors analysis. It was noted earlier that IDIR's purport to provide a description of the total accident sequence; this was, unfortunately, the exception rather than the rule, a fact unknown by NBS investigators at the time the study began. In addition, questions essential to a human factors approach are not part of the IDIR interviewing procedure. Information regarding the dimensions of the human victim (e.g., height, arm span, visual capabilities), the dimensions of the appliance products (weight, noise level), and the physical and psychological aspects of the human-product interface (attractiveness, ease of operation) must be included in the case histories if meaningful analysis is to be accomplished.

Yet improving the quality of the in-depth interview is not enough. More basic research is also needed to provide a perspective against which accident trends may be interpreted. Product use patterns serve as an example. In the present study, certain appliance-related accidents were distributed equally by sex. Such a finding can imply either that both men and women use that particular product equally often, or that some accidents can be attributed to high product exposure and others to unfamiliarity. Because both explanations are viable, the course of future research is ambiguous, since redesigning product features which become hazardous only after prolonged usage is not the same as reducing hazards due to user inexperience. The knowledge of product use patterns would reduce the ambiguity and allow for more efficient reduction of product-related hazards.

A better understanding of how a product is used is also needed. It is well known that consumer products are not always used in the designer's intended way; yet, patterns of product abuse and misuse now become apparent only when accidental injury and emergency room attention result. Product use and abuse patterns should be studied in their own right, initially as a function of product user factors such as age and sex.

Finally, a clear need exists for a better method of indexing accident severity. The validity of the CPSC Hazard Index currently used to determine product research priorities is open to question. NEISS statistics provide the basis for the Hazard Index, and while the intricacies of its computation are not of concern here, it is important to note that product severity is a weighted function of accident

frequency, injury severity, and age of the victim. Higher priorities are awarded younger victims. While injury severity is rated on a nine point scale, NEISS statistics are transmitted daily, indicating that emergency room diagnosis is the only basis for rating severity. Thus patients who later die as a result of product-related injury are not counted as fatalities. Similarly, factors such as length of hospitalization, the existence of long term and/or permanent disabilities, and loss of employment are not reflected in the Hazard Index. Perhaps more importantly, no account is made for frequency of product use. Embarrassing questions ensue. For example, are kitchen ranges (ranked 17th), which are used regularly by most people really more hazardous than wringer washers (ranked 28th), which are used occasionally by some people? Once a more acceptable method of indexing severity is developed, the attempt to identify hazards and hazardous activities associated with the most severe and debilitating accidents will be more fruitful.

4.2 Implications

Despite limitations, the present research has identified certain generic hazards. An open flame, whether associated with a kitchen range, hot water heater, or space heater or heating stove, is clearly the most hazardous feature of the appliances studied. Open flames were related to a variety of accidents, ranging from flammable fabric fires to gas explosions. Another generic hazard concerned hot surface temperatures; here all the studied appliances except wringer washers were involved. A "behavioral" generic hazard concerned leaving young children unattended in the presence of an appliance; this hazard was particularly poignant with wringer washers, but applicable in some degree to all appliances under study. Because such hazards cannot be identified within a total accident pattern of injuries, hazards, and activities, no reasonable recommendation for accident prevention or severity reduction can be specified generically. Instead, recommendations must be limited to specific appliances.

In addition to the delineation of generic hazards, the current results have underscored the strong relationship between age and accidental injury. The younger age groups are clearly over-represented as accident victims; so to a lesser extent are the elderly. Childhood accident proneness may be attributed to a number of factors, including curiosity, unfamiliarity with the environment and its hazards, and still developing perceptual/motor response systems. The elderly also suffer from impaired sensory-motor capabilities, a condition which, coupled with their decreased agility and increased fragility, renders them highly susceptible to accidental injury.

The aged experience a special problem regarding accident severity; half of the accident victims in the oldest ten percent of the population were fatalities or required hospital admission. It may be assumed (though such data were not analyzed) that because of their reduced recuperative abilities, a disproportionate number of long-term hospital stays are also associated with the elderly. Since the number and proportion of individuals who reach "old age" in our

society is currently increasing rather dramatically, the magnitude of problems this group experiences in relation to total product-related accidental injury will also increase.

4.3 Recommendations

In summary, the following recommendations are made:

1. Expand the data base. Redesigning the IDIR report form to include human factors data, i.e., information regarding the interface between the product involved and the human using that product, will contribute to a better understanding of the total accident sequence. This in turn can lead to better accident reduction and prevention programs.

There are immediate difficulties with such a suggestion since the relevant human factors information is often highly product-specific. In the case of a kitchen range accident, for example, the size of the range, the control knob location and type, and the armspan of the range user represent some of the pertinent product-specific human factors information. Collecting such data implies the preparation of a separate form, specific to each product, to accompany the general IDIR form. While such an undertaking is unwieldy, the benefits gained for products ranking high on the Hazard Index may compensate for the extra effort expended.

2. Intensify research efforts to describe product exposure and product use patterns. Answers to questions such as "Who uses the products?" "How often do they use them?" and "How do they use or abuse them?" are prerequisites to a meaningful application of epidemiological analyses such as the present effort, and consequently to any significant strides in product-related accident prevention and reduction.

3. Re-examine priorities. Product-related accident prevention has typically focused on children to the exclusion of other age groups. The current data clearly support the high accident-susceptibility of children but also suggest that their injuries tend to be minor. Perhaps the increasing percentage of elderly, whose accident-proneness represents more of a loss to society in terms of severity and time, should receive more attention.

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APPENDIX

Parameters Delineating the Condition of Space Heaters and Heating Stoves

Space heaters and heating stoves were judged to show "Poor Design" if one or more of the following conditions were observed:

1. An open flame with no protective grill.
2. Materials ignited when near but not touching the heater.
3. The legs were unsteady, or the heater was unbalanced and frequently tipped over.
4. A victim was burned by coming close to but not touching the heater.
5. Outside air currents could cause the flame size to change.
6. Guard rails became notably hot.
7. There was no safety switch on the pilot light to prevent gas accumulation.

Units were judged to "Need Repair" if one or more of the conditions listed below were met:

1. The wiring was worn.
2. Gas leaks were pronounced.
3. The protective glass covering the flames was broken.
4. The flue or internal pipes were disconnected.

Any other space heater or heating stove, which could not be described by any of these characteristics, was assumed in "Satisfactory" condition.

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