NBS TECHNICAL NOTE 867

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Relationship of Garment Characteristics and Other Variables to Fire Injury Severity

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Laura B. Buchbinder

The Cotton Foundation
Memphis, Tennessee 38112

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Programmatic Center for Fire Research
Institute for Applied Technology
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Washington, D.C. 20234

and

The Cotton Foundation
1918 North Parkway
Memphis, Tennessee 38112

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CONTENTS, continued

RELATIONSHIP OF GARMENT CHARACTERISTICS AND OTHER VARIABLES TO FIRE INJURY SEVERITY

Laura Baker Buchbinder[1]

This final report on an in-depth study of apparel fire accident variables focuses on the physical parameters of fabrics and garments involved in apparel fires and the relationship between these parameters and injury severity. Interactions between accident variables are summarized and recommendations for remedial action and further research are included. Garments involved in apparel fire accidents were classified by degree of fit and amount of the body covered. Fires in which the garment configurations involved covered over half the body (the dress/shift and pants/top configurations) were shown to be associated with more extensive burn injuries than fires involving configurations covering smaller areas (loose tops, fitted pants, and loose pants). Degree of fit could not be shown to be directly related to injury severity. Within garment configuration classifications, age was shown to be a major determinant of injury severity, with victims over 65 years of age receiving a significantly higher percentage of severe burns than those in the 21-65 age group. In accidents involving loose tops, fitted pants, and loose pants the presence of flammable liquids in the accident sequence appeared to be the dominant factor in determining injury level. In addition, when accidents involved flammable liquids, (1) the fabrics involved tended to be heavier, (2) the fit of the garment at point of ignition was closer, and (3) the proportion of cellulosic/synthetic blend and 100% synthetic fabrics was higher than in accidents which did not involve flammable liquids. Because of the many human and physical variables shown to be associated with an apparel fire accident, the author suggests a broad fire prevention program which includes both product regulation and public education.

Key words: Accident patterns; apparel; apparel fires; burn injury; FFACTS; fire; flammable fabrics; flammable liquids; garment fires; garment parameters; injury severity; victim's activity; victim's reactions.

1. INTRODUCTION AND STATEMENT OF PURPOSE

A number of variables are involved in an apparel fire accident. The circumstances surrounding the accident, the victim's activity causing or immediately preceding the accident, the flammable fabrics or flammable liquids involved in the accident, and the reactions of the victim and/or

[1]The author is presently working as a Research Associate for the Cotton Foundation at the National Bureau of Standards.

others nearby to apparel ignition are all variables which have influence on the result of the accident. The consequence, in human terms, can range from little or no burn injury to a severe burn injury resulting in permanent disfigurement or death to the victim. Numerous papers have been written about specific aspects of the apparel fire problem. Some [1,2][2] dealt with specific items of apparel involved in fire accidents. Others [3,4] focussed on various ignition sources. Still others [5,6] discussed the medical problems associated with the treatment of burns from apparel fire accidents. Some research [7] has dealt with the human or behavioral aspects of apparel fire accidents. In November 1972, this author initiated a study of the relationships between the fire accident variables, activity, reaction, garment parameters, and injury severity. The study used data from the Flammable Fabrics Accident Case and Testing System (FFACTS)[3] of the Center for Fire Research at the National Bureau of Standards. The purpose of the study was to identify patterns in those variables which describe the activity preceding the accident, the reaction of the victim to clothing ignition, the parameters of the fabrics and garments involved, and the level of severity of injury, and to define the extent and nature of the relationships between these accident variables. The relationships inferred and the understanding gained from the study should aid in defining the types of remedial action which are likely to be most effective in reducing human and economic loss due to apparel fires. In addition, analysis of the role of garment parameters in apparel fires can be useful in developing realistic garment flammability standards which relate to hazard. This is the final report on the results of this in-depth analysis of apparel fire accidents.

This paper includes a discussion and analysis of the contribution of various garment parameters to the extent of injury. The major problem areas associated with the four variables in the study, (1) activity, (2) reaction, (3) garment parameters, and (4) injury severity, are summarized. In addition, the author provides some insight gained from the analysis and offers suggestions for remedial action and areas for further research.

An interim report [8], "Study of Relationships Between Activity, Reaction, Garment Parameter Patterns and Injury Severity for Fire Incidents Involving Apparel," was published in April 1973. This report outlined the study and specified the procedures to be followed in data collection. Preliminary observations on activity patterns were included in the Appendix of that publication. In addition, two papers have been published analyzing specific aspects of the problem. One paper [9] dealt primarily with the relationships between the activity preceding the fire accident, the age and sex of the victim, and the extent of injury incurred from the accident.

[2]Numbers in brackets refer to the literature references listed at the end of this paper.

[3]FFACTS is a computerized data base derived from detailed case history investigations of fire accidents supplied primarily by Food and Drug Administration field investigators, augmented by NBS laboratory analysis of fabric samples submitted with the reports. This data base, with accident investigations now supplied by the Consumer Product Safety Commission, is described in more detail in reference 11.

The second paper [10], identified patterns in the reactions of the victim and other involved persons to garment ignition and related this variable to the level of injury.

2. STUDY DESCRIPTION

The study was based on the analysis of data from 1,126 apparel fire accident cases from FFACTS. The procedures followed in implementing the study were discussed by Buchbinder [8]. However, changes were made in the activity classification system and in the means of determining level of injury severity after that report was published. A discussion of these changes follows in sections 2.1. and 2.2.

2.1. Injury Severity Index

The original outline of the project called for the development of an injury severity index which would incorporate such factors as area of body burned, thickness of burn and the part or parts of the body involved into a single index which would provide an estimate of the severity of the injury. A number of candidate formulas for indices were developed. However, after consultation with several doctors in the burn field and careful evaluation of the quality of the medical data available in FFACTS, it was determined that such an index was more sophisticated than the accuracy of the data merited. Therefore in this study, one data element, percent total area of body burned, was used to estimate injury severity.

2.2. Activity Classification System

The activity classification system was revised to make it more flexible. The multilevel classification system which was used is shown in section B2.1. of the Appendix. The presence or absence of flammable liquids, flammable gases or high voltage electricity was the major criterion for coding in the first level of classification (A_1). In the A_2 classification the general activity of the victim was specified. Classifications A_3 and A_4 gave additional information about the activity and/or ignition source involved in the accident. Codes A_5 and A_6 provided information about the location of the accident, occupational relationship of the victim's activity (e.g., work or nonwork) and the special circumstances surrounding the accident. A report [9] on the results of analysis of data classified by this system has been published.

2.3. Reaction Classification System

The reaction classification system (see Appendix B) dealt with reaction capability as well as the actual post ignition reaction. The results of analysis of these data elements have also been published [10].

2.4. Garment Classification System

The article(s) of clothing contributing most to the injury were classified and coded according to shape, fit at point of ignition, and fit at point of most severe injury. This garment may or may not have been the first item to ignite in the accident. A subjective judgment was made regarding the garment's contribution to injury, and this was also coded. The garment classification system is shown in Appendix C. The analysis of this accident parameter is discussed in section 3.

3. ANALYSIS OF GARMENT PARAMETERS

While FFACTS is one of the most complete and detailed data bases containing information on apparel fires, clothing ignition represents a crisis situation, and detailed information on the sequence of events between ignition and extinction of the fire is limited. Therefore, such variables as the precise point of ignition, the actual fit and configuration of the garment(s) involved, and the time required to recognize and control the fire are often not available from the data base. However, some valuable knowledge can be gained by using available information in the case histories to make generalized assumptions about the less defined aspects of the data. Vickers, Tovey, and Krasny [11] analyzed some of these less well defined garment parameters relating to garment configuration and fit as well as the quantifiable fabric parameters such as fiber content, fabric construction and fabric weight. This paper also focuses on various garment parameters and the relationship between these parameters and injury severity; however, the classifications developed for this study differ to some extent from those used by Vickers, et al [11] resulting in somewhat different conclusions. The data presented in this paper support Vickers' observation that accidents involving loosely fitting dresses, nightgowns, and robes (dress/shift configuration) result in more severe burn injuries than accidents involving other more fitted configurations. However, since in this study the more fitted pants/top configuration also was associated with severe injury levels, it is not clear whether it is the degree of fit, the total body area covered by the garment(s) involved, or age/sex distributions within various configurations which account for the more extensive burn injuries associated with the dress/shift configuration.

The analysis which follows includes an explanation of the garment classifications used in the study and a discussion of the various garment configurations identified and their apparent relationship to injury severity. In addition, data are presented which relate certain fabric parameters such as weight and fiber content to the garment classifications developed for this study. Information is also provided on the degree of fit both at point of ignition and point of most severe injury. Support is developed for the premise that the involvement of flammable liquids in the accident sequence overrides the influence of variables associated with the garments(s) involved.

3.1. Explanation of Garment Configuration Classification

Sixteen garment classifications were developed based on garment configuration or shape [8]. A number of item types were combined into one category when their overall shapes seemed similar. For example, shirts, blouses, and pajama tops were all classified as "loose tops," while nightgowns, robes, and dresses were classified in the appropriate "shift/dress" category depending on the waistline fit. It was hoped that the investigator, reading the case histories, would be able to differentiate between garments with fitted and non-fitted waistlines, both in the dress and pants/top configurations; however, the data were not adequate for such an analysis to be meaningful. Therefore, for analysis all dress/shift configurations (fitted or non-fitted waistline and all pants/top and shorts/top configurations (shirt in - shirt out) were combined into the appropriate general groups (dress/shift, pants/top, and shorts/top).

Pajama pants and coveralls have a characteristically different fit and/or waistline treatment than regular trousers and thus, were classified in the category "loose pants". When both pajama top and pants were involved in the accident, they were classified as "loose top/loose pants". (A fitted "sleeper" type pajama would be classified differently.) Some classifications such as "long shift" and "shorts" or "shorts/top" were not discussed in detail in this analysis because of the limited number of cases involving these configurations.

Grouping of articles of apparel into categories representing degree of fit is difficult at best. Dress styles vary greatly in their degree of fit as do shirts and blouses; therefore, any grouping into classifications of this sort can only be viewed as approximations of fit. The problem of classificaion is further complicated by the fact that a shirt or blouse may be worn either inside or outside pants, and the way it is worn affects the shape or fit and perhaps the behavior of the apparel item in a fire situation. In their analysis, Vickers, Tovey, and Krasny [11] classified shirts as a fitted configuration. Unlike the Vickers study, shirts and pajama tops in this study were grouped into the same category and classified as loosely fitting. (More closely fitted knit shirts and T shirts were not included in this classification.) It was assumed, based on inference from reading the case histories, that the shirt was worn outside of the pants in most of the accidents. As was noted earlier, the data are not available to truly determine whether the shirt was actually worn outside or inside the trousers when the accident occurred. In addition, degree of fit is relative. For example, shirts may be viewed as loose relative to pants, but would be considered fitted relative to most robes.

The classification system allowed for coding of pants/top and shorts/top configurations in cases in which it was evident that both items were involved in the fire. The combined pants/top classifications may be expected to be associated with higher injury levels, since the involvement of two garments would probably indicate a more severe fire. However, it seemed that such a classification would allow recognition of these more extensive fires and contribute to the analysis of them. In addition, it might be misleading to attribute a burn covering much of the body to a

single item, such as a shirt, which covered only half the body.[4] For completeness, the individual items within the pants/top and shorts/top classifications which were judged to contribute most to the injury are listed in table 1. It should be noted that the ratio of pants to tops in the combined pants/top classification was similar to the ratio of pants to tops when classified separately.

Table 1. Numbers of Individual Item Types Contributing Most to Injury Within the Categories Pants/Top and Shorts/Top

	Direct Garment Ignition	Flammable Liquids Involved	Flammable Gases Involved	Total
Shirts or Blouses	10	32	10	52
Jacket	2	3	-	5
T Shirts or Undershirts	-	7	4	11
Sweaters or Sweatshirts	2	1	-	3
Total Number of Tops Involved	14	43	14	71
Pants or Slacks	5	13	4	22
Coveralls	-	4	-	4
Pajamas	1	-	-	1
Jumpsuit-Snow Suit	1	1	-	2
Shorts	-	2	-	2
Total Number of Pants Involved	7	20	4	31
Total	21	63	18	102

Finally, when the case history narrative indicated that ignition occurred at the sleeve, "sleeve" was coded as the garment type regardless of the overall configuration of the garment. Since accidents involving sleeve ignition were prevalent in the data and seemed to constitute a distinct accident type, coding was done in this manner to facilitate analysis of this type of accident and point of ignition.

3.2. Configuration of Primary Garment Involved in Fire Accident

The frequency of involvement of various garment configurations in apparel fire accidents varied with both the type of accident (i.e., one involving flammable liquids or gases versus one not involving such materials) and with the age and sex of the victim. In figure 1 it can be seen that the "dress/shift" and the "loose top" configurations accounted for the largest percentages (36% and 28% respectively) of garments involved

[4]The first-to-ignite single item classification, however, is most useful in identifying "hazardous" garments for the purpose of standard promulgation.

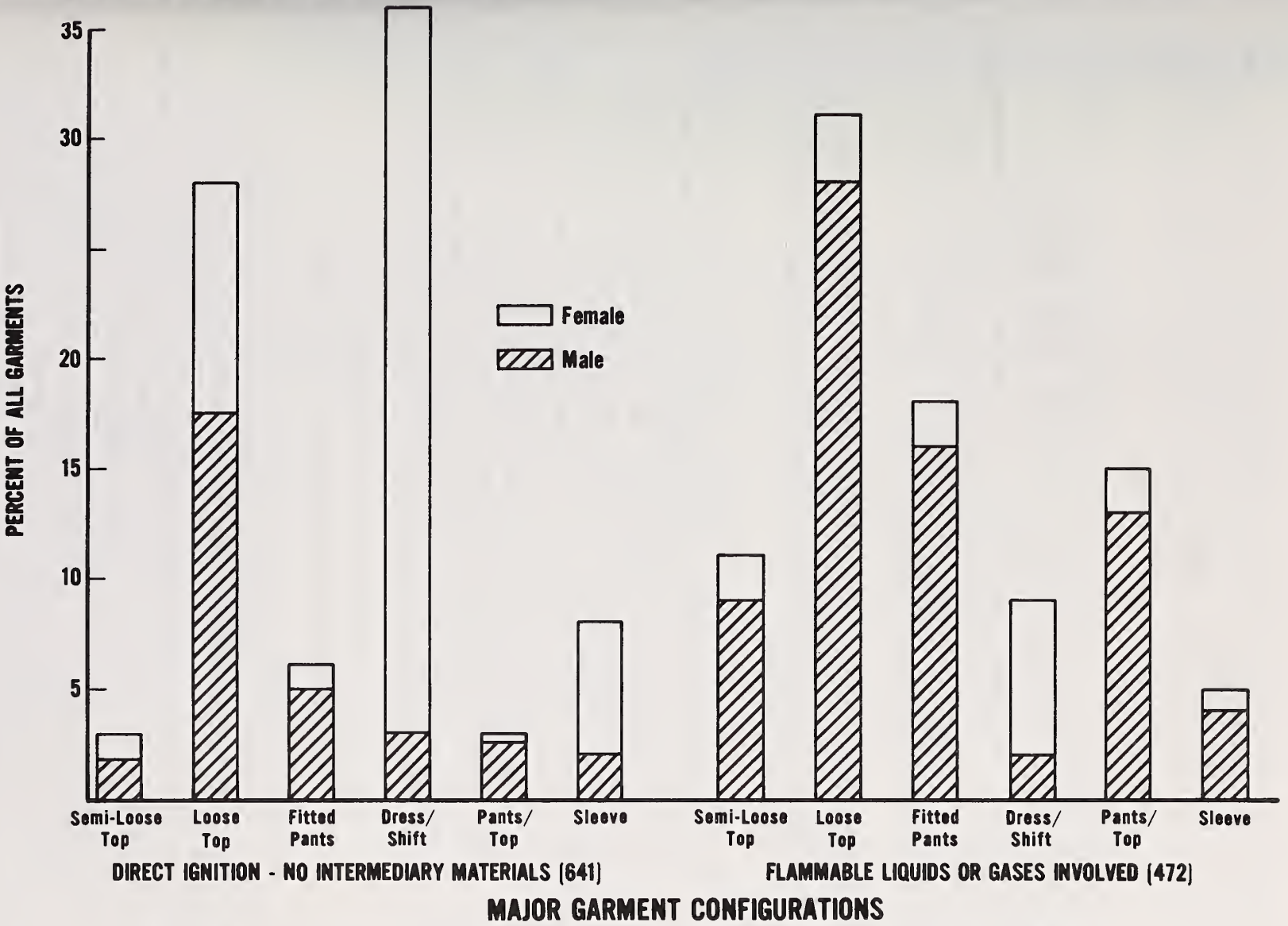

Figure 1. Frequency distribution of major garment configurations for males and females in accidents with and without intermediary materials involved.

in accidents in which there were no intermediary materials involved. When flammable liquid or gas was present in the accident sequence, the "loose top" was again most prevalent, accounting for 31% of the total. "Fitted pants" were second in frequency (18%) and "pants/top" configurations third with 15%.

The distribution of various garment configurations between the two types of accidents (i.e., accidents involving intermediary materials and accidents involving direct ignition of clothing) reflected activity patterns discussed in a previous paper [9]. Garment configurations likely to be worn by males ("loose tops", "fitted pants", and "pants/top") were prevalent in accidents which involved flammable liquids or gases. On the other hand, the dress/shift configuration, worn primarily by females, accounted for the largest percentage of garments in accidents involving direct ignition of clothing.

Only the "loose top" configuration was prevalent in both accident types, perhaps because shirts, blouses, and pajama tops are worn by both males and females for a wide range of activities which may or may not involve intermediary materials.

Table 2 shows the percentages of major configurations within selected age/sex groups when no flammable liquids were involved in the accident sequence. While the "fitted pants" configuration showed the same level of involvement in all four male age groups, the data indicated a slight change from involvement of the "loose top" configuration to involvement of the "dress/shift" configuration for both males and females over 65. This increase in the relative frequency of involvement of the "dress/shift" configuration may be a reflection of the attire typically worn by elderly people. This group may be more sedentary because of age or ill health and thus, wear robes or gowns for a larger portion of the time. Figure 2 shows schematically the age distributions for selected garment classifications. As might be expected, the "dress/shift" and the "pants/top" configurations have the highest percentages of victims over 65 years of age.

3.3. Garment Configuration and Injury Level

To facilitate analysis, garment classifications were divided into two general categories -- those configurations which would be expected to cover half or less of the body and those configurations which would be expected to cover more than half of the body (fig. 3). Each category included configurations with varying degrees of fit. As would be expected, the injury levels for incidents in which the garment involved covered half or less of the body were noticeably less severe than they were in the other category. In the configurations "loose top", "fitted pants", and "loose pants", the degree of fit as defined by these classifications was not shown to be a major factor in injury severity. The category, "semi-loose top", containing such items as T shirts and other knit tops which might be expected to have a closer fit than the average shirt, showed somewhat higher levels of severity than other configurations covering half or less of the body.

Table 2. Percent of Garment Configurations Present in Selected Age/Sex Groups

Major Garment Configurations	Direct Ignition--No Flammable Liquids Involved								Flammable Liquids Involved							
	0-5		6-20		21-65		65+		0-5		6-20		21-65		65+	
	M (%)	F	M (%)	F	M (%)	F	M (%)	F	M (%)	F	M (%)	F	M (%)	F	M (%)	F
Loose Top	40	11	57	25	44	19	37	-	24	28	35	24	35	13	33	14
Shift/Dress	-	51	5	47	-	51	20	64	-	28	-	24	-	43	7	14
Fitted Pants	14	-	13	3	15	-	14	-	12	-	26	18	17	7	7	57
Sleeve	8	1	7	11	2	14	6	14	12	-	5	-	4	5	-	-
Number in Age/Sex Group	65	86	60	110	81	125	35	76	17	7	155	17	184	60	15	14

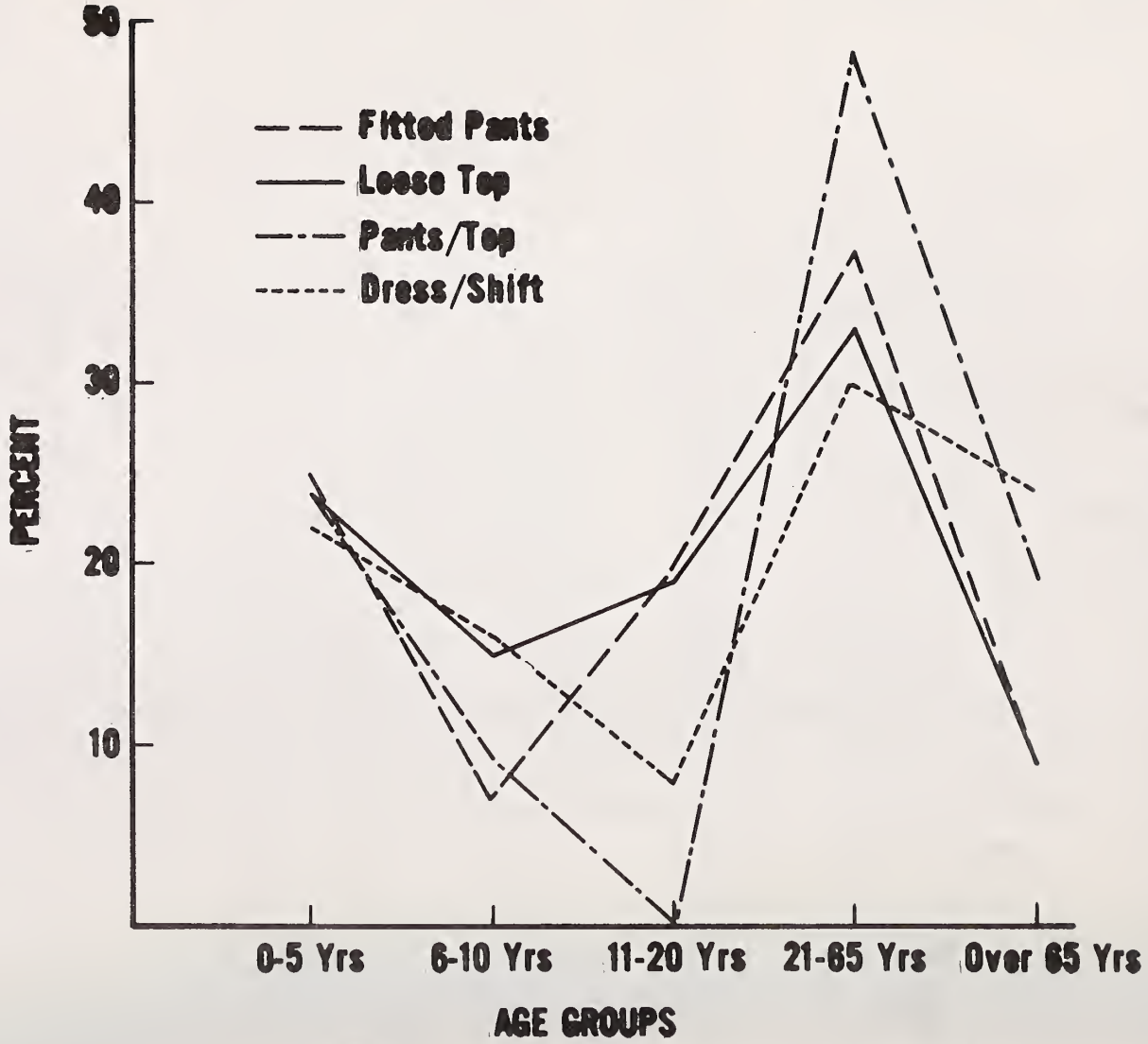

Figure 2. Schematic representation of the percentages of various age groups present within selected garment configurations.

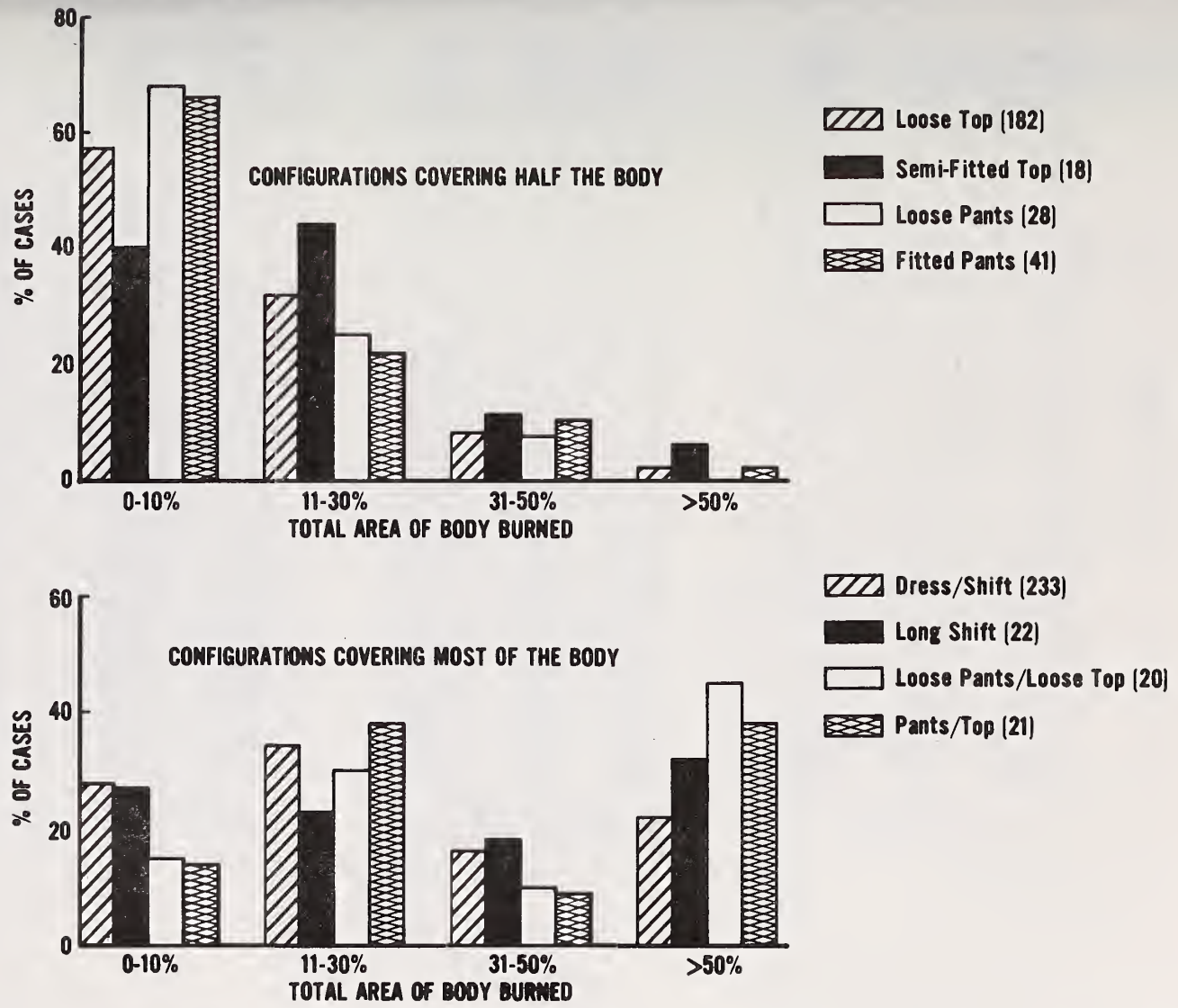

Figure 3. Comparison of the distribution of injury severity for different configurations (a) for configurations covering half the body, and (b) for configurations covering most of the body - in accidents involving no intemediary materials.

3.3.1. Configurations Covering Half of the Body

For each of three configurations, namely, fitted pants, loose tops, and loose pants, the injury level for accidents involving flammable liquids or gas was compared with the injury level for direct ignition. For each of the three configurations, injury levels varied more between accidents involving flammable liquids and accidents involving direct ignition than between the different configurations. Figure 4 shows the injury levels for all three configurations for accidents involving flammable liquids or gas and for direct ignitions. These results would seem to support the premise that the presence of a flammable liquid or gas in the accident sequence does influence the outcome of the accident and may override the effect of certain other factors. However, looseness or closeness of fit as determined by this classification system could not be shown to be a major determinant of injury severity.

3.3.2. Configurations Covering More than Half of the Body

The "dress/shift" and "pants/top" configurations showed more severe injury levels than did other configurations. The injury levels were not influenced as much by flammable liquid involvement as they were in the other configurations. The levels of injury in cases not involving direct fabric ignition were comparable to the levels of injury in accidents involving flammable liquids or gases as intermediary materials. The explanation for this may lie in the age/sex groups involved in the two kinds of accidents or in the flammability characteristics of the configurations.

It was shown in a previous paper [9] that accidents involving flammable liquids tended to result in more serious injuries, and that this trend was even more pronounced within the 21-65 age group. In another paper [10] the ability of the victim to take positive action to extinguish the fire was also related to injury level. Women, young children and elderly persons were found to have poorer responses to ignition than other groups. These findings may partially explain the injury levels shown in both the "dress/shift" and "pants/top" configurations. In incidents involving no flammable liquids, 46% of the victims in the "dress/shift" configurations were either under 5 or over 65 years old. For the "pants/top" configuration 43% were under 5 or over 65 years old. (see fig. 2) This would indicate a relatively large number of victims with inappropriate reactions. When flammable liquids were involved in the accident sequence the percentages of very young and very old dropped to 26% in the "dress/shift" configuration and 8% in the "pants/top" configuration. Though the accident condition may have been more severe, the reactions of the groups involved may have been more effective in those accidents involving flammable liquids. Hence, the negative effect of a larger proportion of victims with poor reactions might equal the negative effect of flammable liquid involvement in the accident, making the injury levels comparable for the two types of accidents.

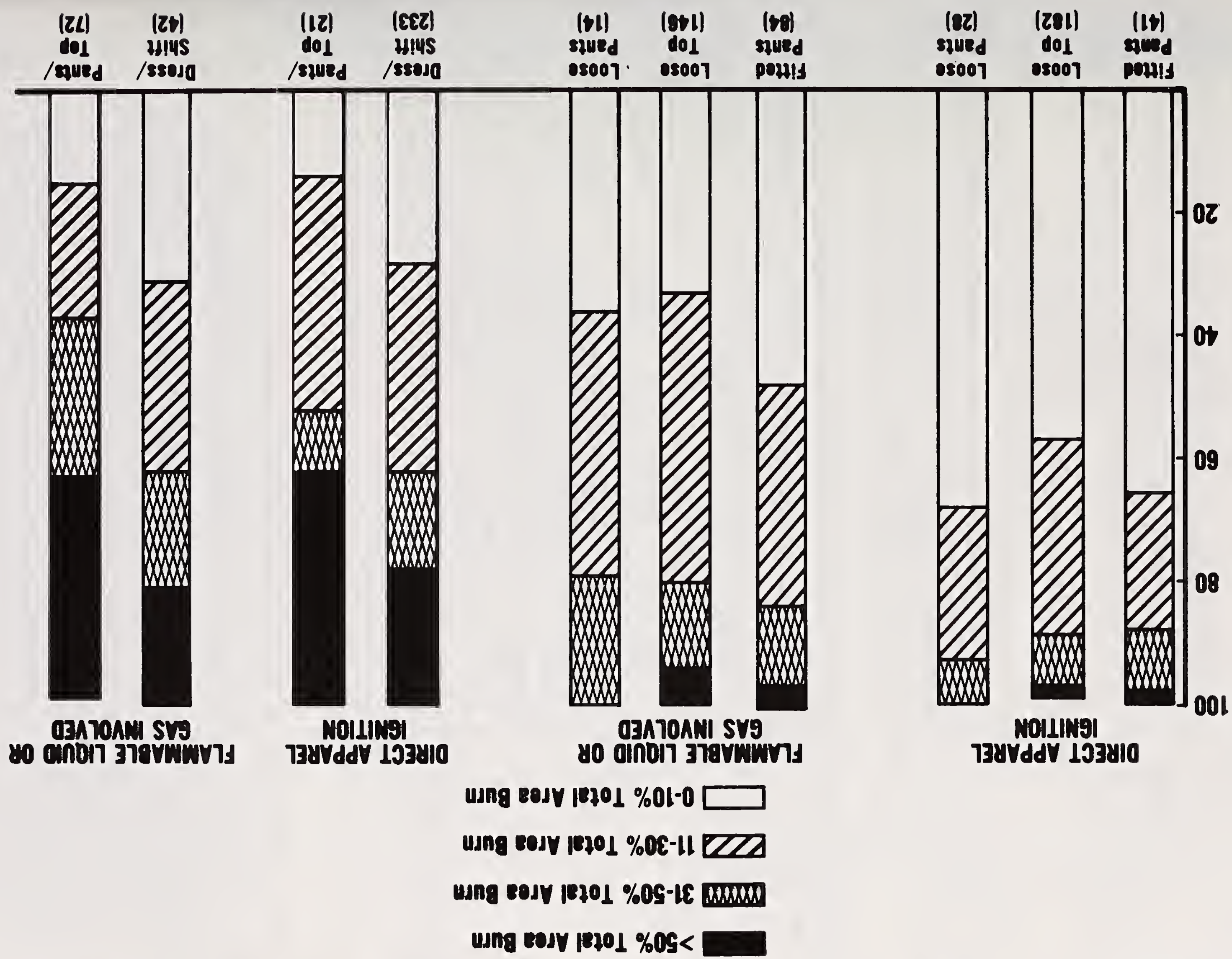

Figure 4. Comparison of injury levels for various garment configurations in accidents involving direct apparel ignition and those involving intermediary materials.

Finally, Vickers, Tovey and Krasny [11] postulated that a loosely fitting configuration which covers more than half of the body such as the "dress/shift" results in more severe burns because of the absence of fire stops such as belts and because of the accessibility of air to sustain the fire. If the characteristics of the garment make it inherently susceptable to the rapid spread of fire, it also may be postulated that the presence of a flammable liquid would make less difference in the progress of the fire in a garment such as this than it would in a configuration in which the rate of flame spread could be expected to be less rapid.

To further define the relationship between garment configuration, age, and injury severity in accidents not involving flammable liquids, chi-square contingency analysis was used. The data shown in table 3 shows how the different data elements were grouped for multi-dimensional chi-squared analysis. From these data, two dimensional chi-square tests were run.

Table 3. Data Grouped for Multi-Dimensional Contingency Analysis

Data Element	Classifications			
Percent total area of body burned (3)	0-10%	11-40%		Over 40%
Age groups (5)	0-5	6-10	11-20	21-65 Over 65
Garment configuration (4)	1/2 body loose fit loose top, loose pants)	1/2 body fitted (semi-loose top, fitted pants, sleeve)	Whole body loose fit (long shift, all shift/ dress configurations)	Whole body fitted (All pants/ top configurations)
Accident type (2)	Direct Ignition, no flammable liquids or gas involved		Flammable liquid or gas involved	

Table 4 shows the data for testing the independence of the two parameters, total area of body burned and garment configuration (whole body, fitted and whole body, loose). A chi-square test was based on data from cases with direct ignition (no flammable liquids or gases involved) and involving only the 21-65 age group. The analysis failed to reject the hypothesis of independence. Conversely, a chi-square test on the data in table 5, for testing independence between total area of body burned and age, showed a highly significant (99% level) absence of independence. In this example, garment configuration was held constant by considering only the "whole body, loose" configuration for direct ignition accidents. Similar significant results were obtained when chi-square analysis was used to compare the total area of body burned within the "loose top" configuration for victims 21-65 and victims over 65.

Table 4. Total Area of Body Burned vs. Garment Configuration, for 21-65 Age Group and Direct Ignition

Total area of body burned	Garment Configuration		Marginal Totals
	Whole body, fitted	Whole body, loose	
0-10%	27	27	54
11-40%	15	28	43
Over 40%	8	20	28
Marginal Totals	50	75	125

Table 5. Total Area of Body Burned vs. Age, for "Whole Body, Loose" Configuration and Direct Ignition

Total area of Body Burned	Age		Marginal Totals
	21-65 yrs	Over 65 yrs	
0-10%	27	4	31
11-40%	28	26	54
Over 40%	20	29	49
Marginal Totals	75	59	134

These results reemphasize the fact that age, especially advanced age, is closely related to injury severity. However, from these data no definitive statement may be made as to the effect of fit on injury severity. While the chi-square test (table 4) showed no significant difference in burn severity between fitted and loose configurations, the fact that two garments rather than one were involved in the fitted pants/top configuration fires may bias this group toward more severe injury levels.

3.3.3. Sleeve Configuration

Of the 76 garments in which the sleeve ignited first, 55% could be classified as "loose tops," 40% as "dress/shift" and 5% as "semi-loose top." Fifty-four of the 76 sleeve ignitions occurred in accidents which had no flammable liquids or gases involved. Females predominated in these direct ignition accidents. Females between the ages of 21-65 accounted for 32% of the victims, and females over 65 an additional 20%. When flammable liquids were involved in the accident sequence, males aged 21-65 were most frequently involved (32%), followed by males 11-20 (22%).

When the distribution of total area of body burned was plotted for accidents in which the sleeve was first to ignite (fig. 5), the large percentage of minor injuries, especially for accidents involving flammable

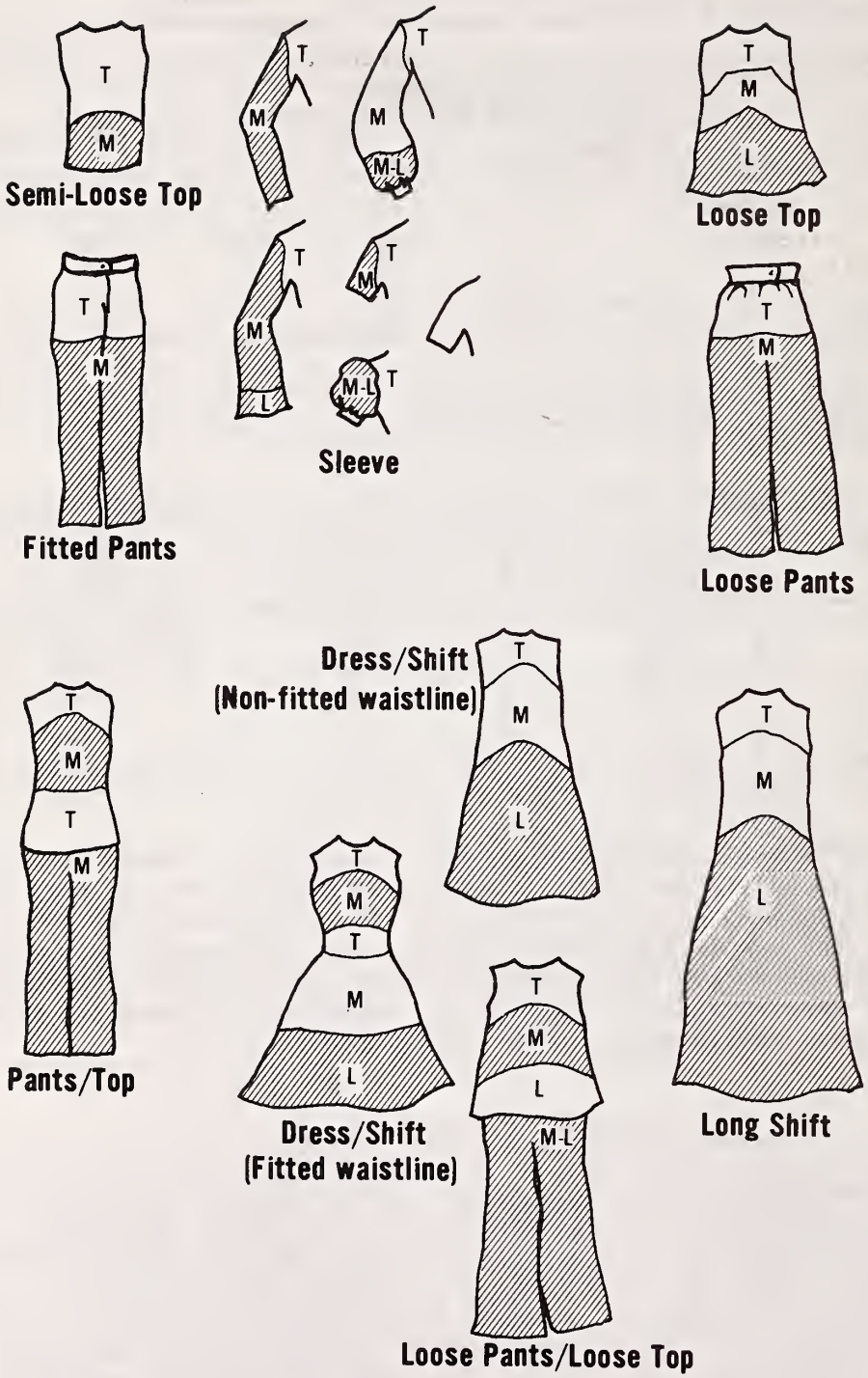

Figure 5. Most frequent degree of fit at point of ignition for various garment configurations -- no intermediary materials involved. (Shaded area denotes the most common degree of fit at point of ignition. T = Tight fit, less than 5 cm (2 in) ease; M = Medium fit, 5-13 cm (2-5 in) ease; L = Loose fit, over 13 cm (5 in) ease.

liquids, was striking. Both the distribution of accidents involving flammable liquid or gas and the distribution for accidents not involving flammable liquids or gas showed a higher percentage of minor injuries and fewer major injuries than did the garment configurations represented within the "sleeve" classification (i.e., "dress/shift" and "loose top"). It seems reasonable that accidents involving sleeve ignition would be less severe. The victims would be almost immediately aware of ignition and could take appropriate action while the fire was contained in a rather limited area. When the awareness of ignition or the ability to take positive action to extinguish the fire was lacking, the fire may then have developed into a serious one. Most of the more serious injuries occurred either with the elderly or the very young age groups with reactions which might be expected to be less effective.

3.4. Fabric Weight Versus Garment Configuration

In a recent paper [11] Vickers, Tovey, and Krasny discussed fabric construction, surface finish and "burn time" of first-to-ignite garments from cases in FFACTS and related these parameters to the extent of the burn injury. They concluded that these factors could not be shown to exhibit a noticeable and consistent influence over burn injury within various garment types. The effect of fiber content on extent of injury was also analyzed. No difference was found in injury level between garments of 100% cellulosic and cellulosic/synthetic blend fabrics. However, 100% single layer synthetic fabrics were associated with less severe injury levels. Since fabric parameters were discussed in detail by Vickers, et al [11], this paper will give supplemental information on fabric weight and fiber content as they relate to garment classifications used in this study.

Table 6 shows the weight ranges for various garment configurations. Since several item types may be contained within one configuration classification, there was considerable variation in fabric weight within classifications. Two things should be noted when viewing this table: (1) only about half the garments in fire incidents recorded in FFACTS have fabric samples included for laboratory analysis; (2) When more than one garment is included in a classification (e.g., "pants/top") the single item which seemed to contribute most to the injury (i.e., covered the most severely or extensively burned portion of the body) was noted for retrieval of fabric data. Therefore, even though the classification was "shorts/top," only the top -- or the shorts -- would be included in the fabric analysis.

The average weight for all garments analyzed was 4.6 oz/sq yd[5]. As would be expected, the classifications "loose top", "shift/dress", and

[5]Oz/sq yd is the unit of measure used in the textile and apparel industries to denote fabric weight. Since this paper deals with information of interest to people in the textile field, fabric weight was expressed as oz/sq yd. However the conversion factor to kg/m^2 is 3.39. Therefore, 4 oz/yd^2 could also be expressed as 1.36 kg/m^2. In computing average weights, 7 oz/sq yd was used as a conservative estimate for the over 6 oz/sq yd grouping.

Table 6. Fabric Weight Ranges by Garment Configuration Classification

Garment Configuration	Fabric Weight in oz/sq yd*						Total
	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	>6.0	
Semi-loose top	-	-	3	10	3	4	20
Loose top	3	40	66	28	8	26	171
Loose pants	-	1	8	2	1	9	21
Fitted pants	-	1	-	1	5	51	58
Shorts or shorts/top	-	-	1	2	-	7	10
Long shift	-	2	6	3	-	-	11
Dress/shift	1	23	74	23	1	19	141
Pants/top	1	3	3	3	5	15	30
Loose pants + Loose top	-	6	4	5	-	2	17
Sleeve	3	6	15	4	4	15	47
Total	8	82	180	81	27	148	526

*See footnote 4, page 17.

"long shift" had a high percentage of fabrics in the weight range 3.1-4.0 oz/sq yd, while "fitted pants", "shorts/top", and "pants/top" configurations had a higher percentage of fabrics in the over 6 oz/sq yd grouping. "Loose pants" (which include both pajama pants and overalls or coveralls) and "sleeves" seemed to fall either in the 3.1-4.0 oz/sq yd or the over 6 oz/sq yd grouping.

3.5. Fabric Weight Versus Contribution to Injury

Criteria for determining the garment's contribution to injury were described in detail in [8]. Basically the description of the accident, the involvement of intermediary materials, and the location of the most severe or extensive burns were used to make a judgement regarding the garment's contribution to injury.

Garments were coded as being (1) a major cause, (2) a secondary cause, (3) a protective factor, (4) not involved, or (5) having an unknown contribution to the burn injury. Sixty-four percent of the 543 garments for which fabric weight was available were classified as being major or primary causes of the burn injury. The average weight of these garments was 4.2 oz/sq yd. Twenty-seven percent were judged as being a secondary cause of the injury. Most of these accidents involved flammable liquids and the flammable liquid was judged to be the primary factor. The average weight of fabrics involved in these accidents was 5.3 oz/sq yd. This may be a reflection of the type of garment worn by age/sex groups likely to be involved with flammable liquids -- i.e., males aged 6-65. However, the fact that heavier fabrics tend to be more difficult to ignite, unless contaminated with a flammable liquid or gas, may also account for the increase in average fabric weight. In the remaining 7% of the cases, the garments were judged to be either protective or not involved with the injury. Again, heavier fabrics were more prevalent with an average weight of 5.2 oz/sq yd. The majority of the accidents in which the clothing was judged to be protective, involved either flammable gas or explosives (28 cases) or flammable liquids (23 cases), totaling 51 out of 59.

3.6. Fiber Content and Garment Configuration

Five hundred and seventy-one garments judged to be the major garment involved in the fire accident had samples which were large enough to be analyzed for fiber content. Table 7 shows the number of garments, within each configuration classification, for which fiber content data were available. It should be noted that in most categories a smaller percentage of the total number of garments involved were sent in for fabric analysis from accidents involving flammable liquids or gas, than from accidents involving no such intermediary material. This difference could be indicative of the relative severity of the accident since in more severe accidents there is often little left of the clothing, or it could represent chance variation. Accident severity probably accounts for the relatively low percentages (38% and 39%) of garments sent in for the

Table 7. Comparison of Number of Garments With and Without Laboratory Test Results on Fiber Content in Accidents Involving Direct Clothing Ignition and Accidents Involving Flammable Liquids or Gas

	Direct Ignition -- No Intermediary			Flammable Liquid or Gas Involved		
	Number of Garments with Fiber Content Tested	Total Number of Garments in Study	Percent of Garments with Fiber Content Information	Number of Garments with Fiber Content Tested	Total Number of Garments in Study	Percent of Garments with Fiber Content Information
Semi-loose Top	12	18	67	11	51	22
Loose Top	111	182	61	64	146	45
Loose Pants	18	28	64	5	14	36
Fitted Pants	22	41	54	37	84	44
Shorts or Shorts + Top	-	-	-	10	21	48
Long Shift	10	22	45	1	1	100
Dress Shift	144	232	62	16	42	36
Pants/Top	8	21	38	28	72	39
Loose Top + Loose Pants	16	20	80	2	3	67
Sleeve	34	54	65	15	22	68
Total	375	618[a]		189	456[a]	

[a]These numbers do not include 23 garments in the "direct ignition" category and 16 garments in the "flammable liquid or gas" category in which the garment configuration was unknown or of a miscellaneous configuration other than those listed above.

pants/top configuration, since injury levels in this classification are high.

Table 8 shows the distribution of fiber content groups among the various garment configurations for accidents involving intermediary materials and for those not involving flammable liquids or gas. While garments of 100% cellulosic were most prevalent in both accident types, accidents which involved intermediary materials showed a higher percentage of cellulosic/synthetic blends and 100% synthetics than did accidents without such intermediary materials. The garments typically involved in the two types of accidents (e.g., synthetic or cellulosic/synthetic blend shirts and pants in accidents involving flammable liquids vs 100% cellulosic dresses, nightgowns and pajamas in accidents not involving flammable liquids) may partially account for the difference. In addition, the presence of a flammable liquid or gas will assure combustion with even a relatively nonflammable fabric such as some fabrics made with 100% thermoplastic fibers.

3.7. Garment Degree of Fit Classification

Garments were also classified according to "fit at point of ignition," and "fit at point of most severe injury." The methodology employed was described in [8]. The data in the case histories on fit and on exact point of ignition were limited. Therefore, the investigator estimated degree of fit based on the way garments usually fit in various areas of the body. An estimate such as this is, of course, subject to a high level of error. The area of most severe burn was determined by studying the burn diagram or description of injuries included in the case history.

3.7.1. Fit at Point of Ignition

When no intermediary materials were involved, the fit at point of ignition was judged to be loose in 267 (42%) cases, medium in 156 (24%) cases and tight in 12 (2%) cases. In 206 cases the fit at point of ignition was unknown or not applicable. Figure 5 shows the major garment configurations and the areas in which ignition was judged to have occurred most frequently. It should be noted that in most instances ignition occurred in the loosest area of the garment. This result was predictable since areas of loose fit would be most likely to contact an ignition source. From a standards development point of view, it would be desirable to know whether the exact point of ignition was at the edge of the garment or on a surface of the garment. Specific information on point of ignition was not included in most case histories.[6]

[6]However, the prevalence of surface ignition over edge ignition may be implied from careful reading of the case histories considering the most frequent ignition sources and the construction and configuration of the item types ignited.

Table 8. Fiber Content of Various Garment Configurations for Accidents Involving Flammable Liquid or Gas and Those Involving Direct Garment Ignition

	100% Cellulosic (Rayon, Cotton Rayon/Cotton blend)		Cellulosic/ Synthetic Blend		100% Wool		100% Acetate		100% Synthetic		Other Blends + Unknown Fiber Content		Total	
	Direct Ignition	Flammable Liquid or Gas Involved	Direct Ignition	Flammable Liquid or Gas Involved	Direct Ignition	Flammable Liquid or Gas Involved	Direct Ignition	Flammable Liquid or Gas Involved	Direct Ignition	Flammable Liquid or Gas Involved	Direct Ignition	Flammable Liquid or Gas Involved	Direct Ignition	Flammable Liquid or Gas Involved
Semi-loose Top	7	6	1	2	1	1	-	-	3	2	-	-	12	11
Loose Top	85	25	23	27	-	1	-	-	3	9	-	2	111	64
Loose Pants	16	4	1	1	1	-	-	-	-	-	-	-	18	5
Fitted Pants	15	13	5	20	1	-	1	-	-	2	-	2	22	37
Shorts + Shorts/Top	-	6	-	3	-	-	-	-	-	1	-	-	-	10
Long Shift	9	1	1	-	-	-	-	-	-	-	-	-	10	1
Dress/Shift	117	8	13	1	-	-	5	3	6	4	3	-	144	16
Pants/Top	-	14	4	10	2	-	-	1	2	3	-	-	8	28
Loose Top + Loose Pants	14	2	2	-	-	-	-	-	-	-	-	-	16	2
Sleeve	29	6	3	4	2	-	-	-	-	5	-	-	34	15
Misc.	5	-	-	-	-	-	-	-	2	-	-	-	7	-
Total	297	85	53	68	7	2	6	4	16	26	3	4	382	189

When intermediary materials such as flammable liquids or gases were involved in the accident, the percentage of cases in which the point of ignition was unknown jumped to 75% of the total 473 cases. The inability to judge point of ignition in this type of accident could be due to simultaneous ignition at several points which sometimes occurs in accidents involving flammable liquids, or could be a result of the sudden explosive ignition often characterizing such ignitions. Unlike garments involved in accidents with no intermediary materials, the majority of the garments in accidents involving flammable liquids for which the point of ignition was known or could be estimated, were ignited in areas of medium fit. The tendency for garments involved in accidents involving flammable liquids to ignite in areas of medium, rather than loose, fit may be accounted for both by the characteristic closer fit of the garments involved in the accident type and by the fact that contamination by a flammable liquid could insure ignition even in areas of close fit.

3.7.2. Fit at Point of Most Severe Injury

The most severe injuries occurred most often in areas of medium fit. However, the percentages (shown in table 9) differed according to accident type.

Table 9. Fit at Point of Most Severe Injury by Accident Type

	No Flammable Liquid Involved	Flammable Liquid Involved	Gas or Explosives Involved
Loose Fit (Over 13 cm ease)	13%	3%	2%
Medium Fit (5-13 cm ease)	52%	42%	12%
Tight Fit (Less than 5 cm ease)	9.5%	9%	6%
Not Applicable i.e., No garment involved at area of injury)	6%	25%	64%

These results seem reasonable since a garment with 2-5 inches of ease is close enough, especially in a cylindrical shape, to give severe burns, yet is loose enough to allow the circulation of some air to support combustion. The high percent (64%) of "not applicable" responses in accidents involving flammable gas may be explained in that while there may be

insufficient heat to cause clothing ignition, there is ample heat to cause severe burns on exposed portions of the body; therefore, in an explosion, areas not covered by clothing are often as severely burned or more severely burned than those which are covered.

3.8. Summary of Garment Parameter Analysis

Garment configuration was shown to be somewhat related to injury level, with configurations covering over half of the body having higher percentages of extensive burn injuries and sleeve ingnitions resulting in lower percentages of extensive burns. However, with the data avilable, it was difficult to determine the exact contribution of fit to the level of injury severity. Loose tops (shirts, blouses and pajama tops) and fitted pants had similar levels of injury severity. When no flammable liguids were involved, ignition generally occurred in areas of loose fit with the most extensive injuries occurring in areas of medium fit. Garments of cellulosic and cellulosic/synthetic blend fabrics were most frequently involved in apparel fire accidents, probably reflecting both the market distribution of such fabrics and their flammability characteristics.

The involvement of flammable liquids or gases in the accident sequence did influence the course of the accident. In fact, for configurations covering half or less of the body, flammable liquids involvement was more closely related to injury level than fit, with accidents involving flammable liquids resulting in more severe injuries. The average weight of the fabric involved in the accident was higher when flammable liquids were involved than when they were not.

4. ANALYTICAL TECHNIQUES EMPLOYED IN DATA ANALYSIS

Analysis of data collected in the study was initiated by viewing one main variable (activity, reaction, garment parameters) at a time, attempting to identify patterns and trends associated with that main variable, and relating these patterns to injury severity. Chi-square contingency tests were used to determine the statistical validity of apparent differences in distributions.

Other, more sophisticated forms of analysis including multiple regression and multidimensional contingency tables were also applied to the data. The regression analysis was not fruitful because the models used accounted for only a small portion of the variation. The multi-dimensional chi-square approach was not effective, probably because the data were too "noisy" and the limitation on classification complexity for the analysis was too severe for these data.

The contribution to extent of injury of the various fire accident variables studied could not be quantified and described statistically as was originally anticipated. However, the more limited forms of analysis and pattern identification used in this study indicated the importance of

human variables in determining injury severity and emphasized the complexity of the interactions between the human and physical variables in an apparel fire accident.

5. RECOMMENDATIONS AND CONCLUSIONS

Table 10 provides a summary of some of the most frequent responses for various study parameter variables. Some of these variables were found to be associated with severe injuries (i.e., burns involving more than 50% of the body). Such variables are listed in upper case and underlined in table 10. Also, more than one of these "negative" data elements (i.e., those associated with severe injuries) may occur in a single case. For example it was not at all uncommon for an elderly lady, wearing a gown and robe (dress/shift configuration) to ignite her robe, panic, run and suffer very severe burns as a result of the accident. Which of the variables -- age and sex, garment configuration, defensive capability, or reaction to ignition -- was primarily responsible for injury severity was difficult, if not impossible, to determine.

Figure 6 is an attempt to show schematically how each main variable affects and is influenced by the other accident variables. It is the interdependence between the variables which makes it difficult to quantify the contribution of any one variable and identify it as the causal factor in injury level. However, certain problem areas may be identified as contributing to injury severity and some solutions seem more appropriate than others.

5.1. Children's Clothing Ignition

Ignition of clothing worn by children is a serious problem because of the frequency of occurrence, the difficulty in prevention of the accident by supervision of the child or the removal of possible hazards (such as matches, ranges, and space heaters), and because of the inability of the child to take appropriate action when apparel ignition occurred. A solution to this problem has been approached by promulgation of the children's sleepwear standards for sizes 0-6X and 7-14. This action alone should reduce the hazard substantially. Modification of the most common ignition source, matches, to make them more difficult for a child to use would also help alleviate this problem.

5.2. Apparel Fires Among the Elderly

The elderly and the physically handicapped constitute another high risk group. Since this group, unlike children, wears the same clothing as other adult age groups not in need of protection, mandatory fabric flammability standards do not seem to be an appropriate solution. However, a need for action in this area is strongly indicated by the data. Flame retardant clothing should be made available in the market place at a

Table 10. Summary of Most Frequent Responses to Study Classifications and Other Main Variables Associated with Apparel Fire Accidents*

	Direct Ignition No Flammable Liquid or Gas Involved		Intermediary Materials Flammable Liquid or Gas Involved	
		641		473
General Activity (A_2)	Using fire	237	Using flammable liquid	130
	Playing with ignition source	141	Using fire (intermediary material involved)	61
Bodily Action (A_3)	Lighting a match	172	Using flammable liquid or ignition source	80
(Specific Activity)	Warming self	58	Lighting a match	60
	Reaching over ignition source (range)	56	Using flammable liquid as cleaning agent	42
			Using ignition source on flammable liquid	36
Ignition source (A_4) or accident situation	Range burner	196	Flammable liquid on clothing	43
	(Matches or lighter	148)	Hot water heater	39
	Space Heater	49	Charcoal grill	37
			Open fire	36
Location-Occupational Relationship (A_5)	Non-work or leisure-Indoors	220	Work related-non-occupational Indoors	96
	Playing indoors	170	Work related-non-occupational Outdoors	72
	Work-related non-occupational Indoors	126	Non-work or leisure-Indoors	67
First Reaction (R_4)	RAN	143	Rolling on ground	101
	Beat with hands	112	RAN	100
Garment Shape (G_1)	DRESS/SHIFT	232	Loose top	145
	Loose top	180	Fitted pants	84
Garment Contribution (G_4)	Major		Secondary	
Sex	FEMALE		Male	
Age†	0-5 years	122	11-20 years	121
	65-100 Years	96	6-10 years	56
Fiber Content of Major Garment	Cotton (100%)	285	Cotton (100%)	79
Contributing factors $(A_6)_1$	Elderly (52 Victim not engaged in activity causing fire (45)			
$(A_6)_2$	Intoxicated (40) Explosion (112)			

*Variables previously noted as being associated with a larger percentage of severe injuries are capitalized and underlined.

†The value for the adult (21-65) age group was divided by 5 to adjust for the size of this age distribution.

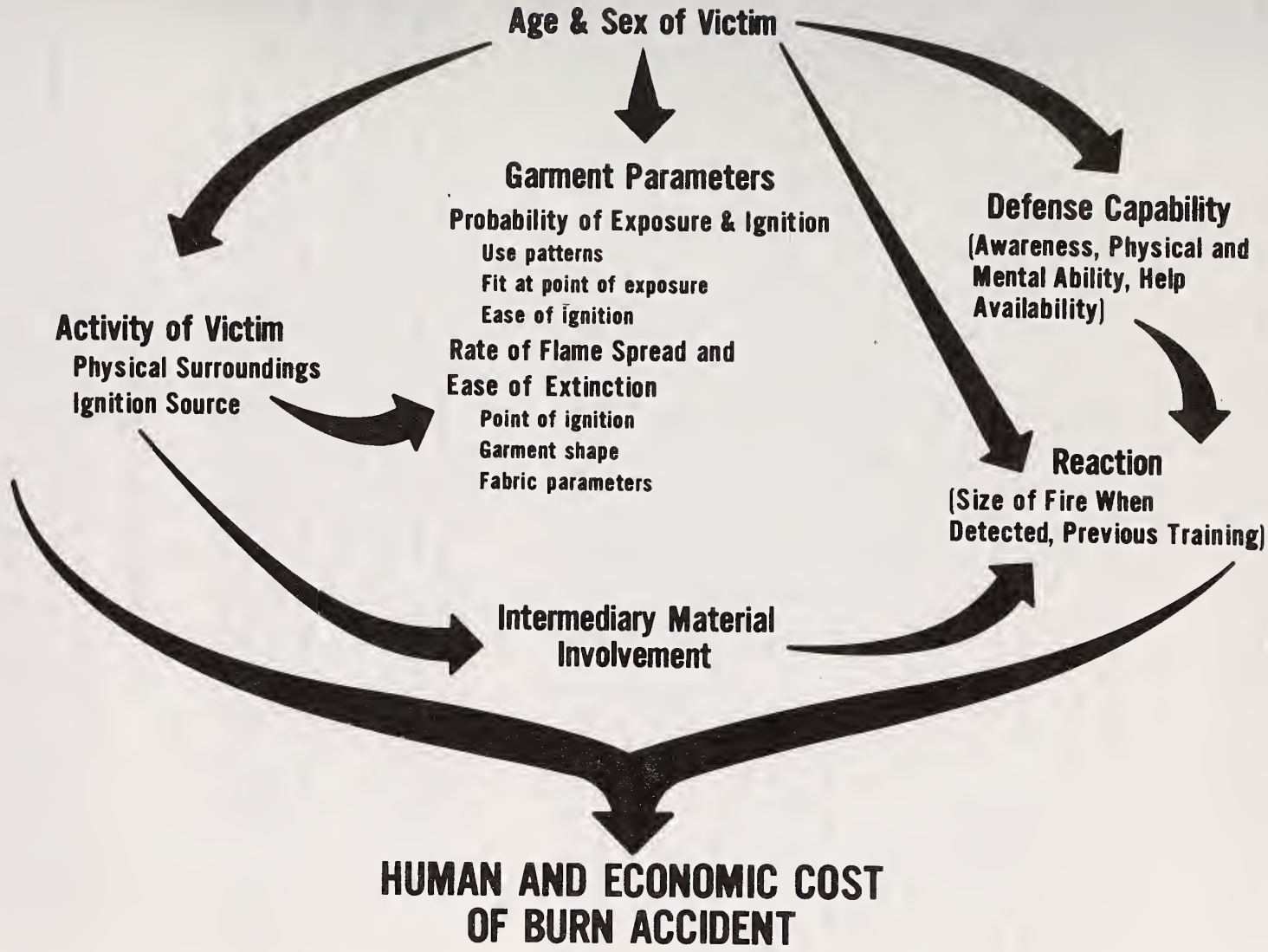

Figure 6. Schematic representation of the interaction of variables in an apparel fire accident.

reasonable price. However, since many elderly people have very limited economic resources, it would seem to the author that some economic incentive, or at least relief, must be provided if flame retardant apparel is to be acceptable to this group.[7]

5.3. Fires Involving Flammable Liquids

Misuse of flammable liquids was another major problem associated with apparel fire accidents. Data in this study indicated that approximately one-third of apparel fire accidents involved either flammable liquids or flammable gases. Many victims are apparently unaware of the volatility of certain flammable liquids, especially gasoline. Gasoline was used for a number of purposes, such as cleaning parts and fueling outdoor fires. Gasoline stored in and around the home seemed to present a special hazard for children. There are indications that the flammable liquid problem may be increasing in magnitude. Data on admissions to the Shriner's Burns Institute in Galveston, Texas show an increase in admissions of children injured in accidents involving flammable liquids from 25% of the cases admitted December-May, 1972 to 42% of the cases admitted December-May, 1974.[8] Contamination of a fabric with a flammable liquid seems to overshadow the flammability characteristics of the fabric involved; therefore, fabric flammability standards will do little to prevent this type of accident. Since the misuse of flammable liquids is primarily a behavioral problem, effective public education or the proper use and storage of flammable liquids seems the best approach to the problem. Tyrrell [12] discussed flammable liquid involvement in fire accidents at length and offered specific recommendations for education in this area.

5.4. Reactions to Apparel Ignition

Another problem area dealing with human behavior was that of victim reaction to apparel ignition. Many of the victims studied panicked and did not immediately take effective action to extinguish the fire. Public education, while not likely to completely prevent panic initiated reactions might reduce the number of unsatisfactory reactions by providing information on what should be done in case of apparel ignition. Another approach might be to develop fabrics which, after ignition, are relatively easy to extinguish. Research on ease of extinguishment [12] has been limited; therefore, additional research could be worthwhile.

5.5. Common Ignition Sources

Finally, some attention should be given to the redesign of some common ignition sources such as matches, kitchen ranges and space heaters to

[7]It is the author's suggestion that some financial relief for the elderly might be achieved by provision of flame retardant sleepwear through an existing health care program such as Medicare.

[8]Date obtained from private correspondence with Sara Bolieu, Dr. Ormond Goldman and Dr. Duane Larson, Shriner's Burns Institute, Galveston, Texas.

minimize misuse and to make their use less of a hazard to the public. Although certain ignition sources appear very frequently in the data, progress in modifying product design to make these ignition sources less of a hazard seems very slow.

5.6. Apparel Flammability

It seems clear that apparel fires present more of a hazard for some segments of the population than for others. While the children's sleepwear standard is aimed at providing maximum protection for a high risk group, the data do not seem to indicate a need for this level of protection for the entire population. The level of protection which is needed is of course subject to debate. In addition to the inherent flammability of some fabrics, mannequin research [14] has indicated that certain garment configurations may present more of a fire hazard than others, both from the standpoint of probability of ignition and the rate of flame spread after ignition. Existing accident data on the relationship between point of ignition, garment shape, rate of flame spread and injury severity is, however, extremely limited. Additional information on these relationships would be valuable in developing a test method which reflects the hazard presented by various garments. In the development of a standard for general apparel, it would seem that both the physical characteristics associated with the garment and the use (or human) characteristics associated with the wearer should be considered. It would seem that a standard that ignores either of these areas is likely to offer insufficient protection to some segments of the population and/or force other segments of the population to pay for protection that is not needed.

If a test method for general apparel could be developed, which would identify several levels or degrees of flammability, the level of protection could be related to the risk. Perhaps with adequate information the consumer could even make the final decision about the level of protection he needs and is willing to pay for.

Finally, some monitoring and analysis of apparel fire accident patterns should continue in the future, both to identify changing problems associated with changing life styles and technology and to measure the effectiveness of programs initiated to reduce fire accident loss.

6. GENERAL CONCLUSIONS

This study attempted to identify and analyze the relationships between various apparel fire accident variables for the purpose of determining which types of remedial action are likely to be most effective in reducing human and economic loss from apparel fires. The results of the study presented in this and previous papers [8,9,10] have shown the problem to be a complex one, with much interaction between physical and human variables. The relationships established between human factors such as age, sex, and defensive capability and injury severity suggest that a purely technologi-

cal solution such as mandatory fabric flammability standards may not be adequate to solve the problem. Just as there are many aspects and variables associated with an apparel fire accident, a program aimed at the prevention of fire injuries and deaths should be multifaceted and broad in approach. Reasonable voluntary and/or mandatory fabric flammability standards seem necessary to provide a minimum level of protection for all consumers and a higher level of protection for certain high risk groups such as children and the elderly. Standards might also be used to protect consumers from products which, through their design, present an unnecessary fire hazard in the home. However, education is also necessary to make the public aware of the apparel fire problem. This public awareness is important, both from the standpoint of modification of hazardous behavior patterns and acceptance and use of safer products developed through technology. If progress could be made in all of these areas, the human and economic loss due to apparel fire accidents could certainly be reduced significantly.

7. ACKNOWLEDGEMENTS

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APPENDIX A. ACTIVITY CLASSIFICATION CODES

A1. Code A1 (Type of Accident)

1 Accidents not involving flammable or volatile liquids or high voltage electricity
2 Accidents involving flammable liquids
3 Accidents involving flammable gases or explosives
4 Accidents involving high voltage electricity

A2. Code A2 (Type of Activity)

Ø General activity unknown
A Starting a fire
B Using fire or similar ignition source
C Using flammable or volatile liquids
D Using special ignition sources
E Extinguishing a fire
F Escaping a fire
G Standing, sitting, or moving near an ignition source
H Standing near an explosion
I Playing or climbing near an ignition source
J Playing with an ignition source
K Playing with flammable or volatile liquid
L Playing with ignition source and flammable liquid
Z Miscellaneous

A3. Code A3 (Additional Information on Activity)

A3.1. Specific Action

Ø Unknown
A Using a range
B Using improper pot holder (skirt, apron, dishtowel, etc.)
C Reaching above ignition source
D Reaching over ignition source
E Leaning back on ignition source
F Warming self
G Sleeping
H Maintaining or repairing machinery or equipment
I Using machinery or equipment
J Driving automobile, tractor, motor cycle, etc.
K Priming a carburetor
L Refueling equipment
M Using welding torch, soldering iron, or other special ignition source
N Tending an open fire
O Smoking
P Lighting a match or lighter
Q Stirring, stomping or disturbing a fire
R Using flammable liquid on or near ignition source

S Using ignition source on or near flammable liquid
T Using flammable liquid to start a fire
U Carrying or transporting flammable liquid
V Using flammable liquid as a cleaning agent
W Using flammable or volatile glue
X Spilling or splashing flammable liquid
Y Heating a flammable substance
Z Miscellaneous
1 Bending over ignition source
2 Falling in or near fire
3 Lighting a cigarette

A4. Code A4 (Additional Information on Activity)

A4.1. Ignition Source

Ø Unknown
A Open fire
B Space heater
C Range burner
D Fireplace
E Campfire
F Incinerator or trash barrel
G Open fire on ground
H Charcoal grill
I Candles
J Matches or lighter
K Cigarettes, cigar, or pipe
L Oven
M Hot water heater
N Furnace
O Fireworks or explosives
P Sparks or shorts
Q Backfire or flashback
R Flaming liquid
S Grease
T Welding or cutting torch
U Soldering iron
V Bunsen burner, etc.
W Farm machinery
X Lawn mower
Y Undesignated smoking materials
1 Flammable liquid on clothing
2 Hot plate
3 Malfunctioning equipment
4 Broiler (range or elec. broiler)
5 Pilot light
6 Trailer or camper range, stove, or tank
7 Heating pad or electric blanket
Z Miscellaneous

A5. Code A5 (Location and Occupational Relationship)

Ø	Unknown location and/or occupational relationship
1	Non-work of leisure -- Outdoors
2	Non-work or leisure -- Indoors
3	Non-work or leisure -- Car
4	Work-related occupational -- Outdoors
5	Work-related nonoccupational -- Outdoors
6	Work-related occupational -- Indoors
7	Work-related nonoccupational -- Outdoors
8	Work-related occupational -- Car
9	Nonoccupational (work or leisure) -- Car
A	Playing Outdoors
B	Playing Indoors
C	Playing in Car
Z	Miscellaneous

A6. Code A6 (Contributing Circumstances)

A6.1. Multivalued

Ø	No known contributing circumstances
1	Physically disabled
2	Mentally disabled, disturbed, or retarded
3	Ill
4	Unconscious
5	Asleep
6	Intoxicated
7	Drugged
8	Elderly
9	Senile
B	Previous problems with fire
C	Victim not engaged in activity causing fire accident
D	Child trying to do adult task
E	Explosion
F	Emotional stress or depression - stated fatigue
G	Garment cited not in data base
Z	Miscellaneous

APPENDIX B. REACTION CLASSIFICATION CODES

B1. Defensive Capability Codes

1	Immediate recognition of danger
A	Delayed recognition of danger
U	Unknown
N	Not applicable

B1.1. Code R2

2 Normal adult reaction capability
B Slowed or illogical reaction due to age, physical, or mental condition
U Unknown
N Not applicable

B1.2. Code R3

3 Help available immediately
C No help available
4 Help available close by (not in immediate vicinity)
U Unknown
N Not applicable

B2. Defensive Action Codes

B2.1. Multivalued

1 Beat flames with hands
2 Roll on ground
3 Wrap in rug, blanket, pillow, etc.
4 Douse with water
5 Try to remove garment
6 Other positive action
A Take no action -- stunned
B Run
C Struggle with help
D Fan flames (jumping, with hands, etc.)
E Panic and other negative actions
F Delay for reason other than above
U Unknown
N Not applicable

APPENDIX C. GARMENT CLASSIFICATION CODES

C1. Code G1 (Garment type of configuration)

A Semi-loose top
B Loose top
C Loose pants
D Fitted pants
E Shorts
F Long shift (Non-fitted waistline probable)
G Dress (Fitted waistline probable)
H Pant-shirt combination (Shirt out)
I Shorts-shirt combination (Shirt out)

J Loose pants-Loose top combination (as in pajamas)
K Pants-shirt combination (Shirt in)
O Sleeve
R Shorts-shirt combination (Shirt in)
S Shift (Dress, gown, etc. with probable non-fitted waistline)
W Pants/shirt combination (Exact configuration unknown)
X Dress (Configuration unknown)
Z Miscellaneous
U Unknown

C2. Code G2 (Fit at point of ignition)

A Mostly loose, some medium fit
B Mostly medium, some loose fit
C Mostly medium, some tight fit
D Mostly tight, some medium fit
L Loose fitting
M Medium fitting
T Tight fitting
U Unknown
N Not applicable

C3. Code G3 (Fit at point of most severe injury)

A Mostly loose, some medium fit
B Mostly medium, some loose fit
C Mostly medium, some tight fit
D Mostly tight, some medium fit
L Loose fitting
M Medium fitting
T Tight fitting
U Unknown
N Not applicable (Garment did not ignite, did not cover area of most severe burn or area covered by clothing less seriously burned than exposed area)

C4. Code G4 (Garment contribution to injury)

M Primary agent (Major contribution to severity of burn injury)
S Secondary agent (Not the primary agent causing injury)
N Not involved in injury (Did not ignite or did not cover area of injury)
P Protected from injury or lessened severity of injury
U Unknown

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This final report on an in-depth study of apparel fire accident variables focuses on the physical parameters of fabrics and garments involved in apparel fires and the relationship between these parameters and injury severity. Interactions between accident variables are summarized and recommendations for remedial action and further research are included. Garments involved in apparel fire accidents were classified by degree of fit and amount of the body covered. Fires in which the garment configurations involved covered over half the body (the dress/shift and pants/top configurations) were shown to be associated with more extensive burn injuries than fires involving configurations covering smaller areas (loose tops, fitted pants, and loose pants). Degree of fit could not be shown to be directly related to injury severity. Within garment configuration classifications, age was shown to be a major determinant of injury severity, with victims over 65 years of age receiving a significantly higher percentage of severe burns than those in the 21-65 age group. In accidents involving loose tops, fitted pants, and loose pants the presence of flammable liquids in the accident sequence appeared to be the dominant factor in determining injury level. In addition, when accidents involved flammable liquids, (1) the fabrics involved tended to be heavier, (2) the fit of the garment at point of ignition was closer, and (3) the proportion of cellulosic/synthetic blend and 100% synthetic fabrics was higher than in accidents which did not involve flammable liquids. Because of the many human and physical variables shown to be associated with an apparel fire accident, the author suggests a broad fire prevention program which includes both product regulation and public education.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

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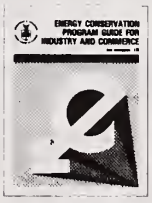

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