basic cost of an emergency room visit is approximately $35 (depending on the part of the country, that can vary from $25 to $40 or more) and we estimate the average cost of a round trip to the hospital to be $5. In addition, we assume that someone accompanies the injured party to the hospital. If we estimate the time spent in travel and at the emergency ward as 2 hours per person and an hourly value of time per person is $5, the value of time foregone as a result of the Class 1 injury is $20. Thus, we estimate Severity Class 1, and consequently Severity Number 10, to be equivalent to $60. (Thus, it appears that every unit in the NEISS Severity Index's geometric progression represents approximately $6.) Extrapolating this result to the other Severity Classes yield the following:

Severity Class	Total Cost
1	$ 60
2	72
3	102
4	186
5	486
6	2,040
7	15,096

Recall that Class 7 injuries are made up of two very different categories of patient disposition: hospitalized Class 6 injuries and fatalities. Our estimate of total cost for Class 7 injuries should apply only to hospitalized Class 6 injuries since the cost of a fatality is dominated by enormous indirect cost and social cost components that are significantly out of proportion to the other injury types. Thus, the evaluation of loss of life must be modified to reflect these differences. It is to this task which we now turn.

4.4.3 The Valuation of Loss of Life

The valuation of human life is a very sensitive subject and, as a result, deserves a few introductory words to avoid misunderstanding. What we are attempting to measure is not the worth of an individual human life, but rather the value of life-saving, of reducing the statistical frequency of death. Asked what they would pay to stay alive, most individuals would say that they would pay anything to avoid death; but that is not the question. In everyday life, individuals are not faced with certain death; they are, however, confronted with some slight, but not irrelevant, probability of death as a result of the riskiness of the activities they engage in. What we ultimately want to know is what it is worth to society to reduce the risk of death from these activities. The problem is that there is virtually no way of divining this value (without knowledge of society's welfare function).

The logical method of discerning the worth of reducing the probability of death is to examine what society does, in fact, pay to reduce the risk of death. If seatbelts cost the individual X dollars and reduce his probability of death by $\frac{I}{Y}$, then the value of life is at least XY dollars.[9] The problem, of course, is that different individuals and that different agencies, or even the same individual or agency at different times, will act so as to indicate widely-varying valuations of life.

As a result, economists have attempted to estimate the value of life in other ways, usually far removed from the original intention of estimating the value to society of reducing the risk of death. Several surrogate methods of estimating the value of life have dominated the economic literature: (1) The value of an individual's life insurance policy, which erroneously is assumed to represent the value one sets on his life, but instead should be interpreted as only part of a family financial portfolio and a reflection of concern for family and dependents; (2) The net contribution of an individual to society as represented by total lifetime earnings minus total lifetime expenditures, which implicitly and erroneously assumes that the value of resources ultimately

[9] This simplified example, of course, presumes a linear risk-of-death function and perfect knowledge on the part of the individual concerning the degree to which the safety-belt reduces the probability of his death.

lies in production rather than in consumption; (3) The discounted value of an individual's expected future earnings, which erroneously assumes that personal values are dependent upon one's contribution to GNP and would imply that the death of a retired person confers a benefit on society; and (4) The discounted expenditures spent by the individual or by society on the individual, which erroneously ignores the productivity of an individual as a contribution to society. Of these four estimating techniques, the value of expected future earnings is probably both the most widely used and the best. For example, a 1964 study[10] estimated the discounted value of future earnings to rise from $59,000 at birth to a peak of $131,000 at age 29 and down to below $1,000 over age 85. (Clearly, these estimates would be about 50 percent larger today). The weakness in these estimates of worth from discounted future earnings is twofold. First, the worth of the elderly (retired) portion of the population is underestimated. This can be remedied by incorporating the fourth estimation technique of human value by expenditure into the technique of estimation of human value by earnings. Namely, we suggest that the value of human life be <u>either</u> the discounted earning of the individual or the discounted expenditures of society on the individual, <u>whichever is larger</u>. Since society spends approximately $10,000 a year (or more) on each elderly person, the discounted value of a retired person's life should still approximate $75,000 to $100,000. The second weakness is that the discounted earnings of the individual ignores the value to society of the individual as a family member and trained worker. A 1965 article by Gary Fromm concerning civil aviation estimated that the cost of the loss to a family of a husband and father and the cost to his firm of retraining a replacement was equal to over 70% of his discounted future earnings. This conclusion is further supported in some work

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[10] Dorothy P. Rice and Barbara S. Cooper, "The Economic Value of Life," <u>American Journal of Public Health</u>, 1964.

performed by the Atomic Energy Commission, which reported that injury awards for loss of life have ranged between $50,000 and $500,000 with a mean of roughly $250,000.[11]

What we conclude from the previous discussion is that the expected value of human life today is almost certainly over $200,000 and probably substantially larger. Since the bathtub and shower accident fatalities in the case studies we have examined are all either the very young or the very old (retired), we would like to be on the conservative side and estimate the value of human life as approximately $200,000. If we resurrect the former NEISS Severity Class 8 for fatalities (with a numerical value of 34,721), it turns out that the (indirect) cost of a fatal injury is $208,326. (Hospitalized Category 6 injuries, as mentioned in the previous section, will still have an estimated cost of $15,096.) Thus, our estimated total costs by NEISS Injury Class is as follows:

Class	Total Cost
1	$ 60
2	72
3	102
4	186
5	486
6	2,040
7	15,096
8	208,326

These estimated costs (and cost savings) will be used in deriving the benefits of alternative intervention strategies.

4.5 Cost/Benefit Analysis

In this section, we will utilize the NEISS data developed during Phase I and the cost/benefit methodology developed during Phase II in order to estimate the potential

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[11] H. J. Otway, "Risk Versus Benefit: Solution or Dream," Los Alamos Scientific Lab, AEC, La-4860-MS, 1972.

benefits from implementating alternative intervention strategies and countermeasures. The purpose of this cost/benefit analysis is to alert manufacturers, government representatives, and consumer groups to those aspects of the bathtub/shower environment where intervention strategies (such as new and retrofit safety devices, product standards, and consumer education) appear to yield the largest return per time and dollar invested. It should be noted that we focussed on the potential benefits of the alternative intervention strategies, rather than on their costs of implementation. These costs are strictly dependent upon the hardware embodiments selected by the manufacturers, the costs of technological development, marketing and production inputs, and the size of the market (or sub-markets). The costs of implementing the intervention strategies were considered at the Safety Conference and were taken into account in our recommendations.

4.5.1 Costs Per NEISS In-Depth Case Study

Our goal in this section is to determine for the United States the annual number of bathtub/shower accidents and their corresponding costs, so that we can quantify the total annual benefits of bathtub/shower accident reduction.

Recall that the prioritization of bathtub and shower area accident factors was based on a sample of 255 in-depth case studies (containing a detailed account of the accident sequence and consequent injury). These case studies were representative of the NEISS survey data except for the fact that the case studies were biased in terms of severity. The case studies contain a relatively large number (in relation to the NEISS survey data) of more severe accidents; but it is assumed that within any severity class the case studies selected are unbiased. In order to make the case studies representative of the NEISS survey data, the following normalization index was employed:

Severity Category:	1	2	3	4	5	6	7[12]
Normalization Index:	5.15	1.00	1.24	.95	.66	.44	.23

Because we subsequently added an eighth severity category in order to distinguish between deaths and hospitalized Category 6 victims, we estimated the normalization indices for Category 7 and Category 8 to be .73 and .06, respectively.

The NEISS survey data, which was assumed to be representative of all U.S. bathtub/shower accidents, was comprised of a sample of 3,669 accidents (Category 0 was deleted) during the period from July 1, 1972 through December 31, 1973. Therefore, each normalized case study (adjusted for frequency) was representative of $\frac{3,669}{255}$ or 11.39 accidents in the NEISS survey data.

The July, 1974, issue of NEISS News estimates that there were 19.53 Bathtub and Shower Structure accidents per year per 100,000 population that are treated in U. S. emergency rooms. By assuming the population of the United States in 1975 to be approximately 220 million persons[13], we therefore estimate that there are approximately $(\frac{220,000,000}{100,000} \times 19.53)$ or 42,966 bathtub/shower area accidents per year in U. S. emergency rooms. This implies that each sample point in the NEISS survey is representative of $\frac{42,966}{3,669}$ or 11.71 bathroom/shower accidents treated annually in U. S. emergency rooms.

NEISS has estimated that approximately 38 percent of all U.S. home accidents are treated in emergency wards. Most of the 62 percent that are not treated in emergency rooms, and are therefore not part of the NEISS sample, are taken to the family physician or go untreated; almost certainly, these accidents are less severe, on the average, than the NEISS survey data. Some accidents not included in the NEISS sample go directly to hospital admittance, to hospital special clinics, or to special institution infirmaries; severity of these, relative to NEISS survey data, is unknown. Finally, a few deaths

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[12] Includes accidental deaths.

[13] Derived from forecasts in the 1972 Statistical Abstract of the United States.

related to bathtub and shower structure may not go to the emergency ward; clearly these cases are more severe than the "average" NEISS survey report. We have, however, assumed the severity levels of the NEISS survey data to be representative of all U. S. home accidents, so that each accident treated in U. S. emergency rooms is representative of $\frac{1.00}{.38}$ or 2.63 accidents in the U.S.[14] (Hence, we estimate that there are (42,966 X 2.63) or 113,000 bathtub and shower area accidents per year in the U.S.)

Each normalized case study, thus, is representative of $(\frac{3,669}{255})$ X $(\frac{42,669}{3,669})$ X $(\frac{113,000}{42,669})$ annual U. S. bathtub/shower accidents. The number of annual U. S. bathtub/shower accidents represented by each case study is equal to the Normalization Index (for the severity category of that case study) multiplied by 11.39 X 11.71 X 2.63. Each case study for the severity category shown thus represents the associated number of annual U. S. accidents with that same level of severity:

Severity Category:	1	2	3	4	5	6	7	8
Annual U. S. Accidents:	2282.3/	431.7/	438.4/	421.0/	292.6/	195.0/	323.4/	26.5

The annual cost represented by each accident in the NEISS case studies is equal to the estimated cost of an accident of that severity type multiplied by the number of accidents annually represented by that case study. Recall that the cost per accident for each severity case (developed during Phase II as part of the Cost/Benefit Methodology) was estimated as:

Severity Category:	1	2	3	4	5	6	7	8
Cost:	$60	$72	$102	$186	$486	$2,040	$15,960	$208,32

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14 One remark is relevant here, as well as to the estimates throughout this section. Our goal is to provide rough estimates of potential benefits rather than highly-accurate figures, which is beyond the capability of the data. We are mainly concerned with orders of magnitude; i.e., are potential benefits fifty thousand, five hundred thousand, five million, or fifty million dollars? In this sense, the simplifying assumptions employed throughout this section, even though they may be inaccurate by ten percent, are adequate for our purposes.

Thus, depending on the Severity Category, each case study accident represents the following annual cost:

Severity Class	Accident/Case Study/Year		Cost/Accident		Cost Represented by Each Case Study
1	2,282.3	X	$ 60	=	$ 136,938.00
2	431.7	X	72	=	31,082.40
3	538.4	X	102	=	54,916.80
4	421.0	X	186	=	78,306.00
5	292.6	X	406	=	142,203.60
6	195.0	X	2,040	=	397,800.00
7	323.4	X	15,960	=	5,161,464.00
8	26.5	X	208,326	=	5,520,639.00

The case study frequencies, disaggregated by Severity Categories 1 through 8, were 5, 39, 48, 102, 37, 15, 2 and 7, respectively. Multiplying these numbers by the corresponding costs represented by each case study yields a total annual cost of all bathtub/shower accidents of approximately 72.7 million dollars:

Severity Class	Costs Represented by Each Case Study		Number of Case Studies		Total
1	$ 136,938.00	X	5	=	$ 684,690
2	31,082.40	X	39	=	1,212,214
3	54,916.80	X	48	=	2,636,007
4	78,306.00	X	102	=	7,987,212
5	142,203.60	X	37	=	5,261,534
6	397,800.00	X	15	=	5,967,000
7	5,161,474.00	X	2	=	10,322,928
8	5,520,639.00	X	7	=	38,644,473
					$72,716,058

4.5.2 Potential Savings from Intervention Strategies and Countermeasures

The benefits of an intervention strategy or countermeasure are the elimination of or reduction in the costs associated with the related accidents, either by prevention of the accidents or by a reduction in their severity. For each intervention strategy and countermeasure introduced during our study, we attempted to estimate the potential annual savings, assuming that it were possible to implement the countermeasures in all bathrooms in the United States and that the countermeasures were 100 percent effective (all accidents potentially related to the countermeasures could be eliminated). Clearly, these assumptions are an oversimplification and will tend to exaggerate savings for three reasons:

(1) Not all homes will utilize the countermeasures. If the countermeasure requires a new tub, for example, only six percent of the stock of tubs in the United States will be affected annually. And even if retrofit were possible, the variety of tubs and showers in existence would require several dozen types (sizes, colors, etc.) of the retrofit product in order to reach the entire tub/shower market.[15]

(2) Normally, the countermeasure will not be 100% effective. For example, anti-skid devices on the bathtub bottom will reduce the number of slips and falls, but they will not eliminate the accident type entirely. To what extent the countermeasure is effective depends upon the technological, engineering, and anthropometric characteristics of the alternative hardware embodiments for each individual countermeasure.

(3) There is serious problem of doublecounting. If several (many) countermeasures are implemented, those accidents that are affected by more than one of these countermeasures will be considered to have been 100 percent eliminated by each of the countermeasures, even though the accident can only be eliminated once. For example, if an anti-skid device and a "soft tub" are both implemented, slip and fall injuries common to both countermeasures will be doublecounted since each countermeasure will take full credit for eliminating the injury. Of course, the degree of doublecounting is completely dependent upon the constellation of countermeasures implemented.

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[15] This would seriously increase production costs, a factor which was discussed at the Conference.

In practice, we estimate that the "effective savings" of a countermeasure, taking into account the three above qualifications, may be substantially less than the potential savings we have derived, depending upon the characteristics of the specific countermeasures implemented.[16]

By referring to the table at the end of Section 4.5.1, we can see that the potential annual savings from the elimination of all bathtub/shower accidents is approximately 72.8 million dollars (minus the hardware costs required to eliminate these accidents). The salient results of our analysis are:[17]

(1) Aside from the elimination of bathing or the abstract total prevention of injury, the intervention strategies with the largest potential benefits (in the $45 million range minus hardware costs) are intervention strategies related to children, including any of the following: bathinettes, child harnesses, and parental presence (or some other attendant) or some tub/shower constraint requiring adult presence. Note that any one of these approaches, if completely effective, will individually yield approximately $45 million in savings annually. This area of intervention seems extremely fertile, both at a conceptual and at a market level.

(2) Ignoring the abstract intervention strategy of erecting physical barriers between the user and harmful levels of energy release (or of alarms to warn of impending releases of energy), we found the next most important area of interven-

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[16] An alternative approach of evaluating the countermeasures is to assume that the countermeasure applies only to new tubs/showers but that the benefits accrue over the life of the new product. In that case, the effective savings of the countermeasures should take account of doublecounting and usage failure.

[17] Note that how we aggregated the data was determined by the conceptual "common denominators" in the intervention strategies. Note further that our list of results are not mutually exclusive, nor should they be, since, in general, there is more than one way to prevent an accident from occurring.

tion to be preventing falls and preventing the accumulation of water at a hazardous depth (both in the $30 and $40 million range). (Thus any one measure, or combination of measures, that prevent all falls, for example, will yield 30 to 40 million dollars annually). Again, the potential for marketable safety products appears enormous.

(3) At approximately the $25 million level are each of a series of intervention strategies that prevent the release of deleterious hot water into the tub/shower. These strategies as well as being of the first magnitude in regard to probable implementation and marketability, benefit from an extremely high effectiveness potential (low mechanical rate of failure and no user action required).

(4) Each of the following five intervention strategies will yield benefits in the $15 to $20 million range: those that prevent unattended children from climbing into the tub and prevent irresponsible and incapacitated users from entering the bathtub/shower area; those that augment the frictional characteristics of the bathtub bottom; those that prevent the release of hot water in the presence of children or the incapacitated; those that involve softer or more energy absorbing material in the tub/shower; and finally, those that involve "breakaway fixtures", which fail before excess energy is applied.

(5) Finally, each of the following reasonable intervention strategies will yield benefits in the $1 to $7 million range: large horizontal surface area on the tub edge for balance; convenient location of accessories and fixtures so as to minimize displacement; lower tub edge for entry; gradual steps at tub edge for entry; friction augmenting surface on the bathroom floor; eliminate multiple bathing, non-shatterable enclosures; recessed or retractable fixtures; tests for sobriety, vertigo, hyperactivity, excess tiredness and hostility; and attendants for handicapped users.

These results are summarized in the following table.

SUMMARY TABLE OF POTENTIAL ANNUAL SAVINGS *

Intervention Strategies	Potential Savings
Supervision of Children	$45 M
Harnesses for Children	$45 M
Bathinettes for Children	$45 M
Slips and Falls Prevented	$30 M - $40 M
Accumulation of Water Prevented	$30 M - $40 M
Deleterious Hot Water Not Released	$25 M
Unattended Children Unable to Enter Bathtub	$15 M - $20 M
Irresponsible and Incapacitated Users Unable to Enter Bathtub	$15 M - $20 M
Frictional Characteristics of Tub Bottom Improved	$15 M - $20 M
Children or Those Incapacitated Prevented from Releasing Hot Water	$15 M - $20 M
"Softer" or More Energy Absorbing Tub Material	$15 M - $20 M
Large Horizontal Tub Edge	$ 1 M - $ 7 M
Lower Tub Edge	$ 1 M - $ 7 M
Gradual Steps at Tub Edge	$ 1 M - $ 7 M
Conveniently Located Accessories and Fixtures	$ 1 M - $ 7 M
Frictional Augmenting Surfaces on Bathroom Floor	$ 1 M - $ 7 M
Multiple Bathing Eliminated	$ 1 M - $ 7 M
Non-Glass Enclosures	$ 1 M - $ 7 M
Recessed or Retractable Fixtures	$ 1 M - $ 7 M
Attendants for Handicapped Users	$ 1 M - $ 7 M
Tests for "Irresponsible Users	$ 1 M - $ 7 M

*The costs of implementing the countermeasure have not been subtracted out

4.5.3 Cost-effective Countermeasures

The cost of implementing intervention strategies and countermeasures, particularly when new products and processes are involved, is always difficult to estimate. New product costs are dependent upon the degree of research and development, the specific hardware embodiment selected by the manufacturer, and production scale (potential economies of scale). Costs of implementing educational programs might best be measured in terms of the level of educational spending that would be cost-effective rather than in terms of the process costs of educational inputs. In this section, we shall estimate for each of the major countermeasures the break-even cost-effective level of spending per bathtub/shower unit. We shall then indicate, based on available information, which countermeasures clearly are or are not cost-effective.

As a prelude to our cost-effectiveness results, however, the following caveats concerning cost-effectiveness are in order: (1) Cost-effectiveness here refers only to a comparison of implementation costs with the dollar savings from reduced injuries. Peripheral factors associated with a specific safety product, such as security, feasibility, convenience, and aesthetics, are not included in the calculations.

Security refers to the fact that most consumers are risk-averters; that is, they are willing to pay something (beyond the cost-effective level) for the psychological satisfaction derived from reducing or eliminating the rpobability of a serious loss (from injury, etc.).

Feasibility refers to the fact that a countermeasure may be cost-effective but impossible to implement because of "system" or technological constraints. For example, turning down the temperature on the hot water heater may not be feasible because of other household requirements for hot water.

Convenience refers to the fact that a countermeasure may be cost-effective but not implemented because consumers do not find the product convenient to use. (Witness the automobile seat belt.) For example, child-proof faucets may be unpopular because of their relative inconvenience for all users.

Aesthetics refers to the fact that a countermeasure may be cost-effective but not implemented because of consumer taste for a less-safe product. For example, non-shatterable tub enclosures are probably cost-effective, but not widely implemented because a large segment of the population "prefers" glass enclosures.

(2) Cost-effectiveness applies not to the total costs of a new safety product or process, but only to those costs in excess of the costs of the existing product or process being replaced.

(3) Cost-effectiveness is a measure only for the "average" consumer. A countermeasure may not be deemed cost-effective, even though individual elements of the population (such as the elderly, handicapped, parents of young children) might find the countermeasures to be cost-effective. In other words, recommendation based on cost-effectiveness apply to the population universe in the United States and, thus, are not dependent upon population profiles in order to be relevant.

(4) Cost-effectiveness measurements of a specific countermeasure assume that ceteris paribus conditions apply to the rest of the tub/shower environment. If numerous countermeasures are implemented, cost savings from injury reduction may be double-counted and cost-effectiveness thus overestimated. The precise constellation of countermeasures implemented determines the amount of savings overlap.

Were all the above four factors included, the calculated cost-effectiveness of these countermeasures would be increased.

Our estimates of "allowable" cost for a countermeasure assume a forty-year life of the countermeasure,[18] a tub population of eighty million, and a total tub and shower stall population of one hundred million.[19] Again, our estimates of cost-

[18] Certain educational programs, children's products, and retrofit products (such as slip-resistant surfaces) might have a substantially smaller effective life. If they do, maximum cost-effectiveness ranges must be reduced accordingly.

[19] We did not discount potential savings over the forty-year period since we assumed that the rate of savings inflation (injury will cost more in the future) is approximately equal to the discount rate.

effectiveness are presented in terms of the maximum cost <u>per tub or shower unit</u> that is warranted by expected saving from a specific countermeasure.

Major countermeasures are listed below, with estimates of their break-even level at which costs equal savings, and an indication whether implementation costs would pay off in terms of accident savings. Taking the first item as an example, if children's harnesses or bathinettes cost less than $22.00 per bathtub unit, then this measure will be cost-effective because accident savings average at least $22.00 per unit. "Cost-effective" in the third column indicates that we believe that harnesses and bathinettes may be made available at this payoff price or less, based on estimates from manufacturers and other sources.

Countermeasure	Break-even Cost Level* (Countermeasure pays off if cost is below this amount)	Cost-effectiveness (Savings exceed costs)
Children's Harnesses and Bathinettes	$ 22.00 per unit	Cost-effective
Parental Education Programs	$ 18.00 per unit	Cost-effective
Slip-Resistant Bathtub Surfaces and Handholds	$ 10.00 per unit	Cost-effective
"Softer" Tub Edge	$ 8.00 per unit	Marginally cost-effective
Non-Sharp Protruding Fixtures	$ 1.00 per unit	Cost-effective
Recessed or Retractable Fixtures	$ 1.00 per unit	Not cost-effective
Non-Glass or Non-Shatterable Glass Enclosures	$ 1.00 per unit	Marginally cost-effective
Child-Proof Faucets	$ 10.00 per unit	Cost-effective
Anti-Scald Device	$ 10.00 per unit	Marginally cost-effective
Turn Down Temperature of Hot Water Heater	$ 10.00 per unit	Cost-effective
Enlarge Tub and Shower Stall	$ 9.00 per unit	Not cost-effective
Floatation Collar or Adjustable Drain	$ 14.00 per unit	Cost-effective

*NOTE: The above are not costs of the countermeasure, but accident savings probable from the use of the countermeasure, and thus the maximum the countermeasure can cost to be cost-effective

5.0 VIDEOTAPING ACTIVITIES

Analyzing the subtle and complex activities of bathing and showering necessitated going beyond the descriptive data on the individual case studies and their related groupings which have been called scenarios.

The methodology used in this study of analyzing accident sequences in bathing using nine scenes, including 67 significant factor variables, is a fairly complex and detailed examination of the process. Yet even this system cannot be said to be a comprehensive examination of the bathing process. In order to increase the thoroughness of our examination of the bathing process and possible bathing accidents, a strategy of videotaping actual and simulated bathing operations was employed. The videotaping offered the opportunity to study in detail the critical events in the bathing process with the interaction of the user and the physical environment. The goal of this activity was to gain greater insight into the actual bathing process, to verify the validity of the scenarios to discover significant factors which might have been omitted in the data base due to biases in the reporting, to aid in establishing the points at which intervention may be applied and finally, to document and effectively communicate the activities and issues in the bathing process to others with interests in this area.

The relative rarity of accident-related intervention in the tub and shower area, as well as the very real risks to the users whose activities were being documented, produced several requirements. One, that our users would be carefully attended when the recording of even accident-free bathing procedures were carried out; two, that this documentation would be a non-intrusive as possible, with apparatus limited to a hand-held camera and with near normal room lighting levels; three, that all users would be users of the research team or their families; four, that simulations of accident interventions would be done by a member of the research team aware of the risks and thoroughly experienced with the procedures.

Using these guidelines bathing activities were examined on two levels. First, normal activities, primarily of children, were examined under standard home conditions in order to gather firsthand information for refinement of intervention strategies and countermeasures. With statistical information already in hand, factors were recorded in this additional dimension.

Second, normal activities of an adult bather were simulated in a mock-up bathroom environment.

Third, accident interactions of an adult bather, based upon a selection of scenarios, were simulated in this prepared area.

Table 5-1 summarizes the videotaped bathroom and shower area interactions. The flow diagram 5-2 which accompanies this table relates these interactions to the intervention strategies discussed. The environment in which these studies were accomplished is graphically reproduced in diagram 5-3.

While it is not within the scope of this study to present a comprehensive videotape documentation and analysis of each bathing sequence, those chosen seemed most useful and appropriate in illustrating bathtub and shower area activity.

In summary, normal bathing of children sequences were chosen because of the special vulnerability of children. The children were two females aged 2 and 7 years and a 4 year old male who were bathing in a home environment shown in the diagram. This unsimulated example of multiple child bathing represented the average activities of the children of this family. Although the circumstances were affected by the cameraman and instruments, the children seemed to settle rapidly into their normal interaction.

Viewing these sequences revealed factors which required further consideration and an unexpectedly high number of clues into hazardous bathtub situations for which interventions were developed. Some of the features of their bathing activity of interest are listed below.

Flow Diagram 5-2

BATHTUB AND SHOWER AREA INTERACTIONS AND INTERVENTIONS

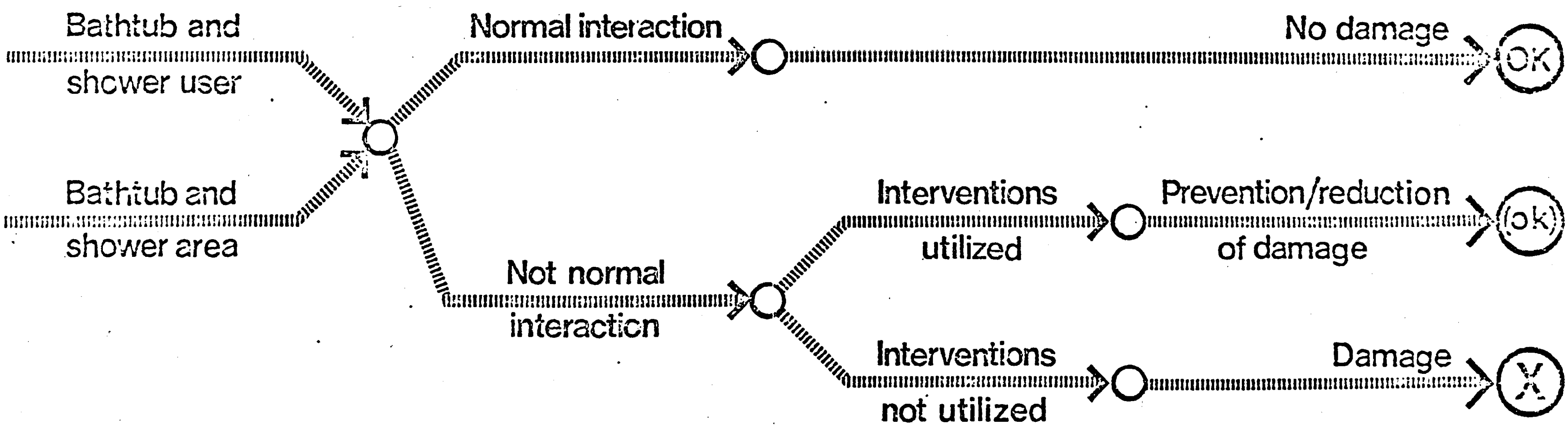

TABLE 5-1 Videotaped Bathroom and Shower Area Interactions

NORMAL INTERACTIONS

Bathtub Bathing of Children - Unsimulated

Bathtub Bathing of Adult - Simulated

Showering in Bathtub of Adulb - Simulated

SIMULATED ADULT

HIGH FREQUENCY ACCIDENTS

Scenario 1	User incapacity present with falls against tub
Scenario 3	Bathroom activity with slips and falls against tub
Scenario 12	Tub entering or leaving activity with slips and falls
Scenario 16	Slips and falls against protruding fixtures
Scenario 14	Tub enclosure glass breaks resulting in lacerations
Scenario 17	Fixture failures under load

- Awkward unbalanced entry to tub by the 4-year-old male.
- 2 1/2-year-old female bathing at faucet end of tub, thus putting the forehead and eye level directly in line with the faucet. Several instances of near contact were noted.
- 4-year-old male left tub for toy, making an awkward and unbalanced exit out onto the wet slippery floor and crumpled bathrug.
- 2 1/2-year-old female leaned over the tub rim (soapy and slippery) to retrieve a plastic bottle dropped outside of the tub. She teetered on the edge with the body center of gravity varying from inside to outside the tub.
- continuous edge interaction by the children.
- 7-year-old female left the tub unbalanced, leaning forward toward the towel rack on the opposite wall.
- 4-year-old male stood, soaping, in very soapy water.
- the edge of the tub was used many times for resting the bar of soap on.
- 2 1/2-year-old female got out of the tub using her left hand, which was covered with soapy water, for support against a smooth tile wall.
- 4-year-old male alone in tub, practiced dunking three times, blowing bubbles and coming up with full expiration of the lungs. The last time, he came up very near the faucet with a violent upward movement. Each time, he stood to clear his hair and water away from his eyes, lacking orientation and balance.
- 4-year-old male left tub awkwardly.
- 4-year-old male leaned over tub edge four times, three times to retrieve toys, and once to empty the tub. He stood unbalanced on the wet floor.

The simulated examples videotaped because of the self-conscious planning required for execution, were more useful in revealing general anthropometric considerations for the adult bather, in this case a 34 year old male. The videotaping of simulated adult accident sequences also served as an effective educational tool for objectively explaining the nature of the bathing activity, the scenario accident types, the points for intervention and some of the intervention concepts.

6.0 BATHTUB/SHOWER AREA SAFETY CONFERENCE

A key element in reducing the incidence and severity of bathtub accidents is the involvement of manufacturers in making bathtubs safer. A conference was held as part of this study to inform manufacturers about intervention strategies and to gain input from the manufacturers on the feasibility of implementing these strategies. The conference was also attended by government and consumer representatives and by standards-setting and product-testing groups, and other interested parties; 60 people in all. These individuals brought different concerns to the problem of bathtub injuries. Their interaction allowed the study team to gain a wider perspective on the issue of implementation of intervention strategies. New product development was also discussed at length, both in the area of accessories and retrofit devices and in original design of fixtures and fittings.

The conference began with presentations to the attendees on typical accident scenarios, possible intervention strategies and countermeasures, and an economic analysis of the benefits (or savings) to be gained through prevention of injuries. Conference attendees as a group responded to this information.

The conference members were then assigned to working groups, within which intervention strategies and countermeasures were examined more closely. (See conference agenda on the following page). The three working groups considered fixtures, fittings and accessories, respectively. Under each of these categories, the workshops discussed general intervention strategies and specific countermeasures. New product ideas were evaluated, and participants identified the major design considerations and obstacles to be overcome. Marketing strategies were also considered. Participants emphasized the idea of educating consumers as well as providing them with safer products. Conference attendees representing special interest groups, notably the elderly and the handicapped, evaluated intervention strategies and new product ideas as they related to their special groups, at times bringing totally new design considerations into the discussion.

Manufacturers also identified design considerations other than those of safety. In addition to function, sanitary standards were a major concern, particularly relating to materials used in bathtub construction.

Thus a variety of reactions to the intervention strategies and countermeasures were gathered. A summary of the opinions expressed at the conference, including our own, is presented in Appendix A at the end of this report. This information, along with the economic analysis, was used extensively in formulation of the final recommendations from this study.

BATHTUB SAFETY CONFERENCE

AGENDA

Wednesday, March 5

8:45	Registration and Coffee
9:15	Welcome and Overview of the Conference
9:35	Introduction to the Consumer Product Safety Commission
9:45	A Safety Conference for Bathtub and Shower Area Products
10:30	BREAK
10:45	Presentation of Accident Scenarios
11:15	Intervention Strategies
11:45	Results of Data Analysis
12:15	Open Discussion
1:15	LUNCH
2:30	Safety Concepts in the Design Process
3:00	Working Groups

Thursday, March 6

8:45	Coffee
9:00	Working Group Reports
9:45	New Working Groups
12:30	LUNCH
1:45	American Society for Testing and Materials Announcement
1:50	Reports from Working Groups
2:15	Summation and Response from Attendees

7.0 RECOMMENDATIONS

The recommendations of this study to reduce the incidence and severity of bathtub and shower area injuries are the results of over ten months of concerted effort by the project team. The development of scenarios to help understand the accident process, the identification of intervention strategies to impact upon the various stages of the accident sequence, and the economic analysis of potential savings of alternative intervention strategies provided the foundation on which these recommendations are based. In addition, comments from the bathtub/shower safety conference, information concerning constraints in the manufacturing process (obtained from various on-site visits with manufacturers) and findings from video tapes of real and simulated bathroom/user interaction were all integrated into the recommendations.

Section 7.1 contains our recommendations concerning the highest-priority issues in bathtub safety: slip-resistance of the bathtub bottom, anti-scald devices, and consumer (particularly parental) education. Section 7.2 contains our analysis of several secondary intervention strategies which are also strongly recommended; however, these secondary recommendations either address a more limited set of accidents or involve some conditional factors that must be resolved for successful implementation. Section 7.3 describes the activities which are required of industry, government, and consumers in order to implement our recommendations; particular emphasis is placed upon the crucial importance of cooperative effort by the three major safety groups.

7.1 Primary Recommendations

7.1.1 Slip Resistant Tub Surface

It is not surprising that slipping on the tub bottom is the accident mode users are most conscious of, since slips and falls on the tub surface (bottom) are far and away the most frequent cause of bathtub/shower injury. It has been estimated during this study that injuries resulting from slips and falls on the tub surface cost society almost twenty million dollars annually. Moreover, it was evident from analysis of the NEISS data that the existing types of integral surfaces (rough, etc.) bath mats, and appliques designed to increase slip resistance are not (totally) successful in eliminating this type of accident. The problem appears to be that these surface products and material are not designed to address typical bathing activities under typical bathing conditions (wet, soapy, etc.) Hence, agreement was readily reached upon the single most important performance guideline to be established:

> "Every tub and shower stall will be provided with a standing surface which is slip resistant."

This performance guideline is important for new fixtures as well as for products designed to upgrade existing tubs and shower stalls. To accomplish the desired level of performance, realistic test methods are badly needed. These test methods must resolve the following issues:

- Definitions of slip-resistance are required.
- Determination of the parameters of movement associated with accident sequences is required.
- A means of establishing the level of slip resistance is required and might be accomplished by evaluating all available slip testers.
- The test chosen must accurately simulate the wet foot and the extremes of bathing activity, as well as the conditions present in typical accident sequences, such as partially filled tubs, wet tubs, and the presence of soapy films. Existing test methods, such as the British "road tester", are simply inadequate.

Nearly every tub manufacturer is already aware of the importance of a slip-resistant finish. In the light of these recommended test measures, however, manufacturers and others will need to reevaluate the various methods with which to achieve an acceptable degree of slip resistance in bathtubs and shower stalls.

Quite possibly, new materials and production processes will need to be investigated. In addition, it is hoped that industry will respond to the problem of slip-resistance by developing appropriate retrofit items, since it is possible that in the area of slip-resistance, retrofit may be the most effective and least costly solution.

7.1.2 Anti-Scald Devices

Our second recommendation addresses the problem of burns from deleterious hot water, which cost society approximately twenty-five million dollars annually. This type of injury is infrequent, but of enormous severity -- over seventy persons a year die from burns sustained in the bathtub/shower area.

For retrofit, as well as for new construction, we believe the most cost-effective countermeasure to bathroom burns is to turn down the temperature on the central water heater to 120°F[1], so that hazard hot water is not available to the tub or shower. We recognize that total implementation of this recommednation may require the redesign of appliances high-temperature water (mainly the dish washer) or redesign of the hot water system. However, most homes can presently implement this countermeasure without cost or complication. This recommendation has the added value of reducing energy costs to the homeowner.

In addition, a performance guideline, to be applicable only to new tubs and shower stalls, should be established that requires a pressure or thermostatic valve to control water temperature and to prevent scalds. Problems are not anticipated in specifying the nature of either the performance guideline or the accompanying test methods. The Commonwealth of Massachusetts has already integrated anti-scald standards into their 1973 and 1974 State Plumbing Code; however, their codes, in order to be fully effective, must as least be amended

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[1] The appropriate temperature should be in the range of 110° to 120°. Any hotter and burns could result; any lower, given, the 5 to 10 degree thermal loss from transmission, and the water may provide insufficient warmth for personal comfort.

to include bath valves as well as shower valves. The reason for our emphasis on anti-scald bath valves is that virtually all of the scalding deaths and most severe burns in the bathroom occur as a result of immersion in hot water rather than as a result of being sprayed by hot water.

The present cost differential of a new pressure control valve in comparison to either a new two-handle valve or a one-handle mixing valve is approximately in the range of five to twenty-five dollars. The average cost differential of approximately fifteen dollars would (marginally) make the anti-scald device cost-effective; but we anticipate that larger-scale production will reduce the unit cost of anti-scald devices so as to reduce or eliminate the cost differential.

We cannot universally recommend anti-scald devices as retrofit measures since the implementation cost of from one hundred to one hundred and fifty dollars is not warranted by the savings in injury reduction. However, safety-conscious households may find anti-scald devices to be a worthwhile retrofit item.

7.1.3 Consumer Education

Perhaps the most surprising result of our analysis was the discovery that children under five years of age, who constitute only 8.4% of the population, account for almost 30% of all bathtub/shower injuries (including over 75% of all tub related deaths) and for almost 65% of the social cost associated with bathtub/shower injuries. The total annual cost to society of children's bathtub/shower injuries is $45 million, and well over 90% of those costs are associated with injuries sustained by the child while unattended or non-continuously attended. Although specific product improvements (such as slip-resistant surfaces and anti-scald devices) could reduce or eliminate certain types of children's injuries, we strongly feel that educating parents not to leave children alone in the tub or shower is the most effective means of addressing the entire problem of children's accidents.

Our reliance on parental education is particularly important as a countermeasure to drownings (and other submersion injuries resulting from the hazardous accumulation of water).[1] The project team could not discover cost-effective mechanical intervention strategies to prevent drownings. Since young children can drown in as little as half an inch of water, it is not surprising that the only alternative to parental supervision as a countermeasure to children's drownings, we determined, is to substitute showering for bathing (eliminating the hazarous accumulation of water) in the case of children. However, showering rather than bathing fails to address the entire problem of children's injuries; hence, we recommend that educating parents to continuously supervise their children in the bathroom is the most effective means of reducing children's injuries. We believe that the present degree of inadequate supervision of children is caused by a general lack of awareness of the dangers involved, which could largely be corrected by parental education programs.

Consumer education may also be a valuable countermeasure to bathtub/shower electrocutions, an area which was not addressed in the current study.[2] In particular, a cursory examination into this area suggests that educating consumers not to use hairdryers, radios, and other electrical appliances in the bathroom and to install ground fault interrupters in all bathroom outlets would significantly reduce injury and death by electrocution.

Section 7.3.3 itemizes some of the methods of implementing consumer (parental) education.

[1] Children's drownings (which number over 100 annually) and submersion injuries cost society the remarkable total of over $20 million a year.

[2] Electrocutions caused by interaction of a "live" appliance with a user in the tub or shower are categorized in the NEISS data by the appliance, not the bathtub/shower. In addition, this electrocution data is highly unreliable in the NEISS data, since it includes only emergency room injuries. Next year, when death certificate data is included in NEISS, would be an appropriate time to examine the area of bathtub/shower electrocutions.

7.2 Secondary Recommendations

There are a number of other important intervention strategies to be considered, which are conditionally recommended as a result of this study. The following intervention strategies are all potentially valuable in reducing injuries; in several cases, however, certain design or cost problems must be addressed before the strategies can be implemented. They are divided into two groups: new and retrofit (although there is some overlap between the two). Because bathtubs are a durable product and new bathtubs account for only a small number of existing bathtubs, retrofit devices offer the greatest potential for immediate improvement in bathtub safety. In the long term, new tubs must be equipped with safety features as well.

Retrofit

1) Handholds:
Handholds are effective in reducing the incidence of slips and falls, because most slips occur while raising up or sitting down in the tub or while entering or exiting the tub. Anthropometric research will reveal how many handholds are necessary in the tub and where they should be placed. Handholds must have rounded edges and be durably fixed in place.

2) Nonshatterable shower enclosure:
Use of nonshatterable materials in shower enclosures will effectively eliminate user lacerations caused by falling against and breaking shower enclosures. Nonshatterable materials need not be more expensive than glass.

3) Cushioned tub edge:
While increasing the resilience of the entire bathtub may make it less stable and harder to clean, cushioning only the tub edge (where most injuries occur) is a promising intervention

strategy. Development of a cushioning device for the tub edge with particular attention to sanitation standards, is recommended.

4) Flexible shower hose:
The flexible shower hose used in Europe, or "telephone shower," allows the user to bathe and rinse off in a seated position, thus reducing the possibility of slips and falls. We recommend that such devices be used and that an anti-siphon feature be perfected, to eliminate the possiblity that unclean water will be siphoned from the tub to the water supply.

5) Design towel racks and soap dishes as handholds:
Towel racks and soap dishes with handles are often used by bathers to maintain balance; therefore, they should be made as stable as handholds. These products might then be sold as dual-function accessories.

6) Seat:
A small bath seat for children is recommended as a means of preventing drownings. Seats are also potentially safer for adults because they will be less likely to slip and fall. For the handicapped, seats are particularly useful for facilitating safe bathing.

7) Shower enclosurers which cannot pinch body parts:
The sharp railing of shower enclosurer may constitue a hazard; therefore, it is recommended that they be designed to prevent pinching or lacerations.

8) Visual display of water temperature:
A device which turns a different color when water is overly hot may be installed in a tub to prevent burnings. Design of such a warning device is recommended for further consideration.

9) Printed Educational messages:
Bathroom products, such as soap or bathtub toys, should contain education messages; for example, warning parents not to leave children in the bathtub unattended.

10) First aid materials available:
Easy availability of first aid information and materials to doctor's telephone number is recommended for minimizing injuries resulting from bathtub accidents.

<u>New</u>

1) Placement of fittings:
It is recommended that fittings such as faucets, drains, and the shower head be placed so that the user can maintain his or her balance, i.e., so that a minimum of bending and stretching is required. Anthropometric studies will determine proper placement.

2) Rounded fittings:
Any protruding fittings should be designed with rounded edges so that a user cannot be injured by falling against them.

3) Recessed fittings:
Recessed fittings are recommended so that the user cannot fall against protruding fittings, causing lacerations or bruises. This measure would not be cost-effective on a national basis, but is potentially valuable to the safety-conscious public.

4) Increase height of tub edge:
A higher tub edge would cause users to enter from a sitting position, thus reducing the chances of slipping and falling. The higher tub edge might be achieved by elevating the entire tub

(i.e. on a platform) or by increasing the height of the sides, and hence the dept of the tub. Further research into this concept is recommended.

5) Increase curvature of tub edge:
Research is recommended to determine whether changed geometry of the tub edge would decrease the number and severity of injuries involving the tub edge.

6) Eliminate combination tub and shower units:
For the safety-conscious user who is able to afford it, separate bathtub and shower units will enhance the safety of the bathroom. Faucets may be more appropriately placed in separate units, and the surface need not be designed both for sitting and for standing.

7) Provide easy discrimination between hot and cold water faucets:
Differentiation between hot and cold water faucets, through shape texture, or color, is recommended as a low-cost item which will help prevent burn injuries.

8) Enlarge shower stall:
Enlargement of the shower stall to 36" x 42" or 42" square will provide safety-conscious users with a shower which allows the user to stand out of the water stream while adjusting the temperature. In addition, a larger shower stall gives the user a place of refuge if overly hot water is accidentally turned on.

9) Telephone or intercom:
It is recommended that parents be made aware of the value of having a telephone or intercom installed in the bathroom so that they can answer it without leaving children alone.