V. Separate in space or time the energy being released from the susceptible structure

Enlarging the shower stall so that the user may easily retreat from overly hot water is an example of this principle. The practice of adjusting the water temperature before stepping into the tub or shower illustrates how the user and the potentially damaging source of energy may be separated in time.

VI. Impose a material barrier between the energy being released and the susceptible structure

Protective clothing, such as a helmet worn by a handicapped person or a child, serves as a material barrier between the user and a possible source of injury. Thermal insulation on exposed pipes or on faucets is another example of this intervention strategy.

VII. Modify the contact surface, subsurface, or basic structure which can be impacted

This strategy is realized by rounding and softening points, edges, and corners with which people come into contact. Its usefulness comes from two effects: first, a soft surface will spread force over a larger body area; second, to the extent that the impact surface exerts a retarding force over distance, it will spread the force over a longer time. Modification of faucets, shower heads, and other fittings or accessories are included in this strategy.

VIII. Strengthen the living and non-living structure which might be damaged by energy transfer

Examples of this strategy are the training of soldiers and the pre-season conditioning of skiers. Because the accident target group for the present study includes the entire population, it is not feasible to consider the intervention strategy of such a wide scale physical training program.

IX. Rapidly detect and evaluate damage and counter its continuation and extension

This process includes the generation of a signal that a response is required, the transmission, reception and evaluation of the signal, and the delivery of an appropriate response. An alarm that notifies a reasonable person when a bathroom user has sustained an injury is an example of this strategy.

X. All those measures which fall between the emergency period following the damaging energy exchange and the final stabilization of the process (including intermediate and long term reparative and rehabilitative)

This strategy is included for completeness and lies principally in the province of the medical care system.

XI. Affect the behavior, or performance, awareness, or control of the human elements involved, such that their active cooperation is enlisted in the prevention or reduction of energy damage as outlined above.

XIa. Educate the bathroom designer and user

This strategy is the first of three behavioral categories developed by the project team, distinguished from the ten of the above system because they depend on action by the user for their effectiveness. Education includes the promulgation of design standards, increasing the user's awareness of potential dangers, and the encouragement of skillful and responsible use of the energies present in the bathroom.

XIb. Warn the user of the accumulation and potential release of damaging energy

Examples of this strategy include signs, labels, and thermometers to measure water temperature. These strategies increase the user's awareness of his or her environment and requires conscious reactions to prevalent dangers.

XIc. Increase the user's control over the release of energy

Examples from this category include any training which specifically applies to the bathtub or shower area circumstance and which allows the "normalization" of the user's behavior in the environment (e.g., with the handicapped) or the establishment of new neuro-motor skills (e.g., with children) to reduce susceptibility.

The above classification system served not only as a means of organizing the numerous intervention strategies but also as a means of generating new ideas and of ensuring full coverage of the topic of bathtub and shower accident prevention. The list of 436 intervention strategies which resulted from this investigation, however, was clearly too long to be useful, so a process of screening ensued. Intervention strategies were screened on the basis of practicality of implementation and effectiveness in terms of potential savings.[2] In addition, strategies addressed to the groups most vulnerable to bathtub accidents -- the elderly, children, and the handicapped -- were singled out for special attention.

Participating in this screening process were manufacturers, consumer representatives, and members of relevant government and standards-setting groups. These individuals were given the opportunity to react to the findings of the study team at a conference.[3] The feasibility of new products implied by certain intervention strategies was also discussed, and areas in need of improved product testing were identified.

The intervention strategies discussed in the following section thus are the result of a consideration of accident scenarios, a thorough examination of possible means of preventing damaging release of energy, and a screening process involving contributions from a range of interested parties and researchers.

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[2]See economic analysis, Chapter 4.

[3]Bathtub Safety Conference, March 5 and 6, 1975, Abt Associates, 55 Wheeler Street, Cambridge, Massachusetts.

3.2 Approach

The following list describes the countermeasures which appear to be most feasible and potentially effective for preventing bathtub and shower injuries. Many of these countermeasures involve development of new products or modification of existing products. Where possible performance guidelines are suggested for these products. Section 4 will estimate the potential benefits from each of these countermeasures and will give some recommendations for implementation of these countermeasures, in the light of potential savings and the expected costs of implementation.

1. Education of adults not to leave children unattended. Particularly for childhood fatalities due to burns or drowning, a strong correlation has been found between the absence of a responsible attendant and the injury. No product has been conceived which could address this problem as effectively as the continuous presence of a responsible attendant.

2. Non-skid bathtub surface. Injuries involving slips and falls are best addressed by increasing the frictional coefficient of the bathtub floor, either in original design or through retrofit devices such as a bathmat or applique. Performance guidelines for a slip-resistant surface should specify that the user's foot shall not slip when loaded with typical human weights of an angle to be determined. Test procedures for slip-resistance should include simulation of a wet foot. The bathtub surface must also conform to standards for sanitation and cleanability.

3. Mobility assists - handholds. Mobility assists such as handholds should be located to facilitate entry exit from the tub and change of position from sitting and standing. In addition to proper placement require-

ments, performance guidelines should specify stability under a certain load. Handholds serve the function both of preventing slips and preventing a slip from leading to a fall.

4. Increased resilience of bathtub surface. To prevent a fall from causing serious injury, the impact suface may be made softer, either in original design or through a retrofit device such as a cushion. The tub edge, which is most frequently the impact surface, is particularly suitable for retrofit with a padded surface. Performance guidelines should specify a required module of elasticity, and sanitation standards must also be met. Testing is necessary to determine the effectiveness of increased resilience.

5. Design tub edge with greater radius of curvature. Injuries resulting from contact with the tub edge may also be reduced by reducing the angularity of the tub edge. Comparison of severty of injuries incurred from varying tub edge designs is necessary.

6. Seats in showers and tubs. A seated bather has virtually eliminated the possibility of slipping and falling. For some users, straps connected to the seat may be necessary to stabilize their position. Seats should be designed so that the user may be seated securely and so that the seat does not present an obstruction.

7. Flexible shower hose ("telephone shower"). The use of a European-style flexible shower hose enables the bather to shower in a sitting position, thus reducing the likelihood of slips and falls. A performance guideline for this device should specify a reasonable length, based on anthropometric research, and an anti-siphon feature.

8. Add-on tub edge. A device designed to effectively raise the tub edge would serve to prevent the children from entering the tub unattended and also to encourage adults to enter from a sitting position.

9. Visual display of water temperature. A thermometer or other means of communicating water temperature visually may be incorporated in original tub design or a retrofit item. The purpose of such a device is to warn the user of water which is too hot.

10. Enlargement of shower stall. Enlarging the shower stall provides room for retreat for the user who is surprised by a burst of hot water. Anthropometric research should lead to determination of desirable size.

11. Placement of fittings to maintain user's balance. Placement of water faucets or drain so that the user must stretch and bend excessively presents greater opportunity for slips and falls. Analysis of movements and body size is required to establish guidelines for fittings placements.

12. Encourage easy discrimination between hot and cold water faucets. Consistent placement, labels, color codes, and differentiation in shape or texture may all be used to aid the user in discrimination between hot and cold water faucets, thus helping to prevent burns and scalds.

13. "Child-proof" faucets. Faucets which cannot easily be used by children, either because physical strength or a complex movement is required, will help prevent misuse of the bathtub by children. Performance guidelines must specify that the faucet must remain readily accessible to adults, including the elderly.

14. Design protruding fittings without sharp edges. Faucets or shower heads which have pointed or sharp edges will cause greater injury to the user who falls against them. The fittings may be designed to be rounded or may be retrofitted with soft devices. These cushioning devices must meet sanitation requirements.

15. Recessed fittings. Rather than softening the edges of fittings, the fittings may be recessed so that the user cannot fall on them.

16. Nonshatterable shower enclosures. Use of a nonshatterable material in shower enclosures eliminates the potential for the user breaking the glass and cutting himself. Performance guidelines should specify a weight which the material can bear without breaking or shattering.

17. Towel racks and soap dishes either conforming to handhold standards or not usable as handholds. The common practice of holding on to a towel rack or soap dish for balance results in injury when the accessory is not anchored securely and cannot hold the user's weight. Towel racks and soap dishes should be designed so that they can not be grasped unless they meet handhold standards.

18. Anti-scald device. A device which does not allow water over a certain temperature into the tub or shower will be highly effective in preventing burns. Such devices may be part of original equipment or may be retrofitted.

19. Drain which limits water accumulation. A drain which does not allow water to accumulate over a certain level, to be specified in the performance guidelines will help prevent drownings, especially of children. Such a drain, which would probably be a retrofit device, could be regulated by the parent.

20. Floatable neck ring for children. A neck ring which would prevent a child's head from going underwater would be highly effective in preventing drowning. of children.

21. Harnesses. While the inconvenience associated with a harness would make it impractical for many users, certain incapacitated users would find it valuable in preventing slips and drownings. Such a harness should be designed to provide a minimum of interference with the bathing process.

22. Alarms. Alarms which warn persons in other parts of the house or the rescue squad when an accident has occurred will aid in fast treatment of the injury.

23. Telephone or intercom in bathroom. Locating a telephone or intercom in the bathroom will help in quick alert when an injury has occurred, as does an alarm.

24. First aid materials and doctor's phone number displayed. The availability of first aid materials will help reduce the severity of injuries through immediate treatment.

25. Display of educational messages. Signs on bathroom products or placed around the bathtub area may serve as an educational device and as a reminder to users of safe bathing practices.

These countermeasures suggest three major areas in which improved product testing is required:

- slip resistance
- anti-scald devices
- resilience

These three areas appear to be most promising for improvement in terms of product safety.

4.0 ECONOMIC ANALYSIS

Two major economic tasks were performed for this bathtub/shower accident study. The first task, a prioritization of bathtub/shower accident factors, was performed during Phase I of the study. The second, a cost/benefit analysis of alternative intervention strategies, was performed during Phase III and was based upon a cost/benefit methodology developed during Phase II. The prioritization of bathtub/shower accident factors involved the utilization of severity numbers to reflect the relative severity of accidents containing a particular factor; however, the selection of the severity numbering scale was arbitrary and unrelated to the social economic costs of an accident. The cost/benefit analysis estimated the relative savings[1] of alternative intervention strategies, aggregated across bathtub/shower causal factors; the benefit (savings) from each intervention strategy were represented in dollar terms, so that they could be compared with rough estimates of the costs of implementing that countermeasure.

In this chapter, we shall first introduce the National Electronic Injury Surveillance System (NEISS) materials that proved to be such an integral part of the factor prioritization and the cost/benefit analysis. Then we shall present the factor prioritization methodology and the actual prioritization. Finally, we shall introduce the cost/benefit methodology and summarize the findings of the subsequent cost/benefit analysis.

4.1 The National Electronic Injury Surveillance System (NEISS)

The National Electronic Injury Surveillance System (NEISS) is operated by the Bureau of Epidemiology of the Consumer Product Safety Commission. NEISS provides three types

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[1] The costs of implementation were not subtracted out.

of data. First, NEISS provides broad national accident frequency and mean severity estimates for several hundred household product categories (including bath and shower structures). These estimates are derived from a second NEISS source, NEISS survey data, which is gathered from 119 statistically selected hospital emergency wards. Detailed accident information, including age, sex, injury diagnosis, body part injured, and hospital disposition breakdowns of the victims, are available from the NEISS survey data for each household product category. The third source available is a set of in-depth case studies of a selected sample (based on severity) of the accidents reported in NEISS survey data (within each household product category).

It became readily apparent from our literature search and from discussions with Blue Cross and insurance actuaries that by far the most comprehensive and most accurate data on bathtub and shower area accidents were those supplied by NEISS.

For the period July 1, 1972 - December 31, 1973, NEISS received 3,739 emergency reports of bathtub and shower accidents. It is assumed that this NEISS survey data is representative of accidents occurring in the United States as a whole (and it is on this assumption that national accident frequency and severity estimates are based), but even within each sample area, it is reported that somewhat over 50% of the accidents that occur are not included in the NEISS survey data. Quite probably, most of the unreported accidents 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 unreported accidents may go directly to hospital admittance, to hospital special clinics, or to special institution infirmaries; the severity of these, relative to NEISS survey data, is unknown. Finally, a few deaths 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. Thus, representativeness of the NEISS survey data is not guaranteed; however, it is the least biased and most accurate data available.

PRIORITY INDEX FOR INJURY CLASSIFICATION

Injury Class	Diagnosis and Body Part	Injury Code
8	All Fatal Injuries	
7	Hospitalized "6" Levels	
6	Foreign Body–25-50% of Body	5684
	Amputation–25-50% of Body	5084
	Amputation–All Parts of Body	5085
	Burn or Scald–25-50% of Body	5184
	Burn or Scald–All parts of Body	5185
	Crushing–25-50% of Body	5484
	Crushing–All parts of Body	5485
	Amputation–Upper trunk and neck	5078
	Amputation–Head	5075
	Fracture–All parts of Body	5785
	Fracture–25-50% of Body	5784
	Amputation–Eye	5077
	Burn or Scald–Eye	5177
	Crushing–Eye	5477
	Avulsion–All parts of Body*	7285
	Avulsion–25-50% of Body*	7284
	Hematoma–All parts of Body	5885
	Hematoma–25-50% of Body	5884
	Amputation–Lower Extremities & Ankle	5081
	Crushing–Lower Extremities & Ankle	5481
	Amputation–Feet	5083
	Crushing–Feet	5483
	Foreign Body–All parts of Body	5685
	Laceration–All parts of Body	5985
	Laceration–25-50% of Body	5984
	Puncture–All parts of Body	6385
	Puncture–25-50% of Body	6384
	Dislocation–All parts of Body*	5585
	Dislocation–25-50% of Body*	5584
	Amputation–Upper Extremities and Wrist	5080
	Crushing–Upper Extremities and Wrist	5480
	Amputation–Hands	5082
	Crushing–Hands	5482
	Cell Damage–All parts of Body	7385
	Cell Damage–25-50% of Body	7384
	Contusions and Abrasions–All parts of Body	5385
	Contusions and Abrasions–25-50% of Body	5384
	Strain or Sprain–All parts of Body	6485
	Strain or Sprain–25-50% of Body	6484
	Anoxia–All parts of Body	6585
	Drowning–All parts of Body	6685
	Electric Shock–All parts of body	6785
	Poisoning–All parts of Body	6885
	Submersion–All parts of Body	6985
5	Concusion of Brain–Head	5275
	Concussion of Brain–Upper Trunk and Neck*	5278
	Concussion of Brain–Face*	5276
	Nerve Damage–Head	6175
	Nerve Damage–Upper Trunk and Neck	6178
	Nerve Damage–Face	6176
	Concussion of Brain–Lower Extremities and Ankle*	5281
	Concussion of Brain–Feet*	5283
	Concussion of Brain–Upper Extremities and Wrist*	5280
	Concussion of Brain–Hands*	5282
	Puncture–Head	6375
	Puncture–Upper Trunk and Neck	6378
	Amputation–Face	5076
	Concusion of Brain–All parts of Body*	5285
	Concussion of Brain–25-50% of Body*	5284
	Nerve Damage–All parts of Body	6185
	Nerve Damage–25-50% of Body	6184
	Crushing–Lower Trunk	5479
	Organ Injury–All parts of Body	6285
	Crushing–Head	5475
	Crushing–Face	5476
	Crushing–Upper Trunk and Neck	5478
	Amputation–Lower Trunk*	5079
	Organ Injury–25-50% of Body	6284
	Organ Injury–Face	6276
	Fracture–Upper Trunk and Neck	5778
	Fracture–Head	5775
	Fracture–Face	5776
	Concussion of Brain–Eye*	5277
	Nerve Damage–Eye	6177
	Avulsion–Head	7275
	Avulsion–Upper Trunk and Neck	7278
	Avulsion–Face	7276
	Hematoma–Head	5875
	Hematoma–Upper Trunk and Neck	5878
	Hematoma–Face	5876
	Nerve Damage–Lower Extremities and Ankle	6181
	Nerve Damage–Feet	6183
	Foreign Body–Head	5675
	Foreign Body–Upper Trunk and Neck	5678
	Foreign Body–Face	5676
	Nerve Damage–Hands	6182
	Nerve Damage–Upper Extremities & Wrist	6180
	Cell Damage–Head	7375
	Cell Damage–Upper Trunk and Neck	7378
	Cell Damage–Face	7376
	Organ Injury–Lower Trunk	6279
	Fracture–Lower Trunk	5779
	Avulsion–Eye	7277
	Cell Damage–Eye	7377
4	Dermatitis–All parts of Body	7485
	Dermatitis–25-50% of Body	7484
	Organ Injury–Eye	6277
	Fracture–Eye*	5777
	Avulsion–Lower Trunk	7279
	Hematoma–Lower Trunk	5879
	Hematoma–Eye	5877
	Laceration–Eye	5977
	Puncture–Eye	6377
	Dislocation–Eye*	5577
	Foreign Body–Lower Trunk	5679
	Laceration–Lower Trunk	5979
	Puncture–Lower Trunk	6379
	Dislocation–Lower Trunk	5579
	Organ Injury–Upper Extremities and Wrist*	6280
	Organ Injury–Hands*	6282
	Organ Injury–Lower Extremities and Ankle*	6281
	Organ Injury–Feet*	6283
	Laceration–Head	5975
	Laceration–Upper Trunk and Neck	5978
	Laceration–Face	5976
	Avulsion–Lower Extremities and Ankle	7281
	Avulsion–Feet	7283

Injury Class	Diagnosis and Body Part	Injury Code
	Puncture–Face	6376
	Dislocation–Head*	5575
	Dislocation–Upper Trunk and Neck	5578
	Dislocation–Face	5576
	Cell Damage–Lower Trunk	7379
	Burn or Scald–Face	5176
	Burn or Scald–Head	5175
	Burn or Scald–Upper Trunk and Neck	5178
	Burn or Scald–Lower Trunk	5179
	Burn or Scald–Upper Extremities and Wrist	5180
	Burn or Scald–Lower Extremities and Ankle	5181
	Burn or Scald–Hands	5182
	Burn or Scald–Feet	5183
	Concussion of Brain–Lower Trunk*	5279
	Nerve Damage–Lower Trunk	6179
	Organ Injury–Upper Trunk and Neck	6278
	Organ Injury–Head	6275
	Hematoma–Hands	5882
	Cell Damage–Lower Extremities and Ankle	7381
	Cell Damage–Feet	7383
	Cell Damage–Upper Extremities and Wrist	7380
	Cell Damage–Hands	7382
2	Dermatitis–Head	7475
	Dermatitis–Upper Trunk and Neck	7478
	Dermatitis–Face	7476
	Contusions and Abrasions–Lower Trunk	5379
	Strain or Sprain–Lower Trunk	6479
	Dermatitis–Lower Trunk	7479
	Foreign Body–Eye	5677
	Contusions and Abrasions–Eye	5377
	Strain or Sprain–Eye*	6477
	Dermatitis–Eye	7477
	Foreign Body–Lower Extremities and Ankle	5681
	Foreign Body–Feet	5683
	Laceration–Lower Extremities and Ankle	5981
	Laceration–Feet	5983
	Dislocation–Lower Extremities and Ankle	5581
	Dislocation–Feet	5583
	Puncture–Lower Extremities and Ankle	6381
	Puncture–Feet	6383
	Foreign Body–Upper Extremities and Wrist	5680
	Foreign Body–Hands	5682
	Laceration–Upper Extremities and Wrist	5980
	Laceration–Hands	5982
	Hematoma–Lower Extremities and Ankle	5881
	Hematoma–Feet	5883
	Fracture–Lower Extremities and Ankle	5781
	Fracture–Feet	5783
	Contusions and Abrasions–Head	5375
	Contusions and Abrasions–Upper Trunk and Neck	5378
	Contusions and Abrasions–Face	5376
	Strain or Sprain–Head*	6475
	Strain or Sprain–Upper Trunk and Neck	6478
	Strain or Sprain–Face*	6476
	Fracture–Upper Extremities and Wrist	5780
	Fracture–Hands	5782
	Avulsion–Upper Extremities and Wrist	7280
	Avulsion–Hands	7282
	Hematoma–Upper Extremities and Wrist	5880
	Puncture–Upper Extremities and Wrist	6380
	Puncture–Hands	6382
	Dislocation–Upper Extremities and Wrist	5580
	Dislocation–Hands	5582
1	Contusions and Abrasions–Lower Extremities and Ankle	5381
	Contusions and Abrasions–Feet	5383
	Strain or Sprain–Lower Extremities and Ankle	6481
	Strain or Sprain–Feet	6483
	Dermatitis–Lower Extremities and Ankle	7481
	Dermatitis–Feet	7483
	Contusions and Abrasions–Upper Extremities and Wrist	5380
	Contusions and Abrasions–Hands	5382
	Strain or Sprain–Upper Extremities and Wrist	6480
	Strain or Sprain–Hands	6482
	Dermatitis–Upper Extremities and Wrist	7480
	Dermatitis–Hands	7482
0	Any diagnosis body part code including the numbers 70, 71, 86 or 87.	

*Diagnosis body part combination extremely unlikely or impossible.

DETERMINATION OF SEVERITY

SEVERITY CATEGORY		SEVERITY NUMBER
1	plus 10	10
2	plus 20% of level 10	12
3	plus 40% of level 12	17
4	plus 80% of level 17	31
5	plus 160% of level 31	81
6	plus 320% of level 81	340
7	plus 640% of level 340	2516

For each of the tasks required during this study -- for accident prioritization, for scenario generation, and for intervention strategies -- we felt that we required more information concerning the entire accident process and the parameters surrounding the victim and the accident environment than were available from the NEISS survey data. Hence, we turned to the 256 in-depth case studies of bathtub and shower accidents. The level of detail in the NEISS case studies was so remarkable, and so superior to any other source, that we decided to develop a complete set of variables related to the accident which could be used in accident prioritization and later, in scenario generation and in devising intervention strategies.

In addition to the NEISS data, the National Electronic Injury Surveillance System has developed two valuable devices for estimating the severity of any accident. These two devices are the NEISS Injury Classification and the NEISS Frequency-Severity Index. The NEISS Injury Classification, summarized in Table 4-1, categorizes injuries into one of seven classes of increasing severity, based upon the body parts injured and the medical diagnosis. (Former Injury Class 8, of all fatalities, has now been incorporated into Injury Class 7.) The relative severity of the seven injury classes has been estimated by the NEISS Frequency-Severity Index as a geometric progression, which is displayed in Table 4-2[2]. The selection of the severity number base is arbitrary and has no economic significance. Only the relationship of the numbers between classes is important.

[2]This index is based upon the joint efforts of physicians, nurses, engineers, economists and government representatives. It should be noted that the function of both the NEISS Injury Classification and the NEISS Frequency-Severity Index is to assist in the selection of injuries for investigation; the Bureau of Epidemiology formally disclaims that they provide an indication of the total severity of the injury.

4.2 Bathtub/Shower Accident Factor Prioritization Methodology

An understanding of the bathtub/shower accident prioritization methodology requires consideration of each of the three critical elements of the prioritization -- the factors to be prioritized, the frequency with which these factors occur, and the severity of the accidents with which these factors are associated -- in relation to the ultimate purpose of this effort, which is to maximize the reduction in the social cost of bathtub and shower accident per intervention dollar spent.

The first element of the prioritization, the factors to be prioritized, is normally taken for granted, since usually the factors to be prioritized are exclusive, exhaustive, and involve the same level of abstraction. None of these desirable features were present or possible in the case of bathtub and shower accident prioritization factors. The reason is that the ultimate goal of the prioritization is to help develop and select intervention strategies, which themselves are neither exclusive nor (necessarily) exhaustive nor involve the same level of abstraction. As a result, bathtub and shower factors were selected for prioritization only if, in addition to receiving significant weight in the accident phenomenon, they were considered to be relevant to any possible intervention strategy.

An example might help explain the impossibility of selecting exclusive prioritization factors with a similar level of abstraction. Suppose a five year old boy is left alone in the tub and, while playing there, slips and falls on the slippery procelain tub bottom and hits his head on the very hard porcelain tub bottom. Several intervention strategies come to mind. One strategy might replace the porcelain tub bottom with a less slick surface in order to prevent the critical incident (slip and fall). Another strategy might be to replace the porcelain tub with a "softer" surface so that if a slip and fall occurs, the resulting injury will be less severe. Both of these strategies are reasonable, and conceptually are far different, but they are not exclusive; in fact, they both

involve the identical factor, the porcelain bottom of the tub. Now consider a third possible intervention strategy, that of educating the parent to supervise young children in the bathtub. (We can ignore for the moment the fact that how we define a young child or dependent requiring supervision materially affects its position in the prioritization.) In no sense can we view dependence as being at the same level of abstraction as energy transfer surfaces or products contributing to the critical incident. Yet, no one would suggest excluding any of these factors from the prioritization, and, in fact, the prioritization would be incomplete and misleading if any of these three factors were not represented. Also, not that we did not prioritize the sex of the child or the age (by itself) of the child or the day of the week on which the child was injured, since we subjectively assumed that these factors were not relevant to any intervention strategy (which is different from saying that these factors cannot suggest other factors capable of reducing accident frequency or severity.)

The prioritization list ranks bathtub and shower area accident factors by weighing the social loss resulting from their presence. The specific weight any factor received was reached by the conventional, and statistically sound, technique of multiplying the frequency of the accidents in which the factor appears by the severity of the accidents in which the factor appears.[3] (Other configurations of frequency and severity are possible, but only if special accident prevention priorities are espoused, which, in turn, would imply that the frequency or severity terms are inappropriate.)

The relative severity of the various bathtub and shower area accidents was determined by applying the NEISS severity index calculated for consumer product related injuries. Although these severity numbers do not represent social cost in any way, what these severity numbers do (presumably) represent is a reasonably accurate estimate of relative severity

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[3]Note that each of the factors involved in an accident bears the the total social loss of the accident. This form of double counting is unavoidable, since it is impossible to partition shares of the accident to various factors.

of an accident, as compared to all other accidents. This is all that is required for bathtub and shower accident factor prioritization.

The final element of the prioritization, the frequency with which prioritization factors occur in bathtub and shower accidents, required normalization of the observed frequency of these factors in the 256 case studies. Recall that the case studies are representative of the NEISS survey data except for the fact that the case studies are biased in terms of severity; the case studies contain a relatively large number of more severe accidents. This means that factors related to more severe accidents are overrepresented (too frequent) in the case studies, and that, conversely, the factors related to less severe accidents are underrepresented (not frequent enough) in the case studies. In order to correct this bias, we had to normalize the observed factor frequency in the case studies. The required normalization for each severity category is presented in Table 4-3. For example, we know that 10.3 percent of the NEISS accidents survey data were in Severity Category 1, while only 2.0 percent of the NEISS case studies were in Severity Category 1. In order to make the number of Severity Category type accidents representative of the NEISS survey data, the factors involved in Severity Category 1 case studies must be multiplied by a factor of 5.15, since, as observed, the Severity Category 1 case studies are known to be over five times too infrequent. Similarly, Severity Category 7 accidents represent 3.1 percent of the case studies but only .7 percent of the survey data; hence, the Severity of Category 7 case study frequency is overrepresented by a factor of over 4. In order to make Severity Category 7 case studies representative of the NEISS survey data, the factors involved in Severity Category 7 case studies must be multiplied by a factor of .23. The underlying assumption is that <u>within</u> any severity class the case studies selected were unbiased; only the number of case studies from each severity class was biased in favor of more severe accidents.

FREQUENCY NORMALIZATION

Severity Category	Weight	% of NEISS Pop.	% of Case Studies	Normalization Index
1	10	10.3	2.0	5.15
2	12	15.2	15.2	1.00
3	17	22.9	18.8	1.24
4	31	38.7	40.6	.95
5	81	9.6	14.5	.66
6	340	2.6	5.9	.44
7	2516	.7	3.1	.23

The difficulty in conceptualizing the normalization process stems from the fact that the prioritization factors usually appear in several severity categories. The appropriate normalization procedure is to multiply, for each factor, the observed case study frequency with which the factor appears in each severity category by the normalization number relevant to each severity category. This adjusted frequency, by the normalization index, makes the case studies representative. Finally, in order to determine the weight attributable to each prioritization factor, sum the products of the adjusted frequencies for each severity category by the geometrically determined severity number representing that category. This is the procedure employed in the bathtub/shower accident factor prioritization.

4.3 Bathtub/Shower Accident Factor Prioritization

Using the above methodology we prioritized the major bathtub/shower accident factors. Note again that the prioritization numbers have no economic significance, but based upon the NEISS Severity Index developed at the Consumer Product Safety Commission, they do represent the relative total severity of a factor. For the 256 case studies we examined and normalized, the maximum severity total obtainable for a factor (were it present in all 256 cases) was 13,598. The following is the prioritized list of bathtub/shower accident factors:

ACCIDENT FACTOR PRIORITIZATION

ACCIDENT CATEGORY	NORMALIZED FREQUENCY TIMES SEVERITY
1. TUB INVOLVED IN ACCIDENT	13132.5
The bathtub was involved in the accident either because the accident occured in the tub, because the bathtub was the energy transfer surface, or because the surface of the tub contributed to the critical incident (eg., slip and fall).	
2. NON-CONTINUOUS ATTENDANCE OF YOUNG CHILDREN (MAXIMUM) *	6647.5
The victim was a child under 7 years of age who was unattended or was not attended continuously or no supervision was mentioned.	
3. NON-ATTENDANCE OF YOUNG CHILDREN (MAXIMUM)	6301.2
The victim was a child under seven years of age who was unattended or unsupervised for longer than one minute or no supervision was mentioned.	
4. SLIPS (AND SLIPS AND FALLS)	5843.2
The critical incident that triggered the accident was a slip or a slip and fall.	
5. BATHING (IN ACT OF)	5526.9
The critical incident occured while the victim was in the act of bathing (not showering)	
6. SLIPS (AND SLIPS AND FALLS) WHILE TUB OR STALL WET (APPROX.)	5447.8
The tub or shower stall was wet when the slip or slip and fall occurred. (The slip may have occurred outside the tub or stall; the important factor here is the probable presence of water on the victim and/or on the slipped-upon surface).	
7. HARDNESS OF TUB AS ENERGY TRANSFER SURFACE	4757.8
The victim's injury resulted from an energy transfer between the tub and the victim. (The resilience of the tub contributed to the severity of the injury.)	
8. NON-CONTINUOUS ATTENDANCE OF INFANT (MAXIMUM)	4669.8
The victim was a child under three years age who was unattended or was not attended continuously or no supervision was mentioned.	

* Maximum refers to the assumption that unstated supervision was treated as no supervision.

9. NON-ATTENDANCE OF INFANT (MAXIMUM) 4428.5

The victim was a child under three years of age who was unattended or unsupervised for longer than one minute or no supervision was mentioned.

10. SLIPPERINESS OF TUB 4286.2

The victim slipped or slipped and fell on the bottom or edge of the tub.

11. OTHER CHILDREN PRESENT 3879.0

A child (or children) other than the victim was present at the time of the accident.

12. HARDNESS OF TUB SIDE/EDGE/RIM 3544.3

The victim's injury resulted from an energy transfer between the side/edge/rim of the tub and the victim. (The resilience of the tub's side/edge/rim contributed to the severity of the injury.)

13. SLIPPERINESS OF TUB BOTTOM 3488.3

The victim slipped or slipped and fell on the bottom of the tub.

14. NON-CONTINUOUS ATTENDANCE OF YOUNG CHILDREN (MINIMUM)* 3479.0

The victim was a child under seven years of age who was reported as being unattended or was not attended continuously.

15. BURN (TYPE OR INJURY) 3275.2

The victim was injured by contact with hot or boiling water.

16. NON-CONTINUOUS ATTENDANCE OF INFANT (MINIMUM) 3170.8

The victim was a child under three years of age who was reported as being unattended or was not attended continuously.

17. OTHER CHILD PRESENT WITH NON-CONTINUOUSLY SUPERVISED YOUNG CHILD (MAXIMUM) 3148.1

The victim was a child under seven years of age who was unattended or was not attended continuously or no supervision was mentioned, and another child or other children were present.

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* Minimum refers to the assumption that unstated supervision was not treated as no supervision.

18. NON-ATTENDANCE OF YOUNG CHILDREN (MINIMUM) 3047.3

The victim was a child under seven years of age who was reported being unattended or was unsupervised for longer than one minute.

19. NON-ATTENDANCE OF INFANTS (MINIMUM) 2929.5

The victim was a child under three years of age who was reported as being unattended or was unsupervised for longer than one minute.

20. WATER HEATER FAILURE 2919.0

Water from the water heater was hot enough to cause injury to the victim.

21. DROWNINGS 2893.4

The victim drowned.

22. PLAYING (INCLUDING HORSEPLAY OR FIGHTING) 2765.4

The victim was playing (including horseplay or fighting) in the bathtub or the shower stall or bathroom when the critical incident occured.

23. LEAVING TUB 2373.2

The critical incident occured as the victim was in the process of leaving the tub.

24. OTHER CHILD PRESENT WITH NON-CONTINUOUSLY SUPERVISED INFANT (MAX) 2089.5

The victim was a child under three who was unattended or was not attended continuously or no supervision was mentioned, and another child or other children were present.

25. GENERAL HEALTH DEFECT 1673.6

The general health of the victim was reported as being something other than good or normal or healthy.

26. OTHER CHILD PRESENT WITH NON-CONTINUOUSLY SUPERVISED YOUNG CHILD (MINIMUM) 1440.0

The victim was a child under seven years of age who was reported as being unattended or was not attended continuously, and another child or other children were present.

27. OTHER CHILD PRESENT WITH NON-CONTINUOUSLY SUPERVISED INFANT (MINIMUM) 1304.0

The victim was a child under three years of age who was reported as being unattended or was not attended continuously, and another child or other children were present.

28. ENTERING TUB 1105.3

The critical incident occurred as the victim was in the process of entering the tub.

29. SOAP DISH FAILURE 1077.4

The soap dish broke or came off the wall.

30. HURRIED 1031.0

The victim was in a hurry at the time of the critical accident.

31. LOST CONSCIOUSNESS (CRITICAL INCIDENT) 827.9

The victim's injury was triggered by the victim's loss of consciousness (epiliptic fit, seizure, fainting, lightheaded, etc.)

32. FAMILY HISTORY OF SIMILAR ACCIDENTS 753.7

The victim or his family have a history of accidents similar to the reported accident.

33. SHOWERING (IN ACT OF) 714.7

The critical incident occurred while the victim was in the act of showering (not bathing).

34. TIRED 682.9

The victim was tired at the time of the critical incident.

35. TEMPORARY PHYSICAL OR MENTAL IMPAIRMENT 669.0

The health of the victim on the day of the accident was reported as being something other than good or normal or healthy.

36. FAUCET (ENERGY TRANSFER) 615.1

The victim's injury resulted from an energy transfer between the faucet (faucet fixtures) and the victim. (Energy transfer may result from the hardness of the faucet fixtures or the sharpness of the fixtures.)

37. BATHROOM FLOOR SLIPPERY 531.4

The victim slipped or slipped and fell on the bathroom floor.

38. SLIPS (OR SLIPS AND FALLS) WITH BATHMAT IN USE 496.6

A bath mat was in use when the slip or slip and fall occurred

39. SHOWER STALL INVOLVED IN ACCIDENT 465.4

The shower stall was involved in the accident either because the accident occured in the shower stall, because the shower stall was the energy transfer surface, or because the surface of the shower stall contributed to the critical incident (eg., slip and fall).

40. SLIPS (OR SLIPS AND FALLS) WITH NON-SLIP SURFACE PRESENT 438.8

A non-slip surface was present when the slip or slip and fall occurred.

41. BROKEN GLASS INVOLVED (ENERGY TRANSFER) 421.3

The victim's injury resulted from contact with broken glass (either from glass shower or tub enclosures or from glass containers).

42. BATH OILS (BUBBLEBATH, WATERSOFTENER) PRESENT 418.4

Bath oil (or bubblebath or watersoftener) was present at the time of the critical incident.

43. SLIPS (OR SLIPS AND FALLS) WHILE TUB OR SHOWER STALL DRY (APPROX.) 395.4

The tub or shower stall was empty and dry when the slip or slip and fall occured. (The slip may have occurred outside the tub or shower; the important factor here is the probable absence of water on the victim and/or on the slipped-upon surface.)

44. UPSET 387.6

The victim was upset at the time of the critical incident.

45. SLIPS (OR SLIPS AND FALLS) INVOLVING A BAR OF SOAP 364.5

A bar of soap was involved in the critical incident either because the soap bar fell, the soap bar was dropped by the victim, the victim attempted to pick up the soap, or the victim stepped on the soap bar.

46. BOILING WATER (ENERGY TRANSFER) 356.2

The victim's injury resulted from contact with boiling water (heated on the oven).

47. SLIPS (OR SLIPS AND FALLS) INVOLVING BATHROOM RUG FAILURE 289.6

The victim's slip or slip and fall occurred at least partially because the bathroom rug slipped or was not lying flat.

48. SOAP DISH (ENERGY TRANSFER) 272.0

The victim's injury resulted from an energy transfer between the soap dish/bar and the victim. (Energy transfer may result either from the hardness or the sharpness of the soap dish/bar.

49. METAL ON TUB ENCLOSURE (INCLUDING TRACK) 253.5

The victim's injury resulted from an energy transfer between metal on the tub enclosure and the victim. (Energy transfer may result either from the hardness or the sharpness of the metal.)

50. TUB DOOR RAILING (TRACK) 241.5

The victim's injury resulted from an energy transfer between the tub-door railing and the victim. (Energy transfer may result either from the hardness or the sharpness of the tub door railing.)

51. BATH MAT FAILURE 207.2

The victim's slip or slip and fall occurred at least partially because the bath mat slipped.

52. DRUNK/DRINKING 154.2

The victim was drunk or had been imbibing alcoholic beverages just prior to the critical incident.

53. POORLY-LIT BATHROOM 82.9

The bathroom was reported as being poorly lit.

54. METAL ON SHOWER STALL ENCLOSURE (ENERGY TRANSFER) 79.0

The victim's injury resulted from an energy transfer between metal on the shower stall enclosure and the victim. (Energy transfer may result either from the hardness or the sharpness of the metal.)

55. TOWEL RACK FAILURE 69.7

The towel rack broke off the wall

56. LEAVING SHOWER STALL 63.4

The critical incident occurred as the victim was in the process of leaving the shower stall.

4.4 Cost-Benefit Methodology

The purpose of accident cost-benefit analysis is to prioritize the alternative accident intervention strategies according to the ratio of total discounted benefits to total discounted costs of each countermeasure.[4] In anticipation of this task, we have developed a methodology that will allow us to select the appropriate costs and benefits for analysis.

4.4.1 The Costs and the Benefits

The costs of an accident intervention strategy are clearly the direct costs of all materials, labor, and services required for the implementation of that countermeasure. In the case of modification in the bathroom environment, either through new bathroom design or retrofit measures, the relevant cost is the cost to the consumer of the modification. (The cost of the countermeasure should include, in addition to the manufacturer's costs of product design, tooling or retooling, and advertising, the manufacturer's business profit that reflects the risk inherent in a new product.) In the case of consumer education, the relevant costs are the total expenses for development of the educational program, educational materials, and advertising, whether these expenses are borne by the consumer or by the government.

The goal of any accident intervention strategy is to eliminate the accident or to reduce the severity of the injury and the concomitant personal and social costs resulting from the accident. Thus, the benefits of an intervention strategy are the elimination of or reduction in the costs associated with the accident, either by prevention of the accident or by

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[4] Discounting refers to the fact that the timing of costs and benefits is important. Money has an opportunity cost, namely the interest rate, so that a dollar today is worth more than a dollor tomorrow. Discounting reflects this depreciation over time of nominal money.

a reduction in its severity.[5] The reduction in costs incurred from the accident, which constitutes the benefits of the intervention strategy, are of two major types: direct costs and indirect costs. Direct costs involve cash outlays incurred as a direct result of the accident and include the following:

1. The costs of ambulance service and other transportation costs related to medical treatment.
2. The cost of professional services of doctors, surgeons, dentists, etc.
3. Hospital costs for room, services, drugs, etc.
4. Additional drugs, supplies, and equipment not included in medical fees or hospital bills.
5. Domestic costs of private nursing services and additional or substitute household services.
6. Replacement or repair of damaged personal property.
7. Additional insurance costs attributable to the accident injury.
8. Personal legal fees.
9. Surplus damages for psychic costs incurred from personal injuries (trauma).

Indirect costs involve the loss of benefits as a result of the accident. The most common indirect cost involves earnings foregone as a result of work time lost by the injured

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[5]The fact that economists talk in terms of minimizing the costs of an accident does not mean that the pain and suffering of the victim and his family are not important. Rather, the preoccupation with costs reflects a desire to deal with quantifiable, and preferably monetized, terms. Pain and suffering cannot easily be calculated in dollar terms so that they are omitted in most instances. In these cases, it is conventionally understood that cost estimates represent only a portion of the total costs to society.

party.[6] In the case of a permanent impairment, or in the extreme case of a fatal injury, the indirect costs from work loss will be the present value of the loss of expected future earnings. (Death by accident may also impose various types of indirect social costs. See Section 4.4.3 for further discussion of the costs of loss of life.) The other indirect cost that is likely to be associated with accident injury is the value of work time lost by persons (presumably family members) other than the injured party taking leave from their employment to drive the injured party to the emergency ward, to care for the injured party, or to look after his interests.

In summary, the total benefit of an intervention strategy is the sum of direct and indirect cost reductions for all those accidents eliminated or made less severe as a result of the intervention strategy. The ratio of these (discounted) benefits to the (discounted) costs of the intervention strategy determine the relative attractiveness of the countermeasure.

4.4.2 The NEISS Injury Classification and the NEISS Frequency-Severity Index

The determination of the NEISS categories was based largely on presumptive severity, the potential for damage to life systems; in other words, the categories reflect medical severity (critical conditions) more than they reflect medical expenses (economic cost). One extreme example points out this difference. Anoxia, a severe deficiency of oxygen to body tissues (in bathtub accidents, primarily by submersion), is represented in Severity Class 6, because of the high potential for anoxia to result in death; however, if anoxia (to all parts of the body) is not fatal, normally no effects of the condition remain after a day. Thus, Class 6 anoxia, which is neither fatal nor hospitalized, may have less severe economic and medical consequences than some Class 2 injuries. In

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[6] Indirect costs should also include the value of "leisure" time foregone. In general, leisure time has psychic value and probably some productive value and is not in any way a free good.

most cases, however, it appears that severity and the NEISS Injury Classes are highly (and positively) related, and that anoxia is one of the few cases to the contrary. More important, after discussion with Blue Cross directors in Boston[7] and after adding in transportation and indirect costs, it appears that the ranges of injury costs by body part and diagnosis are not inconsistent with the NEISS Severity Index. In other words, the NEISS Severity Index appears to reflect the relative total direct and indirect cost outlays of non-fatal injuries. Clearly, a precise calculation of costs is dependent upon the region of the country, the exact degree of injury (how long and deep a cut, etc.), the quality of local medical care, and many other factors, so it is not surprising that Blue Cross estimates of ranges of cost among injury classes contained some overlap. Nevertheless, since the development of our own injury classification and severity index is beyond the scope of this contract[8] and since the relationship of direct costs estimated by the NEISS Severity Index is in accord with verbal estimates from Blue Cross, we have decided that the NEISS Severity Index is most suitable for the purposes of estimating cost reductions from injury reductions.

What remains is to convert the Severity Index numbers into dollar terms. Both Blue Cross and area hospital emergency wards estimate that the direct cost of a NEISS Class 1 injury involves only the expense of the emergency room, and transportation to and from the hospital since normally no physician, drugs, or other direct expenses are required. The

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[7] They wish to remain anonymous since their information is based only on personal experience rather than on published Blue Cross statistics, which have not been aggregated in a form consistent with the NEISS categories.

[8] Requiring expert economic and medical analysis of a large body of data that relates cost to the thousands of combinations of diagnosis and body part injured.