Health Promotion and Aging
"Injury Prevention"

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THE FREQUENCY AND IMPACT OF FALLING IN THE ELDERLY

Falls (ICD-9 codes E880-E888) are the leading cause of death from injury in persons over the age of 65. Approximately two-thirds of reported injury-related deaths of persons 85 years of age and older are due to falls (1). Of the 8200 fatal falls that occurred in the United States in 1985 for persons aged 65 years or older, 59% were those that occurred in the home. This large number of fatal falls listed on death certificates, however, may understate by one-half the number of deaths in which falls are contributing causes (2).

Approximately 250,000 hip fractures per year among persons ages 45 and over result from falls, with an annual medical cost exceeding $7 billion (3). There may also be six times as many fractures of other bones as there are hip fractures in persons over the age of 65 (4), most of which are attributable to falls (5).

The majority of falls in the elderly result in minor physical injury (6), with only a small percentage of falls causing severe injury, such as a fracture. Estimates of the proportion of falls causing a fracture range from four to six percent in ambulatory populations, with one percent or less resulting in hip fractures (6,7). Slightly higher rates of hip fractures per fall have been reported among institutionalized populations (8,9,10).

Most falls, however, go unreported and are not medically attended. Respondents to the 1984 U.S. Health Interview Survey (HIS) Supplement on Aging were asked about their history of falling in the previous 12 months. Among women, 19% of those ages 55-69, 23% of those ages 70-79 and 34% of those age 80 or more said they had fallen in the past year. For men, the percentages were 15, 17 and 28, respectively. Overall, about half of those reporting a fall said they fell more than once. The proportion of multiple falls was highest for those age 80 and over for both sexes (11). The incidence of falls is considerably higher in long-term care facilities than among elderly living in the community (7,8, 9,12,13).

Psychological trauma resulting from falls may be severe and can result in loss of confidence in the ability to perform daily routine, restriction of activity, decreased mobility and increased dependence. Deconditioning, muscle atrophy and joint stiffness or contractures that result from immobility may lead to more falls and further mobility restrictions.

CRITICAL CONCERNS REGARDING HOST, BEHAVIORAL AND ENVIRONMENTAL FACTORS

1. PROBLEMS WITH DATA ON THE OCCURRENCE OF FALLS, RISK FACTORS AND INTERVENTIONS

Reporting Fall-related injuries are not consistently reported in public health

surveillance systems or medical care data bases. Although records of falls are required in most long-term care facilities, there is no standardized reporting system. In addition, efforts are needed to insure standard application of coding systems for falls. Inaccurate self-report of falls by the elderly may also affect research and prevention efforts. One recent study found that 13% of persons with a confirmed fall during a 12-month period failed to recall having a fall when questioned at the end of the 12 months (14). Other problems include absence of a definition of falls that is easily understood by study participants and the "response burden" sometimes placed on participants who report falls.

Risk factors and interventions Until recently, there have been few prospective studies of risk factors for falls or injury from falls. Many presumed risk factors for falls exist among those who do not fall as well as those who do. There are few existing studies that have included statistical analyses of fallers compared to a control group, or that have evaluated the strength of suspected risk factors using odds ratios, relative risks, or attributable risk measures. No studies have used adjustment or multivariate analysis to control for multiple risk factors. Case-control studies of falls are relatively numerous. However, the risk of falling, the risk of injury and factors leading the person to seek medical care, such as perceived severity of the injury or preexisting medical conditions, all contribute to differences between cases and controls, making interpretation difficult.

Finally, there are very few controlled trials of the effectiveness of interventions to prevent falls, and none of the yield and effectiveness of medical workups of previous fallers. Therefore, existing preventive and treatment efforts are empiric in nature, relying mostly on common sense and descriptive studies of the characteristics of falls and fallers. Host and environmental risk factors and behavioral interventions remain an uncertain and an ad hoc undertaking.

2. PROBLEMS ARISING FROM THE COMPLEX NATURE OF FALLS

Falls in the elderly are the common result of a very large number of pathophysiological processes, primary aging processes, behavioral and environmental factors (15). Some falls are an acute symptom of a chronic or episodic cerebrovascular, cardiovascular or neurologic disorder (16-19). Syncopal falls are prototypical of this kind of fall. However, a variety of acute illnesses may manifest nonspecifically in falls in persons with multiple risk factors (12,20). Falls can also be a nonspecific result of disease-related and age-related declines in gait, balance, sensory perception, strength, coordination, reflexes and other aspects of neuromuscular function (12,21). When the healthy, active older person falls, it often involves an unexpected hazard in the environment, one which could also cause a much younger person to take a spill (slippery surfaces or unseen obstacles). However, the older person may be influenced by more subtle environmental factors, such as lighting and visual and spatial design.

The multifaceted, multifactorial nature of falls has prompted attempts to develop a typology of falls (22-25). These typologies focus on the circumstances of falls and provide information about the probable etiologic factors that guide intervention efforts (24). In addition, greater specificity about outcomes would enhance understanding of risk relationships by allowing researchers to link specific risk factors or biologic measurements to specific types of fall. Some examples of these typologies follow:

- unexplained falls versus falls with a self-evident etiology (i.e. syncope, seizure, stroke)
- falls due to host (intrinsic) factors versus falls due to environmental (extrinsic) factors
- pattern or recurrent falls versus occasional or isolated falls

falls occurring in the sick or older elderly (age 75 and over) versus those occurring in the healthy or younger elderly (ages 60-74).

Unfortunately, work on classifying falls is still developmental and may be of limited value in understanding and preventing falls for the following reasons:

a. It is sometimes difficult or impossible to obtain valid information about the circumstances of a fall.

b. Syncopal falls may have an etiology similar to many "unexplained falls" which do not progress to full loss of consciousness but do involve the effects of decreased cerebral perfusion on muscle tone and balance (26,27).

c. Most falls probably have a mixed etiology, involving both host and environment as contributing factors.

d. Trips and slips involving a definite hazard may also implicate 1) age-related changes in gait (28), and 2) decline in the speed and organization of dynamic postural responses to external displacement (29), blurring the distinction between environmental and balance falls.

e. What constitutes an environmental hazard depends on the individual's functional capacity. With functional decline, features of the environment which were once negotiated without difficulty can become major barriers.

f. The same individual can fall for different reasons on different occasions. This makes it difficult to classify individuals as one type of faller or another.

g. Persons at risk for falls because of abnormalities of gait or balance may so restrict their activities that they fall infrequently over the near-term. Such "adaptations" to diminished capacities may be dysfunctional over the long-term, accelerating loss of function and leading to multiple falls.

Prevention of falls must address a large number of risk factors. At present, we know very little about the interaction between risk factors which will be necessary in the development of effective prevention efforts.

3. PROBLEMS ARISING FROM THE UNCERTAIN SIGNIFICANCE OF ANY FALL

Because the etiology of falling is complex, the significance of any individual fall is difficult to determine, both for health care professionals and for the person who falls. This may lead to inappropriate actions at several extremes, including: extensive medical work-ups which have little yield; dismissal of the fall as of no consequence; inappropriate reductions in mobility and activities, including use of physical and chemical restraints (30); or extreme fear of falling again.

In some persons, a fall or series of falls signals serious acute illness, precipitous functional decline and, possibly, imminent death (7,31,32). For these reasons, any fall must be taken seriously by clinicians. However, most falls in the elderly do not carry this meaning. Falling is an ubiquitous experience throughout life, usually resulting in no or only very minor injury.

Though the circumstances of falls appear, on average, to change with age (12,33), the most frequent fall in the elderly is a consequence of persons with diminished functional capacity attempting to meet the intrinsic and external demands of mobility within specific environments. For the relatively fit and functionally able, mobility entails constant exposure to and successful negotiation of a wide range of physical environments. Risk of fall is spread over many diverse situations and environments. As function declines, success in mobility focuses increasingly on basic movements, such as transfer, short walks and quiet standing within a familiar environment. These basic movements then become the focus of exposure to fall risk.

The behavioral response to falling and postural instability affects the trans-

lation of physical decline into reduced mobility (34). A fall or a near fall provides information about activities and circumstances which place a particular person with a given set of capacities at risk as well as information about a mismatch between the external and intrinsic demands of mobility and individual competence (35). This information may motivate a reduction in mobility, in turn resulting in reduced exposure to the risk of falling by decreasing the range of environmental exposures and by decreasing the time at risk while walking, transferring and standing. Indeed, persons who do not adjust their activities to declining capacities may be at especially high risk (12,36).

Clearly, however, adjustments in activity and mobility in response to falls are neither universally appropriate nor sufficient to eliminate the risk of falling. 1) Fear and excessive restrictions in activity may reduce exposure to the risk of falling in the short term, but only increase the long-term risk by undermining self-confidence and physical conditioning. 2) For the elderly whose functional capacity is severely compromised, maintenance of even a minimum of independent mobility may entail substantial risk. 3) Some risk of falling is probably unavoidable if mobility and independence are to be maintained in the presence of functional decline.

The goals of prevention should be realistic and based on our best understanding of the problem. It is realistic to aim for modest reductions in the frequency of falls and perhaps to prevent a recurrence of falling in some individuals. It is not realistic, given our current understanding, to eliminate falls as a feature of aging. Even if every fall does have a set of causes, there will remain a random element in many falls beyond our ability to model, predict or anticipate.

Equally important, prevention efforts must strike a balance between protection from risk and the maintenance of mobility, function, personal autonomy and an acceptable quality of life. To optimize the latter, it may be necessary to accept a certain level of risk. Prevention should focus on modifying risk factors that reduce that level of risk as much as possible while impinging on independence and autonomy as little as possible.

Prevention efforts would benefit from an increased understanding of behavioral and psychological responses to the onset of instability and falls. The nature of this response may have important implications for the individual's short-term and long-term risk. Fear and excessive activity restrictions may only increase risk in the long run. On the other hand, failure to make some behavioral accommodation to aging and disease may also increase risk in the near term. Adaptations to diminished function, while perhaps inevitable, should be appropriate to the threat and emphasize and strengthen residual capacities. In addition, research is needed on what constitutes "risk-taking behavior" in the context of specific functional disabilities.

Finally, preventing the adverse consequences of falls, including injury, fear and the "long lie," may be as important a goal as preventing falls. Severe injury may precipitate maladaptive behavioral responses as well as lead directly to physical deconditioning and further falls.

REVIEW OF HOST AND BEHAVIORAL FACTORS

The following risk factors are limited to controlled studies in which comparisons were made between "fallers" and "nonfallers." Specific study designs vary considerably. Nearly all of the associations between risk factors and falls reported here are univariate and do not control for confounding.

1. GENERAL RISK FACTORS

Age and Sex. These variables may contribute to identifying persons at risk, but tell us little about actual causes of falls or where to intervene to reduce risk.

There is substantial variation in risk within age groups. Biologic and functional variability within age groups may be more important determinants of fall risk than age-dependent variations.

History of Previous Falls and Dizziness. It is not known how the risk of injury is related to the frequency of falling. The ratio of injuries prevented per fall prevented may vary considerably between frequent and infrequent fallers. For example, those who fall frequently may do so in a way that has a low risk of injury or learn to protect themselves from injury. Research is needed on how the mechanics of falling affect the risk of injury (5). Certain interventions may be less effective after a person has fallen. For example, extreme fear of falling may reduce acceptance of exercise programs to improve neuromuscular function.

Health Status, Mobility Limitation and Functional Disability. General health variables appear valuable in identifying elderly at increased risk of falling because their association may reflect a common origin in underlying diseases and conditions. However, mobility limitations and functional disability may also have a direct bearing on prevention to the extent that they indicate a mismatch between the external and intrinsic demands of mobility and personal competence increasing the risk associated with routine activities (35). Residual capacities may be enhanced by environmental modifications that reduce the demands placed on the individual. However, it is not known whether environmental and behavioral interventions that improve function also reduce fall risk. Moreover, the relationship between mobility and fall risk is complex and not well understood.

Mental Status, Psychological Status, and Psychosocial Factors. Cognitive, psychosocial and psychological risk factors for falls in the elderly are not well understood, but are being evaluated in ongoing prospective studies. Neurological disorders affecting cognitive function are often clinically associated with neuromuscular deficits and falls in the elderly, but it is not known if the association is causal (18,37-39). The causal relationships are potentially complex (40). Confusion, impaired judgement, distraction, agitation, depression and lack of awareness may increase exposure to hazardous situations. Associated gait and balance deficits and psychomotor depression may increase the chance that a fall will result. Depression, in turn, may result from falls, injury or physical illness. Antidepressant and sedative medication may increase the risk of falls (41,42). The behavioral aspects of depression that affect fall risk are not well understood. There are no studies of the effect of cognitive or psychological factors on the coping strategies and adaptations of elderly in response to falls and instability.

Physical Activity. Longitudinal studies of physical activity and falls are needed since reduced activity levels may result from previous falls, fear of falling or gait and balance problems. Moreover, increased physical activity could increase exposure to environmental hazards.

Environmental Hazards. Environmental hazards include such factors as stairway design and disrepair, inadequate lighting, slippery floors, unsecured mats and rugs, and lack of non-slip surfaces in bathtubs, among others. These factors have been implicated in about one-third to one-half of all falls or falls injuries in the home (43-45). Most studies that deal with home environmental hazards are difficult to interpret, however, because of differences in case selection criteria, information collected, and presentation of data. Definitions, especially those of environmental hazards, were not provided, making valid comparisons difficult.

Only two investigators who studied the environment used a referrent group of nonfallers for comparison: one of case-control and one of cohort design (31,45). However, these investigators described the environment only for cases and not

for the referrant group, and the environment was not assessed visually. Instead, persons were interviewed to determine what the respondents felt were the causes of their falls. Few studies actually defined the environment or an environmental hazard, and none provided a uniform approach to assessing the environment. Despite indications that several potential risk factors might be interrelated, only one study explored the possibility of such interactions in a limited way (45). More analytic studies need to focus on where falls occur in the home and on the prevalence of various home hazards. The risk attributable to each of these home hazards, especially in relation to a person's time at risk to these exposures, is critical to the design of prevention strategies. Moreover, the definitions of a room, dwelling unit, and home hazard need to be clearly stated, reproducible and valid. The use of analytic techniques that determine risk factors for diseases, such as the determination of the interaction of host factors and the environment, will be key to the etiology of falls and fall injuries. Intervention strategies would then be based on sound epidemiologic principles and would take into account acute and chronic health problems as well as contributing environmental factors.

2. COMMON INTERMEDIATE PATHWAYS: NEUROMUSCULAR FUNCTION

Gait and Balance. Clinical and laboratory assessment of gait and balance is increasingly sophisticated and shows significant promise as a method of assessing fall risk. Important research issues remain, however, including 1) identification of the modifiable causes of gait and balance abnormalities, 2) the relationship of clinical assessments of balance and gait to laboratory measurement of the biological mechanisms of balance and gait, 3) the utility of computerized gait analysis for fall risk assessment and research, 4) the utility of gait and balance measures as intermediate outcome measures for risk factor modification studies, and 5) the relationship of falling to the determinants of total motor reaction time (46).

In addition, the relationship between balance and gait is not well understood. For example, slowed walking speed may be caused by balance problems, fear of falling, or both, or it may be due to pathology not directly related to balance (47). The effect of musculoskeletal conditions on gait and balance performance is not well understood. The ability to influence corrective and protective response through training and learning should be investigated (46). Finally, an understanding of how specific gait and balance problems transform environmental features into "fall hazards" would help focus environmental intervention efforts.

FACTORS AFFECTING NEUROMUSCULAR FUNCTION AND OTHER SPECIFIC RISK FACTORS

Muscle Strength. The effect of improvements in muscle strength on gait or balance, or on the risk of falling, is not known. Upper and lower limb strength may be important in protective responses during a fall which prevent injury, but this has not been studied (5).

Afferent and Efferent Systems. Published studies linking either clinical or laboratory measurement of the sensory and motor nerve systems to data on falls are lacking, though some studies are in progress. There is indirect evidence, however, that simultaneous abnormality in somatosensory, visual and vestibular systems critically impairs dynamic balance (29,48). Clinical assessment of proprioception, vibration sense and reaction time need to be validated against laboratory measures.

Vision. Visual function is degraded by conditions affecting the crystalline lens and other intervening structures, reducing and scattering the light reaching the retina (49). Early detection and treatment of common conditions such as glaucoma and cataract should improve visual function (50) and might reduce falls. Improved correction of acuity is feasible (updated prescriptions, improved compliance) and could also reduce falls. Environmental and behavioral adaptations

to reduced visual performance may improve visual function and also reduce falls, but this has not been studied systematically.

Decreased cerebral perfusion. True syncopal falls in the elderly may be uncommon (24,42), and dizziness may accompany these falls more often than cause them (37). However, there are no data on the incidence of these falls. Falls due to postural hypotension may also be relatively uncommon since many elderly adapt readily to the symptoms of homeostatic dysfunction (51,52). Decreased cerebral perfusion may cause falls by compromising muscle tone and postural control without other symptoms being present (26), but this is not well studied.

Medications and alcohol. The use of individual drugs should not be blamed for falls without appropriate evidence. The most difficult problem is distinguishing the effect on falling of specific drugs (e.g., antihypertensives or hypnotic-anxiolytics) from the effect of underlying diseases (e.g., hypertension or dementia) or from the effect of drug-disease and drug-drug interactions (27,41). The effect of polypharmacy on falling is a potentially important problem (53) that has not received sufficient study. Detailed studies of falls and drug and dose-specific physiologic effects in the elderly are needed to focus intervention efforts. Better methods are needed for collecting data on alcohol use in the elderly and linking it to data on falls. The effect of medication review programs for the elderly on the risk of falling is not known.

Specific diseases. Intensive clinical work-ups of elderly who fall will uncover large numbers of diseases and pathologic conditions thought to contribute to falling (54,55). But many of these conditions will also be frequent in elderly who do not fall. It is not known if the diagnostic search for treatable medical causes of falls has sufficient yield to justify the effort and cost. The presence of multiple pathology and abnormality may be as important a determinant of the risk of falling as individual conditions (20). The effect of specific conditions, such as arthritis and peripheral neuropathy, on falling and intermediate risk factors is relatively unexplored and warrants increased attention.

REVIEW OF PROGRAMS TO PREVENT FALLS BY MODIFYING HOST AND BEHAVIORAL FACTORS

Although fall prevention efforts in the community and health care settings are not uncommon, few of these programs have been systematically evaluated in terms of outcomes or cost. As a result, these efforts have yielded remarkably little useful information. Some of the reasons for this situation are as follows:

1. Many programs are part of comprehensive community-oriented health promotion efforts that treat falls and injury as only one of a sometimes daunting array of objectives. The result is that inadequate resources are devoted to evaluating the program's effect on the incidence of falls or fall-injury.

2. The outcomes of fall prevention programs can be difficult and costly to measure, a problem faced by both clinical and community-based interventions.

- Anticipated effect sizes are small (e.g., 10-15% reductions in the number of falls), necessitating relatively large sample sizes.
- Frequent and intensive contact with individuals is required to assess falls per se in community settings.
- Injurious falls treated in emergency rooms are only a small portion of all falls, increasing sample size requirements, and may be insensitive as indicators of the effect of community programs.
- Falls treated in doctors' offices are more numerous, but may be subject to reporting inaccuracies and are expensive to monitor in an entire community.
- Measurements of intermediate outcomes which could reduce sample size requirements, such as gait and balance performance, are in a developmental stage and require individual contact by trained personnel.

4. The appropriate outcome measure is not always clear (e.g., number of falls, number of injurious falls, fallers, fallers with injury, severity of injurious falls). Individuals with very large numbers of falls may skew the results of analyses of number of falls, even for relatively large sample sizes.

5. Fall prevention programs usually combine several intervention components addressing multiple risk factors. While this is appropriate given the multifactorial causes of falls, most studies have neither an appropriate design nor the statistical power to determine the effectiveness or cost of the separate intervention components.

6. There is an over-reliance on one group, pretest-posttest designs, the results of which are often incorrectly analyzed. The selection criteria for subjects in these studies are often inadequately specified.

7. Many intervention programs in health care settings are undertaken without a rigorous approach to methods resulting in a number of limiting deficiencies.

Review of Prevention Programs

The programs reviewed here were evaluated with a controlled study design and were published with sufficient detail in methods to evaluate the validity of the study findings.

1. Interventions in community populations. There are only a handful of published intervention studies in community populations meeting the above criteria.

a) A multiple risk factor intervention program using the Portland, Oregon, Kaiser Permanente Medicare population focuses on the ambulatory elderly (56). Two thousand five hundred households of the elderly were randomized to intervention and control groups. Both groups were provided with the results of an initial home safety audit, were given a home safety publication, and underwent an assessment of risk factors for falls, including performance measures of strength and balance. Both groups are being followed for 24 months to ascertain falls and fall-related medical care utilization.

The intervention received by the experimental group included: 1) encouragement and assistance in completing safety repairs and modifications identified in the home audit; 2) a series of four falls-prevention workshops covering a) exercises to improve strength, balance, flexibility, posture, and conditioning, b) drug safety and calcium intake, c) falls risk awareness and risk control, d) development of social support skills and an environment for group reinforcement; 3) guidelines for preventive health care, and screening and follow-up care for vision and hearing problems.

This is the most rigorous and best designed fall prevention intervention study to date. Preliminary results indicate that both the intervention group and the control group are experiencing reductions in the rate of self-reported falls per 100 person-years during year 2 compared with year 1 of the study (56). However, with follow-up nearing completion, no consistent differences have emerged in the incidence of fall-related injuries between the control and intervention groups. This study will be one of the few to provide data on the costs of the intervention. However, since the entire intervention group received all of the program components, only limited information will be available on the relative effectiveness of the various tactics.

b) One hundred elderly persons seen in community medical practices in Birmingham, England, and who had fallen in the previous 4 weeks were randomly assigned to two treatment groups (57). One group underwent an intensive, "long" (up to 12 visits) course of home-based exercise physical therapy and the other group received a "short" course (no more than three visits). Participants were followed for four months for falls and changes in balance and mobility. After

four months, there were no differences in outcome between the two groups, but both groups showed improvement in mobility and balance measures. The fact that only half of the study population fell during follow-up was cited as an indicator of effectiveness. However, the historical controls used for comparison provide an insufficient basis for this conclusion.

2. Interventions in Institutions. A large number of institutions have undertaken fall prevention programs, but few have been systematically evaluated.

a) Fife et al.(58) evaluated an individualized nursing intervention to prevent falls in a community hospital in Cleveland, Ohio. The program was implemented in two hospital units, with two units comparable in census and in age of patients used as controls. Patients deemed at high risk of falling were identified (based on an informal risk analysis) at admission to the experimental units (83% of all unit admissions) and an individualized prevention program developed for each patient. At the end of the 12-week study period, there were no differences between the number of falls reported in the experimental and control units. The authors reported contamination of control groups. A reduction in falls on the experimental units compared to historical controls was cited as evidence of effectiveness. However, the appropriateness of the control period and method of comparison were not demonstrated.

b) Rainville (59) reports the result of a similar hospital-based study. Patients on an experimental unit of the hospital were assessed for fall risk upon admission and a "standard care plan" implemented for these patients. The intervention consisted of patient and family education in the hospital on fall hazards, increased staff awareness of the high-risk patient, and a special care protocol focusing on transfer to and from bed. Evaluated with a pretest-posttest design, this study also failed to demonstrate a clinically or statistically significant decrease in falls following implementation of the program.

c) A study reported by Gray-Vickery (60) demonstrates an increased short-term awareness of potential fall hazards in the home among elderly hospital patients receiving safety education classes. However, the study is limited by small numbers and a one group, pretest-posttest design.

3. Clinical Interventions. In spite of numerous articles on the clinical evaluation of the faller, very few studies have systematically assessed the yield of treatable medical disorders in fallers or the effectiveness of treatment in preventing falls.

A "falls clinic" was established at a geriatric care center on Long Island, New York, which emphasized an interdisciplinary approach to diagnosis, treatment and counseling of patients who had previously fallen (54). Intensive medical management was accompanied by a home visit from occupational and physical therapists and by falls-prevention education for patients and their families. A total of 120 potential fall-related diagnoses were identified in 36 elderly fallers by cardiologists, neurologists, physiatrists and geriatricians. A substantial decline in the number of patients who fell during 12 months of post-intervention follow-up compared to before the intervention (22% vs 100%) was cited as evidence of effectiveness. However, patient selection criteria that may have affected the likelihood of falling again are not specified and no information is provided on the cost of the intervention. It is not possible to determine the contribution of the medical workup and treatment to the observed reduction in falls.

Are common sense and the existing state of knowledge of risk factors sufficient, in the absence of adequate experimental evidence to warrant the endorsement and propagation of specific prevention tactics? In the case of low-cost, low-risk interventions such as risk awareness and exercise programs, the answer is probably yes, especially when there are other benefits besides fall prevention. For

higher cost strategies such as home modifications and falls clinics the answer is probably no. In addition to falls, intervention studies should monitor mobility, functional status, dependence and psychosocial outcomes to determine if there are benefits of intervention in addition to reduction in falls and if a reduction in falls comes at the expense of autonomy, level of activity, and quality of life.

MOTOR VEHICLE AND PEDESTRIAN INJURY TO THE ELDERLY

OVERVIEW OF THE TOPIC

Motor vehicle and pedestrian injuries (ICD-9 codes E805.2, E822.7, E810-E819) to older persons (age 65 and above) occur primarily as a result of the transfer of mechanical energy to people in amounts or rates that exceed their injury thresholds (61). Motor vehicle injury is by far the leading cause of fatal injury for all ages, and for the elderly it is the leading cause to age 75 when it is exceeded only by falls.

More than any other injury type, motor vehicle injuries are systematically investigated, and a variety of information is routinely provided on circumstances surrounding the event. Centralized, computerized databases exist at both state and national levels on these injuries, although there is variation in the quality from state to state. Because of the amount of information available on the circumstances surrounding motor vehicle injury, it has been possible to develop interventions aimed at alleviating specific causes of injury.

Although major shortcomings continue to exist, these state crash files can be used alone or in conjunction with other databases to address a wide variety of problems. They can be linked to driver history files. They can provide additional information on highway design characteristics associated with certain kinds of injury-producing crashes and on specific vehicle design characteristics associated with injury to elderly occupants. In some states they can be linked to ambulance run data to evaluate the time required to provide medical attention and how the time delay is related to subsequent outcome. In a few states all these databases can be linked to hospital data, including trauma registries and hospital discharge data. The potential for such data linkage provides the opportunity for addressing such questions as whether certain vehicle design characteristics are associated with a greater probability of post-crash fire resulting in burn injuries to occupants. Likewise, data from trauma registries, if linked to crash files and then to highway files, can be used to determine whether there are certain highway design characteristics, including the presence or absence of pedestrian controls, that are associated with injury to elderly pedestrians. These data can be used in conjunction with other databases such as census data and economic indices to address such questions as how fluctuations in the economy relate to motor vehicle injury and whether some groups are at different risks.

One special problem with using available databases concerns the older person's greater vulnerability to injury and later death from a given crash. The elderly motor vehicle crash victim may die long after the injury producing event as a result of infection or another problem resulting from the crash. If the proximate cause of death is pneumonia, the death may not be readily identified as motor-vehicle-related and thus be lost to the analysis. Investigators in this area need to be sensitive to this problem in attributing causes of death and time frames for defining motor vehicle deaths.

Background National Rates by Age, Race, and Sex

For the population age 65 and older, mortality rates per 100,000 for the years 1978-1982 were much higher for males (34.2) than for females (14.9). Black and other males have 1.6 times the rate of white males until age 75, at which age the rates become similar. Black and other females have between 0.7 and 0.8 times the rate of white females at all ages 65 and over. However, the rates for all groups are gradually decreasing.

When death rates are divided into ages 65-74 and those age 75 and over, rates are much higher for the older age category. These figures do not take into consideration amount of exposure to risk, but there is evidence that exposure decreases with age, so that the increased rates associated with older age would be even greater if exposure were considered.

According to the National Safety Council (62), in 1985 there were 45,600 motor vehicle deaths and 1,700,000 disabling injuries. Approximately 6400 of the fatalities were age 65 and older. Based on the number of licensed drivers, those age 65-74 had lower rates of both fatal crash involvement and total crash involvement than was true for the driving population as a whole. In contrast, drivers age 75 and older had 59 fatal crashes per 100,000 drivers, compared to 38 for drivers of all ages. For total crashes (fatal and nonfatal), this age group had 26 per 100 licensed drivers, compared to 21 for drivers of all ages. While these rates were higher than those for the general driving population, they were lower than those for drivers below age 25.

Crash involvement rates based on mileage driven, rather than number of licensed drivers show drivers over age 65 to be overrepresented in crashes (63-68). Some studies report that on a per mile basis the older driver is second only to the young driver in crash risk, while other analyses rank the elderly driver as having the highest crash risk per mile driven.

Although pedestrian fatalities account for more than 18 percent of all motor vehicle fatalities (62), they account for 23 percent of motor vehicle deaths occurring to persons ages 65-74 and 35 percent of those occurring to persons age 75 and older. Although this overrepresentation may be attributable to greater exposure, a comprehensive study by Tobey et al. (69) reported that persons age 60 and over represented only 7.7 percent of pedestrians observed but accounted for 12.8 percent of the pedestrian injuries (both fatal and nonfatal). Thus it appears that the elderly are overrepresented in pedestrian casualties whether the analysis is based on population or exposure.

Effect of Aging Population on Importance of Motor Vehicle Injury as a Public Health Issue

The elderly are the most rapidly growing segment of our population and it may be anticipated that without efforts to facilitate mobility for the elderly, the magnitude of the motor vehicle and pedestrian injury problem will increase.

One factor that may ameliorate the injury problem is related to driver cohort effect. Many elderly drivers today, particularly women drivers, have limited driving histories, but because of a spouse's death or failing health have increased their driving time or even obtained a license for the first time. As a result, their driving inexperience is reflected in their performance. In contrast, larger proportions of the younger population are obtaining licenses than was previously true. When these young drivers become elderly, they will have a lifetime of driving experience behind them, which in turn should result in more proficient performance and a reduction of the number of collisions and injuries occurring to the elderly.

ENVIRONMENTAL ASPECTS OF THE INJURY PROBLEM

The highway transportation system was designed without taking into account the capabilities and limitations of the elderly (70). Relatively little attention has been given to the special characteristics of the elderly driver. Vehicle design does not consider what features might facilitate or impair the functioning of older operators and highway design has been developed primarily on the basis of performance measures obtained from young males. Sivak, Olson, and Pastalan (71) found that older drivers who had similar results as younger drivers on standard tests of visual acuity still had to get much closer to highway signs at night in order to read them. Consequently they had less distance remaining

in which to react to the information provided. Older people as a group need more light in order to see as well as younger drivers and they have more difficulty with glare recovery.

In both violations and crashes, older drivers are overrepresented in problems associated with intersections. They are especially likely to have problems with yielding right of way, observing stop signs and traffic signals, and maneuvering left turns (66,72,73).

One critical need is to modify vehicle and highway design to facilitate the driving task for the elderly. The National Academy of Sciences (NAS) is currently conducting a major study on improving mobility and safety for older persons and is commissioning a number of papers addressing specific aspects of the problem. Some issues being investigated are improvements in intersection design (for both drivers and pedestrians), vehicle modification to increase crash protection for the elderly, and sign legibility and conspicuousness. However, no attention is given to modifying vehicles so as to facilitate the driving task for the elderly, nor is the highway design in general given serious attention.

An environmental modification that has been given considerable attention in Europe but relatively little in this country is that of exterior vehicle design that would reduce pedestrian injury in the event of a collision. Most pedestrian crashes occur at relatively low speeds (20 mph), and modification in vehicle design, such as softer structured bumpers, can change the probability of victim survival and impairment (74).

Review of Programs or Efforts Attempting to Deal with the Problem

Modifications to the transportation system that simplify the task of driving or walking should aid the elderly. Three specific modifications are far-side bus stops, increased delineation of highways, and redesigned residential areas to reduce the amount and speed of traffic.

The location of bus stops is associated with the probability of injury occurring to passengers disembarking from the bus. Traffic coming from behind a bus cannot see passengers disembarking and crossing an intersection until they are very close. If the bus crosses the intersection before stopping, passengers disembark and cross the intersection behind the bus where they have a better view of traffic. Thus relatively simple changes can reduce the probability of injury.

Increasing the delineation on highways (centerline and edge and lane lines, as well as guide signs and delineator posts) increases the probability that they will be seen. Uniformity of delineation is also important to reduce confusion.

The Woonerf, a design for a living environment implemented in Europe, the Netherlands and Japan that includes joint and safe utilization of space by people for recreational purposes and vehicles reduces the danger of vehicle crashes (75). Residential areas are designed to severely limit through traffic and to reduce drastically the speeds of local traffic.

BEHAVIORAL ASPECTS OF THE INJURY PROBLEM

There is evidence that the elderly as a group restrict their driving as they recognize their increasing limitations (63,76,77). However, elderly drivers are not necessarily aware of some of their problems. Planek et al. (78) examined older drivers' errors that resulted in crashes with how older drivers perceived their driving problems. Failure to yield right of way was the major cause of the crashes, but the older drivers ranked it ninth out of ten maneuvers posing problems. Even with self restriction, on a per mile basis, risk of crash among the elderly is among the highest of any driving group.

A critical concern is that so little has actually been attempted to help older drivers and pedestrians. As a group they appear as responsible and motivated to do well, but it is likely that those most in need of behavioral modification would be least likely to seek and respond to intervention programs.

Review of Programs or Efforts Attempting to Deal with the Problem

Licensing Programs: Very few states have special procedures for driver licensure after a certain age, and none have been carefully evaluated.

A study by Zaidel and Hocherman (79), examining Israel's requirement for vision and medical evaluations for renewal applicants age 65 and older, found that 25 percent of the applicants had to wear corrective lenses. Because many of the applicants had already obtained glasses, only seven percent actually started wearing them as a result of the required vision test. The authors therefore concluded that the requirement was not cost effective. However, vision screening in the licensing station can be conducted at minimal cost, and those applicants already using corrective lenses would not be required to seek professional evaluation. Furthermore, the seven percent of applicants detected who were in need of lenses would translate into many thousands of drivers in this country.

The Florida Senate Committee on Transportation reported that the 70 year and over age group experiences a license examination failure rate that is nearly double that of all drivers similarly tested and that their mileage crash rate is higher than that for all other age groups over 25. Once involved in a crash, their chances of being seriously injured or killed are the highest of any age group.

Related to increased evaluation of older drivers for license renewal is the need for a system to ease older drivers out of the driving population gradually. To be effective, these programs must pay attention to the capabilities of older drivers and the demands placed on them by specified driving circumstances.

In addition to improved evaluation and appropriate restriction of older drivers, there is a need for increased attention to meeting the transportation needs of the elderly through public transportation or other systems such as volunteers or carpooling. The transportation needs of the elderly will increase, and they will be met either by individuals struggling with them one by one or with the help of a more organized, coordinated approach where resources and solutions are shared.

Driver Education: The National Retired Teachers Association/American Association of Retired Persons (AARP) has developed a program for special needs of the elderly called "55 Alive/Mature Driving" (80). The American Automobile Association (AAA) has also developed a program called "Safe Driving for Mature Operators." The AARP program is much more widely used, but neither program reaches more than a tiny fraction of the older driver population. Furthermore, it is highly likely that those taking the course are in least need of improvement.

Pedestrians: Interventions focused on the elderly pedestrian appear to make a difference. These include far-side bus stops, separation of motor vehicle and pedestrian traffic, cessation of all traffic in any direction during the pedestrian signal, enforcement of existing laws and ordinances concerning pedestrians, improved vehicle design, improved lighting of streets used by pedestrians, increased conspicuity of pedestrians, and improved emergency medical services.

HOST FACTORS

In considering the increased impairment accompanying age, J. Waller (81) differentiates between changes that are associated with what he refers to as normative aging and issues involving pathological aspects of aging. While many of these conditions can be identified through careful evaluation, some of them are less readily detected so that increased risk of injury may occur despite efforts to identify potential problems before they arise.

In addition to the older person's higher risk of collision involvement as a driver or pedestrian, it is clear that the elderly are more vulnerable to injury from any given crash. Data from the Fatal Accident Reporting System (FARS) show that a much lower proportion of older drivers survived with no injury and,

conversely, a higher proportion suffered fatal injury (72). Data from FARS as reported by Partyka (73) also show that this increased probability of death steadily increased with increasing age. Partyka concludes that the increased probability of fatality for the older driver is more related to decreased resistance rather than to crash configuration per se. This finding and conclusion are consistent with an earlier report by Baker and Spitz (82).

One more consideration is the use of drugs including alcohol since the elderly are more likely to be on medication, and all too often they have been given no medical counsel as to the potential effects on their functioning (77). An older person of a given weight is likely to reach a higher blood alcohol concentration (BAC) from a specified quantity of alcohol than a younger person of the same weight (83,84). Older persons may recognize this change, for it appears that they modify their alcohol intake (84,85). While frequency of drinking changes little with age, the quantity of alcohol consumed tends to decrease.

The major concern in dealing with host factors is that chronological age is not a good measure of the aging process itself. While there are clear relationships between chronological age and the overall average performance of the elderly, the predictions for individuals are not that reliable. As a result, interventions must be carefully designed to accomplish what is needed while avoiding any discrimination or appearance of discrimination against the elderly.

INTENTIONAL INJURIES: SUICIDE AND HOMICIDE

SUICIDE: Reports in the scientific literature have consistently concluded that suicide (ICD-9 codes E950-E959) increases with advancing years (86-89). The elderly (age 65 and older) constitute about 12% of the U.S. population but comprise 18.7% of all suicides. Moreover, this phenomenon is not limited to the United States, but is a characteristic of all industrialized nations.

The United States ranks at about the median for elderly male suicides and at the lowest for suicides among the female elderly (90). Actually, the suicide rate among the elderly has been decreasing over the past twenty years. However, older persons still are at the greatest risk of suicide despite this relative improvement (91).

The suicide attempts of older persons tend to be more serious and dangerous from a psychological and a medical point of view (92). The first attempt is likely to be successful, and gestures or attempts as cries for help are relatively rare. The elderly tend to use methods that are deadly and certain such as firearms (employed by 64% of the elderly, 57% of the younger cases) and to avoid those methods such as drug overdoses or gas which allow greater opportunity for intervention and rescue (14% of elderly suicides vs. 21% for youthful suicides).

However, suicide rates do not increase with increasing age for all elderly. Rates increase only for white males while they actually decline for black males and for females of both races. Accordingly, prevention measures might be focused on reduction of suicides among white males, the high-risk population, although prevention efforts might benefit all groups.

Age-related Factors

Physical health Sainsbury's study (88) of coroner's cases (N = 409) indicate that physical illness was a factor in 35% of the cases over sixty years of age as contrasted to the youthful cases (ages 15-29) in which illness figured in only 10%. Dorpat, Anderson and Ripley (93) found that in their sample of 80 cases of completed suicide, physical illness was the most frequent precipitating factor by those who were over sixty years of age. The reality of increased physical illness in the elderly leads one to consider the question of voluntary euthanasia and "the right to die" via so-called "rational suicide." The dilemma over whether a person in a free society enjoys the right to take his own life is fraught with emotional conflict almost as pointed as that of the counterpart "right to life" controversy (94,95). As a result of our increasing medical,

pharmacological and technological sophistication, life can be extended quantitatively at the same time it may deteriorate qualitatively.

Despite the reality of physical decline in later life and the heightened risk of suicide therein, certain preventive steps are suggested. First, a study by Motto and Greene (96) found that 42% of a cohort of 175 suicides had some type of medical contact within the six months preceding their suicide. Studies by Robins and Vail have confirmed this finding (97). Educational efforts aimed toward this population by physicians and the medical community could be extremely effective in diagnosis, referral and even treatment of the susceptible elderly patient. Secondly, changes in the budget priorities of this nation that direct greater funding for human and social services could relieve the anxiety that medical expenses can quickly wipe out a lifetime of savings.

Mental Health The incidence of clinical depressive illness preceding serious suicide attempts is quite high among older persons (92,98,99). Research also indicates that the frequency of completed suicides is linked to depressive disorders more than any other form of mental disorder (97). Typical depressive conditions in the person contemplating suicide are rarely of full-blown psychotic dimensions, but rather an individual with no previous history of serious emotional problems whose defense mechanisms of a lifetime are now insufficient to withstand the combination of biological, psychological and social stresses of old age. Butler and Lewis (100) enumerate some of the major diagnostic considerations for suicide in old age in addition to physical illness and being a white male as discussed earlier. These risk factors include depression, withdrawal from social and personal relationships (101), bereavement, especially within the first year of a loss (102), isolation due to widowhood, illness or disengagement (103), expectation of death from some cause, not necessarily suicide (93), induced helplessness often stemming from removal from home and placement in an institutional setting (104) alcoholism (105), and hopelessness (99), which is one of the most serious diagnostic signs. The feeling of exhaustion and failure, the fear of being a burden to others, financially and otherwise, the loss of interest in pleasurable activities are all symptoms of high suicide potential and their overt expression must be taken very seriously.

Treatments for depression include anti-depressive medications, milieu therapy such as the establishment of caring social support networks, and psychotherapy of a supportive nature.

Social forces play a critical role in suicide prevention. In our society, a premium is placed upon appearance, occupational status, and power and financial standing, attributes which almost always decline with age. And yet, as previously noted, there is a significant exception to the finding that suicide increases with age, even in our society. An increase is found only among white males. Conversely, the rates for blacks, Native Americans, and Mexican-American males and for both white and black females actually decline in later years. Are there positive factors that inhibit suicide in certain communities? Several explanatory hypotheses have been proposed (106):

Role of the elderly differs noticeably in the white community and communities of other races. Families in cultures that tend to be extended rather than nuclear provide more interaction and purposeful activity for the elderly, such as child care, housekeeping, and food preparation. Although dictated by necessity, the net result is to establish and strengthen social bonds which Durkheim (86) considered the greatest bulwark against the commission of suicide. Many white elderly, because of economic affluence, live apart and alone without the social nexus and sense of participation found in more traditionally oriented societies.

Status of the elderly is also greater in the communities of races other than whites where wisdom and experience are honored, and the elderly actually enjoy an increase in status as they grow older (107-109). However, the trend is toward changing these traditional values when societies industrialize and modernize.

Relative deprivation is a concept that helps explain the great plurality of white male suicides at the upper ages. White males, as a group, have enjoyed the greatest advantages and the greatest prestige during their active years. Thus, they have the farthest to fall when confronted with the vicissitudes of aging. Presumably the white male who begins to feel his power and influence eroding experiences a greater sense of loss than women or minorities who have long been accustomed to a lowered status due to racism, sexism and economic hardship. Therefore, women and minorities do not have to suffer these losses in old age.

What are the policy and theoretical implications of these findings? First individuals must learn to be realistic in their goals and aspirations since inability to achieve these high-reaching aspirations may lead to depression and other emotional problems as earlier discussed. Second is an appreciation of respect for age underscored by greater acceptance of the aging process and the inclusion of the elderly in the family structure. But foremost is understanding the importance of human relationships and response. The most distressingly difficult part of aging is not the material adversity nor the physical pains and illnesses, but rather the feeling of being useless, unwanted, superfluous. Communities that deal successfully with these issues, through necessity as much as design, provide a role, status and purpose for their elderly population.

HOMICIDE: In 1983, the latest year for which fully reliable and complete vital statistics are available, 20,141 people died by homicide (ICD-9 codes E960-E969) in the United States. Of these, some 1,244 cases or 6.2% were elderly (65 years and older). Since the elderly constitute about twelve percent of the general population it is clear that they are underrepresented by half in the population of homicide victims.

Homicide is very much a condition of the impetuous, youthful years of life. The rate characteristically declines after the first year of life and then begins accelerating through the teen years, reaching a peak at ages 25 to 35 and declining steadily from that point with very minor fluctuations. Males run a risk about 3 to 4 times that of females with the exception of infanticides during the first year of life when the victim is more likely to be female. Blacks have a homicide risk five times greater than that for whites and the risk for young black males can only be described as astronomical. These relative race and sex differences are perpetuated throughout the lifespan; however, the absolute numbers are considerably reduced by the time one reaches later life. In addition to these quantitative differences there are qualitative distinctions between homicide in the elderly as contrasted to the general homicide picture. For instance, the distribution of homicide by method indicates that the elderly are much more likely to be killed by beating or strangling than are their younger counterparts. The predominant motive is robbery and, therefore, they are much less likely to know their assailant (110). Preventive programs or even research studies on the topic of elderly homicides are extremely scant (110). If homicides are considered within the context of elder abuse, there is slightly more to review including a thorough overview by Pedrick-Cornell and Gelles (111) and a systematic study recently published by Powell and Berg (112). However, neither of these sources deal with the problem of homicide per se but rather with the topic of physical abuse of a nonlethal nature. The neglect of this topic in the literature may reflect its underrepresentation in the elderly population. (The incidence of homicide is less than one-fourth of the suicide incidence for this age group.) Accordingly the following recommendations are proposed:

A. It is a truism that the odds of being a victim of a violent crime are tied to neighborhood income. Poor people bear a disproportionate share of the crime burden. For the most part this means the minority elderly who are trapped by poverty and discrimination in areas described as subcultures of violence. This entails a subculture in which members are recruited into a vicious cycle of street crimes followed by prison terms where antisocial behavior patterns are reinforced, encouraging more violence (113). This vicious cycle will only be remedied when we address the conditions that underlie and perpetuate it (114).

B. Since the elderly are perceived by the criminally motivated as representing vulnerable prey, any moves toward strengthening their position through increased social networks (strength in numbers), assertiveness training and political demands for increased police protection will be helpful in changing the perception of vulnerability. However, this cannot be completely overcome since the elderly are realistically more vulnerable due to their relative frailty. There are strong implications here for community education programs directed toward the elderly. Most elderly homicides occur in the victim's home. To decrease the possibility of having to open their doors to strangers, the installation of an inexpensive optical viewer in the front door would be a sufficient preventative step which could be underwritten by community agencies. Other strategies might involve the establishment of mutual aid networks through telephone linkages and the provision of an "eyes on the street" crime prevention program which would have the added benefit of fostering closer interpersonal relationships and emotional support. Such approaches have the advantage of reducing robberies which are the primary ways in which the elderly are murdered and also of reducing through neighborhood contact, the isolation and loneliness which frequently accompany aging.

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