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Economic Dimensions of Slip and Fall Injuries*

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ABSTRACT: This paper provides an update of annual economic costs imposed by fall injuries. Such costs include medical, rehabilitation, hospital costs, and the costs of morbidity and mortality. These costs are projected to the year 2020, based on changing demographic trends.

The market for slip and fall injury prevention is analyzed for the elderly and for those in the workplace—two high risk groups. Questions as to whether this market operates in a socially desirable manner, or whether government intervention is justified on efficiency grounds, are considered.

Essential aspects of cost-benefit analysis are reviewed in the context of a prospective evaluation of interventions to prevent slip and fall injuries. The cost-benefit analysis framework is applied to part of the FICSIT experiment (a major intervention to reduce falls among the elderly) and to recent revisions in Occupational Safety and Health Administration regulations directed at reducing workplace falls.

KEYWORDS: forensic science, walkway safety, fall injuries, economic costs, cost-benefit analysis, government intervention

This paper considers economic aspects of slip and fall injuries in the United States. The substantial growth of the scientific literature on fall injuries, the increased litigation related to fall accidents, and recent governmental efforts to control fall accidents are testimony to the growing recognition of both the current importance and the likely greater future importance of this problem. Rice and MacKenzie (1) report that the economic cost of fall injuries was estimated to be $37.3 billion in 1985. These costs are concentrated within the two major groups affected by fall injuries—the elderly and members of the workforce. This paper considers the economic dimensions of injury prevention for these two groups.

To provide some initial perspective on the magnitude of the fall injury problem, it is noted that 30% of the over 65-year-old cohort living in the community fall each year. (A higher rate prevails among those in nursing home facilities.) Among those over 80, the rate is 40% (2). Moderate to severe injuries are experienced by 20 to 30% of those who fall, causing reductions in mobility and independence, as well as a greater risk of death (3). Falls are the sixth leading cause of death among persons over 65. Nonfatal falls have been statistically associated with greater fear of future falls, functional deterioration, and institutionalization (4). Falls, which account for 17% of work-related injuries and 12% of fatalities in the workplace, are the second highest cause of work-related deaths (5). Approximately one-third of fatalities in the construction industry and 75% of deaths among ironworkers are attributed to falls (6).

The first part of this paper reviews data on the incidence of slip and fall injuries among the population at large, the elderly, and among those in the workplace. Estimates of the economic costs of fall injuries are presented. The second part offers a forecast of these costs, stressing the greater projected relative importance of the elderly in the population. The third part of this paper considers the issue of whether self-interested behavior on the part of affected parties (the elderly, employers, employees, insurance companies, retailers, and consumers) is sufficient to arrive at what might be called the *optimal* number of fall accidents, or whether markets, based upon such self-interested behavior, are inherently flawed. The economist's perspective on the optimal level of falls is explained. To the extent that market flaws are present, it is then possible to justify government interventions affecting fall behaviors. The economic efficiency of various interventions is examined in a conceptual framework. The fourth part of the paper focuses on a cost-benefit analysis of two such interventions. Each intervention is aimed at a major group considered at risk—the elderly and those in the workplace. The paper outlines what cost-benefit analysis is, how it can be used to improve governmental resource allocation, and asks the questions that a practitioner would ask in evaluating the economic efficiency of each of these two interventions.

Economic Costs of Fall Injuries

Before turning to the specifics of the cost of slip and fall injuries, a few words explaining the difference between economic cost and accounting cost are in order. Accounting cost is the narrower of the two concepts and the concept most people have in mind when they hear or use the word "cost." It refers, really, to the out-of-pocket expenses associated with some event or activity. Economic cost, also known as opportunity cost, is a broader, more inclusive concept. The economic cost of an event or activity is the value of the highest valued alternative event or activity. Economic cost includes accounting cost as well as the return that would have been earned in the best alternative use of the resources involved.

These cost concepts are easily applied to fall accidents. When such an event occurs, the result is injury or death. The accounting cost of that event would be the expenses related to such items as the pay of ambulance, emergency room, hospital, physical therapy,

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nursing home personnel, and the supplies they all use. The economic cost of the same event would be the accounting costs plus the loss of the contribution to the productive process (i.e., work) that the injured or killed person would have made but for the fall.

The most comprehensive attempt to measure the economic costs of injuries in the US was conducted by Rice and MacKenzie (1) in 1989. In that work, the authors gathered information from a wide variety of sources to piece together their estimates of the costs of injury. Most of their information came from the results of a series of surveys conducted in the 1980–82 period by a private research firm under contract to the National Center for Health Care Statistics, part of the US Department of Health and Human Services. That series of surveys has only recently been repeated, and the bulk of the results has not yet been published. It is not yet possible to repeat the Rice and MacKenzie study on the basis of more recent data. It is possible, though, to adjust the results of the Rice and MacKenzie study to take account of demographic and price level changes up to the present and to project it into the intermediate future on the basis of already known demographic developments. The results of our efforts to do that will be presented in a later section. To put those results into context, it would be useful to examine the analytical framework of the Rice and MacKenzie study.

Rice and MacKenzie distinguish between accounting and economic costs, although they use terminology associated with actuarial concepts to do so. They call the accounting costs of fall injuries "direct cost." They include in this category, expenditures for hospital and nursing home care, physician and other professional services, rehabilitation, community-based services, drugs and medical equipment, insurance administration, vocational rehabilitation, and home modifications (1, p. 197). They find in various sources, primarily the surveys referred to above, averages of the direct costs of these items on a per-person-injured basis. Because the direct costs often occur over more than one year, especially in the case of serious injuries requiring long recuperation and rehabilitation periods, the costs incurred in the later years are multiplied by the probability of a person of age n surviving to that time. These probabilities come from actuarial data. The costs incurred in later years are discounted to the present to account for the time value of money not expended immediately. Summing these yearly expenditures gives the present value of the average direct cost of a fall injury on a per victim basis.[4,5]

This formulation of direct cost is analogous to accounting cost. To get from the accountant's conception of cost to that of the economist, we must add the value of the lost output attributable to the victims of injury and death via falls.[6] The value of lost output that would have been produced during the period of recovery and rehabilitation plus output that does not occur because rehabilitation is not complete is called morbidity cost. Output that would have been produced during the remaining lifetime of those who are killed is called mortality cost.

Both morbidity and mortality are actuarial concepts and the costs associated with them can, to a large extent, be estimated in the same way. Both are estimated on the basis of the value of the output lost to society as a whole as a result of the injury or premature death of the victim. The output involved is both labor market output, measured by lost earnings, and home production, measured by the imputed market value of the lost housekeeping services. Labor productivity is assumed to grow over time at a constant rate to account for earnings growth that would have accrued over the life cycle of the victim had the injury not occurred. These productivity increases are discounted back to the present to account for the time value of money not expended immediately. All of these values are averages per person.

At this point, the method of calculation of morbidity cost diverges slightly from the method of calculation of mortality cost. Only some of the persons who survive their injuries are totally disabled, so the calculation of morbidity cost must allow for a return to work by those not totally disabled. It does so by dividing the yearly loss of earnings plus the imputed market value housekeeping services by 365 and multiplying the result by the average number of days of restricted activity experienced by a person of age n suffering a fall injury. The average number of days of restricted activity is based on the various surveys referred to above and accounts for the frequency of various types and the severity of injury from falls. The lost output is summed from n to age 99[7] to arrive at the average morbidity cost per fall victim (including victims that are killed by their fall).[8]

Because a victim killed in a fall will never return to work, no parallel adjustment is necessary in the calculation of the average

[4]This measure of average direct cost includes persons who are killed as a result of their fall as well as persons who recover partially or fully.

[5]The present value of the average direct cost of a fall injury per victim is:

$$PVDC = \sum_{n=y}^{99} \left[\frac{P^i_{y,s}(n)\, DC^i_{y,s}(n - y + 1)}{(1 + r)^{n-y}} \right]$$

where

$PVDC$ = present value of direct cost per person,
n = age of the individual,
y = age at which the individual was injured,
$P^i_{y,s}(n)$ = probability that person of gender s with injury i acquired at age y will survive to age n,
s = gender of the individual,
$DC(n)$ = direct costs incurred during the year of a person currently age n, and
r = real discount rate.

[6]Rice and MacKenzie (1) use the human capital approach of measuring the value of a human life. There is also a "willingness-to-pay" approach that is discussed in subsequent sections.

[7]This is in accord with actuarial practice in the life insurance industry that assumes that everyone dies by their 100th birthday.

[8]The present value of morbidity cost is given by:

$$PV_{\text{morbidity}} = \sum_{n=y}^{99} P^i_{y,s}(n) D(n) \frac{[Y_s(n)E_s(n) + Y^h_s(n)E^h_s(n)]}{365} \times \frac{(1 + g)^{n-y}}{(1 + r)^{n-y}}$$

where

$PV_{\text{morbidity}}$ = present value of earnings lost due to injury per person,
$D(n)$ = days of restricted activity during the year of a person currently age n,
$P^i_{y,s}(n)$ = probability that person of gender s with injury i acquired at age y will survive to age n,
n = age of the individual,
$Y_s(n)$ = mean annual earnings of an employed person of gender s and age n,
$E_s(n)$ = proportion of the population of gender s and age n that are employed in the labor market,
$Y^h_s(n)$ = mean annual imputed value of homemaking services of person of gender s and age n,
$E^h_s(n)$ = proportion of the population of gender s and age n that are keeping house,
g = the rate of increase of labor productivity,
y = age at which the individual was injured, and
r = real discount rate.

TABLE 1—*Cost per injured person in 1985 dollars.*

Age Group	Direct Cost	Morbidity Cost	Mortality Cost	Total Cost	Weight (% of all falls)	Weighted Average Cost
Overall:						
0–4	465	395	22	882	0.107	94
5–14	420	626	11	1057	0.202	214
15–24	551	2843	153	3547	0.148	525
25–44	780	3190	274	4244	0.211	895
45–64	1305	2038	215	3558	0.143	509
65 and over	3343	854	29	4226	0.189	799
Total						3036
Males:						
0–4	493	474	29	996	0.123	123
5–14	499	920	18	1437	0.225	323
15–24	618	3626	232	4476	0.19	850
25–44	901	4510	441	5852	0.249	1457
45–64	1403	3131	409	4943	0.127	628
65 and over	3225	817	54	4096	0.086	352
Total						3733
Females:						
0–4	435	308	12	755	0.094	71
5–14	337	321	4	662	0.183	121
15–24	456	1709	40	2205	0.113	249
25–44	637	1626	74	2337	0.178	416
45–64	1237	1286	80	2603	0.156	406
65 and over	3373	863	24	4260	0.276	1176
Total						2439

mortality cost per fall victim (including victims who, to one degree or another, recover from their fall but do not return to work).[9] Summing the direct costs, the morbidity costs, and the mortality costs gives a total cost per fall victim. The total cost of falls in the US is arrived at for a given year by multiplying this number by the number of falls occurring in that year. Rice and MacKenzie (1) found that the cost per fall victim in 1985 was $3,033 overall, $3,735 for males and $2,440 for females (see Table 1).[10] The direct costs are lower for males than for females, but the mortality and morbidity costs are higher for males than for females. The latter result is a reflection of higher rates of labor force participation and pay on the part of males generally. Even more striking is the way the direct costs of fall injuries increase with advancing age in both males and females.

The next step is to restate these figures based on 1985 dollars in terms of 1994 dollars. This is accomplished by multiplying these figures by the percentage change from 1985 through 1994 in an appropriate price index. The direct cost part of the total is composed of expenses on medical goods and services, while the morbidity and mortality costs are composed of lost income. The reason people want income, of course, is to purchase goods and services generally. Therefore, the appropriate price index to adjust the direct cost part of the total is the medical care component of the consumer price index,[11] and the appropriate price index to adjust the morbidity and mortality cost portions of the total is the full consumer price index. These adjustments are reflected in Tables 2 and 3. Table 2 reveals that the cost per fall injury in 1994 for the overall population rises to $4,692 from $3,036 in 1985. The information in Table 3 allows us to estimate total costs of fall injuries in 1994. These were $64.2 billion in 1994 dollars as compared to the 1985 estimated costs of $57.6 billion, as measured in 1994 dollars.

Projections of the Economic Costs of Fall Injuries

Table 1 revealed that the direct costs of fall injuries increase dramatically with advancing age of the victim. As the so-called baby boom cohort approaches retirement age around 2020,[12] the direct costs of fall injuries to society as a whole will rise dramatically. Since everyone who will be in this age group has already been born, and assuming no dramatic changes in life expectancy in the next 25 years and that the incidence of fall injuries by age does not change, it is a straightforward matter of arithmetic to project the number and cost (in 1994 dollars) of fall injuries in 2020. These calculations are summarized in Table 4.

The total number of falls resulting in injury is projected to be 17,293,000 in 2020. Using the same frequencies and the 1995 population gives a projection of 13,743,000 falls resulting in injury in 1995. Therefore, the number of falls is projected to increase by 25.8% between 1995 and 2020. Over that period, the Bureau of the Census (7) projects the US resident population to grow by 23.7%, from 263,434,000 to 325,942,000. The extra 2.1% increase in falls resulting in injury is accounted for by the fact that the population will grow relatively more in age categories that are more prone to falling.

[9]The present value of mortality cost is given by:

$$PV_{\text{mortality}} = \sum_{n=y}^{99} P_{y,s}(n)[Y_s(n)E_s(n) + Y_s^h(n)E_s^h(n)] \times \frac{(1 + g)^{n-y}}{(1 + r)^{n-y}}$$

where

$PV_{\text{mortality}}$ = present value of loss due to premature death of a person,
$P_{y,s}(n)$ = probability that person of gender s and age y will survive to age n, and everything else is defined as before (see footnote 8).

[10]These numbers are taken from Rice and MacKenzie, Table 8 on p. 49 (1). The slight differences between their table and this version of it are attributable to rounding.

[11]The source of the index numbers is the US Department of Labor, Bureau of Labor Statistics.

[12]The year 2020 is chosen because that year is the midpoint in the period during which the cohort born between 1945 and 1955 will be retiring, given the already programmed increase in the Social Security retirement age to 70 years.

TABLE 2—*Cost per injured person in 1994 dollars.*

Age Group	Direct Cost	Direct Cost (adjusted)	Morbidity Cost	Morbidity Cost (adjusted)	Mortality Cost	Mortality Cost (adjusted)	Total Cost (adjusted)	Weight (% of all falls)	Weighted Average Cost
Overall:									
0–4	465	864	395	0	22	30	894	0.107	96
5–14	420	781	626	0	11	15	796	0.202	161
15–24	551	1024	2843	3812	153	205	5042	0.148	746
25–44	780	1450	3190	4278	274	367	6095	0.211	1286
45–64	1305	2426	2038	2733	215	288	5447	0.143	779
65 and over	3343	6215	854	1145	29	39	7399	0.189	1398
Total									4466
Males:									
0–4	493	916	474	636	29	39	1591	0.123	196
5–14	499	928	920	1234	18	24	2185	0.225	492
15–24	618	1149	3626	4862	232	311	6322	0.19	1201
25–44	901	1675	4510	6048	441	591	8314	0.249	2070
45–64	1403	2608	3131	4199	409	548	7355	0.127	934
65 and over	3225	5995	817	1096	54	72	7163	0.086	616
Total									5509
Females:									
0–4	435	809	308	413	12	16	1238	0.094	116
5–14	337	626	321	430	4	5	1062	0.183	194
15–24	456	848	1709	2292	40	54	3193	0.113	361
25–44	637	1184	1626	2180	74	99	3464	0.178	617
45–64	1237	2300	1286	1725	80	107	4131	0.156	644
65 and over	3373	6270	863	1157	24	32	7460	0.276	2059
Total									3992

TABLE 3—*Projected number and total cost (in 1994 dollars) of fall injuries and deaths, 1994.*

Age Group	Projected Population,* thousands	Frequency of Falls,† per 100,000	Number of Falls, thousands	Average Cost per Fall, 1994 dollars	Total Cost of Projected Falls, billions of 1994 dollars
Overall:					
0–4	20129	7313.4	1472	1424	2.095746
5–14	37483	7322.6	2745	1635	4.487634
15–24	36320	4707.6	1710	5042	8.620728
25–44	83487	3552.2	2966	6095	18.076197
45–64	50122	3909.5	1960	5447	10.674032
65–74	18863	6215.2	1172	7399	8.674084
75 and over	14307	10931.7	1564	7399	11.571617
Total	260711		13588		64.200039
Males:					
0–4	10316	7516.7	775	1591	1.233705
5–14	19207	7292.1	1401	2186	3.060997
15–24	18551	5560.6	1032	6322	6.521893
25–44	41576	3922.7	1631	8314	13.559725
45–64	24209	3341.7	809	7355	5.950396
65–74	8344	3309	276	7163	1.977806
75 and over	5115	5778.7	296	7163	2.117329
Total	127318		6219		34.421852
Females:					
0–4	9813	7099.9	697	1238	0.862385
5–14	18275	7354.6	1344	1062	1.427801
15–24	17770	3865.6	687	3193	2.193402
25–44	41913	3194.5	1339	3464	4.637826
45–64	25913	4428	1147	4131	4.740471
65–74	10517	8494.9	893	7460	6.664712
75 and over	9192	13735	1263	7460	9.418244
Total	133393		7370		29.944841

*Bureau of the Census, US Dept. of Commerce. Population Projections of the United States by Age, Sex, Race, and Hispanic Origin: 1993–2050.
†Rice D, MacKenzie E, Associates. Cost of injury in the United States. Washington (DC): National Highway Traffic Safety Administration, Centers for Disease Control; 1989: DTNH22-88-Z-07145 and DTNH22-88-Z-07144.

TABLE 4—*Projected number and total cost (in 1994 dollars) of fall injuries and deaths, 2020.*

Age Group	Projected Population,* thousands	Frequency of Falls,† per 100,000	Number of Falls, thousands	Average Cost per Fall, 1994 dollars	Total Cost of Projected Falls, billions of 1994 dollars
Overall:					
0–4	21957	7313.4	1606	1424	2.286070
5–14	42951	7322.6	3145	1635	5.142287
15–24	43325	4707.6	2040	5042	10.283398
25–44	83215	3552.2	2956	6095	18.017305
45–64	81147	3909.5	3172	5447	17.281148
65–74	30910	6215.2	1921	7399	14.213855
75 and over	22437	10931.7	2453	7399	18.147226
Total	325942		17293		85.371290
Males:					
0–4	11263	7516.7	847	1591	1.346958
5–14	22048	7292.1	1608	2186	3.513764
15–24	22145	5560.6	1231	6322	7.785420
25–44	41304	3922.7	1620	8314	13.471014
45–64	39403	3341.7	1317	7355	9.684971
65–74	14561	3309	482	7163	3.451441
75 and over	9173	5778.7	530	7163	3.797118
Total	159897		7635		43.050687
Females:					
0–4	10693	7099.9	759	1238	0.939721
5–14	20901	7354.6	1537	1062	1.632967
15–24	21180	3865.6	819	3193	2.614308
25–44	41909	3194.5	1339	3464	4.637384
45–64	41744	4428	1848	4131	7.636562
65–74	16348	8494.9	1389	7460	10.359867
75 and over	13270	13735	1823	7460	13.596616
Total	166045		9514		41.417424

*Bureau of the Census, US Dept. of Commerce. Population Projections of the United States by Age, Sex, Race, and Hispanic Origin: 1993–2050.
†Rice D, MacKenzie E, Associates. Cost of injury in the United States. Washington (DC): National Highway Traffic Safety Administration, Centers for Disease Control; 1989: DTNH22-88-Z-07145 and DTNH22-88-Z-07144.

Overall total cost of fall injuries in 1995 will be $64.41 billion, as compared to $85.37 billion in 2020 (both in 1994 dollars). This is a 32.5% increase. Growth in the number of persons, regardless of age, accounts for 23.7% of this increase, but what of the other 8.8%? The age categories that represent the baby boom cohort will experience the most rapid population growth. These are also the age categories which experience relatively more expensive falls in terms of direct cost. Moreover, since the rate of labor force participation among people in the over-65 age groups can be expected to increase, the morbidity and mortality costs of the falls experienced by this group will also increase on both a "per fall" and a "total for the group" basis.

The Market for Fall Injury Prevention

This section of the paper deals with fall accident prevention behavior, explains the conceptual market for fall prevention exhibited by interested persons, and examines possible justifications for government intervention in that market. The discussion offers the economist's perspective as to whether this market for fall accident prevention is efficient, i.e., whether it provides the optimal level of prevention activities.

Markets and Efficiency

The market for fall injury prevention activities is based on the demand and supply for these activities, like any other market. The demand for fall injury prevention is determined by the value of the benefits derived from preventative measures. The benefits offered by fall prevention activities are the reduced probabilities that fall injuries may occur and the resulting reduction in fall injury-related costs. The supply of fall injury prevention activities is determined by the costs of providing those activities (including the out-of-pocket expenses as well as the possible sacrifice of lucrative, but potentially risky activities).

It may be noted that, in some instances, this market is implicit, i.e., involves activities that may not be readily or regularly measured. In other instances (e.g., the availability of commercial home hazard inspection and repair services, the well-known television commercial advertising a communication device to aid the elderly person who transmits, "Help me. I've fallen and I can't get up"; or radio talk show personalities such as Dr. Dean Adell who advises elderly persons and others what preventative steps to take to avoid certain hazards), the market for fall injury prevention is more explicit.

In the course of carrying out our everyday production, consumption, and leisure activities, falls do occur. As explained in more detail below, an efficient level of fall prevention activities, according to standard economic analysis, is very unlikely to be that level that produces no fall accidents, or, even no deaths from fall accidents. If society's goal was that no fall accidents should occur, perhaps everyone would have to be strapped indefinitely in a prone position to a mattress. And this would cost us dearly—the total value derived from our production, consumption, and leisure activities. Few of us would prefer to be immobile and destitute in order to enjoy the benefit of absolute fall prevention. Hence, the efficient, or socially optimal level of measures taken to prevent falls almost certainly coincides with a positive number of fall accidents. To develop a better understanding of the market for fall accident prevention activities and whether the government should intervene in that market, the basic economic concepts underlying markets are developed and then applied to fall accident prevention.

Utility is the capacity of things (goods and services) to satisfy our wants, i.e., generate benefits for its user. *Opportunity cost* is best understood in terms of activities. The opportunity cost of some activity, Q, is the value of the highest-valued activity foregone when we select option Q. Thus, we measure the opportunity cost of Q as the single alternative to Q that we would have valued highest. Note that opportunity cost is a very broad concept—much broader than the accounting concept of cost. The accounting concept of cost deals with money—out of pocket expenses, if you will. The concept of opportunity cost deals with resources. The production of any good involves some opportunity cost. In fact, having an opportunity cost in production greater than zero is an essential part of the definition of an economic good, because that which can be produced without opportunity cost is free and thus outside the range of economic inquiry.

Society must balance the extra utility or benefit of the next unit of a good, say x, consumed against the extra cost. Economists refer to the extra utility of the last unit of good x consumed as the *marginal utility* of good x. The extra opportunity cost of the last unit of good x produced is called the *marginal cost* of good x.

Except in very special cases, the marginal utility of any good diminishes as more and more units of the good are consumed. This is because the early units of consumption will be put to the most highly valued (i.e., highest utility) uses. With the highest utility uses being already completed, later consumption units can only be put to relatively lower utility uses. Thus, the more you have of something already, the lower will be the marginal utility of yet another unit of it, whatever it is. A demand curve for good x is really just a plot of the marginal utility (or marginal benefit) of good x.

Similarly, the marginal cost of any good increases as more and more units of the good are produced. We live in a world in which we can think of more things we would like to have done than we have resources to do them. If we are to produce an additional unit of good x, we have to take resources away from the production of something else. To produce the early production units of good x, we can take resources from relatively low-valued alternative activities. Thus, the opportunity cost of the first several units of good x is relatively low. To produce more and more units of good x, though, requires that we draw more and more resources into the x production process. That means taking resources away from more and more highly valued alternative activities, so the marginal cost of good x must rise as we produce more and more units of good x. A supply curve for good x is really just a plot of the marginal cost of producing successive units of good x. It is because of increasing marginal cost that the supply curve for good x has a positive slope.

To see how the marginal cost of fall prevention measures would increase, consider stairs. Falls occurring while ascending or descending stairs are common to everyone's experience. There are a number of design changes that could be made to a standard staircase to reduce the incidence of falls. Each of these design options would increase the total cost of the staircase and decrease the incidence of falls. The marginal cost of preventing a fall on the stairs would be:

$$MC_{\text{prevention}} = \frac{\Delta\text{Total Cost of Stairway}}{\Delta\text{Number of Falls Averted}}$$

The designer could: (1) add a banister to one side of the staircase; (2) add banisters to both sides of the staircase; (3) add the banisters and narrow the staircase to make it possible to maintain contact with both banisters while ascending or descending; (4) add the banisters, narrow the staircase, and widen the tread of the stairs; or (5) add the banisters, narrow the staircase, and widen the tread of the stairs and install a motorized seat for use by one ascending or descending the stairway.

Obviously, each of the options (1) through (5) would add successively to the total cost of the stairway in terms of additional materials and labor for their construction and in terms of taking up more of the available floor space or restricting the maximum bulkiness of the items that could be moved upstairs or downstairs. It is also true that each option would add successively to the number of falls averted. For $MC_{\text{prevention}}$ to be constant, each additional design feature would have to avert a number of falls that kept pace with the required increase in total cost of the stairway. This is extremely unlikely. Common experience tells us that the much greater likelihood is that the largest number of falls will be averted because of the addition of a single banister. The total number of falls averted would rise with the addition of a second banister but the change in the number of falls averted will most likely go down. The same argument applies *a fortiori* with respect to the combinations of design features (3) through (5).

Examine Fig. 1. The supply curve for good x and the demand curve for good x will intersect at some combination of price (on the vertical axis, also measuring marginal utility and marginal cost) and quantity (on the horizontal axis). This price and quantity combination determined by the intersection of the supply curve and the demand curve is called the *equilibrium price and quantity*. Whenever the actual market price and quantity combination differs from the equilibrium combination, competitive forces, operating through self-interested behavior of producers and consumers, will push the market price and quantity toward the equilibrium. It can be shown that the socially optimal quantity of good x is that quantity at which the marginal utility of the last unit consumed is equal to the marginal cost of the last unit produced. This occurs at the intersection of the supply curve and the demand curve in Fig. 1. Note that the socially optimal quantity is exactly the equilibrium quantity. One of the ways in which competitive market arrangements are efficient is the tendency for such markets to move back toward the socially optimal quantity after a disturbance. This is called *allocative efficiency*. If a market ceases to be (or never was) competitive, there is no reason to think that the socially optimal quantity will be produced or that there are any systematic forces to move the market toward producing the socially optimal quantity.

Although the distinction may be somewhat artificial, we believe that this exposition justifying government intervention to help bring the incidence and severity of fall accidents in line with the "optimal" level of accident activity is furthered by separate considerations of the market for fall accident prevention in the workplace and the market for fall accident prevention among the elderly.

In each case, the level of fall accident prevention is determined by a large number of decisions that explicitly or implicitly take into account the marginal benefits and marginal costs to affected parties of preventing fall accidents. In each case, the optimal level of accident prevention or safety is achieved when safety measures are expanded until the marginal benefits of prevention (the reduction in the costs to society resulting from fall accidents) is equal to the marginal costs to society of providing successive units of

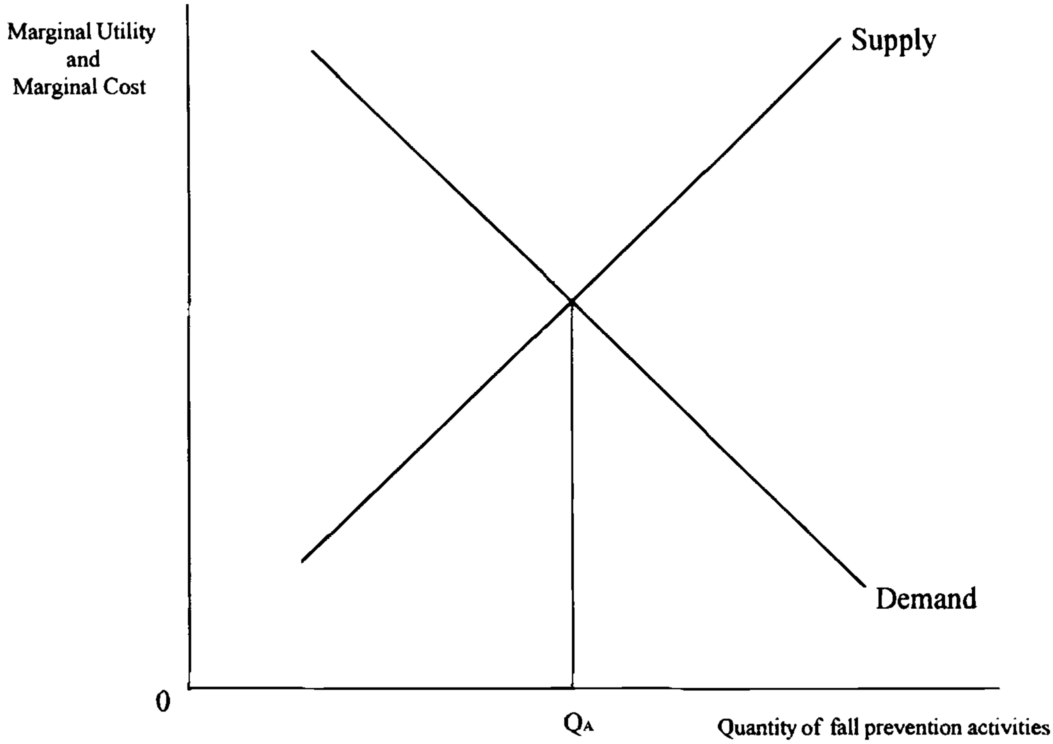

FIG. 1—*The market for fall prevention activities.*

prevention (such as the installation or conversion to safer flooring surfaces or the imposition of "rules" designed to reduce falls by proscribing high risk behaviors). However, the kinds of environments in which falls occur, the decisions of interested parties that may influence fall behavior, and the kinds of government-sponsored efforts to improve fall safety are sufficiently different to justify separate expository treatments of falls among the elderly and falls at the workplace.

Fall Accidents on the Job

In the case of fall accidents at the workplace, the level of prevention activities and the likelihood that such precautions will help to achieve an optimal level will be analyzed in the broader context of overall workplace safety. That is, fall prevention on the job is an example of a broader effort to contend with a large number of threats to worker safety. It has been argued that, in competitive labor markets, a structure of compensating wage differentials would arise whereby, everything else being equal, job tasks or occupations that involve a greater risk of injury would command greater remuneration to compensate for the greater risks (8–10). In essence, employees are assumed to regard such risky jobs as less desirable and would only be willing to offer their labor services in such situations if the marginal remuneration (i.e., wage premium) at least matched the expected value of the marginal costs of injury (including the probability of injury, potential medical expenses, lost earnings from work days missed, the value of avoiding pain and suffering, and, in the extreme case, the prospect of death).[13]

The structure of compensating risk premiums have the important effect of offering employers an incentive to achieve the optimal level of accident prevention. Employer efforts to improve safety (e.g., through safer equipment, mechanical employee restraints, or modified production procedures) would have the effect of reducing the incidence of injuries with riskier jobs and occupations. The rational employer would opt for greater safety until the marginal cost of achieving a given increment in safety would equal the marginal benefit—the additional reduction in wage premiums.

Critics of allocation decisions based strictly on market outcomes would argue that this fortuitous result of market forces creating the optimal level of precaution against workplace injuries, including fall injuries, occurs only to the extent that labor markets are perfectly competitive. One condition of perfect competition is that parties to a transaction have complete information regarding the nature of the goods or services (in this case the safety of the labor services) being transacted. Workers would have to know the probabilities of injury associated with various jobs or occupations and also know the magnitude of the costs associated with the occurrence of an injury. Rea (11) suggests, however, that some economists going back to Adam Smith (8) have argued that workers are inclined to underestimate the risks associated with various occupations. This hypothesis that workers misperceive the risks of job activities or misjudge their ability to influence the risks of certain jobs has been echoed more recently by Oi (12), Gregory and Gisser (13), Nichols and Zeckhauser (14), Diamond (15), Rea (11), and Chelius (16).

To the extent that worker misperception of risk is present, wage premiums would not reflect the true differences in the expected injury costs of various jobs and, therefore, employer efforts to minimize the costs of injuries to firms (increasing safety until the marginal costs of extra units of safety equal the marginal benefits, as measured by the reduction in payments for wage premiums) would no longer generate a level of precaution against injuries

[13]The employee faced with a greater probability of injury and not comfortable with taking on the pecuniary repercussions of an injury would theoretically be inclined to use this wage premium to purchase personal insurance against the loss.

that is optimal for society. For example, to the extent that workers tend to underestimate job-related injury risk, wage premiums understate expected injury costs and employers would opt for a less than optimal level of workplace precaution against injuries.

Under these conditions, market failure [an inherent inability of the market (based on self-interested decisions) to arrive at the optimal level of some activity due to an imperfection in the market] is observed. Market failure is often cited as a justification for government intervention. Such government intervention *may* have the effect of correcting or offsetting the market imperfection so as to create the optimal level of the relevant activity. In the area of workplace safety, government intervention has taken the forms of Workers' Compensation (WC) and direct regulation of workplace environments through the Occupational Safety and Health Administration (OSHA).

If workers could easily demonstrate employer liability and could sue their employers and recover the economic costs of injuries suffered in the workplace, worker misperception of risk or other labor market imperfections would not produce market failure. Employers would then find it to their advantage to continue to improve workplace safety until the marginal cost of such measures equals the marginal benefit (measured by the reduction in court imposed damages, which, in turn, equals the economic cost of worker injuries). However, the inherent difficulties of establishing whether employer or employee negligence was the cause of an injury, the considerable transactions costs of legal processing of such claims, and the delays in seeing such cases to a conclusion left many injured workers without adequate physical or income protection. These problems, in addition to the desire of many employers to make their liability more predictable, helped give rise to Workers' Compensation (WC) laws. New York State passed a WC law in 1909. All other states had passed some type of WC legislation by 1948 (17). Under WC employers are required to carry 'no fault' insurance which covers their employees against work-related injuries, in exchange for which the employees agree to forego their rights to sue their employers when such injuries occur.

In a conceptual sense, a WC system may lead potentially to an optimal level of workplace safety and correct the market failure problem. There is a system of charging insurance premiums to firms based upon their "experience rating", whereby an employer's premium is determined by the level of cost of injury related payments made by the WC program to that employer's workers. Under such a system, the employer's self-interest directs him/her to increase the level of workplace safety as long as the marginal benefit (measured by the reduction in future experience based insurance premiums, which, in turn, measures the economic costs of injuries)[14] exceeds the marginal costs of providing increased levels of safety. The logic of this approach is identical to the earlier proposition that correctly computed wage premiums provide employers the incentive to achieve optimal safety or precaution. In fact, under this type of WC system, the WC payments to indemnify employees against injury replace risk premiums, and remaining wage differentials would no longer be based upon job hazards (18).

Despite the impressive estimates of Moore and Viscusi (19) that WC laws save 2000 lives per year and that in the absence of WC, workplace fatalities would increase by over 40%, there are several features of the WC laws as they are actually written which make it very unlikely that WC can achieve optimal precaution against injuries. One problem rests with experience rating. Small employers, with less than 500 employees, are charged an insurance premium based not on their own experience (because they lack actuarial mass), but on the injury performance of firms in similar businesses. Larger firms, in many states, are eligible for experience rated premiums or may even self-insure—in effect, perfect experience rating. In a 1973 study, Russell (20) estimated that more than 80% of all employees were not fully experience rated. More recently, Krueger (21) concludes that insurance premiums only partially reflect injury experience for the majority of workers. To the extent that there is imperfect experience rating, firms have a less than optimal incentive to reduce workplace accidents.

A second feature of WC threatening optimal workplace safety is that the premiums charged to employers do not cover the full economic costs of worker injuries. No payments are made for pain and suffering. Also, although there is considerable variation among the states in the methods, procedures and generosity of WC payments to workers, workers typically receive only one-half to two-thirds of their lost wages (22). WC does not provide a higher level of earnings replacement to discourage workers from extending their recuperation period following an injury and using WC to finance subsidized leisure. Although this effort to promote employee work incentives may be socially desirable, it conflicts with the objective of achieving optimal safety because it artificially reduces insurance premiums to firms below the value of the cost of injuries and, therefore, may reduce the employer's incentive to achieve an optimal level of precaution against injuries.

Another feature of WC that threatens optimal precaution has been addressed by nearly all economists who have analyzed the WC system in the last twenty years—the issue of moral hazard. Krueger (21) explains,

> "In worker's compensation insurance the potential moral hazard is particularly acute because, by providing workers with income protection in the event of workplace injuries, public policy may inadvertently encourage workers to take greater risks on the job and thus incur even more disabilities."

Krueger's study confirms the findings of six earlier studies demonstrating the positive statistical association between the generosity of WC benefits and the number of reported injuries or WC claims. Krueger acknowledges that this association may be due to workers responding to program benefits by taking less precaution against job risk, or may also be due to workers being more inclined to file claims for borderline or even fraudulent injuries. Butler and Worrall (23) find that greater generosity of WC benefits over time has been associated with more reported claims. However, this increase seems not to reflect a decrease in safety, but rather an increase in worker propensity to take advantage of the WC system of benefits.

A second approach to government intervention is represented by the passage of the Occupational Safety and Health Administration Act of 1970. This legislation created the Occupational Safety and Health Administration (OSHA) within the US Department of Labor to establish and enforce standards designed to identify and eliminate workplace hazards. Standards are enforced through workplace inspections and the issuance of fines to violators. The language of the act calls for the "highest degree of health and safety protection for the employee" (22). This statement of objective is, of course, not consistent with the economist's concept of optimal workplace safety. Rather, OSHA's statutory mission seems closer to an absolute avoidance of injuries. Nonetheless, economists have

[14]Such insurance premiums also include the administrative costs of providing insurance.

been called upon to evaluate particular OSHA regulations and even the overall effectiveness of OSHA.[15] In the following section of the paper, a framework for examining the costs and benefits and, therefore, the economic desirability of an OSHA intervention pertaining to workplace fall injuries is presented.

Running parallel to OSHA's efforts to improve workplace safety are the loss-control programs run by worker's compensation carriers. The self interest at work is, of course, the insurance company's desire to increase profit by reducing claims expenses. As long as the reduction in claims expenses stemming from an additional loss control (i.e., safety) measure is greater than or equal to its cost in terms of business lost to other, less demanding carriers, the insurance company increases its underwriting profit[16] by requiring it. Indeed, insurance carriers will generally offer a premium reduction to those insured who implement loss-control measures in order to minimize the loss of business to other carriers.

Fall Accidents among the Elderly

Moving the focus of the discussion to falls among the elderly, it is once again possible to make a pro-market argument supporting the notion that the self-interested decisions of the elderly would lead to an optimal level/severity of falls. Each rational person would keep increasing his/her precautions against fall injuries until the marginal benefits of these safety measures equals the marginal costs of these measures. For the elderly individual these benefits are the reductions in the expected costs of fall injuries attributable to the precautions. The reductions in these expected costs depend on the probability of fall injuries, the medical costs of treatment and rehabilitation, possible lost labor market earnings, the economic value of reductions in mobility and lifestyle choices if the fall leads to lasting reductions in function, and the value of pain and suffering attributable to a fall. The marginal costs of prevention are based on the expenditures on equipment, other devices, or services to achieve greater safety and the economic value of opportunities foregone because such opportunities may present an unacceptable risk of producing a fall accident.

It is possible to conceive of a "market" for fall injury prevention governed by the demand and supply (i.e., marginal benefit and marginal cost) of fall prevention activities. If this market meets the normal qualifications for perfect competition, then an optimal level of fall prevention among the elderly would occur, suggesting an optimal level of falls among the elderly. In that case there would be no market failure, and no efficiency-based rationale for government intervention could be made.

Once again, if there are imperfections in this market, the market may fail to arrive at the optimal level of fall safety. Such market failure is often the basis of government intervention designed to achieve optimal fall prevention activities.

One possible market imperfection that may impede the market from reaching the optimal level of fall injury prevention is imperfect information. It is possible that many of the elderly do not fully appreciate the toll that age has taken on their fitness, balance skills and visual and auditory perception.[17] Also, it may be part of human nature to experience a certain degree of "denial" in admitting that one's senses and physical skills are not what they might have been only a year or two ago. Even if I have a perfect understanding of the physical deterioration induced by age, I may not have sufficient knowledge of the existence of medical or exercise-based remedies.

The medical community may have the information that allows an elderly person to more accurately assess his/her fitness, balance skills, sensory perceptions, and other functions relating to fall injuries and also to treat the deficits in these areas so as to reduce vulnerability to fall accidents. However, it may be argued that there are certain institutional features of medical delivery mechanisms that are biased against the provision of these diagnostic and treatment services. In such a situation, a less than optimal level of fall prevention activities would be provided.

One such problem relates to the fact that Medicare and most private insurance do not normally pay for preventative medicine. So even if an older person realized that fitness and balance skill deterioration had markedly increased his/her vulnerability to fall accidents, there is a bias in the medical system against prescribing the appropriate fitness or balance skill treatments because they are not covered by insurance. If the same older person came to his/her physician *after* a serious fall, which may have produced lasting physical damage, it is likely that those same fitness and balance skill treatments would be prescribed and covered by Medicare.[18]

Another insurance-related threat to optimal fall prevention activities again relates to the issue of moral hazard. It may be argued that since insurance does pay for medical and rehabilitation treatments brought on by a fall injury, an elderly person may be inclined to take less precaution to avoid such accidents than would be the case if the injury was not insured. Critics of this view would respond that the prospects of pain and suffering, which are not insured, and the possibility of permanent loss of mobility or other function resulting from a fall are sufficient disincentives for careless behavior to render the moral hazard problem negligible.

Other possible market imperfection that threatens fall prevention optimality are the alleged restrictions on labor supply into the market for physicians. These restrictions would limit the competition among physicians and create another possible bias against preventative medicine. Not all economists accept this view of physician supply. However, it has been argued that the American Medical Association (AMA) uses its influence to control the number of approved medical schools and further limits the number

[15]See McConnell and Brue (24) for a review of some of these evaluations.

[16]We have not taken up the possibility that insurers will also engage in cash flow underwriting because that practice is not in conflict with loss control programs.

[17]For a review of the medical literature on the causes of fall injuries among the elderly, see Tinetti, Speechley, and Ginter (2) and Tinetti and Speechley (25).

[18]It is possible that preventative treatments are not normally covered under private or public insurance because such treatments may be generally economically inefficient. In other words, given the often low probability that a given patient is likely to be afflicted with a given threat to health status, a procedure of routinely providing even moderately expensive treatments to a cohort or the population at large may involve incremental costs that far exceed the incremental benefits (recall the swine flu vaccine episode of 1976). Screening patients to select those at greater risk may reduce the treatment expenses relative to indiscriminant provision. However, the total costs of treatment, including the cost of such screening procedures, must still be balanced against the reduction in health costs among the proportion of the cohort or population that receives the preventative treatments.

Considering that 30% of the elderly experience fall accidents a year and that some of the indicators of falls (e.g., muscle fitness, balance skills, vision and hearing impairments, and pharmacological synergies) are fairly easily detected, it may be easier to demonstrate the economic efficiency of treatments to prevent fall accidents. The fact that some economists view health maintenance organizations (HMOs) as a more efficient mechanism for the delivery of health services (see, e.g., Folland, Goodman, and Stano (26), ch. 11) is at least partially based on the efficiency driven incentives that HMOs have in providing more preventative health services instead of the traditional emphasis on fee for services, after the injury or illness occurs.

of new physicians with licensure exams and other requirements. Evidence that such restrictions have had the effect of limiting competition among physicians (therefore limiting patient choice of physicians) and furthering the economic interests of the medical profession has been advanced by Friedman and Kuznets (27), Kessel (28), and Burstein and Cromwell (29).[19] To the extent that patient choice is reduced by this limiting of competition, doctors may find that they have a more lucrative practice by emphasizing the diagnoses and treatments of illness and injuries after the onset of these problems, reinforcing the bias against preventative measures introduced by medical insurance. It may be argued that if there was a greater competition among physicians (i.e., few supply restrictions) physicians would have to compete more for patients/customers by offering a mix of medical services that best promoted the overall health status of patients. This mix may well include more preventative services, either performed by the physician or resulting from physician referral.

The suggested institutional inefficiencies of Medicare bias against preventative care and barriers limiting supply into the market for physicians may not be the result of market failure caused by the inability of self-interested decision makers to achieve an optimal level of fall injury prevention without benign government intervention. Rather, these possible misallocations may themselves be the result of government intervention in the market for health care. The rules and procedures governing treatments and procedures covered by Medicare are, of course, set by the Department of Health and Human Services of the federal government. Since the mid-1800s, when the AMA was formed, state governments have stood behind the AMA and its medical licensing boards in their desire for the licensure of physicians, the AMA's desire in the early 1900s to allow the AMA's Council on Medical Education to accredit medical schools, and the AMA's desire to make graduation from such an accredited medical school a requirement for the taking of a physician licensure exam (30).

Other possible threats to optimal fall prevention among the elderly relate to the legal system. If a hazard in a public facility contributes to a fall injury, it is possible for the injured party to sue for damages to compensate for the economic costs, including pain and suffering, of the injury. As discussed above, the legal system often involves frictions introduced by disputes over the relative negligence of the injured party and the property owner, the costs of advancing a lawsuit, and the often considerable delays in seeing a case to its conclusion. Without these frictions, such lawsuits would be a more accessible remedy and property owners would further their self-interest by increasing the precautions against falls until the marginal costs of such precautions equaled the marginal benefits (the reduced cost of legal damages) of such precautions, yielding optimal safety. Aside from the threats to optimality resulting from the frictions, another problem with this legal remedy is that the economic damages other than pain and suffering are computed on the basis of lost labor market earnings. For most of the elderly, labor market earnings are at or near zero. There is a consensus among economists that the "willingness-to-pay" approach to the valuation of injury or even death is more appropriate than the lost earnings approach.[20] The computation of the loss from injury using the willingness-to-pay approach would be based on the amount that at-risk individuals are willing to pay (or give up) for protective measures to reduce the probability of a hazard by a given amount.

In sum, there are number of possible reasons to believe that the market for fall prevention activities among the elderly is operating at less than the optimal level. To a certain extent, existing government policies may be responsible for this hypothesized inefficiency. Health economist Paul Feldstein (30) argues that in such situations, it is preferable to eliminate the sources of the governmental inefficiency rather than have the government take further actions to offset the suboptimal provision of a health service. The logic of Feldstein's position is appealing to the present authors. However, recent difficulties in bringing about the reform of the American medical and health care services and the apparent preference of most would-be reformers to increase the scope of government involvement in the design and delivery of health care services may make Feldstein's prescriptions impractical for the foreseeable future. Hence, if there is an under-provision of fall prevention activities, government interventions, aimed at diagnosing individual vulnerability to fall injuries by the elderly and designing appropriate treatments, may be the best that society can do to achieve optimal levels of precaution. Of course, economists argue that such efforts (e.g., the FICSIT approach discussed in the next section of the paper) should be monitored for their economic efficiency as well as for their therapeutic efficacy.

Cost Benefit Analysis and Fall Prevention Interventions

As indicated, if market imperfections generate a less than optimal provision of fall injury prevention activities (i.e., the market is operating at a position to the left of point Q_A in Fig. 1), then government interventions in this market *may* move us closer to Q_A and improve allocative efficiency. Of course, this is not to say that any government intervention to increase fall injury prevention would do. Policy makers should search for those particular interventions where the resulting marginal benefits exceed the marginal costs by the greatest possible amount.

Of course, there are seldom readily available published tables which provide measures of the marginal benefits and marginal costs of government interventions. Nor is there an ever-visible neon representation of Fig. 1 that shows the market inching toward Q_A as government prevention programs expand, much as the illuminated ball drops down toward its inevitable destination on New Year's Eve in Times Square. Rather policy makers must rely on economists to use a combination of direct and indirect approaches to measure the costs and benefits of governmental activities. The process of determining the appropriate measure of costs and benefits and selecting alternative measures when the preferred measures are not available is referred to as *cost-benefit analysis.* This section of the paper describes some of the general issues involved in performing cost-benefit analysis and prospectively applies this approach to governmental interventions directed at the elderly and at those at risk in the workplace.

General Cost-Benefit Analysis Concepts

Costs include all resources used to reduce the incidence and severity of slip and fall injuries. For example, the installation of safety nets or the utilization of nonslip steel framing at a construction site reduces the risk of death or injury by falling from an elevated surface. In addition to the cost of the safety nets (or the additional materials cost of the nonslip steel framing), resource

[19]See Feldstein (30, p. 323–8) for a more detailed discussion of the mechanisms allegedly utilized by the AMA to limit physician supply and competition.

[20]See, for example, Mishan (31) and Edward Gramlich (32). The lost earnings, or human capital, versus the willingness-to-pay approaches to valuation are considered at length in the next section of the paper.

costs include the labor, material, and equipment costs of installation. The term *benefit* refers to any increase in utility associated with the intervention. Benefits reflect either the total value that individuals are willing to pay or are willing to accept for marginal changes in the risk of fall-related injury or death.

Benefits can also be regarded as the current damages or costs that society avoids with fall intervention. These damages include all direct and indirect costs associated with fall-related injuries. Direct costs include all medical costs associated with the treatment and rehabilitation of victims. Indirect costs reflect the value of lost productivity because of accidental death and disability, referred to as mortality and morbidity costs, respectively, nonlabor income, the value of pain and suffering, and diminished quality of life and leisure.

Two approaches used to estimate the value of benefits from slip and fall interventions are the willingness-to-pay and human-capital methods. Both methods are based on market data related to individuals injured by falls. However, economists prefer the willingness-to-pay approach because it is the only approach based on economic theory.

The willingness-to-pay approach is based on the theory of individual choice under uncertainty. Individuals make choices everyday which involve tradeoffs between changes in the risk of injury or death and changes in either earnings or consumption of goods and services. For example, people may choose to purchase safer, more expensive cars, become police officers or drive taxis in New York City. What these tradeoffs reveal is the price that an individual is willing to pay for a marginal increase in safety, or the amount an individual is willing to accept for a marginal increase in the probability of injury or death. The price paid or the amount accepted reflects the value of benefits individuals assign to marginal changes in the risk of injury or death. Society's benefit is found by aggregating across individuals.

Once either the price people are willing to pay for marginal increases in safety is known, or the marginal wage people are willing to accept for increased risk of death is known, the value of a life saved is revealed. Suppose there are n persons each with a willingness-to-pay of w_i to reduce the probability of a fatal fall by Ω. The group willingness-to-pay per life saved is then:

$$\sum_{i=1}^{n} \frac{w_i}{n\Omega}$$

For example, suppose an individual is willing to pay five dollars to reduce the risk of death from ten in one million to nine in one million. Then the implied value of life is five million dollars.

The human-capital approach is based on the notion that the value of a life is equal to the present value of the potential stream of future output that society loses as a result of the injury or death of an individual. Benefits from saving a life or from preventing an injury are measured by the present value of the expected flow of the individual's future earnings[21] plus the direct costs associated with failure to avert injury or death.

A major objection to the human-capital approach is that it is not based on principles of economic optimization. Benefits measured by the human capital method are not based on individual choice (i.e., do not reflect the value that we place on our own lives as indicated by the everyday choices that we make) and, therefore, are theoretically inconsistent with standards used to evaluate the economic efficiency of public health interventions. Because the human-capital method does not include non-labor income, and does not account for the value of pain, suffering, decreased quality of life, or the bereavement of family, it merely approximates the value of life as measured correctly by the willingness-to-pay approach. Rice and MacKenzie (1) apply both methods to value indirect costs associated with various injuries and report that the human-capital values range from 16 to 22% of the values measured by the willingness-to-pay method.

Nevertheless, the human-capital approach is the most commonly used method for determining the value of savings associated with injury control. Mishan (31) contends that this is true mainly because the human-capital approach "lends itself easily to quantification." Rice and MacKenzie utilize the human-capital approach and argue that this method is appropriate for determining the savings or costs avoided from injury control interventions aimed at reducing the incidence of falls.

[21]This approach implies that the earnings received by a worker approximate the value of output that the worker produces. This is a conventional result that emerges in competitive labor markets.

Cost-Benefit Analysis Applied to Specific Interventions

A Prevention Program for the Elderly

In recent years there has been an impressive array of interventions designed or implemented that are directed at reducing falls among the elderly. For example, Reinsch et al. (33) used a controlled experiment to measure the effects of a particular exercise program and/or a fall prevention education program. Wagner et al. (34), used a controlled experiment to examine the impact of nurse visits to diagnose and treat those at risk of fall injuries. Two studies (35,36) examined the impact of mechanical restraints on fall injuries in nursing homes. An ongoing study by Hornbrook, Stevens, and Wingfield (37) examines the effects of a behavioral management approach to increase exercise, conditioning, home safety improvements, and mental imagery on fall injury incidence. Dunne et al. (38) examined the impact of the use of sturdy shoes on fall injuries. Dean et al. (39) studied the use of canes as a device to prevent falls.

Among many intervention studies directed at reducing falls among the elderly, we have chosen to focus on the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) program, a major, comprehensive effort underway to advance our understanding of fall behavior and prevention among the elderly. FICSIT is actually a series of eight different interventions at eight sites around the country. Among those eight interventions, we singled out the program administered by the Yale University School of Medicine and led by Mary Tinetti because of the strong reputation achieved by Yale and Dr. Tinetti in research on fall injuries among the elderly over the last ten years. The Yale FICSIT study also offers the advantage of being among the first to report a one year follow-up of findings from their intervention research.

Tinetti et al. (40) studied 301 persons of at least 70 years of age, living in the community and enrolled in a health maintenance organization in southern Connecticut. The participants were mentally competent but possessed at least one of the fall risk factors listed below. Nurse practitioners and physical therapists assessed and administered tailored interventions in the homes of the participants assigned to the test group. Interventions included a combination of changes in medications, education, exercise programs, and environmental modifications. Participants assigned to the control group received routine health care, plus home visits from social-work students. Measures of mobility, self-confidence, and incidence of falls reported monthly by participants served as measures of the experiment's outcome. The results showed that during a twelve-month follow-up period, 47% of the control group fell one or more times and only 35% of the test group fell, a reduction of 25.5%. The proportion of persons in the test group with risk factors decreased, as compared to the control group, and for each unit decrease in risk factors there was an 11% decrease in the risk of falling. The participants in the test group reported not only fewer falls, but also a decrease of falls that required medical treatment.

The multifaceted interventions, such as FICSIT, are efficient if the benefits of reducing falls among elderly persons are greater than or equal to the costs of implementing the interventions. Benefits are equal to the product of the number of injuries of given severity avoided and the average direct and indirect costs per injury of given severity avoided by the interventions. The estimate of the number of injuries reduced depends on estimates of both the aggregate number of injuries to which the intervention applies and the proportion of injuries of given severity that are avoided by the multifaceted intervention.

The resource costs incurred by implementing the multifaceted intervention strategy include development, assessment, modification, and follow-up costs. Development costs include the costs of researching the problems, causes, and cures of falling among elderly persons in the community. The assessment costs include the costs of home visits conducted by nurse practitioners and physical therapists to identify intrinsic, behavioral, and environmental fall risk factors. The physicians' cost of reviewing their patients' use of medications also is included. Modification costs reflect all costs of implementing the interventions, including treatment for mental, visual, hearing, and alcohol problems, behavioral education, strength, balance and gait training, exercise programs, and removal and modification of environmental hazards. Follow-up costs include labor, telephone, and postal costs related to collecting the participants' self-reports, as well as the cost of interpreting the reports. The applicable costs of transportation, communication, materials, equipment (including depreciation expenses), energy, and overhead costs incurred in each stage of the intervention project must be included.

Tinetti et al. (40) provided estimates of the resource costs incurred in a controlled experiment that tested the efficacy of the multifaceted intervention strategy. The authors' estimated costs of implementing the interventions include development, equipment, personnel, travel, and overhead costs. No other details about the exact nature of these costs are provided. This is a problem that plagues most clinical studies of public health interventions. The total cost of the intervention that was estimated to prevent 70 falls (4) was $136,318. The average cost per person in the test group was $891, the average cost per fall prevented was $1,947 and the average cost per fall that required hospital care was $12,392. To serve as an example of how to assess whether or not the multifaceted intervention is efficient, suppose that the average cost per fall is $4,692 (See Table 2). The total cost of 70 falls is $328,440. This total represents the benefits to society attributed to avoiding 70 falls. The total resource cost of preventing 70 falls is $136,290 [70 falls multiplied by $1,947, the average resource cost per fall reduced reported by Tenetti, et al. (40)]. Since the benefits are greater than the resource costs of reducing 70 falls, the multifaceted intervention program promotes allocative efficiency.

A Prevention Program at the Workplace

The same procedures used to determine the efficiency of the multifaceted intervention program to reduce falls among elderly persons can be used to evaluate slip and fall preventive interventions in the workplace. Similar to the case of elderly persons, there is no single cause of fall-related injuries at the workplace. The majority of falls are caused by a combination of behavioral, activity-related, and environmental factors. Behavioral factors include lapse of attention, lack of coordination, and inappropriate footwear. Activity-related factors include working on elevated surfaces, erecting and dismantling of scaffolds, and performing such common tasks as pushing or pulling, carrying objects, and running or turning. Environmental factors include slippery or uneven flooring, contaminants, poor lighting, scaffolding, ladders, and stairs.

According to Minter (41) a high level of fall protection at the workplace may lead to increased productivity, quality, and timeliness of work. Workers' confidence and morale may be enhanced by a reduction in the risk of falling. Companies that provide a high degree of fall protection may have a cost advantage over competitors that, without a comparable level of fall protection, may consider certain jobs too dangerous to accept. Furthermore, companies that lead in the development of job-safety design and protective equipment can market and sell them. The value of these improvements must be added to the direct and indirect costs of injuries and deaths avoided to measure accurately benefits from fall intervention at the workplace.

Resource costs associated with a comprehensive intervention strategy aimed at reducing falls at the workplace include development, implementation, and enforcement costs. Development costs include the costs of researching the risk factors for falls, and of devising strategies that will improve safety conditions at the workplace. Implementation costs include the costs of incorporating fall protection issues in contract negotiations, pre-job safety analysis, worker education and training programs, worksite inspections, nets, guardrails, belts, and all other safety equipment, and the present value of future maintenance and depreciation of fall protection equipment. Enforcement costs include the costs of federal and state seminars on fall safety, distribution of information regarding OSHA's standards and enforcement, educating and training inspectors, and inspection programs.

Subpart M of 29 *Code of Federal Regulations* 1910 and 1926 that deals with fall prevention in the construction industry and shipyards was revised by OSHA in 1995. In their Regulatory Impact Analysis, OSHA (42) estimates that the revision to Subpart M will result in the prevention of 22 fatalities and 15,600 injuries annually. Multiplying 15,622 falls by the $4,692 average cost per fall (from Table 2) yields an annual estimated benefit of $73,298,424 in 1994 dollars.

Against this, OSHA estimates an annual cost of compliance with the revisions of $40 million. This includes providing workers with increased fall protection ($25 million), inspection, and testing of personnel safety nets ($5.4 million) and additional training for employees exposed to fall hazards ($6.6 million). Subtracting $40 million in additional costs from the $73.3 million in additional benefits yields a net benefit of $33.3 million stemming from revision of Subpart M.

The benefits and resource costs mentioned above are associated with slip and fall intervention at the workplace and are neither collectively exhaustive nor mutually exclusive. For example, there may be some workers who are made worse off because they may be perceived as being less macho for wearing safety belts. Others may be made better off because they find winged-tip safety shoes aesthetically pleasing, and yet others may find them to be ugly. Although these costs and benefits are not easily tractable, they must be considered.

Other Examples

Of course, this same kind of cost-benefit analysis can be applied to a variety of other settings, public and private. What follows are several examples suggested to us by an expert in the field of construction standards.

Without purporting to have detailed knowledge of engineering, it is easy for economists to see that many of the common problems of design of walkways and similar surfaces present examples of this process of optimizing by finding a balance between marginal benefits and marginal costs. In designing a ramp for wheelchair access to a building, reducing the steepness of the ramp will reduce the incidence of falls (thereby generating benefits), but doing so takes up more space that could have been put to other valuable uses and also generates more direct costs in terms of the additional materials used.

Increasing the friction level of the floor surface of a commercial kitchen would increase the friction between floor and shoe, and thus reduce the incidence of slipping, but at a cost of freedom of aesthetic choice, the additional production expense, and a reduction in the degree to which the floor can be cleansed of organic material deposited by the cooking process.

Another case relates to discontinuities in the height of walkway surfaces. For example, sidewalks installed in sections may develop such discontinuities over time for a variety of reasons. The current standards normally permit discontinuities of up to 1/4 in. without the necessity of remedial action. Reducing this standard to 1/8 in. would produce a benefit in terms of fewer pedestrian falls, but would result in additional costs as a result of the more frequent repair and replacement of sidewalks.

A final example relates to the use of foot cleaning mats near the entrances of retail and other commercial facilities. Such mats reduce the extent to which moisture, mud, and other foreign matter are tracked into the facility as people enter. These mats generate additional costs at the time of installation, maintenance, and replacement. However, these mats, by reducing the contamination and loss of friction of the remaining floor area, reduce the incidence of slips and falls. Another source of benefit in the form of reduced cleaning costs of the remaining floor area is also generated.

Conclusion

The economic costs borne by society as the result of fall injuries run into the tens of billions of dollars annually and are destined by demographic trends to increase over time. The magnitude and trend in these costs and the corresponding suffering that these costs represent have engendered considerable attention in the scientific and public policy literature aimed at devising remedies or interventions to reduce the incidence of fall injuries.

We argue in this paper that there are two important economic aspects to be considered in the design and assessment of these interventions. First, is there an *a priori* reason to believe that the market forces that influence fall prevention behavior are not functioning in a socially desirable manner? Second, if not, how should a proposed intervention be evaluated? Our answer to this latter question is that there should be a comparison of the marginal benefits and marginal costs generated by any particular intervention and that only those interventions with prospective marginal benefits that exceed marginal costs should be undertaken. *Ex poste,* only those interventions with actual marginal benefits exceeding marginal costs should be maintained. In practice, the task of measuring these marginal benefits and marginal costs should be done within the cost-benefit analysis framework outlined in this paper. Our discussion of cost-benefit analysis has mentioned the fact that cost-benefit analysis frequently requires concessions and circumventions to deal with imperfect, nonexperimental data collection.

Our analysis of these issues has supported the economist's perspective that the ultimate objective of policy should not be to reduce the incidence of falls to zero, but to the level consistent with allocative efficiency, in which marginal benefits and marginal costs of fall prevention activities are equal.

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