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# Challenges of Measuring Individuals versus Events as Health Outcomes: Falls in Elderly as an Example

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## Opinion Article

The need to base health care decisions on evidence from health-related interventions has three parts: (1) the collection of outcomes data, (2) analysis of the data; and (3) interpretation of the data. The purpose of this paper is to emphasize the importance of showing all details of the calculations during the analysis of the data stage. We will walk readers through a detailed hypothetic analysis to numerically show that errors can occur when details of work during the analysis stage are not shown, which lead to assumptions needing to be made. We use falls among elderly as an example throughout this paper. However, this discussion may apply to many other health-related topics.

When collecting intervention outcomes data, we have the choice to tally either the number of outcome events ($N_{ev}$) or the number of people who have events ($N_{ind}$). In the case when there can only be one event per person, both methods are identical. Examples include death, first born child, and measles cases. However, when there is an option for multiple events per person per time period (i.e., malaria infections, elderly falls, school absences, etc.), there are issues that need to be considered when choosing between tallying the number of events versus the number of individuals. We will discuss when these two approaches are equivalent and when they are not. Furthermore, for interventions that report number of individuals as the outcome, tallying the number of individuals who report "at least one event" may be imprecise and misleading, depending on whether the study has as a primary interest in studying either individuals who have "no events" or those who have "multiple events."

The above issue directly affects other public health metrics. For example, if one puts monetary values on outcome events (or the prevention of such events), we could use these values to estimate averted cost components of health economics. With high and rising health care costs, preventing negative event outcomes becomes a very important issue to be weighed against the cost of the intervention itself. However, while interventions may show a high efficacy rate, they may not always be economically sound. For example, advising those exposed to malaria mosquitoes to sleep in air-conditioned rooms may be prohibitively costly, and not worth the effort. On the other hand, interventions with low efficacy rates may be very inexpensive and worth the effort. For example, an educational program to towel off after entering water contaminated with infectious bacteria to prevent skin infections. The framework to address this issue is called the Cost:Benefit analyses, which uses a Return on Investment (ROI) comparison.

In a Cost:Benefit analyses there is a Cost (or Investment) side and a Benefit (or Return) side to the expression.

*ROI=Return (monetary value)÷ Investment (monetary value)*

For this paper, we are focusing on the Benefit (Return) portion of this expression, using elderly falls as the topic. For a given number of fall events ($N_{ev}$), what is the corresponding monetary value? One could determine this value based on the number of events. If the average value of each fall event is defined as $\$Val_{ev}$, then the total value of preventing $N_{ev}$ falls is:

*Expression 1 (Events): Total Value (events)* $= N_{ev} \times \$Val_{ev}$

This same Total Value can be derived for the number of individuals ($N_{Ind}$) who fall:

*Expression 2 (Individuals): Total Value (Individuals)* $= N_{Ind} \times \$Val_{Ind}$

$N_{Ind}$ would be the number of individuals corresponding to the $N_{ev}$ fall events and $\$Val_{Ind}$ is the average monetary value of treating an individual for falls, regardless of how many times they fall. As an aside, $N_{Ind}$ can be either the total number of individuals in one's project (falling or not falling) or just those who fall at least once, as long as $\$Val_{Ind}$ uses the corresponding value of all or just those falling.

Table 1 is an example using a hypothetical event *vs.* individual distribution. The intention of this table is to show that Total values can be made to be the same whether they are calculated for events or for individuals. Falls among elderly is used as the example for this table. If the average cost per event is fixed, then the average cost per individual is dependent on the average number of events per individual.

Suppose we were ONLY given the number of individuals falling "at least once" (during a given time period). In Table 1, we chose, hypothetically, 80 as this number. When "at least once" terms are used, there is an exact tally (zero events) for the 20% who don't fall. However, for the 80% who do fall, there is uncertainty as to how many fell exactly 1,2,3 etc. times. Without knowing the frequency distribution of events among individuals, one cannot determine the total number of events, from which we derive $\$Val_{Ind}$. Without this latter term, we cannot determine the value of the Return. The point is that data tallies of "at least once" may have too much uncertainty for further meaningful calculations.

Number of Falls by Individual Project #1

| # Falls: | 0 | 1 | 2 | 3 | 4 | 5 | Total falls |
|---|---|---|---|---|---|---|---|
| Individuals | 20 | 58 | 18 | 3 | 1 | 0 | 100 |
| Fall Events | 0 | 58 | 36 | 9 | 4 | 0 | 107 |

Assumptions: $\$Val_{ev}$ is set at $1000; $N_{ind}$=100; Number of individuals falling at least once=80

By Event: $\$Val_{ev}$ = $1000 Total = 107 × $1000 = $107,000

By Individual: $\$Val_{Ind}$ = $107,000/80 = $1337.5 Total = 80 × $1337.5 = $107,000

**Table 1:** Distribution of fall events among individuals.

Strictly speaking, the Return side of the Cost:Benefit expression of a fall prevention program would be based on the change in number of outcomes, whether it is in terms of events or individuals. This change is in turn derived from comparing two states, either before *vs.* after intervention or intervention *vs.* control group. The above concepts apply to states as well as changes in states.

The above example is a lot of arithmetic to show the obvious; that when given enough information, tallies of either events or individuals should give the same Return for preventing a given number of falls. The next point is to show that this only applies for each specific situation.

Perhaps some studies report all the parameters of expressions 1 and 2, including average monetary values and outcome numbers for both events and individuals. Unfortunately though, all too often the average $Values are not available for small studies and, instead, they use referenced data for these values from other larger studies [1,2]. Table 2 shows that event values, $\$Val_{ev}$, can be shared among different studies (when we can safely assume that severity of falls is the same between the studies), whereas individual tallies, $\$Val_{Ind}$, have the added issue of whether or not the distributions of events per individual are the same between studies.

Number of Falls by Individual Project #2

| # Falls: | 0 | 1 | 2 | 3 | 4 | 5 | Total falls |
|---|---|---|---|---|---|---|---|
| Individuals | 20 | 21 | 24 | 25 | 10 | 0 | 100 |
| Fall Events | 0 | 21 | 48 | 75 | 40 | 0 | 184 |

Assumptions: $\$Val_{ev}$ is set at $1000; $N_{ind}$=100; Number of individuals falling at least once=80

By Event: $\$Val_{ev}$ = $1000 Total = 184 × $1000 = $184,000

By Individual: $\$Val_{Ind}$ = $184,000/80 = $2300 Total = 80 × $2300 = $184,000.

**Table 2:** Distribution of fall events among individuals.

In the above example, the average $Value per individual (falling at least once) cannot be shared between Projects #1 and #2 (Project #1 indicated a $Value of $1337.50 per individual and Project #2 indicated a $Value of $2300.00 per individual). However, sharing the average $Value per event between the two projects would be valid (with the caveat of similar severity) since the $Value per event was the same ($1000/event for both Project #1 and Project #2). If there are greater number of fall events per individual, then $\$Val_{Ind}$ rises accordingly.

One might just decide to always use event data and avoid the more complex, distribution dependent, issue of individual data. However, individual data might enter at other stages of the Return calculation and it is instructive, based on the above discussion, to have elaborated on the relationship between events and individual outcomes. Here is another example with the topic of elderly falls, when individual data enters calculations of the Return.

Oftentimes, the acute Emergency Department's (ED) care of falls is the most costly monitored aspect of fall costs (excluding nursing home costs), and we choose to track only this aspect of cost as a standard of comparison [1,2]. However, not every fall event in the community goes to the ED for acute care (AC), and for those that don't seek AC, their costs might be considered relatively "negligible". The fall prevention programs that intervene in the community need to be "adjusted" for the number of falls prevented that would have gone for AC. For example, suppose the average cost for those who do report for AC is $23K per event. One study [2,3], found that approximately 10% of community-based falls (events) seek AC. Given this fact, then preventing each community-based fall is worth only $2,300 on average. This adjustment factor needs to be applied to Expressions 1, which tallies events:

$$\textit{Total Value (Events)} = N_{ev} \times \$Val_{ev}$$

But now $\$Val_{ev}$ for a community-based intervention is only 10% of the value of those who come for AC.

Further, some form of this adjustment also needs to be made for expression 2, which tallies Individuals as the outcome. This adjustment can get tricky given the "at least once" concept discussed previously. One study, Carande-Kulis et al., claims that for individuals who fall, 33% go for AC [1]. On reading their reference [4], this report of 33% is an "at least once" concept (go for AC at least once) and the original data source of questionnaires did not obtain more exact counts of number of fall events that report for AC. Furthermore, extrapolations from other data sources would require a check to see that distributions of total falls *vs.* number of falls needing AC (if they were available) would match.

In the preceding section we dealt with the uncertainty that "at least once" tallies introduce. For those who fell at least once, we needed more detailed data of distribution (events *vs.* individuals), to determine the average number of events and corresponding related costs. Now we see that even after knowing this, individuals who fall have another "at least once" issue to deal with, the added criteria of going for AC. As before, there is certainty for the 67% who don't go at least once – they go zero times. But for 33% who do go "at least once", in the subgroup of individuals who fall say 4 times they might go, 1,2,3,4 times. If one makes the assumption that they all go 4 times, this would give an upper value to the $Val of the average individual fourfold higher than the lower limit value if they only report for AC once. A fourfold difference here has as much effect on the Return as a fourfold difference in intervention efficacy, which is a huge potential for error. Rather than use the upper or lower limit one needs to calculate the average number of times that this particular group does seek AC. Then we have to do a similar tally across the other categories of individuals who fall 2,3,5 etc. times.

Liu et al.'s work, which tracked a large cohort of elderly coming to the ED for falls, showed that very few (about 7%) returned for AC of repeat falls within a year [5]. Liu et al. did not report the number of falls per individual of his population. However, Stevens [4] reported that a large proportion of elderly fallers do fall multiple times. We assume this to be true for Liu's study group as well and can deduce that while elderly fall often, they do not go for AC much more than once per year. The reasons for this might be quite complex, involving financial, social, psychological, etc. factors. Carande-Kulis et al. gave no further reference that the overall 33% of individuals who sought AC was based on anything more precise than the "at least once" concept (though this concept was applied to different strata by gender and number of falls) [1,4]. When converting to event percentages, this would overestimate the number of individuals who seek AC by twofold for those falling twice, by three-fold for those falling 3 times, fourfold for those falling 4 times, etc. We use the value of 10%, based on events reported, not derived from the individual "at least once" concept [2,3].

While tallies of events might be more attractive than tallies of individuals, even event outcomes might have to deal with "at least N" assumptions. For example, suppose we tally fall events and want to consider the corresponding hospital costs. We are given the data that 17% of the events are hospitalized for at least two days. The cost for the 83% staying longer is unknown and our estimate of total cost would be inaccurate.

In summary, if one tallies number of individuals instead of number of events as outcomes, this introduces the issue of distributions, including both the average number of events per individual and the corresponding costs per individual. Further, these individual averages will vary among different studies. If we use number of events as the outcomes, the average $value is more constant among different groups of individuals (independent of distribution). Another important issue is the concept of "at least once" event outcome among individuals. Tallies of individuals can be more prone to misinterpret how inexact this tally really is for those with more than one event. The "at least once" issue might enter at various stages of individual-based evaluations (i.e., events, times seeking acute care, and days hospitalization). Rather than prescribe methods for each specific situation, we ask that methods and outcome papers addressing the important issue of cost containment show all details of their calculations.

## References

1. Carande-Kulis V, Stevens JA, Florence CS, et al. (2015) A cost-benefit analysis of three older adult fall prevention interventions. J Safety Res 52: 65-70.
2. Mills K, Sadler S, Peterson K, et al. (2018) An economic evaluation of preventing falls using a new exercise program in institutionalized elderly. J Phys Act Health 15(6): 397-402.
3. Mills KM, Pang LW (2018) Importance of utilizing standardized method of calculating cost benefit of physical activity interventions. J Health Sci Educ Vol 2(5): 1-2.
4. Stevens JA, Ballesteros MF, Mack KA, et al. (2012) Gender differences in seeking care for falls in the aged Medicare population. Am J Prev Med 43(1): 59-62.
5. Liu SW, Obermeyer Z, Chang Y, et al. (2015) Frequency of ED revisits and death among older adults after a fall. Am J Emerg Med 33(8): 1012-1018.

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