Preventing Elderly Falling Through Machine Learning

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ABSTRACT

Using a machine-learning approach, we created, tested, and patented an algorithm that accurately predicts elderly falling. Additionally, using the algorithm our research in a community-based environment we demonstrated the ability to prevent injurious falls. Our algorithm allows clinicians to screen for individual fall risk, with suggestions for appropriate interventions. A significant part of our fall-prevention program incorporates a critical risk factor—specific drugs and drug dosages. This algorithm not only was able to accurately predict a patient's risk of falling but demonstrated a cost benefit by lower healthcare utilization, reducing hospitalization and providing overall economic savings. Specifically, we reduced injurious falls and saved health care providers $2.40 for every $1.00 invested. Our long-term goal builds on the foundation we developed with the creation of this machine-learning algorithm by expanding this approach into a computerized clinical decision support system (CCDSS), which clinicians can use to offer tailored, specific suggestions for fall prevention to their patients. CCDSS is a technology that uses patient-specific data to provide relevant medical knowledge at the point of care. It is an important quality improvement intervention, and the implementation of CCDSS is growing substantially.

Keywords: elderly falling, prescription medications, demography, biosensors

SIGNIFICANCE

As adults age, they develop several co-morbid conditions that need to be managed collectively, especially as they enter their elderly years. The presence of these co-morbid conditions combined with varied drug regimens addressing several ailments compounds the issue further. Moreover, natural aging leads to the development of frailty and changes in spatial orientation put elderly patients at risk for falling. The physical, psychological and economic impacts of elderly falling are a significant public health concern, as falls are the leading cause of injurious deaths among individuals who are over 65 years of age and associated with significant morbidity, hospitalizations and increased healthcare utilization.[1-3] Of the elderly seen in the emergency room for falling, over 40 percent report continued pain or restricted activity.[1-3] Additionally, after the "falling event" many elderly experiences "Fear of Falling" which contributes to decreased exercise.[4] This in turn results in worsening of stability and increases the risk for future falls. Both the incidence of falls and the severity of fall-related complications rise steadily after the age of 60 years. Among community-dwelling, generally healthy older persons aged 65 and over, approximately 35 percent to 40 percent will fall annually.[5] By 2030, the population of individuals who are 65 years of age or older will double, and by 2050, the population of individuals who are 85 years of age or older will quadruple.[6] The social and economic implications of an aging population—and the baby boomers in particular—are likely to be profound. For example, the number of hip fractures due to falling is expected to exceed 500,000 by 2040, and twenty-five percent of elderly persons who sustain a hip fracture die within one year.[7] Sixty percent of fall-related deaths occur among individuals who are 75 years of age or older. Furthermore, more than 64,000 individuals who are over 65 years of age sustain a traumatic brain injury because of a fall.[6] The economic costs associated with these events are often high due to emergency rooms visits, hospitalizations and presence of co-morbid conditions and frailty. The estimated total cost for hospitalizations related to traumatic brain injury due to falls in individuals who are 65 years of age or older is more than $3.25 billion.[8] The costs presented do not consider lost days of work and the productivity of family caretakers. The costs to the Medicare and Medicaid programs and society from falls by elderly persons continue to climb much faster than inflation and population growth. Direct costs alone will exceed $5.2 billion in 2020.[8] The solution to reducing these costs is preventing falls and decreasing patient fall risks. With the aging population growing and the high incidence and costs tied to falling, fall prevention has become a national public health priority. While falling has been on the rise among older adults, falls can be preventable, with screening being the first step in reducing fall risks. Studies have demonstrated that falling can be reduced up to 40 percent by performing fall assessments and addressing a patient's risk factors with proper management, lifestyle adjustments and/or pharmaceutical or medical interventions. This requires improving fall risk assessment and giving caregivers the right tools and technologies. Therefore, to reduce the incidence of falling as well as the mortality and morbidity tied to falling, we developed, implemented, and patented a unique, robust fall assessment tool, that predicts a patient's risk for falling. We have successfully demonstrated proof of concept and proved that our machine-learning algorithm can prevent injurious falls. This algorithm not only was able to

accurately predict a patient's risk of falling but demonstrated a cost benefit by lower healthcare utilization, reducing hospitalization and providing overall economic savings. With the growing pressures of physician time in clinical practice and aging baby boomer population, a computerized assessment tool that accurately helps to predict fall risk and guide strategies for management, will arm clinicians with a standardized, high-quality, cost-effective approach to prevent injurious falls and reduce complications tied to them as well as improve quality of life and economic burden on the healthcare system.

INNOVATION

The american geriatrics society guideline recommends screening for falls at least yearly. With the use of screening tools, evidence-based fall risk assessment and management is feasible and effective. Regrettably, psychometrically sound multi-factorial assessment instruments that include medication data and provide individual risk-profiles are currently unavailable. The key to our fall risk assessment tool is that it includes other identifiable risk factors (e.g., medical conditions, both acute and chronic, polypharmacy, and age) that generates individual risk profiles. This person-centered approach is very important in preventive care as it better prepares patients and clinicians for more appropriate decision-making.[10,11] Risk profiles provide the documentation connecting the relationship between risk factors and planned fall prevention strategies. Such a comprehensive approach has additional benefits since many of the elements important to fall prevention are also crucial in the prevention of other medical issues such as head trauma, hip fracture, and fear-of-falling. In observational studies, several drugs have been associated with an increased fall risk including neuroleptics, antidepressants, sedatives, diuretics, type ia anti-arrhythmics, and digoxin.[12] consequently, improving a patient's drug regimen is one of the most effective means of reducing fall risk, especially in the frail elderly; however, very few researchers have examined specific medications and we are the only researchers who have explored specific medications at the dosage level.[7-8] In addition to frailty and the presence of co-morbid, acute and chronic conditions among elderly patients, a key contributor to falling includes consumption of prescription medications, especially those used in combination to treat multiple ailments. Research has shown that antipsychotics, antidepressants, and benzodiazepines are consistently associated with a higher risk of falls. a unique feature of our assessment tool is that it is the only fall risk assessment tool that takes into account fall risk based on specific drugs and drug dosages. This allows clinicians to screen for individual fall risk and identify the risk of falling at the dosage level, with suggestions for appropriate interventions. There is a dose-response for falling among individuals taking doxepin. If the individual using this medication is also an african american female, with high blood pressure and heart disease, who is taking four other medications, the likelihood of falling over the next two weeks is highly probable.[12-13] Our ccdss would flag this individual for an immediate intervention and present solutions for fall prevention—such as reducing the doxepin dose.

RESULTS

Using a machine-learning approach, we created, patented, and tested an algorithm that accurately predicts elderly falling. A copy of the algorithm is found in Figure 1. This algorithm allows clinicians to screen for an individual's fall risk, with suggestions for appropriate interventions. We employed our algorithm in a fall prevention program (SAFE: Steps Adequate for Falls Among Elders), our research found:

1. The program significantly reduced the frequency of falls by 59%.
2. The program significantly reduced the frequency of injurious falls by 54%.
3. The program significantly reduced the number of prescription drugs consumed by 7%.
4. The program significantly reduced the amount of money spent on prescription drugs by 6%.
5. We reduced injurious falls and saved health care providers $2.40 for every $1.00 invested.

While these algorithms are not intended to replace the independent medical or professional judgment of physicians or other health care providers, when implemented effectively, clinical algorithms may improve quality and decrease costs by guiding clinicians toward more standardized, high-quality, cost-effective clinical strategies.

CONCLUSION

Building on our success with our fall interventions, we have augmented and patented a more robust model which includes biosensors—Figure 2. Through this we intend identity homogeneous clusters of elderly with similar patterns of falling and measure the temporal relationship between these clusters and injurious falling. We will enumerate individual risk profiles and calculate the appropriate diagnostic measures as required by the Standards for Reporting Diagnostic accuracy studies (STARD) initiative.

Predictive algorithms such as ours offer significant advantages for clinicians because the program can correctly register the simultaneous importance of a dozen or more risk factors including medical conditions, demographics, and prescription drugs. The algorithms take the guesswork out of a clinician's decision making, removes the possibility of clinician bias, and ensures that all the risk factors are considered. The growing popularity of clinical guidelines suggests that consistent application of evidence-based medicine is a desirable feature of contemporary medicine. We believe that enhancing the robustness of our machine-learning algorithm and developing a CCDSS for clinical

practice implementation will provide a necessary tool that will not only reduce injurious falls, provide effective and consistent management but also reduce healthcare costs. As we have demonstrated in our research, fall prevention leads to economic savings, better health, and better quality of life.

REFERENCES

1. Cummings RG. Epidemiology of medication-related falls and fractures in the elderly. *Drugs and Aging* 1998; 12(1): 43-53.
2. Kannus Lord SR, Sherrington C, Menz H. Falls in older people: risk factors and strategies for prevention. Cambridge: Cambridge University Press, 2001.
3. Weir E, Culmer L. Fall prevention in the elderly population. *CMAJ.* 2004; 171: 724.
4. Auais M, French S, Alvarado B, Pirkle C, Belanger E, Guralnik J. Fear of Falling Predicts Incidence of Functional Disability 2 Years Later: A Perspective From an International Cohort Study. *The Journals of Gerontology. 2017: Series*
5. G. Bergen, M.R. Stevens, E.R. BurnsFalls and fall injuries among adults aged ≥65 years—United States. *MMWR Morb Mortal Wkly Rep*. 2016;65:993-998
6. J.M. Ortman, V.A. Velkoff, H. Hogan. An aging nation: the older population in the United States: *United States Census Bureau, Economics and Statistics AdministrationUS Department of Commerce*. 2014
7. Lofman O, Berglund K, Larsson L, Toss G. Changes in hip fracture epidemiology: redistribution between ages, genders and fracture types. *Osteoporos Int 2002;13(1):18-25.*
8. Stevens JA, Corso PS, Finkelstein EA, Miller TR. The costs of fatal and non-fatal falls among older adults. *Injury Prevention*. 2006;12(5):290-295. doi:10.1136/ip.2005.011015.
9. Hardigan, P., Schwartz, D. and Hardigan, W. (2013). Using latent class analysis to model prescription medications in the measurement of falling among a community elderly population. *BMC Medical Informatics and Decision Making*, 13(1).
10. Schwartz, D. and Hardigan, P. (2018). Achieving a 54% Reduction in Geriatric Fall-Caused Hospitalizations and a 65% Reduction in Fall-Caused Injuries
11. Stevens JA, Corso PS, Finkelstein EA, Miller TR. The costs of fatal and non-fatal falls among older adults. *Injury Prevention*. 2006;12(5):290-295. doi:10.1136/ip.2005.011015.
12. Bor A, Matuz M, Csatordai M, Szalai G, Bálint A, Benkő R, Soós G, Doró P. Medication use and risk of falls among nursing home residents: a retrospective cohort study. I*nt J Clin Pharm*. 2017:39(2);408-415.
13. Requiring Long-Term Care: A Multifactorial Program Conducted Among 6600 Community Resident Elders in Florida. American Journal of Public Health Research;2016:4(2);75-78.

Figure 1. Augmented patented fall model