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# Examining Contextual Influences on Fall-Related Injuries Among Older Adults for Population Health Management

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## Abstract

The objectives were to assess the associations between fall-related injuries (FRIs) treated in the emergency department (ED) among older adults in California and contextual county-level physical, social, and economic characteristics, and to assess how county-level economic conditions are associated with FRIs when controlling for other county-level factors. Data from 2008 California ED discharge, Medicare Impact File, and County Health Rankings were used. Random effects logistic regression models estimated contextual associations between county-level factors representing economic conditions, the built environment, community safety, access to care, and obesity with patient-level FRI treatment among 1,712,409 older adults, controlling for patient-level and hospital-level characteristics. Patient-level predictors of FRI treatment were consistent with previous studies not accounting for contextual associations. Larger and rural hospitals had higher odds of FRI treatment, while teaching and safety net hospitals had lower odds. Better county economic conditions were associated with greater odds (ß = 0.73, $P = 0.001$) and higher county-level obesity were associated with lower odds (ß = −0.37, $P = 0.004$), but safer built environments (ß = −0.31, $P = 0.38$) were not associated with FRI treatment. The magnitude of association between county-level economic conditions and FRI treatment attenuated with the inclusion of county-level obesity rates. FRI treatment was most strongly and consistently related to more favorable county economic conditions, suggesting differences in treatment or preferences for treatment for FRIs among older individuals in communities of varying resource levels. Using population health data on FRIs, policy makers may be able to remove barriers unique to local contexts when implementing falls prevention educational programs and built environment modifications. (*Population Health Management* 2015;18:437–448)

## Introduction

Falls and fall-related injuries (FRIs), which are associated with chronic health conditions, disability, and exercise, are a pressing public health issue. One third of US older adults experience an accidental fall annually,[1] with 20%–30% of fallers experiencing an FRI.[2,3] Nearly two thirds of those hospitalized for an FRI are later admitted to a long-term care facility[4] and FRI-related hospital and emergency department (ED) costs are projected to reach $43 billion in 2020.[2]

However, effective translation of falls prevention programs to entire communities remains a challenge. Addressing population-wide falls and FRIs requires an understanding of the ''context, availability of resources and ownership of resource allocation, capacity of the community, and integration into established structures.''[5] A number of organizations have embraced this idea. In California, the Fall Prevention Center of Excellence, a consortium of university research centers and organizations from local, state, and federal levels, functions as a falls information and research warehouse and communications center and aims to influence public health policy and improve local capacity for falls prevention efforts.[6] A population-based approach to addressing falls in Canada has involved uncovering the social and policy contexts influencing resource allocation and fall-related treatment and prevention costs, and taking action on regulations requiring fall prevention plans, increasing awareness among policy makers and health care providers, and improving surveillance methods with standardized reporting, testing, and promoting best

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practices for falls prevention.[7] Still others have been concerned with identifying appropriate and effective ways to do population-wide falls and FRI surveillance.[8–10]

Although individual-level interventions have addressed older adult individual fall risk factors, a population health management approach to falls reduction requires an understanding of the ''ecology'' of older adults and their community environments and resources. For instance, the World Health Organization's Innovative Care for Chronic Disease framework[11] and several other interventions can be used to address FRIs at the community level.[12] Six community-based falls prevention interventions involved community walking or other exercise, promotion of physical activity and safety initiatives, environmental modification and home hazard reduction, improved public lighting and conditions of roads and walkways, and engagement with local media and service agencies.[13–16] A systematic review of studies of these interventions showed that, comparing intervention to nonintervention communities, interventions resulted in decreased fall-related hospitalizations, fall-related fractures, and FRI reductions of 6%–75%.[12]

Despite this push toward a population health approach to reducing fall risk, there is a dearth of information about how community-level factors may impact falls among older adults. This study attempts to further understand FRIs in terms of a population health management challenge by identifying potentially modifiable area-level factors associated with these costly and prevalent health events. To enable this research and to conceptually understand potential linkages between county-level risk predictors and individual FRIs, this study adapted Wen's model of ''the relationship between neighborhood economic context and self-rated health and the mediating effects of physical environment, health-enhancing services, and social environment''[17] to develop a model of population health management of falls and FRIs among older adults. The model shows that an area's physical, social, and institutional environments can be associated with individuals' health practices and outcomes.[18–21] The economic structure of an area affects each of these environments. Greater levels of financial resources—or, potentially, the degree of income inequality—in an area can determine an area's environmental conditions.

Three factors mediate the relationship between economic factors and falls and FRIs. First, environmental mechanisms can result in exposure to violence or poor physical conditions of the built environment—public walkways, streets, lighting, and other residential and commercial infrastructure, or the types of food outlets. An area's environmental characteristics have implications for FRIs: physical activity among older adults has been linked to the built environment,[22] with access to physical-activity resources and more accessible neighborhood designs associated with more walking activity.[23] Also, functional limitations have been linked to an area's excessive noise, inadequate lighting, and heavy traffic,[24] while residency in dilapidated environments is associated with decreases in activities of daily living (ADLs).[18] ADL limitations are associated with a decreased likelihood of older adults leaving home and going into town,[25] while individuals with, compared to those without, impaired ADLs have twice the risk of a fall.[26] Balance and gait limitations, which may increase with less activity, are also fall risk predictors.[27] Also, the size and geography of a city has been associated with older adults' fear of falling.[28]

Second, the social environment can influence health and behaviors. This can occur through a community's shared norms and health information, and by helping communities obtain social services.[29] More walkable neighborhoods have been associated with greater social capital, such as individuals knowing their neighbors, trust of neighbors, and other measures of participation in community living[30] and sense of community,[31] suggesting that safer community environments may encourage healthier behaviors. Also, living in areas with lower levels of trust[32] or social capital[33] is associated with increased odds of fair or poor health. At the same time, social isolation, frustration, and fatalism can result in fear of falling and physical activity level reduction,[34–36] which potentially inhibit participation in falls prevention interventions.[37] Thus, the social environment should result in better health and health behaviors, reducing the risk of FRIs. On the other hand, because of greater knowledge of health and the health care system, individuals in a community with strong social capital may be more likely to seek treatment for FRIs; physically active individuals also may have greater opportunity to experience FRIs.[5]

Third, the institutional environment can influence health and falls/FRI risk. Institutional mechanisms are the resources and organizations (schools, medical facilities, and religious institutions) within a community.[21] Areas with fewer resources may contribute to poorer health status for individuals, which in turn can create increased risks for FRIs. For instance, racial/ethnic minorities tend to use health care institutions with substandard processes of care,[38–40] and ''minority-serving'' hospitals[40] are often located in communities with limited numbers of primary care and home health providers and rehabilitation facilities.[41,42] The poorer access to and quality of care for individuals in such communities may have consequences for health and functioning, contributing to FRI risk. Conversely, areas with more and better health care services and supports may have more physically active residents who have more opportunities for FRIs compared to less active individuals. Also, a greater number of institutional resources or the type of health care institutions may reflect or contribute to greater odds of FRIs being treated and/or coded. That is, certain hospitals may have suboptimal coding of patient injuries or lack the administrative availability in their patient databases to accurately code injury-related data.[43]

Of note, older adults are particularly affected by the services and characteristics of their local environment. US adults prefer to ''age in place,'' or live in noninstitutional settings, as they age.[44] Accordingly, compared to younger adults, they are more likely to have lived longer in any given area, are less mobile and thus dependent on local shopping, transportation, and health care options, and have more time for discretionary activities. Although they may develop strong social ties by remaining in an area over time, they also may experience social isolation or safety concerns[45] related to their reduced mobility, frailty, and reliance on transportation from others. Accordingly, the ''environmental ecology,'' or characteristics of the environment in which older adults spend time, influences health and health behaviors as well as interactions with the health care system, with implications for important health outcomes such as FRIs. Thus, a better understanding of environmental risk factors may improve FRI prevention among older adults.

Building on prior studies that have examined contextual area-level associations with individuals' physical and emotional health status, this study aimed to understand (1) whether county-level contextual factors, above and beyond individual-level risk factors, are associated with changes in ED FRIs (ie, whether or not a respondent was treated in the ED for an FRI) and, if so, (2) the extent to which county-level ''economic conditions'' (measured using percentage of children in poverty and income inequality) are associated with the odds of individual FRIs after controlling for several additional county-level factors—the ''built environment'' (presence of healthy food outlets and liquor store outlets), ''community safety'' (crime rates), ''access to medical care'' in a county (non-elderly uninsured rate and primary care provider rate), and obesity levels. It was hypothesized that, controlling for individual patient and hospital characteristics, higher scores on county-level economic conditions would be associated with reduced individual FRI odds, as better economic conditions should result in safer built environments and social norms affecting health-related practices and knowledge related to FRIs.[23,46–48] (Thus, the magnitude of association between county-level economic conditions and individual FRIs should decrease when other contextual predictors are included in the model.) It was alternatively hypothesized that better economic conditions would be associated with greater FRI odds, because (*a*) greater area resources can mean greater investment in health care infrastructure, which translates to a greater likelihood that area residents will seek and receive care and be coded for an FRI, and (*b*) more physically healthy and active residents may have greater opportunities for having FRIs.

### *Fall and FRI risks and county factors associated with health risks*

Studies have previously documented relationships between falls and a number of individual characteristics of older adults. Risk factors for falls and FRIs include a number of chronic illnesses,[49] physical disability,[49] sensory, cognitive, neurologic, and musculoskeletal functioning,[50] vision, feet,[50] balance and gait problems,[27] and muscle strength.[51] In particular, individuals' health practices can affect fall risk. Lack of physical activity[52] and use of certain medications[53] may exacerbate existing sensorimotor problems and heighten fall risk. Non-injurious falls and FRIs share many of the same risk factors,[49] though individuals experiencing FRIs may be at comparatively greater risk for loss of functional independence and even death. Provider fall assessments can identify and intervene with individuals at risk for falls (ie, those with gait and balance, neurological, or functional limitations; those with medication use issues). Thus, provider presence is an additional predictor of fall risk for older individuals.

At the same time, health status and behaviors as well as economic and institutional resources for addressing conditions associated with falls vary considerably across California. According to the County Health Rankings,[54,55] age-adjusted percentages of adults reporting fair or poor health in counties range from 6% to 32%, while the percentages reporting no leisure time physical activity range from 12% to 25%. Just one third of adult residents in 2 counties have access to exercise opportunities (parks, gyms, community centers), while 90% or more in 16 other counties have such access. Meanwhile, county ratios of non-primary care providers (nurse practitioners, physician assistants, and clinical nurse specialists) to population ranges from 4,664:1 to 772:1, while county median household income ranges from $35,000 to $92,000.[55] These characteristics suggest that FRI risk may be divergent across California counties.

These county-level differences are noteworthy because an area's physical, social, and institutional characteristics are linked to the functioning of area residents.[18,19] Older individuals living in areas with better access to physical-activity resources have greater physical activity levels.[22,23] Lower-extremity functioning loss has been associated with neighborhoods' excessive noise, inadequate lighting, and heavy traffic,[24] and living in dilapidated living environments is associated with modest decreases in ADLs.[18] Studies also have found associations between muscle strength,[56] mobility difficulties,[57] disability,[58] physical functioning,[59] and hip fracture-related mortality[60] with area socioeconomic factors.

In terms of the specific importance of an area's economic conditions to individuals' health, Robert[61] found that areas of lower socioeconomic status (eg, percentage of families earning $\geq$$30,000, an area's unemployment percentage) had fewer social services, senior centers, and mental health services, and residency in those areas was associated with individuals' numbers of chronic conditions. Local economic deprivation has been associated with mobility and gait difficulties.[57] Additionally, a longitudinal study of middle-aged inner-city adults found that persons living in poorer areas had greater odds of having 2 or more lower body functional limitations at the study's follow-up.[62]

Accordingly, county-level contextual factors—economic conditions, the built environment, community safety, access to care, and obesity—are also likely associated with older adult FRI risks, even after controlling for individual-level risk factors.

## Methods

### *Data*

This study uses administrative data from the 2008 California Office of Statewide Health Planning (OSHPD) emergency departments (ED) and hospital discharge files to assess FRIs among older adults across California's 58 counties. The California OSHPD releases public data twice per year for ED and ambulatory surgery facility encounters in California and includes demographic, clinical, payer, and facility information. In addition to records for patients who were discharged home and who died in the hospital, the hospital discharge file contains ED records for patients treated and then transferred within the same hospital. County-level contextual data were obtained from the County Health Rankings Web site and matched to the ED and hospital discharge data by county of residence of the hospital patient (or, if such data were missing, the county of the hospital was used). To obtain hospital-level information, data from the 2008 Medicare Impact File were linked to the OSHPD data by Medicare hospital provider number.

### *Study sample*

This study included individuals 65 years of age and older who were treated at the ED (whether or not individuals were

admitted to the hospital following an ED visit). There were 1,712,409 total ED records from 2008 with individual, hospital, and area-level data in the analytic sample. There were 247,711 FRIs in the sample (14.5% of the total ED records).

### Measures

The outcome variable was whether or not an individual had an FRI. FRIs were identified using *International Classification of Diseases, Ninth Revision* (ICD-9) external cause of injury codes (e-codes) 880, 881, 884, 885, and 888, which represent accidental fall injuries, and by also using ICD-9 codes 800–848 (fractures, dislocations, and sprains), 850–854 (intracranial injuries), and 900–924 (contusions with skin surfaces), which are diagnoses commonly associated with FRIs[63] (eg, 90% of hip fractures are associated with falls). This method has been used previously.[63] This method potentially overestimates the number of FRIs by including injuries not related to falls, but the method has been defended as producing valid estimates.[64,65] Alternatively, FRIs were identified using only e-codes. This method likely has fewer false positives than the first method, but also may fail to identify a number of FRIs given the well-known issues with the use of e-codes.[8,9] With this method, there were 186,749 FRIs in the analytic sample (10.9%).

Three sets of independent variables were used: individual-level, hospital-level, and area-level characteristics. At the individual level, sex, age ($\geq 65$), race/ethnicity, and a Charlson comorbidity index score developed from the patient administrative claims data were used.[66] Several hospital-level characteristics were examined: whether the hospital was a ''safety net'' hospital (if the Disproportionate Share Hospital patient percentage in the Impact File was $>30\%$); hospital size, geographic location, and teaching status, based on the resident-to-bed ratio (0 = nonteaching, $>0$ to $<0.25$ = minor teaching, and 0.25 = major teaching); and the hospital occupancy rate, as each of these factors might affect admission and/or coding practices with respect to FRIs.

To measure county-level contextual factors that could affect individual FRIs, this study used the County Health Rankings' county-level standardized scores for economic conditions, the built environment, community safety, access to care, and obesity. (Table 1 describes the measures and the provenance of the measure data.) Economic conditions are measured as a county's percentage of children in poverty and the Gini coefficient of income inequality.[17] Aggregate socioeconomic factors, interpreted as indicating problems in an area or lack of access to resources,[23] have frequently been used in neighborhood effects research to assess health status,[67] with such factors often predicting worse individual-level health or physical functioning. Socioeconomic status has been interpreted variously—area unemployment percentage and proportion of below-poverty level residents have been interpreted as proxy measures for crime, stress, and inadequate housing resources.[23,68,69] Area-level income inequality has been identified as a predictor of individual morbidity and mortality and has been interpreted as leading to poor health outcomes because of an area's underinvestment in institutional resources or disruption of social capital.[29,32]

The built environment is measured as the percentage of zip codes in the county with healthy food outlets and liquor store density. Communities with more healthy food options and lower liquor store density can affect activity levels, perhaps because they also have invested in community parks and recreation, among other factors. For instance, the presence of fast-food outlets has been associated with poorer physical activity levels among middle-aged and older adults.[70] Community safety is measured as the violent crime rate per 100,000 population. Safe communities are likely to encourage physical activity and exercise that reduce FRI risk.

Access to medical care is measured as the percentage of the younger adult population without health insurance and the primary care provider rate per 100,000 population. A

Table 1. Description of Contextual County-Level Measures of Economic Conditions, Built Environment, Community Safety, Access to Medical Care, and Obesity Rates

| | | |
|---|---|---|
| Economic conditions | Percentage of children in poverty (75%) | 2007 US Census and the Current Population Survey's Small Area Income and Poverty Estimates |
| | The Gini coefficient of income inequality[19] (25%) | Computed from the Decennial Census |
| Built environment | Percentage of zip codes in the county with healthy food outlets (50%) | 2006 Census Zip Code Business Patterns |
| | Liquor store density (50%) | Census County Business Patterns and Census 2006 Population Estimates |
| Community safety | Violent crime rate per 100,000 population | Uniform Crime Reporting, Federal Bureau of Investigation |
| Access to medical care | Non-elderly ($<65$) population without health insurance (50%) | Census/Current Population Survey—Small Area Health Insurance Estimates |
| | (Primary care provider rate per 100,000 population (50%) | Health Resources and Services Administration, Area Resource File (ARF) |
| Obesity rates | Percentage of adults reporting obesity (BMI of $\geq 30$) | Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Diabetes Translation |

*Source:* The Robert Wood Johnson Foundation's County Health Rankings, http://www.countyhealthrankings.org/.

*Note:* The percentages in parentheses are the relative weights given to individual measures when creating a composite measure. For instance, the economic conditions measure is a composite of the standardized scores for (*a*) the percentage of children in poverty and (*b*) the Gini coefficient of income inequality. The economic conditions standardized score is calculated by as follows: $0.75a + 0.25b$.

prior study has posited that higher levels of insurance among the non-elderly population could affect health care access among the elderly.[71] Uninsurance among the non-elderly population may have ''spillover effects'' into insured populations such as the elderly, resulting in poorer access to and quality of care and lower patient satisfaction with medical care.[72] Communities with better access to care may impact health status but also result in more treatment opportunities for persons with FRIs. Obesity is measured as the percentage of adults reporting a body mass index $\geq 30$. This variable could represent social resources that affect norms such as exercise and other health behaviors and may mediate the pathway between county-level economic conditions and ED visits for FRIs. Counties with lower proportions of obese individuals may have developed social norms regarding health-related behaviors like walking and other exercise that reduce FRI risks.

Because of concern that multiple county-level contextual factors would be collinear in regression analyses, a set of diagnostics was conducted. The highest correlation was 0.56 (a medium-size correlation) between economic conditions and community safety. All other correlations were between 0.10 and 0.38 and thus were not likely to influence standard errors because of multicollinearity in model estimations.

### *Analytic approach*

This study compared patients admitted to an ED in 2008 with and without an FRI by the study set of individual, hospital, and county-level predictors using *t* tests for continuous variables and chi-square tests for categorical variables. A set of multilevel logistic (random intercept with binary outcome) models was estimated to assess the log odds of FRIs associated with the predictor variables. For simplicity, ''FRI odds'' are referred to as the study outcome.

First, a regression model was estimated using only individual-level predictors (Model 1). Then, the block of hospital-level fixed effects was added (Model 2) and, subsequently, in separate steps, county-level economic conditions (Model 3), community safety and the built environment (Model 4), and then obesity and access to care (Model 5) were added. In this way, the study assessed the separate contributions of the individual, hospital, and various county-level predictors to explaining the odds of an FRI. Models 4 and 5 are expected to produce reduced magnitudes of association between FRIs and economic conditions; Model 5 is expected to produce reduced magnitude of associations between FRIs and each of economic conditions, community safety, and the built environment given that obesity reflects physical activity levels predicted by those 3 risk predictors. In sensitivity analyses, the 3 contextual county-level variables in Model 4 were further explored by assessing the association of quartiles of county-level economic conditions, community safety, and the built environment with individual ED-treated FRIs. Results from these models were very similar to the results from the main models and so only the main results are shown below. Finally, a random coefficient (as opposed to a random intercept model) was estimated to assess variations in the association of area-level economic conditions with individual ED FRI treatment odds. The model showed only limited variation across counties in terms of the association of county-level economic conditions with FRIs and other predictor coefficients were similar—thus, the results of this model are not presented in this article.

## Results

### *Unadjusted results*

Table 2 summarizes information regarding individual and hospital characteristics for 2008 ED observations for older adults. Approximately 15% of observations involved FRIs, which is slightly higher than nationally observed FRI rates in the community-dwelling, older adult population, but unsurprising given that FRIs are the number 1 cause of annual ED visits among older adults.[73] A greater proportion of women compared to men experienced FRIs (falls) and the average age of those experiencing falls (fallers) was slightly higher than those not experiencing falls (non-fallers) treated in the ED. Compared to non-fallers, greater proportions of fallers were white, but a lower proportion were Hispanic, Asian, and black, which is consistent to an extent with prior findings for community-dwelling older adults.[49] Fallers also had lower comorbidity scores than non-fallers. In terms of hospital characteristics, there were no notable differences in the proportions of fallers or non-fallers treated in hospitals of varying size and small differences relating to hospitals' geographic location, teaching status, and safety net designation.

### *Adjusted results*

Results from the 5 random effects logistic models are shown in Table 3. Individual and hospital covariates were all generally associated with individual FRI treatment. Additionally, after controlling for individual and hospital fixed effects and county random effects, several county-level predictors, including economic conditions, were associated with individual FRI treatment. Model 1 estimated the odds of the patient-level regressors on ED-treated FRIs within counties, controlling for patient-level covariates and the random effects by counties. Coefficients from the models represent log odds of an ED FRI. Hispanics, Asians, and blacks each had lower log odds of an ED-treated FRI compared to whites, while women and older ED patients had greater log odds of FRI-related treatment. There was limited inter-county variation in the log odds of an FRI, indicating that the determinants of fall risks were similar across counties.

In Model 2, hospital fixed effects were included. In this model that adjusted for individual-level fixed effects and county random effects, larger hospitals had greater log odds of FRIs, while treatment in large urban compared to rural hospitals was associated with lower log odds of FRIs. All else equal, compared to nonteaching hospitals, treatment in each of minor and major teaching hospitals was associated with reduced log odds of an FRI. Safety net hospital treatment was associated with lower log odds of an FRI (Table 3).

Model 3 added a county-level economic conditions fixed effect to the model. The magnitudes and significance of individual-level and hospital fixed effects remained the same as in prior models, while (as suggested in the alternative hypothesis) a 1 standard deviation increase in county-level economic conditions was associated with a substantial

Table 2. Descriptive Statistics Describing Socioeconomic and Provider Characteristics of California Counties, 2008

| | *Total* | *FRI* | *Non-FRI* |
|---|---|---|---|
| | *Mean (SD) / Percent (%)* | | |
| Female (%)* | 52.3 | 57.0 | 51.5 |
| Age (continuous, ≥65)* | 78.0 (8.3) | 79.6 (8.5) | 77.8 (8.2) |
| Race/Ethnicity (%)* | | | |
| Hispanic | 16.7 | 13.7 | 17.2 |
| Asian | 7.5 | 6.0 | 7.7 |
| Black | 7.1 | 4.2 | 7.6 |
| American Indian/Alaska Native | 0.2 | 0.2 | 0.2 |
| White | 62.7 | 69.6 | 61.6 |
| Charlson Comorbidity Index score* | 1.47 (2.19) | 0.89 (1.68) | 1.57 (2.25) |
| Hospital Size (%)* | | | |
| <200 beds | 38.7 | 39.4 | 38.6 |
| 200–399 beds | 50.7 | 50.6 | 50.8 |
| ≥400 beds | 10.5 | 10.0 | 10.6 |
| Geographic area (%)* | | | |
| Rural | 2.4 | 2.7 | 2.4 |
| Outer urban | 21.8 | 22.4 | 21.7 |
| Large urban | 75.8 | 75.0 | 76.0 |
| Teaching status (%)* | | | |
| Nonteaching | 63.6 | 65.7 | 63.2 |
| Minor teaching | 29.6 | 28.1 | 29.8 |
| Major teaching | 6.8 | 6.1 | 7.0 |
| Safety net hospital (%)* | 46.3 | 43.7 | 46.8 |

*$P<0.05$

*Note*: Data are from 2008 California Office of Statewide Health Planning Emergency Department discharge files. Descriptive statistics are from 1,712,409 ED discharges in the analytic sample.

FRI, fall-related injury; SD, standard deviation

increase in the log odds (ß = 0.73, $P<0.001$, or the equivalent of an odds ratio [OR] of 2.08) of an FRI (Table 3).

It was thought that the inclusion of additional county-level variables would reduce the magnitude or possibly eliminate the significance of county-level economic conditions-FRI association because a county's economic conditions could influence the built environment, community safety, access to care, and average obesity rates. However, the addition of the first 2 variables did not notably change while inclusion of the latter 2 variables only slightly decreased the magnitude of the positive association between county-level economic conditions and individual FRIs. Specifically, the inclusion of community safety and the built environment fixed effects into Model 4 resulted in similar log odds of an FRI associated with economic conditions (OR of 2.32) and a nonsignificant association between the built environment (OR of 1.72) and FRIs. Finally, in Model 5, the introduction of 2 additional county-level fixed effects (obesity and access to care) resulted in a reduced association between economic conditions and FRIs (OR of 1.86) and a significant association between obesity and FRIs (OR of 0.69), but no further significant associations between the other county-level fixed effects and FRIs after accounting for county random effects. Thus, the inclusion of the additional county-level fixed effects in Model 5 resulted in a slight decrease in the magnitude of the association of economic conditions with FRIs (ß = −0.73 to −0.62). Economic conditions thus distinctly explain variance in FRIs beyond what is explained by other county-level factors (Table 3).

### *Analysis using alternative method to identify FRIs*

In the previous section, FRIs were identified using e-codes and ICD-9. When identifying FRIs using e-codes only, results were similar but with several notable exceptions: (1) In Models 3 and 4, the associations between county-level economic conditions and FRIs was of greater magnitude (ß = 1.03 and ß = 1.09 in the models using e-codes vs. ß = 0.73 and ß = 0.84 in the main models) and (2) In Model 5, after inclusion of county-level obesity and access to care, county-level economic conditions were not significantly associated with FRIs.

## Discussion

Study findings indicate that, beyond individual health-related risk factors, individual FRIs are associated with measures representing county-level institutional, built environment, and social environmental factors, with county-level economic conditions having strong and consistent association with FRIs. The findings suggest that the better economic conditions of a county, the greater the odds of an FRI among older adults treated in that county's EDs. This association is persistent even after accounting for community safety, the built environment, obesity levels, and access to care. However, the interpretation of this study's findings regarding economic conditions is less straightforward compared to that of earlier studies examining the impact of place ''effects'' on health status. Unlike outcomes examined in earlier studies, such as physical functioning or mortality,

Table 3. Association of Individual, Hospital, and County Characteristics with Fall-related Injuries in Older Adults, 2008

| *Variables* | *Model 1* | *Model 2* | *Model 3* | *Model 4* | *Model 5* |
|---|---|---|---|---|---|
| Individual | | | | | |
| Race/ethnicity (ref: White) | | | | | |
| Hispanic | −0.28 (0.01)*** | −0.28 (0.01)*** | −0.28 (0.01)*** | −0.28 (0.01)*** | −0.28 (0.01)*** |
| Asian | −0.32 (0.01)*** | −0.32 (0.01)*** | −0.32 (0.01)*** | −0.32 (0.01)*** | −0.32 (0.01)*** |
| Black | −0.58 (0.01)*** | −0.57 (0.01)*** | −0.57 (0.01)*** | −0.57 (0.01)*** | −0.57 (0.01)*** |
| American Indian/ Alaska Native | 0.09 (0.05) | 0.09 (0.05)*MS* | 0.09 (0.05)*MS* | 0.09 (0.05)*MS* | 0.09 (0.05)*MS* |
| Female | 0.20 (0.00)*** | 0.20 (0.00)*** | 0.20 (0.00)*** | 0.20 (0.00)*** | 0.20 (0.00)*** |
| Age | 0.03 (0.00)*** | 0.03 (0.00)*** | 0.03 (0.00)*** | 0.03 (0.00)*** | 0.03 (0.00)*** |
| Charlson Index | −0.20 (0.00)*** | −0.20 (0.00)*** | −0.20 (0.00)*** | −0.20 (0.00)*** | −0.20 (0.00)*** |
| Hospital | | | | | |
| Hospital beds (ref: <200) | | | | | |
| 200–399 | | 0.02 (0.01)** | 0.02 (0.01)*** | 0.02 (0.01)** | 0.02 (0.01)** |
| ≥400 | | 0.03 (0.01)** | 0.03 (0.01)** | 0.03 (0.01)** | 0.03 (0.01)** |
| Location (ref: rural) | | | | | |
| Outer urban | | −0.01 (0.03) | −0.02 (0.03) | −0.02 (0.03) | −0.02 (0.03) |
| Large urban | | −0.08 (0.03)** | −0.10 (0.03)*** | −0.11 (0.03)*** | −0.11 (0.03)*** |
| Teaching status (ref: nonteaching) | | | | | |
| Minor | | −0.05 (0.01)*** | −0.05 (0.01)*** | −0.05 (0.01)*** | −0.05 (0.01)*** |
| Major | | −0.08 (0.01)*** | −0.08 (0.01)*** | −0.08 (0.01)*** | −0.08 (0.01)*** |
| Safety net | | −0.01 (0.00)*MS* | −0.01 (0.00)*MS* | −0.01 (0.00)*MS* | −0.01 (0.00)*MS* |
| Area | | | | | |
| Economic conditions | | | 0.73 (0.16)*** | 0.84 (0.17)*** | 0.62 (0.19)** |
| Community safety | | | | −0.30 (0.26) | −0.39 (0.25) |
| Built environment | | | | −0.54 (0.37) | −0.31 (0.35) |
| Obesity | | | | | −0.37 (0.13)** |
| Access to care | | | | | −0.08 (0.16) |
| Intercept | −3.75 (0.02)*** | −3.71 (0.03)*** | −3.94 (0.03)*** | −3.70 (0.03)*** | −3.84 (0.03)*** |
| Random Variance Component | | | | | |
| Intercept | 0.01 (0.00) | 0.01 (0.00) | 0.01 (0.00) | 0.01 (0.00) | 0.01 (0.00) |

*$P \le 0.05$ **$P < 0.01$ ***$P < 0.001$ *MS* = marginally significant ($P < 0.10$).

*Note*: Sample size for models is 1,712,409. Coefficients and standard deviations represent log odds. Data are from 2008 California Office of Statewide Health Planning Emergency Department discharge files.

FRIs may be reflective of *both* poorer health and better health (ie, greater amounts of FRI-prone physical activity among healthier individuals). For instance, a county that attracts and/or encourages older adults who engage in frequent exercise and outings may have high FRI rates and individuals with high FRI risks. Moreover, because FRIs were measured using hospital discharge data, FRIs may reflect the availability of treatment and/or hospital coding practices. Accordingly, counties with greater economic resources may encourage health behaviors and health care practices that counterintuitively increase the odds of FRIs observed in ED settings.

As with other studies of ''neighborhood effects,'' the direction of the association is uncertain. It may be that certain counties affect individuals' FRI risk by offering different levels and quality of services and supports, institutional care, built and social environments, or because certain counties attract individuals with poorer health and health practices. It is known that individuals with broadly similar characteristics (eg, age, income, sex, race/ethnicity) can cluster geographically, influencing time spent in a defined area such as a neighborhood or city,[74] and their connections to an area's social networks, resources, and institutions.[75]

The specific mechanism, however, has important implications for population health management strategies, given that addressing such modifiable county-level conditions could reduce FRI risk among older adults. In California, Adult Day Health Care, Multipurpose Senior Services Program, and In-Home Supportive Services (IHSS) provide therapeutic, case management, health and social assessment, transportation, caregiving services, and nutrition programs that help older adults maintain their independence in the community.[76] Spending can vary by county in certain programs such as IHSS[77,78] and such spending may help older adults avoid institutionalization, potentially reducing the costs involved with caring for the older adult population. Thus, information about contextual county-wide FRI risks involving supportive services may be useful to localities interested in novel interventions to reduce FRI risk among the older adult population. Local health departments or other policy makers also can integrate information about the significance of contextual county-wide factors like the built environment[79] or community safety[80] for the older adult population's health behaviors and resultant injuries like FRIs when estimating the cost-effectiveness of expenditures on community improvement efforts. Additionally, variation in e-coding practices across hospitals can affect the quality

of FRI surveillance efforts, which in turn affects policy makers' ability to address community needs.

These results have implications for FRI surveillance efforts. First, current surveillance may underestimate risks of FRIs among large groups of older individuals in the state. Counties with poorer individuals may have lower odds of individual FRIs not because of differing medical need, but because of poorer access to care. The finding (from a sensitivity analysis—results not shown) that a greater supply of primary care providers is associated with greater adjusted FRI odds supports this interpretation.

Alternatively, normative practices among older individuals in counties with greater economic resources may differ from those of individuals in counties with fewer economic resources. In this study, higher contextual county-level obesity rates were associated with lower individual FRI odds; when obesity was added as a predictor to model 4, the magnitude of the association between economic resources and individual FRIs was reduced and in the sensitivity analysis using e-codes to define FRIs, the association was no longer significant. It could be that obese individuals are just as likely to fall as nonobese individuals, but are protected from injury by increased body mass.[81] At the same time, greater obesity levels may reflect norms regarding health behaviors that can contribute to FRI risk. If it is the case that county obesity rates (after adjustment for individual health characteristics) reflect social norms, then social norms appear to confound or mediate the relationship between institutional resources and FRIs.

These findings support the idea that communities promulgate different norms of health behaviors depending on levels of economic resources.[82–84] Activity avoidance decreases physical functioning and can result in social isolation[85,86] associated with FRI risk.[87,88] Other studies have used socioeconomic status to proxy for an area's social environment and norms.[48,68] The present study found that greater income may be associated with norms that encourage greater physical activity levels that increase FRIs. Although having physical limitations or chronic illness increases FRI risk, socially and physically active adults who leave a familiar environment, such as their house, may be at greatest risk for falls[89] related to ''precipitating factors,''[90] including slips, trips, or stumbles.[91] Conversely, inactive and obese individuals may have fewer opportunities for FRIs.

Another important finding was variation in individual FRI odds by hospital type. Older individuals treated in larger compared to smaller, and teaching compared to nonteaching hospitals had greater odds of being coded with an ED FRI, while those in urban compared to rural hospitals had lower odds. Currently, FRI surveillance is conducted using hospital and ED administrative data.[92] Section 97227 of the California Code of Regulations requires reporting of external causes of injury on ED and hospital discharge records as well as quality assurance activities aimed at monitoring the completeness of e-codes.[8] Yet, e-codes are often absent in claims data either because of lack of mandatory reporting, the design of state injury reporting systems, or institutional practices.[8,9] For instance, in a 2004 survey, the percentage of injury-related hospitalizations that were e-coded ranged from 51% to 89%.[8,43] Those results suggest that there may be significant variation in hospital coding practices, with important implications for how FRI surveillance data are interpreted and used for policy purposes. Taken together, the present study results underscore that FRIs may be affected by community characteristics and norms. Scaling up falls prevention programs to an entire population in which one third of older adults experiences a fall every year has proved difficult.

Assessing and addressing FRIs at the county or community level may require recognition that there are problems with current surveillance methods or differential access to or preferences for treatment among the state's older adult population—such that older individuals living in communities with fewer economic resources either have less recourse or are less likely to seek treatment for fall injuries. Moreover, coding practices in facilities in counties with worse economic conditions may vary from those in facilities in counties better economic conditions.

Addressing each of these issues requires different solutions. First, as part of a population health management approach to FRIs, it may be appropriate for policy makers to place greater emphasis on removing barriers associated with economic deprivation and social norms, such as an emphasis on physical activity and safe health practices to change the culture of awareness and engagement around falls and FRIs. This may be useful, as many older adults express lack of understanding about the causes of such events[93] or are unwilling to engage in prevention activities.[94] Older adults sometimes do not realize that FRIs can lead to rapid decline in health and functional independence, or even death.[95–100] If older individuals in communities with fewer economic resources are less disposed to seek treatment for FRIs, there is also less opportunity for providers to offer fall risk assessments and prevention assistance. It then becomes incrementally more difficult to prevent future FRIs and FRI-related morbidity and mortality when initial FRIs are not treated or observed by providers. Thus, greater attention to such factors may reduce the odds of FRIs among older individuals in communities with poorer economic conditions. Second, the counterintuitive nature of falls—whereby physically active individuals may have more opportunities for falls compared to less active individuals—is something worth considering when preparing population-level fall interventions. Current fall prevention interventions emphasize exercise[101]; it may be important to emphasize risks involved with physical activity both among those in fall intervention programs and others who are physically active in the community. Finally, further efforts are warranted to improve coding of FRIs and to acknowledge that current surveillance efforts may not fully capture the breadth of FRIs among older individuals.

### *Limitations*

These results should be considered in light of important limitations. First, the data used for this study are ED discharge data rather than survey data. Thus, there is only a record of FRIs (or lack of FRIs) among those treated in the ED. This can result in selection bias, because the comparison group of non-fallers is likely in poorer health than the general population. In this study, those without an FRI had higher Charlson comorbidity index scores compared to those with FRIs, potentially the reverse pattern of what

would be observed among community-dwelling older adults. Though Charlson comorbidity index scores were controlled for, unmeasured health characteristics could result in biased estimates. The effect of such bias on the results is uncertain, however.

Second, the generalizability of these results to the older adult population also might be limited given the use of ED claims data that contain information about a study population that may be in poorer health than the general older adult population. However, approximately half of older adults use the ED in any given year,[102] suggesting that the population in the present study may not be much sicker than the general older adult population.

Third, although this study controlled for several individual-level covariates, it was not able to control for individual-level income because these data were not available. Race/ethnicity, age, and sex may proxy for, but do not perfectly represent, income levels among individuals. Without accounting for individual-level income, this study's area-level economic conditions measures may not represent a compositional community-level association, but rather an individual association with FRIs. However, even if individual-level income data were available for use in the study, the interpretation of the study findings might not change; because community-level income is an average of incomes of individual residents of the community, community-level income might not explain variation in FRIs much differently than individual-level income.

Fourth, the measures used to operationalize the concepts of the physical, social, and institutional environments from the adapted conceptual model of Wen et al[17] are limited. It was not possible to observationally assess the built environments of each county or assess residents' perceptions of either the built or social environments (such as levels of social support). Instead, County Health Rankings data were leveraged; these are an amalgam of federal census and other data, which were useful indicators for this study.

Finally, most neighborhood effects models assess area-level characteristics at the zip code or census tract or block level. It was felt that using the county level was appropriate for one of the levels of analysis, as local policy makers may use the findings as they consider interventions to address FRI risks among their older adult populations.

## Conclusion

This study aimed to add to existing FRI surveillance efforts and population health management strategies by examining county-level risk factors associated with the odds of individual FRIs. The study found that certain potentially modifiable factors are associated with FRIs. Researchers and policy makers can use this FRI surveillance information to improve local FRI awareness. The authors interpret these results as suggesting that population-wide FRI prevention efforts will require broad communication efforts tailored to counties' unique older populations and community resources, and which emphasize changes to remove barriers associated with economic deprivation and social norms relating to awareness and engagement with FRIs. Future qualitative research should clarify the mechanisms by which economic conditions and social norms contribute to variation in FRIs among older adults in order to develop specific interventions to reduce the odds of such injuries, while promoting active living among older adults.

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