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Original Study

Effectiveness of Hip Protectors to Reduce Risk for Hip Fracture from Falls in Long-Term Care

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ABSTRACT

Objective: To generate evidence of the effectiveness of hip protectors to minimize risk of hip fracture at the time of falling among residents of long-term care (LTC) by contrasting rates of hip fractures between falls with and without hip protectors.
Design: A 12-month, retrospective cohort study. We retrospectively reviewed fall incident reports recorded during the 12 months prior to baseline in participating homes.
Setting and participants: A population-based sample comprising all residents from 14 LTC homes owned and operated by a single regional health authority, who experienced at least 1 recorded fall during the 12-month study.
Results: At baseline, the pooled mean (standard deviation) age of residents in participating homes was 82.7 (11.3) years and 68% were female. Hip protectors were worn in 2108 of 3520 (60%) recorded falls. Propensity to wear hip protectors was associated with male sex, cognitive impairment, wandering behavior, cardiac dysrhythmia, use of a cane or walker, use of anti-anxiety medication, and presence of urinary and bowel incontinence. The incidence of hip fracture was 0.33 per 100 falls in falls with hip protectors compared with 0.92 per 100 falls in falls without hip protectors, representing an unadjusted relative risk (RR) of hip fracture of 0.36 (95% confidence interval 0.14–0.90, $P = .029$) between protected and unprotected falls. After adjusting for propensity to wear hip protectors, the RR of hip fracture was 0.38 (95% confidence interval 0.14–0.99, $P = .048$) during protected vs unprotected falls.
Conclusions and implications: Hip protectors were worn in 60% of falls, and the risk of hip fracture was reduced by nearly 3-fold by wearing a hip protector at the time of falling. Given that most clinical trials have failed to attain a similar level of adherence, our findings support the need for future research on the benefits of dissemination and implementation strategies to maximize adherence with hip protectors in LTC.

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Older adults who fracture their hip experience heightened mortality and morbidity,[1,2] psychological damage, including fear of falling leading to activity avoidance,[3] and utilize substantial healthcare services.[4] Falls are the leading cause of hip fracture in older adults, accounting for 95% of hip fracture-related hospitalizations in Canadians over 65 years of age.[5] Rates of falls and hip fractures are at least twice as great for older adults in long-term care (LTC), compared with older adults in the community.[6,7] Preventing falls is challenging in LTC, as they are caused by a multitude of external and internal perturbations to balance that occur during activities of daily living, and often do not involve obvious attempts to recover balance.[8,9] Consisting of specialized garments with soft pads or hard domes secured adjacent to the greater trochanter of the femur, hip protectors are designed to reduce the risk of hip fracture in the event of a fall by absorbing and/or diverting energy away from the proximal femur to less vulnerable tissues upon landing.[10] According to a Cochrane systematic review and meta-analysis of randomized and quasirandomized controlled trials, risk of hip fracture is reduced by 18% [risk ratio = 0.82, 95% confidence interval (CI) 0.67−1.00] when residents of LTC are provided with hip protectors.[11] In recognition of this evidence, clinical practice guidelines have recommended hip protectors as a potential strategy to prevent fractures in LTC.[12]

Yet, the Cochrane estimate of the effectiveness of hip protectors was derived from an "intention to treat" analysis of randomized or quasirandomized controlled trials where there was low adherence in the wearing of hip protectors among participants in intervention groups, often dropping below 50% after 12 months,[11,13,14] as well as variability in the biomechanical properties of hip protectors used across trials.[15] Therefore, the Cochrane estimate may not reflect the value of superior models of hip protectors for those who are willing and able to wear them. As with seatbelts, helmets, and all forms of protective clothing, hip protectors are only effective if worn at the time of a critical accident, which in this context, represents a fall. When risk of hip fracture was compared between falls with and without hip protectors among participants in the intervention groups of randomized or quasirandomized controlled trials using a "per-protocol" method of analysis, risk of hip fracture was up to 90% lower if specific types of hip protectors were worn at the time of falling.[16−18]

By means of a 12-month, population-based, retrospective cohort study, our objective was to generate evidence of the effectiveness of hip protectors to reduce risk of hip fracture if worn at the time of falling among LTC residents. A novel aspect of our study is that it describes the real-life effectiveness of hip protectors in a regional health authority from Canada where hip protectors have been implemented into routine clinical practice for nearly a decade. Based on evidence that the wearing of hip protectors reduces risk for hip fracture and perhaps increases risk for pelvic fracture,[11] we hypothesized risk of hip fracture is lower in falls with hip protectors compared with falls without hip protectors, whereas risks of pelvic and other fractures are comparable between falls with and without hip protectors.

Methods

The study protocol was approved by appropriate ethics review boards from the regional health authority and the first author's primary institutional affiliation.

Experimental Design and Setting

We conducted a 12-month, population-based, retrospective cohort study in 14 publicly subsidized LTC homes situated in the Fraser Valley of British Columbia (BC), Canada.

Context

The Fraser Valley is a regional district in Southwestern BC, with a land area exceeding 13,000 km^2 and a population of roughly 276,000 inhabitants. Participating homes were owned and operated by a single regional health authority. Homes ranged in size from 54 to 234 beds (mean = 137, standard deviation = 61, total = 1923). One participating home specialized in the care of persons with Alzheimer's and related dementia. We enrolled homes in the study between June and December 2015.

Guidelines surrounding the delivery of hip protectors

Residents in participating homes are not provided with hip protectors free of charge; however, each home is encouraged to maintain an in-house inventory of 32 pairs of hip protectors. Best practices are described by the regional health authority as follows. Upon admission (or as the need arises), residents should be assessed to determine if they are eligible for hip protectors according to the following criteria: (1) are independently ambulatory or are nonambulatory but attempt to ambulate; (2) have poor balance and/or poor safety awareness; and/or (3) have a history of falls. Once deemed eligible, residents should be assessed to determine the most appropriate model, style, and size of hip protector, and subsequently issued 2 pairs of hip protectors from the in-house inventory. Care staff are encouraged to monitor adherence every day for the following 2 weeks, and to document signs of discomfort and other adverse effects. If adherence is poor, they should be issued 2 pairs of a different model and/or style of hip protector and monitored for an additional 2 weeks. If the occupational therapist, physiotherapist, or registered nurse then agrees it is appropriate to continue with hip protectors, residents are offered the opportunity to purchase their preferred model of hip protectors. Every time a resident purchases a pair of hip protectors from the in-house inventory, care staff should immediately order replacements to maintain an onsite stock of at least 32 pairs. Residents or other decision-makers can also purchase additional pairs for their personal supply through the LTC home at cost.

Models of hip protectors available for purchase

A variety of styles of Safehip (Tytex A/S, Ikast, Denmark) and HipSaver (HipSaver, Inc., Canton, MA) models of hip protectors were available for purchase at participating homes. These models were selected because they have undergone laboratory testing of their biomechanical efficacy consistent with expert recommendation.[15,19,20]

Staff commitment to hip protectors

Staff within participating LTC homes were generally committed to supporting the application of hip protectors; in a cross-sectional survey of n = 529 staff recruited from participating homes at baseline, the mean (SD) score on a validated, 5-point scale developed to measure staff commitment to hip protectors was 4.15 (0.71).[21,22]

Falls, Adherence, and Fall-Related Hip, Pelvic, and Other Fractures

Provincial legislation mandates that details surrounding the circumstances of every fall involving a person in care must be recorded on incident report forms, regardless of severity. For each participating home, we were provided with the following de-identified data extracted from the BC Patient Safety and Learning System (PSLS) incident-reporting database during the 12 months prior to enrollment in our study: participant identification number [assigned based on first and last name, date of birth, and personal health number (if available)]; facility code; date and time of the fall; use of hip protectors at the time of the fall (yes, no, unknown); the severity (degree of harm) of the fall; and type and location (body part) of injuries.

Demographic and Health Status Data

For each LTC home, we collected summary information on the number, demographics, and health status of residents at baseline from select items of the Resident Assessment Instrument-Minimum Data Set 2.0 (RAI-MDS 2.0). We derived summary information from RAI-MDS 2.0 assessments that occurred nearest to, but not after baseline. In addition, for each fall reported in participating homes during the 12 months prior to baseline, we acquired demographic data and health status information of the resident experiencing the fall from the RAI-MDS 2.0 (Supplementary Table 1 for the list of variables). Whenever possible, demographic and health status data was taken from the closest RAI-MDS 2.0 assessment that occurred on or before the fall date. However, if no assessments were completed on or before the fall date, data was taken from the closest RAI-MDS 2.0 assessment that occurred after the fall date. As RAI-MDS 2.0 assessments occur quarterly, it is possible that a given resident's clinical data varied over the study period.

Data Analyses

Demographics and health status of residents in participating homes at baseline

As we acquired summary data on the mean age of residents in each home, we calculated the pooled mean age and SD[23,24] of residents across participating homes at baseline. All other baseline demographics are expressed as percentages.

Falls and adherence to hip protectors

For each home, we recorded the number of beds and calculated the incidence of falls by dividing the total number of falls recorded in the 12-month study by the total number of beds (falls per bed per year). We calculated the number of fallers, number of multiple fallers (≥2 falls), average number of falls per faller, number (%) of falls that occurred with hip protectors, number (%) of fallers who wore hip protectors during all recorded falls, number (%) of fallers who wore hip protectors in some but not all falls, and number (%) of fallers who did not wear hip protectors in a recorded fall. We performed Student *t*-tests to compare the mean frequency of falling between residents who fell at least once during the 12-month study while wearing hip protectors and residents who always fell without hip protectors, the mean frequency of falling between residents who experienced a fracture and residents who did not experience a fracture, and the mean percentage of protected falls between residents who experienced a fracture and residents who did not experience a fracture. Data were analyzed using JMP v 13.0 (SAS Institute Inc, Cary, NC).

Equivalency between protected and unprotected falls

To assess whether protected and unprotected falls in this observational study were balanced with respect to resident-specific factors that may influence risk for hip fracture, we used generalized estimating equation (GEE) models, specifically multiple logistic regression, to model adherence with hip protectors at the time of falling as a function of select items from the RAI-MDS 2.0. We included items that have previously been associated with risk for falls and/or hip fracture, such as age,[25,26] sex,[25,26] body mass index,[27] cognitive impairment (measured via the Cognitive Performance Scale),[25] wandering behavior,[26] frailty (measured via Changes in Health, End-Stage Disease, and Signs and Symptoms scale),[28] deterioration of activities of daily living performance (assessed via the activities of daily living Self-Performance Hierarchy Scale),[26] use of mobility aides,[25,26] medication use,[29–31] incontinence,[32,33] and chronic conditions.[25,34–38] To account for potential correlation between multiple falls within a given resident, we used de-identified participant identification numbers and information on the date and time of each fall to create an ordinal variable representing the order in which falls were experienced by each faller, which was entered in GEE models as a within-subject variable. Data were analyzed using SPSS v 24 (IBM SPSS Inc, Chicago, IL) and significance was set at $\alpha = 0.05$.

Effectiveness of hip protectors

We expressed rates of hip, pelvic, and other fracture as the number of fractures per 100 falls. We used GEE models, specifically Poisson log linear regressions, to determine unadjusted relative risks (RRs) of hip, pelvic, and other fractures between protected and unprotected falls. To account for potential correlation between multiple falls within a given resident, we included order of falls as a within-subject variable. Using the same approach, we also determined the RR of hip, pelvic and other fractures between protected and unprotected falls, after adjusting for propensity to wear hip protectors at the time of falling.[39] Propensity scores were derived from multiple logistic regression modelling adherence with hip protectors as a function of select items from RAI-MDS 2.0, the details of which are described in the sub-heading of the Methods entitled "Equivalency between protected and unprotected falls". Data were analyzed using SPSS v 24 (IBM SPSS Inc) and significance was set at $\alpha = 0.05$.

Missing data

A total of 3826 fall events were recorded in the BC PSLS during the 12 months prior to baseline. Figure 1 depicts the flow of fall events in our analytic samples. The BC PSLS categorizes the severity of each fall per the following criteria: no harm = 1, minor harm = 2, moderate harm = 3, severe harm = 4, and death = 5. No recorded falls were missing data on degree of harm. Of the 3779 recorded falls retained after excluding missing adherence data, 22.4% (n = 857) were documented as harmful (degree of harm>1). Only recorded falls documented as harmful were presumed to have caused injury. Of the 857 fall events documented as harmful, 30.5% (n = 261) were missing data on the type of injury sustained in the fall. To identify potentially unreported hip, pelvic, and other fractures, a member of the research team reviewed progress notes attached to all fall events categorized as harmful in the BC PSLS incident reporting database. Four types of fractures (1 hip, 2 pelvic, 1 other) were identified in these progress notes. The remainder (n = 259, 6.8%) of falls containing missing injury data were listwise deleted. Accordingly, when comparing the unadjusted risk of hip, pelvic, and other fractures between falls protected by a hip protector and unprotected falls, our analytic sample comprised 3520 fall events. We were unable to identify a corresponding RAI-MDS 2.0 assessment for a further 94 fall events, including 1 fall causing hip fracture. Thus, when assessing equivalency between protected and unprotected falls, and when adjusting the RR of hip, pelvic and other fractures for propensity to wear hip protectors, our analytic sample comprised 3426 fall events.

Results

Demographics and Health Status of Residents in Participating Homes at Baseline

In total, 1817 residents occupied participating LTC homes at baseline. The pooled mean (SD) age of residents in participating homes was 82.7 (11.3) years and 68% were female (Table 1).

Falls and Adherence to Hip Protectors

The mean (SD) incidence of falls in participating homes was 1.86 (0.51) falls per bed per year. The mean (SD) number of falls per faller was 3.41 (4.27), and the range was 1–44. The majority (2108 of 3520 falls, 59.9%) of falls were protected with a hip protector, and 61.0% (630 of 1032) of fallers wore a hip protector during at least 1 fall (Table 2).

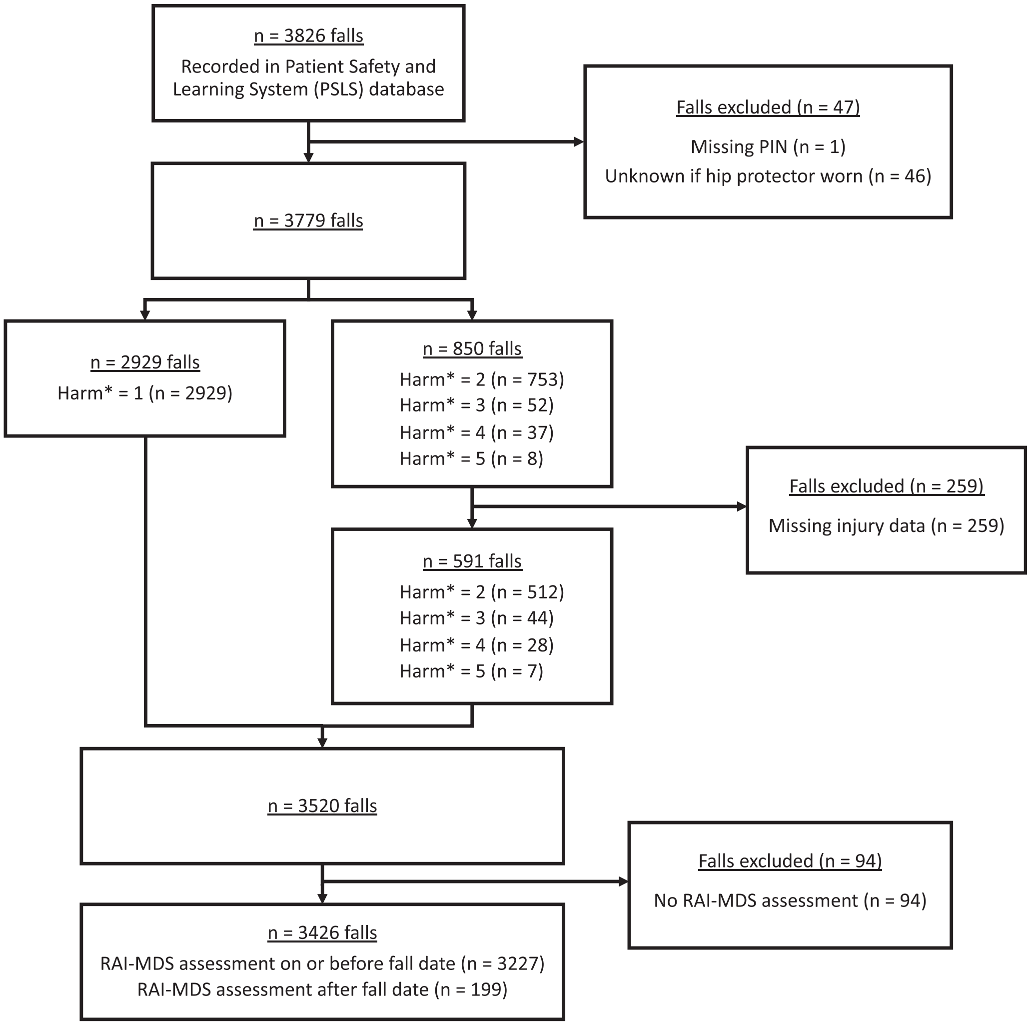

Fig. 1. Flow diagram of included fall records *PIN*, participant identification number. *As categorized in the BC PSLS incident reporting database; 1 = none; 2 = minor; 3 = moderate; 4 = severe; 5 = death.

On average, residents who wore a hip protector during at least 1 fall experienced more falls during the 12-month study than residents who always fell without hip protectors (mean diff = 2.6, 95% CI 2.1–3.0, $P < .001$). There were no differences in the mean frequency of falls (mean diff = 1.4, 95% CI −0.2 to 2.9, $P = .08$) or the mean percentage of protected falls (mean diff = 1.1%, 95% CI −11.7 to 13.8%, $P = .9$) between residents who experienced a fracture and those who did not.

Equivalency Between Protected and Unprotected Falls

Among the subset of falls where we were able to identify a corresponding RAI-MDS 2.0 assessment (n = 3426), demographic and health status data was taken from the closest quarterly assessment that occurred on or before the fall date for the majority of events (n = 3227), with the remainder taken from the closest assessment that occurred after the fall date (n = 199). The following resident-specific factors were associated with likelihood of experiencing a protected fall: male sex (odds ratio [OR] 1.37, 95% CI 1.03–1.83, $P = .032$); moderate to severe cognitive impairment (CPS score 3–6) vs intact to mild impairment (CPS score 0–2) (OR 1.83, 95% CI 1.35–2.47, $P < .001$); cardiac dysrhythmia (OR 1.73, 95% CI 1.01–2.97, $P = .048$); using a cane or walker (OR 1.56, 95% CI 1.11–2.19, $P = .011$); having taken anti-anxiety medication (OR 0.68, 95% CI 0.51–0.92, $P = .013$); having exhibited wandering behavior (OR 1.50, 95% CI 1.12–2.01, $P = .006$); urinary incontinence (OR 1.64, 95% CI 1.19–2.28, $P = .003$); and bowel incontinence (OR 0.68, 95% CI 0.50–0.93, $P = .016$) (Supplementary Table 1).

Effectiveness of Hip Protectors

In total 1.3% of falls (46 of 3520 falls) caused a single fracture; 0.1% (4 of 3520 falls) resulted in 2 fractures. Twenty (0.6%) falls caused hip fracture, 9 (0.3%) resulted in pelvic fracture, and 22 (0.6%) resulted in at least 1 fracture to body parts other than the hip or pelvis. One fall event caused a hip fracture and an upper extremity fracture.

In falls without hip protectors, rates of hip, pelvic, and other fractures were 0.92, 0.21, and 0.71 per 100 falls, respectively. In falls with hip protectors, rates of hip, pelvic, and other fractures were 0.33, 0.28, and 0.71 per 100 falls, respectively. The unadjusted RR of hip fracture was 0.36 (95% CI 0.14–0.90, $P = .029$) during falls protected by a hip protector compared with unprotected falls. There were no differences between falls with hip protectors and falls without hip protectors in the unadjusted risk of pelvic fracture (unadjusted RR 1.34, 95% CI 0.33–5.35, $P = .68$), or the unadjusted risk of other fractures (unadjusted RR 0.96, 95% CI 0.36–2.51, $P = .93$) (Table 3).

After adjusting for propensity to wear hip protectors at the time of falling, the RR of hip fracture was 0.38 (95% CI 0.14–0.99, $P = .048$), the RR of pelvic fracture was 1.46 (95% CI 0.33–6.54, $P = .62$), and the RR of other fractures was 0.94 (95% CI 0.37–2.37, $P = .89$) during falls protected by a hip protector compared with unprotected falls.

Table 1
Number, Demographics, and Health Status of Residents in Participating Homes at Baseline

Characteristics	
No. residents	1817
No. (%) residents with admission background assessment	1810 (99.6)
No. (%) residents with at least one RAI-MDS 2.0 assessment	1763 (97.0)
Demographics (n = 1763)	
Pooled mean (SD) age, y	82.7 (11.3)
No. (%) under 65 y	133 (7.5)
No. (%) over 85 y	855 (48.5)
No. (%) female	1193 (67.7)
No. (%) postsecondary education	390 (21.5)
Responsibility for payment (n = 1810)	
No. (%) Canadian resident, self-pay	390 (21.5)
Diseases (n = 1763)	
No. (%) osteoporosis	287 (16.3)
No. (%) depression	284 (16.1)
No. (%) Alzheimer's disease	207 (11.7)
No. (%) Dementia other than Alzheimer's disease	679 (38.5)
No. (%) Parkinson's disease	90 (5.1)
Continence (n = 1763)	
No. (%) bowel incontinence	706 (40.1)
No. (%) urinary incontinence	1001 (56.8)
Functional outcomes (n = 1763)	
No. (%) CPS ≥ 4*	532 (30.2)
No. (%) ADL Self-Performance Hierarchy Scale ≥3†	1193 (67.7)
Behaviors (n = 1763)	
No. (%) wandering	257 (14.6)
Medications (n = 1763)	
No. (%) received antipsychotic	434 (24.6)

ADL, activities of daily living; CPS, Cognitive Performance Scale
*Severe cognitive impairment.
†Extensive assistance or more required with ADL.

Discussion

Our objective was to build on existing evidence of the effectiveness of hip protectors to prevent hip fractures in LTC by contrasting rates of hip, pelvic, and other fractures between falls with and without hip protectors that occurred under real-world conditions. We have generated additional evidence that hip protectors can be an efficacious strategy to prevent hip fractures in LTC. The risk of hip fracture was reduced by nearly 3-fold by wearing a hip protector at the time of falling (unadjusted RR 0.36; 95% CI 0.14–0.90). As hip protectors were worn in 60% of falls, we estimate the use of hip protectors prevented 6.5 (95% CI 0–15.5) hip fractures per 1000 beds per year.

Our observed effect of hip protectors in reducing fracture risk is greater than the estimate reported by the most recent Cochrane systematic review and meta-analysis of randomized and quasi-randomized controlled trials,[11] where the provision of hip protectors to residents in LTC provided an 18% reduction in risk for hip fracture (RR 0.82, 95% CI 0.67–1.00). The primary reason for this difference is that Cochrane used an "intention to treat" method of analysis to generate its estimate of clinical effectiveness, while we used a "per-protocol" method of analysis. The "intention to treat" method of analysis does not consider whether participants in the intervention group were wearing hip protectors at the time of fracture, and in several trials included in the Cochrane systematic review and meta-analysis, the majority of hip fractures in the intervention group occurred without protection. For example, Cameron et al[40] reported that only 53% of falls experienced by residents in the intervention group occurred while hip protectors were properly applied, and all falls resulting in hip fracture occurred without protection. Not surprisingly, the risk of hip fracture did not differ between intervention and control groups (hazard ratio 1.46; 95% CI 0.51–4.20).[40] In contrast, the "per-protocol" method of analysis provides estimates of the effectiveness of hip protectors by comparing rates of hip fracture between those who adhered to the protocol (wore hip protectors at the time of falling) and those who did not.

Our observations on the "real-life" protective value of hip protectors in LTC are comparable to the results of nested per-protocol analyses of randomized or quasi-randomized controlled trials conducted in similar settings, which compared rates of hip fracture between participants in the intervention group who did and did not wear hip protectors at the time of falling. Kannus et al,[16] for example, reported that the unadjusted risk of hip fracture was reduced by 80% (95% CI 50%–95%) in falls with hip protectors compared with falls without hip protectors, and hip protectors were worn in 74% of falls. In addition, Bentzen et al[18] observed that the odds of hip fracture were 64% (95% CI 23%–83%) lower in falls protected by a soft hip protector, and 59% (95% CI 11%–81%) lower in falls protected by a hard-shell hip protector, compared with unprotected falls, and 49% of falls occurred with hip protectors. Contrarily, our results differ from those of Kiel et al[41] who randomized nursing homes to provide residents with protection to only the right or left hip, and found no difference in rates of hip fracture between protected and unprotected hips, despite an overall adherence rate of 73% after 20 months of follow-up (calculated as the percentage of visits residents were observed to be correctly wearing hip protectors as a function of the total number of visits). However, the Kiel et al[41] study suffered from the use of a biomechanically inferior hip protector (FallGard),[15] as well as the unexpected tendency and lack of adjustment for residents to fall 3 times more often on the protected hip.[41] Subsequent biomechanical testing of the FallGard model of hip protector according to international guidelines[19] revealed it performed in the bottom quartile of 26 commercially available hip protector models.[15]

Unlike past observations, our findings reflect the benefits of hip protectors which can be achieved in practice (beyond the context of clinical trials), and thus, may have strong relevance for real-world decision-making. It is one thing to show effectiveness in a clinical trial, where a team of investigators work to maximize adherence. Our study moves beyond the artificiality of the clinical trial environment, to examine the real-life value of hip protectors in reducing hip fractures in LTC homes from a region of BC that had attained 60% adherence with hip protectors.

We observed that 60% of falls occurred with hip protectors, and 61% of fallers wore a hip protector during at least 1 fall. As we understand it, few studies have reported rates of adherence under authentic conditions where residents were required to purchase their own supply of hip protectors. In an observational study, Klenk et al[42] reported that availability of hip protectors ranged from 0% to 38% across 48 German nursing homes, with one-quarter of homes not making hip protectors available. Two randomized controlled trials have compared rates of adherence between residents receiving hip protectors at no charge (intervention groups) and residents who were required to purchase their own supply of hip protectors (control groups).[43,44] Residents in control groups were found to wear hip protectors in 0%–8% of falls, with 0%–15% of residents wearing hip protectors during at least 1 fall.[43,44] Our observation of 60% adherence with hip protectors in participating homes reflects the success of the

Table 2
Number of Falls, Fallers, and Multiple Fallers, Number (%) of Protected Falls, and Number (%) of Fallers Who Wore Protectors

Outcomes	No. (%)
Falls	3520
Falls with hip protectors	2108 (59.9)
Fallers	1032
Multiple fallers (≥2 falls)	587 (56.9)
Fallers who wore hip protectors during:	
All recorded falls	383 (37.1)
Some recorded falls	247 (23.9)
No recorded falls	402 (39.0)

Table 3
Unadjusted and Adjusted RRs of Hip, Pelvic, and Other Fractures in Falls Protected by a Hip Protector Compared With Falls Without a Hip Protector

Type of Fracture	Falls with a Hip Protector		Falls without a Hip Protector		Unadjusted[‡] RR (95% CI)	*P* Value	Adjusted[§] RR (95% CI)	*P* Value
	No. of Fractures	Incidence* (No. Per 100 Falls)	No. of Fractures	Incidence[†] (No. Per 100 Falls)				
Hip	7	0.33	13	0.92	0.36 (0.14–0.90)	0.029	0.38 (0.14–0.99)	.048
Pelvic	6	0.28	3	0.21	1.34 (0.33–5.35)	0.68	1.46 (0.33–6.54)	.62
Other[‖]	15	0.71	10	0.71	0.96 (0.36–2.51)	0.93	0.94 (0.37–2.37)	.89

*n = 2108 falls occurred with hip protectors.
[†]n = 1412 falls occurred without hip protectors.
[‡]Poisson regression GEE models with order of falls as within-subject variable.
[§]Poisson regression GEE models with propensity score as covariate and order of falls as within-subject variable.
[‖]Includes fractures of the skull (n = 1), shoulders (n = 3), arms (n = 2), olecranon (n = 1), wrists (n = 3), fingers (n = 2), ribs (n = 2), vertebrae (n = 2), legs (n = 2), patella (n = 2), malleolus (n = 3), and feet (n = 2).

implementation process in participating homes, including the strong commitment of staff to support the use of hip protectors.[14,21,22]

Our results provide insight on the characteristics of residents who were more likely to wear hip protectors. We observed that residents who had moderate to severe cognitive impairment, wandering behavior, cardiac dysrhythmia, used a cane or walker, and experienced bladder incontinence were more likely to wear hip protectors at the time of falling. Because each of these factors has previously been associated with risk for falls and/or hip fractures, our findings are consistent with those from a recent systematic review on factors influencing adherence with hip protectors in LTC, which found that residents with established risk factors for falls and fractures are more likely to accept and adhere to the wearing of hip protectors.[14] We observed that residents who had taken antianxiety medication had lower odds of experiencing a protected fall than those who had not. This finding is aligned with those by Honkanen et al[45] who observed that anxiety (OR 0.15; 95% CI 0.04–0.50; $P = .002$) and resistive behaviors (OR 0.43; 95% CI 0.21–0.85; $P = .02$) negatively predicted hours of hip protector use among LTC residents. We also found that bowel incontinence was negatively associated with propensity to wear hip protectors at the time of falling. Additional research is warranted on the circumstances in which incontinence acts to enable or serve as a barrier to adherence.

The mean incidence of 1.86 falls per bed per year across all participating homes is consistent with rates reported previously. Rubenstein et al,[7] for example, reported a mean incidence of falls in LTC equivalent to 1.5 falls per bed per year.[7] We observed an incidence of falls (falls per bed per year) ranging from 0.79 to 3.04 across homes. One home had a relatively low fall rate of 0.79 falls per bed per year. However, at baseline, 22% of residents in this home were under the age of 65 years. This home also housed a specialized unit for ventilator-dependent residents, who probably received a high level of care. Risk of falling increases with advancing age,[7,46] and low fall rates have been reported previously in residents with high care needs,[47] probably because they are often bedridden and less exposed to activities that lead to falls. The unique characteristics of residents in this home likely explain the lower than expected rate of falling.

Rates of fractures were lower than expected in participating homes. Among falls without hip protectors, rates of hip and pelvic fractures were 0.92 and 0.21 per 100 falls, respectively. In comparison, Kannus et al[16] reported rates of hip and pelvic fractures of 2.43 and 0.27 per 100 falls, respectively, in falls without hip protectors. Given that Kannus et al[16] recruited a portion of participants from outpatient care units, if anything we expected to observe slightly higher rates of fractures in our sample of LTC residents. Rates are also lower than those described by Rubenstein et al,[7] who reported that about 4% (range 1%–10%) of falls in LTC cause fracture (vs 1.4% in our sample) based on a review of large-scale published studies.[7] The relatively lower rates of fractures documented in participating LTC homes might be due to a combination of co-intervention (eg, vitamin D_3 supplementation, use of antiresorptive agents, and fall mats), the relatively high use of hip protectors, underreporting of fractures in the BC PSLS incident reporting database, and/or underreporting of non-injurious falls in prior research.

We recognize important limitations of our study. First, we identified fall events via the BC PSLS incident reporting database. Previous research suggests incident reports do not capture every fall event.[48] However, even after excluding fall events with missing data, the incidence of falls in participating homes was consistent with rates reported previously. Second, we did not verify the accuracy of data contained in the BC PSLS incident reporting database, nor fractures against radiologic evidence. Although we could not confirm, we see little reason for believing that there were differences in the accuracy of reporting for padded vs unpadded falls. Third, as is true with all observational research designs, our ability to make causal inferences is limited.

We also acknowledge key strengths of our study. First, we studied a population-based sample comprising all residents from 14 LTC homes owned and operated by a regional health authority who experienced at least 1 recorded fall during the 12-month observation period. The generalizability of findings is supported by the close alignment between baseline demographics and health status indicators of residents in participating homes and those of the general Canadian LTC population. For example, we observed a mean age of residents in participating homes of 83 years. In comparison, between 2017 and 2018, the Canadian Institute of Health Information (CIHI) reported an average age of residents in Canadian LTC homes of 84 years.[49] Furthermore, 68% of residents in participating homes at baseline were female, compared with 65% of residents across Canada.[49] Similarities were also observed in the incidence of several disease diagnoses between our sample and the national population of LTC residents, including diagnoses of dementia (50% and 62%, respectively), Parkinson's disease (5% and 6%, respectively), and osteoporosis (16% and 25%, respectively).[49] Second, to mitigate potential threats to internal validity imposed by nonrandom assignment, we performed a detailed equivalency analysis to determine if protected and unprotected falls were balanced with respect to potential resident-specific confounders of fracture risk. We found that residents who possessed established risk factors for falls or fractures were generally more likely to wear hip protectors at the time of falling. Results of the equivalency analysis are consistent with our observation that residents who wore hip protectors during at least 1 fall experienced more falls, on average, than consistent nonusers of hip protectors. However, after adjusting for propensity to wear hip protectors, the RR of hip fracture in protected compared with unprotected falls remained relatively stable (adjusted RR 0.38; 95% CI 0.14–0.99, $P = .048$). When we also consider there were no significant differences in the rates of pelvic and other fractures between protected and unprotected falls in both the unadjusted and adjusted analyses, our findings collectively suggest that resident-specific factors other than the use of hip protectors were probably not responsible for the observed between-group difference in hip fracture rates.

Conclusions and Implications

We offer additional insight into the circumstances in which hip protectors work to prevent hip fractures in LTC. In the 12-month study duration, hip protectors were worn in 60% of recorded falls, and fall events with hip protectors had 0.36 times the risk of hip fracture than falls without hip protectors. Given that most clinical trials on the effectiveness of hip protectors in LTC have failed to attain a similar level of adherence, our findings support the need for future research on the benefits of dissemination and implementation strategies to maximize adherence with hip protectors in LTC.

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Supplementary Table 1
Multiple Logistic Regression of Factors on the Odds of Wearing Hip Protector

Variables Being Compared	Number (%) of Falls		Univariate Analysis	
	With Hip Protector	Without Hip Protector	OR (95% CI)	*P* Value
Age				
Mean (SD) (y)	84.4 (9.4)	83.0 (12.1)		
One year increase			1.01 (0.99–1.03)	.202
Men vs*	827 (64.4)	458 (35.6)	1.37 (1.03–1.83)	.032
Women	1236 (57.8)	904 (42.2)		
ADL performance				
Dependent vs	1349 (63.7)	769 (36.3)	1.34 (0.98–1.84)	.066
Independent	714 (54.7)	592 (45.3)		
Cognitive impairment *				
Moderate to severe (CPS 3+) vs	1565 (65.6)	819 (34.4)	1.83 (1.34–2.47)	<.001
Intact to mild (CPS <3)	498 (47.9)	542 (52.1)		
High CHESS (2+) vs	508 (61.8)	314 (38.2)	0.99 (0.76–1.28)	.930
Low (<2)	1555 (59.8)	1047 (40.2)		
BMI, kg/m^2				
Top quartile >26.1 vs	431 (50.8)	418 (49.2)	0.73 (0.51–1.06)	.060
Middle 20.1-26.1 vs	1061 (63.9)	599 (36.1)	1.13 (0.81–1.58)	.502
Low quartile <20.1	506 (61.2)	321 (38.8)		
Diabetes vs	415 (58.8)	291 (41.2)	1.09 (0.77–1.54)	.616
No	1648 (60.6)	1072 (39.4)		
Cardiac dysrhythmias vs*	157 (73.4)	57 (26.6)	1.73 (1.01–2.97)	.048
No	1884 (59.4)	1287 (40.6)		
Hypertension vs	1019 (59.0)	709 (41.0)	0.85 (0.65–1.12)	.241
No	1022 (61.7)	635 (38.3)		
Osteoporosis vs	329 (64.6)	180 (35.4)	1.34 (0.93–1.94)	.113
No	1712 (59.5)	1164 (40.5)		
Alzheimer's disease vs	220 (61.1)	140 (38.9)	0.99 (0.68–1.43)	.965
No	1821 (60.2)	1204 (39.8)		
Stroke vs	345 (56.8)	262 (43.2)	0.82 (0.58–1.16)	.257
No	1718 (60.9)	1101 (39.1)		
Dementia vs	1146 (64.1)	641 (35.9)	1.20 (0.92–1.57)	.180
No	917 (55.9)	722 (44.1)		
Parkinson's vs	240 (72.9)	89 (27.1)	1.19 (0.73–1.94)	.496
No	1801 (58.9)	1255 (41.1)		
Depression vs	502 (59.6)	340 (40.4)	1.07 (0.77–1.48)	.690
No	1561 (60.4)	1023 (39.6)		
No. of medications (>9) vs	949 (59.2)	653 (40.8)	1.14 (0.85–1.51)	.384
≤9	1114 (61.1)	710 (38.9)		
Use of antipsychotic vs	841 (61.2)	534 (38.8)	0.88 (0.67–1.15)	.333
No	1222 (59.6)	829 (40.4)		
Use of antianxiety vs*	404 (54.3)	340 (45.7)	0.68 (0.51–0.92)	.013
No	1659 (61.9)	1023 (38.1)		
Use of antidepressant vs	1085 (60.7)	703 (39.3)	1.07 (0.81–1.41)	.658
No	978 (59.7)	660 (40.3)		
Use of hypnotic vs	637 (59.1)	441 (40.9)	0.92 (0.68–1.25)	.591
No	1426 (60.7)	922 (39.3)		
Use of diuretic vs	393 (57.8)	287 (42.2)	0.99 (0.71–1.37)	.936
No	1670 (60.8)	1076 (39.2)		
Use of analgesics vs	1352 (59.4)	926 (40.6)	0.90 (0.67–1.22)	.506
No	711 (61.9)	437 (38.1)		
Bowel incontinence vs*	894 (62.5)	537 (37.5)	0.68 (0.50–0.93)	.016
No	1169 (58.6)	826 (41.4)		
Bladder incontinence vs*	1413 (64.1)	793 (35.9)	1.64 (1.19–2.28)	.003
No	650 (53.3)	570 (46.7)		
Cane or walker user vs*	649 (65.2)	347 (34.8)	1.56 (1.11–2.19)	.011
Nonuser	1392 (58.3)	997 (41.7)		
Wheelchair vs	1051 (60.3)	692 (39.7)	1.04 (0.78–1.39)	.776
Nonuser	990 (60.3)	652 (39.7)		
Wandering behavior vs*	770 (70.0)	330 (30.0)	1.50 (1.12–2.01)	.006
No	1293 (55.6)	1033 (44.5)		

ADL, activities of daily living; BMI, body mass index; CHESS, Changes in Health, End-stage disease, Signs, and Symptoms scale; CPS, Cognitive Performance Scale
*Significant at $P \leq .05$.